Research Article

Fatty Acids Profile of Three Different Regions of Fresh and Ice-packed *Pangasius pangasius* (Hamilton, 1822)

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ABSTRACT

The proximate composition and fatty acids profile of head, dorsal and ventral regions of ice-packed and fresh *Pangasius pangasius* were evaluated. Fatty acids analysis were carried out using Gas chromatography–mass spectrometry (GCMS). The lipid content in the head and dorsal regions of both ice-packed and fresh *Pangasius pangasius* were not significant. However, the study found a significantly high ($p<0.05$) value of lipid in the ventral region of fresh comparing to ice-packed fish. Protein value was found highest in the dorsal region of fresh *P. pangasius*. Ash content was found highest in the head region of ice-packed fish and lowest in the ventral region. Among the fatty acids, palmitic acid (C16:0), oleic acid (C18:1n-9) and linoleic acid (C18:2n-6) respectively were found highest in both the fresh and the ice-packed fish in different proportions. The n-6/n-3 ratio in the head, dorsal and ventral regions were higher in the ice-packed samples compared to the fresh samples. Alpha-linolenic acid (C18:3n-3) was found only in the ice-packed fish and gamma-linolenic acid (C18:3n-6) was detected only in the fresh fish. Fatty acid containing a cyclopropane ring namely cyclopropaneoctanoic acid 2-hexyl was detected in the ventral region of ice-packed *P. pangasius*.

Keywords: Fatty acids, Fresh, Ice-packed, *Pangasius pangasius*, Proximate composition.

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INTRODUCTION

Fish is one of the most indispensable food items of the people of Manipur. More than 90% of the state's population consumed fish of different sizes in varied forms. As per the 2021-22 State Fisheries Department report, Manipur consumed around 57,000 metric tonnes of fish in a year. However, the state produced only around 33,000 metric tonnes and the remaining 24,000 metric tonnes need to be brought in from other states like Andhra Pradesh, West Bengal, Odisha as well as from neighbouring country like Myanmar. As per the 2020-21 State Fisheries Department report, Manipur produces 12.1 tonnes of *P. pangasius* and the productivity rate is 3000 kg per hectare.

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Consumption of fish gave several health benefits as fishes are rich sources of polyunsaturated fatty acids specially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These n-3 fatty acids gave immense benefits to human starting from neonatal development up to the later stages of life. For the neural development of children, a mother has to take an appropriate amount of essential long chain n-3 PUFA during pregnancy and the neonatal period.[1] In general, DHA is very rich in the retina and brain of mammals and also largely demanded by the nervous system of new born.[2] The long chain PUFAs has a significant importance because of the prevention of human coronary artery disease[3-9] and also decreased incidence of certain diseases like breast cancer, rheumatoid arthritis, multiple sclerosis, psoriasis and inflammation.[4,6,10] PUFAs play an important role in the immunological,[11] neuronal[12] and muscular system.[13] The fatty acid compositions are affected by diet, location and season.[14] The marine fishes have higher proportion of n-3 PUFA than fresh water fishes.[15] Among the marine fishes, *Salmo salar* specially the Atlantic Salmon contain high levels of EPA and DHA and was referred to as the "gold standard" for n-3 fatty acids. European Food Safety Authority (EFSA) proposed fatty acid intake values for the general population: 250mg EPA+ DHA; 2g alpha-linolenic acid and 10g of linoleic acid per day.[16] Kris-Etherton *et al.*[17] reported the general recommendations for daily dietary intakes of DHA/EPA: 0.5g for infants and an average of 1g per day for adults and patients with coronary heart disease. FAO and WHO[18] also suggested that consumption of fish twice in a week could be protective against coronary heart disease and ischemic stroke.[18] Fish consumers consumed fishes mainly for its taste and knowledge of nutritional qualities of ice-packed fishes in Manipur was very limited. There were no reports on the fatty acid profiles of ice-packed *P. pangasius* in Manipur. Moreover, preferences of different body regions by the consumers are also different. The present study aim to evaluate the head, dorsal and ventral regions of ice-packed and fresh *Pangasius pangasius* in terms of their proximate composition and fatty acids profile.

