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Changes in Chemical Composition of Tiger Fish and Pebbly Fish from Lake Nasser after Salting and Drying

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Abstract

The aims of this Study on two species of fish from Lake Nasser as Tiger fish (*Hydrocynus froskahlii*) and Pebbly fish (*Alestes dentex*) as affected by salting by 30% salt or drying by oven dry at 70-80 °C for 18-30 and storage at room temperature for two months. Salting or drying samples were analyzed each 10 days, for two months. The approximate chemical composition, protein fractions, and fatty, amino acids composition reactive substances of Thiobarbituric acid (TBA) were studied. The result showed that the moisture contents of all fish samples was decreased as affected by salting or drying and also, it gradually decreased as affected by increasing period of storage. Moreover, as affected by drying and storage the contents of crude protein, crude lipids, ash, pH, (TBA), and sarcoplasmic contents were significantly increased ($p \leq 0.05$) during storage, while after salting the contents of crude protein, crude lipids and myofibrillar were decreased for both fish samples. However, amino and fatty acids composition was gradually increased in both samples as affected by drying, salting and storage for 2 months. Generally, the drying fish samples have high nutrition value but it has the lowest quality as affected by increasing period of storage. So, it is recommended to use drying fish in nutrition recipes. On the other hand, salting process of fish caused comparatively lower changes than drying process.

Keywords: Tiger fish; Pebbly fish; Salting; Drying; Protein Fractions.

Introduction

Lake Nasser is considered one of the most important and largest Egyptian fisheries, both in terms of the total large catch and the great diversity of fish of economic importance **[1].** Fish proteins are characterized by containing essential amino acids in the quantities necessary to meet the body's needs, and they are also easy to digest. Fish were a rich source of vitamins, especially K, E, D, and A. Vitamin D and A was found in the liver of fish. Fish meat and bones were also found to contain minerals **[2].** However, the chemical composition of fish changes from one fish to another depending on age, sex, environment, season and species **[3]**. Fish is considered one of the foods most susceptible to spoilage due to its high moisture content. It also contains high levels of free amino acids and polyunsaturated fatty acids **[4].**

Tiger fish (*Hydrocynus forskahiii*) is from the family Characidae and is an open-water piscivore widely distributed in larger rivers and lakes of western and southern Africa. Within this region, Hydrocynus is often one of the most common of the larger fish species inhabiting larger rivers **[5].** Pebbly fish (*Alestes dentex*) is a species of freshwater fish belonging to one of the endemic families of Characoidei in Africa, the family Alestidae, primarily found in the River Nile [**6].**

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The Salting is one of the oldest and most common methods of preserving fish worldwide due to the simplicity of the process and the low cost of production **[7].** Drying process is one of the oldest methods used to preserve fish. Drying removes water from the fish, which reduces the moisture content to an extent that makes it difficult for microorganisms to cause damage and inhibits the action of enzymes in causing random chemical changes **[8].**

Salting and drying these fish do not result in a high-quality final product. Freshness of fish is the most important and basic criterion to judge the quality of final products. Loss of freshness and quality depends on many factors including: fish species, handling conditions and storage temperature [9]. increased salt content in fish muscles during salting causes conformational changes in proteins (protein denaturation) [10]. Protein denaturation is followed by changes in protein function, protein solubility, protein digestibility, texture, and nutritional quality [11]. Drying reduces the water content in fish, which leads to concentration of proteins. Drying process affects the final properties of products, as it also causes breaking of some protein bonds, which affects the texture [12]. However, due to the potential loss of non – moisture bounds compounds (e.g. volatile fatty acids and vitamins) lower temperatures with extended drying time are often recommended [13].

It is very important to apply proper fish preservation treatments to maintain the functional properties of the protein [14]. The proteins in fish muscle tissue can be divided based on their solubility into the following three groups: Myofibrillar proteins (salt-soluble), Sarcoplasmic proteins (water-soluble) and Tissue proteins (insoluble) [15]. The fatty acid content in fish muscles has been shown to affect fish quality through interaction with other components [16]. The fatty acids that are found in high levels in fish fats are palmitic, stearic, and oleic acids. It was also found that the percentage of saturated fatty acids (SFA) is between 31% and 65%, while between 16 and 33 percent were monounsaturated fatty acids (MUFA). [17]. Essential amino acids are nutrients that the human body cannot manufacture, so they must be obtained through the diet. Fish were a good source of important acids such as threonine, methionine, lysine, tryptophan and cysteine [18]. values of moisture, protein, lipids and pH of both 15% and 20% salted mullet were significantly decreased during storage periods at room temperature, while ash, TBA and total volatile basic nitrogen TVBN were significantly increased [19]. Therefore, this study was carried out to investigate the effects of salting, drying and storage periods on chemical and physical changes in quality of two fish species namely Tigerfish (*Hydrocynus froskahlii)* Pebbly fish (*Alestes dentex*).

Materials and methods

Materials

Fish samples, Tiger fish (*Hydrocynus froskahlii*) and Pebbly fish (*Alestes dentex)* were coughed from Nasser Lake, Aswan, Egypt, during September (2023). About 20 Kg of each sample were used in this study.

Methods:

Preparation of Samples:

Washing the samples by running water, the entrails were removed, the abdominal cavity was washed well byrunning water and fish samples were divided into two groups.

