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ANTIOXIDANT EFFECT OF ROSEMARY EXTRACT AND α-TOCOPHEROL ON THE QUALITY OF COATED FRIED NILE TILAPIA FILLETS (*Oreochromis niloticus*) DURING CHILLING AND FROZEN STORAGE

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Abstract

This study was carried out to investigate the effect of Rosemary extract (R.E.) and α-tocopherol on the quality of coated fried Nile tilapia fillets (*Oreochromis niloticus*) during chilling and frozen storage. Nile tilapia fillets were treated with (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% then stored for 5,10 and 15 days at 4±1°C and for three months at -18±2°C. Then chemical tests including Peroxide value (PV), Thio-barbituric acid (TBA), Tri-methylamine-nitrogen (TMA-N) and Total volatile base-nitrogen (TVB-N) were done to evaluate the preservative effect of (R.E.) and α-tocopherol during storage. The PV and TBA increased in all treatments due to lipid oxidation. Results showed that TMA-N,TVB-N, value of (R.E.) and α-tocopherol treated samples were significantly lower than those of the control samples ($P<0.05$). Results of our investigation revealed that R.E. retarded oxidative changes in chilling and frozen coated fried Nile tilapia fillets whereas R.E. 0.1%, 0.2% and α-tocopherol 0.1% were not as effective as R.E. 0.3% on oxidative stability. Best oxidation inhabitation results on chilling and frozen coated fried Nile tilapia fillets was obtained when employing of R.E. The obtained results also showed that there was a significant ($p<0.05$) enhancement in sensory quality attributes of fried Nile tilapia fillets; samples treated with R.E. and α-tocopherol

Conclusion, The tested R.E. had a high effectiveness as antioxidative and antimicrobial should be utilized for extending the shelf-life through retarded the spoilage and enhancing quality attributes of coated fried Nile tilapia fillets during chilling and frozen storage.

INTRODUCTION

During deep-fat frying, the oil is exposed to elevated temperature in the presence of air and moisture. A number of chemical reactions, including oxidation and hydrolysis, occur during this time, as do changes due to thermal decomposition (Stevenson *et al*., 1984). Lipid oxidation in muscle foods can be initiated by non-enzymatic and enzymatic reactions (Akhtar *et al*., 1998). Lipid oxidation is one of the most important factors responsible for quality deterioration of fish during both refrigerated and frozen storage (Serdaroglu and Felekoglu, 2005). The investigated studies show that freezing is one of the best methods for long-term fish maintenance (Verma and Sriker, 1994; Vidya Sagar Reddy and Sriker, 1996 and Aubourg *et al*., 2005). Freezing prevents microbial spoilage and helps to reduce fat oxidation but cannot prevent it. One of the appropriate methods to access this target is using additives such as antioxidants. The use of antioxidants is emerging as an effective methodology for controlling rancidity in oils and food (Pazos *et al*., 2005; Rostamzad *et al*., 2011 and Taheri *et al*., 2012). The application of synthetic and natural antioxidants to control lipid oxidation in sea foods is well established (Khan *et al.*, 2006).

To prevent and delay the quality changes caused by lipid oxidation in foods and seafood, various synthetic antioxidants have been used (Benjakul *et al*. 2005). However, with growing concerns regarding the safety of synthetic antioxidants, natural antioxidants have been suggested as safe alternative to synthetic antioxidants to retard oxidative processes and to improve the keeping quality of fish. This ability is due to their potential as free radical scavengers which may terminate radical chain reactions and display antibacterial effects against bacterial pathogens (Singh *et al.*, 2005) and (Sarabi *et al.*, 2017). The bacteriostatic effects of spices may occur through two mechanisms: the delay and partial inhibition of DNA and proteins synthesis (Feldberg *et al.*, 1988). Spices and herbs have been added to food since ancient times, not only as flavoring agents, but also as folk medicine and food preservatives (Nakatani, 1994). Furthermore, certain spices and herbs were used as green materials, plant extracts; essential oils (EOs) and powders for prolong the storage life of foods

by preventing rancidity through their antioxidants activity or through bacteriostatic or bactericidal activity, also to food-borne pathogenic bacteria (Shelef *et al.*, 1980). Essential oils (EOs) contain a mixture of compounds, which includes terpenes, alcohols, acetones, phenols, acids, aldehydes, and esters and mainly used as food flavorings or functional components in pharmaceuticals (Corbo *et al.*, 2009)

Among natural antioxidants, rosemary *(Rosemarinus officinalis)* has been used successfully as an antioxidant in different kinds of fish species Sardine *(Sardine pilchardus)* by Serdaroglu and Felekoglu (2005),Escolar *(Lipidocybium flavobrunium)* by **(Sarabi *et al.*, 2017)** and Tilapia *(Oreochromis niloticus)* by Ibrahim and EL- Sherif (2008).

Rosemary (*Rosmarinus officinalis*) oil is well known as a common spice which extensively used in the food industry. Antioxidant efficiency of **rosemary extract** or oil is due to high content of phenolic compounds; monoterpenes (eteric olis), diterpene phenols (carnosic acid, carnosol, rosmanol, epirosmanol, isorosmanol, methylcarnosate), phenolic acids (rosmarinic acid), flavonols and triterpene acids (ursolic acid, oleanolic acid, butilinic acid) which break free radical chain reactions by hydrogen atom donation (Rızna*r et al.*, 2006). The anti-oxidative effect of rosemary is based on its phenolic diterpenes, creosol and carnosinic acid as well as rosmanol, epirosmanol and iso-rosmanol (Inatani *et al*., 1983; Schwarz *et al.*, 1992).

Many studies were carried out to prove the effect of combination of refrigeration and essential oils on extending the shelf-life of fish and fish products (Zakipour and Divband, 2012).

Therefore, this study was carried out to investigate the effect of Rosemary extract and α-tocopherol on improve the quality and extending the shelf-life of fried Nile tilapia (*Oreochromis niloticus*) fillets during chilling storage at 4±1ºC for 15 days and frozen storage up to 3 months by determination of physico-chemical, microbial and sensory quality criteria so, shelf-life periodically during storage period.

MATERIALS AND METHODS

Samples preparation:

Nile tilapia (*Oreochromis niloticus*) was used in this study. An initial batch was directly obtained from special farm in Benghazi. The fish samples were transferred to the laboratory of department of food science and technology (Public Health - Benghazi University). All of the fish (32.200 kg.) were immediately washed with tap water. The head, scales and all fins of the fish were removed using a sharp knife. Therefore, the fish were washed again and soaked in tap water for one hour and dressed in a fillets style weighting of each fillet was approximately 90±10 g, then the fillets were divided into 5 groups. Samples of the first group were left untreated (control) and dipped in edible coating solution (without any antioxidant) and packaged in polyethylene bags. Coating agents including (onion powder, starch, gluten, salt, garlic powder, isolated soy protein, sodium caseinate, lime juice, blend spice, white pepper, red pepper, sodium ascorbate and whole egg) were obtained from local market, Fillets belonging to the second, third and fourth groups were dipped into edible coating solutions containing 0.1%, 0.2% and 0.3% of (R.E.) respectively, whereas the fifth groups were dipped in edible coating solution containing 0.1% α-tocopherol.

