Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 23(2): 411 – 419 (2019)
www.ejabf.journals.ekb.eg

Biochemical changes and economical estimation of salted sand smelt fish (*Atherina boyeri*)

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ARTICLE INFO

Article History:
Received: April 12, 2019
Accepted: May 15, 2019
Online: May 20, 2019

Keywords:
Sand smelt fish
Atherina boyeri
Salted fish
biochemical changes
quality indices
economical estimation

ABSTRACT

The current investigation was planned to investigate the biochemical changes and economical estimation of salted Sand smelt fish (*Atherina boyeri*). Dry salting levels; 10, 15, 20 and 25% were applied. Results showed that the raw whole fish composed 75.49% moisture, 13.02% crude protein, 1.83% lipid and 9.60% ash content. pH value and thiobarbituric acid (TBA) values were 6.35 and 0.88 mg Malonaldhyde (MA)/ kg sample, respectively. Concerning the bacterial load; total plate count (TBC) and Hallophillic bacterial count (HBC) were 2.48 and 2.00 $\log_{10}$ cfu/g samples, respectively. All of these values changed as affected by salt concentration used and storage period. Sensory scores were higher in heavy salted products (20% and 25% salt) than light salted products (10% and 15% salt). Economically, fish salting is a simple technique can be created new working chances (small projects) for many people and also it can be reduced of fish protein gap.

INTRODUCTION

Sand smelt (*Atherina boyeri*) being one of the most abundant species in Mediterranean estuaries and lagoons, it can properly be considered as a proxy for the study of the effects of environmental heterogeneity on fish fauna in transitional waters ecosystems. *A. boyeri* has commercial value due to its abundance and its relative easiness of catch. The fisheries strategy should be planned so that the fishing period follows the reproductive period and comes before the mass mortality phenomena, so that many of the fish will be caught before they died due to fish mass mortality phenomena (Leonardos and Sinis, 2000; Maci and Basset, 2010).

On the other hand, dry salting has been the most commonly used methods by the industry and it is the traditional salt-curing technique used during processing of salted fish in many countries. It depends mainly on freshness and species of fish, particles size and percent of salt, temperature and salting method used. Salting improves specific sensory characteristics to the final product and extends of shelf-life of final products. Salting rates are also influenced by a number of intrinsic factors in the muscle, such as fat content, rigor state and temperature, the contact area, initial weight and presence of skin in the fish fillets (Andrés *et al.*, 2005; Fuentes *et al.*, 2007& 2008; Gallart-Jornet *et al.*,2007; Boudhrioua *et al.*, 2009). Nguyen *et al.*,

(2009) studied the influence of different salt concentrations of 6%, 15%, 18% and 24% (w/w) on mass transfer of water and salt during brine salting of cod loins. They found that the salting kinetic parameter values for total and water weight changes decreased with increasing salt concentration.

Therefore, the present study was planned to investigate the biochemical changes and economical estimation of light salt and heavy salted sand smelt fishery products.

MATERIALS AND METHODS

Materials

Raw Sand smelt fish (*Atherina boyeri* Risso, 1810) samples were purchased from Shakshouk Fish Market, El-Fayoum, Egypt during January, 2019 and they transferred to the laboratory using icebox. The average (Mean±SD) was 5±2g weight and 3±1.5cm length. Sodium chloride (El-Naser Saltines Co., Egypt) and hard plastic bottles (1 kg capacity) were purchased from local market.

Salting technique

Different salt levels (10, 15, 20 and 25%) using with fish layers were completely filled into the bottles and tightly closed. Plastic containers were stored at ambient temperature.

Analytical methods

Chemical composition of whole raw fish and salted were determined (AOAC, 2012). Salt content (%) was determined (Varlık *et al.*, 2007). pH value was measured by checker pocket-sized pH meter with replaceable electrode (HANNA Instruments, USA), 2-thiobarbituric acid (TBA) value and total volatile basic nitrogen (TVBN) were determined (Pearson, 1976). Bacterial load; total plate count (TPC), Halophilic bacterial count (HBC) were investigated (Oxoid, 1979). The colonies were expressed as Log_{10} cfu/g sample. Sensory assessment (appearance, texture, flavor, taste and overall acceptability) by a 10-point hedonic scale for salted fish products were evaluated (Fay and Regenstein, 1982). Statistical analysis; the results were carried out in triplicate and they were subjected to analysis of variance (ANOVA) using the software SPSS (Ver.16). Also, total costs of sweet (light) and heavy salted fish products were economically estimated comparing with marketing prices.

