Lipid Profiles of Raw, Grilled, Steamed and Fried Hardtail Scad (*Megalaspis Cordyla*)

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ABSTRACT: Hardtail scad is a popularly consumed local fish which is high in protein and low in fat. However cooking methods can influence fat and fatty acids composition rendering it unhealthy for consumption. This study is aimed at analysing moisture content; total extractable lipid; and fatty acids composition of raw, microwave-grilled, steamed and fried hardtail scad (Megalaspis cordyla). Moisture content was lowest in fried fish samples (54.65%) with regards to dry sample weight. Significant amount of lipid was found in fried fish sample (19.48%) as exchange of moisture and fats from frying oil took place. Moisture content was highest in raw samples (77.25%) which incidentally had the lowest total extractable lipid (3.35%). Microwave-grilled samples also showed a higher percentage of total extractable lipids (5.05%) although no additional fat or oil was used during or after preparation. This increase is attributable to release of bound lipids to its free form in the fish due to thermal process at elevated temperature (170 ^{o}C). Fried fish sample noted significant decrease in DHA content (C22:6 n-3; 3.79%). PUFAs are generally susceptible to heat thus frying at a high temperature (200 ^{o}C) caused depletion of DHA in fried fish sample. Also recorded were high amounts of oleic acid (18:1 n-9; 44.72%) and a significant increase in palmitic acid (36.12%) due to fat absorption from oil during frying. Steaming and microwave grilling is concluded to be the best method to prepare the fish due to post-cooking high moisture and low total extractable lipid.

Keywords: Cencaru, cooking methods, DHA, fatty acids composition, hardtail scad, Megalaspis cordyla, moisture content, PUFA, total extractable lipid.

Introduction

Megalaspis cordyla (hardtail scad) is one of the major pelagic marine fish species caught in Malaysia (Che Musa, and Nuruddin, 2005). It is also prepared through various cooking techniques (grilling, frying, poaching, steaming etc), using local recipes and is often consumed with rice. Proximate analysis of the fish was documented by Siong and others in 1987 and cholesterol content was documented by S. Mathew and others (Siong *et al*., 1987; Mathew *et al*., 1999). Recently reported was another proximate analysis of *Megalaspis cordyla* showing approximately more than 20% protein and low percentages of fat (approximately 1.53% i.e. lean fish) making it an attractive source of protein for consumption (Nurnadia *et al*., 2011). In another report, fish with less than 2% fat was categorised as lean fish and *Megalaspis cordyla*, which in this particular instance was found to contain only 1.53% fat, was categorised as lean fish (Abd Aziz *et al*., 2012).

Various studies on effects of cooking on proximate analysis and fatty acids composition of a variety of fish species have been carried out in the past (Gladyshev *et al.,* 2006; Gladyshev *et al*., 2007; Ansorena *et al.,* 2010; Ersoy, 2011). Owing to the fact that most cooking processes employ the inevitable use of heat, changes caused by heating alters nutritional content of food, and in this case, fish (Pirini *et al.,* 2010). This work aims to study effects of steaming, microwave-grilling and frying on moisture content, total extractable lipid and fatty acids composition of hardtail scad.

Materials and Methods

Fish sample

20 freshly caught *Megalaspis cordyla* were obtained from the Fisheries Development Authority of Malaysia (Lembaga Kemajuan Ikan Malaysia – LKIM), Batu Maung, Pulau Pinang in a range of 15 to 20 cm long. The fish were brought to Universiti Sains Malaysia in an ice-box and immediately stored in a chiller at 4^{o}C upon arrival. Weight range of fish was from 215 grams to 237 grams. Fish innards were cleaned and fish beheaded and filleted. Samples were handled

without the influence of moisture i.e. without washing to avoid errors during moisture content analysis.

Treatment

Fillets of 15 fish were fried, grilled and steamed using usual household cooking practice. Remaining samples were kept as raw fish samples. 6 fillets (from 3 fish) were used for each cooking condition to allow triplication of data.

Frying was done using palm oil at a temperature range of 200 ± 5^{o}C for about 4 min or until cooked. A wok with a diameter of 40cm was used for frying. Enough oil (approximately 500 ml for three fillets) was used to fully submerge samples during frying. Samples were turned over several times during frying for even cooking.

Grilling was done in a microwave oven (170^{o}C) until cooked (7 to 10 minutes).

A 26cm diameter aluminium stacked steamer was used for steaming. Water in the steamer was first brought to a boil before turning it down to a constant simmer. Fillets were then placed and allowed to cook for 10 minutes. Fillets were arranged in a single layer and only the first rack of the steamer was used. 3 fillets were steamed at one instance to not overcrowd the steamer.

