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QUALITY OF FISH OIL EXTRACTED FROM INDUSTRIAL FISH WASTE AS AFFECTED BY HEAT TREATMENT AND EXTRACTION METHODS

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ABSTRACT: ***Influence of steaming, dry heating and cold extraction of oil from Mackerel and Sardine offal on the percentage of oil extraction and its physicho-chemical properties including fatty acids composition were investigated. The results revealed that mackerel offal had significantly (p<0.05) higher oil percentage (63.7%) than that of sardine (35.5%). Heat process leads to increase the percentage of oil extraction. Refractive index (RI) was significantly (p <0.05) decreased by increasing the temperature of fish offal before solvent extraction. The color of oil tends to be darker as the fish offal subjected to heat treatment (either moist or dry heat) prior to extraction. Acid value of extracted oil from steamed fish offal was significantly (p <0.05) increased, while the lowest value was detected in the oil extracted from offal subjected to dry heating at 105ºC for 30 min. Peroxide value of fish oil was significantly (p<0.05) increased as the temperature of offal increased before extraction. The TBArs value was significantly (p<0.05) increased to reach the maximum in the oil extracted from fish offal by 30% sodium sulfate, while the lowest value was found in the oil extracted from offal treated by dry heating at 50ºC for 30 min. Sponification value of extracted oil from fish offals subjected to steaming was significantly (P>0.05) increased. The main fatty acids in fish oil were $C_{16:0}$, $C_{18:1n-9}$, $C_{18:2n-6}$, $C_{20:1n-11}$, $C_{18:3n-3}$, $C_{22:5n-3}$ and $C_{22:6n-3}$. Contrary, the minor fatty acids were $C_{20:0}$ and $C_{20:3n-3}$. Both Mackrerel and sardine contain a suitable amount of Omega fatty acid. Sardine has lower polyunsaturated omega fatty acids than that of Mackerel oil. Therefore, oil extracted from fish Mackerel and Sardine offal can be used as a good source of ω-3 and ω -6 fatty acids.***

Key Words*: fish offal, oil extraction, fatty acids, omega 3 fatty acids, polyunsaturated fatty acids, physicoshemical properties*

INTRODUCTION

Fish oil contains high levels of polyunsaturated fatty acids (Navarro-Garcia *et al*, 2004) especially omega-3 fatty acids as eicosapentaenoic acid $C_{20:5n3}$ (EPA) and docosahexaenoic acid $C_{22:6n3}$ (DHA) which they have an important roles to prevent some human chronic diseases such as cardiovascular, coronary diseases, anti-inflammatory and anti-thrombosis

effects (Conner, 2000 and JHCI, 2005) and some types of cancer (Marchioli 2001). Also fish oil reduces some risk factors associated with arteriosclerosis (Calder, 2004). Also, n-3 and n-6 polyunsaturated fatty acids are considered essential but since they cannot be synthesized in the human body, they must be obtained through diet (Mahan & Escott-Stump, 2005). Offal from the fishing industry could be used to produce fish meal, which represents a valuable source of high quality protein and energy (New 1996; Gabrielsen & Austreng 1998). Added to that fish oils could be extracted from fish offal which is used in food industry as new raw materials and ingredients (Jacobs et al ,1997). As a matter of fact, utilization of fish processing by-product is an important due to environmental regulations and to gain more values from the byproducts (Smiley *et al.,* 2003). It could predict that fish viscera rich with lipid (45- 80%) constitute about 34 % of the whole fish by-product (Crapo and Bechtel 2003).

Marine fish oil is normally extracted from precious fish such as sardine, tuna, cod and menhaden (Boran *et al*, 2006). In Egypt, Mackerel and Sardine fish are canned and a large amount of their offal including fish viscera is discarded. Satue and Lopez (1996) mentioned that lipid in marine fish viscera is rich in polyunsaturated fatty acids. So this work aimed to produce fish oil from the waste of canned fish through suitable extraction method. Physico-chemical properties and fatty acids composition of the extracted fish oils were also investigated.

