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INFLUENCE OF SOME NATURAL ANTIOXIDANT AND ANTIMICROBIAL ON QUALITY CHARACTERIZATION OF NILE TILAPIA FISH (*Oreochromis niloticus*) FILLETS DURING CHILLED STORAGE

Zakar, A.H.

Department of fish processing and quality control, Central Laboratory for Aquaculture Research, (CLAR), Agriculture Research Center, Egypt.

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Abstract

The effects of the natural antioxidant and antibacterial activities of basil leaf paste and olive leave paste on Nile tilapia fish (*Oreochromis niloticus*) fillets stored at 2 ± 1°C for 15 days were studied. The present study was performed to evaluate the effect of marinating process by mixtures as follow: Olive leaves paste (OLP), basil leaf paste (BLP) and combination of their pastes (BP + OLP) in a ratio of (1:1-w/w) for 15, 30 and 45 min on the quality properties and shelf life of tilapia (*Oreochromis niloticus*) fillets during refrigerated storage at 2 ± 1°C. The quality characterization and shelf- life of fish fillets was assessed by chemical, microbiological and sensoral changes at 2 ± 1°C. There was significant decrease ($P < 0.05$) in pH value and sensory properties with increase storage time, while total volatile basic nitrogen (TVB-N), thiobarbituric acid (TBA), free fatty acids (FFA), and bacterial count were increased with progressive of storage period for all treatments. The obtained results showed that combination of OLP + BLP had strong antioxidant and antimicrobial activity and can maintain the quality parameters and extend the shelf life of refrigerated Nile tilapia fillets longer than control and other treatments. Based on these results, it can be concluded that fish fillets marinated with (OLP + BLP) for 45 min were the best treatment and have longer storage period followed by fillets marinated with (OLP + BLP) for 30 min and fillets marinated with BLP for 45 min compared with control samples.

Keywords: Nile tilapia fish (*Oreochromis niloticus*) fillets, natural antioxidant and antibacterial, physical, chemical, microbiological, sensory changes and cold storage.

INTRODUCTION

Fish products are the cheapest source of animal protein and it plays an important role in the diet of many people in both developed and developing countries. Tilapia *(Oreochromis niloticus)* is considered promising for aquaculture because of its rapid growth, late reproduction and high multiplication rate. It has a firm, consistent and tasty meat of great market acceptance (Luz *et al*., 2012). Also, tilapia fish (*Oreochromis niloticus*) is one of the most important economic freshwater fish of Egypt, and considered one of the important source of protein, excellent quality fish characterized and rich vitamins with firmly textured rusticity and good sensorial properties of flesh making it more suitable and an appetizing fish to the consumers (Corpei, 2001 and Maregoni, 2006).

Fish and fishery products can undergo undesirable changes during storage and deterioration may limit the storage time. These undesirable changes result from protein denaturation (Benjakul *et al*., 2005) and lipid oxidation (Sarma *et al*., 2000; Richards and Hultin, 2002). In addition, the shelf life of fillets is lower than for whole fish, it is necessary to develop methods to retain sensory and nutritional properties of fish. Natural antioxidants used to extend the shelf-life of fish products are receiving great attention (Lin and Lin, 2005; Alonso *et al*., 2007 and Alghazeer *et al.,* 2008).

To extend the shelf life, a great deal of attention is being directed toward to the employment of antioxidants to prevent lipid oxidation, preserve flavour, colour and vitamin content (Moure *et al*., 2001). Recent efforts are focused on the replacement of synthetic antioxidants by natural ones, because of possible adverse side effects of synthetic antioxidants and beneficial effects of natural antioxidants which may provide nutritional and therapeutic effects (Sarkardei and Howel, 2008). Some spices, herbs and plants are generally used in food stuffs for enhancing the flavor or color attributes. Moreover these materials have antimicrobial and antioxidant activity (Bayder *et al*., 2004).

Basil is rich with phenolic compounds, and the major phenolics are rosmarinic gallic, protocatechuic, caffeic acids (Park, 2011). The phenolic acids reported to have antimicrobial activity (Abedini *et al.*, 2013). Basil essential oils and their principal constituents were found to exhibit antimicrobial activity against a wide range of Gram-negative and Gram-positive bacteria, yeast, and mold (Panuwat *et al.*, 2003). Sometimes, basil leaves are used in its fresh form in food preparations (such as flavouring chicken soups, sauces, etc.) and other local purposes. The volatile composition of basil is found to be dependent on the variety and/or geographical cultivation of the basil plant. Linalool and methylchavicol are the major compounds in Egyptian basil (Karawya *et al.*, 1974).

Olive leaf is one of the potent source of plant polyphenols having antioxidant, antimicrobial, antiviral properties due to its rich phenolic content. The most abundant phenolic component of this content is oleuropein which gives the bitter taste to olive and olive oil. In order to utilize oleuropein and other bioactive components within olive leaf effectively enough, they should be extracted from olive leaf (Kerem, 2010). The extract of olive leaves shows a very good antioxidant and antibacterial activities and might be applied in meat and meat products in order to support the quality and shelf life of the products (Khidhir, 2015).

Some additives can be used during marination in order to improve taste and aroma. If these additives are antibacterial and antioxidant, the organoleptic characteristics of the product will be improved and its preservation period will be extended. (Can and Ersan, 2013 and Yıldız, 2016).

The aim of this study was to investigate the effect of olive leaf paste (OLP), basil leaves paste (BLP) and their mixture OLP + BLP (1:1-w/w) on quality properties of tilapia fillets during cold storage time at 2±1°C.

MATERIALS AND METHODS

Samples preparation:

Fresh tilapia fish were bought from the fish farm at the international center for living aquatic resources management (ICLARM), Abbassa, Sharkia governorate, Egypt and transferred to the laboratory within 20 min. The fishes were individually weight 250-300g. The fish were immediately eviscerated, gutted, beheaded and filleted, each fish was filleted into two slices. All fillets were washed with tap water and soaked in 1.5 % salt solution as ratio (1:1, fish: water) for 10 min.

Preparation of herbs paste:

Basil (*Ocimum basilicum*) and olive (*Olea europaea*) leaves were collected from a horticultural farm on the desert road of Cairo-Alexandria, Egypt. The fresh leaves of each plant were put in polyethylene bags immediately after collection and transfer to the laboratory in the next day. Leaves were washed to remove impurities such as dust, after that slightly drying by spreading the plant leaves under shaded area with open air over night. Leaves were blended by moulinex blender (type 643) to obtained herbal paste for each plant individually and stored in the refrigerator until using. The other spices, garlic (*Allium sativum* L.) and black pepper (*Piper nigrum* L.) were purchased from local market. Fresh garlic was peeled and minced, while black pepper was crushed.

