



Quality attributes of artificial dried and dried salted Sand smelt fish (*Atherina boyeri*)

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ARTICLE INFO

Article History:

Received: Sept. 23, 2020

Accepted: Oct. 24, 2020

Online: Oct. 25, 2020

Keywords:

Fish,
Dried salted fish,
Atherina boyeri,
Quality indices.

ABSTRACT

Some quality indices of dried and dried salted Sand smelt fish (*Atherina boyeri*) were investigated. Fish samples were purchased from El-Anfoshy landing; Alexandria during November 2019. The average length and weight were 6.75 ± 0.60 cm and 2.06 ± 0.49 g, respectively. Cleaned fish samples were divided into three portions; raw, dried (without salting) and dried salted (brined in 13% (w/v), for 5, 10 and 15 min) and then artificially dried at 50°C for 6 hrs. Results showed that dried fish sample contained 12.08% moisture, 3.74% NaCl, 0.61 a_w and 0.28% acid insoluble ash. The corresponding values of dried salted samples were ranged of 10.68-10.85%, 7.37-11.00%, 0.57-0.59 and 45-51%, respectively based on salting time. Besides, total viable count and halophilic were 4.18 and 5.61 \log_{10} cfu/g of the dried sample while they ranged 5.04-5.26 and 5.44-6.40 \log_{10} cfu/g of dried salted samples, respectively. However, dried salted fish have got high scores of odour, texture, taste compared with dried fish whereas; there are not significant differences ($P < 0.05$) in appearance and colour tests. In conclusion, artificial drying and salting processes affected markedly in values of quality indices compared with a raw fish sample. However, quality attributes of dried and dried salted Sand smelt were lower than the recommended limits as set by the International Standard Specifications.

INTRODUCTION

Fresh fish contains up to 80% water and is a highly perishable material. If fresh fish is not directly consumed or processed into finished products; it will quickly decay and become waste. The commonest fish preservation method in Indonesia are salting followed by drying (Bala and Mondol, 2001; Sidhi *et al.*, 2018). Sand smelt (*Atherina boyeri*) is one of the most abundant species in Mediterranean estuaries and lagoons, so it has a commercial value (Leonardos and Sinis, 2000; Maci and Basset, 2010). The goals of fish drying are economic considerations, environmental concerns and product quality aspects (Okos *et al.*, 1992), increase shelf life, ease of handling and transportation, improve of sensory characteristics (Sawhney, 2005). In addition, dried

fish is a staple food and is a good source of quality protein (Bellagha et al., 2007). There are different drying methods used to process and preserve shrimp such as; super-heated air drying (Prachayawarakorn et al., 2002), freeze-drying (Lourdes et al., 2007), jet-emitted bed drying and hot air drying (Niamnuy et al., 2007), heat pump drying (Zhang et al., 2008), solar drying (Akonor et al., 2016) and it can be done by open-air sun drying, firewood/fuel drying, electrical drying and solar drying (Tiwari et al., 2016). Moreover, AL-Fadhly (2009) reported that using industrial solar dryer gave better results than natural solar dryer, whereas the natural solar drying method requires a large area and long drying time, this is not exploited economically and on a large scale (Immaculate et al., 2012 and Darvishi et al., 2013). AL-Temimi (2018) found that the microwave drying method gave a high efficiency in drying and eliminating most of the microorganisms. However, some of drying methods have negative effects on the quality attributes (Ajifolokun, 2019). Therefore, this work was planned to evaluate the quality of dried and dried salted Sand smelt fish purchased from daily catch of the Mediterranean Sea at El-Anfoshy landing, Alexandria in November, 2019.

MATERIALS AND METHODS

Fresh Sand smelt (*Atherina boyeri*) samples (Fig.1) were purchased from daily catch at El-Anfoshy Landing, Alexandria during November, 2019. Then, they were directly transported using ice box to the Fish Processing and Technology Lab., National Institute of Oceanography and fisheries (NIOF), Alex. Branch, Egypt. The average length and weight of samples were 6.75 ± 0.60 cm and 2.06 ± 0.49 g, respectively.