RESULTS AND DISCUSSION

Biochemical analysis of raw sand smelt fish

Table (1) shows the biochemical analysis and bacterial load of raw whole sand smelt fish. The proximate composition of whole sand smelt (wet wt.) were 75.49%, 13.02%,1.83 % and 9.60 % for moisture, crude protein, lipid and ash content, respectively. In addition, the values of biochemical attributes for raw whole fish were 6.35 pH and 14.7mgTVB-N/100g sample while the value of TBA was 0.88 mg MA/kg sample. Besides, the bacterial load as TPC and HBC recorded 2.48, 2.00 log_{10} cell/g sample, respectively. On the other hand, Bilgin *et al.*, (2011) found that raw sand smelt flesh contained 78.28% moisture, 19.64% protein, 1.84% lipid and 1.67% ash content. This variation is due to analysis for whole or edible part of sand smelt fish.

Table 1: The biochemical analysis (wet weight basis) and bacterial load of raw whole fish.

Item	%	Item	Value
Moisture	75.49± 0.39	pH	6.35±0.02
Crude protein	13.02±1.24	TVB-N (mg/100 g)	14.8±0.24
Lipid	1.83±0.69	TBARS (mg Malonaldhyde/kg)	0.88±0.07
Ash	9.60±0.02	TVC (log_{10} cfu/g)	2.48
		Halophilic bacteria (log_{10} cfu/g)	2.00

Values are means of triplicate determined ± SD.

Biochemical analysis of salted Sand smelt products

Moisture content

Fig. (1a) shows the moisture content of salted fish treatments during different storage periods. Moisture content decreased to 58.13 to 69.41% in all treatments compared to original value (75.49%). A continuous decrease in moisture was based mainly on salt concentration used and storage period too. However, moisture in all treatments was fluctuated during storage period, may be due to the brine is sucked into the tissues so that weight of fish may return to something like its original value. These results are in agreement with those findings by Thorarinsdottir *et al.*, (2004); El-Sherif and Ibrahim (2006); El-Sherif (2007); Ibrahim and El-Sherif (2008) and Nguyen *et al.*, (2009.

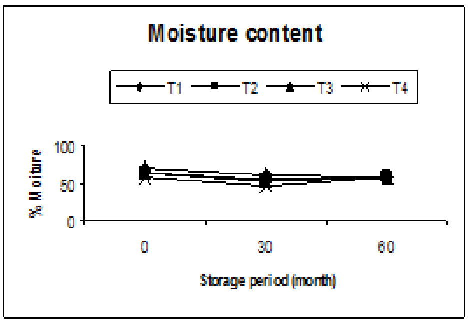

Fig. (1a). Moisture content of salted sand smelt fish products.

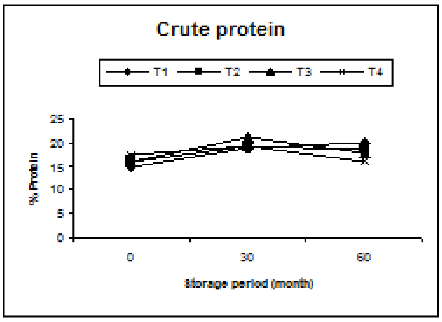

Fig. (1b). Protein content of salted sand smelt fish products.

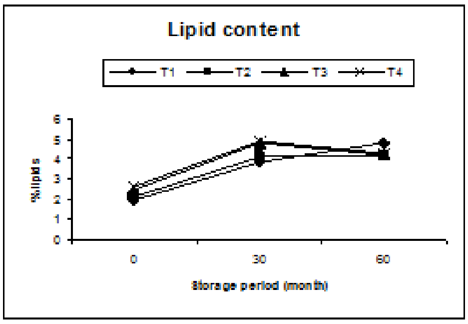

Fig. (1c). Lipid content of salted sand smelt fish products.