Preparation of marinating mixture:

The paste olive leaves (OLP) consisted of olive leaves (65%), garlic (15%), black pepper (10%) and cold water (10%), while basil leaves paste (OLP) consisted of olive leaves (65%), garlic (15%), black pepper (10%) and cold water (10%). The individual aqueous pastes of each plant were prepared by combination of the previous mentioned ingredients and blended in a moulinex blender (type 643).

Application of the paste to tilapia fillets:

The individual pastes were prepared as mentioned above and all fish fillets were then divided into four treatments, one of which formed the control group without marinade mixture, the second treatment was dipping into marinated mixture paste (BLP) the third treatment dipping into marinated mixture paste (OLP) and the fourth treatment was dipping into marinated mixture paste include OLP + BLP in a ratio of (1:1-w/w). Each treatment was individually kept in the marinated mixture for (15, 30 and 45 min) before refrigeration. All samples were kept in polythene pack and stored in cold condition at 2 ±1°C for 15 days. Samples were analyzed every 3 days to determine the changes in physical, chemical, microbiological and sensory attributes during storage period.

Chemical analysis:

The moisture content was quantified by oven-drying at 105°C for 8 h, crude protein (TN×6.25) by Kjeldahl procedure, total lipid by Soxhlet extraction and ash by incineration in a muffle furnace at 550°C for 6 h according to (AOAC,2000). The pH was determined according to (Hernandez *et al.,* 2009). TVBN was measured by the modified methods from Malle and Tao (1987). Thiobarbituric acid reactive substances (TBARS) was measured spectrophotometrically and expressed in mg Malonaldehyde/kg of muscle according to the procedure described method of Lopez *et al.*, (2005). Free fatty acid analysis (FFA), expressed as percentage of oleic acid, and was determined by AOCS (1994).

Microbiological analysis:

Total bacterial count (TBC) and psychrophilic bacteria count (PsBC) were performed according to (AOAC, 2000).

Sensory Analysis:

The sensory evaluation of fish samples was evaluated by six-member panelists. Panelists scored texture, color, flavor and general acceptability using a 5-point scale, as described in Table 1. (Ojagh *et al*., 2010). For flavor, about 100g of individual fish fillets were wrapped with aluminum foil and cooked in hot water steam for 20 min. The panelists were asked to wash their mouths with fresh water for several times before taste scoring.

Table 1. Description of sensory properties scores.

Description	Score
5	highest quality
4	good quality
3	acceptable quality
2	poor quality
1	worse quality

Statistical analysis:

Three replicates of each trial were performed for analysis. Chemical composition, qualitative values and sensory data during storage period were statistically analyzed using tow-way ANOVA. A probability at level of 0.05 or less was considered significant. Standard errors were also estimated. All statistics were run on the computer, using the SAS program (SAS, 2000).

RESULTS AND DISCUSSION

Physicochemical analysis:

pH value:

The detection of pH values is one of the most frequently used physical quality control for fish, seafood and fish products, which is affected by the changes in the lipid hydrolysis, microorganisms or enzymes. (Varlik *et al*., 2000). The effect of pastes and storage time on the pH value of the tilapia fillets during storage at 2 ±1ºC is shown in Table 2. The initial pH value (0 day) of the control samples was 6.95 ± 0.02^{Aa} and ranged from 6.70 ± 0.03^{Ac} to 6.78 ± 0.03^{Ab} for all marinated fillets. These results agreed with Newton and Gell (1981) who reported that pH value of fish varies from 5.8 to 7.2 depending on struggling at the time of harvesting. Similar results of pH values at day zero of chilled storage were recorded by Sallam *et al.* (2007) and Zambuchini *et al.* (2008).

The pH value of control sample was significantly (P< 0.05) higher than other samples with the pastes added throughout the storage period. The pH value was gradually decreased with increase marinating time for all samples treated with herbal paste and reached 6.43 ± 0.02^{Bb}, 6.42 ± 0.02^{Bb} and 6.40 ± 0.02^{Bb} at 3rd day of refrigerated storage for fillets treated with OLP at marinating time 15, 30 and 45 min respectively. Also, it was 6.44 ± 0.03^{Bb}, 6.43 ± 0.01^{Bb} and 6.41 ± 0.01^{Bb} at 3th day of refrigerated storage for fillets treated with BLP at marinating time 15, 30 and 45 min respectively. While, pH value was 6.40 ± 0.02^{Bb}, 6.38 ± 0.01^{Bc} and 6.37 ± 0.01^{Bd} at 3th day of refrigerated storage for fillets treated with (OLP + BLP) at marinating time 15, 30 and 45 min, respectively. In the present study, a significant (P< 0.05) decrease in pH values with progressive storage time for all samples was observed. However, from 9 days onward, the control samples were unacceptable, while treatment of tilapia fillets with (OLP + BLP) for 45 min have lower pH value than other marinated samples. Generally, the changes in pH value may be due to the acid which is a common metabolite from a number of bacteria. These may include lactic acid bacteria, and Enterobacteriaceae (Hansen *et al.*, 1996).

Table 2. Changes in pH value of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C.

Treatments / Storage period (days)	Control	OLP			BLP			OLP + BLP		
		Marinating time (min)								
		15	30	45	15	30	45	15	30	45
0	6.95 ± 0.02^{Aa}	6.76 ± 0.01^{Ab}	6.74 ± 0.02^{Ac}	5.72 ± 0.02^{Ac}	6.78 ± 0.03^{Ab}	6.76 ± 0.02^{Ac}	6.75 ± 0.01^{Ac}	6.73 ± 0.02^{Ac}	6.71 ± 0.03^{Ac}	6.70 ± 0.03^{Ac}
3	6.61 ± 0.01^{Ba}	6.43 ± 0.02^{Bb}	6.42 ± 0.02^{Bb}	6.40 ± 0.02^{Bb}	6.44 ± 0.03^{Bb}	6.43 ± 0.01^{Bb}	6.41 ± 0.01^{Bb}	6.40 ± 0.02^{Bb}	6.38 ± 0.01^{Bc}	6.37 ± 0.01^{Bd}
6	6.28 ± 0.01^{Ca}	6.09 ± 0.03^{Cb}	6.06 ± 0.01^{Cc}	6.04 ± 0.01^{Cc}	6.11 ± 0.02^{Cb}	6.10 ± 0.02^{Cb}	6.07 ± 0.03^{Cc}	6.07 ± 0.01^{Cc}	6.04 ± 0.02^{Cc}	6.03 ± 0.02^{Cc}
9	ND	5.84 ± 0.02^{Da}	5.82 ± 0.02^{Da}	5.80 ± 0.03^{Da}	5.88 ± 0.01^{Da}	5.86 ± 0.01^{Da}	5.85 ± 0.01^{Da}	5.83 ± 0.02^{Da}	5.80 ± 0.01^{Da}	5.76 ± 0.01^{Db}
12	ND	ND	5.58 ± 0.01^{Ea}	5.56 ± 0.01^{Ea}	5.64 ± 0.02^{Ea}	5.61 ± 0.02^{Ea}	5.59 ± 0.03^{Eb}	ND	5.57 ± 0.01^{Ea}	5.52 ± 0.02^{Eb}
15	ND	ND	ND	ND	ND	ND	ND	ND	ND	5.47 ± 0.02^{Ea}

OLP = Olive leaves paste. BLP = Basil leaves paste. OLP + BLP = marinated mixture paste (1:1)

$^{A-E}$ Superscripts in a column are significantly different (P < 0.05).

