Effect of conventional salting and sun dryness periods on the nutritional and sensory properties of unicorn fish collected from the Red Sea

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Abstract:

Fifteen fishes were used to study and to determine nutritional and sensorial properties of unicorn fish in the different seasons, as well as the effect of salting processes on their chemical contents (such as amino and fatty acids). The quality parameters are varied in the different seasons where, protein reached 73.87% and lipids was 8.38% in fresh fish. On the other hand, Histidine recorded 13.71%, Glutamic acid reached 17.03%, Aspartic acid was 12.35%, Alanine was 10.57%, Isoleucine was 1.07%, Methionine was 0.87% and Valine was 6.01%. During summer, within one month of salting and sun dryness, fish recorded 12 amino acids with high amounts of Histidine 22.78% and Glutamic acid 16. 82%. While after 90 days of storage, 14 amino acids were recorded with a high amount of Histidine which recorded 18.32% and Glutamic acid which reached 18.62%. Total protein of dry salting fish recorded 68.98% and total lipid recorded 7.18% after three months.

Ten fatty acids were recorded and identified in fresh fish, the saturated fatty acids recorded higher values than the monounsaturated and polyunsaturated fatty acids. On the other hand, the salting process helps in preserving the ω-3 and ω-6 fatty acid which considered as an important factor in human nutrition.

We concluded that, salted fish has outstanding sensory and help in preserving the nutritional characteristics due to high quality and well-balanced essential amino and fatty acids during different storage periods dried. The high quality of dried fishes was mainly due to hygienic processing, adequate salting, hygienic drying, and use of fresh fish for processing of the dried fishes.

Keywords: **Salting – Dryness - Nutritional and sensory properties - Unicorn fish**

Introduction

Fisheries are important sources of dietary protein in the developing countries especially for the coastal communities (Jeyasanta-K et al., 2016). Where, fish is highly nutritive and rich in proteins that need careful handling (Eyo, 2002). Fish is considered excellent high biological value proteins, minerals, vitamins and polyunsaturated fatty acids (Adebowale et al., 2008). The high water, protein and unsaturated fatty acids contents leads to highly

perishable food. This is because fish spoils easily after capture due to the high tropical temperature which accelerates the activities of enzymes and chemical oxidation of fat (Bate and Bendall, 2010).

Fish products, particularly sea foods have attracted considerable attention as important source of nutrients such as amino acids, peptides, protein and other useful nutrients in the human diet (Sriket et al. 2007). Fish begins to spoil as soon as it is caught, perhaps even before it is taken out of the water. Therefore, the key to delivering a high quality product is close attention to small details throughout the entire process of preparation, catching, landing, handling, storage, and transport. Fish that becomes spoiled or putrid is obviously unusable (Gopakumar, 2000).

The purpose of processing and preserving fish is to get an ultimate consumer in good, usable condition. The steps necessary to accomplish this begin before fishing expedition starts and not finished until the fish is eaten or processed (Karube et al., 2001). Sun drying is simple, effective, and cheap methods for fish preservation that can keep a suitable range of nutritive value for the consumer. Salting is pretreatment for drying are very effective and showed a significant result on the dried products nutritive value (Karrar and Ali, 2017).

Naso unicornis are found in tropical regions throughout the Indo-Pacific and are a target group for artisanal fisheries (Randall 2001; Hardman et al., 2010; Marshell et al. 2011; McIlwain et al. 2012). *N. unicornis* is belonging to family Acanthuridae ans is classified as herbivorous grazer. Its length reached a maximum of 70cm and ages recorded up to 58 years (Eble et al. 2009, DeMartini et al. 2014). Unicorn fishes are known by this name due to the protruding tuberosity from the head (Arai and Sato 2007). There is a high fisheries production rate from artisanal fishers for reef dwelling species (Marshell et al.2011). *N. unicornis* are commonly described as marine algal grazers (on the brown algae phaeophytes) and are playing a vital role in ecosystem function (Choat et al. 2002; Hardman et al. 2010; Hoey and Bellwood 2011).

The present study presents holistic information on the impact of the common and famous traditional processing methods on the nutrient composition of *N. unicornis*. So the main objective of the study is to provide, in qualitative terms, information about the effects of traditional means of salting processing on the proximate fatty and amino acids composition as well as the nutritional quality for consumers in a wide range during the dry salting periods.

