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Sensory, Chemical and Physical Characteristics of Some Traditional Salted Fish Samples from Egyptian Market

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Abstract There are many types of salted fish in Egypt such as Feseekh (prefermented salted mullet), salted sardine and Meloha. Many cases of food poisoning are occurred caused by these salted products especially in Sham ElNassim festival and Eid Elfetr. So, the purpose of the present study was to get a view of the quality of the prefermented salted mullet and salted sardine sold in the Egyptian market. The different kinds of salted fish samples were collected from local markets in Damietta governorate at the north of Egypt. Sensory evaluation, physical measurements (a_w, WHC, pH and plasticity) and chemical analyses (TVN, TSN, NPN, PV, TBA and fatty acids) were determined. The statistical analysis showed that there were highly significant differences at *P>0.01* between each couple of salted fish studied in most chemical and physical attributes. As for sensory evaluation, there were significant differences at *P>0.05* between the two samples of salted mullet in appearance and colour. Meanwhile, there were significant differences at *P>0.05* between the two samples of salted sardine in total score and at *P>0.01* in texture and juiciness. Furthermore, fatty acids profile, palmetic acid ($C_{16:0}$) as a saturated fatty acid came at the first order in both samples, which it represented 21.2% in salted mullet1 and 26.0% in salted sardine1. Linoleic acid $C_{18:2}\omega$-6 represented the highest polyunsaturated fatty acid in salted mullet1, where it was 37.0%. From the obtained results it could be reported that all studied salted fish products were compatible with their standard specifications from chemical and physical view. It could be concluded that there is no documented method to produce such salted products.

Keywords Sardine, Mullet, Salted fish, Egypt, Sensory evaluation, Fatty acids, Food poisoning

1. Introduction

Fish protein is considered one of the sources of animal protein in Egypt, where represented 4.6 g per capita per day rated 21.7% from animal proteins as consumption [12]. The protein of fish muscle is rich in essential amino acids, has a high biological value and can be easily digested. The amount of connective tissue is low (1-2%) compared with warm-blooded animals (10-13%) [23].

Gram and Huss (1996) stated that fish are perishable food commodities which generally spoil faster than other muscle foods. The spoilage of fish is a complex process in which physical, chemical and microbiological mechanisms are implicated. Enzymatic and chemical reactions are usually responsible for the initial loss of freshness, whereas microbial activity is responsible for the overt spoilage which thereby establishes product shelf life [13].

NaCl is added to foods for its effects on sensory, functional and preservation properties. NaCl inhibits microbial growth by restriction of the available water (i.e. lowers a_w) in the meat and fish products. However, its pro-oxidant activity is reported to accelerate the development of lipid oxidation in marinated and salted fatty fish products [3]. Salting is one of the oldest methods for fish preservation. It is based on the penetration of salt into the fish muscle. Nowadays, salting is considered to give specific sensory characteristics to the final product [1, 5, 11].

El-Feseekh (Prefermented salted Egyptian fish) produced from one of *Mugilidae* family items salting to preserve them and to achieve an appropriate degree of aging. Also, to give them the distinctive sensory properties of such product. Dry or wet salting method is used and the products are stored in sealed containers [8]. Mohamed et al. (2009) stated that there are two types of Feseekh in the Egyptian market, the first type having a low salt content and being suitable for consumption after 15-20 days of maturing, while the second has a high salt content and can be eaten after 2-3 months of storage. From the nutritional point of view, Feseekh is a rich source of high quality protein, essential amino acids, vitamins, and minerals [18].

Salted sardines are produced from sardines or like-sardine fish salting to preserve them and to achieve a suitable degree of maturation. Also, to give them distinctive sensory properties of such product without any additional treatments [9].

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Kuda, et al. (2012) studied salted and fermented fish products which purchased from retail shops in Ishikawa and Fukui, Japan in April 2010. They found that salt percentage of salted sardine and salted mackerel ranged from 7.9-14.5% and 4.9-13.4%, respectively. And they found that pH value of these samples ranged from 4.89-5.60 and 4.68-5.32, respectively [15]. Meanwhile, Nguyen, et al. (2012) reported that moisture, salt content, SFA, MUSFA and PUSFA in brined cod (*Gadus morhua*) were 78.8%, 10.1%, 21.39%, 21.42% and 50.72%, respectively. But they found these percentages in dry salted cod after 2 months from storage were 59.3%, 22.1%, 23.96%, 22.59% and 47.81%, respectively [20].

