EFFECT OF SALTING AND PICKLING CONDITIONS ON SOME PHYSIOCHEMICAL PROPERTIES AND HISTOLOGICAL STRUCTURE OF SILVER CARP (*HYPOPHTHALMICHTHYS MOLITRIX*) FILLETS

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Abstract

Pickling is one of the old methods for fish preserving so this investigation was carried out to study the changes in some physicochemical and histological structure for silver carp (*Hypophthalmichthys molitrix*) fillets which were salted and pickled after left it at room temperature (23±3 °C) for 0, 24, 48 and 72 hours directly after fishery.

The obtained results indicated significant differences ($P< 0.05$) between the salted pickled fillets in the studied treatments. However, salted and pickled loss with saturated fatty acids were increased by increasing the salting period, also the moisture content was increased during pickling period. There were decreases in salted and pickled yield of monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and unsaturated / saturated (U/S) acids ratio by increasing the salting time. From the other side, during salting and pickling period, results revealed that, pH-values, total protein and lipid content were decreased, while ash content, total volatile bases nitrogen (TVBN) and thiobarbituric acid (TBA) were increased. Histological examination revealed changes between the salted and pickled fillets in the different periods and the most prominent changes were observed at 72hrs.

The results showed that, freshness indices and histological changes of silver carp fillets left at temperature 21±3°C for 48 hours followed by salting for 5 days and pickled for 2-3 months were more acceptable than the other treatments.

Key Words: salting, pickling, physicochemical, histological structure.

INTRODUCTION

The most common ways of preserving fish in the underdeveloped countries was salting and paste (fermenting). In Africa, a number of different partially fermented products are consumed. These products are preserved by salting and drying accompanied by fermentation. The fermentation period lasts a few days with only partial breakdown of the muscle. (Martin *et al.*, 2000).

In Egypt, 'Feseekh' is the Arabic name for a salted fermented fish. Sensory analysis is essential for assessing salted fish quality before marketing but it is inadequate to compare research data from different laboratories. The fish industry needs reliable indices of salted fish ripening and quality that could supplement sensory evaluation (Herrero *et al.,* 1999).

Salting of fish can be divided into two stages. The first stage includes diffusion of salt into the fish flesh and elimination of water. The rate of salt penetration varies with thickness of muscle, temperature, freshness of fish and fat content. The second stage, longer and slower is ripening, which renders a product with tender consistency and the characteristic pleasant aroma and taste (Filsinger, 1987). The ripening of salted fish includes the biochemical processes that cause typical changes in chemical and physicochemical characteristics of the fish tissues. Theses changes are induced by enzymes which decompose proteins and fats (Voskresensky, 1965). Fat content is important in the quality of the fish. Since fats are highly unsaturated, oxidation of lipids causes changes in color, texture and flavor (Wheaton and Lawson, 1985; Triqui and Reineccius, 1995 and Cho *et al.,* 2004).

The salting and fermenting process of fish resulted in a significant increase in C16:0, while C20:4, C22:5 and C22:6 showed a great decrease. The ratio of unsaturated / saturates (U/S) acids decreased after the salting and fermenting process (El-Sebaiy and Metwalli, 1989). The vinegar pickled sardine contained relatively high amounts of fatty acids such as 20:4, 20:5 and 22:6 polyunsaturated

fatty acids, compared with other processed foods (Lee *et al.,* 1993). In the pickled fish product, oil content was decreased during the 12 months of storage from 13 to 12%. The most abundant fatty acids were oleic (18:1), palmitic (16:0), cetoleic (22:1), and gadoleic (20:1) acids. Monounsaturated acids constituted the main group with a proportion of >50% of all fatty acids. Eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3) comprised together >12% of all fatty acids. During storage, some hydrolysis of triacylglycerol (TAG) occurred, causing a slight reduction in all esterified fatty acids. (Cho *et al.,* 2004 and Aro *et al.,* 2005).

Microscopical examination for histological structure changes can be used to check the quality of products from fish meat with respect to the observation of technological procedures and technical standards (Sigurgisladottir *et al.*, 2000 and Tremlova, 2000). However, Toyohara *et al.* (1999) found that, the precipitation of substantial amounts of sarcoplasmic proteins contributed appreciably to the texture changes during the salt-vinegar curing of mackerel meat. Because salt-vinegar curing not only prolonged the storage period of fish meat but also improved palatability. Fish flesh cured by this method may be acceptable in areas where raw fish meat was not favored.

This investigation was undertaken for the utilization of silver carp fillets (*Hypophthalmichthys molitrix*) for the production of salted pickled fish (Feseekh) and to evaluate the changes in some physiochemical properties and histological structure during salting and pickling periods.

MATERIALS AND METHODS

Samples preparation and treatments

About 30 kg of fresh Silver carp (*Hypophthalmichthys molitrix*) fillets were obtained from Aquaculture Abbassa Abou-Hammad Sharkia during Marsh, 2007. The mean of individual weight of fish was 1.5 Kg. The fish fillets cut into slices

(about 10 x 3 x 2 cm) and thoroughly washed with tap water. The fish fillets were divided into four lots of 7.5 kg, each salted as follows:

The first part was dry-salted by sprinkling dry crystal salt [El-Motaheda Co., Egypt] on the surface of the fish fillets using a salt to fish fillets ratio 1:4. Salted fish fillets were stacked in plastic troughs (10 kg capacity) in layers interspersed with salt. A metal weight (1 kg weight) was put on the top to prevent the fish fillets from floating. The troughs were covered tightly with polyethylene sheets and stored at room temperature (23±3°C) until stability the separated solution. The second, third, fourth parts were left at room temperature (23±3°C) for 24, 48 and 72 hours, respectively, then were salted as described previously.

After the end of salting period (5 days), each lot was washing carefully by flowing tap water on the fillets. Fish slices of each treatment was packed in colorless jars 250 g. capacity, containing the pickling solution (2% salt, 5% sucrose, 5% vinegar [Vinegar 5%, Comty, El-Mohandseen Food Products Co.] and 2% spices [black pepper 2.0gm, ginger 1.5 g., cumin 2.85 g., fennel 1.29g., cloves 1.09 g. and coriander 1.27 g., Zaitsev *et al.* (1969)] and stored at room temperature (23±3 °C) for 3 months.

The salting and pickling time with initial and final weight of each fillet was recorded and the salted pickled yield was calculated by dividing the weight of the salted pickled fillet by the initial weight of the raw fillet. Fish slices were analyzed before and during salting and pickling periods for each treatment.

