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# Fatty acid composition of some Malaysian freshwater fish

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Total lipids extracted from 20 species of freshwater fish in Malaysia were analyzed for their total fat and fatty acids composition. Most of the fish contained less than 20% lipid by weight. The composition of fatty acids showed that total monounsaturated fatty acids (17–53%) were the highest, followed by saturated (15–43%) and polyunsaturated (12–25%). The total ω-6 fatty acids (2·43–26·2%) were found to be higher than the ω-3 (1–11%). Most of the fish had an ω-3/ω-6 ratio of less than 1 except for *Siamese Sepat* (3·38), *Black Siakap* (2·20) and *Tilapia* (1·26).

## INTRODUCTION

Fish and fish oil fatty acids are currently under intense scientific investigation because of the numerous health benefits attributed to them. Researchers have shown that freshwater fish generally contain lower proportions of ω-3 (*n*-3) polyunsaturated fatty acids (PUFA) than marine fish (Mohsen, 1985; Vlieg & Body, 1988). According to Leaf and Weber (1988), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which were found only in fish and other seafoods, possess extremely beneficial properties for the prevention of human coronary artery disease. Fish need PUFAs to provide tolerance to low water temperatures. Decreases in PUFA concentrations in lipids would therefore be expected in warmer waters (nearer the equator) like Malaysia. Although it is generally recognized that PUFA composition may vary among species of fish, little attention has been paid to the PUFA composition of different species when selecting fish for diets (Hearn *et al.*, 1987). Therefore, when fish are suggested as a means of improving health, both the fat content and the PUFA distribution must be considered. Since the fishery department in Malaysia is now encouraging and expanding the freshwater fish industry among the agriculturists and fishermen to increase their income (Karim, 1990), it is timely to conduct a study to evaluate the fatty acid composition (especially the ω-3 and ω-6) of 20 species of common freshwater fish.

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## MATERIALS AND METHODS

All fish, except freshwater eel, were obtained from the Freshwater Fish Research Center, Malacca, and the local markets. The eel was obtained from the Bintang Family Industries, Kelantan. The fish were first wrapped with two layers of polyethylene plastic and were then immediately iced. Before analysis the fish was thawed and duplicate samples were obtained from eviscerated fish consisting of flesh and skin. The tissue was homogenized in 60 ml methanol and 30 ml chloroform (2 : 1) according to the method of Kinsella *et al.* (1977). The resulting lipid fraction was weighed and removed for analysis.

Lipid samples were converted to their constituent fatty acid methyl esters (FAME) by the method of Timms (1978). As much as 0·2 g lipid samples were weighed and diluted in 4 ml hexane followed by 0·2 ml sodium methoxide in a sealed tube. The mixture was shaken using a vortex for 10 s and left for about 30 min until it separated into two phases. The top layer (FAME) was pipetted and dried under nitrogen gas.

Routine analysis of methyl esters was performed by a capillary Gas Chromatograph (GC-17A Shidmadzu) on a fused silica Omegawax 320 (Supelco Inc., USA) column (30 m length × 0·32 mm i.d). Carrier gas was helium at a linear velocity of 25 cm/s (1·7 ml/min). Split injection with a split ratio of 100 : 1 was used. Operating conditions were 250°C injection port; 260°C flame ionization detector, and column temperature was 200°C, isothermal. Compounds were tentatively identified by comparison with retention times of Menhaden oil standards (Sigma Chem. Co.).

## RESULTS AND DISCUSSION

The fat content of the freshwater fish are listed in Table 1. Fish are often classified on the basis of their fat content (Bennion, 1980). Based on this classification, most of the fish studied were lean fish whereby the fat content was lower than 5% by weight. This includes Siamese Sepat (1·17%), Rohu (1·25%), Big Head Carp (1·75%), Common Carp (1·92%), Katla (1·92%), Red Tilapia (2·41%), Tilapia (2·75%), Snakehead (3·25%), Catfish (4·25%) and Wild Sepat (4·5%). The medium fat fish instead have 5–10% fat whereas the fatty fish have more than 10% fat by weight. The fatty fish studied were Freshwater Eel (10·67%), Baung (18·83%), African Catfish (20%) and Red Pomfret (34%). The lean fish stores 50–80% of its fat in the form of triacylglycerol in the liver and it is a good source of fat-soluble vitamins, especially vitamin A and vitamin D (Jacquot, 1961). According to Feeley *et al.* (1972) these low fat fish have a higher water content and, as a result, their meats are whiter in colour. The fatty fish instead stores its fat in muscle tissue (Gurr, 1992) and their meats are pigmented with yellow, grey, pink or other colours.