Materials and Methods

Fifteen fresh fish of *Naso unicornis* (Figure 1a) were collected with an average of 2.5 kg each (a total of 30 kg) from local fishermen at Hurghada, Red Sea. One random sample was chosen to make the chemical analysis of fresh fish and the rest for the dry salting throughout different periods **(**after one month and three months salting**).**

Firstly, salting fishes was prepared by washing of fish in tap water. Then cut off the fish from the tail to the head and using a sharp knife (UNDFFW, 2003). The fish gut (intestine) (Figure 2b) should be removed and washed again with clean running water to prevent bacterial attack before and during processing, preservation and storage (Silva, 2015). Immediate freezing before curing is a recommended necessary for a best final product (Jeyasanta-K et al., 2016).

Second: dry salting can be done for two groups of fish each of 7 fish. The addition of salt is made relevant to weight of the fish; with salt concentrations is 15% (by weight) Bakhet and Khogalie (2012). Each fish was salted separately, with coarsely ground salt, applied all over the body. Layers of fish must be separated by layers of salt (it is a valuable method) (Leistner and Gould, 2002). This method is used to salt down fish and the fish in this case are kept as whole. Some people prefer the taste of the salty fish prepared by this way (FAO, 2005).

Third: Fish can be dried in the sun if they are brought in the early morning (in the shining sun). The fish must be put in dry salted for one night at least and can be dried at the next morning (Deepchill, 2010). After 36hrs, it is necessary to wash the salt away from the fish by soaking it sea water before dryness for about 20 minutes to ensure of prevention of bacterial growth; this depends on the taste and the purpose for which the fish is cured by (Huss, 2009). The fish must be kept dry by covering or transferring them in sheltered place for three days at least (Leistner and Gould, 2002). The fishes are hanged better according to Ananou et al., (2007) to complete dryness.

Analysis

Moisture, crude or total protein and crude fat contents were determined according to the methods described by A.O.A.C. (1995, 2000) to evaluate the nutritional value. Samples were determined in NIOF lab. Analysis of fatty and amino acids were detected in the Faculty of Agriculture Research – Cairo University, using the described method by (Farag et al,1986) using gas liquid chromatograph (GLC). The amino acids were isolated on Amino Acid Analyzer (Model: AAA 400). The acid hydrolysis was carried out according to Csomos and Simon-Sarkadi (2002). Sensory test was applied according to the guidelines appeared in table (1) according to Jeyasanta-k et al. (2016).

Results and Discussion

Spoilage proceeds as a series of complex enzymatic chemical changes begin when the fish is netted (Burt, 2003). This process begins as soon as the fish dies. The rate of spoilage is accelerated in warm climate (Lima Dos Santos et al., 2011). Once the fish is dead, these enzymes begin digesting the stomach itself. Eventually the enzymes migrate into the fish flesh and digest it too. This is why the fish becomes soft and the smell of the fish becomes more noticeable (Karube et al., 2001). Normally, these chemical changes cause the familiar odors of spoilage (Putro, 2005). Oxygen also reacts chemically with oil to cause rancid odors and taste. The aim of fish processing and preservation is to slow down or prevent this enzymatic and chemical deterioration, and to maintain the fish flesh in a condition as near as possible to that of fresh fish (Bate and Bendall, 2010).

In the present study, quality changes during dryness have been identified as color texture and chemical changes. Dryness causes a yellowish color of the salted Unicorn fishes. This agreed Lauritzsen and others (2004a) who reported that reduction of water content is sufficient to cause changes in the color of fish. Br´as and Costa (2010) pointed out the lightness and yellowness increases with increasing drying period. They noticed an inversely proportional trend to water content. The color of the salted fish and probably of the dried salted fish is also influenced by other factors such as the presence of ions of calcium or magnesium in the salt, contributing to a whiter tone Lauritzsen and others 2004a ; Mart´ınez-Alvarez and G´omez-Guill´en 2005). This effect may be a consequence of increased water retention, which is common result with the use of these ions in the preparation of gels in various other food products.

