Annals of Agric. Sci., Moshtohor **ISSN 1110-0419**
Vol. 60(4) (2022), 1145 – 1158 **https://assjm.journals.ekb.eg**

Quality Evaluation of Cold Catfish Soaking with Different Herbal Extracts

Mahmoud, M.M.*, Bahlol, H.E.M. **, Abou-Taleb, M. *, Ibrahim, M. A. * , El-Desouky, A. I. ** and Sharoba, A. M. A. **
* Fish Processing and Technology Lab., National Institute of Oceanography and Fisheries, Cairo, Egypt.
**Food Technology Department, Fac. of Agriculture, Benha Univ., Qalyoubia, Egypt.
***Corresponding author: ashraf.shraouba@fagr.bu.edu.eg**

Abstract

This study aimed to evaluate the physicochemical, microbiological and sensory quality of soaked catfish fillets in herbal extracts during storage at 4±1ºC for 15 days. The obtained results indicated that the physicochemical parameters of pH, TVB-N, TMA-N, PV, TBA values and microbial counts of all soaked samples increased (p <0.05) with increasing the storage time. In contrast, the scores of sensory properties of color, odor, texture and overall acceptability were decreased (p <0.05) during storage period as a result of spoilage advancement. The control sample followed by BHT treatment were exhibited the highest deterioration rate (p <0.05) during cold storage. In the meantime, the herbal extracts were retarded the spoilage as the result of their antioxidant and antimicrobial effects, to be reduced lipid oxidation, and protein degradation by the reduction of microbial growth in treated fish fillets. Therefore, the sensory quality of soaked catfish fillets positively affected by soaking in herbal extracts, to present the best scores during storage period compared to control and BHT treatments. The herbal extracts were extended the consumption acceptability of soaked catfish fillets for 12 days, higher than (p <0.05) of the 6 and 9 days for control sample and BHT treatment, respectively restricted by physicochemical, microbiological and sensory properties.

Keywords: Catfish, herbal extracts, soaking, physicochemical, microbiological, sensory properties.

Introduction

Fish serves as a good source of dietary protein is very inexpensive related to other protein from animal foods, and excellent component of human diet **(Olalekan, 2019)**, primary dietary source of omega-3 polyunsaturated fatty acid (PUFA), including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (**Siscovick *et al*., 2017)**, a good source of several minerals and vitamins are vital to human health **(Gandotra *et al*., 2015)**. For example, catfish (*C. gariepinus*) is most important aquaculture freshwater species with tilapia in Egypt. In 2017, the world aquaculture production quantity of farmed catfish species (*i.e*. freshwater fishes of the order Siluriformes) is 5.5 million tonnes as percent of 4.93% **(FAO, 2019)**. Although, the African catfish meat has high nutritional values, it was reported that the great benefit for human health if these fish are included in the human diet (**Abozid *et al*., 2017 and Linhartová *et al*., 2018)**, good and cheap source for animal protein, other than it has low marketing value compared to other species of fresh water fish, due to less appealing taste and undesirable characteristics such as rapid development of rancid off-flavor due lipid rancidity and change in color, therefrom it is necessary to improve quality properties of such fish **(El-Hanafy, 2013 and El-Shennawy *et al*., 2017)**. On the other hand, fish is extremely perishable comparable other food items, as a result of rapid microbial growth naturally present in fish or from contamination **(Mei *et al*., 2019)**, lipid oxidation **(Isaacs, 2016)**. The decomposition of fish muscle concluded macro and micro nutrients is a result of biological reactions such as lipid and protein oxidation, which are also due to the microbial and enzymatic activity, in either cases muscle decomposition leads to shelf-life reduction in fish and fish products, based on the changes in quality characteristics of fish **(Liu *et al*., 2018, Moniruzzaman *et al*., 2020 and Hussain *et al*., 2021)**.

Concerning the fish processing is an important branch from food processing, always is seeking for maximize the utilization of available aquatic resources to provide human societies by high accepted and safety fishery products. Recently many consumers greatly preferred freshly ready to eat/prepare or cook food items. This could be achieved by cooling, other than the cold storage alone is shortly period, unless it applied with synergistic processing treatments as edible coatings. The coating technique as well as soaking application in herbal extracts and essential oils is one of the leading method of producing new safety and freshly seafood products, the most common edible films/coatings nowadays are from natural preservatives such extracts and essential oils of various spices characterized by antioxidant and antimicrobial activity **(Dehghani *et al*., 2018; Socaciu *et al*., 2018 and Morachis-Valdez *et al*., 2021)**. The natural preservatives such essential oils and herbal extracts have gained by consumer interest due to the awareness on the harmful effect synthetic preservatives because their toxicity. Plant-based phenolic extracts can be used to decrease oxidation

process and increase the shelf life of fish products, additionally antioxidant compounds from different natural sources such herbal extracts have also proven to be effective antimicrobial agents, where it is incorporation of herbal extracts into ice was also found useful for inhibiting the microbial and biochemical spoilage of fresh fish compared to conventional icing **(Akbarirad *et al*., 2016; Viji *et al*., 2017; Ali *et al.*, 2019 and Shahbazi, 2019)**. Herbal extracts have antioxidant activity due to their poly-phenolic, phenolic acids, biological and anticoagulant compounds, which responsible for antimicrobial and antioxidant properties. Generally, essential oil and plant extracts, as natural antioxidants are added to fresh and processed meat and meat products to delay, or prevent lipid oxidation, rancidity, decrease microbial growth, improve color stability and extend shelf-life, without any effect to the sensory or nutritional properties (**Rather *et al*., 2016; Begum *et al*., 2019 and Šojić *et al*., 2019)**. Soaked and chilled fish steaks in natural preservatives are one of fresh ready to eat fish products. The common application methods were dipping, spraying or casting, material was coated or wrapped with film prior to the further process for chilled and frozen stored products **(Viji *et al*., 2017)**. The freshly and naturally ready to eat fish products is proper to maximize utilize of fish meat, such as soaked products with essential oil **(Moawad *et al*., 2017; Morshdy *et al*., 2018; Sönmez *et al*., 2020 and Abbas *et al*., 2021)**. The objective of this investigation mainly was to utilize from preservative effects of clove, thyme and mint extracts to extend the shelf life of soaked catfish fillets during refrigeration, furthermore to developed sensory quality of catfish meat as well as to obtain high quality, safety and accepted ready to eat fish product from low value catfish meat.

Materials and methods

Fish samples: About 30 kg from a live catfish (***Clarias gariepinus*)** with average weight from 2.25 to 3.00 kg, length from 50 to 60 cm were purchased from local market of El-Obour city, Qalyoubia Governorate, Egypt, and transported in icebox to Fish Processing and Technology Laboratory, Fish Research Station, El-Kanater El-Khiria, National Institute of Oceanography and Fisheries. All Fish prepared for processing under hygienic conditions, rewashed, slaughtered, bleeding, beheaded, eviscerated, skin removed and filleted, then rewashed and drained till use.

Herbal materials: Three types of herbals were used to the study as fresh mint (*Mentha sp.*), fresh thyme (*Thymus vulgaris*) and dried clove buds (*Syzygium aromaticum*) obtained from local market (Toukh, Qalyoubia, Egypt).

Synthetic antioxidants, chemicals and media: Butylated hydroxy toluene (BHT), ethyl alcohol 99.9%, methanol, chloroform, sodium hydroxide, trichloroacetic acid, glacial acetic acid, picric acid, hydrochloric acid, thiobarbituric acid, sodium sulphate anhydrous, toluene, and sodium chloride were obtained from Techno Lab for Trade Co. (Cairo, Egypt). Nutrient agar medium obtained from International Trade Association (ITA) Co., (El-Kasr El-Aini, Cairo, Egypt).

Methods:

Herbal preparation and extraction: The herbal of thyme, mint and clove were prepared and extracted by ethanol (99.9%) according to the method of "solid-liquid extraction" as described by **Sung-Jin *et al.* (2013) and Hermund (2016)**.

Catfish soaking: The fresh catfish fillets were cut into slices with dimensions of 2 x 8 x 1.3-1.5 cm (width x length x highest), the fish slices were divided to 8 equal batches and subjected to study the effect of their soaking in various herbal extracts and BHT solution in comparison with control. The soaking treatments were carried out according to **Morshdy *et al.* (2018)** as following: the 1st treatment (T1) soaked in distilled water (control), the 2nd treatment (T2) in 0.1% BHT solution, the 3rd and 4th treatments (T3&T4) in 0.5 and 1% thyme extracts, the 5th and 6th treatments (T5&T6) in 0.5 and 1% clove extracts, and the 7th and 8th treatments (T7&T8) in 0.5 and 1% mint extracts. All soaking treatments separately were carried out in the meantime for 10 minutes with moderate agitation, afterward the treated fillets were separately collected, drained on pored stainless steel board for 5 minutes. After that the all samples were packed in foam plates and stored in polyethylene bags at 4±1ºC for 15 days. Soaked samples were subjected to physicochemical, microbiological and sensory analysis intervals 0, 3, 6, 9, 12 and 15 days.

