

Original Research Paper

Analysis of the Omega-3 Fatty Acids Content in Commercial Omega-3 Supplements in Arab Gulf Countries

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Abstract: The objective of this study was to analyze and compare the eicosapentaenoic acid (C20:5n3; EPA) and docosahexaenoic acid (C22:6n3; DHA) content of omega-3 supplements sold in Arab Gulf Countries with the contents claimed on the product label. Thirty-one commercial supplements purchased from stores in 3 different countries (Saudi Arabia, Kuwait and Bahrain) had their fatty acid composition and content were analyzed using gas-chromatograph with a 100 m SP-2560 fused silica capillary column. The range of measured EPA was 5.09 to 469.63 mg per capsule and for DHA was 10.47 to 357.26 mg per capsule. The percentage of the stated label amount for EPA and DHA ranged from 6.5 to 138.6% and 10.9 to 126.3%, respectively. Using the U.S. Food and Drug Administration (FDA) labeling requirements where a supplement must contain at least 80% of the stated label amount of each component listed, only 43.8% of the supplements were compliant for EPA and 40.6% were compliant for DHA. Additionally, only 21.9% of the measured EPA and DHA fall within the 10% of the stated label amount. These results demonstrate that omega-3 supplements sold in Arab Gulf Countries is not being properly controlled by manufacturers or government agencies and quality testing is needed to ensure compliance.

Keywords: Fatty Acids Content, Commercial Brands, Omega-3 Supplements, Arab Gulf Countries

Introduction

During the past few decades, awareness towards the benefits of omega-3 fatty acids in human health and disease prevention has been increased. Well-documented research supports benefits of omega-3 fatty acids with reduction of cardiovascular morbidity and mortality, infant development, cancer prevention, optimal brain and vision functioning, arthritis, hypertension, diabetes mellitus and neurological/neuropsychiatric disorders (Tapiero *et al.*, 2002; Defilippis *et al.*, 2010; Kaur *et al.*, 2014).

Marine products, nuts, seeds and vegetable oils are rich sources of omega-3 fatty acids (Hunter, 1990; Kinsella, 1990; Whelan and Rust, 2006). Global health organisations recommend daily intake of 250-1000 mg EPA+DHA (GOED, 2019). However, there is a large gap between the actual and the recommended intake of omega-3 fatty acids. Due to low intakes of omega-3 fatty acids rich foods in many western populations, the supplementation of omega-3 fatty acids capsules to

diets seem to be the easiest and the quickest way to elevate the level of omega-3 fatty acids intake. Such products are sold in grocery retailers, pharmacies, health stores, internet retailing and others drug stores in many western societies. The global omega-3 market size was estimated at \$2.29 billion in 2018 and was estimated to expand at a Compound Annual Growth Rate (CAGR) of 9.7% from 2019 to 2025 (Grand View Research, 2019). Population in Arab Gulf Countries are facing epidemic of obesity and its metabolic syndrome. A study by (Al-Rubeaan *et al.*, 2014) showed that the prevalence of type-2 diabetes mellitus is 25.4%. In a study, (Alhyas *et al.*, 2011) reported the prevalence of overweight and obesity in adults in the region was 25-50 and 13-50%, respectively. The dramatic rise in diabetes and obesity represents a real threat to the population and signifies an increased risk of coronary artery disease if left untreated. Rising demand for supplements and functional foods along with increasing disposable income in Arab Gulf Countries

region is anticipated to boost the omega-3 market growth over the forecast period. The omega-3 products market in Middle East and Africa was expected to register a CAGR of 7.8%, during the 2019-2025 period (Grand View Research, 2019).