1- The first group (dry salting) was salted by 30%, and then they were placed in a perforated plastic container to get rid of the water resulting from salting.

2- The second group (drying): The fish were dried in the electric oven at a temperature of 70:80 °C for a period of 18:30 hours.

The two groups were then stored for 60 days at room temperature.

Chemical analysis

Chemical analysis (moisture, crude lipid and ash) were determined according to **[20].** Moisture content was determined by heating samples at 105ºC for 3 hours in a hot air oven. Crude lipid was determined using Soxhlet apparatus (petroleum ether) for 16 hours. Ash was determined in samples by using Muffle furnace at 550ºC for 3 h.

Determination of total protein:

The total protein content of final protein isolates was estimated by the biuret According to [21] [22]. Sample (5g) was homogenized with 50 ml of 0.5 M NaOH; the homogeneous mixture was heated in a water bath at 85 °C for 60 min and cooled in an ice water bath. After cooling, the mixture was centrifuged for 15 min at 6000 rpm. After centrifugation, 2 ml of the filtrate was taken and mixed with 8 ml of Biuret reagent and the absorbance was measured at 540 nm. Bovine serum albumin (Sigma–Aldrich, StLouis, MO, USA) was used as a standard.

Determination of Minerals composition:

The Minerals Mg, Ca, Na and K were measured by a flame atomic absorption spectrophotometer, using a Perkin-Elmer AA spectrophotometer model 3100 (Norwalk, CT, USA) with an air acetylene flame, flow spoiler and corrosion-resistant nebulizer, using a mono elemental hollow cathode lamp for each element. Na and K determinations were performed by flame atomic emission spectrophotometry by [23]. Phosphors (P) analysis was carried out by visible-ultraviolet spectrophotometry, using the ammonium vanadate-molybdate colorimetric method indicated and reading the sample absorbance in a Hitachi-2000 (Tokyo, Japan) double beam molecular spectrophotometer [24].

Determination of Protein Fraction:

Determination of sarcoplasmic protein:

Samples (3.0 g) were homogenized with (30 ml) phosphate buffer (pH 7 - 7.4) for 2 min the homogenate by homogenizer was centrifuged at 6000 rpm for 30 min at 4°C for (Tiger fish) while Pebbly fish at (6000 rpm for 60 min at 4°C), the sarcoplasmic protein concentration was determined by the biuret assay method according to [25].

Determination of myofibrillar protein:

Following, the pellet recovered was resuspended in (30 ml of 10 % NaCl solution for Tiger fish, while Pebbly fish was resuspended in (30 ml of 16 % volumes of NaCl solution). The supernatant was collected, and the myofibrillar protein concentration was determined by the biuret assay method according to [26].

Determination of denatured protein:

The denatured protein was extracted by 30 ml 0.1 N NaOH solution centrifuged at 6000 rpm for 25 min at 4°C. After centrifugation, the supernatant was determined by the biuret assay method according to [27].

Determination of connective tissue (Stroma protein):

Connective tissues were calculated by difference as the following equation:

Connective tissues = Total protein - (myofibrillar protein+ sarcoplasmic protein+ denatured protein) [27].

Determination of Amino acids composition:

The amino acids composition was determined after hydrolysis of the fillet samples, about 0.2 g of the sample was mixed with 5 mL H_2O and 5 mL of HCL (Note: final concn. of HCl is 6 M) and then heated at 120°C for 24 hrs and then filtered. Finally, 1 mL of the filtrate was dried and resuspended in 0.1 M HCL and injected into HPLC apparatus at Agriculture Research Center, Cairo, Egypt) [28].

Determination of fatty acids composition:

The fatty acids composition was determined by GC-MS according to [29]. The methyl esters of fatty acids separated using HP 6890 GC (at The Agriculture Research Center, Cairo, Egypt.). Peak identifications were established by comparing the retention times obtained with standard methyl ester. The areas under the chromatographic peak were measured with electronic integrator.

Quality Properties:

Determination Contain Physio-chemical (pH values):

pH values were determined by using a digital pH meter (JENWAY,3510) according to [30]. The samples were analyzed for titratable acidity according to [31].

Determination of Thiobarbituric acid:

The Thiobarbituric acid (TBA) was determined according to [32]. Fish sample (5g) was homogenized with 12.5 ml of 10 % trichloroacetic acid (TCA) and 12.5 ml of distilled water for 1 min. The suspension was then filtered and 4 ml of the filtrate was added to 1 ml of TBA reagent (0.06 M). The mixture was immersed and heated in boiling water bath at 100°C for 10 min to develop a pink color then cooled with a running water for 10 min. The absorbance of the solution was read at 532 nm by using spectrophotometer (model: T60UV, PG instrument, U. K). The constant 7.8 was used to calculate the TBA number. The TBA value was expressed as mg malonaldehyde / kg sample.

Statistical Analysis:

The statistical analysis was carried out using IBM SPSS Statistics 16, PC statistical software. LSD Multiple Range Test was applied to assess significant differences between means at 5% levels of probability [33].

