

Quality Enhancement of Canned Little Tunny Fish (*Euthynnus alletteratus*) by Whitening Solutions, Pre-Cooking Time and Filling Medium

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Abstract

The impact of three treatments as whitening (brine and/or H₂O₂); pre-cooking time (60 min, 70 min and 80 min) at 102 ± 1°C; and filling medium (brine, olive oil, sunflower oil and/or mixing) on quality of native little tunny (*Euthynnus alletteratus*) during canning were evaluated. A significant difference (P<0.05) in colour fillets was found between treated tunny samples when combining brine 5% with H₂O₂ 3% for 10 min and untreated sample as lightness (L*) value. The pre-cooking at 70 min resulted in reduced microorganism content, loss of moisture (~4.63%) and improved texture. Among all samples, the tunny canned in sunflower oil gained the highest acceptability (P<0.05) however, samples canned in olive oil had the lowest. The brine canned tunny recorded the highest total volatile base nitrogen (TVB-N) and histamine content after 12 months of storage. Results indicated that the different pre-treatments improved the quality of native canned tunny.

Keywords: Canning; *Euthynnus alletteratus*; Processing effects; Colour; Quality

Introduction

Canned tuna is considered one of the most important fish products in many countries, widely consumed in different parts of the world as well as in Egypt because of its availability, convenience and affordability [1]. Additionally, it is a good source of protein, polyunsaturated fatty acids, minerals, vitamins and contains omega fatty acids known to have beneficial effects on health [2]. Egypt has about 13.4 million acres water fisheries and the annual production of different species of fish is about 1.4 million tons [3]. However, Egypt imports canned tuna, approximately 130 thousand tons per year from Thailand, Japan and China [4].

Little tunny (*Euthynnus alletteratus*) one of the pelagic species, high nutritive value and low price, are present in huge quantities in Mediterranean sea, especially the Alexandria coast of Egypt [5]. It is available all around the year, but more abundant during summer months [6]. The major procedures in canning process include pre-cooking, cooling, packing with a filling medium in hermetically sealed cans and sterilization [7]. The pre-cooking is a critical thermal process before retorting because it removes water from muscle [8]. In addition, pre-cooking causes partial protein denaturation and changes in the ultra-structure of meat, which improve cleaning speed, and yield. The pre-cooking period and target temperature are depending on fish species, fish size, initial temperature and desired endpoint. Overcooking beyond the target temperature greatly reduces yield and alters flavor and colour [9].

Brine and vegetable oil are two of the most common packing media used in the canning industry. They have an important role in the canning process as heat transfer, improve taste and reducing lipid oxidation [10]. Filling media may produce a different dilution and partial extraction of some components [7]. Virgin olive oil is among filling oils employed in the tuna canning industry, it has been demonstrated to contain natural polyphenols having a key role in reducing oxidation [11]. Other studies stated that the oil improves palatability and has an active bacteriostatic effect [12]. Moreover, the canning process has been reported to change the composition of albacore tuna, resulting in a great increase in lipid, some increase in protein and a significant decrease in moisture content [13].

Histamine one of the important biogenic amines has been known as the causative toxin of scombroid fish poisoning [14]. Histamine is formed through the decarboxylation of histidine amino acid released by the microbial species, as a result of bacterial contamination during improper handling or storage of fish [15]. Some studies showed the presence of prolific histamine forming bacteria *Raoultella ornithinolytica*, isolated from dried milkfish implicated in food poisoning and commercial tuna sandwich products [16].

Since so far there are, no published technological studies evaluating the canning process of *E. alletteratus* conducted in Egypt and/or other countries, this investigation was focused on the exploitation of little tunny as raw material for producing canned tuna in Egypt. The aim of the present study was to investigate the impact of pre-treatments with (brine and/or H₂O₂) on fillet colour, as well the pre-cooking periods on tunny fillet quality. Additionally, the effect of different filling media (brine, sunflower oil, olive oil and/or mixing) on organoleptic and biochemical properties of canned product during storage was also studied.

Materials and Methods

Chemicals and reagents

Analytical grade absolute ethanol, petroleum ether, formaldehyde, glacial acetic acid, hydrochloric acid, sulfuric acid, rosolic acid, trichloroacetic acid, hydrogen peroxide, sodium bicarbonate, copper sulfate, potassium sulfate, magnesium oxide, methyl red and methylene blue, were purchased from El-Nasr Co., Cairo, Egypt. The

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thiobarbituric acid and lecithin were purchased from Sigma-Aldrich (St. Louis, MO, USA).

Sampling (raw and canned tuna)

Little tunny (*Euthynnus alletteratus*) was purchased fresh from a local fish central market in Abu Qir Bay, Alexandria, Egypt in winter 2014. The fish samples were transported in an isothermal ice box to the laboratory. Fishes were beheaded, gutted, bled and washed immediately after receiving in the laboratory and the yield of fish was calculated. Samples of canned tuna (dolphin) are common commercial products in Egypt, which imported from Thailand that used as (Control; C), were purchased from a supermarket in Cairo, Egypt.

Filling media

Edible salt (Bono, Egyptian Salts and Minerals Co., Egypt), olive oil (Sinai, Arish Co., Egypt) and sunflower oil (Cristal, Arma Co., Egypt) were procured from a local supermarket, Cairo, Egypt. Five different filling media as brine 2% (BS), olive oil (OO), sunflower oil (SO), brine: sunflower oil (1: 1; BSO) and olive oil: sunflower oil (1: 1; OSO) was prepared under laboratory conditions.