$^{a-d}$ Superscripts in a raw are significantly different (P < 0.05).

ND = Not determined because unacceptable by the panelists.

Total volatile basic nitrogen (TVB-N):

Total volatile basic nitrogen (TVB-N) is an important criterion for determining the freshness of fish and fish products (Kose and Koral, 2005). Total volatile basic nitrogen (TVB-N) is a product of bacterial spoilage, and the activity of endogenous enzymes and TVB-N levels are often used as an index to assess the quality and shelf life of products (Ozogul *et al.*, 2006 and Ucak *et al*., 2011).Total volatile basic nitrogen is mainly composed of ammonia and other volatile basic nitrogenous compounds (Pezeshk *et al.* 2013).

Changes in TVB-N values for fillets treated with OLP, BLP and OLP + BLP are shown in Table 3. As the results show, the TVB-N values of all samples were increased significantly ($P < 0.05$) during storage time, but the TVB-N value increased more rapidly for the control at day 6 of storage and reached to $25.85{\pm}1.55^{Ca}$ mg 100 g^{-1} which is higher than the maximum recommended limit (25 mg 100 g^{-1}) for TVB-N in raw fish that is proposed with Gimenez *et al.* (2002). In other treated samples, significant difference ($P< 0.05$) was observed among the samples marinated with OLP; BLP and (OLP + BLP). TVB-N values remained below the limit of acceptability at 6th day of storage period for all marinated samples. At 9th day of refrigerated storage TVB-N values were exceeded the limit (25 mg 100 g^{-1}) for marinated fillets with OLP at 15 and 30 min and reached to $27.41{\pm}1.75^{Cb}$ and $26.00{\pm}2.08^{Cc}$ mg 100 g^{-1} respectively. Also, marinated fillets with BLP at 15 min reached to $26.35{\pm}1.91^{Cc}$ mg 100 g^{-1}. Meanwhile, marinated fillets with (OLP + BLP) at 15, 45 min reached to $26.70{\pm}1.66^{Cb}$, $25.10{\pm}1.77^{Cd}$ mg 100 g^{-1} respectively. El-Marrakchi *et al.* (1990) and Harpaz *et al.* (2003) reported that a level of 30 mg N/100 g is considered to be the upper limit, above which fishery products are considered unfit for human consumption. According to this result, it is found that marinated fish fillets with (OLP + BLP) at 45 min was acceptable to the 12th day of cold storage period, but the control sample was rejected after 6th day of storage. Generally, TVB-N values were significantly ($P< 0.05$) increased during the storage period and decreased with increase marinating time for all treatments. These increases in TVB-N value can be explained by proteolysis driven by the enzymatic and microbial activity of the samples. The action of such enzymes results in the formation of compounds, including ammonia, monoethylamine, dimethylamine, etc. which give fish a characteristic off-flavour (Goulas and Kontominas, 2007). Values similar to our TVB-N data have been reported for marinated fish (Can and Ersan, 2013 and Topuz *et al.*, 2014).

Table 3.Changes in total volatile basic nitrogen TVB-N (mg/100g) of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C

Treatments / Storage period (days)	Control	OLP			BLP			OLP + BLP		
		Marinating time (min)								
		15	30	45	15	30	45	15	30	45
0	11.51 ± 0.56^{Ea}	11.50 ± 0.74^{Fa}	11.47 ± 0.77^{Fa}	11.44 ± 0.85^{Ea}	11.48 ± 0.71^{Ea}	11.45 ± 0.71^{Ea}	11.44 ± 0.66^{Ea}	11.49 ± 0.66^{Fa}	11.46 ± 0.65^{Ea}	11.42 ± 0.71^{Ea}
3	16.71 ± 1.22^{Da}	14.30 ± 1.11^{Eb}	13.60 ± 0.88^{Ec}	12.81 ± 0.77^{Ec}	13.10 ± 0.77^{Ec}	12.95 ± 0.88^{Ec}	12.10 ± 0.72^{Ed}	13.60 ± 0.83^{Ec}	12.95 ± 0.97^{Ec}	12.00 ± 0.71^{Ed}
6	25.85 ± 1.55^{Ca}	20.50 ± 1.41^{Db}	19.50 ± 1.14^{Dc}	18.10 ± 1.11^{Dd}	18.90 ± 1.35^{Dc}	17.60 ± 1.04^{Dd}	16.30 ± 1.03^{De}	19.55 ± 1.06^{Dc}	18.90 ± 1.65^{Dc}	17.15 ± 1.01^{Dd}
9	31.50 ± 2.33^{Ba}	27.41 ± 1.75^{Cb}	26.00 ± 2.08^{Cc}	24.90 ± 1.66^{Cd}	26.35 ± 1.91^{Cc}	24.86 ± 1.38^{Cd}	24.00 ± 1.51^{Ce}	26.70 ± 1.66^{Cb}	25.10 ± 1.77^{Cd}	23.45 ± 1.45^{Ce}
12	35.40 ± 2.47^{Aa}	32.65 ± 2.33^{Bb}	30.20 ± 2.53^{Bc}	28.40 ± 2.17^{Bd}	30.00 ± 1.36^{Bc}	28.60 ± 2.16^{Bd}	26.20 ± 2.35^{Be}	30.30 ± 1.67^{Bc}	29.00 ± 2.33^{Bd}	28.10 ± 1.88^{Bd}
15	37.65 ± 2.53^{Aa}	36.80 ± 2.11^{Aa}	35.30 ± 2.47^{Ab}	34.20 ± 2.35^{Ac}	33.50 ± 2.09^{Ac}	31.90 ± 2.07^{Ae}	31.00 ± 2.15^{Ae}	32.65 ± 2.14^{Ad}	31.20 ± 2.19^{Ae}	30.00 ± 2.11^{Af}

OLP = Olive leaves paste. BLP = Basil leaves paste. OLP + BLP = marinated mixture paste (1:1).
$^{A-F}$ Superscripts in a column are significantly different ($P < 0.05$).
$^{a-f}$ Superscripts in a raw are significantly different ($P < 0.05$).

Thiobarbituric acid (TBA):

TBA index is a widely used indicator for the assessment of degree of lipid oxidation (Nishimoto *et al.*, 1985). Fish and fishery products of good quality will have TBA value less than 2.0 while poor quality TBA value greater than 2.7 mg malonaldhyde /Kg will probably have smell and taste rancid (Bonnell, 1994). Generally, TBA value of 1–2 mg malondialdehyde/kg muscle is an acceptable limit (Shakila *et al.*, 2005).

