



Effect of Frying in Different Cooking Oils on Omega 3 Fatty Acids of Goldstripe Sardinella

R. Shalini*, S. R. Jeya, G. Jeyasekaran and M. Palanikumar

Fisheries College and Research Institute, Tamil Nadu Fisheries University, Thoothukudi - 628 008, India

Abstract

Effect of shallow and deep frying of lesser sardine (*Sardinella gibbosa*) in different cooking oils viz., sunflower, groundnut and gingelly oils on the fat and fatty acid compositions were investigated. The fat content was lesser in deep fried sardines than shallow fried ones. The fatty acid composition of fried sardines were different from that of raw sardines due to the absorption of fatty acids from cooking oil. Oleic and linoleic acids were the predominant fatty acids in fried sardines. PUFA such as EPA and DHA were reduced upon frying. Retention of EPA and DHA was more in shallow fried sardines than the deep fried ones. Results showed that shallow fried sardines imbibed more fat from cooking oil, however retained EPA and DHA much better than deep fried sardines.

Keywords: Sardine, cooking oil, PUFA, shallow and deep frying

Introduction

Fish has been considered as a valuable source of animal protein in human diet for a long time. Fish lipids are recognized for its numerous benefits in human health because of their high polyunsaturated fatty acid levels (PUFA) (Puwastien et al., 1999). Fatty fish normally contains 3-12% lipids. Generally, fish lipids are, high in omega-3 PUFA such as eicosapentaenoic acid (EPA C20:5, n-3), docosahexaenoic acid (DHA C22:6, n-3) and docosapentaenoic acid (DPA C22:5, n-3). PUFA can reduce blood LDL cholesterol and have antithrombotic, anti-inflammatory, anti-arrhythmic and vasodilatory properties (Lombardo & Chicco,

2006). PUFA help to prevent coronary heart disease, hypertension, type 2 diabetes and insulin resistance (Weber et al., 2007). DHA also plays an important role in brain development and retinal function of the foetus and infants (Birch et al., 1998).

In India, marine fish plays an important role in the diet of coastal population. *Sardinella gibbosa* is a pelagic fatty fish widely available along the south east coast, with good source of omega-3 fatty acids. Fish is rarely consumed in raw condition and is usually processed by boiling, baking, roasting, frying or grilling in India. Heat is applied to fish in many ways to improve its hygienic quality by inactivation of microorganisms to enhance its flavour and taste and to increase the shelf life. (Bognar, 1998). However, heat can also damage the vitamins, flavour compounds and PUFA.

Frying is one of the popular ways of processing fish prior to consumption. Fish is either shallow fried or deep fried in any vegetable oils such as sunflower, groundnut, gingelly or coconut oil. Vegetable cooking oil is rich in omega-6 fatty acids. High dietary intake of omega-6 fatty acids is related to an increased incidence of breast, prostate and colon cancers (Carroll & Khor, 1971). Frying became more popular, as it is fast and convenient technique of processing fish with typical colour, flavor, texture and palatability. Heat employed during frying may lead to undesirable modification in the nutritional composition of products. Interactions also occur between components of food and cooking oil (Varela et al., 1999). Fat content of raw fish also influences fat exchanges and interactions between the culinary fat and that of fish on frying (Sanchez- Muniz et al., 1992). Fish that contains PUFA with high EPA and DHA are susceptible to oxidation due to heat and other culinary treatments (Sant' Ana & Mancini, 2000). There are studies relating to the effect of frying on the lipid fraction or composition of fishes (Sanchez- Muniz et al., 1992; Candela et al., 1998;

Received 30 May 2015; Revised 04 July 2016; Accepted 24 August 2017

*E-mail: shalinimisp@gmail.com

Garcia Arias et al., 2003; Gladyshev et al. 2007; Weber et al., 2008; Larsen et al., 2010; Laly & Venketeswarlu, 2016). Most of these studies are done by frying fish in cooking oils such as olive oil, soybean oil, sunflower oil, corn oil, canola oil, coconut oil and lard, either fried as such or after battering. Very few studies are available on the effect of heat on omega-3 fatty acids in fish prepared according to Indian culinary practices. Hence, this work is undertaken to examine the effect of heat on the changes in fatty acid composition upon shallow and deep frying of sardines.

Materials and Methods

Fresh sardines (*Sardinella gibbosa*) were procured from the fish landing centre of Thoothukudi, Tamil Nadu and brought to the laboratory in iced condition. Average length and weight of the sardines were 13.5 cm and 15.8 g, respectively. They were washed, descaled, beheaded and gutted to prepare the dressed fish.