El-Dengawy, et al. (2012) studied chemical and microbiological characteristics of some salted fish samples. They found that total viable bacterial count, aerobic spore forming bacteria, *Staphylococcus aureus*, coliform group, *Clostridium* spp. and anaerobic spore formers producing H2S were studied. They reported that salted fish samples were not compatible with their standards (EOS) from microbiological view, where as it contained *Clostridium spp.* and these salted fish may be harmful in human nutrition [11].

Koral et al. (2013) investigated seventy eight salted fish products collecting from Turkey and European countries. They were analyzed for their content of biogenic amines, water activity (a_w), salt and moisture, and their microbiological counts. About 10% of the samples exceeded histamine levels established by the FDA and/or EU authorities. The highest histamine value was found for brined anchovy as 422 ppm. Among the other biogenic amines, the highest level was obtained for tyramine as 524 ppm [14].

Lee et al. (2015) tried to reduce histamine and biogenic amines during salted fish fermentation by *Bacillus polymyxa* as a starter culture and they stated that the initial TVBN content of salted fish sample was 12.35 mg/100 g. The levels of TVBN in control sample increased rapidly during fermentation time, reaching 155.5 mg/100 g at the end of fermentation after 120 days [16].

The problem is that many cases of food poisoning are occurred caused by these salted products. So, the purpose of the present study was to get an objective overview of the quality of the prefermented salted mullet and salted sardine sold in the Egyptian market.

2. Materials and Methods

2.1. Materials

2.1.1. Fish Product Samples

Salted fish products used in this study were obtained from different local markets in Damietta Governorate, Egypt. Four samples of fish products were examined namely, salted fish: two samples of salted sardine, (SS) and two samples of pre-fermented salted mullet (SM)). All samples were collected during their shelf life and were placed in cold portable insulated boxes and transported to the laboratory for chemical, physical and sensory evaluation in October 2011.

2.2. Methods

2.2.1. Chemical Analyses

Percentage of moisture, ash, protein content, sodium chloride, acidity, crude oil, total nitrogen, free amino nitrogen (FAN), Iodine value (IV), acid value (AV), free fatty acids % and peroxide value (PV) were determined using AOAC (2005) methods [2].

Total volatile nitrogen (TVN) was determined according to Pearson (1968) [21]. Results were expressed as mg nitrogen per 100g sample.

Non-protein nitrogen (NPN) was determined according to Durand (1982) [7].

Total soluble nitrogen (TSN) was determined according to Soloviev (1966) [25].

Fish oil was extracted from dried minced fish samples using the method described by Bligh and Dyer (1959) [4] and extracted oil was kept into dark glass bottles at -18°C until analysis.

Thiobarbituric acid (TBA) value as an index of oil oxidation was determined in fish oil samples as described by Tarladgis et al. (1960) [27]. TBA value was expressed using the following equation: mg malonaldehyde / kg oil = 7.8 x O.D.

Where: O.D = optical density at 538 nm (absorbency). Fatty acids composition of fish oil samples were analyzed out in The Central Laboratory Unit, High Institute of Public Health, Alexandria University, Egypt. Fatty acid methyl esters were prepared according to the procedure of Radwan (1978) [22]. The different fatty acid methyl esters (FAMEs) were determined and identified using a gas chromatography (HP 6890) equipped with a flame ionization detector (FID). A HP-5 column (30 m) [5% dimethyl 95% diphenyl polysiloxane]. The detector and injector temperatures were 250°C and 220°C, respectively.

2.2.2. Physical Properties

pH value was measured, as described by Lima dos Santos et al. (1981) [17], using a digital pH meter (HANNA instruments pH 211 Microprocessor pH meter).

Water activity (a_w) was theoretically calculated from the determined moisture and salt content using the following equation according to (Demeyer, 1979) [6].