Moisture Content

Samples were homogenised prior to oven-drying at 100^{o}C for 24 hr or until no change in weight was observed (AOAC, 1995). Moisture content was thereafter calculated;

% dry weight = (dried sample weight/initial sample weight) × 100%
% moisture = 100% - % dry weight

Total Extractable Lipid (%)

Dried and homogenised samples were weighed and analysed using Acid Hydrolysis method (AOAC, 1990). 2 g of sample was mixed with 2 ml of ethanol and 10 ml of 7 N HCl and heated up in a boiling water bath for about 40 minutes. 10 ml of ethanol was then added and mixture was cooled to room temperature. Cooled sample was flushed with 25 ml diethyl ether after which 25 ml petroleum ether was added and shaken vigorously for 1 min. Top layer of ether-fat mixture was skimmed, filtered and weighed. Extraction was repeated twice. Ether-fat mixture was evaporated and then dried at 100^{o}C for 90 min. Cooled and dried samples were then weighed.

% lipid of dried sample = (lipid weight/dried sample weight) × 100

Fatty Acids Composition

Fatty acids composition was determined by gas chromatographic (GC) method using BF3-methanol (AOCS, 1991). 1 µL of extracted methyl-esters solution using BF3-methanol method was injected directly into a gas chromatograph (Hewlett Packard Series II) equipped with a flame ionization detector (FID) and capillary column 30 m long, 0.25 mm inner diameter and a 0.25 µm film (Omegawax 320). The column oven was programmed at 200 ^{o}C, injection temperature at 220 ^{o}C and detector temperature at 250 ^{o}C. Helium was used as carrier gas at a flow rate of 25 cm/sec. Quantitative data were analysed using Hewlett Packard 3396A model integrator against fatty acids standards.

% fatty acid composition = (A/B) × 100

Where, A = area of specific fatty acid; B = total area of fatty acids present

Data Analysis

Statistical significance of data was performed by One-way analysis of variance (ANOVA) using SPSS version 17.0 (SPSS Inc., Wacker Drive, Chicago, IL, USA). Post hoc analysis was carried

out using Tukey's test. Values were termed significantly different from each other at a significance level of $p<0.05$.

Results and Discussion

Moisture Content

Table 1: Percentage of moisture content and total extractable lipid in raw fish and fish subject to different cooking processes

Analysis	Sample			
	Raw	Steamed	Fried	Microwave
Moisture content (%)	77.25 ± 0.06^{a}	70.04 ± 0.06^{b}	54.65 ± 0.07^{c}	63.13 ± 0.14^{d}
Lipid (%)	3.35 ± 0.07^{a}	3.80 ± 0.43^{a}	19.48 ± 0.44^{b}	5.06 ± 0.31^{c}

Values are means ± standard error (n = 3).

$^{a, b, c, d}$ Means within a row with the same letter are not significantly different ($P > 0.05$).

Moisture content of raw fish samples and fish samples subject to different cooking processes is shown in **Table 1**. Various cooking process used significantly decreased moisture content of fish samples and which is similar to previous reports on fish proximate analysis subject to different cooking techniques (Weber *et al*., 2008; Larsen *et al*., 2010; Ansorena, Guembe *et al*., 2010). In this case, raw fish samples had the highest moisture content (77.25%), followed by steamed fish samples (70.04%), microwave-grilled fish samples (63.13%), and fried fish samples (54.65%). Moisture content for raw samples was similar to Nurnadia, Azrina, and Amin's work with the same species i.e. 77.67% (Nurnadia *et al.,* 2011). Significant difference in moisture of steamed samples is attributable to loss of moisture in the form of vapour.

Total extractable lipid (%)

Total extractable lipid of raw fish and fish samples subject to different cooking processes is shown in **Table 1**. From total extractable lipids of raw samples it can be concluded that the fish is a low fat fish (lipid percentage in the range of 2% to 4%) as described by Abd Aziz *et al*.,