Cooking oils used for frying the sardines were sunflower oil, sesame or gingelly oil and peanut or ground oil purchased from local super market. Dressed sardines were divided into three lots to process with different cooking oils. Each lot was then sub-divided into two sub-lots. One sub-lot was shallow fried in a flat pan with the addition of each oil for 5-7 min separately, and other sub-lot was deep fried in a pan in each oil for 4-5 min. The temperature of oil varied from 125-147°C during shallow frying and 147-165°C during deep frying. Fried sardine, spent oil and cooking oil used for frying were examined for fatty acid composition. The moisture and fat contents of raw and fried sardines were also determined by standard methods (AOAC, 1995). Fish lipids from the raw and processed sardines were extracted following the procedure of Folch et al. (1957). The extracted lipid was used for methylation by boron trifluoride (BF₃) methanol (AOAC, 1995). Fresh cooking oil and spent oil were used directly for methylation. Lipid (250 mg) was taken in a screw capped tube, to which, 4 mL of 0.5 M methanolic NaOH was added and refluxed for 10 min under stream of nitrogen at 100°C. Five mL of BF₃-methanol was then added and refluxed for another 2 min. Saturated sodium chloride was added to separate the saponified fraction. Methyl esters were then separated out by the addition of 2.5 mL of hexane. The upper hexane layer was carefully removed and concentrated to dryness under the stream of nitrogen to 1 mL.

Fatty acid composition was determined by gas chromatography following the method described by Stephen et al. (2010) with slight modification. Perkin Elmer Autosystem XL Gas Chromatography, USA fitted with a flame ionization detector (FID) and a fused silica capillary column (PE-225, 0.25 mm ID, 30 m length) was used for the separation. The operating conditions were injector temperature - 250°C and detector temperature -300°C. A temperature gradient programme was followed with initial oven temperature set at 70°C for 1 min, which was then increased to 180°C at the rate of 30°C min⁻¹ and to 220°C at the rate of 10°C min⁻¹. The carrier gas used was nitrogen at 20 psi pressure. Peaks were identified by comparison of their retention times with those of authentic fatty acid standard mixture (Sigma Chemicals Co., St. Louis, USA 99% purity) and expressed as peak area percentages. The total n6 and n3 fatty acids of raw and fried sardine in various cooking oils were found and from this, n6/n3 ratio were calculated.

All data represent average of triplicate samples. Data analysis was carried out using one way ANOVA using Statistical Package for Social Science (SPSS) software version 16.0 (SPSS Inc, Chicago, Liinois, USA). All mean separations were carried out by Duncan multiple range test using significance level of 95% (p< 0.05).

Results and Discussion

Sardines shallow fried in sunflower, groundnut and gingelly oils had 56.90, 56.33 and 59.90% moisture respectively which were significantly lesser (p<0.05) than raw sardines (74.55%) Table 1. The deep fried sardines had 3-10% lower moisture than shallow fried ones. Reduction in moisture content during frying was reported by several authors in fried cod (Gladyshev et al., 2007) and in fried silver catfish (Weber et al., 2007) and this was due to the evaporation of water during frying. The fat content of the raw sardine was 9.60% (on dry weight basis) (Table 2). Upon frying, uptake of oil by sardines had increased the fat contents to 31.64%, 35.78 and 34.86% in shallow fried sardines but the increase was lower (p<0.05) in deep fried sardines when compared to shallow fried ones. Release of fat from fish took place upon heating in deep fried sardines. Larsen et al. (2010) reported that during pan frying of king salmon, there was release of lipid residues. According to Cuesto & Sanchez- Muniz (2001), during frying, bath oil penetrates the food, after

Table 1. Moisture and fat content of raw and fried sardine

S. No.	Sample	Moisture (%)	Fat (%) on dry weight basis
1	Raw fish	74.55±1.11 ^a	9.60±0.68 ^a
2	Sunflower oil shallow fried	56.90±2.14 ^b	31.64±1.21 ^b
3	Sunflower oil deep fried	52.60±1.62 ^c	27.65±0.97 ^c
4	Ground nut oil shallow fried	56.33±2.1 ^{bc}	35.78±1.13 ^d
5	Ground nut oil deep fried	54.91±1.31 ^{bce}	26.80±1.04 ^c
6	Gingelly oil shallow fried	59.90±0.99 ^f	34.86±0.96 ^d
7	Gingelly oil deep fried	53.85±1.45 ^{cd}	29.01±1.19 ^c