MATERIALS AND METHODS

Fish Collection and Sample Preparation

Ice-packed *Pangasius pangasius* weighing 1025-1045g with standard length 41.6-41.8cm were purchased from three different fish vendors of Imphal-West district, Manipur, India and brought to the Fishery laboratory at the Department of Life Sciences, Manipur University in insulated ice box. The fresh *Pangasius pangasius* weighing 960-1000g with standard length 39.3-39.5cm were collected from local fish farm at Wangoi Makha Leikai, Imphal-West district, Manipur, India in the same month of the year. The fishes were washed properly in running tap water. The viscera and fins were removed and the head, dorsal and ventral parts were taken from six fishes each of fresh and ice fishes for various analysis. The different parts were minced separately and grounded using mortar and pestle to ensure proper homogenization.

Proximate Composition Analysis

The proximate composition of fresh and ice-packed *P. pangasius* were analysed by following the method of AOAC.[19] Moisture value was determined by Hot air oven method of AOAC at 60°C for 6 days until a constant weight was obtained.[19] The Nitrogen was estimated by modified Micro-Kjeldahl's method.[19] Crude protein was obtained by multiplying the nitrogen value with a conversion factor of 6.25. Total lipid was extracted with a chloroform:methanol mixture following Singh *et al.*[20] method. Carbon-free white ash was determined by incinerating dry sample of known weight at 550°C for 4 hr in muffle furnace.[19]

Fatty Acid Analysis

Preparation of Fatty acid methyl esters (FAMEs) was done by transesterification of lipid using boron trifluoride (BF3) in methanol following the method of Metcalfe *et al.*[21] The fatty acid methyl esters were analysed by gas chromatography-mass spectrometry(Shimadzu GCMS-QP2010 plus), ionization energy of 70eV and fitted with Rxi-5Sil MS capillary column (30m×0.25mm) and film thickness of 0.25μm. Helium gas was used as the carrier gas. The sample was injected at the injection port with an injection volume of 2μl at a constant flow of 1.21ml/min with a 1:10 split ratio at 260°C and the oven temperature was programmed to increase from 140-280°C at the rate of 4°C/min keeping it stable for 50 min. To obtain relative abundance of m/z ranging from 40 to 650, the MS (mass spectrometer) need to be adjusted. Quantification of fatty acids were done by comparing the spectrum of unknown fatty acids with the spectrum stored in the NIST and WILEY library. Each fatty acid was expressed as area percentage of the total fatty acids quantified.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 21.0 for windows was performed for statistical analysis. The proximate and the fatty acids composition of head, dorsal and ventral regions of fresh and ice-packed *P. pangasius* were analysed using one way analysis of variance (ANOVA) and the significant differences between means were determined by post hoc Tukey's multiple range test at the Significant level $p<0.05$. Correlation among proximate composition and among fatty acids were also performed using this SPSS version.

RESULTS

Proximate Composition

The proximate composition of different body regions of ice-packed and fresh *P. pangasius* were shown in Table 1. The moisture content in the head of fresh (60.46±0.39%) was significantly higher than the head of ice-packed (55.63±0.27%) *P. pangasius*. The dorsal region of fresh (75.89±0.10%) have significantly lower moisture content than ice-packed (76.79±0.26%) fish. And the ventral region also has significantly lower moisture content in the fresh sample (70.69±0.03%) as compared

Table 1: Proximate composition (%) of ice-packed and fresh *Pangasius pangasius*.

Proximate Composition	Head		Dorsal		Ventral	
	Ice-packed	Fresh	Ice-packed	Fresh	Ice-packed	Fresh
Moisture	55.63±0.27[a]	60.46±0.39[b]	76.79±0.26[f]	75.89±0.10[e]	72.10±0.27[d]	70.69±0.03[c]
protein	10.87±0.02[b]	15.84±0.02[d]	11.08±0.02[c]	19.38±0.01[e]	9.10±0.03[a]	10.85±0.05[b]
Lipid	15.80±0.20[c]	16.00±0.10[cd]	1.00±0.10[a]	1.00±0.00[a]	3.25±0.15[b]	16.30±0.20[d]
Ash	9.32±0.04[e]	8.76±0.02[d]	1.05±0.01[c]	1.01±0.00[bc]	0.75±0.00[a]	0.99±0.00[b]

Data represented as mean ± SD. Means within the same row having different superscript are significantly different ($p<0.05$).

Table 2: Pearson's correlation among Proximate composition.