The fat content in fish varies according to seasons, species and geographical variation. Age variation and sex maturity in the same species also contribute to the significant differences in the total lipid contents (Piggott & Tucker, 1990; Tsuchiya, 1961). Generally, themonounsaturated fatty acid content (17–53%) was higher in freshwater fish than the saturated fatty acid content (15–45%) and polyunsaturated fatty acid content (12–38%) (Table 2). This is similar to the study carried out by Nair and Gopakumar (1978). The total unsaturated fatty acid $\omega$-6 (2·43–26·2%) was found to be higher than that of $\omega$-3 (1–11%) in the 20 fish studied (Table 2). The same tendency was also reported by Suzuki *et al.* (1986) in their study with cultured catfish and carp. This could be due to the fact that organisms in the North Australian and Malaysian tropical waters are also rich in polyunsaturated $\omega$-6 fatty acids (O'Dea & Sinclair, 1982; Gibson 1983).

Fish oils have been proposed as antithrombotic dietary supplements. The rationale is that oils rich in C20:5$\omega$-3 would provide substrate for the production of platelet antiaggregatory factors such as $TXA_3$ and $PGI_3$, but concern has been expressed over the wisdom and efficacy of such proposals (Budowski, 1981; Goodnight *et al.*, 1982). While the 3 series prostanoids may be antithrombotic, there is no doubt that the 2 series prostaglandins derived from C20:4$\omega$-6 have a diverse and essential role to play in the processes of the body. Bowman and Rand (1980) reported that arachidonic acid (C20:4$\omega$-6) is a precursor for prostaglandin and thromboxan which will influence the blood clot and its attachment to the endothelial tissue during wound healing. Apart from that, the acid also plays a role in growth. Fish which were found to be high in arachidonic acid (AA) were Eel (15·1%), Big Head Carp (14·0%), Common Carp (15·3%), Rohu (8·51%), Snakehead (2·22%) and Freshwater Eel (2·48%) (Table 3). The high level of polyunsaturated fatty acid, especially C20:4$\omega$-6, in fish is most probably due to lower oxygen solubility in warmer water (Smith & Miller, 1980).

The values of eicosapentaenoic acid (EPA) and docosahexaenoic acids (DHA) of freshwater fish studied are also listed in Table 3. The amounts of EPA were found to be less than 3·5% with Freshwater Eel being the highest (3·48%) followed by Eel (2·66%). This would explain the usage of these two fish as a traditional

**Table 1. Lipid content of 20 freshwater fish in Malaysia**

| Common name | Scientific name | Mean (wt kg) | Lipid (g/100 g) | Lipid (SD) |
|---|---|---|---|---|
| Siamese Sepat | *Trichogaster pectoralis* | 0·11 | $1{\cdot}17^{no}$ | 0·05 |
| Rohu | *Labearohibita* | 1·36 | $1{\cdot}25^{no}$ | 0·16 |
| Big Head Carp | *Aristichthys nobilis* | 2·02 | $1{\cdot}75^{mn}$ | 0·87 |
| Common Carp | *Cyprinus carpio* | 1·80 | $1{\cdot}92^{lmn}$ | 0·10 |
| Katla | *Catla catla* | 0·75 | $1{\cdot}92^{lmn}$ | 0·56 |
| Red Tilapia | *Oreochromis mossambicusx O. niloticus* × *O. aureus* | 0·39 | $2{\cdot}41^{lm}$ | 0·32 |
| Tilapia | *Oreochromis mossambicus* | 0·30 | $2{\cdot}75^{kl}$ | 0·09 |
| Snakehead | *Channa striatus* | 0·32 | $3{\cdot}25^{k}$ | 0·63 |
| Catfish | *Clarias macrocephalus* | 0·56 | $4{\cdot}25^{j}$ | 0·16 |
| Wild Sepat | *Trichogaster trichopterus* | 0·13 | $4{\cdot}50^{j}$ | 0·03 |
| Indonesian Carp | *Puntius gonionotus* | 0·58 | $5{\cdot}17^{i}$ | 0·64 |
| Patin | *Pengasius pengasius* | 0·42 | $5{\cdot}67^{hi}$ | 0·39 |
| Eel | *Monopterus albus* | 0·13 | $6{\cdot}25^{gh}$ | 0·09 |
| Black Siakap | *Lates* sp. | 0·47 | $6{\cdot}50^{gh}$ | 0·38 |
| Silver Carp | *Hypopththalmiehthys molitrix* | 1·95 | $7{\cdot}08^{f}$ | 0·48 |
| Malaysian Carp | *Leptobarbus hoevenii* | 1·11 | $7{\cdot}92^{e}$ | 0·16 |
| Freshwater Weel | *Anguilla mauritiana* | 0·37 | $10{\cdot}67^{d}$ | 0·94 |
| Catfish | *Mystus nemurus* | 0·77 | $18{\cdot}83^{c}$ | 0·77 |
| African Catfish | *Claria grapienus* | 0·35 | $20{\cdot}00^{b}$ | 0·20 |
| Red Pomfret | *Piaractus brachyponus* | 2·30 | $34{\cdot}00^{a}$ | 0·20 |