Fig. (1). Raw Sand smelt (*Atherina boyeri*).

Sodium chloride; Bono salt composed 98.5% min. sodium chloride, 30-70 ppm potassium iodate and 0.3% max humidity. It produced by the Egyptian salts & minerals Company (EMISAL) was used.

Technological processes; the whole fresh fish were washed with clean sea water to remove any impurities and drained. Then cleaned whole fish samples were divided into 5 portions; the first one (control) was stored as it is at -20°C until analysis, the second portion was unsalted, in addition to the third, fourth and fifth portions were salted using brine 13% (w/v) for 5, 10 and 15 (min), respectively under room temperature.

Drying process; the whole salted fish were quickly washed to remove excess salt and drained again for about 5 min, in addition to unsalted sample were dried at 50°C for 6 hrs. in an air drying oven. The dried (unsalted) and dried salted fish were left inside the dryer till cooled, packed in clear polyethylene bag and analyzed.

Analytical methods

Chemical composition; moisture, crude protein (total N \times 6.25), lipid and ash content of raw, dried and dried salted samples (AOAC, 2005), total carbohydrates content (Maclean *et al.*, 2003), salt content as %NaCl (Mol *et al.*, 2010) and acid insoluble ash content (Codex, 2003) were determined. Water activity (A_w) (Mol *et al.*, 2010) using Novasina water activity meter, labstart - a_w , Switzerland and pH value (Zaika *et al.* (1976)) using pH-meter type Orion Research digital Lonalyzer 1501 were measured. Total volatile basic nitrogen (TVB-N) and trimethylamine content (AMC, 1979), and 2-Thiobarbituric acid value (Tarladgis *et al.*, 1960) were determined. Total plate count (TPC) and halophilic bacterial count (HBC) were examined (Oxoid, 1982). Sensory evaluation; dried and dried salted Sand smelt samples were evaluated (Huss, 1995) by ten panelists chosen from the staff members NIOF, Alex., Egypt. The panelists were asked for scoring the quality attributes, appearance, color, taste, odor, texture (mouth-feel) and overall acceptability of by giving scores ranged between 0 to 10 according to the scheme 10 ideal; 9 excellent; 8 very good; 7 good; 6 fairly good; 5 acceptable; 4 fair; 3 poorly fair; 2 poor; 1 very poor and 0 repulsive. The obtained results were statistical analyzed by analysis of variance (One-way ANOVA) using a significance level of $P < 0.05$ the SPSS 16 computer program (SPSS).

RESULTS

Raw Sand smelt fish

The proximate analysis and quality indices of fresh Sand smelt muscles (flesh) are shown in Table (1). Fresh Sand smelt flesh composed 75.26 \pm 0.39% moisture, 17.47 \pm 0.54% crude protein, 4.32 \pm 0.44% lipid, 2.53 \pm 0.15% ash, 1.14 \pm 0.08% NaCl and 0.43 \pm 0.35% carbohydrate content (wet wt.). Concerning quality attributes, the values of physico-chemical quality attributes of Sand smelt flesh were pH 6.58 \pm 0.17, TVBN 14.27 \pm 1.16mg\100gm, TMA 3.51 \pm 0.50mg\100gm and TBA 0.63 \pm 0.01mg MDA\kg sample. Concerning the microbial quality of raw fish samples, the counts of total plate and halophilic bacteria were 4.68 and 4.18log₁₀ cfu/g, respectively.

Table (1). Proximate analysis (mean \pm SD) and quality indices of raw Sand smelt fish.