Canning procedure and thermal processing

The dressed tunny was washed in potable water for pre-cooking, fish fillets were placed belly-side down on perforated trays and steamed in a horizontal retort ($102 \pm 1^\circ\text{C}$) for different periods of time (60, 70 and 80 min) in an autoclave (Model No. 5682; John Fraser and Sons Ltd., UK). After pre-cooking, the fish fillets were kept in chilled room at 10°C and held at room temperature for 2 h. After de-skinning, the samples were cut centrally into two halves along the backbone and the red meat was separated by hand. Solely light colour meat was used for canning after cutting the meat into 3.0 cm thick pieces. About (145 ± 2 g) of muscle portions were placed into clean cans (190 ml). The cans were divided into five batches for filling media as brine 2% (BS), olive oil (OO), sunflower oil (SO), brine: sunflower oil (1: 1; BSO) and olive oil: sunflower oil (1: 1; OSO). Hot brine and/or oil were added to each can for maintaining headspace and sealed immediately. The cans were sterilized in a steam heated retort at (117°C for 65 min). After thermal processing, the cans were gradually cooled immediately by pumping chilled potable water. Cans were air dried and kept at ambient temperature ($25 \pm 1^\circ\text{C}$) and storage for 12 months.

Analytical methods

Moisture content, crude protein, crude fat and total ash were determined in tunny samples according to AOAC [17]. The energy value, expressed as kcal 100 g⁻¹ edible part, was estimated using factors 9.02 and 4.27 kcal g⁻¹ for fat and protein, respectively [18]. All tests were performed in triplicate.

Fish quality assessment

Raw material, pre-cooked and canned samples were analyzed for various quality parameters. Total volatile base nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N) were determined as the method proposed by Egan et al. [19]. The thiobarbituric acid (TBA) was assessed spectrophotometrically [20]. TBA values were expressed in mg malonaldehyde (MDA)/kg sample. The free histamine was extracted and determined according to the method described by Hwang et al. [15].

Fatty acid composition

The fatty acid methyl esters (FAMES) were prepared by a

methylation of the triacylglycerols, as the method described by Cronin et al. [21]. The FAMES were analyzed by gas chromatograph (Shimadzu 17A, Kyoto, Japan), equipped with a flame ionization detector. The fused silica capillary column (50 mm - 0.32 mm and 0.20 mm of Carbowax 20 M) was used. The column temperature was programmed at 2°C min^{-1} from 150°C to 240°C . The injection port and detector were maintained at 220 and 245°C , respectively. The carrier gas was hydrogen (1.2 mL min^{-1}), the make-up gas was nitrogen (40 mL min^{-1}) and the split used was 1: 100. Fatty acids were identified by comparison with the retention time of appropriate standards.

Colour evaluation of treated fish fillets

The colour value of untreated and treated tunny fillets with brine (2.5% to 5%; w/v) and/or H_2O_2 (1% to 3%; v/v), as well soaking time (5 and 10 min) at pH 10.5 was determined by measuring L^* (lightness), a^* (redness/greenness) and b^* (yellowness/blueness) values using a Minolta spectrophotometer CM-508d (Minolta Corp., Ramsey, NJ, USA). The instrument was calibrated using a standard white tile L^* -value of 92.28, a value of 1.95 and b value of 1.35 [22]. Colour differences, ΔE^* were calculated by the equation [23].

$$\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$$

Where,

ΔL^* , Δa^* and Δb^* represents the differences in the colour parameters between the sample and the white standard.

Organoleptic properties

Twelve panelists of the staff members and students from the Food Technology Department, Faculty of Agriculture, Benha University, were evaluating the canned tunny (up to 12 months). The score was distributed as (20; colour), (20; taste), (20; odour), (20; texture), (20; juiciness and (100; overall acceptability) according to Maheshwara et al. [24]. This test was used to select the best treatment for a wide scale production. Results were expressed as mean \pm SD.

Statistical analysis

The statistical analysis was carried out using SPSS program (ver. 19) with multi-function utility regarding to the experimental design under significance level of 0.05 for the whole results and multiple comparisons were carried out applying LSD with Duncan according to Steel and Torrie [25].

Results and Discussion

Fish constituents and yield percentage of raw and pre-cooked little tunny

The yield of the dressed tunny meat after head removal, viscera and tail was 72.24%. During the pre-cooking stage, the tunny meat lost weight (~20.61%) based on skin, backbone and moisture. After the pre-cooking process, the yield of the dressed tunny meat was 51.63%. However, after removal the dark meat 12.85%, the white meat (edible part) was 38.78%. The results demonstrated that the meat yield in little tunny (*Euthynnus alletteratus*) is higher than *Ethynnus affinis* and *Katsuwonus pelamis* [26]. Therefore, the little tunny seems a proper choice for canning process in Egypt.

Effect of treatment solutions on tunny fillets colour

The effect of brine (2.5% to 5%; w/v) and H_2O_2 (1% to 3%; v/v), as well as the soaking time (5 and 10 min), on the colour of light (as this muscle is slightly pink) fillets of little tunny was evaluated and

Soaking time (min)	Treatment solution		Tristimulus colour values			
	Brine (%)	H ₂ O ₂ (%)	L*	a*	b*	ΔE*
5	0	0	39.45 ± 0.88 ^e	3.76 ± 0.22 ^a	7.28 ± 0.44 ^e	53.36 ± 2.14 ^a
	2.5	0	40.33 ± 1.22 ^e	2.86 ± 0.35 ^b	7.75 ± 0.37 ^e	52.53 ± 1.75 ^a
	5	0	41.63 ± 1.06 ^d	1.65 ± 0.19 ^c	8.92 ± 0.52 ^d	51.43 ± 1.92 ^b
	0	1	41.85 ± 2.04 ^d	1.22 ± 0.29 ^c	9.31 ± 0.47 ^c	51.29 ± 1.54 ^b
	2.5	2	43.52 ± 1.53 ^c	0.65 ± 0.11 ^d	10.28 ± 0.26 ^b	49.85 ± 1.34 ^c
	5	3	47.49 ± 0.92 ^b	-0.78 ± 0.14 ^e	11.12 ± 0.38 ^a	46.23 ± 1.78 ^d
10	0	0	39.62 ± 1.16 ^e	3.44 ± 0.43 ^a	7.35 ± 0.42 ^e	53.19 ± 2.88 ^a
	2.5	0	40.61 ± 1.32 ^d	2.72 ± 0.27 ^b	7.87 ± 0.22 ^e	52.27 ± 2.45 ^a
	5	0	41.89 ± 1.55 ^d	1.36 ± 0.33 ^c	8.64 ± 0.38 ^d	51.13 ± 2.32 ^b
	0	1	42.58 ± 1.43 ^d	0.87 ± 0.12 ^d	9.75 ± 0.23 ^c	50.66 ± 2.81 ^c
	2.5	2	46.76 ± 1.13 ^b	-0.64 ± 0.11 ^e	10.64 ± 0.51 ^b	46.82 ± 1.65 ^d
	5	3	50.38 ± 1.05 ^a	-1.79 ± 0.21 ^e	11.54 ± 0.37 ^a	43.62 ± 2.17 ^e