Intake of omega-3 fatty acids capsules was found to have positive effects in cardiovascular health, endothelial cell function and body immunological defense (Stenson *et al.*, 1992; Holub and Holub, 2004; Vu *et al.*, 2019). However, some consumer organizations and the results of some researches indicate that the composition and quality of omega-3 fatty acids supplements available on the market might not meet the proposed quality requirements (Albert *et al.*, 2015; Kleiner *et al.*, 2015; ConsumerLab, 2019). The growth in the popularity of the health benefits of omega-3 fatty acids in recent years has led to rapid growth in the number of omega-3 supplements available to consumers. Therefore, it is important that label claims for EPA and DHA are accurate. The objective of the current research was to determine and compare omega-3 fatty acids

content of omega-3 supplements sold in Arabic Gulf Countries with their label claims.

Materials and Methods

The purchases of omega-3 supplements samples were from three different countries (Saudi Arabia, Kuwait and Bahrain). Thirty-one omega-3 supplements sold in these countries was selected for this study. Supplements were from different stores and at various times of the year. From each supplement brand, we used a minimum of two samples (2 to 6) with different production dates to avoid bias related to seasonal variations. There were, however, two brands, where only one sample was used. Samples were air shipped to the USA and then immediately stored at 4°C until analyzed for fatty acids content. We excluded samples with apparent damages to containers/bottle or seals from this study. Supplements brand name, country of production and production dates are presented in Table 1. From every containers/bottle, oil from 4 different capsules was extracted and combined to obtain a composite sample for fatty acids analysis.

Table 1: Omega-3 supplements products information

Product name	Country of production	Production date	Antioxidant	Type of oil	EPA (mg)	DHA (mg)
Maxepa Forte	UK	Jun 2017	Vit E		310	210
Maxepa Forte	UK	Jun 2018	Vit E		310	210
Bio Marine	Denmark	Mar 2017			190	110
Bio Marine	Denmark	Aug 2017			190	110
Bio Marine	Denmark	Feb 2017			190	110
Bio Marine	Denmark	Mar 2018			190	110
Jamieson	Canada	Oct 2017		Wild salmon	180	120
Jamieson	Canada	Aug 2017		and fish oil complex Wild salmon and fish oil complex	180	120
Vitabiotics	UK	Feb 2017	Vit E		165	116
Vitabiotics	UK	Apr 2017	Vit E		165	116
JP Omega 3	KSA	Mar 2017			170	85
JP Omega 3	KSA	May 2017			170	85
JP Omega 3	KSA	Jan 2017			170	85
JP Omega 3	KSA	May 2018			170	85
Omacor	Holland	Jan 2017	Vit E		460	380
Omacor	Holland	Mar 2017	Vit E		460	380
Omacor	Holland	Apr 2017	Vit E		460	380
Omacor	Holland	Jul 2017	Vit E		460	380
Omacor	Holland	Sep 2017	Vit E		460	380
Omacor	Holland	Sep 2018	Vit E		460	380
Smarty	UAE	Sep 2017			60	282
Sedico	Egypt	Feb 2017			180	120
Sedico	Egypt	Dec 2017			180	120
GNC	USA	Jun 2018	Vit E		180	120
21st Century	USA	Dec 2017		Herring, anchovy, mackerel, Sardine, sprat, salmon	70	45
21st Century	USA	Apr 2018		Herring, anchovy, mackerel, Sardine, sprat, salmon	70	45
Nature's Bounty	USA	Dec 2017	Mixed natural tocopherol	Herring, anchovy, mackerel, Sardine	647	253
Nature's Bounty	USA	July 2017	Mixed natural tocopherol	Herring, anchovy, mackerel, Sardine	647	253
Mar in Oil	Spain	May 2017	Vit E	Salmon	90	60
Mar in Oil	Spain	Feb 2017	Vit E	Salmon	90	60
Mn Marnys	Spain	Mar 2017	Vit E	Salmon	90	60
Mn Marnys	Spain	Jun 2017	Vit E	Salmon	90	60

EPA- eicosapentaenoic acid; DHA- docosahexaenoic acid

The total oil content in capsules (g/capsule) was also measured by the difference in weight between the whole capsule and the weight of the capsule gelatin. The oil in a capsule was collected by pinching a tiny hole in capsules and then squeezing the oil out by hand.