Analytical methods:

Proximate chemical composition: The proximate analysis on basis of the moisture, crude protein, fat and ash contents were determined according to the methods recommended by the **AOAC (2000)**, total carbohydrates was calculated by difference.

Physicochemical analysis: The freshness tests and chemical quality of soaked catfish treatments concluded the pH value was carried out according to the procedure of **Abdel-Aziz *et al*. (2019)**, the total volatile basic nitrogen (TVB-N) and trimethyle amine nitrogen (TMA-N) contents were determined according to the method described by **Pearson (1976)**. Peroxide Value (**PV**) was determined using the method of **Egan *et al*. (1997)**, and the thiobarbituric acid (TBA) value was measured according to the method described by **Tarladgis *et al*. (1960).**

Microbiological examination: the fish samples were primarily prepared for microbiological analysis according to **Heydari *et al*. (2015)**, then pour plating method was utilized for microbiological analysis of total viable count (TVBC) by using nutrient agar

media incubated at 37±1 ºC for 48 h as described by **Heydari *et al*. (2015)**. Total psychrophilic bacterial count (TPBC) was determined by using nutrient agar media incubated at 5±1ºC for 7days as described by **Sönmez *et al*. (2020)**, all microbiological results are expressed as log of the colony forming units (cfu) per gram of sample, all analyses were done in triplicate.

Sensory evaluation: The sensory evaluation of soaked catfish fillets was carried out according to the procedure of **Greeshma *et al.* (2019)**, it was done in terms of color, odor, texture and overall acceptability. All sensory properties of tested soaked catfish fillets were evaluated by 10 panelists. A 9 point hedonic scale was employed in this sensory analysis.

Statistical analysis:

Three replicates of each trial were performed for each parameter, and values expressed as the mean ±SD. Statistical analyses were performed using Statistical package social science (SPSS) version 16.00 for Windows. Analysis of variance (ANOVA) was used and statistical significance was set at p <0.05 to detect the significant effect between means during storage periods according to **Duncan' test (1955)** to separate means at a probability level of p <0.05.

Results and Discussion:

The chemical composition (w/w) of fresh flesh and raw soaked catfish fillets was presented in **Table (1**), The moisture, crude protein, crude fat, total ash and total carbohydrate contents were 69.92, 14.99, 13.31, 1.10 and 0.69%, respectively. This results are in agreement with those obtained by **Akpambang (2015); Yu *et al*. (2017) and Sudirman *et al*., 2018)**. Meanwhile, there were changes in moisture, protein, fat, ash and carbohydrate contents of fish fillets after soaking treatment to be 71.41, 14.07, 13.12, 0.90 and 0.50%, respectively. Apparently the soaking process of fish fillets in aqueous solutions caused slight increasing in moisture contents compared to raw fillets, in counter to inconsiderable loss in protein, fat, ash and carbohydrate contents compared to fresh fish fillets.

Table 1. Chemical composition of fresh and soaked catfish fillets (on wet weight bases).

Fish samples	Components (%)					Energy value Kcal/100g
	Moisture	Crude Protein	Crude Fat	Total Ash	* Carbohydrate	
Fresh catfish fillets	69.92±0.63	14.99±1.53	13.31±2.77	1.10±0.53	0.68±0.06	182.47
soaked catfish fillets	71.41±1.85	14.07±1.82	13.12±3.16	0.90±0.03	0.50±0.07	176.36

Data are the mean ± SD, n = 3 *carbohydrates percent calculated by difference.

The similar change in chemical composition due to soaking likewise washing caused by water absorption into fish tissue, and outing water soluble substances such some soluble proteins, pigments, enzymes and minerals, also surface fat loss through floating in water phase and removed afterward with drain water or solution, such observations were also noticed by **Das *et al*. (2015) and El-Shennawy *et al*. (2017)** after washing fish fillets during surimi preparation, and **Moawad *et al*. (2017)** after soaking Tilapia fish fillets in aqueous solutions of marjoram oil or sodium tri polyphosphate.

pH value: The pH value is a useful quality index of fish products, which affected by the changes in protein and lipids of fish during storage. The changes in pH of soaked catfish fillets in some aqueous herbal extracts during storage at 4±1ºC were shown in **Table (2**). The pH values of fresh soaked catfish fillets treatments as well as T1, T2, T3, T4, T5, T6, T7 and T8 were 6.57, 6.52, 6.50, 6.48, 6.46, 6.46, 6.47 and 6.42, respectively. Then, a gradual increase (p <0.05) in pH values of all treatments was observed during cold storage period. The difference between control and treated fish fillets samples was significant during cold storage period (p <0.05), the pH values of control and T2 samples were the highest (p <0.05) in comparison with herbal extracts treated catfish fillets, which had pH values of 7.16 and 7.12 at the 9th day of cold storage, respectively. In contrast, all herbal extracts treatments were presented pH value below 7.10, wherever the excess on this level is considering an index for outset of spoilage as reported by **Özyurt *et al*. (2009)**.

The increase of pH values during the storage period might be attributed to the production of volatile basic compounds from proteins breakdown, due to the activity of spoilage bacteria and autolysis enzymes **(Biswas *et al*., 2017; Li *et al*., 2017; Pal *et al*., 2017 and Nisar *et al*., 2019)**. Noteworthy, the herbal extracts especially that obtained from clove were more effective in suppressing pH value from increasing upper value of 7.00 in soaked catfish fillets till 12 days of cold storage as shown in **Table (2)**, because their antimicrobial effects contributed to their contents of bioactive phenolic compounds. Therefore, the difference between herbal extracts in controlling the raise of pH value also might be discussed by the difference in their contents of phenolic compounds, likewise the highest extract level the lowest pH value. These results are in accordance with those found by **Moawad *et al*. (2017); Morshdy *et al*.**

(2018); Lahreche *et al* (2019); John and Siddappaji (2019) and Elhafez *et al.* (2020).

Table 2. pH values of soaked catfish treatments during cold storage period at 4±1ºC.

Storage period (day)	Control	BHT	Treatments					
			Thyme (TH)		Clove (CL)		Mint (MI)	
			0.5%	1%	0.5%	1%	0.5%	1%
0	6.57^{Ca} ±0.06	6.52^{Eab} ±0.04	6.50^{Eab} ±0.05	6.48^{Eab} ±0.05	6.46^{Eb} ±0.05	6.46^{Db} ±0.07	6.47^{Eb} ±0.08	6.42^{Eb} ±0.05
3	6.65^{Ca} ±0.09	6.64^{Da} ±0.03	6.50^{Eb} ±0.10	6.47^{Eb} ±0.07	6.46^{Eb} ±0.05	6.46^{Db} ±0.04	6.50^{Eb} ±0.02	6.49^{Eb} ±0.05
6	6.87^{Ba} ±0.05	6.81^{Ca} ±0.03	6.68^{Db} ±0.04	6.69^{Db} ±0.04	6.69^{Db} ±0.01	6.67^{Cb} ±0.04	6.73^{Db} ±0.05	6.71^{Db} ±0.03
9	7.16^{Aa} ±0.06	7.12^{Ba} ±0.05	6.93^{Cb} ±0.04	6.90^{Cb} ±0.02	6.92^{Cb} ±0.03	6.74^{Cc} ±0.03	6.93^{Cb} ±0.03	6.90^{Cb} ±0.01
12	R*	7.31^{Aa} ±0.08	7.16^{Bbc} ±0.01	7.11^{Bc} ±0.02	7.13^{Bc} ±0.03	6.91^{Bd} ±0.03	7.23^{Bb} ±0.02	7.13^{Bc} ±0.03
15	R*	R*	7.35^{Aab} ±0.04	7.30^{Ab} ±0.03	7.32^{Ab} ±0.06	7.15^{Ac} ±0.06	7.42^{Aa} ±0.06	7.32^{Ab} ±0.04

Means of triplicate ± Standard deviation on wet weight basis. Mean values in the same row (small letter) or column (capital letter) with the same letter are not significantly different (at p <0.05). R*= rejected.

Total volatile basic nitrogen (TVB-N): Generally, the TVB-N may be considered an important quality index for fish. Respecting the effect of herbal extracts on TVB-N values of soaked catfish fillets during cold storage at 4±1ºC was shown in **Fig. (1)**. At zero time, the TVB-N values of T1, T2, T3, T4, T5, T6, T7 and T8 were 12.78, 12.33, 11.71, 11.43, 11.15, 11.60, 11.88 and 11.32 mg/100g, respectively which indicated to good quality of raw soaked fish fillets. Afterthought, the TVB-N values of all soaked fish treatments was increased (p <0.05) with different rates during cold storage period, based on treatment type. The highest increment (p <0.05) of TVB-N was observed in T1 and T2 which reached to 34.28 and 35.06 mg/100g in the 9th and 12th days of storage, respectively to be exceeded the maximum acceptable limit of TVB-N as 30 mg/100g for chilled fish according to **ESS (2019)**. While, all herbal extracts treatments significantly reduced (p <0.05) TVB-N formation during storage compared to control and BHT treatments, as spoilage delaying to have TVB-N values below the rejection limits till 12 days of cold storage more than 6 and 9 days for T1 and T2, respectively. The increasing in TVB-N during storage of fish was associated with activity of endogenous enzyme and bacterial growth **(Moawad *et al.*, 2017)**.