During the present study it is appeared that the protein and lipid concentration are greater after three months of dry salting (see table 2) then one month dryness. Where the fish processing is help in increasing the storage periods and make the product form more attractive for consumers. This agreed the results of Tawari and Abowei (2011) who illustrated the dry salting periods influencing the taste of salted fish and could preserve the ratios of protein and lipid. The present study pointed out that the percentage of protein decreased after one month (51.98 ± 0.08%) more than three months dryness (68.98±0.56%). These ratios pointed that protein content was affected by the dehydration process, changing from 73.87 ±0.06 % in the raw fish (fresh fish before salting or dryness) and decreased to 51.98 ± 0.08% and 68.98±0.56% in the salted and dried fish (after one month and after three months respectively). Moreover, the well salting and drying way could prevent the growth of pathogenic microorganisms or bacteria. This is in agreement with the findings of Bakhet and Khogalie (2012) who reported that due to the use of salt, the growth of pathogenic microorganisms was controlled and prevented.

After 90 days of ripening (salting completeness), the protein content increased from 51.89 ± 0.08% to 68.98 ± 0.56 indicating that dry salting processes help to preserve the important macronutrient component of food by increasing time of dry salting. This agreed with Ahmed (2006) who found that the decrease in protein level was related to the decrease in salting periods less than two months. So the increased period of dry salting (3 months at least) help to preserve a high dietary protein levels and act as very useful practice to preserve the dietary rich in protein content and needed energy as alternative source rather than the prohibitive animal protein.

The moisture content of raw fish in fresh basis was 67.81 ± 1.01%, while among the two seasons (Salted 1 month, Salted 3 month) recorded (22.24 ± 0.77%, 18.37 ± 0.24%) respectively. Variations due to the treatment period could be attributed to the variation of dry salting time. Salting treatment period decreased significantly the moisture content of fish due to adding coarse salt which resulting draught of the fish tissues causing slight dehydration (Bakhet and Khogalie, 2012). This agreed the result of Jeyasanta-k et al. (2016) who reported that dry salting produced considerable loss of water constituent due to heavy uptake of salts leading to very tough texture and high salt content retain in the flesh. Where, Salt penetrates into the fish muscle by dialysis mechanism, and water is diffused out by osmotic pressure (Horner, 1997).

The main features of salting are the removal of some water from the fish flesh and its partial replacement by salt (Turan et al., 2007) without affecting the quality of fish muscles (Fuentes et al., 2007). Salting in the atmospheric temperature for several hours causes rapid protein denaturation and coagulation occurs preventing further penetration of salt into fish muscle and giving rise to a condition known as salt burn Gallart et al (2007). The strength of sun-drying has its abilities to reduce the moisture content or water activity in a product thus extending the shelf life (Akintola, 2015).

Fatty Acids

Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) are the most important omega-3 fatty acids which are present in the *N. unicornis*. The percentage of EPA and DHA in dry salted fishes during different seasons seems to be lower compared to the fresh fish. The highest ratio of EPA and DHA was found in the fresh fish 0.05% and 2.180.06% respectively), but the lowest values (2.01 ± 0.11% and 1.54 ± 0.2%) was recorded after one month (Table 2). These acids are very important In general there was no significant difference after one month or after three months of dry salting periods. Omega-3 (n-3) long-chain polyunsaturated fatty acids (LC-PUFAs) of marine origin, especially EPA (eicosapentaenoic acid, C20:5n-3) and DHA (docosahexaenoic acid, C22:6n-3), have been associated with potential benefits on cardiovascular health in many experimental, clinical and observational studies (Mozaffarian and Wu 2012).

Eleven fatty acids were identified in fresh fish and dry salted fishes in two periods as shown in table (3). Polyunsaturated fatty acids (PUFAs) recorded the highest percentage (49.76 %) followed by saturated fatty acids (SFAs) in the fresh fish meat (45.12 %). SFAs were the most dominant after one month (59.66%), while after three months PUFAs recorded the most dominant fatty acids (59.66%). The MUFAs recorded approximately sub-equal values (5.12 %, 6.82 % and 4.98 %) in the fresh flesh, after one month of salting and after three months of salting respectively.

