Proximate and fatty acid composition of three tuna species from Hadhramout coast of the Arabian Sea, Yemen

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Abstract

The Proximate and fatty acid composition were evaluated in three species of tuna; Yellowfin tuna (*Thunnus albacares*), longtail tuna (*T. tonggol*), little tuna (*Euthynnus affinis*) caught from Hadhramout coast of the Arabian Sea. The results of proximate composition showed high protein content in the flesh of all species, ranged from 22.52% to 24.36%. The average moisture, lipid and ash contents in the flesh of the three fish species were in the range of 70.13–74.0%, 2.34–4.66% and 1.25–1.37%, respectively. Fatty acid profile of all fish was dominated by saturated fatty acids, (31.76–36.77%), followed by polyunsaturated fatty acids (31.21–31.59%) and then monounsaturated fatty acids (20.58–25.87%). Palmitic acid, docosahexaenoic acid (DHA) and oleic acid were the most abundant fatty acids in the flesh of all species, with values in the range of 19.69–24.05%, 18.49–20.48% and 11.62–15.75%, respectively. The flesh of all fish contained almost similar levels of omega-3 polyunsaturated fatty acids (omega-3 PUFA), ranging from 26.60 to 27.08%. The majority of these omega-3 PUFA was primarily contributed by DHA (69.51–75.63%), then eicosapentaenoic acid (EPA, 13.98–17.52%). These results demonstrate that the three species of tuna studied in the present work are excellent sources of protein and the health-beneficial omega-3 polyunsaturated fatty acids.

Keywords: Proximate composition, fatty acids, tuna, Hadhramout, Yemen.

Introduction:

Yellowfin tuna, *Thunnus albacores*, (locally known as thamad), longtail tuna, *T. tonggol*, (locally known as zynoob), and little tuna/kawakawa, *Euthynnus affinis*, (locally known as sherwy) are important fishery resources in Yemen. Yellowfin tuna, in particular, is the most important fish in terms of the commercial value. The annual catch of yellowfin tuna from the Yemeni seas for the year 2012 was 35669 tons. This contributing to about 16% of the country's total fish production, making this species the second most landed fish in Yemen, just after sardine [25]. The majority of the Catch of yellow fin tuna is locally marketed; primarily as fresh fish for consumption of local communities nationwide, with significant amounts being oriented to the local tuna canning industry. Some of the catch of yellowfin tuna are also processed and exported to regional and EU markets. Longtail tuna and little tuna are also caught in commercial quantities along the coastal waters of Yemen. According to Ministry of Fish Wealth [25], the annual catch of these fish in 2012 was 4823 and 6823 tons, respectively. This production is almost entirely consumed by local communities, except a small portion of longtail tuna which utilized in the canning industry.

The nutritional value of fish as a human food is generally attributed to their proteins and lipids of high biological value, with long-chain polyunsaturated fatty acids, as well as certain minerals and vitamins that fish contains [35]. Fish proteins are of high quality, containing all of the essential amino acids in good quantity and in balanced amounts, and is easily digested, with digestibility values of greater than 90% [33]. Fish lipid is characterized by its high content of omega-3 PUFA, particularly the long-chain highly unsaturated fatty acids (HUFA); eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). These fatty acids are generally found in all fish, but with higher concentrations in marine species, with those from high latitudes having higher amounts than tropical low-latitude species [10, 11, 17]. The consumption of fish and/or fish oil containing omega-3 PUFA, especially EPA and DHA, is currently known to play vital roles in human nutrition, disease prevention, and health promotion. Some of the most well-documented benefits of these fatty acids include their ability to reduce the blood lipid level, particularly the serum triacylglyceroles, protect against cardiovascular diseases, especially the acute complications of coronary heart disease. They play a vital role in the development and functions of the nervous system, photoreception, and the reproductive systems [10, 21, 35, 37].