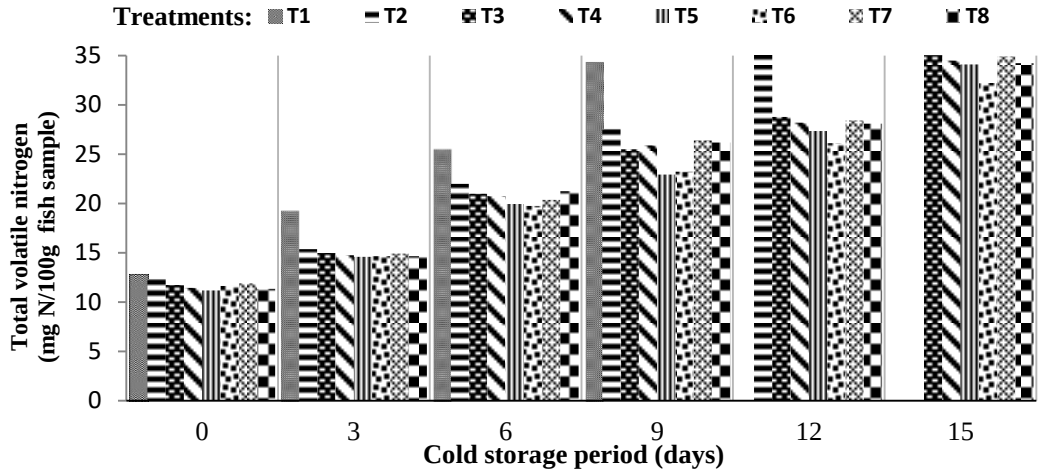

Fig. (1): Total volatile basic nitrogen values of soaked catfish fillets treatments during cold storage period at 4±1ºC.

Thereof, the efficacy of herbal extracts to be reduced the formation of volatile bases more related by their antimicrobial activity, but the statistically analysis was also presented difference (p <0.05) in values of TVB-N between treated samples with different herbal extracts themselves, while the difference between applied concentrations (0.5 and 1%) of every extract was not significant (p > 0.05). This variation might be influenced by their antimicrobial activity, due to the difference in their contents and types of bioactive compounds. The highest reduction obtained from clove extracts

compared to thyme and mint extracts (p <0.05). This results are similarly with those found by **Moawad *et al.* (2017); Kuzgun (2019); John and Siddappaji (2019); Elhafez *et al.* (2020) and Sönmez *et al.* (2020).**

Trimethylamine nitrogen (TMA-N): The TMA-N is considered helpful indicator of freshness of fish and fish products, enzymatically formed from trimethylamine oxide (TMA-O), and due to enzyme and microbial activity. Data in **Fig. (2)** show the changes in TMA-N contents of soaked catfish fillets treatments during cold storage at 4±1ºC. At zero time, the TMA-N contents of soaked fish fillets treatments of T1, T2, T3, T4, T5, T6, T7 and T8 were 1.06, 1.04, 0.95, 0.95, 0.90, 0.90, 1.01 and 0.98 mg N /100g, respectively. Thereafter, the TMA-N values of all fish treatments slowly increased (p <0.05) during cold storage, the significant difference (p <0.05) between control sample and treated catfish fillets samples was detected after 9 days of cold storage.

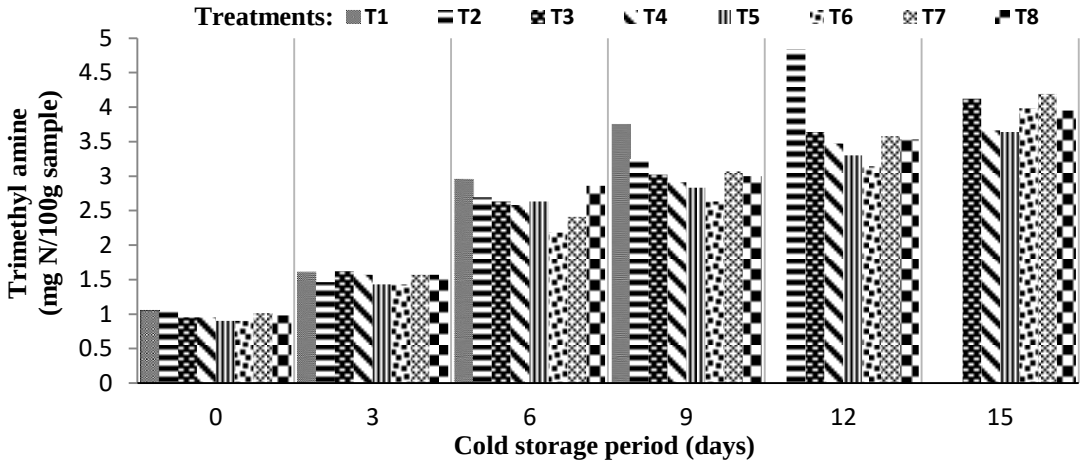

Fig. (2): Trimethyl amine values of soaked catfish fillets treatments during cold storage period at 4±1ºC.

Further the TMA-N formation as a result of protein degradation was formed in control samples faster than (p <0.05) treated samples with clove, thyme and mint extracts and BHT, respectively during cold storage, the highest TMA-N contents was 3.75 mg/100g in control sample on the 9th day of cold storage. The increase in the TMA-N content could be attributed to the TMA-N oxide, naturally present in fish tissues, which chemically reduced to the TMA-N by either SH group existing in fish protein and to the formation of the TMA-N itself from betaine and choline which also naturally occur in fish tissues **(Rodríguez *et al.*, 2009)**. Likewise TVB-N, all herbal extracts were successfully retarded spoilage in fish fillets through their inhibitory effects on spoilage microorganisms, subsequently reduced the formation of volatile bases produced from protein degradation such TVB-N and TMA-N. Noteworthy, the TMA-N values of all treatments were remained with values below the acceptable limit of 10 mg/100 g according to **ESS (2019)**. These results are in agreement with those found by **Pal *et al.* (2017); Morshdy *et al.* (2018) and John and Siddappaji (2019)**.

Peroxide value: The chemical oxidation of unsaturated fatty acids in fish and fish products could be determined by peroxide value (PV), due to primary oxidation. Data in **Table (3)** show the changes in PV of soaked catfish fillets samples during cold storage at 4±1ºC. At zero time the PV of soaked catfish treatments of T1, T2, T3, T4, T5, T6, T7 and T8 were 1.59, 1.72, 1.78, 1.76, 1.32, 1.51, 1.82 and 1.66 meq O_2/Kg fat, respectively. The initial values were referred very good fresh soaked fish fillets according to **Uçak *et al.* (2011)** reported that the peroxide value is expected to be below 2 meq O_2/ kg lipids in very good material, and not to exceed 5 meq O_2/ kg lipids in good material. Then, PV of all soaked catfish treatments gradually increased (p <0.05) in slow rate during the first 3 days of cold storage, subsequently this rate increased in all treatments during remained storage periods. There was significant difference (p <0.05) between T1 and treated catfish samples during cold storage. The control sample showed the highest PV till the 9th day of storage as 5.83 meq O_2 Kg fat compared to the lowest values of 5.23, 5.28, 5.36, 5.64, 5.20, 5.69 and 5.58 meq O_2 /Kg fat for T2, T3, T4, T5, T6, T7 and T8, respectively by the same day of analysis. Generally, the soaking catfish fillets in herbal extracts and BHT solutions were significantly (p <0.05) lowered peroxides formation during cold storage, due to their antioxidant activity, over than this activity of different materials was differed (p <0.05), in relation to their contents from bioactive compounds those responsible for antioxidant property.