Results and discussions

Change in chemical analysis of fish samples:

Data illustrated in Table (1) showed the moisture content of Tiger fish and Pebbly fish. The moisture of drying or salting is decreased as compared to fresh samples. Also, there were significant differences between samples at level ($P \geq 0.05$) as affected by salting or drying process. Also, moisture content is gradually decreased as increasing period of storage. Salted samples exhibited the lowest moisture content at the end of the storage period in tow species (43.41%) and (41.63%) for Tiger and Pebbly fish, respectively. These results are in agreement with those of [19, 34, 35 and 36]. Also, groups that were drying (7.27%) (4.5%), this decrease during salting was due to the difference in osmosis, the decrease during drying is due to the evaporation of moisture as a result of using hot air. Results are in agreement with those of [37, 38 and 39].

Data in Table (1) showed that higher lipid values than fresh samples in salting for two species then decreases during the storage period (5.72% - 12.95%), this due to its migration lipid from viscera to tissue during preparation and storage and breaking lipoprotein during salting and liberalization lipids to tissue muscles. These results are in agreement with [34 ,35 and 36] and disagreement with [19]. While in drying, the percentage increased after treatment from fresh, and then continued to increase during storage (19.61% -31.54 %), due to the increase in total soluble solids in the drying treatment. These results are in agreement with [37, 38 and 39].

Also, in Table (1) was noticed that the total protein in muscles of two species at the end of the storage period, it was decreased during salting (37.70% - 35.79% respectively). Because in salting protein denaturation occurs due to the strong influence of salt, these results are in agreement with [19, 34, 35 and 36]. While the total protein in Tiger fish and Pebbly fish increased during drying treatment (81.24% - 94.18% respectively). The reason for this is the decrease in moisture content and thus the increase in total soluble solids, these results are in agreement with [37, 38 and 39].

Ash content in two fish samples was increased after salting process at zero time and gradually increased until the end of the storage period it was (44.27% - 35.23%) as shown in Table (1), due to salt absorption during salting. These results are in agreement with those of [35 and 36]. So, during drying, the ash increases from the fresh then a slight increase occurs during the storage period (7.80% - 6.60%). This is due to the increase in total soluble solids in the drying treatment. These results are in agreement with those of [37, 38 and 39].

Changes in minerals content of fish samples after salting and drying:

In Table (2) showed that mineral content of Tiger fish and Pebbly fish calculated as (mg/kg). Calcium content of fresh fish samples was (925-700 mg/kg), its content was decreased after salting process it became at the end of the storage period in Tiger fish and Pebbly fish (275-575 mg/kg) respectively. While the calcium content was increased after drying process and became (1625-925 mg/kg). The potassium content of fresh fish was (3700 - 3525mg/kg). The potassium content in salting decreased as it became at the end of the storage period in both species (3500-1500 mg/kg). These results are in agreement with [40]. Also, Potassium content increased during drying treatment and became (5000-9250 mg/kg). Sodium content of fresh fish samples was (525 - 725mg/kg).

Table (1): Change in Chemical Composition (%) (on dry weight basis) of Tiger fish and Pebbly fish Samples after salting and drying

Species		Moisture				Lipids				Protein				Ash			
		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish	
Treatments		Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying
Storage period / Days	Fresh	77.13±0.23^{a}		73.78±0.13^{a}		3.09±0.12^{gf}		12.80±0.06^{fg}		71.59 ± 0.23^{ag}		78.77 ± 0.32^{ag}		5.91±0.39^{f}		5.18±0.02^{hd}	
	0	51.36±0.31^{b}	12.58±0.28^{b}	49.52±0.04^{b}	9.33±0.58^{b}	10.20±0.66^{a}	15.68±0.30^{e}	16.55±0.15^{a}	25.45±0.30^{f}	43.75±0.26^{b}	78.49±0.06^{f}	47.90±0.32^{b}	90.07±0.10^{f}	40.47±0.22^{e}	6.66±0.12^{e}	26.51±0.20^{g}	6.22±0.07^{c}
	10	48.65±0.17^{c}	11.45±0.29^{c}	47.11±0.25^{c}	9.00±0.00^{b}	9.21±0.17^{b}	16.56±0.18^{d}	15.77±0.17^{b}	26.38±0.23^{e}	40.51±0.44^{c}	78.76±0.08^{e}	46.40±0.32^{c}	90.35±0.11^{f}	40.91±0.16^{e}	7.14±0.02^{d}	29.05±0.04^{f}	6.25±0.13^{c}
	20	46.41±0.30^{d}	11.35±0.07^{c}	45.97±0.06^{d}	6.7±0.21^{c}	8.68±0.29^{c}	16.70±0.14^{d}	14.81±0.16^{c}	26.44±0.03^{e}	39.75±0.04^{d}	79.16±0.06^{d}	43.82±0.08^{d}	91.56±0.47^{e}	41.58±0.18^{d}	7.39±0.22^{dc}	31.70±0.07^{e}	6.37±0.08^{bc}
	30	45.56±0.30^{e}	10.09±0.27^{d}	44.55±0.36^{e}	5.37±0.24^{d}	8.53±0.19^{c}	16.78±0.55^{d}	14.10±0.69^{d}	27.43±0.11^{d}	38.98±0.11^{e}	79.85±0.09^{c}	41.23±0.06^{e}	92.13±0.04^{d}	42.92±0.21^{c}	7.46±0.04^{bc}	32.95±0.34^{d}	6.45±0.04^{ab}
	40	45.24±0.09^{e}	9.88±0.05^{d}	43.12±0.44^{f}	4.87±0.06^{e}	8.71±0.16^{d}	18.55±0.65^{c}	13.68±0.60^{de}	28.99±0.10^{c}	38.76±0.49^{ef}	80.28±0.15^{b}	39.62±0.11^{f}	92.64±0.03^{c}	43.55±0.60^{b}	7.59±0.20^{ac}	33.66±0.12^{c}	6.47±0.05^{ab}
	50	44.68±0.17^{f}	7.64±0.15^{e}	42.87±0.16^{f}	4.65±0.29^{e}	6.81±0.11^{e}	18.99±0.09^{b}	13.35±0.87^{e}	29.70±0.32^{b}	38.40±0.27^{f}	80.33±0.17^{b}	37.21±0.35^{g}	93.47±0.11^{b}	43.97±0.17^{ab}	7.71±0.09^{ab}	34.78±0.15^{b}	6.51±0.06^{ab}
	60	43.41±0.10^{g}	7.27±0.06^{f}	41.63±0.08^{g}	4.50±0.19^{e}	5.72±0.10^{f}	19.61±0.21^{a}	12.95±0.18^{fe}	31.54±0.24^{a}	37.70±0.05^{g}	81.24±0.06^{a}	35.79±0.10^{h}	94.18±0.06^{a}	44.27±0.30^{a}	7.80±0.08^{a}	35.23±0.29^{a}	6.60±0.27^{a}