Constituent	%	Quality indices	Value
Moisture	75.26 \pm 0.39	pH value	6.58 \pm 0.17
Protein	17.47 \pm 0.54	¹ TVB (mg\100g)	14.27 \pm 1.16
Lipid	4.32 \pm 0.44	² TMA (mg\100g)	3.51 \pm 0.50
Ash	2.53 \pm 0.15	³ TBA (mg\kg)	0.63 \pm 0.01
NaCl	1.14 \pm 0.08	⁴ TPC (log ₁₀ cfu/g)	4.68
Carbohydrate	0.43 \pm 0.35	⁵ HBC (log ₁₀ cfu/g)	4.18

¹TVB: total volatile bases; ²TMA: trimethylamine; ³TBA: thiobarbituric acid; ⁴TPC: total plate count; ⁵HBC: halophilic bacteria count.

Dried and dried salted fish

Table (2) shows the proximate composition of dried and dried salted whole Sand smelt fish. Values of chemical composition of dried whole Sand smelt were 12.08±0.35% moisture, 66.39±0.23% crude protein, 10.87±0.74% lipid, 8.38±0.375 ash, 3.74±0.33% NaCl and 2.28±0.21% carbohydrate content. Concerning dried salted whole fish, the corresponding values of dried salted fish were changed to record 10.68±0.03%, 57.15±0.04%, 13.82±0.11%, 16.47±0.13%, 7.37±0.17% and 1.88±0.25%, respectively of samples salted for 5 min, 10.85±0.18%, 58.20±0.23%, 11.69±0.25%, 17.08±0.01%, 8.31±0.16% and 2.19±0.68%, respectively of samples salted for 10 min, and 10.71±0.01%, 56.61±0.38%, 11.51±0.06%, 18.94±0.38%, 11.00±0.17% and 2.21±0.03%, respectively of samples salted for 15 min.

Table (2). Proximate analysis (mean±SD) of dried and dried salted Sand smelt fish.

Constituent (%)	*Dried fish	Dried salted fish treatments;		
		5 min	10 min	15 min
Moisture	12.08±0.25 ^a	10.68±0.02 ^b	10.85±0.13 ^b	10.71±0.01 ^b
Protein	66.39±0.16 ^a	57.15±0.03 ^c	58.20±0.17 ^b	56.61±0.38 ^d
Lipid	10.87±0.52 ^c	13.82±0.08 ^a	11.69±0.18 ^b	11.51±0.05 ^b
Ash	8.38±0.26 ^d	16.47±0.09 ^c	17.08±0.01 ^b	18.94±0.38 ^a
NaCl	3.74±0.33 ^d	7.37±0.17 ^c	8.31±0.16 ^b	11.0±0.17 ^a
Carbohydrate	2.28±0.15 ^a	1.88±0.18 ^a	2.19±0.48 ^a	2.21±.28 ^a

*Dried fish: unsalted fish; Letters in same row represent significant difference ($p<0.05$)

Quality attributes of dried and dried salted fish

Physico-chemical quality attributes of dried and dried salted whole Sand smelt fish are presented in Table (3). Dried fish samples have pH 6.66±0.11, a_w 0.61±0.01, acid insoluble ash 0.28±0.02%, TVB 74.99±0.18mg\100g, TMA 5.06±0.23 mg\100g, and TBA 1.12±0.03mg MDA\kg sample. With regard to the dried salted fish, the values of treatments; 5, 10 and 15min were 6.69±0.14, 6.51±0.17 and 6.75±0.01 of pH, 0.59±0.01, 0.59±0.02 and 0.57±0.02 of a_w , 0.45±0.16, 0.46±0.05 and 0.51±0.05% of acid insoluble ash, 77.41±0.86, 83.49±1.65 and 89.02±1.70 mg\100g of TVB, 5.79±0.27, 6.42±0.26 and 7.46±0.15 mg\100g of TMA and 2.07±0.08, 2.25±0.012.28±0.01mg MDA\kg, respectively.

Table (3). Quality indices (mean±SD) of dried and dried salted Sand smelt fish.