Table 3. Peroxide values (meq O_2/ kg) of soaked catfish fillets treatments during storage period at 4±1ºC**.**

Storage period (days)	Treatments							
	Control	BHT	Thyme (TH)		Clove (CL)		Mint (MI)	
			0.5%	1%	0.5%	1%	0.5%	1%
0	1.59^{Dbc} ±0.06	1.72^{Eab} ±0.11	1.78^{Fab} ±0.14	1.76^{Fab} ±0.04	1.32^{Fd} ±0.04	1.51^{Fc} ±0.15	1.82^{Ea} ±0.19	1.66^{Fabc} ±0.03
3	2.31^{Cabc} ±0.31	2.39^{Dab} ±0.15	2.20^{Ebc} ±0.08	2.49^{Eab} ±0.12	2.24^{Ebc} ±0.19	1.92^{Ec} ±0.14	2.35^{Eab} ±0.39	2.66^{Ea} ±0.04
6	4.33^{Ba} ±0.59	4.02^{Ca} ±0.25	4.17^{Da} ±0.28	4.27^{Da} ±0.09	4.19^{Da} ±0.12	4.16^{Da} ±0.05	4.21^{Da} ±0.13	4.18^{Da} ±0.19
9	5.83^{Aa} ±0.33	5.23^{Bb} ±0.32	5.28^{Cb} ±0.18	5.36^{Cab} ±0.33	5.64^{Cab} ±0.32	5.20^{Cb} ±0.20	5.69^{Cab} ±0.36	5.58^{Cab} ±0.36
12	R*	6.24^{Ab} ±0.34	6.47^{Bab} ±0.23	6.40^{Bab} ±0.19	6.32^{Bab} ±0.46	6.34^{Bab} ±0.24	6.91^{Ba} 0.34	6.71^{Bab} 0.44
15	R*	R*	7.54^{Aabc} ±0.13	7.34^{Abc} ±0.21	7.20^{Ac} ±0.29	7.10^{Ac} ±0.20	7.92^{Aa} ±0.44	7.77^{Aab} ±0.33

Means of triplicate ± Standard deviation on wet weight basis. Mean values in the same row (small letter) or column (capital letter) with the same letter are not significantly different (at p <0.05). R*= rejected.

Consequently, the clove extract was presented the highest antioxidant efficacy to be delayed lipid oxidation better than 0.1% BHT and similar levels of thyme and mint extracts. Generally, the means of PV for all fish treatments were lesser than permissible limits of 8–10 meq O_2/kg as reported by **Varlik *et al*. (1993)**. These results are over lab with those obtained by **Heydari *et al.* (2015); John and Siddappaji (2019) and Lahreche *et al*. (2019)**.

Thiobarbituric acid value (TBA): TBA is expressing for secondary oxidation in fish and fish products. TBA index gives a measure of malonaldehyde formed in the muscle as a result of oxidation of lipid peroxides. The changes in TBA values of soaked catfish fillets during storage at 4±1ºC are showed in **Fig. (3)**. The TBA values of soaked catfish fillets were 0.73, 0.59, 0.56, 0.51, 0.51, 0.48, 0.55 and 0.52 mg mal/kg for T1, T2, T3, T4, T5, T6, T7 and T8, respectively at zero time of cold storage, the TBA values of fresh soaked fish fillets lower than acceptable limits of 4.5 mg mal/kg for chilled fish according to **(ESS, 2019)** indicated to high quality raw fish products. Thereafter, as cold storage prolonged the TBA values of all catfish treatments significantly increased (p <0.05) with significant difference (p <0.05) amongst fish treatments. Whereas, the treated fish fillets were possessed the lowest values (p <0.05) of TBA to be confirmed their antioxidant efficacy, compared to control sample. Since, malonaldehyde is forming from peroxides breakdown, so the control sample also presented the highest TBA values during storage in similarity finding of PV determination. The increase in TBA value during the chilled storage may be attributed to the partial dehydration of fish and to the increased oxidation of unsaturated fatty acids **(Mendes *et al*., 2008)**. Moreover, the TBA values of treated fish fillets with showed significant differences amongst treated samples themselves affected by their contents of bioactive constituents.

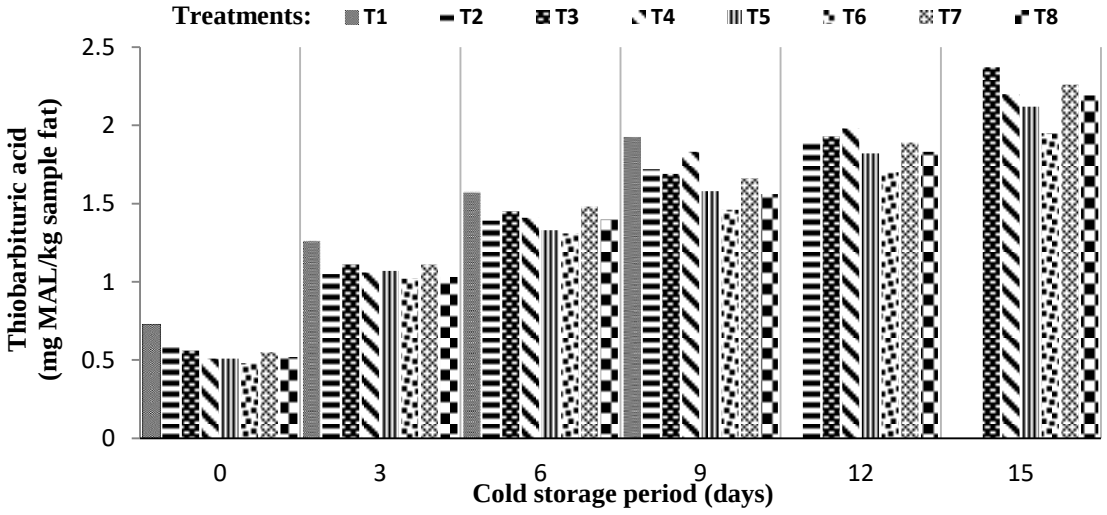

Fig. (3): Thiobarbituric acid values of soaked catfish fillets treatments during cold storage period at 4±1ºC.

The TBA value of control sample was the highest (p<0.05) as 1.92 mg mal/kg after 9 days of cold storage, in contrast with the lowest value (p <0.05) was 1.46 mg mal/kg for 1% clove treatment in the same time. Generally, the treated samples with 1% clove extract significantly (p<0.05) reduced lipid oxidation, as well as hydro-peroxidation and successively secondary oxidation (TBA) better than the other herbal extracts. Although, the increasing pattern in the TBA value during storage, the TBA values of all treatments were much lower than the maximum permissible value (4.5 mg MAL /kg fish flesh) reported by **ESS (2019)** for chilled fish. These results are similarities between obtained results and those found by **Morshdy *et al.* (2018); Kuzgun (2019); Elhafez *et al.* (2020); Sönmez *et al.* (2020) and Abbas *et al.* (2021).**

Total viable bacterial count (TVBC): Respecting the TVBC is an index could be given an idea for the evolution of bacterial growth during storage, the spoilage of fish products usually limited by the numbers of total bacteria based on local/ global standardizations. As expected, the TVBC as $\log_{10}$ cfu/g were developed during cold storage in soaked fish fillets in aqueous preservatives as illustrated in **Table (4)**. The means of TVBC of soaked catfish treatments in terms of T1, T2, T3, T4, T5, T6, T7 and T8 were 4.92, 4.78, 4.60, 4.60, 4.67, 4.59, 4.62 and 4.66 (log cfu/g), respectively with difference (p < 0.05) between untreated and treated fillets with herbal extracts. The initial counts of all soaked catfish samples were lower than the maximum acceptable limits of 6 $\log_{10}$ cfu/g according to **ESS (2019)**, and indicate to good fish products. Afterthought, the progress of storage periods significantly caused a gradual increase (p < 0.05) in TVBC of all catfish treatments, to be presented the highest increment in the control sample as 7.18 (log cfu/g) in the 9th day of cold storage, followed by 7.03 (log cfu/g) for T2 on the 12th day of cold storage. Meanwhile, the herbal extracts significantly reduced this increasing to retain with values lower than value of 7.00 log cfu/g, which used a permissible limit of microbial spoilage in fish and fish products according to **(ICMSF, 1986 and Sallam, 2007)**.

Table 4. Total viable bacterial counts as log cfu/g of soaked catfish fillets treatments during cold storage period at 4±1ºC.

Storage period (days)	Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
0	4.92^{Ba} ±0.06	4.78^{Db} ±0.03	4.60^{Ec} ±0.09	4.60^{Fc} ±0.03	4.67^{Dbc} ±0.08	4.59^{Ec} ±0.02	4.62^{Fc} ±0.13	4.66^{Fc} ±0.01
3	5.43^{Ba} ±0.03	5.27^{Cb} ±0.03	4.96^{Ec} ±0.04	4.84^{Ed} ±0.02	4.85^{Dd} ±0.12	4.72^{Ee} ±0.05	4.98^{Ec} ±0.07	4.89^{Ecd} ±0.05
6	6.87^{Aa} ±0.07	6.77^{Bb} ±0.06	6.12^{Dc} ±0.05	6.04^{Dcd} ±0.06	5.95^{Cd} ±0.05	5.84^{De} ±0.05	5.98^{Dd} ±0.02	5.86^{De} ±0.04
9	7.18^{Aa} ±0.58	6.76^{Bb} ±0.04	6.43^{Cb} ±0.04	6.46^{Cb} ±0.05	6.43^{Bb} ±0.09	6.34^{Cb} ±0.07	6.48^{Cb} ±0.04	6.39^{Cb} ±0.16
12	R^*	7.03^{Aa} ±0.02	6.69^{Bbc} ±0.06	6.70^{Bbc} ±0.03	6.67^{Bbc} ±0.11	6.58^{Bc} ±0.04	6.75^{Bb} ±0.05	6.63^{Bbc} ±0.13
15	R^*	R^*	7.47^{Aa} ±0.26	7.37^{Aa} ±0.03	7.45^{Aa} ±0.31	7.35^{Aa} ±0.15	7.42^{Aa} ±0.06	7.40^{Aa} ±0.08

Means of triplicate ± Standard deviation on wet weight basis. Mean values in the same row (small letter) or column (capital letter) with the same letter are not significantly different (at p <0.05). R^*= rejected.