The effect of the natural herbs paste on the lipid oxidation (TBARS values) of tilapia fillets refrigerated for 15 days are shown in Table 4.In the current study, the initial TBA value of control sample was increased progressively ($P < 0.05$) with storage time from 0.50 ± 0.01^{Ba} mg malonaldhyde /Kg at zero time to 1.84 ± 0.03^{Aa} mg malonaldhyde /Kg at 3rd day of refrigerated storage. At each day of determining throughout storage, higher TBA value ($P<0.05$) in the control samples were found in comparison to tilapia fillets marinated with OLP, BLP and (OLP + BLP). TBA value was significantly decrease ($P<0.05$) with increase marinating time for all treatments. Rancidity started being sensorial detected by tasters at 9th day of storage in control sample. These results indicating that formation of secondary lipid oxidation products took place during storage. Lipid in fish muscle has typically a high percentage of polyunsaturated fatty acids and is consequently prone to oxidative reaction. Higher TBA values in marinated fillets with OLP compared with marinated fillets with BLP and (OLP + BLP) were observed during storage period. These results are agreement with (Sarkardei and Howell, 2008 and Kenar *et al*., 2010); they reported that the use of different antioxidants has been reported to cause TBARS values to decrease in fish and fish products. Also, Charupat *et al*. (2009) suggests that pepper-garlic paste could retard lipid oxidation immediately during mixing and during storage. However, marinated fillets with mixture of pastes (OLP + BLP) for 45 min showed the lower TBA value compared with other treatments during cold storage. Also, these treatment retard TBARS values to remain below 2 mg malonaldehyde/kg sample after 15 days of storage at 2 ±1°C. From the results it could be deduced that marinated fillets with mixture of pastes (OLP + BLP) for 45 min was suitable treatment for retarding lipid oxidation throughout storage. These results are in agreement with Aubourg *et al*. (2004) who reported that soaking pretreatment of fish fillets in naturally antioxidants led to lipid oxidation inhibition.

Table 4. Changes in thiobarbituric acid value TBA (mg malondialdehyde/Kg) of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C.

Treatments / Storage period (days)	Control	OLP			BLP			OLP + BLP		
		Marinating time (min)								
		15	30	45	15	30	45	15	30	45
0	0.50 ± 0.01^{Ba}	0.56 ± 0.02^{Da}	0.54 ± 0.02^{Da}	0.50 ± 0.02^{Ea}	0.52 ± 0.01^{Da}	0.51 ± 0.01^{Da}	0.49 ± 0.01^{Da}	0.50 ± 0.02^{Da}	0.49 ± 0.03^{Da}	0.48 ± 0.01^{Da}
3	1.71 ± 0.04^{Aa}	0.75 ± 0.03^{Bb}	0.64 ± 0.04^{Bc}	0.62 ± 0.02^{Bc}	0.60 ± 0.02^{Cc}	0.53 ± 0.04^{Dd}	0.52 ± 0.03^{Dd}	0.59 ± 0.03^{Cc}	0.52 ± 0.04^{Dd}	0.51 ± 0.02^{Dd}
6	1.84 ± 0.03^{Aa}	1.60 ± 0.04^{Ba}	1.51 ± 0.04^{Ba}	1.00 ± 0.03^{Cd}	1.42 ± 0.04^{Bb}	1.32 ± 0.08^{Cc}	0.97 ± 0.05^{Cd}	1.40 ± 0.08^{Bb}	0.95 ± 0.05^{Cd}	0.86 ± 0.04^{Ce}
9	ND	1.99 ± 0.09^{Aa}	1.81 ± 0.09^{Ab}	1.40 ± 0.05^{Bd}	1.89 ± 0.06^{Aa}	1.65 ± 0.06^{Bc}	1.34 ± 0.04^{Bd}	1.93 ± 0.07^{Aa}	1.36 ± 0.07^{Bd}	1.21 ± 0.05^{Be}
12	ND	ND	ND	1.96 ± 0.08^{Aa}	ND	1.87 ± 0.07^{Aa}	1.72 ± 0.06^{Ab}	ND	1.91 ± 0.08^{Aa}	1.70 ± 0.07^{Ab}
15	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.95 ± 0.09^{Aa}

OLP = Olive leaves paste. BLP = Basil leaves paste. OLP + BLP = marinated mixture paste (1:1).
$^{A-E}$ Superscripts in a column are significantly different ($P < 0.05$).
$^{a-e}$ Superscripts in a raw are significantly different ($P < 0.05$).
ND = Not determined because unacceptable by the panelists.

Free Fatty Acids (FFA):

Changes in FFA values of fish fillets stored at 2 ±1°C are given in Table 5. The initial level of FFA in fish fillets was in the range of 0.9 ± 0.3^{Eb} – 9.4 ± 0.4^{Aa} % for control sample; 0.9 ± 0.4^{Eb} – 8.7 ± 0.4^{Ab} % for marinated fish fillets with OLP; 0.6 ± 0.01^{Ec} – 8.2 ± 0.4^{Ac} % for marinated fish fillets with BLP and 0.5 ± 0.01^{Ed} – 8.0 ± 0.3^{Ad} % for marinated fish fillets with OLP + BLP. At 2 ±1°C in present study, FFA content of control fish sample was found to be less than the acceptable limit (5%) on 3rd day (2.9 ± 0.1^{Da} %), while crossed the acceptable limit on 6th day (5.4 ± 0.2^{Ca} %). Meanwhile, FFA values were slightly decrease by increase marinating time for marinated fish with BLP and (OLP + BLP), while were slightly increase by increase marinating time for marinated fish with OLP. FFA content was increased with increase cold storage period for all samples. There were considerable differences ($P<0.05$) in FFA between the control and the treated samples during cold storage. Therefore, the higher value of FFA is possibly due to the action of lipolytic enzymes on lipid from higher bacterial load leading to increase in the release of free fatty acids, which contribute positively to the generation of undesirable aroma and flavor (Al-Sherick, 2005). The lower FFA was observed for marinated fillets with (OLP + BLP) for 45 min than other treatments, and reached to 4.8 ± 0.2^{Bf} % which under the acceptable level, even after 12 days, while the highest FFA value was found for the control sample during cold storage. Lipid hydrolysis developed at a slower rate in the samples treated with natural antioxidants and antimicrobial these results agreed with Pacheo-Aguillar *et al*. (2000) and Uçak *et al*. (2011).

Table 5.Changes in free fatty acids (FFA) of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C.