Different letters along columns indicate a significant difference ($P < 0{\cdot}05$).

**Table 2a. Fatty acid composition of freshwater fish (results are expressed as a percentage of the total fatty acids present)**

| Fatty acid | Species | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Menhaden (Standard) | Baung | Red Pomfret | Eel | Snake-head | Malaysian Carp | Big Head Carp | Silver Carp | Katla | African Catfish |
| C14:0 | 9·02 | 1·03 | 2·77 | 0·72 | 3·42 | 0·74 | 0·44 | 0·83 | 2·34 | 1·44 |
| C16:0 | 17·1 | 26·6 | 15·94 | 15·6 | 13·5 | 26·6 | 14·5 | 12·7 | 19·0 | 18·6 |
| C18:0 | 2·83 | 10·2 | 2·02 | 7·93 | 5·88 | 10·5 | 9·58 | 1·80 | 6·83 | 1·64 |
| C20:0 | 1·00 | — | 0·22 | 0·28 | 0·33 | 0·13 | 0·55 | — | 0·35 | 0·20 |
| C22:0 | 0·18 | 0·47 | 0·08 | 0·23 | 0·22 | 0·03 | 0·68 | 0·19 | 0·44 | 0·11 |
| C23:0 | 0·34 | 0·64 | — | 1·53 | 1·22 | 1·85 | 1·56 | 0·14 | 0·82 | 0·30 |
| C24:0 | 0·32 | — | 0·04 | — | 0·89 | 0·02 | — | 0·03 | 0·15 | 0·19 |
| Σ Saturated | 30·8 | 38·92 | 21·07 | 26·3 | 25·5 | 39·9 | 27·3 | 15·7 | 29·9 | 22·5 |
| C16:1ω-7 | 12·02 | 2·98 | 6·30 | 1·48 | 5·68 | 1·96 | 0·96 | 5·29 | 3·91 | 6·46 |
| C18:1ω-9 | 6·51 | 34·34 | 44·52 | 15·2 | 11·62 | 20·5 | 11·4 | 33·4 | 25·7 | 43·2 |
| C18:1ω-7 | 2·72 | — | — | — | — | — | — | — | — | — |
| C20:1ω-9 | 0·20 | 0·25 | 1·05 | 0·60 | 0·30 | 0·54 | 0·45 | 0·70 | 0·67 | 0·81 |
| C24:1 | 0·28 | — | 0·55 | 4·80 | 0·14 | 9·61 | 13·9 | — | 5·78 | 0·06 |
| Σ Monounsaturated | 21·7 | 35·6 | 52·42 | 22·1 | 17·7 | 32·6 | 26·7 | 39·4 | 36·0 | 50·5 |
| C18:2ω-6 | 1·33 | 10·4 | 20·13 | 5·56 | 8·22 | 9·65 | 2·79 | 25·4 | 14·4 | 20·4 |
| C20:4ω-6 | 0·90 | 0·36 | 0·65 | 0·67 | 2·22 | 1·30 | 14·0 | 0·84 | 0·43 | 1·30 |
| Σ Acid ω-6 | 2·23 | 10·7 | 20·78 | 6·23 | 10·4 | 11·0 | 16·8 | 26·2 | 14·8 | 21·7 |
| C18:3ω-3 | 0·96 | 0·11 | 0·08 | 0·93 | 0·51 | 0·06 | — | — | 0·10 | — |
| C18:4ω-3 | 2·68 | 0·27 | 1·24 | 0·12 | 4·78 | 0·06 | | 0·39 | 0·59 | 0·02 |
| C20:4ω-3 | 1·31 | 0·08 | 0·01 | 0·13 | 0·69 | 0·69 | 0·62 | 0·28 | 0·65 | 0·05 |
| C20:5ω-3 | 15·0 | — | 0·05 | 2·66 | 0·32 | 0·15 | 0·26 | 0·04 | 0·19 | 0·08 |
| C21:5ω-3 | 0·72 | — | 0·06 | 0·13 | 0·04 | 0·08 | 1·03 | 0·24 | 1·67 | — |
| C22:5ω-3 | 2·56 | 0·33 | 0·18 | 1·92 | 0·11 | 0·07 | 1·00 | | | |
| C22:6ω-3 | 10·62 | 0·34 | 0·04 | 0·21 | 1·54 | 0·71 | — | 0·79 | 0·07 | 0·14 |
| Σ Acid ω-3 | 33·81 | 1·13 | 1·66 | 6·10 | 7·99 | 1·82 | 3·11 | 10·50 | 7·95 | 1·19 |
| C16:2ω-4 | 2·25 | 0·08 | 0·27 | 0·18 | 1·54 | 0·64 | 0·64 | 0·15 | 0·71 | 0·27 |
| C16:3ω-4 | 2·51 | 0·28 | 0·29 | 0·56 | 0·51 | 1·15 | 0·47 | 0·26 | 0·33 | 0·60 |
| C16:4ω-1 | 1·00 | 0·70 | 0·01 | 0·04 | 0·36 | 0·30 | 0·03 | 0·47 | 0·17 | 0·01 |
| C18:2ω-4 | 0·38 | — | — | 0·36 | 0·16 | 0·39 | 0·36 | 0·53 | 0·42 | — |
| C18:3ω-4 | 0·60 | — | 0·32 | 0·13 | 0·29 | 0·60 | 1·61 | — | 1·94 | 2·24 |
| Σ Polyunsaturated | 42·78 | 12·91 | 23·33 | 13·60 | 21·29 | 15·85 | 22·98 | 38·13 | 26·33 | 25·99 |