The methylation of fatty acids was done using the two steps procedure as outlined by (Kramer *et al.*, 1997). Briefly, 0.1 g of the composite oil sample was placed into a screw capped culture tube and a 1 mL of prepared internal standard was then added. Two mL of sodium methoxide-0.5 M solution in methanol was then added to each tube and then incubated in a 50°C water bath for 10 min. Tubes were then removed from the water bath and allowed to cool for 5 min. Subsequently, we uncapped the tube and added 3 mL of 5% methanolic HCl to each tube and then the tubes incubated in 80°C water bath for 10 min. Tubes were then removed from the water bath and cooled for 7 min before adding 2 mL of hexane and 7.5 mL 6% potassium carbonate. Tubes were then centrifuged at 1200 rpm (Centra-GP8, Needham Heights, MA, international equipment company) for 5 min to separate layers and the supernatant was transferred to 2 mL vials for Gas Chromatography (GC) analysis.

The methylated fatty acids were analyzed via A Shimadzu GC-2010 gas chromatograph (Shimadzu Scientific Instruments Inc., Columbia, MD, USA), with a 100-m SP-2560 fused silica capillary column (Restek Stabil WAXDA column, Bellefonte, PA, USA). The GC temperature was programmed to 130°C for 60 min, increased at 3°C/min to a final temperature of 250°C, which was held for 10 min. The column temperature was maintained at 130°C and flame ionization detector temperature at 250°C. The injector and detector temperatures were set at 255°C. Peaks were identified by comparing the retention times with those of the corresponding standards (Nu-Chek-Prep., Elysian, MN; Supelco, Bellefonte, PA; and Larodan Fine Chemicals, Malmo, Sweden).

Results

Information about the omega-3 supplement samples used in this study is presented in Table 1. There were thirteen different brands of omega-3 supplements manufactured in eight different countries. The omega-3 supplements samples were from the USA (3 brands), UK (2 brands), Spain (2 brands), Canada (1 brand), Denmark (1 brand), Holland (1 brand), Egypt (1 brand), UAE (1 brand) and Saudi Arabia (1 brand). Only brands manufactured in the USA, Canada and Spain specified the type of fish oil used in the product (i.e., salmon, herring, anchovy, mackerel and sardine). Vitamin E was used as an antioxidant in seven brands and six brands did not list any antioxidants in their label.

The Long-Chain Unsaturated Fatty Acids (LCUFA) composition for the omega-3 supplements are presented in Table 2. The LCUFA ranged from 30 to 92% of the total fatty acids. The EPA and DHA were the main fatty acids in most supplements accounting for 58 to 97% of the total LCUFA. However, in three brands (21st Century, Mar in Oil and Mn Marnys), EPA and DHA accounted for less than 18% of the total LCUFA (7.5-17.4%). In these three brands, C18 unsaturated fatty acids were the main fatty acids ranging from 44 to 65% of the total LCUFA.

The measured EPA and DHA contents in the omega-3 supplements was compared to the contents claimed in the product labels using three reference ranges (Table 3). A reference range between 90-110% of the manufacturer's claimed contents was the standard and in compliance, a reference range between 80-120% of the manufacturer's claimed contents was substandard but still in compliance and a reference range with <80 or >120% of the manufacturer's claimed contents was non-compliant. Using the above arbitrary reference range, only 21.9% of the supplements fall in the standard compliance range for EPA and DHA. Of the total supplements tested, 56.3% were in non-compliance for EPA and 59.4% were in non-compliance for DHA (Table 3). Therefore, using the U.S. Food and Drug Administration (US FDA, 2019) labeling requirements where a supplement must contain at least 80% of the stated label amount of each component listed, only 44-41% of the supplements were complainant for EPA and DHA.

There is a wide variation between measured versus claimed amount of omega-3 fatty acids. Nine samples did not specify the amount of omega-3 fatty acids on the label. The range of measured EPA was 5.9 to 540.0 mg per capsule and for DHA was 12.0 to 410.9 mg per capsule.