These results indicated that, the reduction in total bacteria in treated samples with herbal extracts might be ascribed to their antimicrobial activity, while the difference between treated samples themselves contributed with quantity and type of phenolic compounds of each extract. Therefore, the maximum shelf life of control sample was 6 days under refrigeration condition, in contrast with the clove, mint and thyme extracts could be extended the shelf life of soaked catfish fillets by additional 3 days over than 9 days for BHT treatment. This results are with those found by **Greeshma *et al.* (2019); John and Siddappaji (2019); Kuzgun (2019); Sönmez *et al.* (2020) and Elhafez *et al.* (2020)**.

Total psychrophilic bacterial count (TPBC): Psychrophilic bacteria are the main microorganisms responsible for most of the spoilage such as off flavor, easily capable of growing under low cold storage temperature. Psychrophilic bacteria load of fish fillets could change depending on processing, handling, and fish species. Data in **Table (5)** show the changes TPBC as log cfu/g of catfish fillets after soaking in aqueous solutions without/with 0.1% BHT, 0.5 and 1% of thyme, clove and mint extracts during cold storage. The initial counts of TPC in catfish treatments as well as T1, T2, T3, T4, T5, T6, T7 and T8 were 3.63, 3.61, 3.59, 3.46, 3.55, 3.42, 3.61 and 3.50 (log cfu/g), respectively. In order to the increase of storage period, the counts of psychrophilic bacteria of all fish treatments

significantly increased (p <0.05), and its evolution significantly affected (p <0.05) by treating with herbal extracts in comparison with control. The TPBC was quickly increased in T1 and T2 to 4.85 and 4.79 log cfu/g, respectively at the 9th day of cold storage. On contrary, the herbal extracts significantly lowered (p <0.05) these counts in treated catfish fillets, due to their activity against bacteria because the presence of phenolic compounds. The 1% of clove extract in (T6) was more effective in reducing of psychrophilic bacterial counts compared the other treatments. The impact of herbal extracts and essential oils to be reduced the increase counts of psychrophilic bacteria during cold storage were observed in previously fish studies carried by **Heydari *et al.* (2015); Moawad *et al.* (2017); Kuzgun (2019); Elhafez *et al.* (2020) and Sönmez *et al.* (2020)**.

Table 5. Total psychrophilic bacterial counts as log cfu/g of soaked catfish fillets treatments during cold storage period at 4±1ºC.

Storage period (days)	Treatments							
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
0	3.63^{Da} ±0.04	3.61^{Da} ±0.10	3.59^{Dab} ±0.03	3.46^{Dab} ±0.13	3.55^{Dab} ±0.12	3.42^{Eb} ±0.10	3.61^{Da} ±0.02	3.50^{Cab} ±0.12
3	4.00^{Ca} ±0.02	3.97^{Ca} ±0.03	3.67^{Db} ±0.11	3.58^{Dbc} ±0.11	3.47^{Dcd} ±0.12	3.39^{Ed} ±0.06	3.59^{Dbc} ±0.04	3.48^{Ccd} ±0.07
6	4.72^{Ba} ±0.03	4.73^{Ba} ±0.05	4.35^{Ccd} ±0.12	4.30^{Cde} ±0.12	4.38^{Cbcd} ±0.06	4.18^{De} ±0.10	4.51^{Cb} ±0.05	4.45^{Bbc} ±0.05
9	4.85^{Aa} ±0.08	4.79^{Ba} ±0.02	4.56^{Bb} ±0.04	4.48^{BCbcd} ±0.08	4.51^{BCbc} ±0.05	4.40^{Cd} ±0.03	4.53^{Cbc} ±0.04	4.45^{Bcd} ±0.03
12	R*	5.35^{Aa} ±0.16	4.71^{Bb} ±0.02	4.60^{Bbc} ±0.05	4.66^{Bbc} ±0.01	4.56^{Bc} ±0.04	4.68^{Bb} ±0.02	4.60^{Bbc} ±0.02
15	R*	R*	5.26^{Aa} ±0.16	5.14^{Aa} ±0.09	5.20^{Aa} ±0.14	4.70^{Ab} ±0.07	5.23^{Aa} ±0.16	5.14^{Aa} ±0.15

Means of triplicate ± Standard deviation on wet weight basis. Mean values in the same row (small letter) or column (capital letter) with the same letter are not significantly different (at p <0.05). R* = rejected.

Sensory evaluation: The Sensory characteristics of food items are the main keys for consumer's acceptance, fish and fish products are unique food items especially concerning color, odor and texture properties. The changes in sensory properties of soaked catfish fillets in some herbal extracts, compared to control and BHT are shown in **Table (6)**. The initial scores of different sensory attributes of soaked catfish treatments as well as T1, T2, T3, T4, T5, T6, T7 and T8 were 7.20, 7.60, 7.40, 7.60, 7.70, 7.60, 7.20 and 7.40, respectively for color property, 7.40, 7.60, 7.80, 8.00, 8.20, 8.40, 8.00 and 8.20, respectively for odor property and 7.40, 7.20, 7.40, 7.40, 7.60, 8.00, 7.20 and 7.60, respectively for texture property. Meanwhile, the overall acceptability scores were 7.20, 7.40, 7.60, 7.60, 7.80, 8.00, 7.60 and 7.60, respectively.

Table 6. Sensory evaluation of soaked catfish fillets treatments during cold storage at 4±1ºC.

properties	Storage period (days)	Treatments							
		T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Color	**0**	7.20^{Aa} ±0.45	7.60^{Aa} ±0.55	7.40^{Aa} ±0.55	7.60^{Aa} ±0.55	7.70^{Aa} ±0.67	7.60^{Aa} ±0.55	7.20^{Aa} ±0.45	7.40^{Aa} ±0.55
	3	6.90^{Aa} ±0.55	7.00^{Aa} ±0.61	7.20^{Aa} ±0.57	7.40^{Aa} ±0.55	7.30^{ABa} ±0.45	7.50^{ABa} ±0.50	7.10^{Aa} ±0.42	7.20^{ABa} ±0.45
	6	5.60^{Bc} ±0.55	5.70^{Bbc} ±0.67	6.30^{Babc} ±0.67	6.50^{Bab} ±0.50	6.80^{Ba} ±0.57	7.00^{ABa} ±0.79	6.40^{Babc} ±0.42	6.70^{Ba} ±0.45
	9	5.10^{Bb} ±0.55	5.60^{Bb} ±0.55	5.50^{Cb} ±0.50	5.40^{Cb} ±0.55	5.80^{Cb} ±0.27	6.70^{BCa} ±0.45	5.80^{Cb} ±0.57	5.80^{Cb} ±0.57
	12	R*	5.00^{Bb} ±0.00	5.10^{CDb} ±0.55	5.20^{Cb} ±0.45	5.20^{Db} ±0.27	6.10^{CDa} ±0.74	5.20^{Db} ±0.27	5.60^{Cab} ±0.55
	15	R*	R*	4.40^{Db} ±0.55	4.90^{Cab} ±0.42	4.90^{Dab} ±0.22	5.40^{Da} ±0.55	4.90^{Dab} ±0.22	5.20^{Ca} ±0.27
Odor	**0**	7.40^{Ac} ±0.55	7.60^{Abc} ±0.55	7.80^{Aabc} ±0.45	8.00^{Aabc} ±0.00	8.20^{Aab} ±0.45	8.40^{Aa} ±0.55	8.00^{Aabc} ±0.00	8.20^{Aab} ±0.45
	3	5.80^{Bd} ±0.84	6.00^{Bcd} ±0.71	6.60^{Bbc} ±0.55	7.00^{Bab} ±0.00	7.20^{Bab} ±0.45	7.60^{Ba} ±0.55	6.80^{Bb} ±0.45	6.80^{Bb} ±0.45
	6	4.40^{Cd}	4.40^{Cd}	6.00^{Bbc}	6.20^{Cbc}	6.60^{Cab}	7.00^{Ca}	5.60^{Cc}	6.00^{Cbc}