Water holding capacity (WHC) and plasticity (cm^2/g) were determined as described by Soloviev (1966) [25]. Plasticity (as indicator for tenderness) was calculated as follows: $Cm^2/g = Cm^2$ internal zone/ Sample weight.

2.2.3. Sensory Evaluation Methods

The sensory attributes of salted fish was evaluated by a panel of 15 panelists using hedonic scale method according to Sallam et al. (2007) [24].

2.2.4. Statistical Analysis such as Mean, Standard Error and Independent T Test were Done Using SPSS (2008) [26] Version 17 Program for Windows.

3. Results

Gross chemical composition of collected salted fish samples (salted sardine "SS" and salted Mullet "SM") was shown in Table 1. The results showed that salted mullet 2 sample had the highest value of moisture content (57.92%), while salted sardine1 had the least value (45.62%). Ash content (DW) was 15.53% in salted mullet 2 and 36.34% in salted sardine 2. salted mullet 2 sample had the highest value of crude oil (40.86% DW), while salted sardine 2 had the least value (8.48%). Crude protein % (DW) ranged from 36.75% in salted sardine1 to 60.96% in salted sardine 2.

Table 2 showed protein fractions percentage (TVN, TSN, NPN and FAN) of collected samples. From tabulated data, TVN values ranged from 21.41 mgN/100g sample in SS2 to 40.79 mgN/100g sample in SM1 which represented 0.47% and 1.22% as a percentage of total nitrogen, respectively.

As for the rest of protein fractions, SM2 sample (had the least NaCl value) had the highest value of TSN%, NPN% and FAN% being 0.868%, 0.579% and 0.482%, respectively. The same manner was observed in these fractions as percent of total nitrogen (33.38%, 22.27% and 18.55%, respectively). Statistical analysis showed that there were highly significant differences between the two salted mullet samples in all protein fractions. These results agree with those obtained by Nassar (2001) [19].

Collected salted fish oil indices were tabulated in Table 3. Acid value which reflects hydrolytic rancidity of oil varied from 3.82 mg KOH/g oil in SM2 to 45.59 in SS2. Consequently, FFA% had the same manner (1.92% and 22.92%, respectively).

Iodine value, unsaturation indicator, was around 111 g I/100g oil for salted sardine and ranged from 117.51 to 120.72 for salted mullet.

Table 1. Approximate chemical composition of collected salted fish samples

Components / Fish samples	Moisture%	Ash %	Crude Protein%	Crude oil%
Salted Sardine1	45.62±1.44	15.15±0.39	19.99±0.00	18.79±0.05
Salted Sardine2	51.06±1.06	17.04±0.47	28.59±0.36	3.98±0.12
T test value	-4.18**	-3.15*	-23.79**	11.34**
Salted Mullet1	50.88±0.47	16.04±0.12	20.93±0.01	11.01±0.28
Salted Mullet2	57.92±0.55	7.14±0.28	16.28±0.01	17.19±0.11
T test value	-10.66**	30.36**	28.75**	-21.65**

Mean values ± standard error (n=3). * means significant at P> 0.05, while ** means significant at P> 0.01

Table 2. Nitrogen fractions (TVN, TSN, NPN and FAN) of collected salted fish samples

Nitrogen compounds / Fish samples	TVN mg N/100g	TSN %	NPN %	FAN %
Salted sardine1	24.82±0.01	0.183±0.00	0.183±0.00	0.187±0.00
Salted sardine2	21.41±0.01	0.210±0.03	0.189±0.02	0.207±0.00
T test value	20.82**	-1.04N.S	-0.35 N.S	-14.07**
Salted mullet1	40.79±0.61	0.307±0.03	0.201±0.02	0.218±0.01
Salted mullet2	21.42±0.44	0.868±0.00	0.579±0.00	0.482±0.01
T test value	25.60**	-20.04**	-19.56**	-44.39**

Mean values ± standard error (n=3). * means significant at P> 0.05, while ** means significant at P> 0.01, N.S means there are no significant differences.