Means with different letters (a, b, c, d, e, f, g, h) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

Table (2) : Change in Minerals (mg/kg fishmeat) of Tiger fish and Pebbly fish after salting and drying

Storage period	Fresh		after salting and drying				after 60 Days			
Species	Tiger fish	Pebbly fish	Tiger fish		Pebbly fish		Tiger fish		Pebbly fish	
Fatty acids/ treatments			Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying
Ca	925 ^{b}	700 $^{b\,c}$	1225 ^{a}	262.5 ^{c}	1125 ^{a}	900 ^{b}	275 ^{c}	1625 a	575 c	925 ^{a}
K	3700 ^{b}	3525 $^{b\,c}$	7825 ^{a}	3525 ^{b}	4125 ^{a}	6125 ^{b}	3500 ^{c}	5000 ^{a}	1500 ^{c}	9250 ^{a}
Na	525 ^{c}	725 c	57500 ^{a}	725 ^{b}	37000 ^{a}	900 ^{b}	38125 ^{b}	1325 ^{a}	21250 ^{b}	2625 ^{a}
Mg	300 ^{c}	325 ^{c}	1325 ^{b}	375 ^{b}	875 ^{b}	500 ^{b}	1375 ^{a}	525 ^{a}	1150 ^{a}	725 ^{a}
P	2050 ^{bc}	2025 $^{b\,c}$	3400 ^{a}	2850 ^{b}	2300 ^{a}	3650 ^{b}	1300 ^{c}	4650 ^{a}	900 ^{c}	5475 ^{a}

Means with different letters (a, b, c) in the same row different significantly at p≤0.05, while those with similar letters are not significant by different.

Sodium content in salting process increased as it became at the end of the storage period for both species (38125-21250 mg/kg). Salting treatment increased sodium content which significantly at ($P \leq 0.05$). Sodium content increased due to added sodium chloride in processing. Also, it increased during drying process until the end of storage period was (1325- 2625 mg/kg). Magnesium content of fresh fish samples was (300-325 mg/kg). Also, Magnesium content in salting increased as it became at the end of the storage period for both species (1375-1150 mg/g). Also, it increased during drying until it became (525- 725 mg/kg). Phosphorus content of fresh fish samples was (2050-2025 mg/kg). Phosphorus content in salting decreased as it became at the end of the storage period for both species (1300 - 900 mg/kg). While its content was increased after drying was (4650 - 5475 mg/kg). These results are in agreement with [38, 39 and 41].

Change in protein fractions of fish samples:

In Table (3) showed that sarcoplasmic protein (S.P), of Tiger fish and Pebbly fish in fresh was (25.54 %), (28.87 %), respectively on dry weight basis. it was decreased after salting and then increased gradually by increasing period of storage it was were (14.85%) (15.89%) Tiger fish and Pebbly fish respectively on dry weight basis. at the end of storage, on the other hand as drying treatment, it was increased during storage until the end of period (31.12%) (36.66%) on dry weight basis.

Also, myofibrillar protein (M.P) content of Tiger fish and Pebbly fish as result treatment by salting or drying it was decreased and continued to decrease until the end of the storage period, but in salting it decreased at a greater rate from (35.74) (37.85) to (3.09% – 2.74 %) (14.24%- 17.11%) respectively. These results are in agreement with [42].

In Table (3) found that denatured protein of Pebbly fish was higher than that of Tiger fish at fresh, it was (9.89%), (8.20 %) on dry weight basis also, after 60 days of storage the denatured protein was gradually increased during storage period in two species of fish, Tiger fish (19.54-34.76%), Pebbly fish (20.75- 38.42%). Also, the connective tissue protein at fresh Tiger fish and Pebbly fish, it was (2.11%) and (2.16 %), respectively. Moreover, it was decreased as result of treatments for both species and gradually decrease until the end of the storage period, Tiger fish it was (0.22 -1.12%), Pebbly fish (0.12- 1.28%).