MATERIALS AND METHODS

Samples of two different fish spices Mackerel (*Scomberomorus commerson*) and Sardine (*Sardinella aurita*) were obtained from local fish market during summer of 2006 (Alexandria, Egypt). They were prepared according to the common household practices, such as evisceration, removing head, backbone, skin, tail and fins yielding two portions of fillets and offal. The offal of each fish type individually collected and then randomly divided into 5 homogenous portions of ~500 g each, which were subjected to oil extraction after heat treatments.

Fish oil extraction

Fish offal of sardine was divided into 5 portions. Fish oil was extracted from the first portion by ethanol chloroform (1:2 v/v) solvent at room temperature as described by Folch *et al* (1957) and treated as control sample. Fish oil was also cold extracted from the second portion by adding 30% anhydrous sodium sulfate (30% w/w) to the offal homogenate and mixed for 3 min, then centrifuged at 1150*g* for 20 min at 25°C according to McGill and Moffat (1992) (T_1). Crude oil at the top layer was collected and the yield was determined according to the following Equation:

$$\text{Yield \%} = \frac{wt\ of\ crude\ oil \times 100}{wt\ fish\ offal}$$

The third portion of fish offal was steamed in an autoclave at (~100°C) for 30 min (T_2). While the fourth and fifth portions of fish offal were subjected to dry heating in an electric oven, individually, at 105°C (T_3) and 50°C (T_4) for 30 min, respectively. The oil content of 50 g aliquot of heated fish offal homogenate was immediately determined by Sohxlet extraction according to AOAC (1995 method 948.16) using petroleum ether as a solvent. The same procedures were repeated with mackerel fish offal.

The extracted oil from the five methods was divided, individually, into 15 ml aliquots in Teflon tight caped small glass vials and stored at −30°C under nitrogen gas till further analysis. Chemical and physical properties as well as fatty acids composition of fish oil were determined.

Determination of Some Physical Properties

Some physical properties of extracted fish oil including refractive index (RI) using Abeé refractometer at 20°C (methods 921.08) was determined following the methodology outlined in the AOAC (1995) and oil color was measured by Leavobond tentometer (model E AF 900UK) using a (5-25 ml) cell following the procedure of AOCS (1998) (Method Cc 1e-92).

Determination of Some Chemical Properties

Acid value (AV), saponification value (SV) (method 921.160), peroxide value (PV) was determined according to the AOCS (1998) Official Method Cd-8b-90 (n = 3, a = 1). and thiobarbeturic acid reactants (TBArs) of the extracted fish oil were carried out according to the method described in AOAC (1995). Physical and chemical properties of extracted fish oils were done in triplicates.

Determination of Fatty Acids Composition

Fatty acids composition of fish oil was performed by converting about 5 mg oil containing 200 µg pentadecanoic acid ($C_{15:0}$) as an internal standard to their fatty acid methyl esters with a mixture of methanol: sulfuric acid (32:1 v/v) according to Atta and Imaizumi (2002). The fatty acid methyl esters derived from the oil were analyzed in a Shimadzu GC-14A Gas Chromatograph on a 30-meter (0.32 mm) glass capillary column coated with OMEGA wax 320 equipped with an FID detector. The chromatographic conditions were: injection port and detector temperature were 240°C and 260°C, respectively. The temperature program was 50 to 220°C. An electronic laboratory data system, Shimatzu C-R 5A Chromatopac (chart speed 10 mm/min), was used. The injector volume was 1 µl (fatty acid methyl esters). Identification of fatty acid methyl esters was based on comparison of retention times of unknown peaks to the authentic fatty acid methyl esters. The quantity of each fatty acid methyl ester was estimated by comparison with the known amounts of pentadecanoic methyl ester. Fatty acids composition was expressed as weight percentage of total fatty acid methyl ester.

STATISTICAL ANALYSIS

Means are the average of three determinations and standard deviation (SD) were calculated using Excel Microsoft version (2003). The data were subjected to conformation of homogeneity of variance, and then comparisons between means were determined by one-way ANOVA. Significance was accepted at probabilities of 0.05 or less and, where appropriate.