*All values are mean ± standard deviation of triplicate analysis (n=3). Different superscripts in the same column indicate significant differences (p<0.05)

Table 2. Fatty acid content of sardine fried in sunflower oil

Fatty acid	Raw sardine	Shallow fried sardine	Deep fried sardine	Fresh oil	Used oil shallow fry	Used oil deep fry
Capric C10:0	0.11±0.02	n.d.	n.d.	n.d.	n.d.	n.d.
Myristic C14:0	6.14±0.30	n.d.	1.09±0.04	0.07±0.01	n.d.	n.d.
Palmitic C16:0	24.17 ±1.84	12.22 ±0.84	9.61±0.21	6.10±0.08	9.37±0.92	2.01±0.03
Margaric C17:0	1.29±0.18	n.d.	n.d.	n.d.	n.d.	n.d.
Stearic C18:0	7.44±0.83	5.05±0.40	n.d.	n.d.	n.d.	n.d.
Arachidic C20:0	2.58±0.41	0.88±0.09	0.3±0.01	n.d.	n.d.	n.d.
Behenic C22:0	n.d.	n.d.	0.56±0.08	n.d.	n.d.	n.d.
Tricosylic C23:0	0.38±0.01	0.18±0.03	n.d.	n.d.	n.d.	n.d.
Lignoceric C24:0	0.69±0.02	n.d.	n.d.	n.d.	0.12±0.03	n.d.
Total SFA	42.69±3.59 ^a	18.33±1.36 ^b	11.56±0.34 ^c	6.17±0.01	9.52±0.95	2.01±0.03
Palmitoleic C16:1	4.24±0.14	1.38±0.06	0.43±0.00	n.d.	n.d.	n.d.
Oleic C18:1	7.79 ±0.36	27.69 ±1.28	29.28 ±1.16	34.36±1.42	28.99±2.01	45.37±1.69
Erucic C22:1	n.d.	n.d.	n.d.	0.67±0.03	n.d.	n.d.
Total MUFA	12.03±0.50 ^a	29.07±1.34 ^b	29.71±1.16 ^b	35.06±1.45	28.99±2.01	45.37±1.69
Linoleic C18:2(n6)	n.d.	36.91±2.01	48.42±2.63	56.27±2.35	45.07±2.51	50.59±3.14
Linoleidic C18:2(n3)	2.21±0.04	1.61±0.04	1.86±0.10	n.d.	n.d.	n.d.
Linolenic C18:3(n3)	1.90±0.02	n.d.	0.17±0.01	n.d.	n.d.	n.d.
Dihomog Linolenic C20:3(n6)	1.1±0.01	0.03±0.01	n.d.	n.d.	0.08±0.02	0.18±0.10
Eicosa pentaenoic C20:5(n3)	6.72±0.32	2.06±0.26	0.88±0.08	n.d.	0.9±0.2	0.77±0.01
Docosa hexaenoic C22:6(n3)	18.51±1.21	4.94±0.96	1.48±0.05	n.d.	0.26±0.03	1.12±0.03
Total PUFA	30.45±1.60 ^a	45.55±2.2 ^b	52.81±2.87 ^c	56.27±2.35	46.31±2.76	52.66±1.28

*All values are mean ± standard deviation of triplicate analysis (n=3). Different superscripts in the same row indicate significant differences (p<0.05)

water was partially lost by evaporation. Candela et al. (1998) have also reported an increase in fat content of salmon, spanish mackerel and sardines upon frying. Sanchez- Muniz (1992) observed that the moisture content reduced by 70% and the fat content increased several times in sardines fried in lard, sunflower oil and olive oil. Similarly in our study the increases in fat contents were 3.29, 3.72 and 3.63 times in sardines shallow fried and only 2.88, 2.79 and 3.02 times sardines deep fried sardines in sunflower oil, ground nut oil and gingelly oil respectively.

Table 2 shows the fatty acid profile of raw, shallow fried and deep fried sardines in sunflower oil, fresh sunflower oil and used sunflower oil. The saturated

fatty acid (SFA) content of raw sardine was 42.69% and the major SFA present in raw sardine were myristic acid C14:0 (6.14%), palmitic acid C16:0 (24.17%) and stearic acid C18:0 (7.44%). The palmitic acid has been reported to be the major saturated fatty acid in marine fish by many authors (Bandarra et al. 1997; Stephen et al. 2010). Oleic acid C18:1 (7.79%) is the only major monounsaturated fatty acid (MUFA). EPA (C20:5, 6.72%) and DHA (C22:6, 18.51%) were the dominant polyunsaturated fatty acids (PUFA).