(2012). This categorization is also in agreement with Osman, Suriah and Law's work which considered fish containing less than 5% fat content as lean fish by referring to Bennion's (1997) work (Bennion, 1997; Osman *et al*., 2001). Findings by Osman *et al.* were more similar to results found in this study with regards to total extractable lipids i.e. approximately 3.08% (Osman *et al.,* 2001). Total extractable lipids related inversely to moisture content of samples. Total extractable lipid was recorded highest in fried fish samples (19.48%), which incidentally had lowest moisture content. Significant increase in total extractable lipid is evidently due to absorption of oil during frying coupled with loss of moisture due to elevated temperatures (Anwar *et al.,* 2006). Results pattern is similar to Larsen and others' work i.e. total extractable lipid inversely correlates to moisture content. From a mechanical point of view, changes during cooking process make sample tissues softer, thus easily homogenized allowing more extractable lipids (Larsen *et al*., 2010). Mechanical change is evident in increase of total extractable lipid in microwave-grilled samples as no additional fat was used during or prior to cooking (5.06%). Cooking process also aids release of bound lipids in the tissue matrix of fish to its free form making it accessible for extraction (Larsen *et al.,* 2010). However, there was no significant increase in total extractable lipid for steamed samples (3.80%).

Fatty Acids Composition

Table 2: Fatty acids composition (% of fatty acids) of raw fish and fish subject to different cooking processes

Fatty Acid	Fatty acid content (% of fatty acids)			
	Raw	Steamed	Fried	Microwave
C14	0.11 ± 0.05^{a}	0.10 ± 0.01^{a}	0.28 ± 0.02^{b}	0.18 ± 0.01^{c}
C16	30.15 ± 0.45^{a}	30.79 ± 0.09^{a}	36.12 ± 0.56^{b}	26.88 ± 0.14^{c}
C18	23.14 ± 0.07^{a}	18.29 ± 0.02^{b}	0.35 ± 0.03^{c}	19.28 ± 0.08^{d}
C20	0.87 ± 0.09^{a}	0.58 ± 0.01^{b}	0.26 ± 0.04^{c}	0.90 ± 0.06^{a}
C22	0.78 ± 0.01^{a}	0.54 ± 0.02^{b}	0.10 ± 0.01^{c}	0.72 ± 0.06^{a}
C23	0.32 ± 0.01^{a}	0.26 ± 0.02^{b}	n.d.	0.28 ± 0.02^{b}
C24	0.58 ± 0.05^{a}	n.d.	0.13 ± 0.03^{b}	0.54 ± 0.05^{a}
C16:1	3.74 ± 0.04^{a}	5.12 ± 0.01^{b}	0.96 ± 0.06^{c}	3.48 ± 0.21^{d}
C18:1 n-9	15.03 ± 0.13^{a}	12.07 ± 1.56^{b}	44.72 ± 1.09^{c}	14.06 ± 0.29^{a}
C24:1	1.35 ± 0.13^{a}	1.21 ± 0.03^{a}	0.27 ± 0.03^{b}	1.27 ± 0.07^{a}
C18:2 n-6	3.96 ± 0.05^{a}	1.45 ± 0.06^{b}	10.12 ± 0.18^{c}	3.62 ± 0.14^{d}
C18:3 n-6	0.87 ± 0.01^{a}	0.67 ± 0.03^{b}	0.16 ± 0.01^{c}	0.76 ± 0.10^{ab}

C18:3 n-3	0.32 ± 0.04[ac]	0.41 ± 0.02[b]	0.30 ± 0.02[a]	0.36 ± 0.02[c]
C18:4 n-3	0.71 ± 0.01[a]	0.60 ± 0.01[b]	0.39 ± 0.03[c]	0.64 ± 0.02[d]
C20:2 n-6	0.31 ± 0.01[a]	0.30 ± 0.02[a]	n.d.	0.32 ± 0.03[a]
C20:3 n-6	n.d.	n.d.	n.d.	n.d.
C20:3 n-3	0.27 ± 0.03[a]	0.42 ± 0.01[b]	n.d	0.29 ± 0.03[a]
C20:4 n-6	1.74 ± 0.04[a]	2.41 ± 0.06[b]	0.48 ±0.03[c]	2.18 ± 0.12[d]
C20:5 n-3	1.80 ± 0.02[a]	3.79 ± 0.03[b]	0.58 ± 0.02[c]	2.46 ± 0.03[d]
C21:5 n-3	0.23 ± 0.01[ab]	0.20 ± 0.01[a]	0.26 ± 0.02[b]	0.54 ± 0.03[c]
C22:4 n-6	0.26 ± 0.03[a]	0.48 ± 0.03[b]	n.d.	0.36 ± 0.03[c]
C22:5 n-6	1.27 ± 0.18[a]	1.66 ± 0.11[b]	0.42 ± 0.03[c]	1.79 ± 0.13[b]
C22:5 n-3	0.67 ± 0.02[a]	2.06 ± 0.06[b]	0.24 ± 0.01[c]	1.04 ± 0.05[d]
C22:6 n-3	11.51 ± 0.25[a]	16.58 ± 1.64[b]	3.79 ± 0.10[c]	17.90 ± 0.42[b]

Values are means ± standard error (n = 3).

n.d. means not detected

[a, b, c, d] Means within a column with the same letter are not significantly different ($P > 0.05$).