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Data of chemical composition of fish is essential to have a basic knowledge about their nutritional characteristics in order to make the best use of them as food as well as for the planning of appropriate processing technologies [12]. Such data has been long established for most fish species worldwide. However, with the exception of our recent findings about proximate and fatty acid composition of Indian sardine (*Sardinella longiceps*) and Indian mackerel (*Rastrelliger kanagurta*) [7], no scientific information is currently available about the nutritional characteristics of any of the fishery resources in the Exclusive Economic Zone (EEZ) of Yemen, including the important tuna species. Therefore, the current work was carried out to study the proximate and fatty acid composition of three of the most important tuna species in the EEZ of Yemen.

Materials and Methods:

Collection and Preparation of samples:

Fresh yellowfin was obtained from Borum Fisheries Company, Asheher, Hadhramout, Yemen. While, longtail tuna (*Thunnus tonggol*) and little tuna (*Euthynnus affinis*) were purchased from the central fish market in Mukalla, Hadhramout, Yemen. Flesh tissues (approximately 200g) were sampled from individual 10 fish of each species. Samples from each species were divided into two sub-samples (5 fish each). Each sub-sample was then homogenized and stored in freezer (at -18°C) in polyethylene film sealed within plastic zipper bags for subsequent analyses.

Proximate analysis:

The proximate analysis of flesh samples were conducted according to AOAC standard methods [6]. Briefly, Moisture was determined by drying the samples in an oven at 105°C until constant weight. Crude protein was determined by digesting the samples with concentrated H_2SO_4 followed by alkali distillation and acid titration (Kjeldahl method). Ash content was determined by incineration in a muffle furnace at 550°C for 5 hours. Total lipids were extracted from samples with chloroform-methanol (2:1 v/v) based on the procedure of Bligh and Dyer [9].

Fatty acid analyses:

Extracted crude lipids were methylated and transesterified with methanolic boron trifluoride [6]. Fatty acid methyl esters (FAMEs) were then resolved and analyzed using a Shimadzu gas-liquid chromatography (GC- A14). The esters were separated in an OmegawaxTM 320 fused silica capillary column (30m × 0.32mm, L × ID, 0.25µm film thickness) from Supelco, Bellafonte Park, USA. An SPL-14 injector with a split ratio of 100:1 was used. Injector port and detector temperatures were set at 250°C and 260°C respectively. The temperature program was an initial temperature of 150°C for 2 min, with increase rate of 3°C/min to a final temperature of 220°C and held at this temperature for 10 min. Fatty acids were identified relative to retention time of known standards (Supelco 37 component FAME mix; Supelco, Bellafonte, PA) and areas beneath the identified chromatographic peaks were calculated by integration. Individual fatty acid content was shown as a percentage of the sum of total fatty acids detected.

Statistical analysis:

All analyses were conducted in duplicates, and results were expressed as mean values ± standard deviation (SD). The data was subjected to one-way analysis of variance (ANOVA) to test statistical differences between the three fish species using the SPSS program, version 17.0 for Windows (SPSS lnc., Chicago, IL, USA). Differences between means were determined by Duncan's Multiple Range Test and were considered to be significant at a P-value < 0.05.

Results and discussion:

Proximate composition:

Table 1. shows results of the proximate analysis of the flesh of the three tuna species. All components were significantly different (P < 0.05) between the fish species. It's well known that nutritional components of fish vary greatly among species and from an individual fish to another depending on various biological and environmental factors, such as age, sex, maturity, feed intake, environment, geographical location and season [16, 33].

Table 1. Proximate composition (%, wet weight) of tuna samples[1]

Tuna species	Composition			
	Moisture	Protein	Lipid	Ash
Yellowfin	$74.00^{a} \pm 1.08$	$22.52^{c} \pm 0.15$	$2.46^{b} \pm 0.07$	$1.25^{b} \pm 0.02$
Longtail	$70.13^{bc} \pm 1.20$	$24.36^{a} \pm 0.17$	$4.66^{a} \pm 0.06$	$1.37^{a} \pm 0.02$
Little	$71.70^{b} \pm 1.30$	$24.04^{b} \pm 0.01$	$2.34^{c} \pm 0.07$	$1.37^{a} \pm 0.01$

[1]Values were reported as means ± S.D. of duplicate groups of 5 fish (n = 10). Within the different species, mean values in the same column with different superscripts were significantly different ($P < 0.05$).