^{abc} Values in the same column for each attribute followed by different letters are significantly different (P<0.05).

Table 1: Changes in the colour values of little tunny fillets after treating by whitening solutions (brine and/or H₂O₂).

Treatments	Parameters				
	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Energy value (kcal 100 g ⁻¹)
Raw fish	71.58 ± 0.39 ^a	1.35 ± 0.1 ^b	24.83 ± 0.41 ^c	2.10 ± 0.1 ^b	118.20 ± 1.45 ^d
Pre-cooking at 60 min	67.98 ± 0.15 ^b	1.69 ± 0.01 ^a	26.96 ± 0.21 ^b	2.92 ± 0.23 ^a	130.36 ± 1.64 ^e
Pre-cooking at 70 min	66.95 ± 0.22 ^b	1.85 ± 0.05 ^a	27.44 ± 0.32 ^a	3.42 ± 0.15 ^a	133.86 ± 1.23 ^b
Pre-cooking at 80 min	65.44 ± 0.14 ^c	2.01 ± 0.05 ^a	28.19 ± 0.27 ^a	3.92 ± 0.31 ^a	138.50 ± 1.38 ^a

^{abc} Values in the same column for each attribute followed by different letters are significantly different (P<0.05).

Table 2: Changes in proximate composition and energy value of raw and pre-cooked tunny fillets.

presented in Table 1. Untreated fillet was used as control in that L*, a* and b* values could be used as a baseline to determine colour deviation (ΔE); an index of colour improvement after bleaching. The results illustrated that by increasing the concentrations both brine and H₂O₂ as well time of soaking, the fillets became whitened. Significant differences (P<0.05) were detected between untreated and treated samples with (brine and H₂O₂) as L* value greater and b* value lower. Usually, 'L'-values' were used to indicate the differences in lightness and even whiteness [27]. Significant differences (P<0.05) of ΔE* were observed between untreated and treated samples. However, the treated samples in combining brine with H₂O₂ for ten minutes were whiter than the samples treated for five minutes. Additionally, the treated samples in combining (brine; 5%) with (H₂O₂; 3%) were greater than that treated with brine only. The mode of action of H₂O₂ as a whitening agent is due to a reduction of the myoglobin (pigment of muscle) to more stable composite which is ferryl-myoglobin. The latter in time can be transformed into metmyoglobin through reduction. These results agree with those reported by Chaijan and Panpipat [28].

Proximate composition and quality indices of raw and pre-cooked tunny

The changes in proximate composition and energy value of little tunny during different processing stages are given in Table 2. The composition of fresh tunny such as moisture, fat, protein and ash contents was 71.58%, 1.35%, 24.83% and 2.10%, respectively. The results indicated that the little tunny is a low fat, very good source of protein and minerals. The obtained results in the present study are similar to the results reported for *Euthynnus affinis* species [24]. The pre-cooking process of tunny at different retention periods resulted in a decrease in the moisture content, while an increase in fat, protein and ash contents. The decrease in the moisture content of little tunny was significantly different (P<0.05) for various pre-cooked treatments compared to fresh tunny. Pre-cooking resulted in loss of moisture