Fatty acids composition of raw fish samples and fish samples subject to different cooking processes is shown in **Table 2**. Important fatty acids present in raw fish samples include palmitic acid (16:0, 30.15%), stearic acid (18:0, 23.14%), oleic acid (18:1n-9, 15.03%) and docosahexanoic acid (DHA, 22:6n-3, 11.51%). Although low in fat the fish has high proportions of DHA. However, values of fatty acids bore difference to Osman, Suriah and Law's work which reported 16:0 (palmitic acid) at 3.15%, 18:0 (stearic acid) at 1.80%, 16:1 (oleic acid) at 0.90% and DHA at 28.60% (Osman *et al.,* 2001). Recent studies by Chedoloh, Karrilla, and Pakdeechanuan have concluded that unsaturated fatty acids (UFA) content in this particular species, *Megalaspis cordyla*, exceeded 67% but is in contrary to our finding as UFA content of fresh fish sample did not exceed 44% (Chedoloh *et al.,* 2011). All these dissimilarities are however subject to differences caused by fish diet, season, and also extraction methods when comparing between studies (Amira *et al*., 2009; Larsen *et al.,* 2010). There is notable loss of DHA, in fried fish sample (3.79%) compared to raw (11.51%), steamed (16.58%), and grilled (17.90%) samples. PUFAs in general are the most unstable fatty acids due to its susceptibility to heat with degree of instability increasing in fatty acids that are lower in saturation (Sioen *et al.,* 2006; MnariBhouri *et al.,* 2010). Frying was done at 200^{o}C, higher in temperature and heat than the rest of the cooking methods causing a crossover in temperature threshold leading to degradation of PUFA in fish samples (Rosnes *et al.,* 2011). It can be deduced that although hardtail scad was a species with low total extractable lipid, excessive increase in fat due to frying

leads to loss of important PUFAs and thus is generally an undesirable method to prepare seafood for consumption. There were also prominent loss of 16:1 (0.96%) and 18:0 (0.35%) fatty acids in fried fish samples. Significant increase of oleic acid (44.72%) and palmitic acid (36.12%) in fried fish sample is due to the type of cooking oil used thus further explaining the fat-moisture exchange that happens during frying process and excess fat absorption from cooking oil (Nurhan, 2007; Yanar *et al.,* 2007). Indeed palm oil has high percentages of oleic (40.5%) and palmitic (42.8%) fatty acids as reported by Kincs (1985). There is also notable increase in linoleic acid of fried fish fillets (C18:2 n-6) from 3.96% to 10.12% which is also indication that fat absorption from frying oil has taken place as palm oil has approximately 10% of the said fatty acid (Kincs, 1985).

Conclusion

The study revealed that steaming and microwave grilling had the most desirable affect as opposed to frying for preparation of *Megalaspis cordyla*. Frying it however depletes moisture and cause significant increase in lipid uptake from the cooking oil. The fish is low in fat with high proportions of DHA making it desirable for consumption.

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References

Abd Aziz, N., Azlan, A., Ismail, A., Mohd Alinafiah, S. and Razman, M. R. (2012). Quantitative determination of fatty acids in marine fish and shellfish from warm water of Straits of Malacca for nutraceutical purposes. *BioMed Research International*, *2013*.

Amira, M. B., Hanene, J. H., Madiha, D., Imen, B., Mohamed, H. and Abdelhamid, C. (2009). Effects of frying on the fatty acid composition in farmed and wild gilthead sea bream (*Sparusaurata*). *International Journal of Food Science & Technology*, **45**:113-123.

Ansorena, D., Guembe, A., Mendizábal, T. and Astiasarán, I. (2010). Effect of fish and oil nature on frying process and nutritional product quality. *Journal of Food Science*, **75**:62-67.

Anwar, F., Bhanger, M. I., Latif, S. and Manzoor, M. (2006). Lipid content and fatty acid composition of some deep fried and fast foods from Sindh, Pakistan. *Journal of the Chemical Society of Pakistan*, **28**:374-379.

AOAC (1990). Official methods of analysis. Washington DC: Association of Official Analytical Chemists.