In Table (3) the obtained data revealed the connective tissue protein of fresh Tiger fish and Pebbly fish were (2.11%) and (2.16 %), respectively, and it gradually decreased as affected by treatments for both species until the end of the storage period, Tiger fish (0.22 -1.12%), Pebbly fish (0.12- 1.28%).

Change in amino acids composition of fish samples after salting and drying

Amino acids (AA) composition of Tiger fish and Pebbly fish calculated in (mg/g) are shown in Table (4). Nonessential and essential amino acids, determined to be (91.58 -65.59) mg/g, respectively in fresh Tiger fish and (106.15-75.21) mg/g, respectively in the fresh Pebbly fish. Glutamic, Aspartic, Arginine acids were considered a major nonessential amino acid in the two species of fish in Tiger fish and Pebbly fish recording (30.31-34.04), (18.41- 20.71), (9.59 - 11.51) mg/g, respectively. While Leucine, Lysine, Threonine were considered a major essential amino acid in Tiger fish and Pebbly fish which ranged (14.09 -16.12), (15.13 -16.00), (8.96- 10.16) mg/g.

Table (3): Change in Protein Fractions (%) (on dry weight basis) of Tiger fish and Pebbly fish Samples after salting and drying

		Sarcoplasmic				Myofibrillar				Denaturated				Connective tissue			
Species		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish	
Treatments		Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying
Storage period / Days	Fresh	25.54 ± 0.64 $^{a\ f}$		28.87 ± 0.45 $^{a\,h}$		35.74 ± 0.53 ^{a}		37.85 ± 0.34 ^{a}		8.20 ± 0.40 $^{e\,h}$		9.89 ± 0.78 $^{d\,g}$		2.11 ± 0.32 ^{a}		2.16 ± 0.41 ^{a}	
	0	14.34 ± 0.52 ^{d}	29.35 ± 0.85 ^{e}	15.17 ± 0.38 ^{c}	35.58 ± 0.62 ^{g}	9.94 ± 0.73 ^{b}	15.46 ± 0.20 ^{b}	11.80 ± 0.38 ^{b}	17.81 ± 0.44 ^{b}	19.00 ± 0.20 ^{d}	32.15 ± 0.18 ^{g}	20.40 ± 0.23 ^{c}	35.01 ± 0.13 ^{f}	0.47 ± 0.10 ^{b}	1.53 ± 0.27 ^{b}	0.53 ± 0.21 ^{b}	1.67 ± 0.30 ^{b}
	10	14.59 ± 0.37 ^{f}	29.72 ± 0.34 ^{d}	15.76 ± 0.26 ^{b}	35.87 ± 0.19 ^{f}	6.17 ± 0.29 ^{c}	15.12 ± 0.43 ^{c}	9.58 ± 0.14 ^{c}	17.60 ± 0.13 ^{c}	19.35 ± 0.60 ^{c}	32.47 ± 0.20 ^{f}	20.62 ± 0.20 ^{b}	35.29 ± 0.34 ^{f}	0.40 ± 0.25 ^{c}	1.45 ± 0.13 ^{c}	0.44 ± 0.16 ^{c}	1.59 ± 0.20 ^{c}
	20	14.75 ± 0.40 ^{bc}	29.98 ± 0.46 ^{c}	15.85 ± 0.18 ^{b}	36.04 ± 0.19 ^{e}	5.25 ± 0.27 ^{d}	15.01 ± 0.66 ^{c}	6.88 ± 0.24 ^{d}	17.45 ± 0.06 ^{d}	19.41 ± 0.69 ^{bc}	32.79 ± 0.89 ^{e}	20.69 ± 0.22 ^{a}	36.55 ± 0.42 ^{e}	0.34 ± 0.14 ^{d}	1.38 ± 0.16 ^{d}	0.40 ± 0.20 ^{cd}	1.52 ± 0.15 ^{d}
	30	14.81 ± 0.26 ^{b}	30.10 ± 0.22 ^{c}	15.86 ± 0.79 ^{b}	36.25 ± 0.17 ^{d}	4.28 ± 0.73 ^{e}	14.85 ± 0.32 ^{d}	4.30 ± 0.38 ^{e}	17.38 ± 0.40 ^{de}	19.48 ± 0.66 ^{ab}	33.60 ± 0.44 ^{d}	20.71 ± 0.25 ^{a}	37.01 ± 0.32 ^{d}	0.31 ± 0.16 ^{de}	1.33 ± 0.22 ^{e}	0.38 ± 0.15 ^{d}	1.49 ± 0.27 ^{d}
	40	14.82 ± 0.27 ^{b}	30.37 ± 0.13 ^{b}	15.87 ± 0.48 ^{b}	36.38 ± 0.26 ^{c}	4.13 ± 0.28 ^{f}	14.48 ± 0.14 ^{e}	2.77 ± 0.74 ^{f}	17.31 ± 0.19 ^{ef}	19.51 ± 0.36 ^{a}	34.17 ± 0.33 ^{c}	20.72 ± 0.57 ^{a}	37.54 ± 0.31 ^{c}	0.30 ± 0.22 ^{ef}	1.26 ± 0.30 ^{f}	0.22 ± 0.12 ^{e}	1.41 ± 0.13 ^{e}
	50	14.83 ± 0.52 ^{b}	30.51 ± 0.11 ^{b}	15.88 ± 0.82 ^{b}	36.54 ± 0.55 ^{b}	3.78 ± 0.18 ^{g}	14.31 ± 0.15 ^{f}	2.76 ± 0.47 ^{f}	17.23 ± 0.08 ^{f}	19.52 ± 0.55 ^{a}	34.32 ±0.32 ^{b}	20.73 ± 0.49 ^{a}	38.35 ± 0.15 ^{b}	0.27 ± 0.02 ^{f}	1.19 ± 0.14 ^{g}	0.15 ± 0.10 ^{f}	1.35 ± 0.2 ^{f}
	60	14.85 ± 0.86 ^{b}	31.12 ± 0.37 ^{a}	15.89 ± 0.24 ^{b}	36.66 ± 0.30 ^{a}	3.09 ± 0.39 ^{h}	14.24 ± 0.09 ^{f}	2.74 ± 0.41 ^{f}	17.11 ± 0.27 ^{g}	19.54 ± 0.89 ^{a}	34.76 ± 0.16 ^{a}	20.75 ± 0.54 ^{a}	38.42 ± 0.55 ^{a}	0.22 ± 0.12 ^{g}	1.12 ± 0.11 ^{h}	0.12 ± 0.09 ^{f}	1.28 ± 0.16 ^{g}