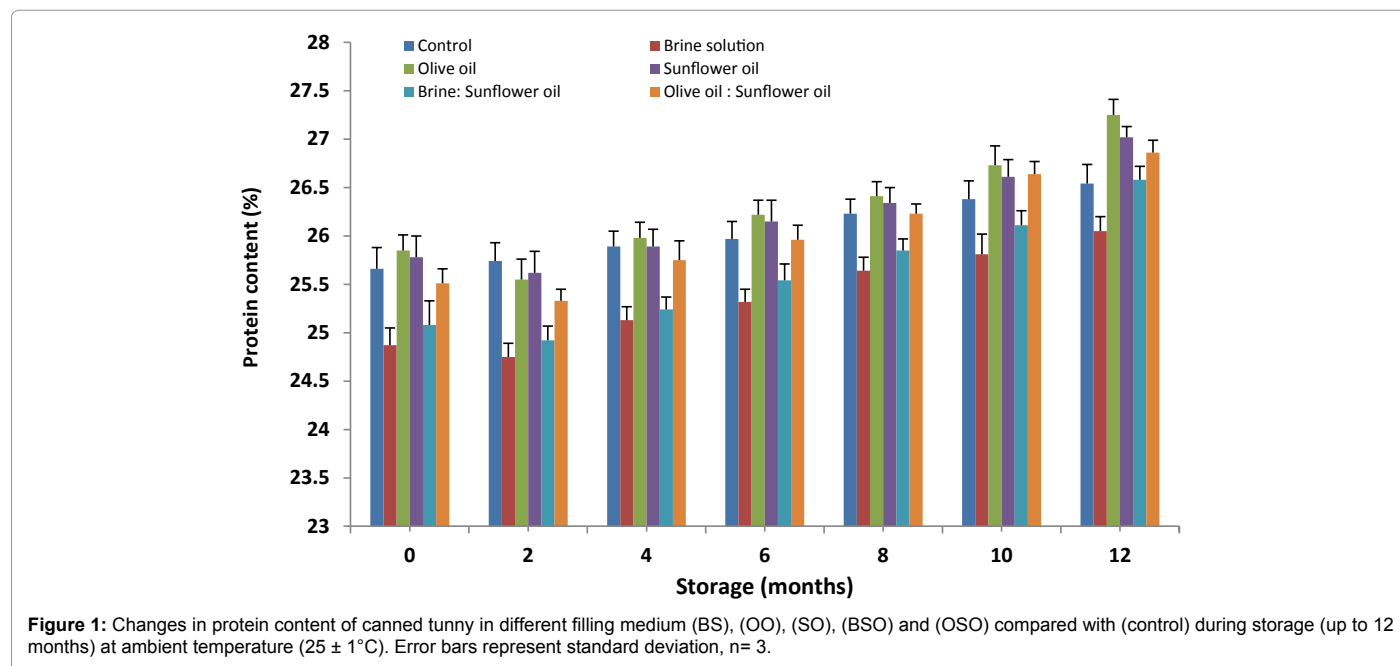
content ranged between 3.6% to 6.14% for both pre-cooking at 60 and 80 min. These results are in agreement with those reported by Zhang et al. [8]. However, pre-cooking process resulted in a slight increase in fat content ranging between 0.34% to 0.66%. There was no significant difference (P>0.05) in the fat content among the pre-cooked tunny at different retention times. Generally, the light meat of little tunny has a low fat content this is an advantage, especially in product development, because the problem of rancidity can be reduced [29]. A significant increase (P<0.05) was noticed in protein and ash contents for various pre-cooked samples. The increase in protein (2.13% to 3.36%) and ash (0.82% to 1.82%) was due to some loss of moisture during the process [30]. The energy value of fresh tunny was 118.20 kcal 100 g⁻¹, that increased significantly (P<0.05) with the thermal processing. The increase in the energy value of different samples could be attributed mainly to the fat and protein contents. These results are in agreement with those reported by Mohan et al. [30].

As presented in Table 3, The quality indices of fresh tunny were TVB-N 6.07 mg/100g, TMA-N 2.15 mg/100g and TBA 0.18 mg MDA/Kg. The results indicate that the freshness of the tunny fish used in the study. The pre-cooking process of tunny at different retention periods resulted in increased TVB-N, TMA-N and TBA values. A significant difference (P<0.05) was found in TVB-N and TMA-N levels between the pre-cooked samples. This increase could be attributed to the heat induced breakdown of proteins, amino acids and other nitrogenous compounds such as trimethylamine oxide and amines [24]. The TBA values assessment was performed to follow lipid oxidation and hydrolysis after pre-cooking treatment. No significant difference (P>0.05) was recorded with the TBA values among raw and pre-cooked tunny at different retention times. The obtained results were in agreement with reported by Zhang et al. [8]. According to researchers, the TBA value must be less than 3 mg MDA/kg and not higher than 5 mg MDA/kg in good material [31].

Treatments	Biochemical Parameters		
	TVB-N (mg/100g)	TMA-N (mg/100g)	TBA (MDA)/kg
Raw fish	6.07 ± 0.25 ^c	2.15 ± 0.11 ^c	0.18 ± 0.01 ^a
Pre-cooking at 60 min	7.25 ± 0.23 ^b	3.54 ± 0.21 ^b	0.23 ± 0.02 ^a
Pre-cooking at 70 min	7.93 ± 0.21 ^a	4.19 ± 0.15 ^a	0.29 ± 0.01 ^a
Pre-cooking at 80 min	8.63 ± 0.23 ^a	4.86 ± 0.14 ^a	0.35 ± 0.01 ^a

^{abc}Values in the same column for each attribute followed by different letters are significantly different (P<0.05).

Table 3: The biochemical quality of raw and pre-cooked tunny fillets.



Changes in composition and quality indices of canned tunny in different filling medium during storage at (25 ± 1°C)

Protein and fat content: Data presented in Figure 1 demonstrates that the protein content of canned tunny was increased as during storage time, regardless of filling medium. Thus, the protein content was 26.54%, 26.05%, 27.25%, 27.02%, 26.58% and 26.86% for (C), (BS), (OO), (SO), (BSO) and (OSO), respectively after twelve months. Similar observations were made by Mohan et al. [30]. This increase in protein may be due to the reduction in moisture content during thermal processing and subsequent storage. As shown in Figure 2 a significant difference (P<0.05) in the fat content was observed at time zero and stored tunny with different filling medium. The increase in fat content could be attributed to the relative decrease in the moisture content as well as the penetration of oil content from the filling medium into the muscle. These obtained results are in an agreement with those reported by Krzynowek and Murphy [32].

TVB-N and TMA-N values: The TVB-N and TMA-N contents are an important freshness index of fish quality. As shown in Figure 3, the TVB-N of stored canned tunny was gradually increased to 20.65 mg/100 g, 24.45 mg/100 g, 18.35 mg/100 g, 19.54 mg/100 g, 18.47 mg/100 g and 19.14 mg/100 g for (C), (BS), (OO), (SO), (BSO) and (OSO), after 12 months. Additionally, data in Figure 4, illustrated that TMA-N of canned tunny was 8.66 mg/100 g, 10.78 mg/100 g, 7.42 mg/100 g, 8.25 mg/100 g, 7.95 mg/100 g and 8.24 mg/100 g for (C), (BS), (OO), (SO), (BSO) and (OSO), after 12 months of storage. This increase could be attributed to the heat treatment (pre-cooking and/or

sterilization) which may have caused irreversible changes in the muscle as the breakdown of proteins, amino acids and other nitrogenous compounds such as trimethylamine oxide, nucleic acids and amines [24,33]. The value of 30 mg/100 g for TVB-N and 15 mg/100 g for TMA-N is considered as the limit for acceptability of freshness of canned fish [34]. Therefore, the values obtained in the present study are much less than acceptable limits for freshness index of fish.