After three months of dry salting the flesh of *N. unicornis* has the lowest SFAs content (26.5%) due to the decreased value of palmitic acid (11.43%) which is known to increase the total and low density lipoprotein (LDL)-cholesterol (Stanley 2009). This offers consumers a better choice since long-chain SFAs are known to increase levels of cholesterol, namely low density lipoprotein (LDL)-cholesterol,

connected with increased coronary heart disease (CHD) mortality. The values of Stearic Octadecanoic (18:0) were lowsed approximately by 2.57 % and in fishes after three months of dry salting compared to the fresh samples (5.15%). This implies that consumption will lower the risk for cardiovascular disease since stearic acid unlike other forms of SFAs produces a neutral effect on blood total and LDL cholesterol levels (Mensink 2005). While after one month of dry salting SFAs recorded the highest vale (59.66%) which causes the increase in LDL cholesterol and affect the human health. Among the PUFAs, the Linoleic , octadecadienoic (C18:2 n-6) is considered one of the essential fatty acids for human. Sun drying and salting impacted greatly on its concentration. linoleic acid (C18:2 ω-6) is the most abundant monounsaturated fatty acid in fishes after three month from dry salting which presented highest linoleic acid content (27.38%) while fishes after one month from dry salting presented the lowest Linoleic acid content (20.32%).

Polyunsaturated fatty acids of marine origin play an important role in human health. Indeed several studies reported that the ω-3 fatty acids have an effect on gene expression and the liver. They are not only used as an energy source and as components of membrane phospholipids and also are important mediators of gene regulation (Raclot, 2000). There is an increase attention on impacts of preservation on nutritional qualities of dietary fish. Fish products, particularly sea foods have attracted considerable attention as important sources of nutrients such as amino acids, peptides, protein and other useful nutrients in the human diet (Sriket et al. 2007).

Amino Acids

In the present study the concentrations of Leucine, Valine, Lysine, threonine and Alanine were significantly lowered after dry salting of one and three months. The reduction of available lysine from fresh fish (2.21 %) to (1.01% and 0.98%) dried Salted (after one month and three months respectively). Sannaveerapa et al. (2004) reported that loss of lysine in fish subjected to salt and sun drying, while the highest Isoleucine ratio (7.07) was obtained in dried fish Salted after three month. Methionine values (5.99) showed an increase after one month compared to fresh fish (0.87) and the dried fish Salted after three month (0.18) reduced indicating the impact of processing times.

Histidine value was highest in the two seasons and perhaps offered better deal when in quest for growth and repair of tissue as well as in

the production of blood cells (Erkan et al. 2010). In fishes after one month from dry salting produced the highest concentration. (Akintola et al. 2013) suggesting that impacts of both sun drying processes may also be related to muscle structural. Nevertheless, it is apt that this study confirmed the tendency of histidine to be raised when subjected to sunlight because of its scavenge of free radicals (Fang et al. 2002) produced during exposure to ultra violet radiation from the sun. Sun dried samples when consumed will provide functions such as prevention of seafood allergy and according to Fang et al., (2002) dietary foods functioning as antioxidant prevent many human diseases including cancer, atherosclerosis, stroke, rheumatoid arthritis, neurodegeneration, and diabetes. In the same vein, values of Aspartic acid were significantly lowered statistically.

Protein of dry salting *N. unicornis* had Glutamate as the most abundant amino acid in the two periods of dry salting (Table 4). Tyrosine values were increased in the dried fish Salted after three month (0.28) compared with fresh fish (0.08). Tyrosine is the substrate for the enzyme tyrosinase and the yield of ortho-quinone which drives enzymatic browning: one of the food industry's major problems especially for seafood (Loizzo et al. 2012) leading to the search for natural and synthethic tyrosinase inhibitors. Where, WHO (2007) stated that the lack of tyrosine causes hypothyroidism. So, the process of dry salting offered a better product after three months. The ratio of essential amino acid, EAA to the non-essential amino acid, NEAA was highest in the fresh (0.69). EAA/ NEAA ratios after one month and after three month were 0.24 and 0.28 respectively. This ratio was lower than that described by Iwasaki and Harada (1985) who recorded average ratio of 0.70 for many fish species. Hence, the dry salting after three months could be described as balanced with respect to EAA.