All fish fillets groups were left at room temperature and then pan-fried using an electrical fryer pan in frying oil (without antioxidant) heated at 170°C for 4 minute, then drained in a basket to remove excess oil and then packed and chilling storage at 4±1ºC for 15 days and frozen storage up to 3 months at -18°C to evaluate the effects of antioxidant of RE and α-tocopherol during the storage. Samples were randomly drawn for analysis at every 5, 10 and 15 days through chilling storage and at every one month periods through frozen period. For all five groups of fish fillets analyses were carried out after the chilling and freezing process. For each kind of fillets, five different batches (n=5) were considered and analyzed separately in order to achieve the statistical analysis.

Plant Extract:

Rosemary (*Rosemarinus officinalis* L.) was dried, extracted by ethanol (80%) in the laboratory of department of food science and technology (Public Health - Benghazi University), and then extract was concentrated by rotary evaporation and freeze drying system.

Lipid oxidation measurements:

Peroxide value (PV) was determined in the lipid extract according to the method described by AOAC (2000). Results are expressed as milliequivalents oxygen per kg lipid (meq O2/kg lipid). Thio-barbituric acid (TBA) was determined calorimetrically by the Porkony and Dieffenbacher method as described by Kirk and Sawyer (1991). Results are expressed as mg malonaldehyde/kg (mg MAL/kg) fish muscle. on base total oxidation, including primary and secondary oxidation products. Which is a combination of PV and TBA (Totox value =2PV+TBA).

Volatile amine formation:

Total volatile base-nitrogen (TVB-N) values were measured by the direct distillation method according to Goudlas and Kantians (2005). The results are expressed as mg TVB/N 100 g-1 muscle. Tri-methylamine-nitrogen (TMA-N) values were determined by means of the picrate method, as previously describe by (Aubourg *et al*., 2007). This involves the preparation of a 5% (w/v) trichloroacetic acid extract of fish muscle. The results are expressed as mg TMA/N 100 g-1 muscle.

Organoleptical evaluation:

Samples were organoleptically evaluated for colour, taste, flavour and overall acceptability. A group of 10 staff members of department of food science and technology (Public Health - Benghazi University), as judges checked the organoleptic properties of the samples and grades ranged from zero to 10 (Teeny and Miyauchi, 1972) as mentioned in Table (1).

Table 1. Description of organoleptic properties scores.

Score	Description	Score	Description
10	Ideal	4	Fair
9	Excellent	3	Poorly fair
8	Very good	2	Poor
7	Good	1	Very poor
6	Fairly good	0	Repulsive
5	Acceptable		

Statistical analysis:

Three replications of each trial were performed. Moisture, protein, fat, ash, total volatile bases nitrogen (TVBN), trimethylamine nitrogen (TMAN), thiobarbituric acid (TBA), peroxide value (PV), and sensory data were analyzed using ANOVA and means were separated by Duncan' test (1955) at a probability level of $P<0.05$ (SAS, 2000).

RESULTS AND DISCUSSION

Chemical composition of Raw fish fillets and treated fried Nile tilapia fillets:

Proximate composition of raw fish fillets, untreated and treated fried fillets with α-tocopherol and Rosemary extract during storage. Mean values for the proximate chemical composition of fresh raw fish fillets and storage coated fried fillets untreated and treated are given in Table 2. For raw fillets; the moisture, crude protein, fat, ash and carbohydrates contents were 77.33, 84.47, 8.00, 5.99 and 1.54%, respectively. Meanwhile, the corresponding values in fried fillets treated with Rosemary extract 0.3% and α-tocopherol 0.1% were 61.50- 62.92, 82.31-83.57, 9.44-9.15, 5.34-5.71and 2.91- 1.57% (on dry weight basis), respectively. From these results, it could be observed that due to frying of Nile tilapia fillets, the moisture content was significantly reduced ($P<0.05$), while fat was significantly increased ($P<0.05$). Frying increased fat content, possibly as a result of both moisture content losses and absorption of some frying sun flower oil inside the tissues. It is clear from the present results that parameters chemical composition in frying of Nile tilapia fillets were not

affected by inclusion of the plant essential oils as there were no significant different ($p<0.05$) between their means and those of control. These results are nearly accordance with obtained by Elagba *et al.* (2010).

It could be observed that chilling and frozen storage of fried Nile tilapia fillets resulted in significant changes ($p>0.05$) of gross chemical composition compared with the fried Nile tilapia fillets at zero time. In general, by storage at chilling at 4±1°C and freezing at –18±2°C, the moisture, protein and ash were slowly reduced. It might be assumed that with drip separated during thawing of freezing samples, some losses of moisture, protein and ash were occurred, as reported by Wen-Hsin and Lillard (1998); Puwastien *et al.* (1999); Santerre *et al.* (2000), Musaiger (2008); Erkan *et al.* (2010) and Ansorena *et al.* (2010**).**

Table 2. Proximate composition of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.) on dry weight basis.

Source	moisture	Protein *	Fat *	Ash *	Carbohydrates*	Energy (calories)
Raw fish fillets	77.33 ± 0.2 ^{a}	84.47± 0.03^{a}	8.00 ± 0.04 ^{b}	5.99 ± 0.01 ^{a}	1. 54 ± 0.02 ^{b}	416.04± 0.03^{b}
α-tocopherol	62.92±0.04^{b}	83.57±0.20a^{b}	9.15±0.04^{ab}	5.71±0. 07^{a}	1.57±1.03^{b}	422.91±0. 08^{a}
R.E.(0.1)	62.39±0.06^{b}	82.59±0.07^{b}	9.34±0.01^{a}	5.36±0.03^{a}	2.71±0.07^{a}	425.26±0.04^{a}
R.E.(0.2)	61.79±0.07^{bc}	82.42±0.09^{b}	9.39±0.03^{a}	5.32±0.01^{a}	2.87±0.05^{a}	425.67±0. 03^{a}
R.E.(0.3)	61.50±0.05^{bc}	82.31±0.06^{b}	9.44±0.05^{a}	5.34±0.06^{a}	2.91±0.08^{a}	425.84±0.05^{a}

$^{a-bc}$Means within a raw with the different superscript are significantly different ($p<0.05$).
Values are expressed as Mean ± SE.

Changes in peroxide value (PV) and **thiobarbituric acid (TBA):**

Lipid oxidation development was measured according to the PV Changes in PV values of control and treatments RE (0.1%, 0.2%, 0.3%) and α-tocopherol (0.1%) during chilling storage at 4±1°C for 15 days and frozen storage at -18°C for 3 months are shown in (Table 3). Initial PV values of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found

5.81, 5.42, 5.37, 5.29 and 5.52meq O_2/ kg and increased to 11.98, 8.94, 6. 87, 5.63 and 9.96, respectively after chilling storage period and increased to 11.81, 8.71, 7.63, 5.54 and 9.84 respectively after freezing storage period.