The stated label amount for EPA (in %) is in Fig. 1. The percentage of the stated label amount for EPA ranged from 6.5 to 138.6%. Only eight supplements (25.8%) contained at least 100% of the stated label-claim for EPA. Therefore, 23 supplements (74%) contained less than the stated label amount of EPA. Seven supplements (22.5%) contained less than 50% of the claimed EPA content with four of them containing less than 25% of the label claim.

The stated label amount for DHA (in %) is depicted in Fig. 2. The percentage of the stated label amount for DHA ranged from 10.9 to 126%. Only four (12.9%) supplements contained at least 100% of the stated label claim for DHA. Therefore, 27 supplements (87%) contained less than the stated label amount of DHA as illustrated in Fig. 2. Eight supplements (25.8%) contained less than 50% of the claimed DHA content with two of them containing less than 15% of the label claim.

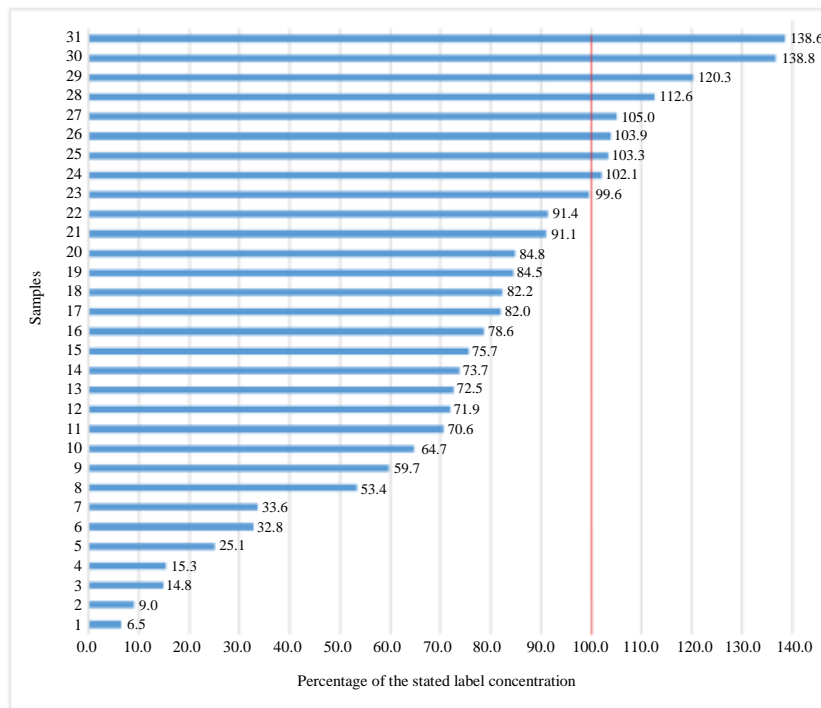


Fig. 1: Stated label concentration (%) of Eicosapentaenoic Acid (EPA)