RESULTS AND DISCUSSION

Percentage of Oil Extraction

As shown in Table (1) and percentage of extracted oil from fish offal was varied according to the extraction method and the type of fish. For instance, mackerel offal had significantly (*p<0.05*) higher oil percentage (63.7%) than that of sardine (35.5%). Also it was observed that heating process lead to increase the percentage of oil extraction. Since, the highest amount of oil (56.1%) was obtained from the offal's subjected to dry heating in an electric oven at 105°C for 30 min (T_3), which was not significantly different than fish offal subjected to steaming in autoclaved at (~100°C) for 30 min (T_2). On the other hand, the lowest amount of oil (41.0%) was gained by cold extraction using 30% anhydrous sodium sulfate and centrifugation (T_1). The increment in oil extraction from fish offal may be due to the fact that lipid cells were ruptured to a greater extent with 85ºC. Moreover, cooking can coagulate the protein of fish offal so that liquids and solids can be mechanically separated. These results are in agreement with those reported by Chantachum, *et al* (2000).

Table (1): Yield Percentage of oil extracted from both Mackerel and Sardine offal's as affected by heat treatment and extraction methods

Treatments	Mackerel	Sardine	Mean
Control (Folch *et al*, 1957)	58.5 ± 6.2	32.2 ± 3.3	45.4 ± 4.7 [c]
T_1 (Cold extraction)	51.9 ± 4.6	30.1 ± 3.2	41.0 ± 3.7 [d]
T_2 (Steaming ~100°C for 30 min)	69.9 ± 5.6	40.9 ± 3.9	55.4 ± 4.7 [a]
T_3 (Dry heating 105°C for 30 min)	71.5 ± 7.2	40.6 ± 4.6	56.1 ± 6.0 [a]
T_4 (Dry heating 50°C for 30 min)	66.8 ± 8.8	35.8 ± 3.7	51.3 ± 6.1 [b]
Average ± SD	63.7 ± 6.3**	35.5 ± 3.6	

In the columns, means having the same superscript small letters are not significantly different at 0.05% level

**** High significant at 0.01% level**

Refractive Index (RI) and Color of Extracted Oil

As shown in Table (2) refractive index (RI) of oils extracted from untreated Mackerel and Sardine offal were 1.4811 and 1.4791, respectively. The value was markedly decreased by increasing the temperature of fish offal before solvent extraction. For the meantime, no markedly change was found between control oils and oils extracted from offal by 30% sodium anhydrous sulfate (T_1). The oil extracted from untreated Sardine offal had reddish yellow

color, while the color of oil extracted from untreated Mackerel offal was bright yellow. The color of Sardine oil tend to be darker as the fish offal treated with heat (either moist or dry heat) prior to extraction process. This may be related to the reaction between the hydrolysed compounds of proteins and carbohydrates in fish offal during heat processing. Moreover, the peroxides products such as aldehydes, alcohols, ketones and carboxylic compounds well react with fish lipid and undergo browning reactions (Swern, 1964 and Fujimoto & Kaneda, 1973). As the result, oils extracted from heated fish offal tend to be darker than control one.

Table (2): Refractive index (RI) and color of extracted oil from Mackerel and Sardine offal as affected by offal treatment and extraction method.

Treatment	Mackerel oil				Sardine oil			
	R. I.	Color			R.I.	Color		
		R	B	Y		R	B	Y
Control (Folch *et al*, 1957)	1.4811	8	15	73	1.4791	22	15	70
T_1 (Cold extraction)	1.4810	5	17	70	1.4792	26	17	70
T_2 (Steaming ~ 100°C)	1.4772	5	17	70	1.4764	26	17	70
T_3 (Dry heating 105°C)	1.4792	5	17	70	1.4765	26	17	73
T_4 (Dry heating 50°C)	1.4805	5	17	70	1.4760	26	16	73

Value represents the average of three replicates

Some Chemical Properties of Extracted Oil

Acid value (AV)