All samples of fried Nile tilapia fillets showed an increase in PV value in when the chilling and frozen storage increased ($P<0.05$). Control samples showed highest formation rate of peroxide value in compare with all the treatments and after that, the highest rate was found is samples contained 0.1% α-tocopherol during storage period. Samples contained 0.3% of RE showed the lowest rate of peroxide formation.

Table 3. Changes of Peroxide values (meq O_2/kg Oil) during Cold and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.) for 15 days at 4±1°C and for three month at -18±2°C.(On wet weight basis).

Treatment		Storage Period					
		Chilling storage period			Frozen Storage period		
	Fried(0)	5 Days	10 Days	15 Days	1month	2month	3month
Control	5.81±0.7[a]	8.09±0.03[a]	10.09±0.02[a]	11.98±0.02[a]	7.92±0.04[a]	9. 90±0.02[a]	11. 81±0.01[b]
α-tocopherol	5.52±0.6[a]	6.53±0.01[b]	9.58±0.03[b]	9. 96±0.04[b]	6.42±0.01[b]	8. 52±0.01[b]	9. 84±0.03[b]
R.E. (0.1)	**5.42±0.02[a]**	**5.83±0.03[c]**	7.79±0. 02[c]	8.94±0.03[c]	5.73±0.07[c]	7.32±0.07[c]	8.71±0.02[c]
R.E. (0.2)	5.37±0.04[a]	5.61±0.02[c]	6.68±0.05[d]	6.87±0.04[d]	5.44±0.05[c]	6.56±0.02[d]	7.63±0.04[d]
R.E. (0.3)	5.29±0.03[a]	5.39±0.01[c]	5.54±0.02[e]	5. 63±0.02[e]	5.31±0.06[c]	6.45±0.02[d]	5. 54±0.01[e]

[a-e]Means within a raw with the different superscript are significantly different ($p<0.05$).
Values are expressed as Mean ± SE.

As shown in (Table 4). Initial TBA values of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 0.34, 0.27, 0.23, 0.20 and 0.32meq O_2/ kg and increased to 1.31, 0.95, 0.86, 0.69 and 1.17 respectively after chilling storage period and increased to 1.2, 0.82, 0.73, 0.62 and 1.05 respectively after freezing storage period.

There were an increased TBA value in fried Nile tilapia fillets when the chilling and frozen storage period increased (P<0.05). The TBA values of RE treatments were significantly lower than the control and α-tocopherol after 5 days of chilling storage and one month of frozen storage (p<0.05). After storage more differences were found in TBA values between the control and RE treatments. The increment in TBA and PV during storage could be resulted from lipid oxidation; these results are in harmony with those obtained by Darweash (1996); Raju *et al.* (1999) and Aro *et al.* (2000).

Table 4. Changes of Thio-barbituric acid (mg mal/kg fish muscle) during Cold and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.)for 15 days at 4±1°C and for three month at -18±2°C.(On wet weight basis).

Treatment	Storage time						
	Chilling Storage time				Frozen Storage time		
	Fried(0)	5days	10days	15days	1 month	2 month	3 month
Control	0.34±0.02^{a}	0.74±0.03^{a}	1.07±0.2^{a}	1.31±0.03^{a}	0.63±0.03^{b}	0.91±0.02^{a}	1.2±0.02^{a}
α-tocopherol	0.32±0.06^{a}	0.67±0.07^{ab}	0.91±0.03a^{b}	1.17±0.02^{ab}	0.52±0.08^{a}	0. 78±0.05^{ab}	1. 05±0.05^{ab}
R.E. (0.1)	0.27±0.04^{ab}	0.53±0.03^{b}	0.79±0.0 2^{b}	0.95±0. 04^{b}	0.44±0.03^{ab}	0.67±0.06^{b}	0.82±0.06^{b}
R.E. (0.2)	0.23±0.04a^{b}	0.51±0.02^{b}	0.68±0.05^{bc}	0. 86±0.03b^{c}	0.39±0.05^{a}b	0.59±0.04^{bc}	0.73±0.05b^{c}
R.E. (0.3)	0.20±0.03^{b}	0.42±0.05^{c}	0.56±0.2^{c}	0.69±0.01^{c}	0.31±0.05b	0.47±0.07^{c}	0.62±0.02^{c}

$^{a-c}$Means within a raw with the different superscript are significantly different (p<0.05).
Values are expressed as Mean ± SE.

The peroxide value of a sample indicates the concentrations of peroxides and hydro-peroxides that are produced during the early stages of lipid oxidation. The peroxide values are monitored for a sample and when it sharply increases, it indicates the end of the shelf life for that sample. The main use of a peroxide value is to determine the quality of oil sample (Kaya *et al*., 1993). Increase of PV in control samples in contrast with all treatments showed development of off-flavor is one of the major effects of lipid oxidation (Fagan *et al*., 2003 and Sahari *et al*., 2009) and at the further stage of lipid peroxidation; changes in color and nutritional value are observed (Sahari *et al*.,

2009). In control samples PV<20 meq O2/kg were obtained at the end of the period. However, all treatments (RE 0.1%, 0.2%, 0.3% and α-tocopherol 0.1%) showed a progressive but slow increase (P<0.05) with storage period. The lowest PV was observed for fried Nile tilapia fillets treated with RE 0.3%. According to the results, it is concluded that RE treatments had significant effect on delaying lipid oxidation. Similar to our findings Serdaroglu and Felekoglu (2005) reported the anti-oxidative effect of rosemary extract for sardine *(Sardina pilchardus)*. Increase in PV values of fried and chill-reheated samples also reported by Nikoo *et al.* (2010) which indicated that lipid oxidation took place during frying and reheating process. As reported by Al-Saghir *et al.* (2004) in addition of heat treatment, the kind of cooking oil also can alter the peroxide value. Similar to our results, Nessrien Yasin and Abou-Taleb (2007) reported that PV value increased in semi fried mullet fish fillets during cold storage. At the end of storage period, lowest TBA value was recorded as 5.54 mg MAL/ kg oil for the RE 0.3% treatment. TBA values indicated that control samples had more rancid than samples treated with RE, throughout the storage period.

Treatment with containing of synthesis antioxidant (α-tocopherol), showed lower antioxidant effect in comparison with all of the concentrations of rosemary. Similar results were found for the same process by Nessrien Yassin and Abotaleb (2007) that they studied on antioxidant effect of thyme and marjoram on semi fried mullet fish fillet in 4°C storage. These results are in agreement with those reported by Ibrahim and EL-Sherif (2008).

Totally, the results showed that usage of RE and α-tocopherol had positive influence on delaying lipid oxidation and increasing shelf-life of fillets (P<0.05). TBA values indicated that control samples and samples with added α-tocopherol were more rancid than samples treated with RE throughout the storage time. Frying and chilled storage followed by reheating also increased the TBA value, indicating that the secondary products of oxidation increased during the procedure.