Means with different letters (a, b, c, d, e, f, g, h) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

Table (4): Change in amino acids (mg/g fish meat) of Tiger fish and Pebbly fish after salting and drying

Storage period	Fresh		Control				60 Days			
Species	Tiger fish	Pebbly fish	Tiger fish		Pebbly fish		Tiger fish		Pebbly fish	
Amino acids/ treatments			Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying
Aspartic	18.41	20.71	31.60	74.61	27.87	62.81	19.43	80.16	28.87	63.68
Glutamic	30.31	34.04	55.88	131.09	48.85	103.79	35.83	141.40	49.36	105.81
Serine	7.24	8.27	11.91	30.01	10.87	25.25	7.07	31.55	11.14	25.00
Proline	4.77	5.52	8.61	22.61	7.10	29.18	6.57	29.05	10.28	24.18
Glycine	8.18	10.67	14.53	42.20	13.03	33.05	14.04	43.29	12.46	33.30
Arginine	9.59	11.51	15.48	45.12	13.85	35.60	9.37	45.63	15.24	36.10
Alanine	8.12	9.27	16.19	38.03	14.34	28.59	12.12	37.74	13.85	29.89
Tyrosine	4.94	6.16	11.53	24.35	9.74	20.01	7.60	24.83	8.87	19.24
Cystine	ND	ND	2.31	3.33	2.67	1.89	1.14	2.67	1.75	2.36
Nonessential Amino Acids	91.58	106.15	168.03	411.34	148.33	340.16	113.17	436.32	151.81	339.57
Histidine	3.81	5.15	7.76	18.39	6.27	15.83	4.54	18.11	6.15	15.59
Threonine	8.96	10.16	15.31	36.85	14.61	29.09	9.70	38.41	13.59	30.32
Phenylalanine	7.40	8.44	13.54	29.93	12.02	24.06	9.04	30.98	10.98	24.14
Isoleucine	6.71	8.13	12.60	32.05	10.05	22.85	8.28	32.05	12.02	25.50
Leucine	14.09	16.12	26.39	61.69	22.17	48.66	16.59	63.58	22.72	49.00
Lysine	15.13	16.00	21.38	42.41	17.45	24.65	14.97	42.21	19.83	33.31
Valine	6.98	8.45	13.14	31.13	11.23	22.04	9.19	31.95	11.19	25.59
Methionine	2.50	2.77	7.92	20.34	5.02	14.97	3.66	23.79	6.85	17.86
Essential Amino Acids	65.59	75.21	118.04	272.79	98.83	202.15	75.97	281.08	103.35	221.32
Total	157.17	181.36	286.08	684.13	247.15	542.31	189.14	717.40	255.15	560.88

ND: Not detected

These results are in agreement with [41]. After (60) days, at end of storage, Tiger fish nonessential amino acids in drying treatment was higher than salting treatment (436.32- 113.17 mg/g), respectively. Also, Pebbly fish after (60) days of storage was higher content of nonessential amino acids in drying treatment than salting treatment as (339.57 – 151.81 mg/g), respectively. Also, essential amino acids in drying treatment were higher than salting treatment in both species (281.08-221.32) (75.97-103.35) mg/g, respectively. In salted fish there was increase in total amino acids compared to fresh. These results are in agreement with [42].