Acid value (AV) or free fatty acid (FFA) is an important parameter to detect rancidity of oils and fats. As shown in Tables (3 and 4) the acid value of control Mackerel oil and Sardine oil was 3.15 and 3.95 mg KOH/ 100 g, respectively. It is obviously that acid value of Sardine oil was higher than that of Mackerel one. Acid value of oil extracted from fish offal's significantly (*p<0.05*) increased to 5.24 in both oils extracted from offal subjected to steaming for 30 min (T_2). The increase in acid value may be related to the effect of steaming which promote the breakdown of ester bonds between glycerol and fatty acids in the triglyceride (Erickson and Hung 1997). Since, lipid undergo hydrolysis in the presence of moisture and heat (Nawar, 1990). On the other hand, the lowest value was detected in the oil extracted from offal subjected to dry heating at 105ºC for 30 min (T_3). This decrease in acid value may be due to the loss of volatile fatty acids at high temperature (Bimbo 1990). These results are in agreement with those reported by El Marrakchi *et al* (1990) and Aidos *et al* (2003).

Table (3): Effect of offal treatment and extraction method on some chemical characteristics Mackerel oil

Treatment	Acid Value	Per. value	TBArs	Sapon. Value
Control (Folch *et al*, 1957)	3.15 ± 0.03^{c}	5.39 ± 0.04^{b}	1.59 ± 0.03^{b}	135 ± 0.0^{c}
T_1 (Cold extraction)	4.55 ± 0.02^{a}	6.16 ± 0.02^{b}	2.23 ± 0.00^{a}	159 ± 0.01^{b}
T_2 (Steaming ~ 100°C)	5.24 ± 0.04^{a}	8.78 ± 0.01^{a}	2.10 ± 0.00^{a}	210 ± 0.02^{a}
T_3 (Dry heating 105°C)	4.13 ± 0.02^{b}	5.13 ± 0.03^{c}	2.15 ± 0.00^{a}	190 ± 0.16^{a}
T_4 (Dry heating 50°C)	4.37 ± 0.02^{b}	10.37 ± 0.01^{a}	2.00 ± 0.00^{a}	147 ± 0.29^{b}

Table (4): Effect of offal treatment and extraction method on some chemical characteristics Sardine oil

Treatment	Acid Value	Peroxide Value	TBArs	Sapon. Value
Control (Folch *et a*l, 1957)	3.95±0.03^{b}	7.10±0.04^{c}	1.29±0.03^{c}	159±0.03^{c}
T_1 (Cold extraction)	4.67±0.02^{a}	8.76±0.02^{b}	2.23±0.00^{a}	179±0.01^{b}
T_2 (Steaming ~ 100°C)	5.24±0.04^{a}	9.85±0.01^{b}	1.70±0.00^{b}	239±0.02^{a}
T_3 (Dry heating 105°C)	3.97±0.02^{b}	7.13±0.03^{c}	1.95±0.00^{a}	210±0.16^{a}
T_4 (Dry heating 50°C)	4.00±0.02^{b}	14.10±0.01^{a}	1.20±0.00^{c}	190±0.29^{b}

In the column, means having the same superscript letters are not significantly different at 0.05% level

Peroxide value (PV)

Peroxide value of oils extracted from untreated fish offal was 5.39 and 7.10 mequ O_2 / kg for Mackerel and Sardine, respectively (Tables 3 and 4). The peroxide value for sardine oil seems to be higher than that of Mackerel. Generally, peroxide value of fish oil was significantly ($p<0.05$) increased as the temperature of offal treatment increased except T_3 of Sardine oil. Since, PV of control oils extracted from Mackerel were increased to 8.78 and 10.37 mequ O_2 / kg when the offal's subjected to steaming and dry heat at 50°C for 30 min (T_2 and T_4), respectively. The corresponding values for Sardine oil were 9.85 and 14.10 mequ O_2 / kg.. The increment of PV may be due to the presence of iron ions that released from offal proteins such as myoglobin which support the oxidation process of fish lipids (Decker and Xu, 1998). Converse, lower peroxide value of oil extracted from fish offal's subjected to high temperature (105°C for 30 min) may be explained by the decomposition of hydroperoxide that formed at low temperature and inhibition of lipoxygenase in the fish offal's during the heat treatment (German & Kinsella, 1985 and Chantachum, *et al*, 2000).