Physicochemical examination

PH-value was estimated according to the method mentioned by Aitken *et al.* (1962). Salt content was determined using the method described by Lees (1975). Homogeneous mixtures of each fillet (3-5g.) were dried at 105°C to constant weight for moisture determination, total protein was determined by kjeldahl procedure using a 6.25 conversion factor, total lipid was measured by extraction using a 2 g. portion of dried samples for each treatment, ash was determined at

550°C using a muffle furnace, the constituent of fatty acids present in the lipid extracted from each fillet was measured by gas-liquid chromatography after liberatation and esterification as described in AOAC (2000). Total volatile bases nitrogen (TVBN) was determined according to the method recommended by the AMC (1979). Thiobarbituric acid (TBA) was measured according to the method described by Tarladgis *et al.* (1960).

Sensory evaluation

Samples were organoleptically evaluated for texture and flavor of fermented fillets during storage period. A group of 10 staff members of Technology and Quality Control Department, Central Laboratory for Aquaculture Research as judges checked the organoleptic properties of the samples and grades ranged from zero to 10 (Teeny and Miyauchi, 1972) as follows (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		

Histological examination

Samples approximately 4 x 4 x 10 mm from salted silver carp fillets (at 0 and 5 days) and salted pickled fillets at 1, 2 and 3 months storage period were trimmed and fixed in 10% neutral phosphate buffered formalin. Samples embedded in paraffin wax followed by five micron thick paraffin sections prepared, stained with hemotoxylin and eosin, (H&E) (Bancroft, *et al.*, 1996) and examined under light microscope.

Statistical Analysis

Three replications of each trial were performed. Moisture, total protein, total lipid, ash, fatty acids, total volatile bases nitrogen, thiobarbituric acid, texture and flavor data were analyzed using Analysis of Variance (ANOVA) and means were separated by Duncan' test (1955) at a probability level < 0.05 (SAS, 2000).

RESULTS AND DISCUSSION

Salting, pickling loss and yield

From results presented in Table 2, the salting and pickling loss was significantly ($P<0.05$) gradually increase with increasing the period before salting (at 00, 24, 48 and 72 hours). The highest levels of salted and pickled loss were found in fillets salted after 72 hrs., which reached to 30.2 and 31.8%, respectively. On the other side, the salting and pickling yield percentages of fish fillets was gradually significant decreased with increasing the period after fillets salting. Results indicated that, fillets salted after zero hr., salting and pickling yield were 72.7 and 71.5%, respectively, while reached to 69.8 and 68.2%, respectively, for fillets salted after 72hrs.

The increasing in salting and pickling loss and decreasing in salting and pickling yield with increasing the period at room temperature before the salting for pickling fillets. These changes may be attributed to their moisture loss and diffusion salt through the fillets. These results are in agreement with those obtained by Segi (2006).

PH-value and salt content

The results presented in Table 3 showed the changes in pH-value and salt content of silver carp fillets during salting and pickling period at room temperature ($23\pm3^{\circ}C$). pH-values were gradually decreased during salting and pickling periods. pH-values in samples salted after 72hrs at room temperature were significantly ($P<0.05$) smaller than other samples and followed by samples salted after 48, 24

and zero hrs. at room temperature. Decreasing of pH-values may be due to protein denaturation and production of amino acids and free fatty acids in different amount before and during salting and pickling at room temperature.

Table 2. Average values for total weight (g), loss (%) and yield (%) of silver carp fillets after salting and pickling period at room temperature (23± 3°C).

Fillets / Hours before salting	Fresh Weight (g)	Salted			Pickled		
		Weight (g)	Loss (%)	Yield (%)	Weight (g)	Loss (%)	Yield (%)
00	2500 ± 3.0 ^{a}	1787.5 ± 4.0 ^{a}	28.5 ± 0.1 ^{bc}	71.5 ± 0.5 ^{a}	1817.5 ± 5.0 ^{a}	27.3 ± 0.3 ^{bc}	72.7 ± 0.4 ^{a}
24	2500 ± 5.0 ^{a}	1760.0 ± 3.0 ^{b}	29.6 ± 0.2 ^{b}	70.4 ± 0.3 ^{ab}	1792.5 ± 4.0 ^{b}	28.3 ± 0.5 ^{b}	71.7 ± 0.2 ^{ab}
48	2500 ± 3.0 ^{a}	1727.5 ± 4.0 ^{c}	30.9 ± 0.1 ^{ab}	69.1 ± 0.3 ^{b}	1765.0 ± 5.0 ^{c}	29.4 ± 0.5 ^{ab}	70.6 ± 0.3 ^{b}
72	2500 ± 4.0 ^{a}	1705.0 ± 2.0 ^{d}	31.8 ± 0.3 ^{a}	68.2 ± 0.4 ^{bc}	1745.0 ± 3.0 ^{d}	30.2 ± 0.5 ^{a}	69.8 ± 0.3 ^{bc}

$^{a-d}$ Means within a column with the same superscript are significantly different ($P<0.05$). Values are expressed as Mean ± SE.

The statistical analysis indicated that the salt content percentages gradually increased during salting period. While, the results showed gradual decreases in salt content during the period of pickling at room temperature. The highest significant level ($P<0.05$) of salt content showed in the pickled fillets which salted after 72hrs. for 3 months. The changes in the salt content in the products stored at ambient temperature may be due to the accelerated rate of diffusion (salt up take and moisture removal) and chemical composition of salt and pickled solution. The present data are in agreement with those reported by (Jin-Hwan *et al.*, 1986; El-Sebaiy and Metwalli, 1989 and Paludan *et al.*, 1999).

Table 3. Changes in pH-value and salt content (%) of silver carp fillets during salting and pickling period at room temperature (23±3°C).

Parameters		pH-value				Salt content (%)			
A period before salting		00 Hour	24 Hours	48 Hours	72 Hours	00 Hours	24 Hours	48 Hours	72 Hours
Salting period (Days)	0	6.65± 0.03 ^{a}	6.57 ± 0.03 ^{a}	6.47 ± 0.04 ^{ab}	6.36 ± 0.03 ^{ab}	0.96 ± 0.02 ^{b}	1.00 ± 0.01 ^{ab}	1.05 ± 0.02 ^{a}	1.09 ± 0.01 ^{a}
	5	6.53± 0.05 ^{a}	6.43 ± 0.03 ^{a}	6.31 ± 0.04 ^{ab}	6.19 ± 0.05 ^{b}	10.32± 0.03 ^{b}	10.47± 0.05 ^{b}	10.81± 0.04 ^{ab}	11.32± 0.03 ^{a}
Pickling period (Months)	1	5.45± 0.04 ^{a}	5.35 ± 0.05 ^{a}	5.23 ± 0.03 ^{ab}	5.10 ± 0.03 ^{b}	8.00 ± 0.05 ^{b}	8.09 ± 0.04 ^{b}	8.29 ± 0.03 ^{ab}	8.57 ± 0.03 ^{a}
	2	5.15± 0.03 ^{a}	5.1± 0.04 ^{a}	4.99 ± 0.03 ^{ab}	4.87± 0.05 ^{b}	6.89 ± 0.04 ^{b}	7.00 ± 0.03 ^{b}	7.18 ± 0.03 ^{ab}	7.50 ± 0.05 ^{a}
	3	4.95± 0.05 ^{a}	4.86 ± 0.04 ^{a}	4.76 ± 0.04 ^{ab}	4.65 ± 0.04 ^{b}	6.03 ± 0.05 ^{c}	6.25 ± 0.03 ^{b}	6.53 ± 0.06 ^{ab}	6.80 ± 0.04 ^{a}