Histamine content: Histamine is a main chemical hazard causing significant health and safety concern. Data presented in Figure 5, illustrated that the histamine content in canned tunny samples was increased to 7.51 ppm, 8.12 ppm, 6.58 ppm, 6.49 ppm, 6.78 ppm and 6.77 ppm for (C), (BS), (OO), (SO), (BSO) and (OSO), during long-term storage (up to 12 months). The increase in histamine levels could be due to the heat induced degradation of histidine to histamine. However, the levels of histamine in the present study in various samples were well within the acceptable limits less than 10 ppm [30].

Fatty acid composition: The profile of the most important fatty acids of the raw, precooked, whitened and canned tunny is shown in Table 4. The most abundant fatty acids found in raw, precooked and whitened tunny fillets were Docosahexaenoic acid (C22: 6n-3), Palmitic acid (C16: 0), Oleic acid (C18: 1n-9), Stearic acid (C18: 0), and Eicosapentaenoic acid (C20: 5n-3). These findings are in agreement with those obtained by Selmi and Sadok [29], Connell [35]. Raw tunny also showed considerable amounts of Vaccenic acid (C18: 1n-7), Palmitoleic acid (C16: 1n-7), Myristic acid (C14: 0), and Linoleic acid (C18: 2n-6). Except for Pentadecylic acid (C15: 0) and Alpha linolenic

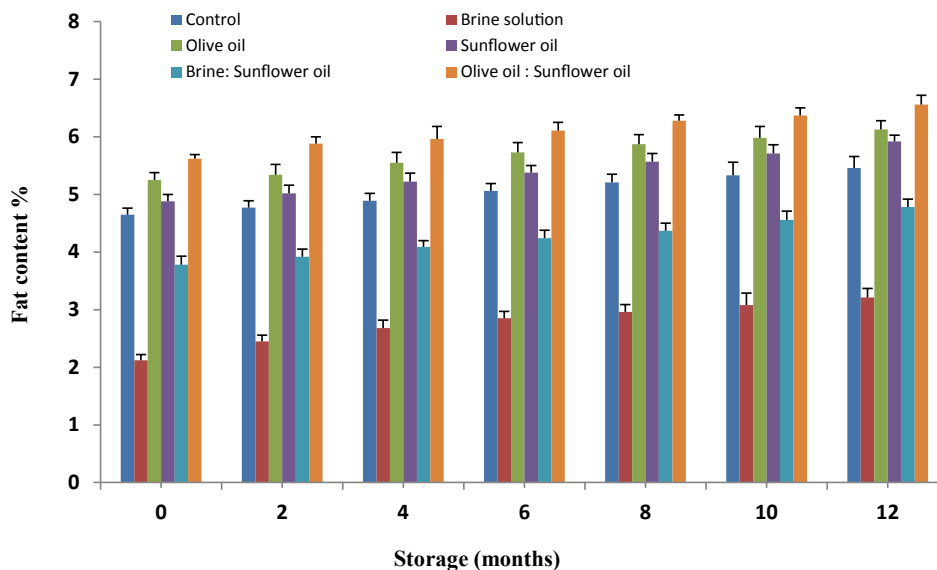


Figure 2: Changes in the fat content of canned tunny in different filling medium (BS), (OO), (SO), (BSO) and (OSO) compared with (control) during storage (up to 12 months) at ambient temperature ($25 \pm 1^\circ\text{C}$). Error bars represent standard deviation, $n = 3$.

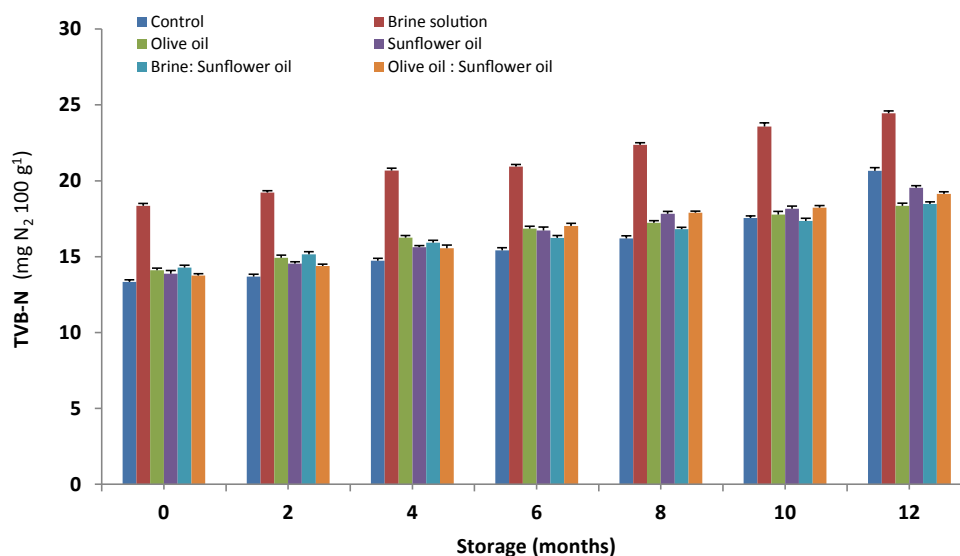


Figure 3: The changes in total volatile base nitrogen (TVB-N) content of canned tunny in different filling medium (BS), (OO), (SO), (BSO) and (OSO) compared with (control) during storage (up to 12 months) at ambient temperature ($25 \pm 1^\circ\text{C}$). Error bars represent standard deviation, $n = 3$.

acid (C18: 3n-3), steam cooking had no effect on the fatty acids content of tunny. A previous study made by Zhang et al. [8] demonstrated no differences as a result of cooking in the content of PUFA. However, a slightly decreased in the PUFA was observed in whitened sample. The decrease may be due to the interaction between the PUFA and H_2O_2 , which is finding an agreement with reported by Himonides et al. [27].