Table 3. Oil indices of collected salted fish samples

Fish samples / Oil Indices	Acid value (AV) mg KOH/g	Free fatty acids FFA% as Oleic acid	Iodine value (IV) as " g I/100 g oil"	Peroxide value (PV) "miliequivalant O2/kg oil"	Thiobarbituric acid (TBA) "mg malonaldehyde /Kg flesh"
Salted Sardine1	15.37±0.23	7.72±0.12	111.11±1.02	21.75±0.60	16.122±0.13
Salted Sardine2	45.59±1.37	22.92±0.69	111.32±1.23	5.22±0.15	1.749±0.02
T test value	-21.79**	-21.85**	0.14N.S	26.93**	10.46**
Salted Mullet1	36.81±0.74	18.50±0.37	117.51±1.28	19.93±0.14	5.164±0.06
Salted Mullet2	3.82±0.12	1.92±0.06	120.72±0.74	31.41±1.04	0.286±0.02
T test value	44.13**	44.05**	-1.16 N.S	-10.94**	79.89**

Mean values ± standard error (n=3). * means significant at P> 0.05, while ** means significant at P> 0.01, N.S means there are no significant differences.

Oxidative rancidity that measured by peroxide and TBA values help to achieve the shelf life of such salted products. PV ranged from 5.22 miliequivalant O_2/kg oil in SS2 to 31.41 in SM2. These peroxide values did not refer to spoilage because all values nearly were less than 30. But, TBA reactive substances give a reverse view of oil rancidity. TBA value was 16.122 mg malonaldehyde/ Kg flesh in SS1 and was 5.164 in SM1.

Statistical analysis showed highly significant differences between each couple of salted fish in all oil indices except in case of Iodine value. These results agree with those obtained by Nassar (2001) [19].

Fatty acids composition of fresh and salted mullet sample (1) and fresh and salted sardine sample (1) were illustrated in Table 4.

From obtained data, palmetic acid ($C_{16:0}$) as saturated fatty acid came at the first order in all samples, which it represented 21.146% in SM1, 21.359% in fresh mullet, 26.034% in SS1 and 23.877% in fresh sardine. While, $C_{14:0}$ fatty acid came at the second order representing 3.611% and 11.23% in SM and SS, respectively. So, saturated fatty acids content of SS1 was higher than SM1 (43.507>28.376%). In contrast, total unsaturated fatty acids content of SM1 was higher than SS1 (62.189>50.694%).

As for monounsaturated fatty acids, $C_{16:1}$ came at the first order in SM_1 (10.485%) and SS_1 (11.682%). $C_{18:1}$ came at the second order representing around 4.0% in both studied samples. Also, SS_1 contained amount of $C_{22:1}$ and $C_{20:1}$. So, monounsaturated fatty acids content was 22.195% in SS_1. Linoleic acid $C_{18:2}\omega$-6 represented the highest polyunsaturated fatty acid in SM_1, where it was 37.023%. On the other hand, SS_1 contained 9.412% from this fatty acid. There was a noticeable amount of $C_{20:4}$ and $C_{22:2}$ in SS_1 (9.359% and 5.913%, respectively). Polyunsaturated fatty acids content reached 45.641% in SM_1 and 28.499% in SS1.

From the previous table, it could be clearly noticed that salting and maturation process caused some changings in the percentage of specific fatty acids such as $C_{14:0}$ and $C_{20:4}$ in sardine samples. This note could be due to loss of fish fluids during salting and maturation. Generally, these results refer to the high biological value of fish oil.

Table 5. showed some physical parameters of collected salted fish samples. NaCl% ranged from 5.64% in SM2 to 15.48% in SM1. While, SS1 sample had the least value of a_w (0.7879) and SM2 had the highest value (0.9415). Therefore, it was expected that SM2 sample will be the faster to spoil because of more availability of free water for microbiological and enzymatic activities.

pH values of collected salted fish samples varied from 5.47 in SM1 which had the highest value of NaCl to 6.31 in SM2 that had the least value of NaCl. This high pH value of SM2 was compatible with its protein fractions. Consequently, acidity % as lactic acid had the reverse or counter manner of pH.