Although the lipid oxidation occurred during frying or subsequent storage and reheating, TBA value were lower than acceptability level for human consumption reported by Nikoo *et al.* (2010). The level of 7-8 mg MAL/kg oil is the limit of acceptability of TBA. Results showed that RE 0.3% was the most effective antioxidant. Similar results were reported by Serdaroglu and Felekoglu (2005) on Sardine mince and Nikoo *et al.* (2010) on Kutum.

Changes in total volatile bases nitrogen (TVBN):

Production of total volatile bases nitrogen (TVBN) and increment in trimethylamine nitrogen (TMAN) in fish muscles during storage could be used as indicator of bacterial activity. TVBN and TMAN are considered a valuable tool in the evaluation of fish quality during storage because it's rapid accumulation in muscles under storage conditions. Increasing mean values of TVB-N were observed with longer storage periods (Table 5). Initial (TVBN) values of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 13.77, 13.43, 13. 28, 13.1and 13.61 meq O_2/ kg and increased to 14.21, 13.56, 13.20, 13.12 and 13.98, respectively after chilling storage period and increased to 14.1, 13.44, 13.10, 12.91 and 13.88 respectively after freezing storage period.

All samples showed an increased TVB-N value in coated fried Nile tilapia fillets when the chilling and frozen storage period increased ($P<0.05$), there were Significant differences between control and all treatments during storage period ($P<0.05$) whereas significant difference was recorded between treatment groups (RE 0.1%, 0.2%, 0.3% and α-tocopherol 0.1%) during storage period ($P<0.05$), at the end of storage time the lowest TVB-N level was found in samples treated with RE 0.3%. In general, as the concentration of RE increased, the TVB-N value was decreased.

Table 5. Changes of TVB-N values (mg/100g sample) during Cold and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.) for 15 days at 4±1°C and for three month at -18±2°C.(On wet weight basis).

Treatment	Storage Period						
	Chilling Storage Period				frozen Storage Period		
	Fried (0 time)	5 Days	10 Days	15 days	1month	2month	3month
Control	13. 77±0.04^{a}	13.56±0.01^{a}	13.83±0.02^{a}	14.21±0.01^{a}	13.44±0.07^{a}	13. 71±0.02^{a}	14. 1±0.01^{a}
α. tocopherol	13.61±0.06^{a}	13.37±0.04^{a}	13.57±0.03^{a}	13.98±0.03^{ab}	13. 26±0.04^{a}	13. 42±0.01^{a}	13. 88±0.02^{ab}
R.E.(0.1)	13.43±0.04^{a}	13.07±0.03^{a}	13.25±0.05^{a}	13.56±0.04^{ab}	12.95±0.07^{ab}	13. 16±0.05^{ab}	13. 44±0.03^{b}
R.E.(0.2)	13. 28±0.03^{ab}	12.87±0.02^{ab}	13.04±0.02^{a}	13.20±0.05^{ab}	12. 76±0.05^{b}	12.93±0.02^{ab}	13.1±0.04^{b}
R.E.(0.3)	13.1±0.05a^{b}	12.74±0.05^{ab}	12.86±0.02^{ab}	13.12±0.02^{ab}	12.62±0.02^{b}	12. 78±0.04^{b}	12. 91±0.03^{bc}

$^{a-bc}$Means within a raw with the different superscript are significantly different ($p<0.05$).
Values are expressed as Mean ± SE.

The TVB-N content quantifies a wide range of basic volatile compounds (ammonia, methylamine, di-methylamine, tri-methylamine, and etc) that should be produced as a result of microbiological activity during the chilling storage or arise from the thermal breakdown of endogenous compounds during cooking (Rodrıguez *et al*., 2008). In comparison with the values reported by (Nessrien Yassin and Abotaleb, 2007), formation of TVB-N was slightly higher for all treatments from the beginning until the end of period of storage. Increase in TVB-N during storage can be due to increase of released ammonia from amination of adenosine monophosphate or histamine (Sahari *et al*., 2009).

In this study, increase in TVB-N level may be a result of ammonia releasing and other volatile amines from muscular damaged tissue. The increment in TVB-N content during storage period may be due to bacterial activity. However, the breakdown occurred in fillet proteins in rosemary extract was of low rate and might be due to antimicrobial agent of rosemary extract (Ibrahim and EL-Sherif, 2008). The level of TVB-N in freshly caught fish is generally between 5 and 20 mg N/100g muscle. However, the levels of 30-35

mg N/100g muscle are considered the limit of acceptability for ice-stored cold water fish (Zarei *et al*., 2011). In our study TVB-N value for all treatment groups did not exceed 15 mg/100g sample.

Changes in trimethylamine nitrogen (TMAN):

Amine formation in coated fried Nile tilapia fillets during storage period was also measured by the TMAN content (Table 6). Initial (TMA-N) values of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 2.35, 1.71, 1.49, 1.38 and 2.10 meq O_2/ kg and increased to 2.79, 2.07, 1.87, 1.76 and 2.50, respectively after chilling storage period and increased to 2.68, 1.96, 1,78, 1.65 and 2.39 respectively after freezing storage period.

All samples showed an increased TMA-N value in fried Nile tilapia fillets when the storage period increased ($P<0.05$). There were Significant differences between control and all treatments in storage period ($P<0.05$) whereas significant difference was recorded between treatment groups (RE 0.1%, 0.2%, 0.3% and α-tocopherol 0.1%) during storage period ($P<0.05$). At the end of storage time the lowest TMA-N level was found in samples treated with RE 0.3%.

Concerning TMA-N its content slightly increased may be due the conversion of TMAO oxide to TMA (Ibrahim and El-Sherif, 2008). TMA-N is often used as an index in assessing the shelf-life and keeping quality of sea food products because rapidly accumulates in the muscle under cold and frozen conditions. The TMA-N production in fish tissue during cold storage could be used as an indicator of bacterial activity and it is an accepted deterioration measure. The pungent odor of spoiled fish has been often related to TMA-N tissue levels, also with the number of spoiling organisms present in many fish species and the rejection limits is usually from 5 to 10 mg TMA/N 100 g-1 muscle (Zarei *et al*., 2011). Our results were far below the limit of acceptability of 10-15 mg TMA/N 100 g-1 (Selmi and Sadok, 2008) in all treatments during cold and frozen storage period. TMA formation in the actual fried samples can be explained by means of two different pathways: (1) As a result of TMAO

bacterial catalysis breakdown during the chilled storage, and (2) TMA can be produced from TMAO by thermal breakdown during the frying process (Rodriguez *et al.*, 2008). From the TMA-N results, the samples treated with 0.3% RE have higher effect on the bacterial growth in fish samples during cold and frozen storage than other treatments. The application of natural antioxidant (rosemary) in coating layer of Nile tilapia fillets stored under cold conditions resulted in a decreased microbial population compared to control samples as proved by several other studies on the essential oils of natural antioxidants (Nessrie Yasin and Abou-Taleb, 2007). Similar to our results, Ibrahim and El-Sherif (2008) reported that TMA-N levels of rosemary extract added to Tilapia fillets were significantly lower than control samples after 4 months storage at -18°C.