Sensory evaluation

Many factors, including quality and condition of the raw material, the type, concentration and quality of salt, as well as the method used for salting the fish, are believed to influence the quality and characteristics of the final product (Thorarinsd´ottir and others 2001, 2004; Andr´es and others 2002). Fresh raw materials and good manufacturing practices during salting, drying, and desalting are essential to improve fish quality and shelf life (Pedro and others 2002a). For sensory analysis, replicate samples are assessed to evaluate the general characteristics of the salted fishes (either after one month or

after three months). General shape, color, odor, taste and dryness were assessed. The samples scoring 3 or above were considered acceptable for human consumption (Table 5). The appearance, color, odor, texture, taste and aroma were checked by the taste panel using the acceptability grade from 1 to 5. Samples scoring 3 or above were considered acceptable for human consumption.

The term quality refers to the sensory characteristics of a product, such as its appearance, flavor, odor and texture but it can also indicate changes in biochemical characteristics. Death initiates a series of deteriorative changes resulting in spoilage. Therefore it has been suggested that no single spoilage or freshness indicator for fish can be used, but rather a combination of selected indicators that represent the different changes (Olafsdottir et al., 1997). In the present study also a combination between sensory assessment, proteins and lipid hydrolysis were assessed. The changes in sensory properties of dry salting *N. unicornis* are depended on the time of the two periods of dryness, where the three months duration indicated great sensory evaluations (see table 5). The average acceptability scores were taken from the mean of 8 sample and the results are shown in the mentioned table and ranged from 4.375 to 4.75. Dry salting after one month (Figure 1c) having medium general appearance, discoloration, bad odor (sea weedy odour), slightly too salty rancid and loss of dryness ranged between 2.625 and 3.25. While, dry salting after three

months (Figure 1d) having excellent general acceptability, yellow color, slight dry fish odor, slight salt and dryness. Dry salting produced considerable loss of constituent water due to heavy uptake of salt leads to very tough texture and high salt content retain in the flesh, this agreed the findings of Sikorski (1990) and Petrus et al (2013) who found the sensory evaluation showed that sample added with 15% salt had the highest score for texture: 5.90; aroma: 5.89; taste: 5.93 and color: 5.64. So, the aim of salting and drying fresh is not only to get a shelf stable product able to be stored for several months, but also to promote important sensory changes that remain during desalting and cooking and make this product very valued by consumers (Andr´es and others 2005b). Sun drying is simple, effective, and cheap methods for fish preservation that can keep a suitable range of nutritive value for the consumer. Salting as pretreatments for drying are very effective and showed a significant result on the dried products nutritive value (Karrar and Ali,2017)

Conclusion and Recommendations

Fish preservation and processing is a very important aspect of the fisheries. When the fishes are caught in numbers, greater than the amount of consumption, their preservation becomes a necessity for their future use. Therefore, preservation and processing become a very important part of commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time، with a minimum loss of flavor, taste, odor, nutritive value and the digestibility of their flesh.

Naso unicornis which caught from Red Sea in Egypt has not marketed because of its large size, so it is important to preserve the surplus of this species for the market needs by freezing or drying. Curing by dry salting is a simple and cheap method of processing required least technical expertise, but it has great significance and relevance in the socio economic system of small scale fisher folk.

Table1: Sensory score sheet for salted and sun dried fish

Quality attributes salted and dried fish	Sensory scores
Very firm texture, complete dryness, straw yellow color, slight dry fish odor, no discoloration, No salt to palate, no detectable rancidity, Excellent flavor, excellent general acceptability.	5
Firm texture, dryness, no discolorations, Slight loss of fishy odor, slight salt, slightly detectable rancidity, good flavor, and good general acceptability.	4
Fairly firm texture, dryness, no discolorations, no-off odor/flavor, and acceptable salt, medium rancid, medium general acceptability.	3
Soft texture, loss of dryness, slight medium flavor, discoloration, slight off odor, slightly too salty highly rancid, slightly undesirable flavor, bad general acceptability.	2
Very soft texture, loss of dryness, yellow or black discolorations, putrid odor, rancid sour, too salty, salt deposit on the surface, Extremely rancid, undesirable flavor, general acceptability was very bad.	1

1- Very bad 2- bad 3- fair (not bad) 4- good
5- very good/excellent

Table (2) Chemical composition and omega-3 fatty acids of *Naso unicornis*

%	Raw Fish	One month dryness	three months dryness
Prot	73.87±0.06	51.98±0.08	68.98±0.56
Lip	8.33±0.72	6.98±0.14	7.18±0.66
Moist	67.81 ±1.01	22.24 ±0.77	21.37±0.24
EPA	0.05	0.11	2.08±0.11
DHA	2.18±0.06	1.54±0.2	1.98±0.16

*Values are means of three replication □SD

Table (3): The fatty acids in the fresh sample, after one and three months of dry salting.