Thiobarbeturic Acid Reactive Substance (TBArs)

Results of Tables (3 and 4) revealed that TBArs value of oil extracted from Sardine offal's was (1.29 mg/kg) lower than that of mackerel (1.59 mg/kg). This could be explained by Mackerel oil involved more unsaturated fatty acids than that of Sardine. The TBArs value of oil was significantly (*$p<0.05$*) increased to reach the maximum 2.23 mg /kg in the oil extracted from Mackerel and Sardine offal's by 30% sodium sulfate (T_1). The TBArs was significant (*$p<0.05$*) increased in the oil extracted from offal's subjected to steaming as well as dry heating (T_2, T_3 and T_4) comparing with control. Whereas, TBArs value of oil extracted from offal's heated at 105ºC (T_3) was 2.15 and 1.95 mg/kg for Mackerel and Sardine, respectively, followed by oil extracted from offal's subjected to steaming (T_2) (2.10 and 1.70 mg/Kg). Contrary, the lowest value was found in the oil extracted from offal's treated by dry heating at 50ºC (T_4). The increase in TBArs value of oil may be related to the destruction of peroxides that created by oil and fat oxidation during heat treatments of fish offal. Since, TBArs test is based on the formation of

colored products when TBA is reacted with malonaldehyde or other TBArs which are presumed to be produced from oxidized lipids/fats (Kanner & Rosenthal, 1992). These results are in agreement with those reported by Zuta *et al* (2007)

Saponification value (SV)

Saponification value (SV) is an excellent parameter to determine the chain length of fatty acids in the oil and fats (Low and Ng, 1987). Oil extracted from untreated (control) Mackerel and Sardine offal saponification value was 135 and 159 mg KOH/g, respectively (Tables 3 and 4). This means that oil extracted from control Mackerel offal characterized by longer chain fatty acids than that found in Sardine one. It is clear that SV was significantly (P>0.05) increased owing to the increase in the temperature of heat treatment for both oils to reach 210 and 239 mg KOH/g in oil extracted from Mackerel and Sardine offal treated by steaming, respectively. Thus, augmentation in the SV of oil indicating that oil from control offal had higher molecular weight fatty acids than oil from heated offal. These results are in agreement with those reported by Chantachum et al (2000).

Fatty acid composition

The result in Table (5) displayed that the main fatty acids (> 5%) in Mackerel oil were $C_{16:0}$ (10.08%), $C_{18:0}$ (5.70%), $C_{16:1}$ (5.40%), $C_{18:1n-9}$ (15.20%), $C_{18:2n-6}$ (9.00%), $C_{20:1n-11}$(6.41%), $C_{18:3n-3}$ (10.83%), $C_{22:5n-3}$ (7.45%) and $C_{22:6n-3}$ (10.24%). While the major fatty acids in Sardine oil were C14:0 (7.90%), $C_{16:0}$ (10.90%), $C_{16:1}$ (5.62%), $C_{18:1n-9}$ (5.33%), $C_{20:1n-11}$ (10.87%), $C_{18:2n-6}$ (14.27%),$C_{18:3n-3}$ (14.00%), $C_{20:5n-3}$ (5.77%) and $C_{22:6n-3}$ (8.67%). Contrary, the minor fatty acids in both oils were $C_{20:0}$ (0.15% & 0.18%) and $C_{20:3n-3}$ (0.79% & 0.15%) for Mackerel and Sardine oils, respectively. It was obviously that Sardine has lower polyunsaturated omega fatty acids than that of Mackerel oil.

The predominant saturated fatty acid in both oils was palmitic. By analogous $C_{18:3n-3}$ the first polyunsaturated fatty acid followed by $C_{22:6n-3}$. Also, the major monounsaturated fatty acid in mackerel oil was oleic and $C_{20:1n-11}$ in Sardine oil.