Table 6. Changes of TMA-N values (mg/100g sample) during chilling and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.) for 15 days at 5±1°C and for three month at -18±2°C. (On wet weight basis).

Treatment		Storage Period					
		Chilling Storage Period			Frozen Storage Period		
	Fried(0)	5 Days	10 Days	15 Days	1month	2month	3month
Control	2.35±0.03^{a}	2. 59±0.01^{a}	2.69±0.01^{a}	2.79±0.02^{a}	2.46±0.01^{a}	2.57±0.03^{a}	2.68±0.02^{a}
α-tocopherol	2.10±0.01^{a}	2.31±0.03^{a}	2.42±0.02^{a}	2.50±0.03^{a}	2.20±0.02^{a}	2.27±0.02^{a}	2.39±0.03^{a}
R.E. (0.1)	1.71±0.05^{ab}	1. 93±0.02^{ab}	1.99±0.04^{ab}	2.07±0.04^{ab}	1. 83±0.03^{a}	1.87±0.04^{ab}	1.96±0.04^{ab}
R.E. (0.2)	1.49±0.03^{ab}	1.75±0.05^{ab}	1.82±0.03^{ab}	1. 87±0.02^{a}	1.64±0.04^{ab}	1.69±0.02^{ab}	1.78±0.02^{ab}
R.E. (0.3)	1.38±0.04^{b}	1.60±0.04^{ab}	1.68±0.02a^{b}	1.76±0.05^{ab}	1.45±0.02^{ab}	1.54±0.01^{ab}	1.65±0.05^{ab}

$^{a-b}$Means within a raw with the different superscript are significantly different ($p<0.05$).
Values are expressed as Mean ± SE.

Organoleptic evaluation:

Organoleptic evaluation scores of colour, taste, flavour and overall acceptability estimated during chilling and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract for 15 days at 4±1°C and for 3 month at -18±2°C are presented in Table 7.

Initial colour scores of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 9.3,9.2,9.1,9.0, and8.9 respectively and decreased to 8.4, 8.0, 8.3, 8.5 and 8.0 respectively after chilling storage period and decreased to 8.6, 8.4,8.5,8.6 and 8.31 respectively after freezing storage period.

Table 7. Colour and taste scores during chilling and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.) for 15 days at 4±1°C and for three month at -18±2°C.

		Colour					
Treatment		**Storage period**					
		Chilling Storage period			**Frozen Storage period**		
	Fried(0)	**5 Days**	**10 Days**	**15 Days**	**1month**	**2month**	**3month**
Control	9.3±0.3^{a} (E.)	8.9±0.2^{a} (V.G.)	8.7±0.1^{a} (V.G.)	8.5±0.4^{a} (V.G.)	9.0±0.5^{a} (E.)	8.9±0.3^{a} (V.G.)	8.7±0.1^{a} (V.G.)
α-tocopherol	8.9±0.5^{a} (V.G.)	8.5±0.1^{a} (V.G.)	8.3±0.4^{a} (V.G.)	8.0±0.3^{a} (V.G.)	8.8±0.2^{a} (V.G.)	8.5±0.4^{a} (V.G.)	8.3±0.3^{a} (V.G.)
R.E.(0.1)	9.2±0.3^{a} (E.)	8.9±0.2^{a} (V.G.)	8.7±0.3^{a} (V.G.)	8.4±0.5^{a} (V.G.)	9.0±0.4^{a} (E.)	8.7±0.2^{a} (V.G.)	8.5±0.3^{a} (V.G.)
R.E.(0.2)	9.1±0.4^{a} (E.)	8.6±0.5^{a} V.G.)	8.5±0.2^{a} V.G.)	8.3±0.1^{a} V.G.)	9.0±0.5^{a} (E.)	8.4±0.3^{a} (V.G.)	8.0±0.4^{a} (V.G.)
R.E.(0.3)	9.0±0.2^{a} (E.)	8.8±0.4^{a}(V.G.)	8.6±0.1^{a}(V .G.)	8.5±0.5^{a}(V.G.)	8.9±0.2^{a}(V.G.)	8.6±0.3^{a}(V.G.)	8.5±0.4^{a}(V.G.)
		Taste					
Treatment		**Storage period**					
		Chilling Storage period			**Frozen Storage period**		
	Fried (0)	**5 Days**	**10 Days**	**15 Days**	**1month**	**2month**	**3month**
Control	9.3±0.2^{a} (E.)	8.9±0.1^{a} (V.G.)	8.7±0.3^{a} (V.G.)	8.4±0.5^{a} (V.G.)	9.0±0.4^{a} (E.)	8.8±0.2^{a} (V.G.)	8.6±0.1^{a} (V.G.)
α-tocopherol	8.8±0.1^{a} (V.G.)	8.6±0.4^{a} (V.G.)	8.4±0.2^{a} (V.G.)	8.0±0.5^{a} (G.)	8.7±0.3^{a} (V.G.)	8.4±0.1^{a} (V.G.)	8.1±0.2^{a} (V.G.)
R.E.(0.1)	9.3±0.4^{a} (E.)	8.5±0.2^{a} (V.G.)	8.3±0.3^{a} (V.G.)	8.0±0.5^{a} (V.G.)	8.7±0.2^{a} (V.G.)	8.6±0.1^{a} (V.G.)	8.4±0.3^{a} (V.G.)
R.E.(0.2)	9.2±0.2^{a} (E.)	8.7±0.5^{a} (V.G.)	8.6±0.3^{a} (V.G.)	8.3±0.2^{a} (V.G.)	8.9±0.1^{a} (V.G.)	8.7±0.3^{a} (V.G.)	8.5±0.2^{a} (V.G.)
R.E.(0.3)	9.1±0.3^{a} (E.)	8.8±0.1^{a} (V.G.)	8.7±0.2^{a} (V.G.)	8.5±0.2^{a} (V.G.)	8.9±0.4^{a} (V.G.)	8.8±0.5^{a} (V.G.)	8.6±0.2^{a} (V.G.)

E= Excellent. V.G.= Very good. G= Good. F.G.= Fairly good.

Initial taste scores of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 9.3,9.3,9.2,9.1, and8.9 respectively and decreased

to 8.5, 8.4, 8.3, 8.5 and 8.0 espectively after chilling storage period and decreased to 8.7, 8.5,8.0,8.5 and 8.3 respectively after freezing storage period.

Initial flavor scores of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 9.5,9.4,9.2,9.3, and9.1 respectively and decreased to 8.5, 8.5, 8.3, 8.5 and 8.0 espectively after chilling storage period and decreased to 8.7, 8.5,8.0,8.6 and 8.3 respectively after freezing storage period.