Moisture was significantly highest (74.0%) in yellowfin tuna, followed by little tuna (71.70%), and then the longtail tuna (70.13%). These values were within the range of 70–80% that commonly observed for fish [12, 16]. Comparable values were reported for the same species in previous studies (Table 2) [3, 18, 24, 27, 28, 30] .

The portent content was high in the three tuna species, ranged between 22.52–24.36%. The highest value ($P < 0.05$) for protein was recorded in longtail tuna, while the lowest one ($P < 0.05$) was found in the yellowfin tuna. It's widely accepted that the average protein content in most fish is within the range of 16 to 21% [16, 29]. However, in tunas the protein content has commonly been reported to be at or beyond the high-end of this range (Table 2). In accordance with our present results, the values of protein have been found to be in the range of 22.6–24.8% in yellowfin tuna [2, 8, 27, 29, 32], 23.2–24.8% in longtial tuna [3, 4] and 20.7–24.2 in little tuna [18, 24].

Table 2. Proximate composition (%, wet weight) of the three species of tuna from studies conducted in regional areas

Tuna species	Composition				Reference
	Moisture	Protein	Lipid	Ash	
Yellowfin	***74.00 ± 1.08***	***22.52 ± 0.15***	***2.46 ± 0.07***	***1.25 ± 0.02***	***Present study***
	(69.56–72.96)	24.82 (20.18–26.41.7)	2.88 (2.24–4.59)	(1.35–2.26)	Al-Busaidi et al., 2015
	73.1 (71.9–74.3)	24.7 (24.0–25.3)	0.7 (0.56–0.90)	1.3 (1.3–1.4)	Ali et al., 2013
	73.28	23.18	1.52	1.52	Biji et al., 2016
	72.44	21.42	0.88	1.12	Karunarathna and Attygalle, 2010
	72.67	23.33	1.79	2.62	Mohan et al., 2015
	71.50	26.25	1.28	1.18	Mumthaz et al., 2010
	73.25	22.59	0.64	1.83	Murthy et al., 2012
	73.57	23.52	1.93	1.54	Peng et al., 2013
Longtail	***70.13 ± 1.20***	***24.36 ± 0.17***	***4.66 ± 0.06***	***1.37 ± 0.02***	***Present study***
	72.50	23.19	2.85	1.52	Al-Busaidi et al., 2011
	72.8 (71.8–73.9)	24.8 (24.7–24.8)	1.8 (0.60–3.08)	1.2 (1.1–1.2)	Ali et al., 2013
	71.0	23.2	4.2	1.4	Kumar et al., 2017
Little	***71.70 ± 1.30***	***24.04 ± 0.01***	***2.34 ± 0.07***	***1.37 ± 0.01***	***Present study***
	73.41	20.73	0.60	1.03	Karunarathna and Attygalle, 2010
	72.00	22.00	4.40	1.30	Kumar et al., 2017
	73.10	24.20	1.37	1.43	Maheswara et al., 2011
	70.15	27.73	0.39	1.20	Mumthaz et al., 2010

Lipid was much higher ($P < 0.5$) in longtial at 4.66%, than in yellowfin tuna (2.46%) and little tuna (2.34%). Tunas are usually categorized as lean fish, where their lipid content is usually lower than 5% [16]. Our results agreed with this classification, and are comparable to several earlier studies (Table 2), in which the lipid content was found to be in the range of 1.8–2.9% in yellowfin tuna [2, 27, 32] and at 4.40% in longtail tuna [22]. On the other hand, different values of lipid have been also reported for the same species (Table 2). Noticeably lower values were found in these fish, ranged between 0.64% to 1.53% in yellwofin tuna [4, 8, 18, 28, 30], 0.60% to 3.08% in longtail tuna [3, 4] and 0.39% to 1.37% in little tuna [18, 24, 28]. Besides, high lipid content was reported in little tuna, at 4.4% [22]. The lipid fraction of fish is the component that shows the greatest variation [16] and such differences in lipid content is well-established even within the same species due to season, geographical location as well as variations in age and maturity [33].