Treatments / Storage period (days)	Control	OLP			BLP			OLP + BLP		
		Marinating time (min)								
		15	30	45	15	30	45	15	30	45
0	0.9 ± 0.3^{Eb}	0.9 ± 0.4^{Eb}	1.0 ± 0.01^{Ea}	1.1 ± 0.01^{Ea}	0.8 ± 0.02^{Eb}	0.7 ± 0.02^{Ec}	0.6 ± 0.01^{Ec}	0.7 ± 0.01^{Ec}	0.6 ± 0.01^{Ec}	0.5 ± 0.01^{Ed}
3	2.9 ± 0.1^{Da}	2.6 ± 0.1^{Db}	2.8 ± 0.1^{Da}	2.9 ± 0.1^{Da}	2.5 ± 0.1^{Db}	2.4 ± 0.1^{Dc}	2.3 ± 0.1^{Dc}	2.6 ± 0.1^{Db}	2.5 ± 0.03^{Db}	2.0 ± 0.1^{Dd}
6	5.4 ± 0.2^{Ca}	4.4 ± 0.2^{Cc}	4.9 ± 0.2^{Cb}	5.0 ± 0.2^{Cb}	3.6 ± 0.2^{Cd}	3.5 ± 0.2^{Ce}	3.4 ± 0.2^{Ce}	3.8 ± 0.2^{Cd}	3.7 ± 0.04^{Cd}	3.3 ± 0.1^{Ce}
9	7.8 ± 0.3^{Ba}	6.1 ± 0.2^{Bc}	6.4 ± 0.2^{Bb}	6.6 ± 0.2^{Bb}	6.0 ± 0.4^{Bc}	4.8 ± 0.4^{Bd}	4.7 ± 0.3^{Cd}	4.9 ± 0.3^{Cd}	4.8 ± 0.1^{Bd}	4.4 ± 0.1^{Be}
12	8.2 ± 0.3^{Aa}	7.8 ± 0.3^{Ab}	7.9 ± 0.4^{Ab}	8.1 ± 0.2^{Aa}	7.6 ± 0.4^{Ac}	6.5 ± 0.4^{Bd}	6.3 ± 0.4^{Bd}	6.2 ± 0.3^{Bd}	5.7 ± 0.2^{Be}	4.8 ± 0.2^{Bf}
15	9.4 ± 0.4^{Aa}	8.3 ± 0.3^{Ac}	8.5 ± 0.3^{Ab}	8.7 ± 0.4^{Ab}	8.2 ± 0.4^{Ac}	7.9 ± 0.3^{Ad}	7.8 ± 0.3^{Ad}	8.0 ± 0.3^{Ad}	7.6 ± 0.3^{Ae}	7.0 ± 0.3^{Af}

OLP = Olive leaves paste. BLP = Basil leaves paste. OLP + BLP = marinated mixture paste (1:1).
$^{A-E}$ Superscripts in a column are significantly different (P < 0.05).
$^{a-f}$ Superscripts in a raw are significantly different (P < 0.05).

Microbiological analysis:

Microbial activity is responsible for spoilage of most fresh and several lightly of preserved seafood. Possibly, for this reason, the total number of microorganisms has been used in mandatory seafood standards (Lund *et al*., 2000). Özogul *et al.* (2004) mentioned that when the aerobic plate count reaches 10^6 CFU/g or mL in a food product, it is assumed to be at, or near, spoilage. Total bacterial count (TBC) and psychrophilic bacterial count (PsBC) of fish fillets with and without the addition of the herbal pastes and refrigerated for 15 days are shown in Table 6. Initially (day 0), TBC of control sample was 2.38 ± 0.05^{Af} $\log_{10}$ CFU/g indicates the aquaculture fish are expected to be of good hygienic quality since they live in a controlled environment and are slaughtered through good practices. Moreover handling, distribution and storage conditions are usually more controlled than in wild fish. Gradually increase of TBC until 6th day was observed for control sample. In general, the highest microbial growth was obtained from the control samples, while the lowest microbial development was observed in samples treated with OLP, BLP and (OLP + BLP). In this study, TBC exceeding 6 $\log_{10}$ CFU/g were observed in the control sample after 9 days of cold storage (6.60 ± 0.1^{Ac} $\log_{10}$ CFU/g), while other samples were under the standard level, even after 12 days except marinated fillets with OLP for 15 min. These results are agree with Arashisar *et al.* (2004), they reported when aerobic plate counts reached 6 $\log_{10}$ CFU/g, the food product was assumed to be at or near spoilage. This is also supported by ICMSF (1986) which stated that the upper acceptability limit of total viable bacterial count in fresh fish is 7 $\log_{10}$ CFU/g flesh, and 6 $\log_{10}$ CFU/g is the maximum permissible limit of APC recommended by EOS (2005) in chilled fish. Hence, fillets treated with BLP and (OLP + BLP) had lowest microbial development until to the end of cold storage period. These result are agreement with Om Kalthoum *et al.* (2015) who showed that more resistant of bacterial strains with olive than with basil indicating stronger antimicrobial activity of basil than that of olive.

Table 6.Changes in total bacterial count (TBC) and psychrophilic bacterial count (PsBC) (log_{10} CFU/ g) of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C.