Initial Overall acceptability scores of control, (R.E.) 0.1%, 0.2%, 0.3% and α-tocopherol 0.1% treatments were found 9.0, 9.1, 9.0, 9.1, and 8.8 respectively and decreased to 8.4, 8.0, 8.2, 8.3 and 79.0 respectively after chilling storage period and decreased to 8.6, 8.4, 8.3, 8.5 and 8.2 respectively after freezing storage period.

Samples after frying directly showed the highest scores for colour, taste, flavour, and overall acceptability, respectively, compared with the samples of Nile tilapia fillets fried after chilling for 15 days at 4±1°C and frozen storage period for three months at –18±2°C respectively. The scores of colour, taste, flavour and overall acceptability showed a significant decreases ($P<0.05$) after storage periods.

Therefore, it could be concluded that, the gradual decrease in colour, taste, flavour and overall acceptability scores throughout the storage period at different temperatures, could be attributed to the protein denaturation, hydrolysis and fat oxidation, which are the major factors of changes in organoleptic properties during storage periods. These results are in agreement with those given by Darweash (1996); Schubring (1996) and Raju *et al.* (1999).

From the results obtained in the present study, it may be recommended that, the best consumption of fried Nile tilapia fillets is after processing directly, followed by 15 days at 4±1°C and frozen storage period for three months at–18±2°C respectively.

Table 8. Flavour and Overall acceptability scores during chilling and frozen storage of coated fried Nile tilapia fillets that were pretreated by α-tocopherol and Rosemary extract (R.E.) for 15 days at 4±1°C and for three month at -18±2°C.

Flavour							
Treatment		**Storage period**					
		Chilling Storage period			**Frozen Storage period**		
	Fried(0)	**5 Days**	**10 Days**	**15 Days**	**1month**	**2month**	**3month**
Control	9.5±0.3[a] (E.)	9.2±0.3[a] (E.)	8.9±0.3[a] (V.G.)	8.5±0.3[a] (V.G.)	9.4±0.3[a] (E.)	9.1±0.3[a] (E.)	8.8±0.3[a] (V.G.)
α-tocopherol	9.1±0.1[a] (E.)	8.7±0.1[a] (V.G.)	8.5±0.1[a] (V.G.)	8.3±0.1[a] (V.G.)	9.0±0.1[a] (E.)	8.7±0.1[a] (V.G.)	8.5±0.1[a] (V.G.)
R.E.(0.1)	9.4±0.2[a] (E.)	9.0±0.2[a] (E.)	8.9±0.2[a] (V.G.)	8.7±0.2[a] (V.G.)	9.2±0.2[a] (E.)	9.0±0.2[a] (E.)	8.9±0.2[a] (V.G.)
R.E.(0.2)	9.2±0.3[a] (E.)	8.9±0.3[a] (V.G.)	8.8±0.3[a] (V.G.)	8.6±0.3[a] (V.G.)	9.1±0.3[a] (E.)	9.0±0.3[a] (E.)	8.9±0.3[a] (V.G.)
R.E.(0.3)	9.3±0.1[a] (E.)	8.9±0.1[a] ((V.G.)	8.8±0.1[a] (V.G.)	8.5±0.1[a] (V.G.)	9.0±0.1[a] (E.)	8.9±0.1[a] (V.G.)	8.7±0.1[a] (V.G.)
Overall acceptability							
Treatment		**Storage period**					
		Chilling Storage period			**Frozen Storage period**		
	Fried(0)	**5 Days**	**10 Days**	**15 Days**	**1month**	**2month**	**3month**
Control	9.0±0.1[a] (E.)	8.9±0.1[a] (V.G.)	8.7±0.3[a] (V.G.)	8.4±0.5[a] (V.G.)	9.0±0.4[a] (E.)	8.8±0.2[a] (V.G.)	8.6±0.1[a] (V.G.)
α-tocopherol	8.8±0.2[a] (V.G.)	8.4±0.4[a] (V.G.)	8.2±0.2[a] (V.G.)	7.9±0.5[a] (G.)	8.6±0.3[a] (V.G.)	8.4±0.1[a] (V.G.)	8.2±0.2[a] (V.G.)
R.E.(0.1)	9.1±0.1[a] (E.)	8.5±0.2[a] (V.G.)	8.3±0.3[a] (V.G.)	8.0±0.5[a] (V.G.)	9.0±0.2[a] (E.)	8.6±0.1[a] (V.G.)	8.4±0.3[a] (V.G.)
R.E.(0.2)	9.0±0.3[a] (E.)	8.7±0.5[a] (V.G.)	8.4±0.3[a] (V.G.)	8.2±0.2[a] (V.G.)	8.9±0.1[a] (V.G.)	8.7±0.3[a] (V.G.)	8.3±0.2[a] (V.G.)
R.E.(0.3)	9.1±0.2[a] (E.)	8.8±0.1[a] (V.G.)	8.6±0.2[a] (V.G.)	8.3±0.2[a] (V.G.)	9.0±0.4[a] (E.)	87±0.5[a] (V.G.)	8.5±0.2[a] (V.G.)

E= Excellent. V.G.= Very good. G= Good. F.G.= Fairly good.

CONCLUSION

As a result of a chilling and frozen storage period, a marked content increase was found in the PV, TBA, TMA-N and TVB-N value. However, a preserving effect on such parameters could be observed due to the Rosemary and α-tocopherol treatment. Results of our investigation revealed that rosemary extract and α-tocopherol retarded oxidative changes in coated frozen Fried Nile tilapia fillets whereas RE 0.1%, 0.2% and α-tocopherol as not as effective as RE

0.3% on oxidative stability. The efficiency of antioxidant inhibiting lipid oxidation throughout chilling and frozen storage was in the following order: RE 0.3% > RE 0.2% > RE 0.1% > α-tocopherol > control ($P<0.05$).

REFERENCE

Akhtar, P.; J.I. Gray; A.M. Booren and D.L. Garling, 1998. Effect of dietary components and surface application of oleoresin RE in lipid stability of rainbow trout *(Oncorhynchus mykiss)* muscle during refrigerated and frozen storage. Journal of Food lipids, 5: 43–45.

Al-saghir, S.; K. Thurner; K.H.G. WangerFrisch and W. Luf, 2004. Effects of different cooking procedure on lipid quality and cholesterol oxidation of farmed salmon fish *(Salmo salar).* Journal of Agriculture Food Chemistry, 52: 5290-5296.

Ansorena, D.; A. Guembe and T. Mendizábal, 2010. Astiasarán effect of fish and oil nature on frying process and nutritional product quality. J Food Sci., 75 (2): H62-7.

AOAC., 2005. Official methods of analysis (18th ed.), Association of Official Analytical Chemists International, Maryland, USA.

Aro, T.; R. Tahvonen; T. Mattila; J. Nurmi; T. Sivonen and H. Kallio. 2000. Effects of season and processing on oil content and fatty acids of Baltic herring (*Clupea harengus membra*s). J. Agric. Food Chem., 48: 6085-6093.