As for texture indices, pound water ranged from 23.03% in SS2 to 54.13% in SM2. This parameter was in correlation with NaCl% and pH value. But plasticity (Cm^2/g) will help to understand pound water % results. Where the highest value of plasticity was 13.00 Cm^2/g in SM2 and this mean that SM2 sample was highly hydrolysed.

Table 6. showed sensory evaluation of collected salted fish samples which examined consumer acceptability for these widespread products.

Table 4. Fatty acids composition of fresh and salted fish samples as percentage of total fatty acid methyl esters

Fish samples	fish samples			
	Mullet		Sardine	
Fatty acids	Fresh	Salted	Fresh	Salted
$C_{6:0}$	0.026	0.023	0.036	0.015
$C_{8:0}$	0.024	0.092	0.023	0.099
$C_{10:0}$	0.133	0.014	0.077	0.018
$C_{11:0}$	-	0.020	-	0.052
$C_{12:0}$	0.011	0.025	0.132	0.124
$C_{13:0}$	0.074	0.048	0.029	0.034
$C_{14:0}$	4.577	3.611	0.055	11.229
$C_{15:0}$	1.037	0.040	0.610	0.511
$C_{16:0}$	21.359	21.146	23.877	26.034
$C_{17:0}$	0.848	0.469	0.397	0.432
$C_{18:0}$	2.783	2.547	5.236	4.541
$C_{20:0}$	0.332	0.224	0.320	0.274
$C_{21:0}$	0.025	0.052	0.031	0.144
$C_{22:0}$	-	0.065	-	-
Σ(Saturated)	31.229	28.376	30.82	43.507
$C_{14:1}$	0.097	0.078	0.130	0.131
$C_{15:1}$	0.066	0.188	0.057	0.218
$C_{16:1}$	11.584	10.485	13.815	11.682
$C_{17:1}$	0.508	0.549	0.125	0.124
$C_{18:1}$	5.589	4.162	8.368	4.216
$C_{20:1}$	4.697	0.913	7.574	2.775
$C_{22:1}$	1.256	0.173	0.560	3.049
Σ(Monounsaturated)	23.797	16.548	30.63	22.195
$C_{18:2}$ ω-6	23.924	37.023	6.125	9.412
$C_{18:3}$	1.192	1.864	0.632	1.703
$C_{20:2}$	2.732	1.315	1.103	-
$C_{20:3}$	1.385	0.862	1.792	1.024
$C_{20:4}$	1.223	2.579	3.874	9.359
$C_{20:5}$	0.128	0.726	0.146	0.781
$C_{22:2}$	0.987	1.035	0.979	5.913
$C_{22:6}$ ω-3	0.185	0.237	0.210	0.307
Σ(Polyunsaturated)	31.756	45.641	14.86	28.499
Total	86.782	90.565	76.31	94.201
Total unsaturated	55.553	62.189	45.49	50.694
(UNSAT/SAT)*	1.78	2.192	1.48	1.165

(UNSAT/SAT)* means: Total unsaturated fatty acids / Total Saturated fatty acids

Table 5. NaCl %, water activity (aw), pH value, total acidity% (as lactic acid), pound water% and plasticity of collected salted fish samples

Indices / Fish samples	NaCl%	a_w	pH	Acidity %	Pound water %	Plasticity cm^2/gm
Salted Sardine1	14.43±0.00	0.7879±0.000	6.03±0.01	0.72±0.00	31.33±0.21	3.80±0.14
Salted Sardine2	13.75±0.11	0.8317±0.002	6.24±0.03	0.49±0.00	23.03±0.28	3.91±0.03
T test value	6.41**	-28.54**	-7.27	--	23.80**	-0.77NS
Salted Mullet1	15.48±0.15	0.7939±0.002	5.47±0.01	0.82±0.00	35.67±0.23	3.74±0.09
Salted Mullet2	5.64±0.03	0.9415±0.0002	6.31±0.01	0.65±0.00	54.13±0.05	13.00 ±0.06
T test value	62.92**	-63.07**	-15.84**	--	-78.44**	-86.10**

Mean values ± standard error (n=3). * means significant at P> 0.05, while ** means significant at P> 0.01, N.S means there are no significant differences