Index	*Dried fish	Dried salted fish treatments;		
		5 min	10 min	15 min
pH value	6.66±0.11 ^a	6.69±0.14 ^a	6.51±0.17 ^a	6.75±0.01 ^a
Water activity (a_w)	0.61±0.01 ^a	0.59±0.01 ^a	0.59±0.02 ^a	0.57±0.02 ^a
Acid insoluble ash (%)	0.28±0.02	0.45±0.16	0.46±0.05	0.51±0.05
¹ TVB (mg\100g)	74.99±0.18 ^c	77.41±0.86 ^c	83.49±1.65 ^b	89.02±1.70 ^a
² TMA (mg\100g)	5.06±0.23 ^c	5.79±0.27 ^b	6.42±0.26 ^b	7.46±0.15 ^a
³ TBA (mg\kg)	1.12±0.03 ^c	2.07±0.08 ^b	2.25±0.01 ^a	2.28±0.01 ^a

*Dried fish: unsalted fish; ¹TVB: total volatile bases; ²TMA: trimethylamine; ³TBA: thiobarbituric acid. Letters in same row represent significant difference ($p<0.05$).

Microbial examination

The microbial aspects of dried and dried salted fish samples are shown in Fig. (2). TVC was $5.61 \log_{10}$ cfu/g of dried fish sample while it recorded 5.04 and 5.26 \log_{10} cfu/g of dried salted fish samples soaked for 5, 10 and 15min, respectively. On the other side, HBC was $4.18 \log_{10}$ cfu/g of dried fish sample and it reached to 5.60, 5.44 and 6.40 \log_{10} cfu/g of dried salted fish samples soaked for 5, 10 and 15min, respectively.

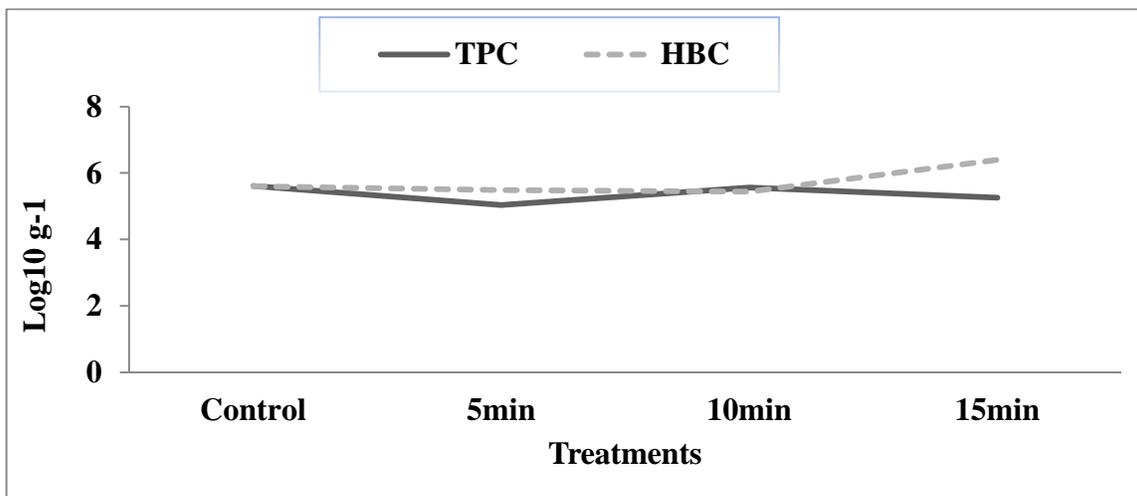


Fig. (2). Microbial aspects (Log_{10} cfu g^{-1}) of dried (control) and salted dried Sand smelt fish.

¹TPC: total plate count; ²HBC: halophilic bacteria count.

Sensorial quality

Sensory properties of dried and dried salted Sand smelt fish are exhibited in Table (4). A high score (7.7 ± 0.67) of appearance property was given by panelists to dried salted treatment 10 min, followed by treatments 5 and 10min (7.5 ± 0.85) and dried sample (7.4 ± 0.84). Colour test, the highest score (7.7 ± 0.82) was given to dried sample than other ones and the lowest score of colour (7.3 ± 0.67) was given to treatment 15 min than other treatments. Treatment 5 has got a high score in texture property compared to others. The highest scores (7.9 ± 0.52) of odour and taste properties were given to treatment 10min compared to others. The best score (8.0 ± 0.47) of overall acceptability was given to treatment 10 min.