Aubourg, S.; F. Perez-Alonso and J.M. Gallardo, 2004. Studies on rancidity inhibition in frozen horse mackerel *(Trachurus trachurus)* by citric acid and ascorbic acids. European Journal of Lipid Science and Technology, 106: 232-240.

Aubourg, S.; V. QuitralAngelica; M. Larraın; A. Rodrıguez; J. Gomez; L. Maier and J. Vinagre, 2007. Autolytic degradation and microbiological activity in farmed coho salmon *(Oncorhynchus kisutch)* during chilled storage. Food Chemistry, 104: 369–375.

Aubourg, S.; A. Rodriguezand; J.M. Gallardo, 2005. Rancidity development during frozen storage of mackerel *(Scomber scombrus)*: effect of catching season and commercial presentation. European Journal of Lipid Science and Technology, 107: 316- 323.

Benjakul, S.; W. Visessanguan; V. Phongkanpai and M. Tanaka, 2005. Antioxidative activity of caramelisation products and their preventive effect on lipid oxidation in fish mince. Food Chemistry, 90; 231-239.

Corbo, M. R.; A. Bevilacqua; D. Campaniello; D. Amato; B. Speranza and M. Sinigaglia, 2009. Prolonging microbial shelf-life of foods through the use of natural compounds and non-thermal approaches-a review. International Journal of Food Science and Technology, 44: 223-241.

Darweash, B.M., 1996. Chemical composition of kobebah from carp and bolti fish. Egypt. J. Food Sci., 24 (3): 345-358.

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

Elagba Mohamed, H.A.; R. Al-Maqbaly and H. Mohamed Mansour, 2010. Proximate composition, amino acid and mineral contents of five commercial Nile fishes in Sudan. African Journal of Food Science, 4(10): 650-654.

Erkan, N.; S.Y. Tosun; S. Ulusoy and G. Üretener, 2011. The use of thyme and laurel essential oil treatments to extend the shelf life of bluefish (*Pomatomuss altatrix*) during storage in ice. J. Verbr. Lebensm, 6: 39-48.

Erkan, N.; O. Ozden and A. Selçuk, 2010. Effect of frying, grilling, and steaming on amino acid composition of marine fishes. J. Med. Food, 13 (6): 1524-31.

Fagan, J.D.; R.T. Gormley and M. Huircheartaigh, 2003. Effect of freeze-chilling, in comparison with fresh, chilling and freezing, on some quality parameters of raw whiting, mackerel and salmon portion. Food Science and Technology, 36: 647-655.

Feldberg, R.; S. Chang; A. Kotik; M. Nadler; Z. Neuwirth; D. Sundstorm and N. Thompson, 1988. In vitro mechanism of inhibition of bacterial cell growth by allicin. Antimicrob Agents Ch., 32(12): 1763–1768.

Goudlas, A.E. and M.G. Kontaminas, 2005. Effect of salting and smoking-method on the keeping quality of chub mackerel *(Scomber japonicus)*: biochemical and sensory attributes. Food Chemistry, 93: 511-520.

IEbrahim, S.M. and S. A. EL-Sherif, 2008. Effect of some plant extracts on quality aspects of frozen Tilapia (*Oreochromis niloticus* L.) fillets. Global Veterinaria, 22: 62-66.

Inatani, R.; H. Nakatani; H. Fuwa and H. Seto, 1983. The stereochemistry of the OH group on C-7 rosmanol has been revealed to be a configuration as the structure 1 on the basis of a re-examination of the NOE analysis. Journal of Agriculture Bio Chemistry, 47: 521–528.

Kaya, A.; A.R. Tekin and M.D. Oner, 1993. Oxidative stability of sunflower and olive oils: comparison between a modified active oxygen method and long term storage. Lebensm Wiss Technology, 26: 464-468.

Khan, M.A.; C.C. Parrish and F. Shahidi, 2006. Effects of mechanical handling, storage on ice and ascorbic acid on lipid oxidation in cultured Newfoundland blue mussel *(Mytilus edulis)*. Journal of Food Chemistry 99: 605-614.

Kirk, R. and R. Sawyer, 1991. Pearson's composition and Analysis of Foods, 9th ed. Longman scientific and technical, 642-643.

Musaiger, A.O., 2008. The effects of different methods of cooking on proximate, mineral and heavy metal composition of fish and shrimps consumed in the Arabian Gulf. Arch Latinoam Nutr. Mar., 58 (1): 103-9.

Nakatani, N., 1994. Antioxidative and antimicrobial constituents of herbs and spices, in: Spices, Herbs and Edible Fungi (ed. G. Charalambous). Elsevier Science, New York, 251- 271.

Nessrien Yassin, M.N. and M. Abou-Taleb, 2007. Antioxidant and Antimicrobial Affects of Marjoram and Thyme in Coated Refrigerated Semi Fried Mullet Fish Fillets. World Journal Dairy and Food Science 2: 01-09.

Nikoo, M.; M. Ghomi; E. Zakipour Rahimabadi; S. Benjakul and B. Javadian, 2010. The effects of deep-frying, refrigerated storage and reheating on the fat content, oxidation and fatty acid composition of the fish Rutilus frisii kutum. Journal of Food Processing and Technology, 1: 1-4.

Pazos, M.; J.M. Gallardo; J.L. Torres and I. Medina, 2005. Activity of grape polyphenols as inhibitors of the oxidation of fish lipids and frozen fish muscle. Food Chemistry, 92: 547-557.

Puwastien, P.; K. Judprasong; E. Kettwan; K. Vamnachitt; Y. Nakngamanong and L. Phattacharjee, 1999. Proximate composition of raw and cooked Thai freshwater and marine fish. J. Food Composition and Analysis, 12 (1): 9-16.

Raju, C.V.; N.A.T. Ramachandra and T.J. Rameshha, 1999. Development of ready to fry fish cutlet from pink perch, (*Nemipterus japonicus*). Indian J. Nutrition and Dietetics, 36 (1): 23-27.

Rızner, K.; S. Celan; Z. Knez; M. Skerget; D. Bauman and R. Glaser. 2006. Antioxidant and antimicrobial activity of rosemary extract in chicken frankfurters. Food Chemistry and Toxicology, 71: 425-429.

Rodrıguez, A.; N. Carriles; J. Cruzb and S. Aubourg, 2008. Changes in the flesh of cooked farmed salmon *(Oncorhynchus kisutch)* with previous storage in slurry ice (-1.5ºC). Food Science and Technology, 41: 1726-1732.

Rostamzad, H.; B. Shabanpour; A. Shabani and H. Shahiri, 2011. Enhancement of the storage quality of frozen Persian sturgeon fillets by using of ascorbic acid. International Food Research Journal, 18: 109-116.

Sahari, M.A.; S. Nazemroaya and M. Rezaei, 2009. Fatty Acid and Biochemical Changes in Mackerel *(Scomberomorus Commerson)* and Shark

(Carcharhinus dussumieri) fillets during frozen storage. American-Eurasian Journal of Sustainable Agriculture, 3: 519-527.