Treatments	Marinating time	0day	3rdday	6thday	9thday	12thday	15thday
		TBC (log cfu/g)					
Control	-	2.38±0.05^{Af}	3.32±0.04^{Ae}	3.85±0.01^{Ad}	6.60±0.01^{Ac}	6.97±0.01^{Ab}	8.65±0.01^{Aa}
OLP	15	2.28±0.07^{Af}	2.90±0.03^{Be}	3.15±0.08^{Bd}	4.60±0.01^{Bc}	6.00±0.01^{Bb}	7.40±0.01^{Ba}
	30	2.10±0.03^{Bf}	2.40±0.03^{De}	3.06±0.08^{Bd}	4.10±0.03^{Cc}	5.45±0.02^{Cb}	6.75±0.09^{Ca}
	45	1.95±0.02^{Ce}	2.00±0.02^{Ee}	2.80±0.09^{Cd}	3.90±0.01^{Dc}	5.00±0.01^{Db}	6.20±0.08^{Da}
BLP	15	2.25±0.04^{Af}	2.78±0.03^{Ce}	2.89±0.07^{Cd}	4.20±0.09^{Cc}	5.35±0.01^{Cb}	6.50±0.09^{Ca}
	30	2.00±0.03^{Ce}	2.15±0.05^{Ee}	2.95±0.07^{Cd}	4.00±0.08^{Cc}	5.00±0.02^{Db}	5.43±0.08^{Ea}
	45	1.80±0.03^{De}	1.98±0.04^{Ee}	2.45±0.07^{Dd}	3.30±0.08^{Fc}	4.75±0.01^{Eb}	5.25±0.06^{Fa}
OLP+BLP	15	2.26±0.04^{Af}	2.83±0.07^{Be}	3.00±0.07^{Bd}	4.40±0.08^{Bc}	5.40±0.01^{Cb}	6.00±0.07^{Da}
	30	2.05±0.05^{Bf}	2.25±0.06^{De}	2.90±0.06^{Cd}	3.89±0.07^{Dc}	4.92±0.01^{Db}	5.30±0.05^{Ea}
	45	2.00±0.05^{Be}	2.15±0.05^{Ee}	2.40±0.05^{Dd}	3.60±0.09^{Ec}	4.90±0.01^{Db}	5.20±0.08^{Fa}
		PsBC (log cfu/g)					
Control	-	1.42±0.02^{Ae}	1.72±0.02^{Ad}	2.15±0.02^{Ac}	2.88±0.03^{Ac}	3.30±0.03^{Ab}	5.00±0.04^{Aa}
OLP	15	1.30± 0.01^{Ad}	1.45±0.02^{Bd}	1.64±0.03^{Bc}	1.83±0.02^{Bc}	2.20±0.02^{Bb}	3.65±0.03^{Ba}
	30	1.25±0.01^{Bd}	1.29±0.01^{Dd}	1.50±0.01^{Cc}	1.77±0.02^{Cc}	2.00±0.02^{Bb}	3.22±0.02^{Ba}
	45	1.20±0.02^{Bd}	1.24±0.01^{Dd}	1.43±0.01^{Dc}	1.55±0.02^{Ec}	1.70±0.03^{Eb}	3.18±0.03^{Ba}
BLP	15	1.22±0.01^{Bd}	1.35±0.01^{Cd}	1.52±0.01^{Cc}	1.74±0.02^{Cc}	2.10±0.03^{Bb}	3.30±0.02^{Ba}
	30	1.18±0.02^{Cd}	1.24±0.02^{Dc}	1.38±0.02^{Ec}	1.64±0.03^{Db}	1.86±0.02^{Db}	3.15±0.03^{Ba}
	45	1.17±0.01^{Cb}	1.20±0.02^{Db}	1.30±0.02^{Eb}	1.45±0.02^{Fb}	1.64±0.03^{Fb}	3.12±0.03^{Ba}
OLP+BLP	15	1.20±0.02^{Bd}	1.34±0.02^{Cc}	1.50±0.02^{Cc}	1.60±0.03^{Dc}	1.98±0.03^{Cb}	3.22±0.02^{Ba}
	30	1.17±0.01^{Cc}	1.23±0.02^{Db}	1.33±0.03^{Eb}	1.42±0.02Fb	1.77±0.02^{Eb}	3.10±0.02^{Ba}
	45	1.16±0.02^{Cc}	1.19±0.01^{Eb}	1.28±0.01^{Fb}	1.36±0.02^{Gb}	1.54±0.03^{Gb}	3.00±0.02^{Ca}

OLP = Olive leaves paste. BLP = Basil leaves paste. OLP +B LP = marinated mixture paste (1:1).

$^{A-G}$ Superscripts in a column are significantly different (P < 0.05).

$^{a-f}$ Superscripts in a raw are significantly different (P < 0.05).

Psychrophilic bacteria count (PsBC) are very important since they cause most of the changes in odour, texture and flavour as a result of production of different metabolic compounds such as ketones, aldehydes, volatile sulphides and biogenic amines (Safari and Yosefian, 2006). Initial of PsBC in fish fillets ranged from 1.42 ± 0.02^{Ae} to 5.0 ± 0.04^{Aa} log10 CFU/g for control sample during storage period are shown in Table 6. In the present study, PsBC was gradually decreased with increase marinating time for all treated samples. Meanwhile, PsBC was increased with increasing storage time for all treatments. Significant differences ($P<0.05$) were observed among all samples. Antibacterial effect of OLP + BLP on psychrophilic bacterial growth was slightly higher than that of other pastes used. So, the lowest PsBC of marinated fillets with OLP + BLP for 45 min (3.00 ± 0.02^{Ca} $\log_{10}$ CFU/g) were observed after 15th day of storage at 2±1°C. Generally, the extent of the inhibitory effects of the herbal pastes could be attributed to their phenolic composition (Korukluoglu *et al*., 2010). Moreover, these changes may be due to the effects of the garlic and pepper content Charupat *et al*. (2009).

Sensory analysis:

Organoleptic assessment is the most popular way of evaluating the freshness of fish. It is simple, fast, and provides immediate quality information. Also, sensory properties of food products are the key factors in consumer attraction (Gray *et al*., 1996). All the initial samples at zero time had high scores for texture and colour (Table 7). This means that all samples were fresh according to Huss (1995). Throughout the refrigerated storage period there were significant decrease ($p < 0.05$) in texture and colour scores for control and all treated samples. According to different marinating time of treatments the maximum texture scores were obtained in fillets treated by mixture of OLP + BLP for 45 min compared to control and other marinated samples. In this study, herbal pastes and length of refrigerated storage (2 ±1°C) had an effect on texture score for all samples, which tended to decrease as the storage time increased. Texture scores of fish samples were gradually decreased during the storage period at 2 ±1°C. The samples treated with OLP + BLP were the most preferred fillets followed by the samples with BLP.

As stated by Scideman *et al*., (1984) meat colour is considered one of the most important quality attributes in the acceptance or rejection of the product. Colour scores were significant decrease ($p < 0.05$) with increase marinating time and with progressively of storage period for all treatments. This might be implicated to the possibly penetration of chlorophyll pigments and their subsequent interference with other biochemically active compounds in tilapia fillets, which caused an undesirable change in meat colour. In addition, black pepper and garlic had particularly effects on colour of marinated fillets. These results are agreement with (Charupat *et al*., 2009 and Yıldız, 2016).

Table 7. Changes in texture and colour of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C.