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

Chemical composition

Data presented in Table 4 revealed the changes in moisture content and total protein (%) of silver carp fillets during salting and pickling period at room temperature (23±3°C). Results indicated a gradual decreases in moisture content % and total protein % during salting period, while during pickling period moisture content were gradually increased and total protein were decreased. Moisture content reached to 74.05, 72.79, 71.91 and 71.11% in pickled fillets which salted after00, 24, 48 and 72hr, respectively, at the end of 3 months of storage. Total protein percentage was recorded lowest limits 67.82% in pickled fillets which salted after 72hr. at the end of 3 months of storage.

Table 4. Changes in moisture content and total protein (%) of silver carp fillets during salting and pickling period at room temperature (23±3 °C).

Parameters		Moisture (%)				Total protein (%)			
A period before salting		00 Hour	24 Hours	48 Hours	72 Hours	00 Hours	24 Hours	48 Hours	72 Hours
Salting period (Days)	0	76.2 ± 0.3 ^{a}	74.80± 0.2 ^{a}	73.69± 0.3 ^{ab}	72.76± 0.1 ^{b}	70.5± 0.03 ^{a}	70.36± 0.04 ^{a}	70.19± 0.03 ^{a}	69.85± 0.02 ^{ab}
	5	72.85± 0.2 ^{a}	71.49± 0.4 ^{ab}	70.41± 0.5 ^{b}	69.51± 0.3 ^{bc}	69.71± 0.04 ^{a}	69.58± 0.02 ^{a}	69.29± 0.03 ^{ab}	69.00± 0.02 ^{b}
Pickling period (Months)	1	73.85± 0.5 ^{a}	72.09± 0.2 ^{a}	71.26± 0.5 ^{ab}	70.36± 0.3 ^{b}	69.22± 0.03 ^{a}	69.00± 0.05 ^{a}	68.79± 0.04 ^{a}	68.36± 0.04 ^{ab}
	2	73.85± 0.3 ^{a}	72.49± 0.3 ^{ab}	71.66± 0.5 ^{b}	70.81± 0.5 ^{bc}	68.85± 0.05 ^{a}	68.63± 0.04 ^{a}	68.39± 0.05 ^{ab}	67.90± 0.03 ^{b}
	3	74.05± 0.4 ^{a}	72.79± 0.2 ^{ab}	71.81± 0.5 ^{b}	71.11± 0.5 ^{bc}	68.65± 0.04 ^{a}	68.50± 0.03 ^{a}	68.16± 0.05 ^{ab}	67.82± 0.05 ^{b}

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

On the other side, changes in lipid and ash content of silver carp fillets during salting and pickling periods at room temperature (23±3°C) are shown in Table 5. Results indicated that, through the whole storage and pickling periods, a slight decrease in lipid contents%, started with 18.78, 18.70, 18.61 and 18.46% at zero time of storage for salted fillets after 00, 24, 48 and 72hr., respectively, then reached to 17.85, 17.72, 17.54 and 17.32%, respectively, at the end of 3 months of pickling period.

Data presented in Table 5 showed a gradual increases in ash content in all fillets during salting and pickling period at room temperature up to 3 months of storage, and there are significant differences ($P<0.05$) between the fillets salted after 72 hr. compared with the other samples fillets.

Table 5. Changes in lipid and ash contents (%) of Silver carp fillets during salting and pickling period at room temperature (23±3°C).

Parameters		Lipid (%)				Ash (%)			
A period before salting		00 Hour	24 Hours	48 Hours	72 Hours	00 Hours	24 Hours	48 Hours	72 Hours
Salting period (Days)	0	18.78± 0.03 ^{a}	18.70± 0.02 ^{a}	18.61± 0.04 ^{a}	18.46± 0.02 ^{ab}	10.12± 0.05 ^{b}	10.34± 0.05 ^{b}	10.79± 0.04 ^{ab}	11.40± 0.05 ^{a}
	5	18.46± 0.02 ^{a}	18.34± 0.03 ^{a}	18.24± 0.05 ^{ab}	18.00± 0.03 ^{b}	11.53± 0.04 ^{b}	11.90± 0.04 ^{b}	12.29± 0.04 ^{ab}	12.65± 0.04 ^{a}
Pickling period (Months)	1	18.26± 0.05 ^{a}	18.16± 0.05 ^{a}	18.04± 0.03 ^{ab}	17.90± 0.03 ^{b}	11.62± 0.05 ^{b}	11.96± 0.04 ^{b}	12.51± 0.05 ^{ab}	12.71± 0.05 ^{a}
	2	18.09± 0.04 ^{a}	17.96± 0.05 ^{a}	17.78± 0.04 ^{ab}	17.64± 0.04 ^{b}	12.06± 0.03 ^{b}	12.48± 0.05 ^{b}	13.11± 0.05 ^{ab}	13.50± 0.04 ^{a}
	3	17.85± 0.03 ^{a}	17.72± 0.03 ^{a}	17.54± 0.05 ^{ab}	17.32± 0.05 ^{b}	12.40± 0.04 ^{b}	12.81± 0.03 ^{b}	13.67± 0.03 ^{ab}	14.21± 0.05 ^{a}

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

Changes in chemical composition of silver carp fillets during salting and pickling period at room temperature are probably due to the activity of natural and microbial enzymes during storage period. These results coincide with those cited by several investigators; El-Sebaiy and Metwalli (1989) Triqui and Reineccius (1995) and Cho *et al.* (2004).

Table 6. Changes in fatty acids composition (%) of silver carp fillets after 3 months of pickling period at room temperature (23±3°C).