Ash content was higher, in longtail tuna and little tuna, with the same value of 1.37%, compared with a lower value of 1.25% in yellowfin tuna. According to Sidwell [36], ash content in fish muscle can be widely varied between 0.5% and 1.8%. As regarding to tuna particularly, ash values earlier recorded in the three species of tuna investigated in the current work has been reported to be around our results [2, 3, 4, 18, 24, 28].

Fatty acid composition:

The fatty acid compositions of fish samples are shown in Table 3. The general trend of the fatty acid profiles of the three tuna species were almost comparable. However, statistical analysis showed significant differences ($P < 0.05$) between the three fishes in values for the majority of fatty acids.

Table 3. Fatty acid composition (%) of tuna samples[1]

Fatty acid	Species			Significance[2]
	Yellowfin	Longtail	Little	
Saturated fatty acids (saturates)				
C12:0	0.02 ± 0.00	0.08 ± 0.01	0.06 ± 0.01	*
C14:0	2.73 ± 0.18	4.53 ± 0.10	4.19 ± 0.32	*
C16:0	20.59 ± 0.14	19.69 ± 0.30	24.05 ± 0.84	*
C18:0	8.42 ± 0.22	7.85 ± 0.0.6	8.47 ± 0.03	*
Monounsaturated fatty acids (monoenes)				
C16:1n7	4.71 ± 0.02	5.88 ± 0.16	4.91 ± 0.18	*
C18:1n9	14.36 ± 0.31	15.75 ± 0.01	11.62 ± 0.08	*
C18:1n7	3.13 ± 0.12	ND[3]	2.64 ± 0.05	*
C20:1n9	1.44 ± 0.06	2.26 ± 0.04	0.94 ± 0.01	*
C22:1n11	1.08 ± 0.04	1.98 ± 0.05	0.47 ± 0.07	*
Polyunsaturated fatty acids (PUFA)				
C18:2n6	1.54 ± 0.05	1.76 ± 0.01	1.54 ± 0.02	*
C18:3n6	0.43 ± 0.01	0.52 ± 0.13	0.33 ± 0.02	*
C18:3n3	0.54 ± 0.01	0.84 ± 0.01	0.58 ± 0.05	*
C18:4n3	0.58 ± 0.02	0.60 ± 0.01	0.75 ± 0.03	*
C20:3n6	0.18 ± 0.01	0.21 ± 0.00	0.16 ± 0.02	*
C20:4n6	2.32 ± 0.01	1.74 ± 0.02	2.02 ± 0.07	*
C20:3n3	0.09 ± 0.00	0.19 ± 0.00	0.08 ± 0.00	*
C20:4n3	0.29 ± 0.00	0.32 ± 0.01	0.24 ± 0.01	*
C20:5n3	3.73 ± 0.03	4.66 ± 0.04	3.84 ± 0.09	*
C22:5n6	0.44 ± 0.01	0.38 ± 0.03	0.29 ± 0.01	*
C22:5n3	1.69 ± 0.10	1.50 ± 0.04	1.11 ± 0.03	*
C22:6n3	19.76 ± 1.17	18.49 ± 0.37	20.48 ± 1.02	*
Total saturates	31.76 ± 0.10	32.15 ± 0.35	36.77 ± 1.20	*

Total monoenes	24.72 ± 0.50	25.87 ± 0.08	20.58 ± 0.27	*
Total PUFA	31.59 ± 0.99	31.21 ± 0.57	31.42 ± 1.33	NS
Total n-3 PUFA	26.68 ± 1.03	26.60 ± 0.36	27.08 ± 1.23	NS
Total n-6 PUFA	4.91 ± 0.05	4.61 ± 0.20	4.34 ± 0.09	*
n-3: n-6	5.43 ± 0.26	5.77 ± 0.18	6.24 ± 0.15	*

1Values were reported as means ± S.D. of duplicate groups of 5 fish (n = 10).
* Significant ($P < 0.05$); - not significant ($P \geq 0.05$).
3ND = nondetectable.