In the sardines shallow and deep fried in sunflower oil, there was a significant reduction in the SFA contents from 42.69 to 18.33 and 11.56%, respectively. Muniz et al. (1992) have also reported a

Table 3. Fatty acid content of sardine fried in ground nut oil

Fatty acid	Raw sardine	Shallow fried sardine	Deep fried sardine	Fresh oil	Used oil shallow fry	Used oil deep fry
Capric C10:0	0.11±0.02	n.d.	n.d.	0.02±0.01	0.07±0.02	0.06±0.02
Lauric C12:0	n.d.	n.d.	n.d.	0.31±0.01	n.d.	n.d.
Myristic C14:0	6.14±0.30	1.32±0.07	0.94±0.04	n.d.	1.15± 0.06	1.00±0.03
Palmitic C16:0	24.17 ±1.84	35.61 ±2.01	34.15 ±1.85	37.37±2.45	37.51±2.32	37.97±2.80
Margaric C17:0	1.29±0.18	0.33±0.01	0.36±0.09	n.d.	0.03±0.01	n.d.
Stearic C18:0	7.44±0.83	4.91±0.06	5.97±0.29	n.d.	4.72±0.09	n.d.
Arachidic C20:0	2.58±0.41	0.71 ±0.05	0.86 ±0.03	0.64±0.03	0.35±0.03	0.23±0.02
Behenic C22:0	n.d.	n.d.	0.38±0.01	n.d.	0.18±0.02	n.d.
Tricosylic C23:0	0.38±0.01	0.47±0.03	n.d.	n.d.	n.d.	n.d.
Lignoceric C24:0	0.69±0.02	n.d.	n.d.	n.d.	n.d.	n.d.
Total SFA	42.69±3.59 ^a	43.35±2.23 ^b	42.66±2.32 ^b	38.34±2.5	44.01±2.55	39.32±2.87
Palmitoleic C16:1	4.24±0.14	n.d.	0.74±0.06	n.d.	n.d.	n.d.
Oleic C18:1	7.79 ±0.36	37.67±2.13	34.14±1.72	44.06±1.58	41.04±2.15	46.26±1.25
Total MUFA	12.03±0.50 ^a	37.67±2.13 ^b	34.88±1.78 ^c	44.06±1.58	41.04±2.15	46.26±2.43
Linoleic C18:2 (n6)	n.d.	8.83±0.96	7.52±0.85	8.44±0.74	8.57±0.61	9.79±1.07
Linoleidic C18:2 (n3)	2.21±0.04	0.9±0.02	0.85±0.03	n.d.	n.d.	n.d.
Linolenic C18:3 (n3)	1.90±0.04	n.d.	0.68±0.02	n.d.	n.d.	n.d.
Dihomog Linolenic C20:3 (n6)	1.1±0.01	n.d.	n.d.	n.d.	n.d.	n.d.
Eicosa pentaenoic C20:5 (n3)	6.72±0.32	1.37 ±0.07	0.87 ±0.09	n.d.	0.08±0.01	0.02±0.01
Docosadienoic C22:2 (n3)	n.d.	0.23±0.01	n.d.	1.01±0.02	n.d.	0.21±0.04
Docosahexaenoic C22:6 (n3)	18.51±1.21	3.85±0.04	3.02±0.42	n.d.	n.d.	n.d.
Total PUFA	30.45±1.60 ^a	15.18±1.1 ^b	13.25±1.41 ^b	9.45±0.76	8.65±0.62	10.02±1.12

*All values are mean ± standard deviation of triplicate analysis (n=3). Different superscripts in the same row indicate significant differences (p<0.05)

decrease in the SFA content of batter coated sardines fried in olive oil and sunflower oil. Oleic acid (C18:1), on the other hand, increased from 7.79% in raw sardines to around 29% in shallow and deep fried sardines. This was due to the migration of this fatty acid from the cooking oil into the fish. Larsen et al. (2010) have also observed an increase in oleic acid of pan fried king salmon. PUFA increased from 30.45% in raw sardines to 45.55% in shallow fried and to 52.81% in deep fried sardines and this was attributed to the migration of linoleic acid from cooking oil. The retention of EPA (2.06%) and DHA (4.94%) was more in shallow fried sardines than deep fried ones, where the EPA was only 0.88% and DHA was 1.48%. The destruction in EPA and DHA was more in deep fried ones due to higher frying

temperatures. In addition, the absorption of sunflower oil by sardine had also contributed for the corresponding reduction in the proportion of EPA and DHA. Sanchez- Muniz et al. (1992) reported that in fatty fishes an exchange of fat between the food and frying oil takes place, thus increasing the losses of some specific fatty acids, such as EPA and DHA.