A period before salting	Fresh	00 Hours	24 Hours	48 Hours	72 Hours
C14:0	2.30 ± 0.02^{d}	3.00 ± 0.03^{c}	3.15 ± 0.01^{c}	4.10 ± 0.03^{b}	5.72 ± 0.01^{a}
C16:0	12.98 ± 0.1^{cd}	15.85 ± 0.1^{c}	19.38 ± 0.2^{b}	21.70 ± 0.2^{b}	29.77 ± 0.1^{a}
C18:0	3.90 ± 0.2^{c}	4.20 ± 0.2^{b}	4.31 ± 0.1^{b}	5.30 ± 0.2^{ab}	6.61 ± 0.3^{a}
C20:0	2.81 ± 0.01^{bc}	2.91 ± 0.01^{bc}	3.10 ± 0.01^{b}	3.50 ± 0.02^{ab}	4.83 ± 0.02^{a}
C22:0	1.58 ± 0.02^{c}	1.62 ± 0.03^{c}	1.75 ± 0.02^{c}	2.15 ± 0.03^{b}	3.56 ± 0.01^{a}
C23:0	1.31 ± 0.01^{b}	1.35 ± 0.02^{b}	1.51 ± 0.01^{b}	1.93 ± 0.01^{ab}	2.80 ± 0.02^{a}
C24:0	0.82 ± 0.02^{c}	0.87 ± 0.01^{c}	0.90 ± 0.01^{b}	0.92 ± 0.01^{b}	1.71 ± 0.01^{a}
Σ SFA*	25.7 ± 0.03^{cd}	29.8 ± 0.06^{c}	34.1 ± 0.05^{bc}	39.6 ± 0.07^{b}	55.0 ± 0.07^{a}
C16:1	4.97 ± 0.2^{a}	4.91 ± 0.1^{a}	4.80 ± 0.1^{a}	4.12 ± 0.2^{a}	2.76 ± 0.1^{b}
C18:1	34.3 ± 0.7^{a}	33.9 ± 0.5^{ab}	33.4 ± 0.6^{ab}	32.57 ± 0.5^{b}	28.94 ± 0.7^{c}
C20:1	0.95 ± 0.02^{a}	0.90 ± 0.01^{a}	0.70 ± 0.02^{b}	0.51 ± 0.02^{c}	-----
C22:1	0.38 ± 0.01^{a}	-----	-----	-----	-----
Σ MUFA**	40.5 ± 0.23^{a}	39.8 ± 0.2^{a}	38.9 ± 0.24^{ab}	37.2 ± 0.24b	31.7 ± 0.4^{c}
C18:2	30.05 ± 0.6^{a}	26.6 ± 0.7^{b}	23.19 ± 0.6^{bc}	19.35 ± 0.8^{c}	9.43 ± 0.7^{d}
C18:3	3.75 ± 0.03^{a}	3.80 ± 0.02^{a}	3.81 ± 0.32^{b}	3.85 ± 0.01^{a}	3.87 ± 0.03^{a}
Σ PUFA***	33.8 ± 0.32^{a}	30.4 ± 0.36^{ab}	27.0 ± 0.32^{b}	23.2 ± 0.32^{b}	13.3 ± 0.37^{c}
U/S Ratio	2.89 ± 0.02^{a}	2.36 ± 0.03^{a}	1.93 ± 0.2^{ab}	1.53 ± 1.53^{b}	0.82 ± 0.03^{c}

$^{a-b}$ Means within a raw with the same superscript are significantly different (P<0.05).

Values are expressed as Mean ± SE.

*SFA, S.: Saturated fatty acids. **MUFA : Mono unsaturated fatty acids.

***PUFA : Poly unsaturated fatty acids. U.: Unsaturated fatty acids.

Fatty acids

Data in Table 6 showed the changes in fatty acids composition of silver carp fillets after 3 months of pickling period at room temperature (23±3°C). Fillets salted after 00, 24, 28 and 72 hr. had a gradual increases in saturated fatty acids as the time after salting increase. While, it had a gradual decreases in the fatty acids (Monounsaturated fatty acids- MUFA, polyunsaturated fatty acids- PUFA and unsaturated/saturated ratio- U/S). as the time after salting increased compared with the fresh fillets.

On the other side, the predominant fatty acids were C16:0, C18:1 and C18:2 in the fillets (fresh and treated fillets). The changes in fatty acids composition after 3 months in all treatments compared with the fresh fillets, were greatly affected by the lipid content of fillets with the autolysis occurred during pickling period. These results agree with those achieved by Cho *et al.* (2004) and Aro *et al.* (2005).

Quality and freshness indices evaluation

Changes in total volatile bases nitrogen (TVBN) and thiobarbituric acid (TBA) of silver carp fillets during salting and pickling periods at room temperature (23±3°C) are presented in Table 7. Results indicated gradual increases in TVBN and TBA in all samples up to the end of salting and pickling periods.

The highest levels in TVBN and TBA contents were observed in fillets salted after 72 hours. From the other hand, there were significant differences ($P< 0.05$) between fillets salted after 72 hours compared with the other samples. However, the increase in TVBN and TBA during salting and pickling periods at room temperature (23±3°C) may be due to the activity of natural and microbial enzymes with pigments occurred in salted pickled fish fillets which can act as peroxidant. These results are in accordance with those previously reported Voskresensky (1965); Herrero *et al.* (1999) and Morzel *et al.* (2000).

Table 7. Changes in total volatile basis nitrogen (TVBN) and thiobarbituric acid (TBA) in silver carp fillets during salting and pickling periods at room temperature (23 ± 3°C).

Parameters		TVBN (mg/100g)				TBA (mg malonaldhyed/ kg)			
A period before salting		00 Hour	24 Hours	48 Hours	72 Hours	00 Hours	24 Hours	48 Hours	72 Hours
Salting period (Day)	0	11.00± 0.1 ^{ab}	11.22± 0.2 ^{ab}	11.51 ± 0.1 ^{a}	11.93 ± 0.3 ^{a}	0.21 ± 0.01 ^{ab}	0.23 ± 0.02 ^{ab}	0.26 ± 0.01 ^{a}	0.30 ± 0.01 ^{a}
	5	12.09 0.2 ^{ab}	12.33± 0.2 ^{ab}	12.64± 0.1 ^{a}	13.10± 0.1 ^{a}	0.30 ± 0.02 ^{b}	0.32 ± 0.01 ^{ab}	0.36 ± 0.02 ^{a}	0.41 ± 0.02 ^{a}
Pickling period (Months)	1	14.18 ± 0.1 ^{b}	14.46± 0.1 ^{ab}	14.82± 0.3 ^{ab}	15.35 ± 0.2 ^{a}	0.45 ± 0.01 ^{b}	0.48 ± 0.01 ^{b}	0.54 ± 0.01 ^{ab}	0.61 ± 0.01 ^{a}
	2	16.87± 0.2 ^{b}	17.20± 0.1 ^{ab}	17.62± 0.1 ^{ab}	18.25± 0.2 ^{a}	0.62 ± 0.02 ^{c}	0.67 ± 0.01 ^{bc}	0.74 ± 0.02 ^{b}	0.83 ± 0.01 ^{a}
	3	19.76± 0.2 ^{b}	20.10 0.1 ^{ab}	20.59± 0.3 ^{ab}	21.30± 0.3 ^{a}	0.85 ± 0.01 ^{d}	0.91 ± 0.01 ^{c}	1.02 ± 0.02 ^{b}	1.13 ± 0.02 ^{a}

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

Sensory evaluation

Data given in Table 8 represents the effect of salting and pickling periods at room temperature (23±3°C) on texture and flavor of fermented salted fillets of silver carp fish.