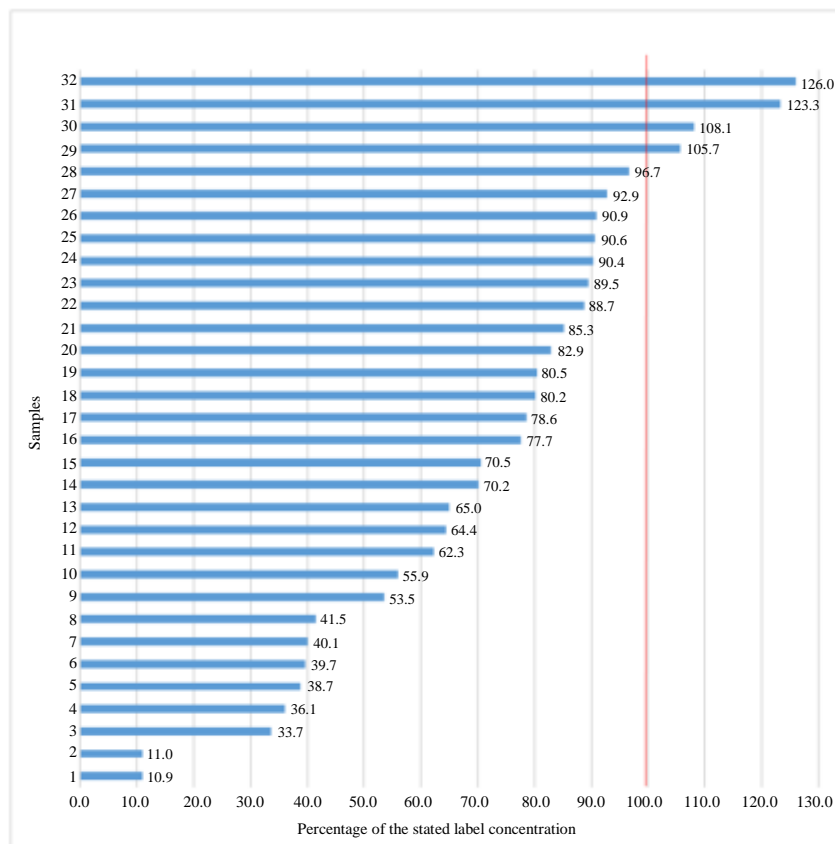


Fig. 2: Stated label concentration (%) of Docosahexaenoic Acid (DHA)

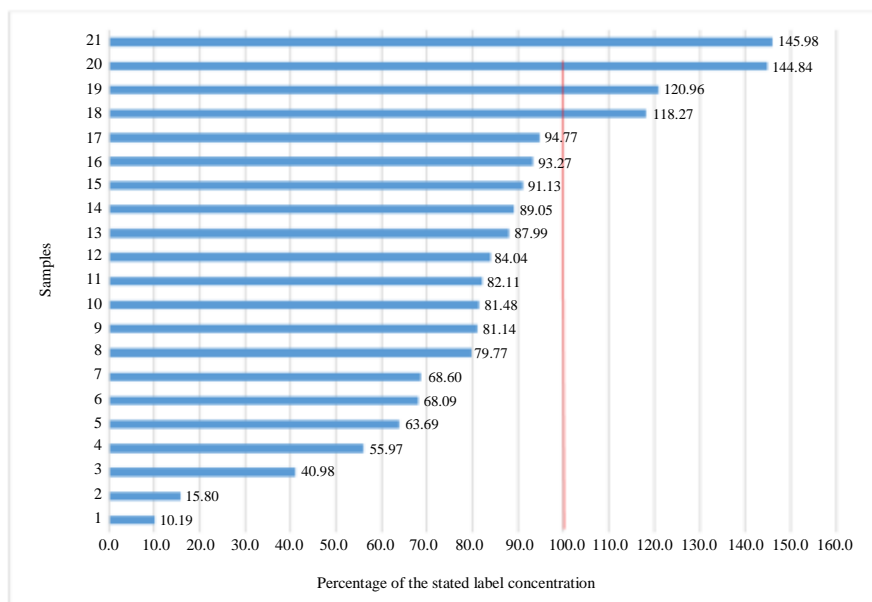


Fig. 3: Stated label concentration (%) of total omega-3 fatty acids

Table 2: Fatty acid composition (g/100 g of fatty acids) for the omega-3 supplements