		±0.55	±0.55	±0.71	±0.45	±0.55	±0.00	±0.55	±0.00
	9	3.90^{Cd}	4.20^{Ccd}	5.20^{Cbc}	5.20^{Dbc}	5.60^{Dab}	6.40^{Da}	5.20^{CDbc}	5.20^{Dbc}
		±0.22	±0.27	±0.84	±0.84	±0.55	±0.55	±0.84	±1.10
	12	R^*	4.10^{Cc}	4.70^{CDb}	4.60^{Ebc}	5.00^{Eb}	5.80^{Ea}	4.90^{Eb}	5.10^{Db}
			±0.22	±0.67	±0.42	±0.00	±0.45	±0.22	±0.55
	15	R^*	R^*	4.00^{Dc}	4.00^{Fc}	4.60^{Eb}	5.00^{Fa}	4.10^{Fc}	4.30^{Ec}
				±0.00	±0.00	±0.42	±0.00	±0.22	±0.27
	0	7.40^{Ab}	7.20^{Ab}	7.40^{Aab}	7.40^{Aab}	7.60^{Aab}	8.00^{Aa}	7.20^{Aab}	7.60^{Aab}
		±0.55	±0.45	±0.55	±0.55	±0.55	±0.00	±0.45	±0.55
	3	6.10^{Bc}	6.00^{Bc}	6.50^{Bbc}	6.70^{Bab}	6.90^{Bab}	7.20^{Ba}	6.70^{ABab}	6.90^{Bab}
		±0.55	±0.35	±0.50	±0.45	±0.22	±0.45	±0.45	±0.22
	6	5.20^{Cb}	5.40^{Cb}	6.10^{Ba}	6.30^{Ba}	6.40^{Ba}	6.80^{BCa}	6.50^{Ba}	6.20^{Ca}
Texture		±0.84	±0.65	±0.22	±0.45	±0.55	±0.27	±0.50	±0.45
	9	4.10^{Dd}	4.60^{Dcd}	5.30^{Cbc}	5.60^{Cb}	5.70^{Cb}	6.50^{Ca}	5.30^{Cbc}	5.40^{Db}
		±0.22	±0.22	±0.67	±0.55	±0.45	±0.50	±0.45	±0.89
	12	R^*	4.20^{Dc}	4.80^{CDb}	5.10^{CDab}	5.00^{Db}	5.60^{Da}	4.90^{CDb}	5.20^{Dab}
			±0.27	±0.27	±0.55	±0.35	±0.55	±0.55	±0.27
	15	R^*	R^*	4.50^{Dab}	4.70^{Eab}	4.30^{Eb}	4.90^{Ea}	4.60^{Dab}	4.90^{Da}
				±0.00	±0.27	±0.45	±0.22	±0.42	±0.22
	0	7.20^{Aa}	7.40^{Aa}	7.60^{Aa}	7.60^{Aa}	7.80^{Aa}	8.00^{Aa}	7.60^{Aa}	7.60^{Aa}
		±0.84	±0.55	±0.55	±0.55	±0.45	±0.00	±0.55	±0.55
	3	6.20^{Bc}	6.40^{Bbc}	6.80^{Bab}	7.00^{Aa}	7.20^{Ba}	7.20^{Ba}	6.80^{Bab}	7.00^{Aa}
		±0.45	±0.55	±0.45	±0.00	±0.45	±0.45	±0.45	±0.00
	6	4.20^{Cc}	4.60^{Cc}	5.80^{Cb}	6.20^{Bab}	6.40^{Cab}	6.60^{Ca}	5.80^{Cb}	6.20^{Bab}
		±0.45	±0.55	±0.45	±0.45	±0.55	±0.55	±0.45	±0.84
	9	4.00^{Cc}	4.50^{Cbc}	4.80^{Dbc}	5.20^{Cb}	5.40^{Dab}	6.20^{CDa}	5.00^{Dbc}	5.00^{Cbc}
Overall acceptability		±0.35	±0.50	±0.84	±0.84	±0.55	±0.45	±1.00	±1.00
	12	R^*	4.20^{Cc}	4.40^{DEc}	4.80^{CDb}	5.00^{Db}	5.80^{Da}	4.90^{Db}	5.00^{Cb}
			±0.27	±0.22	±0.27	±0.35	±0.45	±0.22	±0.00
	15	R^*	R^*	4.00^{Ec}	4.20^{Dbc}	4.10^{Ebc}	5.00^{Ea}	4.10^{Ebc}	4.40^{Cb}
				±0.00	±0.27	±0.22	±0.00	±0.22	±0.42

Means of 10 degrees ± Standard deviation on wet weight basis. Mean values in the same row (small letter) or column (capital letter) with the same letter are not significantly different (at p <0.05). R^*= rejected.

However, the scores of all sensory attributes revealed to good acceptable and high quality of soaked fish fillets, but the odor was significantly affected by treating catfish fillets with herbal extracts of thyme, clove and mint, to be improved (p <0.05) as effect of aromatic compounds in such extracts. Thereafter, the scores of all properties for all soaked fish treatments affected by the increase of cold storage period and consecutively declined (p <0.05). The deterioration rate in sensory properties of control sample was the fastest to be 5.10, 3.90, 4.10 and 4.00 for color, odor, texture and overall acceptability, respectively after 9 days of cold storage. The color of soaked fish greatly inclined to the color of original fish fillets, the color of fish meat is different than other foods and extremely spoilage during processing and storage due to oxidation, consequently caused discoloration. As expected, the herbal extracts and BHT were reduced the oxidation of color during progressively storage in relation with their antioxidant activity. The difference amongst all treated fillets with BHT and herbal extracts was non-significant (p >0.05) till 9 days of cold storage, while at the 12th day the highest color score significantly observed in T5 and T6 (p <0.05).

Concerning the changes of fish odor is extremely associating with fish deterioration due to accumulation of volatile compounds in fish meat from nitrogenous and fatty substrates degradation as a result of microbial and enzyme activity. Many odors are forming during spoilage that finally led to fish samples rejection. There was significant difference (p <0.05) in odor scores between catfish fillets soaking in herbal extracts solutions compared to control sample, which correlated with spoilage degree of each treatment interval cold storage periods, the odor scores were rapidly decreased in control and BHT treatments more than treated samples with herbal extracts during cold storage, the odor score of either T1 or T2 declined to be lower than acceptable grade of (5) on the 6th day of cold storage although they still had low acceptability till 9 days of cold storage. On contrary, the application of herbal extracts improved (p <0.05) the primary odor of fish fillets, and reduced undesirable changes in odor during cold storage. Regarding fish texture is usually referred to the consistency of fish tissues in relating of protein fibers profile. The decline in fish texture during cold storage was measured by the developing of softness occurrence as a result of

protein degradation due to microbial and enzymes activity during storage. The T1 and T2 samples were deteriorated faster than (p <0.05) other treated samples. With respect to the score of (5) was indicated to slightly hard opposite with the score of (3) referred to slightly soft, the treated catfish fillets with herbal extracts were acceptable for cold storage period longer than (p <0.05) control and BHT treatments, respectively. Thus, the soaking catfish fillets in 0.5 and 1% of thyme, clove and mint significantly retarded the texture deterioration. Finally, the changes in overall acceptability of soaked fish fillets was separately assessed however it was influenced by the color, odor and texture properties of catfish fillets, there was a significant difference (p <0.05) between treatments, the variance more attributed to the effect of herbal extracts on spoilage retarding as well as oxidation of color, microbial and enzymes activation during cold storage period compared the T1 and T2. The highest acceptability (p <0.05) was obtained from samples treated with herbal extracts, in particular T5 and T6. The scores of acceptability of all treatments as shown in **Table (6)** were greatly supported the results obtained from pH, TVB-N, lipid oxidation parameters (PV and TBA), and microbiological examination. It could be concluded that, the catfish fillets treatments (T3, T4, T5, T6, T7 and T8) partially retained with accepted odors and firmness by time longer than T1 and T2. Therefore, the dipping fish fillets in 0.5 and1% of clove, thyme and mint extracts improved (p <0.05) fish odor and restrained undesirable odors appearance during cold storage compared to control and BHT treatments. Nevertheless, the odor of fish fillets treated with 1% of herbal extracts was better (p <0.05) than fillets soaking in 0.5% of herbal extracts. The impact of different herbal extracts at concentrations of 0.5 and 1% during cold storage on sensory properties of soaked fish fillets as well as color, odor, texture and overall acceptability were similar with those results obtained by **Moawad *et al*. (2017); Morshdy *et al*. (2018); Greeshma *et al*. (2019); Kuzgun (2019); Elhafez *et al*. (2020) and Sönmez *et al*. (2020)**.

Conclusion: The physicochemical together microbiological supported by sensory evaluation of soaked catfish samples confirmed the fact efficacy of herbal extracts in protecting food products from deterioration, and improving quality of fresh foods especially during cold storage as wishes of many consumers nowadays. The both concentrations (0.5&1%) of clove, thyme and mint extracts effectively reduced (p <0.05) the formation of volatile amines (TVB-N & TMA-N) subsequently restrained the elevation of pH value, lowered the occurrence of lipid oxidation that determined as the amounts of peroxides followed by malonaldehyde. Moreover, reduced the bacterial growth (TVBC & TPBC) and enhanced sensory properties of soaked catfish during cold storage, in comparison with control and BHT samples. Therefore, the herbal extracts in current study retarded fish spoilage caused by lipid oxidation and microbial activity as their antioxidant and antimicrobial activity. Thereof, the herbal extracts are increasing the interesting of their application in fish products, to produce fresh, safe and accepted fish product from low accepted catfish meat, in addition could be extend the shelf life of catfish fillet.