Obviously, the obtained scores of texture and flavor showed gradual increases during pickling period. Fermented salted fillets prepared after 48 hours at room temperature (23±3°C) showed the highest grade, they were 7.5 (Good), 8.9 (Very good), 9.4 (Excellent) and 9.4 (Excellent) for the texture, while they were 7.3 (Good), 8.4 (Very good), 9.2 (Excellent) and 9.4 (Excellent) during pickling period 0, 1, 2 and 3 months, respectively, compared with the other treatments. However, the fermented salted fillets prepared directly after zero hour

from filleted preparation showed the lowest scores, which were 6.6 (Fairly good), 6.7 (Fairly good), 7.2 (Good) and 7.3 (Good) for the texture, while they were 6.7 (Fairly good), 6.7 (Fairly good), 7.0 (Good) and 7.0 (Good) for flavor during 0, 1, 2 and 3 months of pickling period, respectively.

Table 8. Changes in texture and flavor in silver carp fillets during pickling periods at room temperature (23±3 °C).

Parameters		Texture				Flavor			
A period before salting		00 Hour	24 Hours	48 Hours	72 Hours	00 Hours	24 Hours	48 Hours	72 Hours
Pickling period (Months)	0	6.6± 0.2 ^{ab} (fg)	7.0± 0.2 ^{ab} (g)	7.5± 0.1 ^{a} (g)	7.0± 0.1 ^{ab} (g)	6.7± 0.2 ^{ab} (fg)	7.1± 0.1 ^{a} (g)	7.3± 0.3 ^{a} (g)	6.8± 0.1 ^{ab} (fg)
	1	6.7± 0.4 ^{b} (fg)	7.5± 0.2 ^{ab} (g)	8.9± 0.3 ^{a} (vg)	7.4± 0.1 ^{b} (g)	6.7± 0.1 ^{b} (fg)	7.8± 0.3 ^{a} (g)	8.4± 0.2 ^{a} (vg)	7.0± 0.2 ^{ab} (g)
	2	7.2± 0.1 ^{b} (g)	8.8± 0.3 ^{ab} (vg)	9.4± 0.4 ^{a} (e)	7.5± 0.3 ^{b} (g)	7.0± 0.3 ^{b} (g)	8.5± 0.2 ^{ab} (vg)	9.2± 0.1 ^{a} (e)	7.5± 0.2 ^{b} (g)
	3	7.3± 0.2 ^{b} (g)	8.9± 0.1 ^{ab} (vg)	9.4± 0.1 ^{a} (e)	7.7± 0.2 ^{b} (g)	7.0± 0.2 ^{b} (g)	8.8± 0.1 ^{ab} (vg)	9.4± 0.3 ^{a} (e)	7.5± 0.1 ^{b} (g)

$^{a-b}$ Means within a row with the different superscript are significantly different ($P<0.05$).
Values are expressed as Mean ± SE.
fg = Fairly good g = Good vg = Very good e = Excellent.

Generally, there were significant differences in texture and flavor of the examined fermented salted fillets. These results may be attributed to the protein denaturation, hydrolysis and fat oxidation which the major factors are influencing the changes in organoleptic properties during pickled period. These results are nearly similar to those reported by other investigators; Wheaton and Lawson (1985), Filsinger (1987), Triqui and Reineccius (1995), Herrero *et al.* (1999), and Toyohara *et al.* (1999).

Histological examination

Variation in histological structure due to salting and pickling from each of the five groups of silver carp fillets, fillet samples stored for 0 and 5 day than 1, 2 and 3 months salting and pickling which left at room temperature (23±3°C) for 0, 24, 48 and 72 hours directly after the fishery before salted and pickled.

Microscopical examination of the cross-sections of silver carp fillets salting for 0 days storage period after 00, 24, 48, 72 hours from the fishery are shown in (Fig.1): At 00hr. the muscle bundles showed normal bound with cross striation and typical hexagonal arrangement of myofibrils (Fig.1a). Moreover, the connective tissues (endomysium, perimysium and epimysium) were closely joined with the neighboring muscle fibers with intact nucleus. After 24 hrs., salting fillets sarcomeres exhibited focal autolysis of myofibrils with typical normal hexagonal arrangement of muscle bundles (Fig.,1b). Muscle samples after 48hrs. of salting period showed focal granulation and homogenous amorphous eosinophelic myofibrils (Fig.1c). While, muscle samples after 72hrs revealed gradual diffused autolysis and granulation of muscle bundles with connective tissues (Fig.1d). This picture could be due to the freshness of muscles which observed at 00hr. The histological alterations were seen in samples at 24, 28 and 72 hrs. accompanied by autolysis of protein, lipid, carbohydrates with changes in water molecules as well as salt content due to the activity of natural and microbial enzymes during storage period. Ofstad *et al.* (1995).

Microscopically, the cross-sections of silver carp fillets salted for 5 days after 00, 24, 48, 72 hours from the fishery: showed, mild shrinkage of muscle bundles after 00 hr. the fillets salted (Fig.2a). While fillets salted after 24 hrs revealed, mild increase in sarcoplasmic space (Fig.2b). After 48 hrs the muscles showed, mild shrinkage and amorphous eosinophelic with an irregular myofibrils filaments (Fig.2c). Mild increased in extracellular spaces between muscle bundles, loss the hexagonal arrangement and moderate shrinkage with granulation of myofibrils were observed after 72 hours (Fig.2d). This finding may be due decrease in

moisture content of fillets as well as increase in the salt and ash during first 5 days of preparing period compared to the silver carp fillets at 0 days. A similar relation has been reported by Srikar *et al* (1993) and Sigurgisladottir *et al.* (2000).