**Table 2b. Fatty acid composition of freshwater fish (results are expressed as a percentage of the total fatty acids present)**

| Fatty acid | Species | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Keli Bunga | Indonesian Carp | Lee Koh | Fresh-water Eel | Patin | Rohu | Wild Sepat | Siamese Sepat | Black Siakap | Tilapia | Red Tilapia |
| C14:0 | 0·79 | 3·01 | 0·33 | 3·92 | 3·80 | 0·87 | 2·77 | 2·48 | 4·74 | 5·48 | 3·53 |
| C16:0 | 23·4 | 29·5 | 11·3 | 17·4 | 32·9 | 14·5 | 15·1 | 15·4 | 20·7 | 16·1 | 25·1 |
| C18:0 | 8·42 | 11·4 | 7·30 | 7·21 | 7·48 | 10·9 | 7·26 | 9·75 | 0·09 | 10·1 | 5·61 |
| C20:0 | 1·04 | 0·28 | 0·62 | 0·79 | 0·28 | 0·33 | 0·25 | 0·37 | — | 0·40 | 2·51 |
| C22:0 | 0·11 | 0·13 | 0·16 | 0·18 | 1·46 | 0·37 | 0·11 | 0·29 | 4·78 | 0·21 | 0·15 |
| C23:0 | 0·36 | 0·42 | 2·53 | 1·01 | 0·46 | 2·03 | 0·93 | 1·28 | 0·92 | 0·02 | 0·71 |
| C24:0 | 0·17 | 0·51 | 2·61 | 2·47 | 0·73 | 0·85 | — | — | — | 2·79 | 0·06 |
| Σ Saturated | 34·3 | 45·2 | 24·8 | 33·0 | 47·1 | 29·9 | 26·5 | 29·5 | 31·2 | 35·1 | 37·7 |
| C16:1ω-7 | 1·50 | 2·48 | 1·33 | 6·09 | 1·50 | 1·48 | 6·10 | 4·77 | 7·27 | 5·71 | 5·80 |
| C18:1ω-9 | 27·7 | 27·9 | 13·1 | 24·8 | 31·5 | 16·9 | 27·1 | 17·1 | 8·18 | 14·9 | 32·2 |
| C18:1ω-7 | — | — | 0·03 | 0·06 | — | 0·02 | — | — | — | — | — |
| C20:1ω-9 | 0·19 | 0·74 | 0·64 | 1·81 | 1·76 | 0·37 | 1·35 | 0·70 | 0·59 | 0·78 | 0·07 |
| C24:1 | 0·12 | 0·06 | 14·3 | 9·33 | 2·26 | 13·3 | — | 20·6 | — | 5·16 | 1·43 |
| Σ Monounsaturated | 29·5 | 31·2 | 29·4 | 42·0 | 37·0 | 32·1 | 34·5 | 43·2 | 16·0 | 26·6 | 39·5 |