Common name	Lipid name		Fatty acid**%**		
			fresh	1 month	3 months
Caprylic Acid	8:00		5.825	5.94	4.726
Tetradecanoic Acid (Myristic)	14:00	Saturated	5.09	6.47	4.54
Pentadecanoic	15:00	Saturated	8.34	9.26	7.89
Hexadecanoic	16:00	Saturated	26.54	36.98	11.43
Octadecanoic	18:00	Saturated	5.15	6.95	2.57
Oleic acid	18:1(n-9)	Unsaturated	5.12	6.82	4.98
	18:2(n-6)		21.04	20.32	27.38
Alpha-linolenic acid (ALA)	18:3 (n-3)	Poly Unsaturated	7.53	8.60	7.63
	19:0(n-6)	Poly Unsaturated	15.36	1.05	29.52
Eicosapentaenoic acid (EPA)	20:5(n-3)	Poly Unsaturated	3.65	2.01	2.08
Docosahexaenoic acid (DHA)	22:6(n-3)	Poly Unsaturated	2.18	1.54	1.98
Saturated Fatty acids%			45.12	59.66	26.43
Monounsaturated Fatty acids%			5.12	6.82	4.98
Poly unsaturated Fatty acids%			49.76	33.52	68.59

Table (4): The percentage (%) of amino acids contents of the salted and fresh samples of *Naso unicornis*

Item	Fresh raw fish	One month salting	Three months salting
Essential amino acid			
Lysine	2.21	1.01	0.98
Therionine	3.28	1.75	2.70
Valine	6.01	5.49	3.87
Methionine	0.87	5.99	0.18
Leucine	9.68	ND	ND
Isoleucine	1.07	0.01	7.07
Phenyl-lanine	6.29	5.25	7.05
Total	29.41	19.5	21.85
Non- Essential amino acid			
Serine	6.09	5.47	5.79
Glycine	10.01	10.79	9.22
Proline	0.75	1.65	1.44
Alanine	10.57	7.36	7.14
Aspartic acid	12.35	15.63	17.14
Tyrosine	0.08	ND	0.28
Histidine	13.71	22.78	18.32
Glu	17.03	16.82	18.82
Total	70.59	80.5	78.15

Table (6): Average of sensory evaluation of *N. unicornis* during different periods of salting (one month to three month)

Factor	One month salting	Three month salting
General shape	3.25	4.75
Specific color	3.125	4.625
Odor of salted fish	2.625	4.5
Taste of salted fish	2.625	4.375
Dryness	2.875	4.625