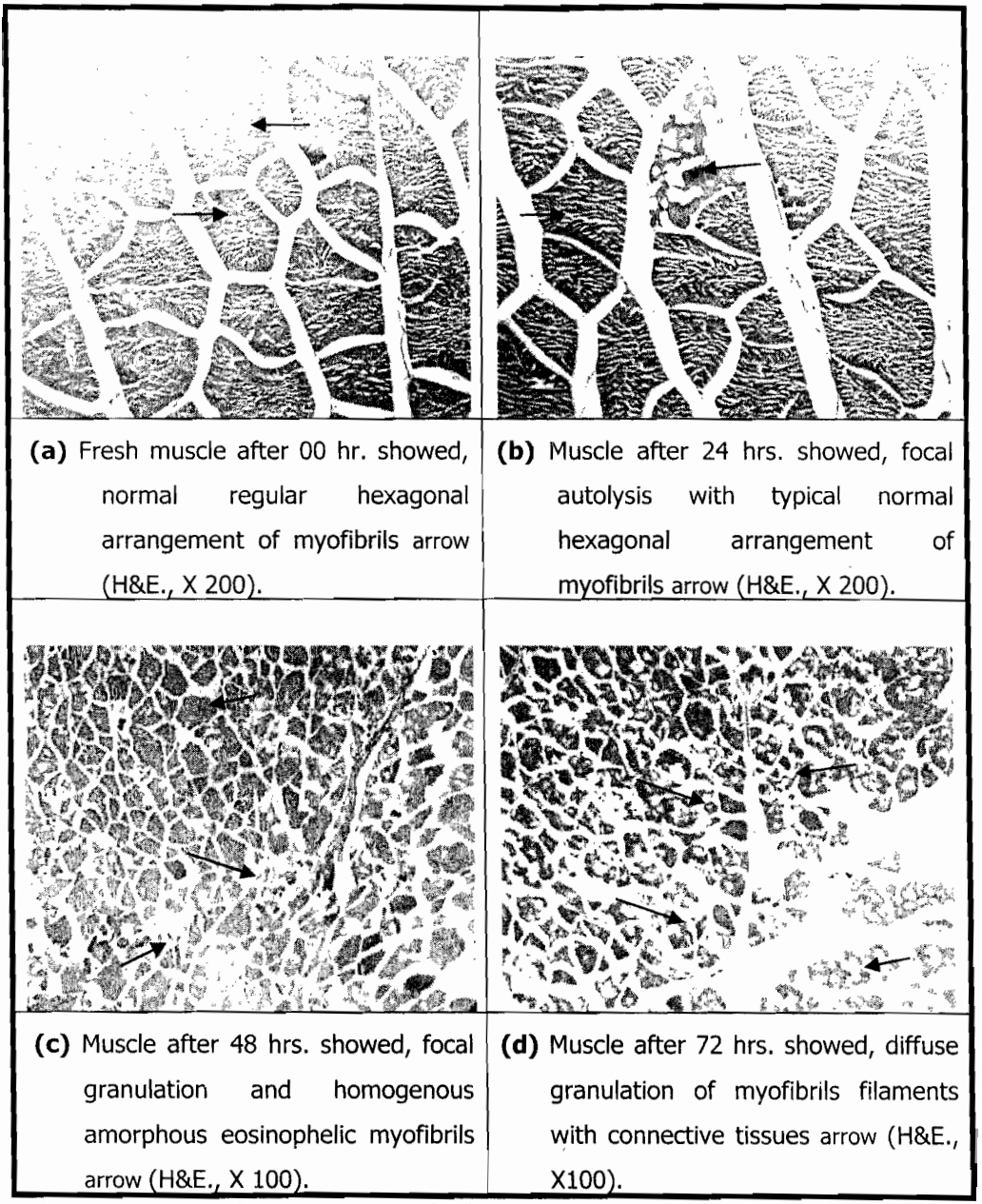
The cross-sections of silver carp fillets salted and pickled for 1 and 2 months after 00, 24, 48, 72 hours from the fishery showed, the same picture but in 2 months the histological changes were severe (Fig.3). Samples prepared after 00 day revealed, slight swelling of muscle bundles (Fig.3a). From other hand in all treatments, extracellular spaces among muscle bundles became wider due to continues loss of water from the cells by migration to the extracellular spaces. Also, the absorption of the pickling solution by fish fillets (Fig.3b). Vacuolation, hyalineization of the muscles fibers with an irregular border and the residues of the connective tissues appeared as homogenous amorphous eosinophelic material among muscles fibers (Fig.3c). Fillets salted and pickled after 72 hrs. revealed, moderate granulation with amorphous eosinophelic myofibrils bundles (Fig.3d). This picture showed due to the effects of salting and pickling solution on muscles during storage period.

All treatments after 3 months of preparing period (Fig.4) exhibited, swelling and hyalineization of the muscles fibers with amorphous eosinophelic material as well as severe increase in the extracellular spaces among muscle bundles (Fig.4a and b). Muscle after 48 hrs. showed round surface of muscles bundles, residues of connective tissues and increase sarcoplasmic space among myofibrils (Fig.4c). This picture may be due to a small amount of water retention in the muscles and breakdown of amino and fatty acids. In addition to the difference in molecular/ionic mobility of water and salt. Sometimes, whole muscles fibers were granulated leaving continuous layers of granulated substances after 72hrs. salting and pickling for 3 months (Fig.4d).

These findings could be attributed to proteolytic enzymes which hydrolyzed the tropomyosin bridges which held the myosin and actin filaments as well as

collagen and elastin. These results coincide with those given by Tremlova (2000) and Aaraas *et al.* (2004).

From the results obtained in this study, it could be concluded that the best conditions for salting of silver carp fish fillets was after 48 hrs. and pickled for 2-3 months at room temperature. So, a silver carp fillet was feasible to produce salted pickled fish.



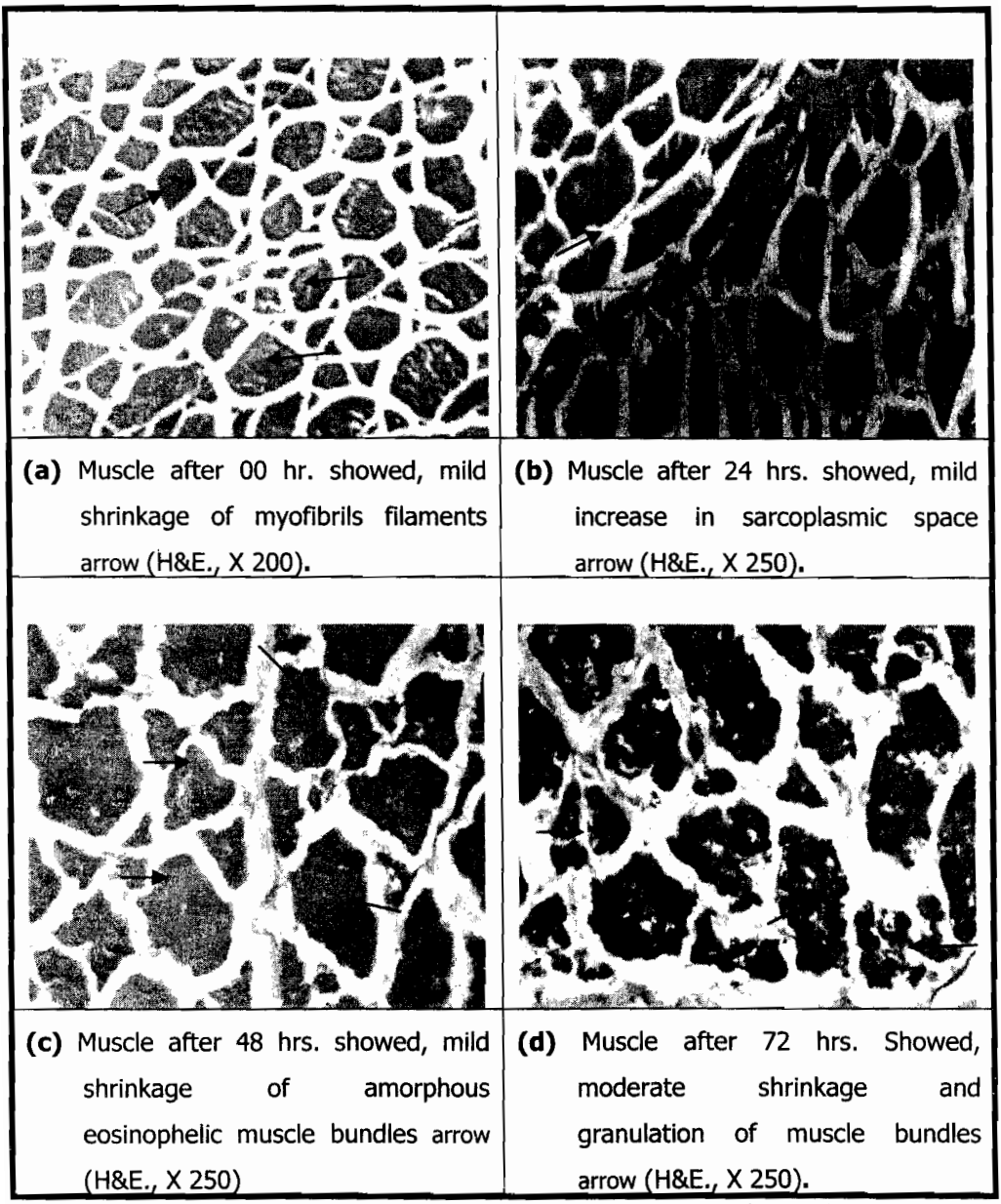
(a) Fresh muscle after 00 hr. showed, normal regular hexagonal arrangement of myofibrils arrow (H&E., X 200).