Saturated fatty acids (SFA) were the most predominate class of fatty acids in the three fishes, with values in the range of 31.76–36.77%. This followed by polyunsaturated fatty acids (PUFA) whose also found in high levels, ranged from to 31.21–31.59 %. Whereas, monounsaturated fatty acids (MUFA) were the least abundant class at 20.58–25.87% of total fatty acids. High levels of omega-3 PUFA were found in all of the three tunas, representing about 27% and 85% of total fatty acids, and total PUFA, respectively. These omega-3 PUFA were primarily comprise of DHA (69.51–75.63%), and then EPA (13.98–17.52%). Whereas, omega-6 PUFA were recorded at low levels, representing 4.34–4.91% and 13.81–15.54% of total fatty acids, and total PUFA, respectively.

As for individual fatty acids, the most abundant fatty acids for all fish were similar, as follows; palmitic acid (16:0) > DHA (22:6n-3) > oleic acid (18:1n9) > stearic acid (18:0) > palmitoleic acid (16:1n-7) at proportions of 19.69–24.05%, 18.49–20.48%, 11.62–15.75%, 7.85–8.47% and 4.71–5.88% respectively.

The general trend of the classes and individual fatty acids recorded in tunas analyzed in the current study is very common for many species of marine fish, particularly from warm waters including but not excluding to Indian oil sardine and Spanish mackerel [23], threadfin bream [31] and Indian mackerel from the same area [10]. Concerning tuna particularly, comparable trend has been recorded in yellowfin tuna collected from the Indian coast of the Arabian Sea [5]. Khoddami et al. [20] have also reported that SFA and palmitic acid were the predominate among the classes and individual fatty acids in the lipid fraction of head, intestine and liver of little tuna. Whereas, high levels of PUFA and low levels of SFA and MUFA, with DHA was the most abundant fatty acid have characterized the fatty acid profile of the same species of tuna caught from various areas of Arabia Sea including Oman [2, 13], India [8, 28] and Sri Lanka [18] (Table 4).

Table 4. Polyunsaturated fatty acid (%) of the three species of tuna from studies conducted in regional areas

Tuna species	Composition				Reference
	PUFA	omega-3 PUFA	EPA	DHA	
Yellow fin	***31.59***	***26.68***	***3.73***	***19.76***	***Present study***
	28.45	10.10	0.43	8.30	Aneesh et al., 2012
	58.79	51.24	5.51	45.14	Biji et al., 2016
	72.36	61.09	~ 16 [1]	~ 10 [1]	Karunarathna and Attygalle, 2010
	39.60	32.90	6.70	20.50	Liyanage et al., 1989
	52.40	NA[2]	5.90	47.60	Mumthaz et al., 2010
	218.09	185.20	29.35	148.28	Al-Busaidi et al., 2015[3]
Long tail	***31.21***	***26.60***	***4.66***	***18.49***	***Present study***
	53.77	50.61	4.91	38.83	Guizani et al., 2014[3]
Little	***31.42***	***27.08***	***3.84***	***20.48***	***Present study***
	59.80	NA[2]	5.90	47.30	Mumthaz et al., 2010

1EPA and DHA values estimated from the available figure.
2NA; data not available.
3Expressed as mg of fatty acids per 100 g of wet tissue.

It's well established that the fatty acid profile of fish differs greatly from species to another and within the same species depending on feeding, age, sexual maturity, season and environmental variables such as temperature, pH, and salinity [14, 15, 19, 31, 34]. For example, Khan et al. [19] observed some differences in the fatty acid composition of kingfish (*Scomberomorus commerson*) from two coastal regions of Oman with different environmental conditions; Batinah (on the Gulf of Oman) and Dhofar (on the Arabian Sea).

One of the most important features highlighting the nutritional value of fish as a healthy food is their lipids of high omega-3 PUFA [26, 35]. In the present study, the high levels of omega-3 PUFA reported in all tuna in the present study (ranged from 26.60 to 27.08%), being comparable to the levels of omega-3 PUFA reported for some well-known commercial fish oils such as Atlantic mackerel, *Scomber scombrus* (18.8%) and Japanese sardine, *Sardinops melanosticta* (25.9%) [1]. The n-3/n-6 PUFA ratio is also used as a good indicator to compare the nutritional value of fish oils. In the current study, high value of this index was found in the three tunas at 5.43 – 6.24%. In modern human diets, due to the combination of decreasing the consumption of fish and other n-3 PUFA-rich foods, together with the steady increase in dietary vegetable oils rich in n-6 PUFAs, the ratio of n-3/n-6 has significantly decreased to 1:4–1:6 in Eastern diet and 1:15–1:20 or greater in Western diet [39]. While, the n3/n6 ratio that has been recommended to be optimal for nutritional purposes is 1:1 [38]. Hence, the high n3/n6 ratio found in the three tunas in the current study (at 5.44–6.23%) indicates that the consumption of these fishes is supposedly beneficial for balancing the n3/n6 ratio in our diet.