| C18:2ω-6 | 17·9 | 15·6 | 5·06 | 6·60 | 9·97 | 11·9 | 9·28 | 2·19 | 2·88 | 5·09 | 15·4 |
| C20:4ω-6 | 1·60 | 0·45 | 15·3 | 2·48 | — | 8·51 | 0·66 | 0·24 | 0·20 | 0·53 | 1·37 |
| Σ Acid ω-6 | 19·5 | 16·1 | 20·4 | 9·08 | 9·97 | 20·4 | 9·94 | 2·43 | 3·08 | 5·62 | 16·8 |
| C18:3ω-3 | 0·68 | 0·12 | 0·48 | 0·69 | 0·94 | 0·76 | 0·17 | 0·59 | 0·45 | — | 0·09 |
| C18:4ω-3 | 1·23 | 0·05 | 1·20 | 0·22 | 4·91 | 0·04 | 3·17 | 5·25 | 0·43 | 4·89 | 0·13 |
| C20:4ω-3 | 0·06 | 0·49 | 0·13 | 0·55 | 0·41 | 0·16 | 0·01 | 0·02 | 0·21 | 1·01 | 0·35 |
| C20:5ω-3 | 0·08 | 0·22 | 0·36 | 3·48 | 0·08 | 1·34 | 0·41 | 0·44 | 0·43 | 0·84 | 0·24 |
| C21:5ω-3 | 0·35 | 0·21 | 0·24 | 0·19 | 0·05 | 0·08 | 0·04 | 0·04 | 0·11 | 0·17 | — |
| C22:5ω-3 | 0·55 | 0·50 | 0·01 | 0·17 | 2·39 | 1·33 | — | — | 1·39 | 0·18 | 0·76 |
| C22:6ω-3 | 0·48 | — | 0·11 | 0·89 | — | — | 1·57 | 1·88 | 3·78 | — | 0·08 |
| Σ Acid ω-3 | 3·43 | 1·59 | 2·53 | 6·19 | 8·78 | 3·71 | 5·37 | 8·22 | 6·80 | 7·09 | 1·65 |
| C16:2ω-4 | 0·11 | 0·83 | 1·08 | 1·06 | 0·59 | 0·14 | 1·32 | 1·52 | 0·18 | 2·18 | 0·52 |
| C16:3ω-4 | 0·45 | 0·46 | 0·49 | 2·28 | 1·49 | 0·34 | 1·48 | 0·73 | 1·34 | 2·47 | 0·98 |
| C16:4ω-1 | 0·72 | 0·20 | 0·25 | 0·05 | 0·03 | 0·08 | 0·37 | 0·24 | 1·40 | 0·38 | 0·32 |
| C18:2ω-4 | — | 0·06 | 0·06 | 0·12 | 0·16 | — | 0·07 | — | 1·02 | 0·09 | 0·08 |
| C18:3ω-4 | 0·07 | 0·48 | 0·14 | 0·59 | 0·63 | 0·05 | 0·92 | 0·48 | 0·19 | 0·61 | 1·26 |
| Σ Polyunsaturated | 24·3 | 19·70 | 24·9 | 19·4 | 21·7 | 24·7 | 19·5 | 13·6 | 14·0 | 18·4 | 21·6 |