Sunflower oil is a non-volatile oil compressed from sunflower and used popularly as frying oil throughout the world. The major fatty acids in fresh sunflower oil were oleic (34.36%) and linoleic acids (56.27%) and the total SFA was 6.17%. In the used sunflower oil, the major fatty acids identified were oleic (C18:1) and linoleic acids (C18:2) similar to that of fresh oil. There were small quantities of EPA

Table 4. Fatty acid content of sardine fried in gingelly oil

Fatty acid	Raw sardine	Shallow fried sardine	Deep fried sardine	Fresh oil	Used oil shallow fry	Used oil deep fry
Capric C10:0	0.11±0.02	n.d.	0.02±0.01	0.03±0.02	n.d.	0.03±0.01
Lauric C12:0	n.d.	0.05±0.02	0.03±0.01	0.31±0.06	n.d.	n.d.
Myristic C14:0	6.14±0.30	1.34±0.26	0.36±0.08	n.d.	n.d.	n.d.
Palmitic C16:0	24.17±1.84	13.58±1.12	11.69±1.29	8.35±0.85	11.14±0.96	9.98±1.14
Margaric C17:0	1.29±0.18	0.52±0.06	0.17±0.01	n.d.	n.d.	n.d.
Stearic C18:0	7.44±0.48	n.d.	n.d.	n.d.	5.58±0.08	n.d.
Arachidic C20:0	2.58±0.41	1.19±0.41	n.d.	0.59±0.12	—	0.16±0.02
Behenic C22:0	n.d.	n.d.	n.d.	1.01±0.06	1.02±0.04	n.d.
Tricosylic C23:0	0.38±0.01	n.d.	n.d.	n.d.	n.d.	n.d.
Lignoceric C24:0	0.69±0.02	n.d.	n.d.	n.d.	0.02±0.01	n.d.
Total SFA	42.69±3.59 ^a	16.7± 1.86 ^b	12.25±1.39 ^c	10.29±1.1 1	17.75±1.09	10.17±1.17
Palmitoleic C16:1	4.24±0.14	1.07±0.02	0.39±0.02	n.d.	n.d.	n.d.
Oleic C18:1	7.79±0.36	40.52±2.49	46.68±2.86	43.69±1.35	42.97±2.54	48.61±2.65
Eicosenoic C20:1	—	—	—	0.63±0.03	1.02±0.03	0.63±0.17
Total MUFA	12.03±0.50 ^a	41.59±2.51 ^b	47.07±2.88 ^b	44.32±1.38	43.99 ±2.57	49.24±2.82
Linoleic C18:2(n6)	2.21±0.04	28.89±1.42	34.48±2.34	37.46±2.68	32.71±1.98	37.58±2.14
Linolenic C18:3(n3)	1. 90±0.04	0.08±0.01	n.d.	n.d.	n.d.	n.d.
Dihomog Linolenic C20:3(n6)	1.1±0.01	0.02±0.01	n.d.	0.14±0.05	n.d.	0.06±0.02
Eicosa pentaenoic C20:5(n3)	6.72±0.32	1.5±0.03	0.09±0.02	0.2±0 .01	n.d.	n.d.
Docosadienoic C22:2(n3)	n.d.	n.d.	0.07±0.01	n.d.	n.d.	n.d.
Docosahexaenoic C22:6(n3)	18.51±1.21	5.96±0.38	0.18±0.01	n.d.	0.08±0.01	n.d.
Total PUFA	30.45±1.60 ^a	36.44±1.84 ^{ab}	34.75±2.37 ^b	37.8±2.74	32.79±1.99	37.64±2.16

*All values are mean ± standard deviation of triplicate analysis (n=3). Different superscripts in the same row indicate significant differences (p<0.05).

and DHA, which confirmed the migration of these fatty acids from sardines into the oil upon frying. As the sardines fried in sunflower oil had lesser SFA and fairly good proportions of EPA and DHA, this oil can be considered as suitable cooking oil for shallow frying.