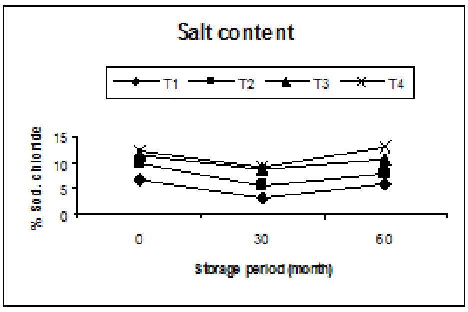

Fig. (1d). Salt content of salted sand smelt fish products.

Fig. (1a,b,c,d,): Chemical composition of raw and salted sand smelt fish products [T1: salted sand smelt fish (10% salt), T2: salted sand smelt fish (15% salt), T3: salted sand smelt fish (20% salt), T4: salted sand smelt fish (25% salt)].

Protein content

Protein content of salted fish treatments during different storage periods is presented in Fig. (1b). Protein content (dry weight) was ranged from 38.49 to 48.94 % of treatments at the first day of salting compared with its original content

(53.12%). High loss was found in treatment containing 25% salt and attributed with prolonging storage period and salt concentration. Loss in protein content is due to the breakdown of fish proteins which produce small nitrogenous compounds as a result of fermentation process (Lauritzsen *et al.,* 2004 and Thorarinsdottir *et al.,* 2004) or function of the salt concentration or chloride ions bind to the proteins, causing repulsion in the protein matrix (Lauritzsen *et al.*, 2004). The chemical fluxes are also influenced by pressure gradients within the muscle which change during salting due to denaturation/ aggregation of the muscle proteins (Jittinandana *et al.,* 2002; Sannaveerappa *et al.,* 2004 and Thorarinsdottir *et al.,* 2004).

Lipid content

Lipid content of salted fish treatments during different storage periods is exhibited in Fig. (1c). Original lipid content (dry weight) was 7.47%, decreased after salting in all treatments. Loss in lipid may be due to fat oxidation that take place in further reactions, particularly with amines and decomposition products of protein to produce changes in texture and taste of final product. During storage period, its content increased in all treatments (9.34 – 10.285). This increment may be due to loss in water content. Similar findings were reported by Sarhan (2003); Gallart-Jornet *et al.,* (2007) and Ibrahim and El-Sherif (2008).

Salt content

Salt content of salted fish treatments during different storage periods is shown in Fig. (1d).Salt content (wet wt.) was ranged from 6.70% to 12.37% at the first day of salting. It was decreased markedly after 30 days and then increased at the end of 60 days storage in particular in case of treatment 25% salt. These changes may be due to salt and water transfer in fish muscle during the salting process. Also, the brine concentration affects the rate of water and salt diffusion. This data is in accordance with those reported by Andrés *et al.,* (2002); Barat *et al.,* (2002 & 2003); Sarhan (2003); Erikson *et al.,* (2004); El-Sherif and Ibrahim (2006); Bellagha *et al.,* (2007); Ibrahim and El-Sherif (2008) and Boudhrioua *et al.,* (2009).

Quality indices of raw and treatments

pH value

The pH value was slightly reduced in all treatments comparing to its original value (6.35) at the first day of salting (Fig. 2a). After that, its value was higher (6.44) in treatment (10% salt) than that contained 25% (5.12) at 30 days storage. This decrease in pH value could be attributed to the formation of organic acids resultant growth of microorganisms and exogenous hydrolytic enzymes. pH values were increased with extend of storage period in all treatments especially in treatments contained low salt concentration (10 and 15%). Similar results are reported by El-Sherif and Ibrahim (2006); Ibrahim and El-Sherif (2008).

TBA value

The initial TBA value was 0.88 mg MA/ kg whole fish sample and increased in all treatments as shown in Fig. (2b). TBA value was higher in heavy salt treatments (20 and 25%) than those contained light salt (10% and 15%) at the first day of salting. TBA decrease in MA may be caused by interaction between MA and amino acids, proteins, glucose and other fish constituents (Fernandez *et al.,* 1997). Moreover, the high TBA value was found in light salted treatments at 30 days storage while in case of heavy salted treatments was observed at 60 days. This increase observed in TBA value is referring to fat oxidation which takes place and other organic compounds in fish tissues and sodium chloride that may be enhanced both oxidation and hydrolysis or encourage the growth of lipolytic bacteria (Sarhan, 2003; El-Sherif and Ibrahim, 2006 ; Ibrahim and El-Sherif, 2008).