Crude oils extracted from Sardine treated offal under different conditions had higher amounts of omega 3 and 6 fatty acid. In contrast, saturated fatty acids decreased. On the other hand, saturated fatty acids in Mackerel oil extracted from offal subjected to heat (T_2&T_3) increased, while it was decreased when the oil extracted from offal at low temperature (T_1&T_4). Moreover, oil extracted from treated Sardine offal had higher TU/TS ratio comparing with control one. While TU/TS ratio of mackerel oil augmented in T_1&T_4. Also it is interesting to note that n-3/n-6 ratio in the most oils extracted from treated offal increased except T_4 which was slightly decreased and ranged between 1.75 to 2.05 whereas optimum of omega 3

/omega 6 ratio should be 1/4 or more in the diet (FDA 2000). This may be related to lipooxygenase activity in fish offal at 50ºC (Kanner and Rosenthal, 1992).

Also, heating possibly resulted in a higher release of phospholipids located in the cell membrane. As a result, unsaponified matter was much higher in the oil from treated offal. Phospholipid has been reported to contain more polyunsaturated fatty acids than triglycerides (Stansby *et al* 1990). Therefore, the oil from fish offal's can be used as a good source for n-3 and n-6 fatty acids. These results are in agreement with (Chantachum *et al* 2000).

Table (5): Fatty Acid Composition of Fish Oil Extracted from Fish Offal's as Affected by Heat Treatment and Extraction Method

Fatty acid	Mackerel Offal					Sardine Offal				
	Co	T_1	T_2	T_3	T_4	Co	T_1	T_2	T_3	T_4
Saturated fatty acids										
C14:0	1.44	1.87	1.78	1.87	2.00	7.90	8.12	7.41	7.56	9.67
C15:0	0.46	0.41	0.42	0.38	0.39	0.48	0.45	0.41	0.45	0.38
C16:0	10.08	10.72	12.50	13.33	10.21	10.90	9.48	8.87	9.34	9.69
C18:0	5.70	3.34	3.41	3.04	4.17	1.49	1.61	1.52	1.50	1.99
C20:0	0.15	0.34	0.21	0.20	0.44	0.18	nd	0.80	nd	0.19
Total(TS)	*17.83*	*16.68*	*18.32*	*18.82*	*17.21*	*20.95*	*19.66*	*19.01*	*18.85*	*21.92*
Monounsaturated fatty acids										
C16:1	5.40	4.41	4.81	4.67	4.73	5.62	5.52	5.62	5.89	5.51
C18:1n-6	1.99	nd	nd	nd	nd	2.78	2.11	2.55	3.00	2.90
C18:1n-9	15.02	15.52	16.91	15.35	15.20	5.33	5.08	5.58	7.91	6.90
C20:1n-11	6.41	8.49	7.66	6.51	7.18	10.87	11.67	11.82	12.10	12.00
Total	*28.82*	*32.42*	*29.38*	*26.53*	*27.11*	*24.60*	*24.38*	*25.57*	*28.90*	*27.31*
Polyunsaturated fatty acids (ω6)										
C18:2n-6	9.00	9.99	12.41	11.17	12.88	14.27	14.65	15.55	14.45	14.07
C20:2n-6	0.46	0.33	0.30	0.36	0.21	1.27	1.28	1.34	1.41	1.30
C20:3n-6	2.12	2.55	2.40	2.30	2.25	0.24	0.12	0.18	0.19	0.90
C20:4n-6	3.80	2.31	2.34	2.38	2.95	0.53	0.33	0.41	0.45	0.31
C22:4n-6	1.83	1.90	1.11	1.85	0.50	0.13	0.12	0.23	0.25	0.13
Total	*17.21*	*17.08*	*19.56*	*18.06*	*18.79*	*16.02*	*16.50*	*17.71*	*16.75*	*16.71*
Polyunsaturated fatty acids(ω3)										
C18:3n-3	10.83	12.18	12.76	13.68	12.59	14.00	16.00	16.91	17.05	14.58
C20:3n-3	0.79	0.62	0.41	0.46	0.75	0.15	0.31	0.29	0.30	0.23
C20:5n-3	3.12	2.53	2.84	2.80	3.00	5.77	5.81	5.93	5.93	5.51
C22:5n-3	7.45	6.65	6.15	8.40	6.41	0.95	0.96	1.41	1.40	1.25
C22:6n-3	10.24	9.58	9.82	9.22	10.21	8.67	9.80	9.28	9.09	8.07
Total	*32.43*	*32.83*	*33.98*	*35.56*	*32.96*	*29.54*	*32.88*	*33.82*	*33.77*	*29.64*
TKFA (%)	96.29	98.01	98.24	97.97	96.07	91.11	93.42	96.11	98.27	95.58
TUFA (%)	3.71	1.99	1.76	2.03	3.93	8.89	6.58	3.89	1.73	4.42
TU (%)	78.46	82.33	82.92	80.15	78.86	70.16	73.76	77.1	79.42	73.66
TU/TS	4.40	4.94	4.32	4.26	4.58	3.35	3.75	3.92	4.21	3.36
n-3/n-6	1.88	1.92	2.05	1.97	1.75	1.84	1.99	1.91	2.02	1.77