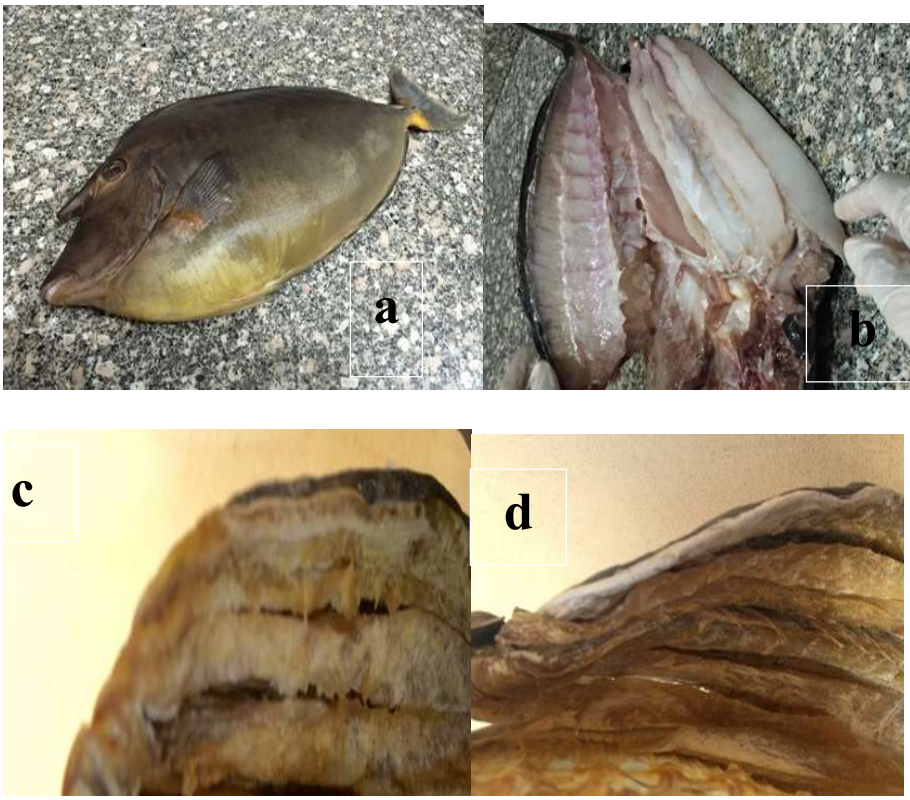

Figure (1): The general shape of *Naso unicornis* fish before salting (a), during dissecting and preparing for salting process (b), the shape after one month of salting and dryness (c) and its shape and color after three monthe of salting and dryness.

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تأثير طريقة التمليح التقليدية والتجفيف الشمسى على الخصائص التغذوية والحسية للأسماك أبو قرن فى البحر الأحمر

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الملخص العربى:

استخدمت للدراسة خمسة عشر من أسماك أبو قرن لتحديد الخصائص التغذوية والحسية في الفصول المختلفة وكذلك لدراسة تأثير طريقة التمليح على محتوياتها الغذائية (مثل الأحماض الأمينية والأحماض الدهنية). اختلفت الخواص تبعاً لإختلاف المواسم حيث بلغ البروتين ٧٤.٦٨٪ والدهون ٨.٣٧٪ . خلال موسم الصيف سجل الهستيدين ١٣.٧١٪ وحمض الجلوتاميك ١٧.٠٣٪ و حمض الأسبارتيك ١٢.٣٥٪ وألالانين ١٠.٥٧٪ وابزوليوسين ١.٠٧٪ و ميثيونين ٠.٨٧٪ و فالين ٦.٠١٪ . بعد شهر واحد من التمليح والتجفيف الشمسى ظهرفى عينة الأسماك ١٢ نوع من الأحماض الأمينية وسجل الهستيدين كميات عالية ٢٢.٧٨٪ وحمض الجلوتاميك ١٦.٢٨٪، في حين بعد ٩٠ يوما من التمليح والتجفيف الشمسى ظهرفى عينة الأسماك ١٤نوع من الأحماض الأمينية مع كمية عالية أيضاً من الهستيدين التى سجلت ١٩.٣٥٪ وحامض الجلوتاميك الذى وصل إلى ١٨.٦٢٪ .

وبلغ مجموع البروتين من الأسماك المملحة ٧٠.٠٪، وبلغ إجمالي الدهون٧.٤٢٪ أظهرت التحاليل تواجد عشرة أحماض دهنية في الأسماك الطازجة، سجلت الأحماض الدهنية المشبعة قيم أعلى من الأحماض الدهنية الأحادية غير المشبعة و الأحماض الدهنية غير المشبعة . إن عملية التمليح تساعد في الحفاظ على الأحماض الدهنية أوميجا ٣ وأوميجا ٦ التي تعتبر عاملا هاما في تغذية الإنسان . كما لوحظ إنخفاض فى قيمة أوميجا٣ من ٤.٥٤ في العينة الطازجة إلى ٣.٧٧ جرام / ٥٠٠ جرام فى العينة المجففة ،أما بالنسبة للتقييم الحسى فنجد أن أسماك أبو قرن المملحة لها خواص حسية واضحة تساعد في الحفاظ على الخواص الغذائية للأسماك بسبب نوعيتها الجيدة واحتوائها على الأحماض الأمينية والدهنية الأساسية المتوازنة خلال فترات التمليح المختلفة .وترجع نوعية الأسماك المجففة أساسا إلى المعالجة الصحية، والتمليح الكافي، والتجفيف الصحي، واستخدام الأسماك الطازجة لتجهيز الأسماك المجففة

الكلمات الدالة: طريقة التمليح – التجفيف الشمسى – الخصائص الغذائية والحسية – أسماك أبو قرن – البحر الأحمر