As presented in Table 4. The canning involves an exchange of fatty acids between the fat in the tunny and the filling media utilized, the interaction between both fatty items caused an increase in the tunny muscle of the proportion of the fatty acids abundant in the filling oils. The MUFA content of tunny increased when canned in sunflower oil. Oleic acid (C18: 1n-9) increased about 31% when tunny muscle was canned in olive oil and decreased when canned with sunflower

oil. Linoleic acid (C18: 2n-6) increased about 15 and 4 times when it was canned in sunflower and olive oil, respectively. The tunny samples canned in olive oil had a higher MUFA content and a lower PUFA content than sunflower oil canned samples. These changes were similar to those found by Naseri et al. [11] in canned silver carp, canned (*Thunnus alalunga*) [36]. On the other hand, the canning samples in brine minimally affected the fatty acid composition. This effect must be mostly a result of no exchange of fatty acids between the tunny muscle and filling media (brine). The observed changes were not homogeneous for various fatty acids because some fatty acids decreased, some increased and others didn't change. The changes in fatty acids content of brine canned samples due to the action of heat in the canning process. The results demonstrated the amount of SFA, MUFA, and

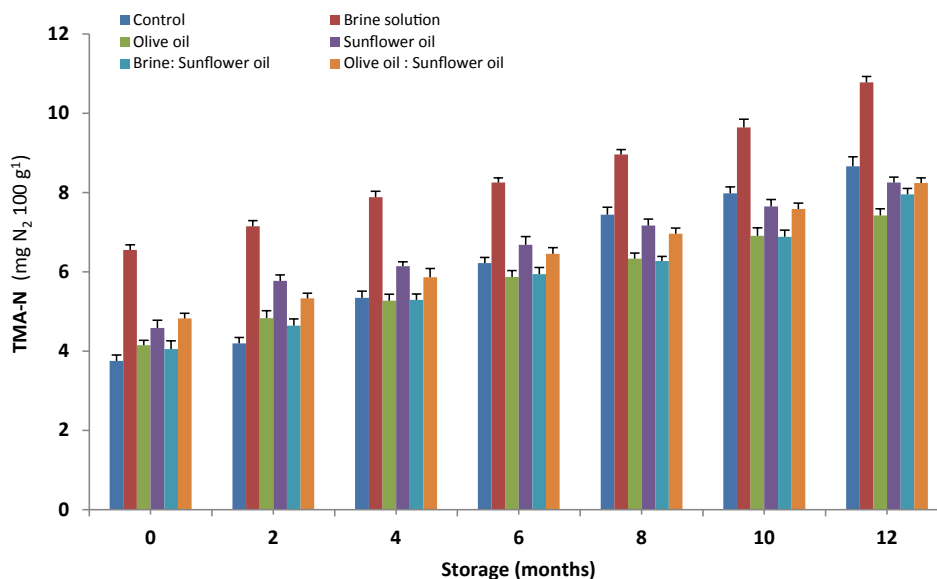


Figure 4: The changes in trimethylamine nitrogen (TMA-N) content of canned tunny in different filling medium (BS), (OO), (SO), (BSO) and (OSO) compared with (control) during storage (up to 12 months) at ambient temperature (25 ± 1°C). Error bars represent standard deviation, n= 3.

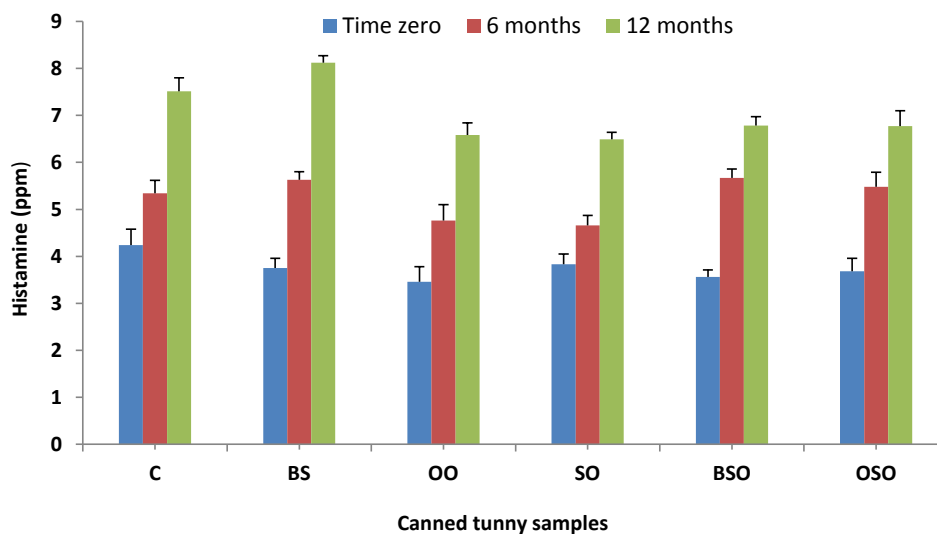


Figure 5: Changes in histamine content of canned tunny in different filling medium (BS), (OO), (SO), (BSO) and (OSO) compared with (control) during storage (up to 12 months) at ambient temperature (25 ± 1°C). Error bars represent standard deviation, n= 3.

PUFA did not alter in brine canned samples when compared with pre-cooked fillets [11,35,36].