The overall results of the current study revealed that all the three tuna species are good sources for nutrients, principally proteins, omega-3 PUFA and DHA. Further studies are required to provide more detailed data on the nutritive values of these fish, especially the amino acid and mineral compositions as well as the seasonal variation of these components.

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References:

1- Ackman, R., 1990. Seafood lipids and fatty acids. Food Reviews International 6, 617-646.
2- Al-Busaidi, M., Poulose, Y., Al-Rabhi, W., Al-Harthy, K., Al-Waili, A., Al-Mazrooei, N., Al-Habsi, S., 2015. Fatty acid profile and selected chemical contaminants in yellowfin tuna from the Arabian Sea. International Journal of Food Properties 18, 2764-2775.
3- Al-Busaidi, M.A., Yesudhason, P., Al-Falahi, K.S., Al-Nakhaili, A.K., Al-Mazrooei, N.A., Al-Habsi, S.H., 2011. Changes in scomberotoxin (histamine) and volatile amine (TVB-N) formation in longtail tuna (*Thunnus tonggol*) stored at different temperatures. Sultan Qaboos University Research Journal-Agricultural and Marine Sciences 16, 13-22.
4- Ali, A., Al-Abri, E., Goddard, J., Ahmed, S., 2013. Seasonal variability in the chemical composition of ten commonly consumed fish species from Oman. Journal of Animal and Plant Sciences 23, 805-812.
5- Aneesh, P., Varkey, J., Anandan, R., Mathew, S., Asha, K., Lakshmanan, P., Sankar, T., Mohanty, B., 2012. Omega-3 polyunsaturated fatty acid profile of four Indian food fishes of Arabian Sea. Nutritional Medicine Health and Wellness 1, 295-300.
6- AOAC, 1997. Official methods of analysis of the AOAC international 16 ed. AOAC International, Arlington, VA, USA.
7- Bahurmiz, O.M., Adzitey, F., Ng, W.K., 2017. Nutrient and fatty acid composition of the flesh of oil sardine (*Sardinella longiceps*) and Indian mackerel (*Rastrelliger kanagurta*) from Hadhramout coast of the Arabian Sea, Yemen. International Food Research Journal 24, 2387-2393.
8- Biji, K., Kumari, K., Anju, K., Mathew, S., Ravishankar, C., 2016. Quality characteristics of yellowfin tuna (*Thunnus albacares*) in the fish landing centre at Cochin, India. Fishery Technology 53, 313-319.
9- Bligh, E.G., Dyer, W.J., 1959. A rapid method of total lipid extraction and purification. Canadian Journal of Biochemistry and Physiology 37, 911-917.
10- Cahu, C., Salen, P., De Lorgeril, M., 2004. Farmed and wild fish in the prevention of cardiovascular diseases: Assessing possible differences in lipid nutritional values. Nutrition, Metabolism and Cardiovascular Diseases 14, 34-41.
11- Garrido, S., Rosa, R., Ben-Hamadou, R., Cunha, M.E., Chícharo, M.A., van der Lingen, C.D., 2008. Spatio-temporal variability in fatty acid trophic biomarkers in stomach contents and muscle of Iberian sardine (*Sardina pilchardus*) and its relationship with spawning. Marine Biology 154, 1053-1065.
12- Gokoglu, N., Yerlikaya, P., 2015. Seafood chilling, refrigeration and freezing: science and technology. John Wiley & Sons.
13- Guizani, N., Rahman, M.S., Al-Ruzeiqi, M.H., Al-Sabahi, J.N., Sureshchandran, S., 2014. Effects of brine concentration on lipid oxidation and fatty acids profile of hot smoked tuna *(Thunnus albacares*) stored at refrigerated temperature. Journal of Food Science and Technology 51, 577-582.
14- Haliloğlu, H.İ., Bayır, A., Sirkecioğlu, A.N., Aras, N.M., Atamanalp, M., 2004. Comparison of fatty acid composition in some tissues of rainbow trout (*Oncorhynchus mykiss*) living in seawater and freshwater. Food Chemistry 86, 55-59.
15- Hong, H., Fan, H., Wang, H., Lu, H., Luo, Y., Shen, H., 2015. Seasonal variations of fatty acid profile in different tissues of farmed bighead carp (*Aristichthys nobilis*). Journal of Food Science and Technology 52, 903-911.
16- Huss, H.H., 1995. Quality and quality changes in fresh fish. Food and Agriculture Organization, Rome, Italy.
17- Huynh, M.D., Kitts, D.D., 2009. Evaluating nutritional quality of pacific fish species from fatty acid signatures. Food Chemistry 114, 912-918.
18- Karunarathna, K., Attygalle, M., 2010. Nutritional evaluation in five species of tuna. Vidyodaya Journal of Science 15, 7-16.
19- Khan, A., Al-Oufi, H., McLean, E., Goddard, S., Srikandakumar, A., Al-Sabahi, J., 2003. Analysis of fatty acid profiles of kingfish (*Scomberomorus commerson*) from different coastal regions of Sultanate of Oman. International Journal of Food Properties 6, 49-60.
20- Khoddami, A., Ariffin, A., Bakar, J., Ghazali, H., 2012. Quality and fatty acid profile of the oil extracted from fish waste (head, intestine and liver)(*Euthynnus affinis*). African Journal of Biotechnology 11, 1683-1689.
21- Kris-Etherton, P.M., Harris, W.S., Appel, L.J., 2002. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circulation 106, 2747-2757.
22- Kumar, V., Farejiya, M., Dikshit, A., Siva, A., Rama Rao, K., Mali, K., 2017. Proximate Composition, nutritive value and share of protien to the diet of coastal population from four neritic tunas occurring along North Western Indian EEZ. International Journal of Educational Research and Technology 8, 34-40.
23- Liyanage, D., Wijesundera, R., Wikramanayake, T., 1989. Some nutritionally important fatty acids in seven varieties of fish eaten in Sri Lanka. Ceylon Journal of Medical Science 32, 23-32.
24- Maheswara, K., Raju, C., Naik, J., Prabhu, R., Panda, K., 2011. Studies on thermal processing of tuna-A comparative study in tin and tin-free steel cans. African Journal of Food, Agriculture, Nutrition and Development 11, 5539-5560.
25- Ministry of Fish Wealth, 2015. Quantity and value of production of fish and other marine life caught (traditional fishing) by the coastal provinces, institutions and companies for the year 2012. Ministry of Fish Wealth, Sana'a, Yemen.
26- Mısır, G., Tufan, B., Köse, S., 2016. Variations in total lipid and fatty acid contents of edible muscle,