Change in fatty acids profiles of fish samples after salting and drying:

Fatty acids profiles (%) of fresh, after treatments and after the end of storage samples are shown in Table (5). Twenty-three fatty acids were identified in the samples. Total fatty acids, determined to be 99.97 % in fresh Tiger fish and 100 % in the fresh Pebbly fish these results also are in agreement with [43]. The content of saturated fatty acids (SFA) was lower than the unsaturated fatty acids (UFA) in fresh Tiger fish (43.14 – 56.83 %) and Pebbly fish (34.34 -65.66 %) these results also are in agreement with [44]. After 60 days at the end of storage period total fatty acids of fish samples were slightly increased, similar to the increase in control samples and the increase in salting treatment higher than drying treatment for both fishes (100-99.99 %) (100-99.99 %) and unsaturated fatty acids higher than saturated fatty acids in two species fishes all treatment respectively at salting (62.77-64.98 %) and drying (58.85-73.73 %). These results are in agreement with [45]. Palmitic acid (C16:0) was the most abundant saturated fatty acids are abundant in both species, constituting (23.19 - 19.34 %). Followed by stearic acid (C18:0), recorded (7.89 - 4.5%), then myristic acid (C14:0), recorded (3.13 – 4.36), heptadecanoic (C17:0) recorded (2.26 – 2.02 %). These results are in agreement with [44]. Oleic acid (C18:1) recorded (18.7- 28.01%), docosahexaenoic acid (C22:6) ranged (12.59 – 3.42%), eicosatetraenoic acid (C20:5) ranged (4.91 – 4.02%), Linoleic acid (C18:2) ranged (3.15 – 5.24%), linolenic acid (C18:3) ranged (2.01 – 3.64 %) which was the major USFA in both the two fish species, these results are in agreement with [46].

Change in Quality Properties of fish samples:

Data presented in Table (6) showed the change in pH value Tiger and Pebbly fish of as affected by salting and drying treatments and during storage period. The values of pH at fresh samples in Tiger fish and Pebbly fish, 7.20, 6.9; respectively were approximately neutral. These results are in agreement with [47]. At the end of storage, pH values were significant increased at ($p \leq 0.05$). pH values were increased continuously during storage period after salting (7.33–7.00) and drying (7.4-7.20). There was an increasing in pH value especially at the end of storage periods, due to an increase in volatile bases from the decomposition of nitrogenous compounds. These results are in agreement with [47], and disagreement with [19].

As recorded in Table (6) changes in acidity values of the two types of fishes were significantly increased at ($p \leq 0.05$) during storage period. Effects of salting and drying method on acidity in Tiger fish, Pebbly fish during storage period, the samples at fresh (1.39%, 1.65%). The acidity's values were increased in Tiger fish at all treatments (2.64 – 2.76%). While for Pebbly fish it was increased after salting and drying (2.92 – 2.64%) but at salting decreased only control for (1.40%).

Table (5): Change in fatty acids (%) of Tiger fish and Pebbly fish after salting and drying

Storage period	Fresh		Control				60 Days			
Species	Tiger fish	Pebbly fish	Tiger fish		Pebbly fish		Tiger fish		Pebbly fish	
Fatty acids/ treatments			Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying
Lauric acid (C12:0)	ND	1.55	ND	0.31	0.5	0.38	0.38	0.19	0.5	0.63
Tridecanoic acid (C13:0)	ND	ND	ND	0.17	ND	ND	0.59	ND	ND	ND
Tridecanoic acid (C13:1)	ND	ND	ND	0.18	ND	0.18	0.48	ND	0.97	0.23
Myristic acid (C14:0)	3.13	4.36	5.47	4.28	4.95	6.7	3.92	3.34	6.36	5.09
Myristoleic acid (14.1)	ND	0.94	1.36	1.16	1.28	1.55	0.96	0.89	1.07	2.83
Myristolinoleic (C14:2)	0.75	1.21	0.84	1.17	ND	0.76	0.48	ND	ND	1.51
Pentadecanoic acid (C15:0)	ND	0.67	0.75	0.41	0.86	0.59	0.87	0.9	0.68	1.6
Palmitic acid (C16:0)	23.19	19.34	21.87	20.27	22.37	20.18	20.52	23.26	20.76	15.26
Palmitoleic acid (C16:1)	5.49	13.98	15.53	15.75	13.53	17.23	9.49	10.32	10.48	10.14
Palmitoleic acid (C16:1, n7)	4.71	1.37	1.06	0.99	1.49	0.49	ND	1.06	0.88	17.24
Heptadecanoic acid (C17:0)	2.26	2.02	1.17	2.55	1.9	0.87	2.11	2.12	0.75	0.18
Cis-10-Heptadecanoic acid (C17:1)	ND	ND	ND	ND	0.9	0.33	ND	ND	1.18	ND
Stearic acid (C18:0)	7.89	4.3	4.28	6.68	4.26	1.39	6.06	8.17	5.22	2.43
Oleic acid (C18:1n9c)	18.7	28.01	26.55	30.1	31.24	30.05	35.9	30.38	34.7	18.92
Linoleic acid (C18:2n6c)	3.15	5.24	5.41	3.27	3.89	2.95	3.73	2.75	7.98	17.6
α- Linolenic acid (C18:3n3)	2.01	3.64	5.4	2.29	3.71	5.11	1.96	2.07	3.07	2.26
Arachidic acid (C20:0)	ND	1.35	1.47	2.18	0.97	0.58	0.39	ND	ND	ND
Gadoleic acid (C20:1)	ND	2.26	0.79	ND	1.26	1.9	1.75	1.54	1.43	ND
Eicosapentaaenoic acid (C22:5)	4.91	4.02	1.95	2.12	2.06	3.85	2.93	3.38	1.34	1.8
Behenic acid (C22:0)	0.23	0.75	1.06	0.47	ND	1.15	0.36	1.29	ND	0.23
Arachedonic acid (C20:4)	4.52	1.57	2.63	0.59	1.61	1.4	2.24	0.97	0.73	0.42
Lignocereic acid (C24:0)	6.44	ND	0.83	0.94	1.35	0.94	2.03	1.87	0.75	0.84
Docosahexaenoic acid(C22:6)	12.59	3.42	1.59	4.12	1.87	1.56	2.85	5.49	1.15	0.78
Saturated Fatty Acids	43.14	34.34	36.9	38.26	37.16	32.78	37.23	41.14	35.02	26.26
Un saturated Fatty Acids	56.83	65.66	63.11	61.74	62.84	67.36	62.77	58.85	64.98	73.73
Total	99.97	100	100.01	100	100	100.14	100	99.99	100	99.99