Organoleptic properties of canned tunny: Organoleptic properties of canned tunny are presented in Table 5. A significant difference ($P < 0.05$) was observed in canned tunny samples at different filling medium compared to the control sample in most organoleptic characteristics. The results illustrated that all the canned tunny samples were acceptable to the taste panel up to 12 months of storage. Among all samples, the tunny canned in sunflower oil gained the highest acceptability ($P < 0.05$), however samples canned in olive oil had the lowest. The colour, odour, taste, texture and juiciness characteristics were improved through long-term storage. These improvements could be attributed to the thermal treatment, which can lead to breakdown

and further interactions of a wide number of fish constituents. The findings, which are in agreement with data reported by Maheshwara et al. [24].

Conclusion

This study demonstrates that little tunny which is very rich in protein, available at a low price, and commercially unexplored in Egypt. Also, it has potential for being a commercial product, and is suitable to be canned to ensure long term storage. The soaking and tumbling of tunny muscle in combination of brine; 5% and H₂O₂; 3% at pH 10.5 for 10 min produced the best whitening of the fillets and subsequently improved the colour. The pre-cooking process of fillets with steam for 70 min resulted in decreased moisture content, and improved the textural quality. Most of oil and/or brine liquid media

Fatty acids	Raw	Precooked	Whitened	Brine canned	Olive oil canned	Sunflower oil canned
14:0	1.30 ± 0.11 ^a	1.41 ± 0.13 ^a	1.32 ± 0.09 ^a	1.48 ± 0.12 ^a	1.09 ± 0.09 ^b	1.11 ± 0.1 ^b
14:1	0.22 ± 0.04 ^b	0.21 ± 0.05 ^b	0.25 ± 0.03 ^b	0.37 ± 0.05 ^a	0.20 ± 0.02 ^b	0.18 ± 0.01 ^c
15:0	0.10 ± 0.02 ^b	0.15 ± 0.01 ^a	0.11 ± 0.03 ^{ab}	0.19 ± 0.01 ^a	0.09 ± 0.01 ^b	0.1 ± 0.01 ^b
16:0	21.71 ± 0.43 ^a	20.24 ± 0.51 ^b	20.36 ± 0.34 ^{ab}	19.69 ± 0.29 ^c	18.58 ± 0.23 ^c	17.37 ± 0.19 ^d
16:1n-7	1.53 ± 0.06 ^a	1.61 ± 0.03 ^a	1.47 ± 0.06 ^a	1.51 ± 0.09 ^a	1.31 ± 0.11 ^{ab}	1.25 ± 0.12 ^b
17:0	0.81 ± 0.06 ^a	0.75 ± 0.02 ^a	0.74 ± 0.04 ^a	0.77 ± 0.05 ^a	0.72 ± 0.03 ^{ab}	0.68 ± 0.04 ^b
18:0	8.95 ± 0.15 ^a	8.99 ± 0.21 ^a	8.83 ± 0.18 ^a	8.79 ± 0.21 ^a	8.63 ± 0.21 ^{ab}	8.46 ± 0.24 ^b
18:1n-9	11.16 ± 0.22 ^b	11.03 ± 0.32 ^b	10.31 ± 0.25 ^c	10.58 ± 0.32 ^c	14.72 ± 0.26 ^a	10.35 ± 0.29 ^c
18:1n-7	2.51 ± 0.13 ^c	2.64 ± 0.11 ^b	2.45 ± 0.14 ^c	2.84 ± 0.12 ^a	2.78 ± 0.13 ^a	2.57 ± 0.15 ^b
18:2n-6	1.28 ± 0.1 ^c	1.33 ± 0.09 ^c	1.26 ± 0.07 ^c	1.56 ± 0.09 ^c	5.23 ± 0.19 ^b	20.11 ± 0.15 ^a
18:3n-3	0.92 ± 0.05 ^b	1.2 ± 0.04 ^a	0.9 ± 0.03 ^b	1.33 ± 0.07 ^a	1.01 ± 0.04 ^b	0.87 ± 0.06 ^b
20:0	0.26 ± 0.02 ^b	0.24 ± 0.01 ^b	0.28 ± 0.02 ^b	0.45 ± 0.03 ^a	0.31 ± 0.05 ^b	0.37 ± 0.03 ^a
20:4n-3	0.46 ± 0.04 ^a	0.39 ± 0.02 ^a	0.43 ± 0.04 ^a	0.36 ± 0.05 ^a	0.3 ± 0.04 ^b	0.24 ± 0.02 ^b
20:5n-3 (EPA)	7.63 ± 0.27 ^a	7.57 ± 0.23 ^a	7.61 ± 0.21 ^a	7.67 ± 0.24 ^a	7.23 ± 0.22 ^b	7.10 ± 0.25 ^b
22:0	0.21 ± 0.02 ^a	0.28 ± 0.02 ^a	0.2 ± 0.01 ^a	0.18 ± 0.01 ^{ab}	0.15 ± 0.01 ^b	0.17 ± 0.01 ^b
22:6n-3 (DHA)	31.32 ± 0.44 ^a	31.11 ± 0.49 ^a	30.18 ± 0.42 ^a	28.42 ± 0.37 ^{ab}	27.84 ± 0.32 ^b	27.66 ± 0.3 ^b
ΣSFA	33.34 ± 0.37 ^a	32.06 ± 0.42 ^a	31.84 ± 0.37 ^a	31.55 ± 0.41 ^b	29.57 ± 0.39 ^c	28.26 ± 0.32 ^c
ΣMUFA	15.42 ± 0.23 ^b	15.49 ± 0.21 ^b	14.48 ± 0.32 ^b	15.3 ± 0.22 ^b	19.01 ± 0.24 ^a	14.35 ± 0.26 ^b
ΣPUFA	41.61 ± 0.42 ^b	41.59 ± 0.52 ^b	40.38 ± 0.46 ^c	39.34 ± 0.43 ^c	41.63 ± 0.51 ^b	55.98 ± 0.64 ^a
ΣPUFA/SFA	1.25 ± 0.11 ^c	1.3 ± 0.08 ^{bc}	1.27 ± 0.05 ^c	1.25 ± 0.06 ^c	1.41 ± 0.09 ^b	1.98 ± 0.11 ^a
EPA/DHA	0.24 ± 0.02 ^b	0.24 ± 0.02 ^b	0.25 ± 0.03 ^{ab}	0.27 ± 0.05 ^a	0.26 ± 0.02 ^a	0.26 ± 0.02 ^a

Values are percent of total fatty acid expressed as mean ± SD of three separate determinations.