Table (4). Sensory properties of dried and dried salted Sand smelt fish.

Property	*Dried fish	Dried salted fish treatments;		
		5 min	10 min	15 min
Appearance	7.4 ± 0.84^a	7.5 ± 0.85^a	7.7 ± 0.67^a	7.5 ± 0.85^a
Colour	7.7 ± 0.82^a	7.6 ± 0.97^a	7.6 ± 0.97^a	7.3 ± 0.67^a
Odour	6.4 ± 0.69^b	7.5 ± 0.71^a	7.9 ± 0.52^a	7.7 ± 0.67^a
Taste	6.4 ± 0.52^c	7.4 ± 0.96^{ab}	7.9 ± 0.99^a	6.9 ± 0.58^{bc}
Texture	7.2 ± 0.63^c	8.1 ± 0.99^a	7.8 ± 0.79^{ab}	7.8 ± 0.79^{ab}
Overall acceptability	6.4 ± 0.52^c	7.2 ± 0.42^b	8.0 ± 0.47^a	7.0 ± 0.47^b

*Dried fish: unsalted fish; Letters in same row represent significant difference ($p < 0.05$).

Crucial quality and safety parameters

Table (5) shows the crucial quality and safety parameters for dried and dried salted fish products. Values of moisture, water activity, sodium chloride, acid insoluble ash content were lower than the recommended values as set by the international standard specifications.

Table (5). Comparison between the present study and the international standard specifications.

References	Standard Specifications of dried and dried salted fish;							
	Dried fish				Dried salted fish			
	Moisture %	a_w	NaCl %	Acid insoluble ash %	Moisture %	a_w	NaCl %	Acid insoluble ash %
The present study	12.08	0.61	3.74	0.28	10.68 – 10.85	0.57-0.59	7.34-11.00	45-51
Codex Stan .189 - 1993	Not more than 18%	-	-	-	-	-	-	-
CODEX STAN 236-2003, Amendment, 2013	-	0.75	-	1.5	-	0.75	-	1.5
Indian Std., 2001	8-20	-	2.5-7.5	1.0-1.5	30-40		10-30	1.5
Philippines Std., 2015	Not more than 40%	0.70	15 (DW)	1.5	Not more than 40%	0.70	15 (DW)	1.5

-: not found.

DISCUSSION

In this study, the chemical composition of raw Sand smelt fish (Table 1) was disagreement except moisture content (75.26%) with those findings by **Ibrahim *et al.* (2019)**; they found that the proximate composition of raw Sand smelt (wet wt.) were 75.49%, 13.02%, 1.83% and 9.60 % for moisture, crude protein, lipid and ash content, respectively and also, **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. Variation in chemical composition of fish is due to environment of catch, age, sex, season of catch, feeding behavior and analyzed portion as reported by several studies (**Huss *et al.*, 2004**). Concerning quality attributes (Table 1), value of pH (6.58 ± 0.17) of fresh Sand smelt sample was lower than 6.7-7.0 (**Huss, 1995**). Also, the results were disagreement exception TVB ($14.27 \pm 1.16 \text{mg} \backslash 100 \text{gm}$) with those reported by **Ibrahim *et al.* (2019)**; raw fish had 6.35 pH and $14.7 \text{mg TVB-N} / 100 \text{g}$ sample while the value of TBA was 0.88 mg MA/kg sample.