(b) Muscle after 24 hrs. showed, focal autolysis with typical normal hexagonal arrangement of myofibrils arrow (H&E., X 200).

(c) Muscle after 48 hrs. showed, focal granulation and homogenous amorphous eosinophelic myofibrils arrow (H&E., X 100).

(d) Muscle after 72 hrs. showed, diffuse granulation of myofibrils filaments with connective tissues arrow (H&E., X100).

Fig. 1. Images of cross-section of silver carp fillets salted for 0 day at room temperature (23± 3°C).



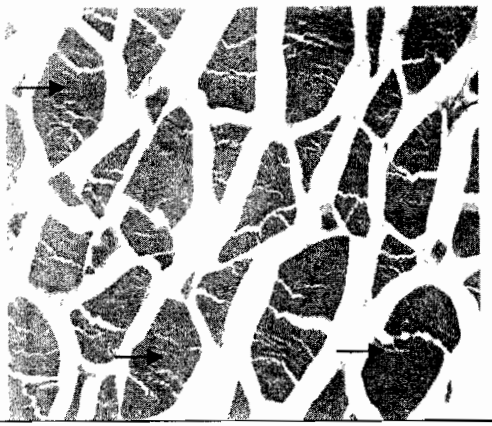
(a) Muscle after 00 hr. showed, mild shrinkage of myofibrils filaments arrow (H&E., X 200).

(b) Muscle after 24 hrs. showed, mild increase in sarcoplasmic space arrow (H&E., X 250).

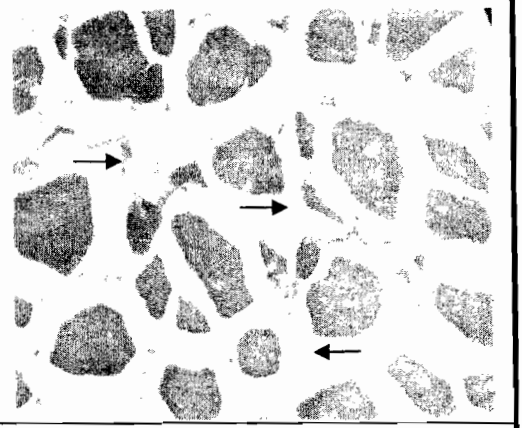
(c) Muscle after 48 hrs. showed, mild shrinkage of amorphous eosinophelic muscle bundles arrow (H&E., X 250)

(d) Muscle after 72 hrs. Showed, moderate shrinkage and granulation of muscle bundles arrow (H&E., X 250).

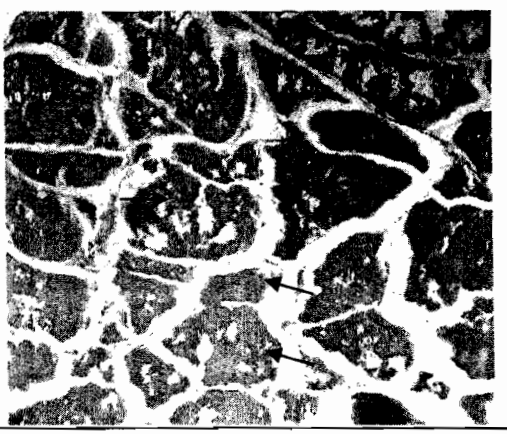
Fig. 2. Images of cross-section of silver carp fillets salted for 5 days at room temperature (23+ 3°C).



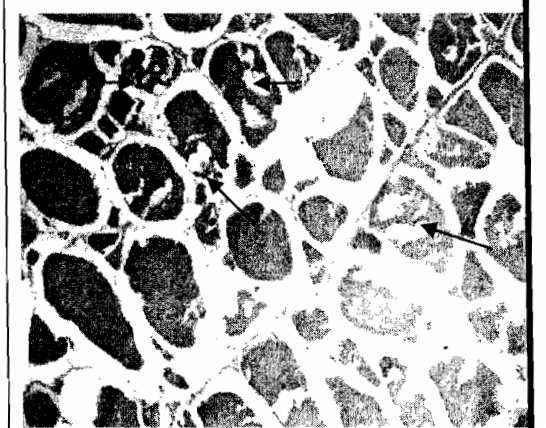
(a) Muscle after 00 hr. showed, slight swelling of muscle bundles arrow (H&E., X 200).



(b) Muscle after 24 hrs. showed, increase extracellular spaces among muscle bundles arrow (H&E., X200).