ND: Not detected

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Table (6): Change in quality properties of Tiger fish and Pebbly fish Samples after salting and drying

	pH				Acidity (%)				TBA (mg malonaldehyde /kg sample)			
Species	Tiger fish		Pebbly fish		Tiger fish		Pebbly fish		Tiger fish		Pebbly fish	
Treatments	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying	Salting	Drying
Fresh	7.20±0.00^{bcd}		6.90±0.00^{ec}		1.39±0.11^{dc}		1.65±0.28^{ge}		0.84±0.08^{d}		1.02±0.08^{gf}	
0	6.70±0.00^{e}	7.20±0.00^{cd}	6.80±0.00^{f}	6.70±0.00^{e}	1.58±0.05^{d}	2.00±0.05^{b}	1.40±0.04^{f}	2.09±0.10^{d}	1.34±0.12^{c}	2.39±0.17^{c}	1.93±0.05^{e}	4.04±0.04^{f}
10	7.30±0.00^{a}	7.30±0.00^{b}	7.00±0.00^{d}	6.80±0.00^{d}	1.97±0.16^{c}	2.04±0.16^{b}	1.76±0.05^{eg}	2.27±0.06^{cd}	1.80±0.10^{b}	2.55±0.18^{bc}	1.98±0.07^{e}	9.50±0.05^{e}
20	7.13±0.06^{b}	6.90±0.00^{e}	7.30±0.00^{b}	6.60±0.00^{f}	2.05±0.14^{bc}	2.70±0.05^{a}	1.96±0.11^{de}	2.33±0.01^{bd}	1.84±0.21^{b}	2.56±0.34^{bc}	2.01±0.04^{e}	12.63±0.05^{d}
30	7.13±0.12^{b}	7.17±0.06^{d}	7.50±0.00^{a}	7.07±0.06^{b}	2.11±0.10^{bc}	2.72±0.13^{a}	2.07±0.03^{d}	2.36±0.06^{bc}	1.91±0.04^{b}	2.57±0.12^{bc}	2.47±0.10^{d}	17.34±0.07^{c}
40	6.90±0.00^{d}	7.23±0.06^{c}	7.30±0.00^{b}	6.50±0.00^{g}	2.14±0.23^{bc}	2.73±0.14^{a}	2.48±0.06^{c}	2.56±0.10^{ab}	2.36±0.11^{a}	2.63±0.07^{bc}	3.46±0.12^{c}	17.42±0.07^{c}
50	7.00±0.00^{c}	7.40±0.00^{a}	7.10±0.00^{c}	6.53±0.06^{g}	2.20±0.06^{b}	2.75±0.10^{a}	2.70±0.04^{b}	2.60±0.24^{a}	2.40±0.09^{a}	2.79±0.16^{b}	3.75±0.07^{b}	18.39±0.04^{b}
60	7.33±0.06^{a}	7.40±0.00^{a}	7.00±0.06^{d}	7.20±0.00^{a}	2.64±0.05^{a}	2.76±0.05^{a}	2.92±0.09^{a}	2.64±0.04^{a}	2.42±0.08^{a}	3.83±0.08^{a}	4.26±0.10^{a}	18.80±0.04^{a}
Storage period / Days												

Means with different letters (a, b, c, d, e, f, g, h) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

In Table (6), it noticed that the TBA values were low in fresh fish at Tiger fish and Pebbly fish ranging between 0.84 and 1.02 mg malonaldehyde /1000 g and the TBA values were markedly increased with progressing in storage time, that indicates the fat oxidation with the formation of malonaldehyde. These results are in agreement with [37]. The TBARS value is an extensively used indicator to evaluate the quality of the dried fish, after the drying process and storage period. The TBA values significant increased at ($P \leq 0.05$). Increased in salting and drying, also notice increased during drying treatment more than salting in both species during storage period reached the end TBA values at drying treatment for both species (3.83- 18.80). While in salting reached (2.42- 4.26) mg malonaldehyde /1000g. These results are in agreement with [34 ,47 and 48].

Conclusion:

Salting or drying treatments and storage for 60 days at room temperature effect on the nutritional quality of the Tiger fish and Pebbly fish. The chemical changes and physical properties of protein fractions occur as affected by drying treatment than those of salting. Also, Treatments affected on myofibrils, sarcoplasmic and stroma proteins which decreased in both species, while the percentage of denatured proteins and amino acids were increased. Also, fatty acids and TBA are very affected by treatments its which are increased gradually. Generally; salting process of fish caused comparatively lower changes than drying process.

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