**Table 3. Arachidonic acid (AA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) of freshwater fish in muscle**

| Species | %AA (20:4ω-6) | %EPA (C20:5ω-3) | %DHA (C22:6ω-3) |
|---|---|---|---|
| Menhaden (Standard) | 0·90 | 15·0 | 10·6 |
| Baung | 0·36 | — | 0·34 |
| Red Pomfret | 0·65 | 0·05 | 0·04 |
| Eel | 15·1 | 2·66 | 0·21 |
| Snakehead | 2·22 | 0·32 | 1·54 |
| Malaysian Carp | 1·30 | 0·15 | 0·71 |
| Big Head Carp | 14·0 | 0·26 | — |
| Silver Carp | 0·84 | 0·28 | 0·79 |
| Katla | 0·43 | 0·65 | 0·07 |
| African Catfish | 1·30 | 0·05 | 0·14 |
| Keli Bunga | 1·60 | 0·08 | 0·48 |
| Indonesian Carp | 0·45 | 0·22 | — |
| Lee Koh | 15·3 | 0·36 | 0·11 |
| Freshwater Eel | 2·48 | 3·48 | 0·89 |
| Patin | — | 0·08 | — |
| Rohu | 8·51 | 1·34 | — |
| Wild Sepat | 0·66 | 0·41 | 1·57 |
| Siamese Sepat | 0·24 | 0·44 | 1·88 |
| Black Siakap | 0·20 | 0·43 | 3·78 |
| Tilapia | 0·53 | 0·84 | — |
| Red Tilapia | 1·37 | 0·24 | 0·08 |

medicine for muscle pain (Mohsin & Ambak, 1983). The DHA levels were below 2%, except for Black Siakap (3·78%). Results also indicated that the ω-3:ω-6 ratios of the fish were lower than 1, except for Siamese Sepat (3·38), Black Siakap (2·20) and Tilapia (1·26) (Table 4). Wang *et al.* (1990) found that the ω-3:ω-6 ratio of freshwater fish was lower than marine fish, whereby the ratio ranged from 4·7 to 14·4. Freshwater fish normally consist of more ω-6 polyunsaturated fatty acid, i.e. linoleic acid (C18:2) and arachidonic acid (C20:4), whereas the marine fish are rich in ω-3, especially DHA and EPA (Wang *et al.*, 1990).

Piggott and Tucker (1990) suggested that the ω-3:ω-6 ratio is a better index in comparing relative nutritional value of fish oil for different species. However, there is no recommended intake in terms of ω-3:ω-6 ratio, but evidence in wild animals and estimated nutrient intake during human evolution suggested a diet ratio of 1:1 (Simopoulos, 1989). There was no correlation found between the ratio of ω-6:ω-3 fatty acids and the polyunsaturated fatty acid. This is in line with what was reported by Iritani and Fujikawa (1982).

**Table 4. Fatty acid ω-3:ω-6 ratio in the muscle**

| Species | ω-3:ω-6 Ratio |
|---|---|
| Siamese Sepat | 3·38 |
| Black Siakap | 2·20 |
| Tilapia | 1·26 |
| Eel | 0·88 |
| Patin | 0·88 |
| Snakehead | 0·77 |
| Freshwater Eel | 0·68 |
| Katla | 0·54 |
| Wild Sepat | 0·54 |
| Big Head Carp | 0·43 |
| Silver Carp | 0·40 |
| Keli Bunga | 0·18 |
| Rohu | 0·18 |
| Malaysian Carp | 0·17 |
| Lee Koh | 0·12 |
| Baung | 0·11 |
| Indonesian Carp | 0·10 |
| Red Tilapia | 0·10 |
| Red Pomfret | 0·08 |
| African Catfish | 0·05 |

Although it is generally recognized that PUFA composition may vary among species of fish, little attention has been paid to the PUFA composition of different species when selecting fish for diets. All fish are considered to be of similar nutritional value, and selection is chiefly based on availability, freshness, flavour and similar factors (Hearn *et al.*, 1987). Results of clinical and epidemiological research suggest that EPA and DHA, found only in fish and seafoods, possess extremely beneficial properties for the prevention of human coronary artery disease (Leaf & Weber, 1988). Therefore, when fish are suggested as a means of improving health, both the fat content and the PUFA distribution must be considered. Even though results (Tables 1 and 3) suggest that, generally, the freshwater fish studied are not good sources of ω-3 fatty acids or C20:4*n*-6 fatty acids due to the low fat content in the fish, they are still very important components of the Malaysian diet, constituting 60–70% of the national animal protein intake. As a result of this the demand for fish has grown considerably in recent years and its perceived benefits to health has made it a more upmarket food (Malaysia Agricultural Directory & Index 1993/1994). The fish does therefore contribute significantly to the amount of ω-3 fatty acids in the Malaysian diet.

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