Product name	C18:1n9	C18:2n6	C18:3n3	C20:5 (EPA)	C22:5n3	C22:6 (DHA)	LCUFA
Maxepa Forte	2.21	2.08	2.06	31.83	4.87	23.38	66.43
Maxepa Forte	2.23	1.40	2.21	32.45	4.30	24.08	66.67
Bio Marine	4.82	1.79	1.93	33.67	4.51	22.86	69.58
Bio Marine	4.81	1.77	1.91	33.36	4.49	23.76	70.10
Bio Marine	2.70	5.07	2.14	31.20	4.71	22.32	68.14
Bio Marine	11.89	5.20	nd	35.92	4.70	25.29	83.00
Jamieson	11.91	3.35	2.76	18.08	2.25	11.30	49.65
Jamieson	9.90	3.79	3.13	18.71	2.43	12.17	50.13
Vitabiotics	10.99	1.79	1.62	34.15	2.93	22.39	73.87
Vitabiotics	11.43	1.89	1.73	35.95	3.23	23.08	77.31
JP Omega 3	2.14	nd	2.51	45.53	11.06	20.70	81.94
JP Omega 3	1.82	0.48	2.57	44.37	11.93	20.01	81.18
JP Omega 3	2.55	nd	3.54	51.16	10.39	19.23	86.87
JP Omega 3	4.97	nd	2.63	45.91	6.44	20.29	80.24
Omacor	nd	nd	2.24	46.73	2.95	39.29	91.21
Omacor	nd	nd	2.23	46.56	2.96	39.61	91.36
Omacor	nd	nd	nd	55.37	2.99	34.02	92.38
Omacor	nd	nd	nd	52.30	3.34	35.08	90.72
Omacor	nd	nd	1.79	52.10	3.30	32.62	89.81
Omacor	nd	nd	1.53	52.31	3.44	34.77	92.05
Smarty	0.81	1.00	8.05	13.94	8.65	54.65	87.10
Sedico	10.30	8.09	2.88	18.62	1.91	13.08	54.88
Sedico	8.03	3.93	2.99	18.84	2.50	12.87	49.16
GNC	2.88	3.41	2.77	18.29	0.49	2.08	29.92
21st Century	1.60	23.82	18.50	6.27	nd	3.17	53.36
21st Century	17.12	18.92	26.59	5.18	nd	2.89	70.70
Nature's Bounty	nd	1.83	6.33	55.41	3.95	17.12	84.64
Nature's Bounty	1.88	2.63	6.98	52.85	4.70	19.85	88.89
Mar in Oil	47.81	15.64	1.63	2.03	1.01	3.30	71.42
Mar in Oil	41.49	13.80	1.73	4.56	2.28	7.95	71.81
Mn Marnys	42.42	14.05	1.71	4.47	2.06	7.40	72.11
Mn Marnys	42.97	14.31	1.70	4.42	1.92	6.74	72.06

EPA- Eicosapentaenoic Acid; DHA- Docosahexaenoic Acid

nd: not detected

LCUFA- Long-Chain Unsaturated Fatty Acids (C18:1+C18:2+C18:3+ EPA+ DHA+C22:5)

Table 3: Percentage of samples within 0-10%, 10-20% and >20% of the label claim

	C20:5n3 (EPA) (%)	C22:6n3 (DHA) (%)
0-10%	21.88	21.88
10-20%	21.88	18.75
>20%	56.25	59.38

EPA- Eicosapentaenoic Acid; DHA- Docosahexaenoic Acid

Only 21 samples reported the total omega-3 fatty acids content (Fig. 3). The total omega-3 concentration ranged from 10.2 to 146.0% of the stated label concentration. Only 4 (19%) supplements contained at least 100% of the stated label claim for total omega-3 concentration. Therefore, 17 supplements (80.9%) contained less than the stated label amount of total omega-3 concentration as illustrated in Fig. 3.

Discussion

The consumption of omega-3 fatty acids has gained popularity in Arab Gulf Countries. The omega-3 supplements are mainly imported from different countries, while small amount of omega-3 supplements sold in Arab Gulf Countries are encapsulated locally. Although the Gulf Cooperation Council Standardization Organization (GSO) and the food and drug authorities of local governments regulate the omega-3 oil supplements in the region, there is still no available data on the quality of omega-3 supplements sold in the region. To the best of our knowledge, this is the first study to evaluate the label claims of omega-3 supplements sold in the Arabic Gulf Countries.