Treatments	Marinating time	0day	3rd day	6th day	9th day	12th day	15th day
				Texture			
Control	-	5.0 ± 0.07^{Aa}	4.7 ± 0.05^{Aa}	3.6 ± 0.04^{Bb}	2.0 ± 0.03^{Dc}	1.8 ± 0.03^{Dc}	1.5 ± 0.03^{Ed}
OLP	15	5.0 ± 0.08^{Aa}	4.7 ± 0.06^{Aa}	3.7 ± 0.04^{Bb}	2.7 ± 0.04^{Cc}	2.1 ± 0.04^{Dd}	1.9 ± 0.03^{Dd}
	30	5.0 ± 0.09^{Aa}	4.8 ± 0.06^{Aa}	3.9 ± 0.06^{Bb}	3.5 ± 0.03^{Bc}	3.1 ± 0.03^{Cd}	2.7 ± 0.04^{Ce}
	45	5.0 ± 0.11^{Aa}	4.8 ± 0.05^{Aa}	3.8 ± 0.07^{Bb}	3.6 ± 0.04^{Bb}	3.2 ± 0.02^{Bd}	2.8 ± 0.04^{Be}
BLP	15	5.0 ± 0.08^{Aa}	4.8 ± 0.07^{Aa}	4.3 ± 0.06^{Ab}	3.3 ± 0.05^{Bc}	3.0 ± 0.04^{Cd}	2.6 ± 0.05^{Ce}
	30	5.0 ± 0.07^{Aa}	4.9 ± 0.08^{Aa}	4.5 ± 0.04^{Ab}	3.7 ± 0.06^{Bc}	3.4 ± 0.05^{Bd}	3.1 ± 0.07^{Ae}
	45	5.0 ± 0.06^{Aa}	4.9 ± 0.06^{Aa}	4.5 ± 0.08^{Ab}	4.0 ± 0.07^{Ac}	3.9 ± 0.04^{Ac}	3.2 ± 0.08^{Ad}
OLP+BLP	15	5.0 ± 0.05^{Aa}	4.8 ± 0.04^{Aa}	4.2 ± 0.07^{Ab}	3.9 ± 0.08^{Ac}	3.4 ± 0.05^{Bd}	3.0 ± 0.07^{Be}
	30	5.0 ± 0.07^{Aa}	4.9 ± 0.04^{Aa}	4.5 ± 0.04^{Ab}	4.1 ± 0.05^{Ac}	3.7 ± 0.07^{Ad}	3.3 ± 0.06^{Ae}
	45	5.0 ± 0.08^{Aa}	4.9 ± 0.07^{Aa}	4.6 ± 0.05^{Ab}	4.3 ± 0.09^{Ab}	3.8 ± 0.06^{Ad}	3.4 ± 0.06^{Ae}
				Colour			
Control	-	5.0 ± 0.04^{Aa}	4.6 ± 0.06^{Ab}	3.0 ± 0.04^{Bc}	2.8 ± 0.05^{Bc}	2.4 ± 0.04^{Cd}	2.2 ± 0.03^{Cd}
OLP	15	4.9 ± 0.05^{Aa}	4.4 ± 0.07^{Ab}	2.9 ± 0.04^{Bc}	2.7 ± 0.05^{Cc}	2.3 ± 0.04^{Cd}	2.1 ± 0.04^{Cd}
	30	4.8 ± 0.05^{Aa}	4.2 ± 0.08^{Cb}	2.8 ± 0.03^{Cc}	2.5 ± 0.04^{Cd}	2.2 ± 0.05^{Ce}	2.0 ± 0.05^{Cf}
	45	4.7 ± 0.07^{Ba}	4.1 ± 0.08^{Cb}	2.7 ± 0.05^{Cc}	2.3 ± 0.03^{Dd}	2.1 ± 0.05^{De}	2.0 ± 0.04^{Ce}
BLP	15	4.9 ± 0.06^{Aa}	4.5 ± 0.09^{Ab}	3.1 ± 0.04^{Bc}	3.0 ± 0.06^{Ac}	2.8 ± 0.06^{Bd}	2.5 ± 0.03^{Ae}
	30	4.8 ± 0.05^{Aa}	4.3 ± 0.07^{Bb}	3.0 ± 0.05^{Bc}	2.9 ± 0.04^{Bc}	2.7 ± 0.05^{Bd}	2.4 ± 0.02^{Be}
	45	4.7 ± 0.07^{Ba}	4.2 ± 0.08^{Bb}	2.9 ± 0.03^{Bc}	2.8 ± 0.03^{Bc}	2.6 ± 0.05^{Bd}	2.3 ± 0.01^{Be}
OLP+BLP	15	4.9 ± 0.05^{Aa}	4.6 ± 0.06^{Aa}	3.5 ± 0.02^{Ab}	3.2 ± 0.07^{Ac}	3.0 ± 0.06^{Ad}	2.7 ± 0.03^{Ae}
	30	4.8 ± 0.05^{Aa}	4.4 ± 0.04^{Ab}	3.3 ± 0.02^{Ac}	3.1 ± 0.07^{Ac}	2.7 ± 0.06^{Bd}	2.6 ± 0.02^{Ad}
	45	4.7 ± 0.04^{Ba}	4.3 ± 0.07^{Bb}	3.2 ± 0.03^{Bc}	2.9 ± 0.02^{Bd}	2.6 ± 0.04^{Be}	2.5 ± 0.04^{Ae}

BLP = Basil leaves paste. OLP = Olive leaves paste. BLP + OLP = marinated mixture paste (1:1).

$^{A-E}$ Superscripts in a column are significantly different ($P < 0.05$).

$^{a-f}$ Superscripts in a raw are significantly different ($P < 0.05$).

The effect of herbal pastes and storage time on the flavour and overall acceptability scores are shown in Table 8. Decreasing flavour and overall acceptability scores were observed for all treatments during storage time.

Moreover, significant differences ($P < 0.05$) were found among different periods of storage and between different treatments. All treatments developed off-flavour with increased storage time, with the lowest and the highest off-flavour detected on samples treated with OLP + BLP at 45 min and OLP at 15 min, respectively. Meanwhile, the early signs of off-flavour appeared in fillets treated with OLP at 15 min and the control sample on day 6 but developed in other treatments after 9 days of storage time.

The sensory data showed that the marinated fillet with OLP + BLP samples were still in acceptable condition at the end of storage, due to the effect of combination of OLP + BLP on limiting microbiological activity and decreasing the TVB-N value as well as the positive attributes of its flavour. These conclusions were supported by the results from microbiological and chemical quality analyses. Similar results have been reported in other recent studies (Ozpolat *et al.,* 2010 and Duman *et al.,* 2012). Our results were indicated that treatments of tilapia fillet with (OLP + BLP) effectively extended the shelf-life of fillets with high acceptability throughout the storage of 15 days. Therefore, it was suggested that the herbal paste might retard bacterial growth and lipid oxidation, leading to the shelf-life extension and improve quality of tilapia fillets.

Table 8. Changes in flavour and overall acceptability of tilapia (*Oreochromis niloticus*) fillets treated with OLP, BLP and OLP + BLP during chilling storage at 2 ±1°C.