liver, and roes of spotless shad, *Alosa immaculata*, during catching season in Black Sea. Journal of Aquatic Food Product Technology 25, 2-14.
27- Mohan, C.O., Remya, S., Murthy, L.N., Ravishankar, C.N., Asok Kumar, K., 2015. Effect of filling medium on cooking time and quality of canned yellowfin tuna (*Thunnus albacares*). Food Control 50, 320-327.
28- Mumthaz, V., Yathavamoorthi, R., Thomas, A., James, R., Gopal, T., 2010. A comparative evaluation of the biochemical composition of three tuna species, National Seminar on Conservation and Sustainability of Coastal Living Resources of India. Society of Fisheries Technologists (India), Cochin, India, pp. 742-753.
29- Murray, J., Burt, J., 1969. The composition of fish. Torry Research Station, Aberdeen, Scotland.
30- Murthy, L., Rao, B., Prasad, M., 2012. Biochemical and microbiological evaluation of tuna Loin processing waste. Fishery Technology 49, 45-49.
31- Osman, F., Jaswir, I., Khaza'ai, H., Hashim, R., 2007. Fatty acid profiles of fin fish in Langkawi Island, Malaysia. Journal of Oleo Science 56, 107-113.
32- Peng, S., Chen, C., Shi, Z., Wang, L., 2013. Amino acid and fatty acid composition of the muscle tissue of yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*). Journal of Food and Nutrition Research 1, 42-45.
33- Pigott, G.M., Tucker, B., 1990. Effects of technology on nutrition. Marcel Dekker Inc., New York, USA.
34- Sahena, F., Zaidul, I., Jinap, S., Saari, N., Jahurul, H., Abbas, K., Norulaini, N., 2009. PUFAs in fish: Extraction, fractionation, importance in health. Comprehensive Reviews in Food Science and Food Safety 8, 59-74.
35- Sidhu, K.S., 2003. Health benefits and potential risks related to consumption of fish or fish oil. Regulatory Toxicology and Pharmacology 38, 336-344.
36- Sidwel, V., 1981. Chemical and nutritional composition of finfishes, whales, crustaceans, mollusks, and their products. NOAA Washington, DC, p. 432.
37- Simopoulos, A.P., 1991. Omega-3 fatty acids in health and disease and in growth and development. The American Journal of Clinical Nutrition 54, 438-463.
38- Simopoulos, A.P., 2002. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomedicine and Pharmacotherapy 56, 365-379.
39- Simopoulos, A.P., 2008. The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. Experimental Biology and Medicine 233, 674-688.