Groundnut oil, also known as peanut oil or arachis oil, is a mild tasting vegetable oil and is commonly used for frying foods. There was an increase in the palmitic acid (C16:0) and decrease in stearic (C18:0) and arachidic (C20:0) acids in sardines shallow and deep fried in groundnut oil, and hence had the same total SFA content as that of raw sardines (Table 3). There was a significant increase ($p<0.05$) in MUFA due to increase in oleic acid (C18:1) which had migrated from groundnut oil. There was also an increase in linoleic acid (C18:2) and reduction in EPA and DHA, resulting in significant decrease ($p<0.05$) of total PUFA content. Unsaturated fatty acids are more heat labile as the degree of unsaturation increases and they become less stable. Thermal treatment thus increases the susceptibility of omega-3 PUFA towards oxidation. (Ilow & Ilow, 2002). In fresh ground nut oil, the major fatty acids were palmitic acid (C16:0-37.51%), oleic (C18:1-44.06%) and linoleic (C18:2- 8.44%). The fatty acid profile of the used groundnut oil was almost similar to that of fresh oil. The presence of myristic (C14:0), stearic (C18:0) and EPA (C20:5) in the used oil indicated their migration from raw sardines. Compared to frying in sunflower oil, the total SFA of sardines shallow and deep fried in groundnut oil were significantly higher ($p<0.05$) and the total PUFA content were lower ($p<0.05$).

Gingelly oil or sesame oil is an edible oil derived from sesame seed and popularly used as cooking oil in South India. In the sardines shallow and deep fried in gingelly oil there was a significant reduction ($p<0.05$) in total SFA content and increase ($p<0.05$) in total MUFA and PUFA similar to that of sardines

fried in sunflower oil (Table 4). However, the retention of DHA in shallow fried sardines was the highest and the levels of EPA and DHA in deep fried sardines were lower among the sardines fried in different oils. In gingelly oil, the major fatty acids in fresh oil were oleic (C18:1 43.69%), linoleic (C18:2- 37.46%) and palmitic (C16:0-8.35%) acids. The compositions of used and fresh gingelly oil were almost the same. There was a migration of stearic acid (C18:0) from sardine into the oil. The concentration of stearic acid (C18:0) in the oil was high due to their migration from sardine as triacyl glycerols. EPA was found in negligible quantity (0.08%) in the spent oil of shallow fried sardine and absent in the spent oil after deep frying. DHA was absent in the spent oils after the shallow and deep frying process. As the temperature of cooking oil used for deep frying was 147-165°C, and the fatty acids released from the fish into the oil might have undergone oxidation at such high temperatures during frying operation.

Fish being a very good source of PUFA has lower omega-6 to omega-3 ratio which is beneficial to human from health point of view. In hunter gatherers, diet the omega-6 to omega-3 ratio was closer to 2. The enormous infusion of vegetable oils into our diet had increased the dietary omega-6 to omega-3 ratios upto an unhealthful value of 10. The omega-6 to omega-3 ratio of raw sardine was 0.037 (Table 5). This ratio increased several folds in fried sardines. However, the omega-6 to omega-3 ratio was much lower in ground nut oil shallow fried sardines (1.39) and ground nut oil deep fried sardines (1.31) mainly due to lower percentage of linoleic acid (C18:3 omega-6) in the groundnut oil and higher retention of DHA content in deep fried sardines.

In shallow and deep frying of sardines in different cooking oils, there was a reduction in moisture due to evaporation and an increase in fat content due to

Table 5. n6/n3 ratio of raw and fried sardine

Fatty acid	Raw sardine	Shallow fried sardine in			Deep fried sardine in		
		Sunflower oil	Ground nut oil	Gingelly oil	Sunflower oil	Ground nut oil	Gingelly oil
Total n6	1.1±0.01	36.94±2.02	8.83±0.96	28.89±1.42	48.42±2.63	7.52±0.85	34.48±2.34
Total n3	29.34±1.5	8.61±0.26	6.35±0.14	7.57±1.44	4.39±0.24	5.73±0.25	0.34±0.03
n6/n3	0.037	4.29	1.39	3.81	18.41	1.31	101.41

absorption of cooking oil. The destruction of PUFA such as EPA and DHA were more in deep fried sardines than shallow fried sardines. The presence of EPA and DHA in used cooking oil also suggested their migration from sardine. The omega 6/omega 3 ratio increased several fold suggesting that consuming fish in fried form especially in deep fried form is not a good source of omega 3 fatty acid.

Acknowledgement

The authors wish to express their acknowledgement for the support of TANUVAS Research Corpus Fund to carry out this project.

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