References

Abbas, M.M.; Shehata, S.M.; Talab, A.S. and Mohamed, H. (2021). Research on Effect of Natural Additives on the Quality Attributes of Cultivated Common Carp Fillets during Frozen Storage, Journal of Fisheries Sciences, 15(2): 7- 17.

Abdel-Aziz, M.E.; Ali, M.R.; Hammad, K.S. M. and Morsy, N.F. (2019). Preservative effect of carboxymethyl cellulose coating enriched with oregano (*Origanum vulgare* L.) essential oil on European eel (*Anguilla anguilla*) fillets during cold storage, Egyptian Journal of Nutrition, 34 (2): 1- 40.

Abozid, M.M.; Draz, S.N.; El-Kadousy, S.A.; Khaleil, S.M. and El-Debas, A.A. (2017). Biochemical evaluation for three fish types collected from different water sources in Egypt. Menoufia J. Agric. Biotechnology, (2): 43- 52.

Akbarirad, H.; Gohari Ardabili, A.; Kazemeini, S.M. and Mousavi Khaneghah, A. (2016). An overview on some of important sources of natural antioxidants. Int. Food Res. J., 23(3): 928- 933.

Akpambang, V.O. (2015). Proximate composition of some tropical fish species. Pelagia Research Library. Der Chemica Sinica, 6(4): 125- 129.

Ali, M.; Imran, M.; Nadeem, M.; Khan, M.K.; Sohaib, M.; Suleria, H.A. and Bashir, R. (2019). Oxidative stability and Sensoric acceptability of functional fish meat product supplemented with plant−based polyphenolic optimal extracts, Lipids in Health and Disease, 18 (35): 1- 16.

AOAC. (2000). Official Methods of Analysis of the Association of Analytical Chemists, 18th Ed., Washington, D.C., USA.

Begum, T.; Mahmud, J.; Naimul-Islam, Md. and Khan, R.A. (2019). Essential oils and biodegradable packaging materials: application on food preservations. Scientific Review, (5)1: 1- 7.

Biswas, O.; Talwar, N.A.; Bhattacharya, D.; Das, S.K. and Chaudhary, S. (2017). Effect of refrigeration on quality and stability of fresh

fish and poultry muscles. Indian J. Anim. Hlth., 56(1): 65- 76.

Das, N.; Khuntia, B.K.; Raychaudhuri, U.; Dora, K.C. and Ganguly, S. (2015). Effect of Water Washing on the Functional Properties of Fish Meat. International Journal of Medical Microbiology and Tropical Diseases October-December, 1(1):8- 12.

Dehghani, S.; Hosseini, S.V. and Regenstein, J.M. (2018). Edible films and coatings in seafood preservation: A review. Food Chemistry, 240: 505- 513.

Duncan, D.B. (1955). Multiple range and F test. Biometrics, 11: 1- 42.

Egan, H.; Kirk, R. and Sawyer, R. (1997). Pearson's chemical analysis of food. 9th ed. Edinburgh, UK: Churchill Livingstone; Pp: 609- 634.

Egyptian Organization for Standardization and Quality (ESS). (2019). Egyptian Standards for Chilled Fish: No (3494/2019), Arab Republic of Egypt.

Elhafez, M.A.; Yehia, N.; Amin, R.; Emam, W.; Hamouda, S. and El-Magd, M.A. (2020). Quality enhancement of frozen Nile tilapia fillets using rosemary and thyme oil, Arq. Bras. Med. Vet. Zootec., 72 (5): 1821- 1829.

El-Hanafy, A.I. (2013). Storage stability and quality evaluation of fish patties produced from common carp and catfish flesh, Abbassa Int. J. Aqua., 6 (3): 577- 596.

El-Shennawy, E.A.; Ez-El-Rigal, A.I.; Sulieman, A.M. and ELbadwi, A.A. (2017). Improving quality properties of catfish mince, Zagazig J. Agric. Res., 44 (6b): 2641- 2647.

FAO. (2019). Top 10 species groups in global aquaculture 2017. Rome, Italy: Food and Agriculture Organization (FAO); 2019.

Gandotra, R.; Koul, M.; Gupta, S. and Gupta, V. (2015). Studies on the effect of Vacuum Packaging on some quality changes in *Labeo rohita* during frozen storage period. Int. J. of App. Biol. and Pharm.Techn., 4: 1533- 1539.

Greeshma, S.S.; Sarika, K.; Priya. E.R.; Lekshmi. R.G.; Kumar, J.T.; Joseph, C.; Pandey, M.C. and Prasad, M.M. (2019). Shelf life characteristics of *Pangasianodon hypophthalmus* fillets treated with *Moringa oleifera* (Lam) leaf extract. Fishery Technology, 56: 285- 291.

Hermund, D.B. (2016). Extraction, characterization and application of antioxidants from the Nordic brown alga *Fucus vesiculosus*. Kgs. Lyngby: National Food Institute, Technical University of Denmark.

Heydari, R.; Bavandi, S. and Javadian, S.R. (2015). Effect of sodium alginate coating enriched with horsemint (*Mentha longifolia*) essential oil on the quality of bighead carp fillets during storage at 4° C. Food Sci. Nutr., 3 (3): 188- 194.

Hussain, M.; Sumon, T.; Mazumder, S.; Ali, M.; Jang, W.J.; Abualreesh, M.; Sharifuzzaman, S.M.; Brown, C.; Lee, H.T. and Lee, E.W. (2021). Essential oils and chitosan as alternatives to chemical preservatives for fish and fisheries products: A review. Food Control, 129, 108244.

ICMSF. (1986). Microorganisms in foods 2: Sampling for microbiological analysis: Principles and specific applications. 2nd Ed, Canada: University of Toronto Press; Pp: 131- 448.

Isaacs, M. (2016). The humble sardine (small pelagics): fish as food or fodder. Agriculture and Food Security, 5: 27: 1- 14. DOI 10.1186/s40066-016-0073-5

John, E. and Siddappaji, S. (2019). Preservative Effect of green tea extract on the storage stability of mackerel fillets stored in ice. Int. J. of Sci. and Eng. Res., 10 (11): 376- 387.

Kuzgun, N.K. (2019). Effect of Garlic (*Allium sativum* L.) essential oils on *Oncorhynchus mykiss* fillets during storage. Progress in Nutrition, 21 (3): 709- 714.

Lahreche, T.; Uçar, Y.; Kosker, A.R.; Hamdi, T.M. and Ozogul, F. (2019). Combined impacts of oregano extract and vacuum packaging on the quality changes of frigate tuna muscles stored at 3±1°C. Veterinary World, 12(1): 155- 164.

Li, D.; Zhang, L.; Song, S.; Wang, Z.; Kong, C. and Luo, Y. (2017). The role of microorganisms in the degradation of adenosine triphosphate (ATP) in chill-stored common carp (*Cyprinus carpio*) fillets. Food Chemical, 224: 347- 352.

Linhartová, Z.; Krejsa, J.; Zajíc, T.; Másílko, J.; Sampels, J. and Mráz, J. (2018). Proximate and fatty acid composition of 13 important freshwater fish species in central Europe. Aquaculture International, 26: 695- 711.

Liu, X.; Huang, Z.; Jia, S.; Zhan, J.; Li, K. and Luo, Y. (2018). The roles of bacteria in the biochemical changes of chill-stored bighead carp (*Aristichthys nobilis*): Proteins degradation, biogenic amines accumulation, volatiles production, and nucleotides catabolism. Food Chem., 255: 174- 181.

Mei, J.; Ma, X. and Xie, J. (2019). Review on natural preservatives for extending fish shelf life, Foods, 8 (490): 1- 22. doi:10.3390/foods8100490

Mendes, R.; Pestana, C. and Gonçalves, A. (2008). The effects of soluble gas stabilization on the quality of packed sardine fillets (*Sardina pilchardus*) stored in air, VP and MAP. International Journal of Food Science and Technology, 43: 2000- 2009.

Moawad, R.K.; Mohamed, G.F.; El-Banna, H.A.; Bareh, G.F. and Mahmoud, K.F. (2017). Assessment of hurdle technology to preserve Nile tilapia fillets during refrigeration with the application of marjoram oil/polyphosphates dipping. Asian J. of Sci. Res., 10: 116- 127.

Moniruzzaman, M.; Kumar, S.; Das, D.; Sarbajna, A.; Chakraborty, S.B. (2020). Enzymatic, non-enzymatic antioxidants and glucose metabolism enzymes response differently against metal stress in muscles of three fish species depending on different feeding niche. Ecotoxicol. Environ. Saf., 202: 110954.