TVB-N content

TVB-N content decreased in all salted treatments in particular those contained heavy salt at the first day of salting compared to original content of raw whole fish (14.80 mg/100g whole fish) as illustrated in Fig.(2c). The reduction in TVB refers to high concentration minimized reduced the microbial growth, enzymatic activity and autolysis occurred in fish proteins. TVB-N was progressively increased in all treatments especially treatment 10% salt followed by 15, 20 and 25% till at the end of storage period. This increase may be due to microbial activity and breakdown in fish proteins as affected by storage period extend. Similar observations were reported by El-Sherif and Ibrahim (2006) and Ibrahim and El-Sherif (2008).

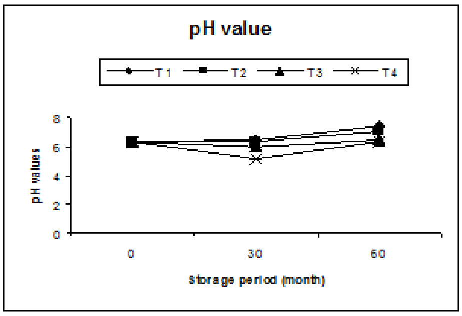

Fig. (2a): pH values of salted sand smelt fish products.

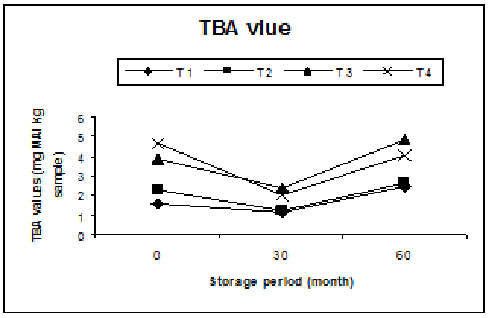

Fig. (2b): TBA value of salted sand smelt fish products.

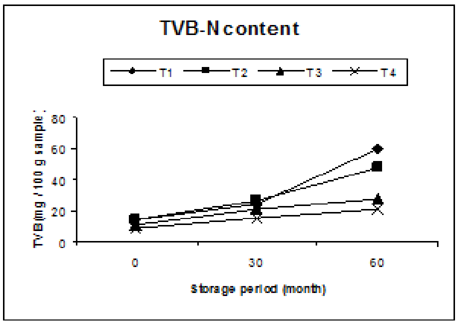

Fig. (2c): TVB-N content of salted sand smelt fish products.

Fig. (2a,b,c): Quality indices of raw and salted sand smelt fish products [T1: salted sand smelt fish (10% salt), T2: salted sand smelt fish (15% salt), T3: salted sand smelt fish (20% salt), T4: salted sand smelt fish (25% salt)].

Bacterial load of raw and treatments

TBC was increased from 2.60 to 3.04 at the first day of salting compared to original count (2.48 $\log_{10}$ cell /g whole sample). However, it was reduced at the end of storage period (60 days) as pointed in Fig. (3a). Heavy salt treatments were more effective in reduction in TBC than light salt treatments. On the other hand, HBC was taken the similar trend of TBC and also its count was low. HBC was not detected in heavy salted samples (20% and 25% salt) as shown in Fig. (3b). This reduction in microbial load may be due to salting are generally aimed at reducing water activity (aw) to inhibit growth of spoilage microorganisms as well as inactivate autolytic enzymes (Horner, 1997). Also, salt is a powerful depressor of aw of the food, and it is convenient to use as an inhibitor of microbial growth (Turan *et al.*, 2007). Moreover, chloride ions are toxic for some microorganisms. Our results are in agreement with found by Andrés *et al.*, (2005); Rodrigues *et al.*, (2003) and Mol *et al.*, (2010).