TKFA = Total Known Fatty Acids, TUFA = Total Unknown Fatty Acids
TU = Total Unsaturated Fatty Acids, TS = Total Saturated Fatty Acids
n-3 / n-6 = Omega 3 Fatty Acids / Omega 6 Fatty Acids Ratio
nd= not detected

CONCLUSION

From these results, it would be expected that, fish oil extracted from industrial wastes of Mackerel and Sardine canning would be a good source of essential fatty acids especially n-3 and n-6 polyunsaturated fatty acids (EPA and DHA). Heat treatment either moist or dry heat could increase the percentage of the oil yield as well as inhibit liooxygenase. So that, oxidation process in the extracted oil decreases to the minimum. Also, heat treatment in general did not decrease the content of polyunsaturated fatty acids especially EPA and DHA in extracted oil.

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جودة زيت السمك المستخلص من مخلفات صناعة التعليب ومدى تأثره بالمعاملة الحرارية وطرق الاستخلاص

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الملخص العربي

تم دراسة تأثير تعريض مخلفات تعليب سمك السردين و الماكريل للحرارة الجافة والبخار وطرق استخلاص الزيت من هذه المخلفات على البارد على كمية الزيت المستخلص ومدى تأثر الصفات الكيماوية والطبيعية لهذا الزيت وكذلك محتوى الزيت من الأحماض الدهنية. وقد أوضحت النتائج المتحصل عليها أن مخلفات سمك الماكريل تحتوي على كمية أكبر من الزيت مقارنة بمخلفات سمك السردين كما أن تعريض هذه المخلفات لدرجة حرارة مرتفعة قبل عملة الاستخلاص تؤدي إلى زيادة كمية الزيت المستخلص مع انخفاض معامل انكساره. ويزداد رقم الحموضة ورقم التصبن للزيت المستخلص من المخلفات التي تعرضت للبخار بينما كانت أقل رقم حموضة للزيت المستخلص من المخلفات التي تعرضت لدرجة حرارة ١٠٥°م لمدة نصف ساعة في فرن التجفيف. يزداد رقم البيروكسيد للزيت بزيادة درجة الحرارة التي تعرضت لها المخلفات السمكية بينما كان أعلى قيمة لحامض الثيوباربيوتريك للزيت المستخلص على البارد بواسطة إضافة ٣٠% كبريتات الصوديوم اللامائية للمخلفات السمكية ثم الاستخلاص. هذا وتعتبر الأحماض $C_{16:0}$، $C_{18:1n-9}$، $C_{18:2n-6}$، $C_{20:1n-11}$، $C_{18:3n-3}$، $C_{22:5n-3}$ $C_{22:6n-3}$ هي الأحماض الدهنية الأساسية (تتواجد بنسبة اكبر من ٥%) بينما كانت الأحماض $C_{20:0}$ and $C_{20:3n-3}$ هي الأحماض الدهنية الموجودة بنسبة ضئيلة(تتواجد بنسبة أقل من ١%). عامة الزيت المستخلص من مخلفات تعليب سمك السردين والماكريل يمكن استخدامه في إنتاج الزيت الغني بالأحماض الدهنية عديدة عدم التشبع من النوع أوميجا (٣–٦).