AOCS (1991). Official methods and recommended practice. Washington DC: American Oil Chemists' Society.

AOAC (1995). Official methods of analysis. Washington DC: Association of Official Analytical Chemists.

Bennion, M. (1997). Introductory Foods (7th ed.) MacMillan: New York, USA.

Che Musa, C. U. and Nuruddin, A. A. (2005). Trash fish production and national fish feed requirement in Malaysia. *In: Regional Workshop on Low Value and "Trash Fish" in the Asia-Pacific Region,* Hanoi, Vietnam, 7-9.

Chedoloh, R., Karrilla, T. T. and Pakdeechanuan, P. (2011). Fatty acid composition of important aquatic animals in Southern Thailand. *International Food Research Journal*, **18**:758-765.

Ersoy, B. (2011). Effects of cooking methods on the proximate, mineral and fatty acid composition of European eel (*Anguilla anguilla*). *International Journal of Food Science & Technology*, **46**:522-527.

Gladyshev, M. I., Sushchik, N.N., Gubanenko, G. A., Demirchieva, S. M. and Kalachova, G.S. (2006). Effect of way of cooking on content of essential polyunsaturated fatty acids in muscle tissue of humpback salmon (*Oncorhynchusgorbuscha*). *Food Chemistry*, **96**: 446-451.

Gladyshev, M. I., Sushchik, N. N., Gubanenko, G. A., Demirchieva, S.M. and Kalachova, G. S. (2007). Effect of boiling and frying on the content of essential polyunsaturated fatty acids in muscle tissue of four fish species. *Food Chemistry*, **101**:1694-1700.

Kincs, F.R. (1985). Meat fat formulation. *Journal of The American Oil Chemist's Society* (JAOCS), **62**:815-818.

Larsen, D., Quek, S. Y. and Eyres, L. (2010). Effect of cooking method on the fatty acid profile of New Zealand King Salmon (*Oncorhynchustshawytscha*). *Food Chemistry*, **119**:785-790.

Mathew, S., Ammu, K., Viswanathan Nair, P. G. and Devadasan, K. (1999). Cholesterol content of Indian fish and shellfish. *Food Chemistry,* **66**:455 - 461.

Mnari Bhouri, A., JrahHarzallah, H., Dhibi, M., Bouhlel, I., Hammami, M. and Chaouch, A. (2010). Nutritional fatty acid quality of raw and cooked farmed and wild sea bream (*Sparusaurata*). *Journal of Agricultural and Food Chemistry*, **58**:507-512.

Nurhan, U. (2007). Change in proximate, amino acid and fatty acid contents in muscle tissue of rainbow trout (*Oncorhynchusmykiss*) after cooking. *International Journal of Food Science & Technology*, **42**:1087-1093.

Nurnadia, A. A., Azrina, A. and Amin, I. (2011). Proximate composition and energetic value of selected marine fish and shellfish from the West coast of Peninsular Malaysia. *International Food Research Journal*, **18**:137-148.

Osman, H., Suriah, A. R. and Law, E. C. (2001). Fatty acid composition and cholesterol content of selected marine fish in Malaysian waters. *Food chemistry*, **73**:55-60.

Pirini, M., Testi, S., Ventrella, V., Pagliarani, A. and Badiani, A. (2010). Blue-back fish: fatty acid profile in selected seasons and retention upon baking. *Food Chemistry*, **123**:306-314.

Rosnes, J.T., Skara, T. and Skipnes, D. (2011). Recent advances in minimal heat processing of fish: effects on microbiological activity and safety. *Food and Bioprocess Technology*, **4**:833-848.

Sioen, I., Haak, L., Raes, K., Hermans, C., De Henauw, S., De Smet, S. and Van Camp, J. (2006). Effects of pan-frying in margarine and olive oil on the fatty acid composition of cod and salmon. *Food Chemistry,* **98**:609–617.

Siong, T.E. (1987). Nutrient Composition of Malaysian Marine Fishes. *Asean Food Journal*, **3(2)**:68-69.

Weber, J., Bochi, V. C., Ribeiro, C. P., Victorio, A. M. and Emanuelli, T. (2008). Effect of different cooking methods on the oxidation, proximate and fatty acid composition of silver catfish (*Rhamdiaquelen*) fillets. *Food Chemistry*, **106**:140-146.

Yanar, Y., Küçükgülmez, A., Ersoy, B. and Çelik, M. (2007). Cooking effects on fatty acid composition of cultured sea bass (*Dicentrarchuslabrax*) fillets. *Journal of Muscle Foods*, **18**:88-94.