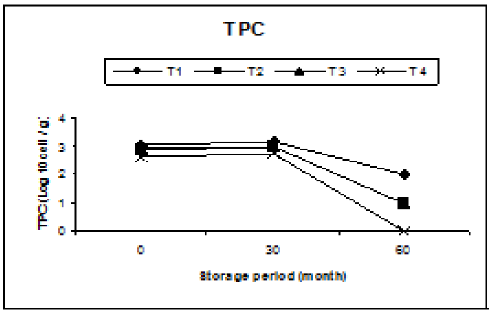

Fig. (3a). TPC of salted sand smelt fish products.

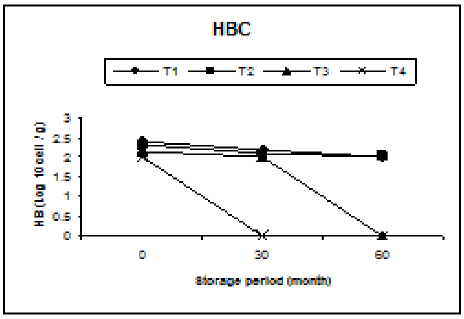

Fig. (3b). HBC of salted sand smelt fish products.

Fig. (3a,b): Bacterial counts of raw and salted sand smelt fish products [T1: salted sand smelt fish (10% salt), T2: salted sand smelt fish (15% salt), T3: salted sand smelt fish (20% salt), T4: salted sand smelt fish (25% salt)].

Sensory evaluation of treatments

Light and heavy salted products were sensory evaluated (odor, taste and desirability) at 30 and 60 days storage (Table 2). High scores of investigated tests had been given for heavy salted treatments (25% and 20%). High significant differences (*P≤ 0.05*) were found between light (10 and 15%) and heavy salted treatments (20% and 25%).

Table 2: Mean of sensory properties of salted fish products during storage periods.

Treatments	**Storage periods (day);** 30	60	***LSD (P≤ 0.05)**
	Odor		
10%	5.5	5.1	**0.039**
15%	7.2	7.5	**0.463**
20%	8.3	8.5	**0.391**
25%	9.0	9.5	**0.122**
	Taste		
10%	5.5	5.7	**0.062**
15%	6.4	6.8	**0.238**
20%	7.4	8.8	**0.013**
25%	8.6	9.0	**0.420**
	Overall acceptability		
10%	5.5	5.0	**0.001**
15%	6.2	6.8	**0.272**
20%	8.0	8.5	**0.183**
25%	**9.5**	**9.5**	**0.074**

Values are means of replicates (n =10). *LSD: Least significant difference.
Excellent: 8.5 > 10, Very good: 7.5 > 8.5, Good: 6.5 > 7.5, Accepted: 5.0 > 6.5.

Economical estimation of salted fish products

Economically, Sand smelt fish is considered a by-catch and low price, so it should be exploited to obtain a salted fish as value added product. Besides, fish salting is a simple technique can be created a new working chances for many people and also it can be reduced of fish protein gap. The following Table (3) shows the costs for materials used to obtain light and heavy salted fish products.

Table 3: Costs (Egyptian Pound) for materials used for sweet and heavy salted fish production.

Item	Unit	Salted sand smelts fish products;			
		Light		Heavy	
		10%	15%	20%	25%
Raw sand smelts fish	Kg	8.00	8.00	8.00	8.00
Hard plastic bottle	1 kg capacity	0.40	0.40	0.40	0.40
Sod. chloride	Kg	0.30	0.45	0.60	0.76
Total	Egypt. Pound	8.70	8.85	9.00	9.16
Market price	Egypt. Pound	20.00	22.00	23.00	25.00
Gain	Egypt. Pound	11.30	13.15	14.00	15.84

Results showed that total coasts for salted fish production were estimated by 8.70, 8.85, 9.00 and 9.16 Egypt. Pound for 10%, 15%, 20% and 25% salt, respectively. Comparing with marketing price, the gain of these products can be reach about 11.30, 13.15, 14.00 and 15.84 Egypt. Pound, respectively.

CONCLUSION

This study recommends that Sand smelt fish can be exploited as a delicious salted product and it creates new work chances (small projects). Heavy salted fish products (20 and 25%) were more accepted than others.

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