Table 6. Sensory evaluation of collected salted fish samples

properties / samples	Salted Sardine1	Salted Sardine2	T test value	Salted Mullet1	Salted Mullet2	T test value
Appearance 8	5.00±0.195	5.77±0.319	-2.618*	5.03±0.241	5.60±0.321	-1.412 N.S
Colour 8	4.73±0.358	5.67±0.28	-2.033*	5.33±0.287	5.60±0.335	-0.604 N.S
Texture 8	5.17±0.337	5.86±0.336	-1.471 N.S	5.30±0.308	6.60±0.349	-2.793**
Odor 8	5.07±0.330	5.23±0.253	-0.401 N.S	4.90±0.435	4.73±0.442	0.270 N.S
Rancidity 8	5.47±0.446	5.13±0.376	0.571 N.S	5.20±0.262	5.47±0.496	-0.475 N.S
Juiciness 8	5.43±0.312	5.30±0.323	0.297 N.S	4.80±0.296	6.47±0.350	-3.636**
Sour 8	6.33±0.333	5.73±0.330	1.278 N.S	5.27±0.345	5.40±0.321	-0.283 N.S
Flavor 8	5.43±0.361	5.37±0.241	0.153 N.S	5.90±0.346	5.73±0.502	0.273 N.S
Overall 9	6.17±0.275	6.13±0.363	0.073 N.S	5.77±0.374	6.10±0.508	-0.529 N.S
Total 73	48.80±1.490	50.20±1.759	-0.607 N.S	46.77±1.227	51.70±2.094	-2.032*

Mean values ± standard error (n=3). * means significant at P > 0.05, while ** means significant at P > 0.01, N.S means there are no significant differences

From Tabulated results, there were no significant differences between the two salted sardine samples in all sensory properties (texture, odor, rancidity, juiciness, sour, flavour, overall and total). But there were significant differences in case of appearance and colour.

As for salted mullet samples, SM2 had higher total score (51.70) with significant differences at p>0.05. There were highly significant differences between the two samples in case of texture and juiciness. This sensory evaluation ensured the fact that Egyptian consumer had a strange and special think of quality attributes.

4. Discussion

From the above mentioned results (Table 1) indicated the high nutritional value of such salted products. There were highly significant differences between each couple of salted fish. This note could be explained that there was no homogeneity or ideal method to prepare these products. Traditional processing method for each area was different.

All TVN values were in permissible limit of fresh fish except in case of SM1. However the high value of TVN in salted fish did not mean or equal spoilage because some biochemical changes were occurred in such products to produce special taste and flavour.

All results related to protein fractions stated that there was a high enzymatic activity in all salted fish samples especially SM2 which contains the least amount of NaCl. All these differences mean that there was no documented method for Feseekh process in the studied Governorate and this ancient process depended on accumulated experiences through the past.

Peroxide value and TBA values showed heavily oxidation state in these products, may be due to the high content of NaCl which is considered as pro-oxidant and bad conditions of handling.

The Fatty acid results were in compatible with those obtained by Nguyen et al. (2012) [20], who found that SFA, MUSFA and PUSFA in brined cod (*Gadus morhua*) were 21.39%, 21.42% and 50.72%, respectively.

There were highly significant differences between each couple of salted fish samples in all physical parameters studied. These previous results were in agree with those obtained by Nassar (2001) [19] and Kuda et al. (2012) [15].

In fact, salted fish as general had a high nutritive value (protein and oil), but high NaCl% will be harmful for pressure patients and bad conditions of processing, handling and storage represented a huge problem for food scientists.

5. Conclusions

Finally, it could be concluded some positive points such as studied salted fish contained amount of protein and oil help to provide human with daily requirements. Also, there was variety of rich fatty acids in these products especially polyunsaturated fatty acids.

Meanwhile, the high acid value of these samples referred to high hydrolytic enzymes released from microorganisms. Also, the high TBA value of such products reflects the accumulation of secondary oxidative products.

Although salted mullet sample 2 had the highest value of moisture, a_w and the least value of NaCl, consequently, high enzymatic activity, it had the highest value of sensory score. This mean that there were difference between chemical/ physical attributes and consumer acceptability of such products.

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