In the current study, the EPA content of supplements was higher than that of DHA, except for the Smarty product. This may be due to the type of oil used in the supplements. Fish and krill oils are characterized by a higher EPA content (Kleiner *et al.*, 2015), while DHA content is higher in algae oil (Fedorova-Dahms *et al.*, 2011). In the current study, the omega-9/omega-6 fatty acid contents of supplements were lower than that of omega-3 fatty acids. However, the omega-9/omega-6 fatty acid contents of 21st Century, Mar in Oil and Mn Marnys were higher than that of omega-3 fatty acids. The EPA and DHA contents of these brand were also significantly varied suggesting these supplements contained vegetable oils rich in omega-9/omega-6 fatty acid in addition to fish or algae oil (Malainey *et al.*, 1999; Mann *et al.*, 2003).

In the current study, results showed a wide variation between measured vs claimed EPA and DHA amounts consistent with the findings from previously published studies from other countries. For example, (Opperman *et al.*, 2011) tested 45 commercially available omega-3 supplements sold in

South Africa and found 56% contained less than 90% of the EPA and DHA amounts stated on the label. Fierens and Corthout (2007) also examined 16 commercially available fish oil products in Europe and obtained similar results to this study, with seven products failing to meet label claims for EPA and/or DHA. Fantoni *et al.* (1996) examined 16 different encapsulated omega-3 supplement products in Brazil. Of these samples, only five stated EPA and DHA contents on the label and two were found to be below the stated amount. Kleiner *et al.* (2015) analyzed EPA and DHA from 47 commercial supplements in the United States. They found that 74% of the supplements tested contained less than the stated label amount of EPA and DHA. However, (Hamilton *et al.*, 2010) observed a close agreement between supplements tested and the stated label of omega-3 content sold in Australia. Tatarczyk *et al.* (2007) found that all omega-3 products in Austria met their label claims. These different results suggest that adherence to quality of omega-3 fatty acids may vary according to the country of production.

The total omega-3 fatty acid concentration in the tested supplements ranged from 31.4 to 1009.0 mg per capsule and the concentrations were different between the different samples of the same brand (e.g., Bio Marine, JP Omega 3, Nature's Bounty, 21st Century, Mar in Oil and Mn Marnys). The inconsistent values in the same brand might be attributed to infrequent or poor batch-control analyses during the encapsulation. In general, a wide variation during the encapsulation leads to an increase in the variation in the final omega-3 fatty acid content of the supplements (Albert *et al.*, 2015).

The wide variability of measured versus claimed concentrations could also be related to the seasonal variation in the fatty acid profile of fish tissues (Gamez-Meza *et al.*, 1999). Furthermore, fish from different sources (i.e., farmed or wild) may also have different dietary levels of fatty acids, based on feeding regimens (Jangaard *et al.*, 1967; Iverson *et al.*, 2002; Sprague *et al.*, 2016). Additionally, the differences in omega-3 fatty acid profile may be due to fatty acid oxidation and degradation during encapsulation, packing, transport, storage and analysis. Several researchers speculated that oxidative damage was possibly the main reason for the loss of EPA and/or DHA in omega-3 supplements (Chee *et al.*, 1990; Srigley and Rader, 2014). Albert *et al.* (2015) obtained a positive relationship the loss of EPA and DHA values with oxidative damage. In contrast, (Sprague *et al.*, 2018) did not observe any relationship between the loss of EPA and DHA contents and oxidative damage.

Conclusion

The current study's results showed a wide range between the stated label concentrations of EPA and DHA

in omega-3 supplements with the majority of omega-3 dietary supplements sold in Arab Gulf Countries contain less than the stated label amount of EPA and DHA. The results indicate the need for governmental agencies to improvement in the regulation of omega-3 dietary supplements and in the quality assurance processes of omega-3 supplement's manufacturers.

Authors' Contributions

Fatmah Alghamdi: Conduction of study, analysis and interpretation of data, drafting of manuscript.

Mohammed G. Embaby: Laboratory analysis.

Mevlüt Günal: Drafting of manuscript.

Amer A. AbuGhazaleh: Experimental design, interpretation of data and drafting of manuscript.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

Disclosure Statement

The authors warrant that there are no conflicts of interests among authors and between authors and other people, institutions or organizations.

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