^{abc} Values in the same row for each attribute followed by different letters are significantly different (P<0.05).

SFA: Saturated Fatty Acid; MUFA: Monounsaturated Fatty Acid; PUFA: Polyunsaturated Fatty Acid.

Table 4: Fatty acids composition of raw, precooked, whitened and different canned little tunny.

Storage	Filling medium	Organoleptic attributes					Overall Acceptability (100)
		Colour (20)	Odour (20)	Taste(20)	Texture(20)	Juiciness (20)	
Time Zero	Control	17.8 ± 1.14 ^{ab}	18 ± 0.74 ^a	18.2 ± 1.14 ^a	16.4 ± 1.43 ^d	17.8 ± 1.03 ^b	91.7 ± 3.33 ^b
	Brine solution	16.7 ± 0.67 ^c	16.3 ± 2.31 ^c	17.4 ± 1.07 ^{ab}	17.8 ± 1.4 ^b	17.5 ± 1.08 ^b	84.9 ± 8.03 ^e
	Olive oil	15.3 ± 1.42 ^d	15 ± 2.58 ^d	14.7 ± 2 ^d	16.4 ± 2.59 ^d	15.7 ± 1.49 ^d	81.5 ± 7.09 ^g
	Sunflower oil	18.3 ± 0.95 ^a	17.8 ± 0.63 ^{ab}	17.9 ± 0.74 ^{ab}	18.1 ± 0.99 ^b	18.2 ± 0.92 ^b	91.4 ± 2.07 ^b
	Brine: Sunflower oil	17.5 ± 0.85 ^{ab}	17.6 ± 1.17 ^{ab}	17.7 ± 0.67 ^{ab}	17.8 ± 0.79 ^b	18 ± 0.82 ^b	90.7 ± 2.83 ^c
	Olive oil : Sunflower oil	16.8 ± 0.74 ^c	17.5 ± 0.71 ^{ab}	17.2 ± 2.2 ^{ab}	17.5 ± 0.97 ^b	17.4 ± 0.7 ^c	89.8 ± 3.08 ^c
6 months	Control	18.1 ± 0.88 ^a	18.3 ± 0.67 ^a	18.4 ± 0.97 ^a	16.7 ± 1.25 ^c	17.9 ± 0.88 ^b	92 ± 3.3 ^b
	Brine solution	16.9 ± 0.57 ^c	16.5 ± 2.32 ^c	17.5 ± 0.97 ^{ab}	17.7 ± 1.05 ^b	17.6 ± 0.97 ^b	85.4 ± 4.49 ^e
	Olive oil	15.5 ± 0.97 ^d	15.3 ± 2.36 ^d	15 ± 1.7 ^c	16.6 ± 75 ^d	15.9 ± 1.37 ^d	82 ± 3.32 ^f
	Sunflower oil	18.5 ± 0.53 ^a	18.1 ± 0.57 ^a	18.2 ± 0.79 ^a	18.3 ± 0.95 ^a	18.4 ± 0.84 ^a	92.6 ± 2.01 ^b
	Brine: Sunflower oil	17.6 ± 0.7 ^{ab}	17.9 ± 0.99 ^{ab}	17.9 ± 0.57 ^{ab}	18 ± 0.67 ^b	18.1 ± 0.74 ^b	91.5 ± 2.46 ^b
	Olive oil : Sunflower oil	17 ± 0.67 ^c	17.7 ± 0.67 ^{ab}	17.5 ± 1.72 ^{ab}	17.7 ± 0.82 ^b	17.5 ± 0.71 ^b	90.3 ± 2.58 ^c
12 months	Control	18.6 ± 0.84 ^a	18.6 ± 0.63 ^a	18.8 ± 1.03 ^a	17.2 ± 1.14 ^c	18.3 ± 0.48 ^a	94.2 ± 1.62 ^a
	Brine solution	16.9 ± 0.88 ^c	16.1 ± 1.73 ^c	17.3 ± 0.95 ^{ab}	17.7 ± 1.06 ^b	17.4 ± 0.84 ^c	87.9 ± 3.82 ^d
	Olive oil	15 ± 1.25 ^d	14.9 ± 1.97 ^e	14.8 ± 1.03 ^d	16.5 ± 1.43 ^d	15.8 ± 1.32 ^d	82.1 ± 3.34 ^f
	Sunflower oil	18.9 ± 0.57 ^a	18.8 ± 0.79 ^a	19.1 ± 0.57 ^a	19 ± 0.67 ^a	19 ± 0.82 ^a	95.1 ± 2.88 ^a
	Brine: Sunflower oil	18.2 ± 0.79 ^a	18.4 ± 0.52 ^a	18.3 ± 0.48 ^a	18.4 ± 0.52 ^a	18.5 ± 0.53 ^a	93 ± 1.89 ^a
	Olive oil : Sunflower oil	17.6 ± 0.7 ^{ab}	18.1 ± 0.74 ^a	18.1 ± 0.74 ^a	18.1 ± 0.88 ^b	18.1 ± 0.57 ^b	92.1 ± 2.23 ^b

^{abc} Values in the same column for each attribute followed by different letters are significantly different (P<0.05).

Mean ± SD, n=12.

Table 5: Organoleptic properties of canned tunny in different filling medium during storage.

for canned tunny were stable and sensorially acceptably during storage (up to 12 months). The beneficial aspects of little tunny canning as demonstrated in this study, clearly warrant scale-up trials under a large production volume typical of commercial conditions.

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