Treatments	Marinating time	0day	3rdday	6thday	9thday	12thday	15thday
		Flavour					
Control	-	5.0 ± 0.08^{Aa}	3.8 ± 0.03^{Db}	2.1 ± 0.03^{Ec}	ND	ND	ND
OLP	**15**	4.6 ± 0.09^{Aa}	4.0 ± 0.05^{Cb}	2.8 ± 0.03^{Bc}	ND	ND	ND
	30	4.8 ± 0.07^{Ba}	4.7 ± 0.04^{Ba}	3.7 ± 0.04^{Cc}	3.0 ± 0.05^{Cd}	ND	ND
	45	4.9 ± 0.08^{Aa}	4.8 ± 0.06^{Aa}	4.0 ± 0.03^{Ac}	3.3 ± 0.04^{Bd}	ND	ND
BLP	**15**	4.8 ± 0.09^{Aa}	4.5 ± 0.05^{Bb}	3.2 ± 0.04^{Dc}	ND	ND	ND
	30	4.9 ± 0.07^{Aa}	4.9 ± 0.09^{Aa}	3.9 ± 0.03^{Bc}	3.1 ± 0.05^{Cd}	ND	ND
	45	4.9 ± 0.07^{Aa}	4.9 ± 0.09^{Aa}	4.1 ± 0.06^{Ac}	3.4 ± 0.07^{Ad}	ND	ND
OLP+BLP	**15**	4.7 ± 0.08^{Ba}	4.6 ± 0.09^{Ba}	3.7 ± 0.05^{Cb}	ND	ND	ND
	30	4.9 ± 0.08^{Aa}	4.7 ± 0.07^{Ba}	4.0 ± 0.06^{Ab}	3.5 ± 0.06^{Bc}	ND	ND
	45	4.9 ± 0.08^{Aa}	4.8 ± 0.08^{Aa}	4.1 ± 0.07^{Ab}	3.6 ± 0.06^{Ac}	3.0 ± 0.07^{Ad}	ND
		Overall acceptability					
Control	-	5.0 ± 0.11^{Aa}	4.36 ± 0.07^{Bb}	2.90 ± 0.04^{Dc}	ND	ND	ND
OLP	**15**	4.83 ± 0.06^{Aa}	4.36 ± 0.07^{Bb}	3.13 ± 0.04^{Cc}	ND	ND	ND
	30	4.86 ± 0.06^{Aa}	4.56 ± 0.04^{Ab}	3.46 ± 0.05^{Bc}	3.00 ± 0.05^{Cd}	ND	ND
	45	4.86 ± 0.05^{Aa}	4.56 ± 0.04^{Ab}	3.50 ± 0.05^{Bc}	3.06 ± 0.05^{Cd}	ND	ND
BLP	**15**	4.90 ± 0.07^{Aa}	4.60 ± 0.05^{Ab}	3.53 ± 0.05^{Bc}	3.15 ± 0.08^{Bd}	ND	ND
	30	4.90 ± 0.08^{Aa}	4.70 ± 0.05^{Ab}	3.80 ± 0.06^{Ac}	3.23 ± 0.07^{Bd}	ND	ND
	45	4.86 ± 0.08^{Aa}	4.66 ± 0.06^{Ab}	3.83 ± 0.06^{Ac}	3.40 ± 0.06^{Ad}	3.25 ± 0.06^{Ad}	ND
OLP+BLP	**15**	4.86 ± 0.05^{Aa}	4.66 ± 0.07^{Ab}	3.80 ± 0.06^{Ac}	3.55 ± 0.06^{Ad}	3.20 ± 0.04^{Ae}	2.85 ± 0.03^{Af}
	30	4.90 ± 0.07^{Aa}	4.66 ± 0.08^{Ab}	3.93 ± 0.07^{Ac}	3.56 ± 0.04^{Ad}	3.20 ± 0.05^{Ae}	2.80 ± 0.02^{Af}
	45	4.86 ± 0.07^{Aa}	4.66 ± 0.09^{Ab}	3.96 ± 0.06^{Ac}	3.60 ± 0.07^{Ad}	3.13 ± 0.05^{Ae}	2.95 ± 0.02^{Af}

BLP = Basil leaves paste. OLP = Olive leaves paste. BLP + OLP = marinated mixture paste (1:1).
$^{A-E}$ Superscripts in a column are significantly different (P < 0.05).
$^{a-f}$ Superscripts in a raw are significantly different (P < 0.05).
ND = Not determined because unacceptable by the panelists

CONCLUSION

Marinating of tilapia fillets into olive leaves paste (OLP), basil leaf paste (BLP), and (OLP + BLP) have a positive effect on the product's physicochemical, microbial and sensory attributes during cold storage (2 ±1°C). Overall, the use of herbal paste showed a synergistic effect, extending the shelf life of tilapia fillets. According to the results of TVB-N and TBA analyses, shelf life of marinated tilapia fillets with (OLP + BLP) for 45 min was extended during refrigerated storage compared with other treatments. Samples treated with BLP were reported to have an antioxidant activity with clear reduction in the TBA value in compared with control and other samples. Fillets treated with BLP and with (OLP + BLP) had lowest microbial development until the end of cold storage. High scores for sensory properties of fillets treated with OLP + BLP were recorded. It was concluded that the samples marinated with BLP + OLP were favored for the overall quality maintenance of fillets.

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تأثير بعض مضادات الاكسدة ومضادات البكتريا الطبيعية على خواص الجودة لشرائح سمك البلطى المخزنة بالتبريد

احمد زكار حسب الله

قسم بحوث مراقبة الجودة وتصنيع الاسماك، المعمل المركزي لبحوث الثروة السمكية، مركز البحوث الزراعية، مصر.

الملخــص العربـــى

تم دراسة تأثير مضادات الأكسدة ومضادات البكتيريا الطبيعية لمعجون اوراق الريحان ومعجون اوراق الزيتون على شرائح أسماك البلطي النيلي (*Oreochromis niloticus*) المخزنة على درجة حرارة 2 ± 1 درجة مئوية لمدة 15 يوم. اجريت هذه الدراسة لتقييم تأثير عملية النقع بالمخاليط كما يلي: معجون أوراق الزيتون (OLP) ، معجون أوراق الريحان (BLP) ؛ مزيج منهما (OLP + BLP) بنسبة (1: 1 – وزن / وزن) لمدة 15 و 30 و 45 دقيقة على خواص الجودة وفترة الصلاحية لشرائح البلطي خلال التخزين بالتبريد على درجة 2 ± 1 مئوية . تم تقييم خصائص الجودة والعمر التخزينى لشرائح السمك من خلال التغيرات الفيزيائية والكيميائية والميكروبيولوجية والحسية على 2 ± 1 درجة مئوية. قد لوجظ ان هناك انخفاض معنوى ($P<0.05$) في قيم الرقم الهيدروجيني pH والخواص الحسية مع زيادة وقت التخزين، بينما زادت قيم القواعد النيتروجينية الطيارة الكلية TVB–N وحمض الثيوباربتيوريك TBA والاحماض الدهنية الحره FFA والعدد البكتيرى مع تقدم فترة التخزين لكل المعاملات. كما أظهرت النتائج التي تم الحصول عليها أن خلط الـ BLP+ OLP لها نشاط مضاد للأكسدة ومضاد للميكروبات وبذلك يمكن أن تحافظ على معايير الجودة وتطيل فترة صلاحية شرائح البلطي النيلي المبردة لفترة أطول مقارنة بعينة الكنترول. وبناءً على هذه النتائج ، يمكن الاستنتاج بأن شرائح السمك المنقوعة فى (OLP + BLP) لمدة 45 دقيقة هي أفضل معاملة ولها فترة تخزين طويلة ، يليها شرائح السمك المنقوعة فى (OLP + BLP) لمدة 30 دقيقة ثم شرائح السمك المنقوعة فى BLP لمدة 45 دقيقة مقارنة بعينات الكنترول.