Morachis-Valdez, A.G.; Santillán-Álvarez, Á.; Gómez-Oliván, L.M.; García-Argueta, I.; Islas-Flores, H. and Dublán-García, O. (2021). Effects of peppermint extract and chitosan-based edible coating on storage quality of common carp (*Cyprinus carpio*) fillets. Polymers, 13(3243): 6- 16. https://doi.org/ 10.3390/polym13193243.

Morshdy, A.M.; Hussien, M.A. and ELshimaa, A.N. (2018). Effects of some food additives on refrigerated fish. 5th International Food Safety Conf., Damanhour Uni., 13/10/2018.

Nisar, T.; Yang, X.; Alim, A.; Iqbal, M.; Wang, Z-C. and Guo, Y. (2019). Physicochemical responses and microbiological changes of bream (*Megalobrama ambycephala*) to pectin based coatings enriched with clove essential oil during refrigeration. Int. J. Biol. Macromol., 124:1156- 1166.

Olalekan, A. S. (2019). Effect of smoking methods and natural spices on quality and consumer acceptance of smoked silver catfish (*Chrysichthys nigrodigitatus*). Recent Patents on Food, Nutrition & Agriculture, 10: 152- 163.

Özyurt, G.; Kuley, E.; Özkütük, S. and Özogul, F. (2009). Sensory, microbiological and chemical assessment of the freshness of red mullet (*Mullus barbatus*) and goldband goatfish (*Upeneus moluccensis*) during storage in ice. Food Chem., 114: 505- 510.

Pal, D.; Chowdhury, S.; Nath, S.; Dora, K.C. and Majumder, R. (2017). Assessment of The Shelf Life of Fish Fillet Treated With Green Tea Extracts Under Refrigerated Condition. Biochem. Cell. Arch., 17 (2): 499- 505. www.connectjournals.com/bca

Pearson, D. (1976). The Chemical Analysis of Food. Chem. Pub. Comp. Inc., New York.

Rather, S.A.; Masoodi, F.; Akhter, R.; Rather, J.A. and Shiekh, K.A. (2016). Advances in use of natural antioxidants as food additives for improving the oxidative stability of meat products. Madridge J. Food Tech., 1(1): 10- 17.

Rodríguez, A.; Carriles, N.; Gallardo, J.M. and Aubourg S.P. (2009). Chemical changes during farmed coho salmon (*Oncorhynchus kisutch*) canning: Effect of a preliminary chilled storage. Food Chem., 112 (2): 362- 368.

Sallam, K.I. (2007). Antimicrobial and antioxidant effects of sodium acetate, sodium lactate, and sodium citrate in refrigerated sliced salmon. Food Control, 18: 566- 575.

Shahbazi, Y. (2019). Antioxidant, antibacterial, and antifungal properties of nanoemulsion of clove essential oil. Nanomed. Res. J., 4(4): 204- 208. DOI: 10.22034/nmrj.2019.04.001

Siscovick, D.S.; Barringer, T.A.; Fretts, A. M.; Wu, J.H.; Lichtenstein, A.H.; Costello, R.B.; Krisetherton, P.M.; Jacobson, T.A.; Engler, M.B. and Alger, H.M. (2017). Omega-3 polyunsaturated fatty acid (fish oil) supplementation and the prevention of clinical cardiovascular disease: A science advisory from the American heart association. Circulation, 135: 867- 884.

Socaciu, M-I.; Semeniuc, C.A. and Vodnar, D.C. (2018). Edible films and coatings for fresh fish packaging: focus on quality changes and shelf-life extension. Coatings, 8, 366; doi:10.3390/coatings8100366.

Šojić, B.; Tomović, V.; Džinić, N.; Jokanović, M.; Ikonić, P.; Skaljac, S. and Pavlic, B. (2019). Plant extracts as natural antioxidants in meat processing. Bulgarian J. of Agri. Sci., 25(1): 27- 30.

Sönmez, P.E.; Kuzgun, N.K. and Kirbağ, S. (2020). Quality changes and storage life of common carp (*Cyprinus carpio*) with the use of Ginger (*Zingiber officinale*) essential oil. Progress in Nutrition, 22(4): 1- 10.

Sudirman, S.; Herpandi.; Lestari, S.D. and Andayani, W. (2018). Effects of weight and body parts of Siamese catfish (*Pangasius hypophthalmus*) on the nutritional content. Food Res., 2 (4): 307- 313. DOI:https://doi.org/10.26656/fr.2017.2(4). 280

Sung-Jin, K.; Min, S.C.; Hyo-Jin, S.; Yun- Jeong, L.; ReumCho, A.; Kim, S.Y. and Han, J. (2013). Evaluation of the antioxidant activities and nutritional properties of ten edible plant extracts and their application to fresh ground beef. Meat Sci., 93: 715- 722.

Tarladgis, B.G.; Watts, B.M.; Younathan, M.T. and Dugan, Jr.L. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc., 37: 44- 48.

Uçak, I.; Özgul, Y. and Durmus, M. (2011). The effects of rosemary extract combination with vacuum packing on the quality changes of Atlantic mackerel fish burgers. Int. J. Food Sci. Tech., 46: 1157- 1163.

Varlik, C.; Uĝur, M.; Gökoĝlu, N. and Gün, H. (1993). Principles and methods in sea food quality control. _Istanbul: Food Tech. Ass. Publication Number: 17:174. (inTurkish).

Viji, P.; Venkateshwarlu, G.; Ravishankar, C. and Gopal, T.S. (2017). Role of plant extracts as natural additives in fish and fish products – A Review. Fishery Techn., 54: 145- 154.

Yu, L.C.; Zzaman, W.; Akanda, Md. H.; Yang, T.A. and Easa, A.M. (2017). Influence of superheated steam cooking on proximate, fatty acid profile, and amino acid composition of catfish (*Clarias batrachus*) fillets. Turkish J. of Fish. and Aqua. Sci., 17: 935- 943.

تقييم جودة شرائح أسماك القراميط المعاملة بمستخلصات الأعشاب

مصطفى مصطفى محمود*، أحمد إبرهيم الدسوقي، همام الطوخي محمد بهلول **، محمد أبوطالب*، محمد عبدالهادي إبراهيم* و أشرف مهدي عبد الحميد شروبة****

*معمل تكنولوجيا وتصنيع الأسماك – المعهد القومى لعلوم البحار و المصايد – القناطر الخيرية – مصر

**قسم الصناعات الغذائية – كلية الزراعة – جامعة بنها– القليوبية – مصر

تهدف هذه الدراسة إلى تقييم خصائص الجودة الفيزيوكيميائية، الميكروبيولوجية والحسية لشرائح أسماك القرميط المعاملة بمستخلصات الأعشاب خلال فترة التخزين بالتبريد على 4±1°م لمدة 15 يوم. وأشارت النتائج المتحصل عليها إلى أن قيم الخصائص الفيزيوكيميائية (الأس الهيدروجيني، القواعد النيتروجينية الكلية الطيارة، ثلاثي ميثيل الأمين، رقم البيروكسيد ورقم حامض الثيوباربيتوريك) والمحتوى الميكروبي (العد الكلى للبكتيريا الحية و البكتيريا المحبة للبرودة) تزداد تدريجيا ($p < 0.05$) بزيادة فترة التخزين. متماشياً مع التناقص التدريجي للتقييم الحسي (اللون، الرائحة، القوام والقابلية العامة) خلال فترة التخزين كنتيجة لحدوث الفساد في المنتج. كما أشارت النتائج إلى أن أعلى معدل ($p <0.05$) للفساد لوحظ في عينة الكنترول يليها شرائح أسماك القراميط المعاملة بمادة بيوتيل هيدروكسي تولوين (BHT) بتركيز 0.1%؛ بينما أدى إستخدام مستخلصات الأعشاب ($p <0.05$) إلى تأخير حدوث الفساد وخاصةً مستخلص القرنفل بتركيز 0.5 و1% نتيجة لتأثيرها المضاد للأكسدة والميكروبات حيث أدت إلى خفض كلاً من أكسدة اللبيدات وتحلل البروتينات وذلك نتيجة لقدرتها على خفض معدل النمو الميكروبي. علاوة على ذلك فقد تأثرت أيضاً الخواص الحسية لشرائح أسماك القراميط نتيجة لمعاملتها بمستخلصات أعشاب كلاً من النعناع والقرنفل وسجلت أعلى درجات التقييم الحسي خلال فترة التخزين مقارنة بعينة الكنترول والمعاملة بالـBHT. وأظهرت النتائج المتحصل عليها أن إستخدام مستخلصات الأعشاب أدت إلى زيادة فترة قابلية شرائح أسماك القراميط للإستهلاك إلى 12 يوم بدلاً من 6 و9 أيام لكل من عينة الكنترول وعينة المعاملة بالـ BHT على التوالى.

الكلمات المفتاحية: أسماك القراميط، مستخلصات الأعشاب، النقع، الخصائص الفيزوكيميائية، الميكروبيولوجية و الحسية.