Santerre, C.R.; R. Ingram; D.H. XU; G.W. Lewis and L.G. Lane, 2000. Chlordane and toxaphene residues following cooking of treated channel catfish fillets. J. Food Protection, 63 (6): 763-767.

Sarabi, M.; J. Keramat and M. Kadivar, 2017. Antioxidant effect of rosemary extract and BHT on the quality of coated fried Escolar *(Lipidocybium flavobrunium)* fish fillets during frozen storage. International Food Research Journal, 24(2): 525-533.

SAS. 2000. SAS User's Guide: Statistics, SAS Institute Inc., Cary, NC.

Schubring, R., 1996. Colour measurement on battered and breaded fish products. Informationen Für die Fiscwirtschaft, 43 (2): 84-88. C.F.: FSTA. 1997. 29 (1): 1 R 41.

Schwarz, K. and W. Ternes, 1992. Anti-oxidative constituents of *Rosmarinus officinalis* and *salvia officinalis*. I. Determination of phenolic di-terpenes with anti-oxidative activity amongst toco-chromanols using HPLC. Z. Lebensm Unters 19: 95–98.

Selami, S. and S. Sadoki, 2008. The effect of natural antioxidant (*Thymus vulgaris* (Linnaeus)) on flesh quality of tuna (*Thunnus thynnus* (Linnaeus)) during chilled storage. Pan-American Journal of Aquatic Sciences, 3: 36-45.

Serdaroglu, M. and E. Felekoglu, 2005. Effects of using rosemary extract and onion juice on oxidative stability of sardine *(Sardina pilchardus)* mince. Journal of Food Quality, 28: 109-120.

Shelef, L.; O. Naglik and D. Bogen, 1980. "Sensitivity of some common food-borne bacteria to the spices sage, rosemary and allspice", J. Food Sci., 45: 1042- 1044.

Singh, G.; P. Marimuthu; H. Murali and A. Bawa, 2005. Antioxidative and antibacterial potentials of essential oils and extracts isolated from various spices materials. J. Food Safety, 25: 130–145.

Stevenson, S.G.; M. Vaisey-Genser and N.A.M. Eskin, 1984. Quality control in the use of deep frying oils. Journal of American Oil Chemist Society, 61: 1102– 1108.

Taheri, S.; A.A. Motallebi; A. Fazlara; Y. Aftabsavar and S. Aubourg, 2012. Effect of previous ascorbic acid treatment on the fatty acid profile of cobia *(Rachycentron canadum)* fillets during frozen storage. Grasas y Aceites, 63: 70-78.

Teeny, F.M. and D. Miyauchi, 1972. Preparation and utilization of frozen block of mince block fish muscle. J. Milk Food Technology, 35 (7): 414-417.

Verma, J.K. and L.N. Srikar, 1994. Protein and lipid changes in pink perch *(Nemipterus japonicus)* mince during frozen storage. Journal of Food Science and Technology, 31: 238-240.

Vidya Sagar Reddy, G. and L.N. Sriker, 1996. Effect of preprocess ice storage on lipid change of Japanese threadfin bream *(Nemipterus japonicus)* mince during frozen storage. Asian Fisheries Science, 9: 109-114.

Wen-Hsin, W. and D.A. Lillard, 1998. Cholesterol and proximate composition of channel catfish (*Ictalurus punctatus*) fillets – changes following cooking by microwave heating, deep-fat frying and oven baking. J. Food Quality, 21 (1): 41-51.

Zakipour, R.E. and M. Divband, 2012. The effects of coating and *Zatariamulti floraboiss* essential oil on chemical attributes of silver carp fillet stored at 4°C. International Food Research Journal, 19(2); 685-690.

Zarei, M.; A.Fazlara; D. Jamaledin and M. Mojtahedi, 2011. Microbial and chemical quality of vacuum-packed frozen fillet of narrow-barred spanish mackerel *(Scomberomorus commerson)* and silver promfret *(Pampus argenteus)* market in Iran. World Journal of Fish and Marine Science, 3: 410-413.

تأثير مضادات الأكسدة لمستخلص الروزمارى والفا-توكوفيرول على جودة شرائح سمك البلطى النيلى *Oreochromis niloticus* المقليـة خـلال التخزيـن بالتبريـد والتجميـد

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الملخـص العربـى

أجريت هذه الدراسة لدراسة تأثير مستخلص روزماري، الفا-توكوفيرول على جودة شرائح سمك البلطى النيلى *Oreochromis niloticus* المقلية خلال التخزين بالتبريد والتجميد. تم معاملة شرائح البلطي النيلي بنسبة 0.1٪، 0.2٪، 0.3٪ من مستخلص نبات الروزمارى والفا-توكوفيرول0.1 ٪ ثم تم تخزينها لمدة5 ، 10، 15 يوم عند 1 ± 5 درجة مئوية، ولثلاثة أشهر عند 2 ± 18- درجة مئوية .ثم تم إجراء اختبارات مركبات الجودة الكيميائية) القواعد النيتروجينية الكلية الطيارة، والنيتروجين الأميني ثلاثي الميثيل، وحمض الثيوباربتيوريك، ورقم البيروكسيد (وكذلك الخواص الحسية لتقييم تأثير الحفظ لمستخلص الروزمارى كمضاد اكسدة طبيعى، الفا–توكوفيرول أثناء التخزين .وكانت النتائج زيادة فى قيم PV ، TBA في جميع المعاملات بسبب أكسدة الدهون .وأظهرت النتائج أن قيم (TMA-N)، (TVB-N) لشرائح الاسماك المعاملة بمستخلص الروزمارى، الفا–توكوفيرول كانت أقل بكثير من تلك الموجودة في عينات الكنترول ($P < 0.05$). وأظهرت النتائج تحسن معنوي ($p < 0.05$) في خصائص الجودة الحسية لشرائح البلطي المقلية للعينات التي تمت معالجتها مع الزيوت العطرية من روزماري و الفا–توكوفيرول بالمقارنة بالشرائح المقلية غير المعاملة.

أظهرت نتائج البحث أيضا أن مستخلصات الروزمارى أعاقت التغيرات التأكسدية في شرائح البلطي المحفوظة خلال فترة التخزين بالتبريد والتجميد ، في حين أن مستخلصات الروزمارى (0.1٪ ، 0.2٪)، والفا–توكوفيرول(0.1٪) لم تكن لها تاثير فعال مثل مستخلص روزماري (0.3٪) على تثبيط الأكسدة. وكانت افضل نتائج للتاثير المثبط للاكسدة المعاملة بمستخلص الروزمارى (0.3٪) لشرائح سمك البلطى النيلى المقلية اثناء التخزين بالتبريد والتجميد.

مستخلص الروزماري له فعالية عالية كمضاد للاكسدة والميكروبات لذا يجب استخدامه لزيادة فترة التخزين بالتبريد والتجميد لشرائح سمك البلطى النيلى المقلية.