Concerning dried and dried salted fish, a different significant ($P \leq 0.05$) in proximate analysis of dried and dried salted Sand smelt samples (Table 2) is due mainly to effect of salting and drying processes (**Al-Rubai *et al.*, 2020**). Similar trends according to different drying methods were reported by **Nooralabettu (2008)**; **Gwabrawy (2013)**; **Farid *et al.* (2017)**; **AL-Temimi (2018)** and **Patterson *et al.* (2018)**. Quality attributes of dried and dried salted fish products (Table 3), pH value was lower than the pH values of dried *Mugil cephalus* and *Harpodon nehereus* (**Azam *et al.*, 2003**) and also than 5.60 of

industrial solar dried Thalha fish (AL-Fadhly, 2009). Moreover, some results also were partially agreement with those findings by Al-Noor (2008). Values of water activity were in accordance with those reported by Quek *et al.* (2007) and Aberoumand (2010); all microbial growth is inhibited at water activity below 0.60. Values of acid insoluble ash were lower than the recommended value (1-1.5%) as set by Indian Std. (2001) and Philippines Std. (2015) and there is a significant different between dried and dried salted treatments. TVB and TMA (Table 3) in dried and dried salted fish samples increased progressively. Similar trend was found by Al-Noor (2008). Also, the results of TVB were higher than those reported by Azam *et al.* (2003); TVB value of dried *Mugil cephalus* was 62.23 mg/100g in winter and decreased to 57.82 mg/100 g in the summer. Values of TBA were accepted increased in dried fish and dried salted fish samples compared to its original value 0.63mg MDA/kg (Table 1). Values of TBA were within in the range of TBA value (1.81- 6.32 mg MA/kg) for dried fish samples (Al-Shatty, 2006). While they were higher than 0.531, 0.382 and 0.402 mg MA/kg fish for dried fish by using vacuum solar dryer, vacuum electric dryer, and natural solar drying, respectively (AL-Gwabrawy, 2013) and also than 0.71 mg MDA/100g of dried fish (Patterson *et al.*, 2018).

Concerning microbiological quality, TPC of raw fish sample (Table 1) was lower than the upper acceptability limit ($7 \log_{10}$ CFU/g flesh) for total viable count in fresh fish as recommended by ICMSF (1986). Results of TPC and HBC were higher values than 2.48, 2.00 \log_{10} cfu/g, respectively of raw Sand smelt fish (Ibrahim *et al.*, (2019). Data presented in Fig. (2), it was observed that salting then drying caused suppress in TVC and encouraged in growth of HBC. This phenomenon agrees with those findings by Mol *et al.* (2010) and Wang *et al.* (2011). Moreover, the results of microbial counts of dried and dried salted samples were lower than those reported by Ajifolokun (2019); the oven-dried shrimp powder at 70°C had the lowest total plate count (TPC) of 12×10^5 cfu/g (i.e. 6.08 \log_{10} CFU/g) than the sun-dried shrimp powder (36×10^5 cfu/g (i.e. 6.56 \log_{10} CFU/g).

With regard to sensorial quality (Table 4), dried salted fish samples had high scores than only dried samples. There are significant differences ($P \leq 0.05$) in texture, odour, taste, and overall acceptability between dried and dried salted treatments, and also within dried salted treatments however, appearance and colour properties were not found. The results of sensory evaluation of dried and dried salted fish are based mainly on season of catch (Azam *et al.*, 2003), fish species (AL-Gwabrawy, 2013 and Farid *et al.*, 2017), salting and drying methods (Immaculate *et al.*, 2013; Patterson *et al.*, 2018; Ajifolokun, 2019 and Al-Rubai *et al.*, 2020). From Table (5) our results were lower than the recommended limits (30-40% moisture, 0.75 a_w , 1.5% acid insoluble ash content) as set by Codex (1993 & 2003); Indian Std. (2001) and Philippines Std. (2015).

CONCLUSION

Based on the results obtained, biochemical quality of raw Sand smelt fish proved that fish samples had a high degree of freshness. Salting and drying processes and also time of salting caused desirable changes in quality indices of fish products investigated. Also, quality attributes in both dried and dried salted fish products were lower than the recommended limits of international standard specifications.

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