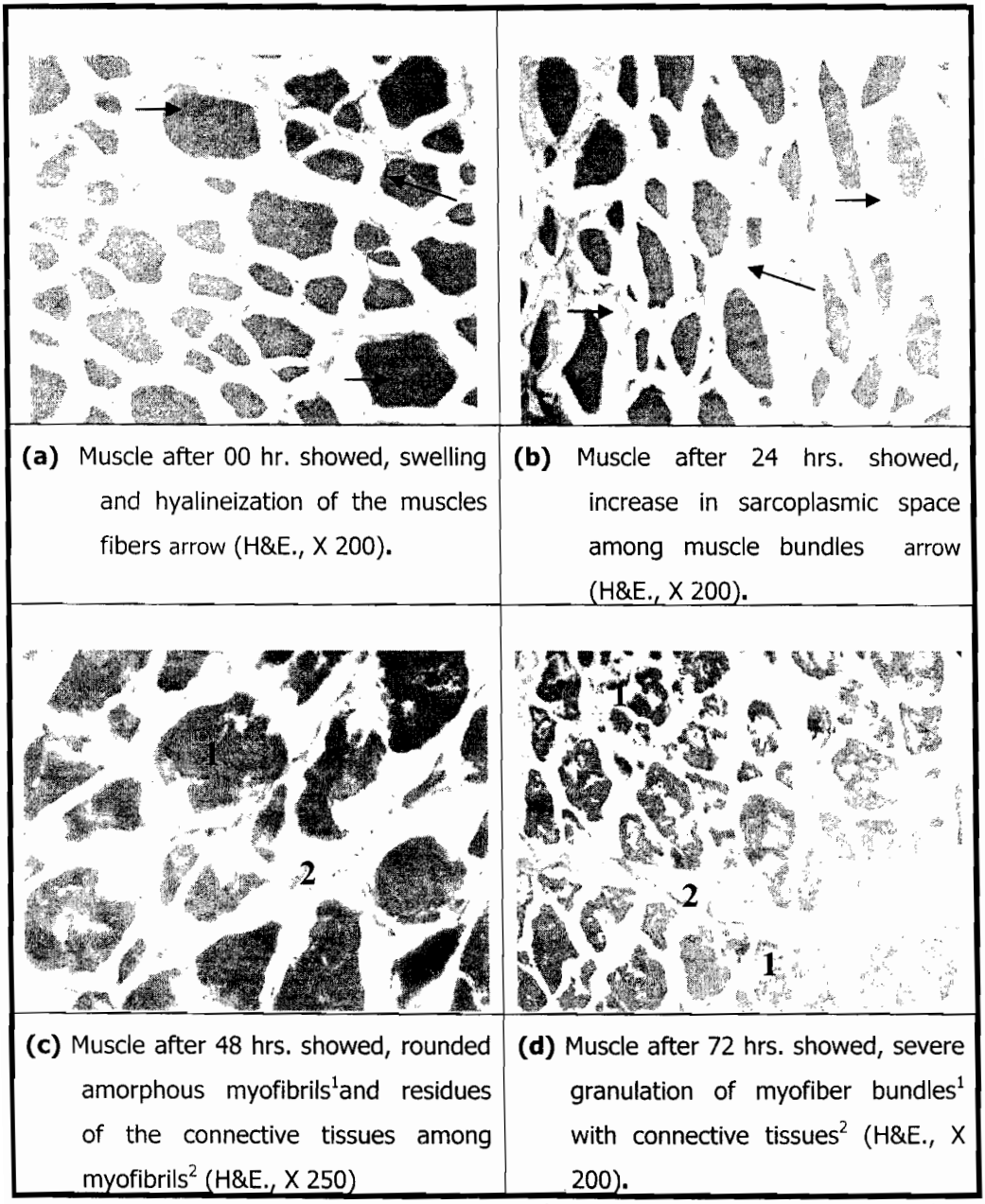


(c) Muscle after 48 hrs. showed, vacuolation with an irregular borders of muscle bundles arrow (H&E., X 250).



(d) Muscle after 72 hrs. showed, moderate granulation of muscle bundles arrow (H&E., X 250).

Fig. 3. Images of cross-section of silver carp fillets salted and pickled for 2 months at room temperature (23± 3°C).



(a) Muscle after 00 hr. showed, swelling and hyalineization of the muscles fibers arrow (H&E., X 200).

(b) Muscle after 24 hrs. showed, increase in sarcoplasmic space among muscle bundles arrow (H&E., X 200).

(c) Muscle after 48 hrs. showed, rounded amorphous myofibrils[1]and residues of the connective tissues among myofibrils[2] (H&E., X 250)

(d) Muscle after 72 hrs. showed, severe granulation of myofiber bundles[1] with connective tissues[2] (H&E., X 200).

Fig. 4. Images of cross-section of silver carp fillets salted and pickled for 3 months at room temperature (23± 3°C).

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تأثير ظروف التمليح والتخليل على بعض الخواص الفيزيوكيميائية والتركيب النسيجى لشرائح سمك المبروك الفضي

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المعمل المركزى لبحوث الثروة السمكية ، مركز البحوث الزراعية ، وزارة الزراعة ، مصر.

التخليل هو إحدى الطرقِ القديمةِ لتصنيع وحفظ الأسماك ولقد تمت هذه الدراسةِ فى المعمل المركزى لبحوث الثروة السمكية – مركز البحوث الزراعةِ. حيث تمت دراسة التغيرات فى الخواص الطبيعية والكيميائية والهستولوجية لشرائح سمك المبروك الفضى المملحة المخللة بعد تركها على درجة حرارة الغرفة (٢٣±٣ °م) لمدد صفر، ٢٤، ٤٨، ٧٢ ساعة من إعداد الشرائح بعد الصيد مباشرة.

أشارت النتائج إلى وجود اختلافات معنوية بين الشرائحِ المملّحةِ المخلّلةِ بالطرقِ المختلفةِ. حيث ارتفعت قيم كل من الفقد بالتمليح والتخليل والأحماض الدهنية المشبعة كلما زادت الفترة قبل التمليح وكذلك لوحظ انخفاض مستوى الرطوبة خلال فترة التمليح بينما حدث ارتفاع تدريجى لها خلال فترة التخليل. لوحظ انخفاض فى محصلة التمليح والتخليل وكذلك فى المحتوى من الأحماض الدهنية احادية عدم التشبع، عديدة عدم التشبع والنسبة بين الأحماض الدهنية المشبعة والغير مشبعه كلما زادت الفترة قبل التمليح. ومن ناحية أخرى، أوضحت النتائج انخفاض مستوى رقم الحموضة والبروتين الكلى والدهون، بينما لوحظ ارتفاع مستوى القواعد النيتروجينية الكلية الطيارة وحمض الثيوباربتيوريك وذلك خلال فترات التمليح والتخليل. كما أظهرت النتائج تغيرات واضحة فى التركيب النسيجى خلال عمليات التمليح والتخليل وكانت أكثر وضوحا بعد٧٢ ساعة.

حيث أظهرت نتائج هذه الدراسة أنّ شرائح سمك المبروك الفضى المملحة لمدة خمسة أيام بعد ترك الشرائح لمدة ٤٨ ساعة من إعداد الشرائح بعد الصيد على درجة حرارة الغرفة والمخللة لمدة ٢-٣ شهور كانت الأكثر قبولا مقارنة بالمعاملات الأخرى.