التركيب الكيميائي والأحماض الدهنية للحوم ثلاثة أنواع من أسماك التونة من ساحل حضرموت على بحر العرب، اليمن

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الملخص

أجريت هذه الدراسة للتعرف على التركيب الكيميائي التقريبي (محتوى الرطوبة، والبروتين، والدهن، والرماد)، وتركيب الأحماض الدهنية للحوم ثلاثة أنواع من أسماك التونة هي الثمد (التونة صفراء الزعنفة (Thunnus albacares) ، والزينوب (التونة طويلة الذيل) (T. tonggol) ، والشروي (التونة الصغيرة) (Euthynnus affinis) المصطادة من ساحل حضرموت على بحر العرب. أظهرت النتائج أن محتوى البروتين كان عالياً في جميع الأنواع (تراوح بين 22.52% إلى 24.36%). وتراوحت قيم الرطوبة، والدهن، والرماد في لحوم الأنواع الثلاثة من التونة بين 70.13–74.0%، و 2.34–4.66%، و 1.25–1.37%، على التوالي. أظهرت نتائج تركيب الأحماض الدهنية أن نسبة مجموعة الأحماض الدهنية المشبعة كانت هي الأعلى من بين مجاميع الأحماض الدهنية الأخرى في جميع الأسماك (31.76–36.77%)، تليها الأحماض الدهنية عديدة عدم التشبع (31.21–31.59%)، ثم الأحماض الدهنية وحيدة عدم التشبع (20.58–25.87%). وفيما يتعلق بالأحماض الدهنية المفردة، فقد جاء حمض النخيل(palmitic acid) ، وحمض docosahexaenoic acid (DHA) وحمض الزيت (oleic acid) في مقدمة الأحماض الدهنية لهذه الأسماك، وبقيم بلغت 19.69–24.05%، و 18.48–20.48%، و 11.62–15.75%، على التوالي. احتوت لحوم هذه الأسماك على نسب متشابهة من الأحماض الدهنية عديدة عدم التشبع من فئة الأوميقا – 3 (تراوحت بين 26.60–27.08%) ، أسهم في معظمها الحمض الدهني docosahexaenoic acid (DHA) ، بنسبة 69.51–75.63%، يليه الحمض الدهني eicosapentaenoic acid (EPA)، بنسبة 13.98–17.52%. يتبين من هذه نتائج أن الأنواع الثلاثة من أسماك التونة المدروسة في هذا العمل، ذات قيمة غذائية جيدة، وبالذات من حيث محتواها من البروتين، والأحماض الدهنية عديدة عدم التشبع من فئة الأوميغا – 3.

الكلمات المفتاحية: التركيب الكيميائي، الأحماض الدهنية، أسماك التونة، حضرموت، اليمن.