	Moisture	Protein	Lipid	Ash
Moisture	1			
Protein	.125	1		
Lipid	-.811**	-.153	1	
Ash	-.946**	.093	.690**	1

** Correlation is significant at the 0.01 level (2-tailed).

to ice-packed sample (72.10±0.27%). Crude protein content was found higher in the dorsal (19.38±0.01%), head (15.84±0.02%) and ventral (10.85±0.05%) regions of fresh fish as compared to dorsal (11.08±0.05%), head (10.87±0.02%) and ventral (9.10±0.03%) regions of ice-packed fish. The lipid content in the head and dorsal regions of both the fresh and ice-packed fish were not significant. However, the ventral region of fresh has significantly higher (>5folds) lipid content (16.30±0.20%) than ice-packed (3.25±0.15%) fish. The ice-packed fish have higher ash content in the head (9.32±0.04%) and dorsal (1.05±0.01) regions than that of fresh fish while in the ventral region, the ash content was significantly higher in the fresh (0.99±0.00%) than ice-packed (0.75±0.00%) *P. pangasius*.

Table 2 showed the Pearson's correlation among proximate composition of different body regions of ice-packed and fresh *P. pangasius*. Moisture content showed positive correlation with protein content with correlation co-efficient of 0.125 and negatively correlated with lipid content (-0.811) and ash content (-0.946). The protein content was again positively correlated with the ash content (0.093) and negatively correlated with the lipid content (-0.153). The lipid content showed positive correlation with ash content (0.690).

Fatty Acids Composition

The fatty acids profile of the head, dorsal and ventral regions of ice-packed and fresh *Pangasius pangasius* were represented in Tables 3, 4 and 5 respectively. The fatty acids composition in the head of ice-packed *P. pangasius* was found to be 41.76±0.03% (SFAs), 25.64±0.01% (MUFAs) and 6.25±0.01% (PUFAs). Among SFAs, palmitic acid> stearic acid> myristic acid were dominant. Oleic acid (C18:1n-9) was found highest (17.95±0.06%) among MUFAs. Linoleic acid was found highest (4.95±0.02%) among PUFAs and no EPA and DHA were detected. In the head of fresh *P. pangasius*, the fatty acid composition was found 36.25±0.07% (SFAs), 37.65±0.01% (MUFAs), and 7.86 ± 0.08% (PUFAs). Among SFAs, palmitic acid> stearic acid> myristic acid were predominant. Oleic acid was the highest (30.83±0.08%) followed by palmitoleic acid (C16:1n-7) among MUFAs. Among PUFAs, arachidonic acid > mead's acid > DHA > EPA.

In the dorsal region of ice-packed *P. pangasius*, the fatty acid composition was 36.69±0.03% (SFAs), 23.78±0.01% (MUFAs) and 18.19±0.03% (PUFAs). Palmitic acid> stearic acid> myristic acid were present higher among SFAs. Oleic acid content was highest among MUFAs and among PUFAs, linoleic acid> arachidonic acid> DHA> EPA were predominant. And in the dorsal region of fresh *P. pangasius*, the fatty acid composition was found to be 40.49±0.02% (SFAs), 24.28±0.035% (MUFAs) and 12.91±0.01% (PUFAs). Palmitic acid was the highest among SFAs. Oleic acid was the highest among MUFAs and linoleic acid> EPA> mead's acid> arachidonic acid> DHA were dominant among PUFAs.

The fatty acid composition in the ventral region of ice-packed *P. pangasius* has 40.27±0.15% (SFAs), 30.51±0.16% (MUFAs) and 7.36±0.08% (PUFAs). Among SFAs, Palmitic acid (17.69±0.12%) was the highest. Oleic acid (22.43±0.11%) was the highest among MUFAs and EPA>11,14-Eicosadienoic acid >DHA> Clupanodonic acid were predominant among PUFAs. And in the ventral region of fresh *P. pangasius*, the fatty acid composition has 39.00±0.12% (SFAs), 40.16±0.18% (MUFAs) and 6.70±0.02% (PUFAs). Palmitic acid was found highest among SFAs. Oleic acid was the highest among MUFAs and mead's acid>EPA> arachidonic acid> DHA were dominant among PUFAs.

Table 3: Fatty acid profiles in the head region of Ice-packed and fresh *Pangasius pangasius*.

Fatty acids	Ice-packed	Fresh	Significant difference
Saturated (SFA)			
C13:0	0.38 ± 0.02[a]	ND	
C14:0	4.78 ± 0.03[a]	5.16 ± 0.06[b]	s
C15:0	2.27 ± 0.05[b]	0.33 ± 0.08[a]	s
C16:0	22.74 ± 0.12[b]	20.54 ± 0.08[a]	s
C17:0	1.55 ± 0.05[b]	0.61 ± 0.03[a]	s
C18:0	7.91 ± 0.08[a]	8.16 ± 0.05[b]	s
C19:0	ND	0.22 ± 0.01[a]	
C20:0	0.72 ± 0.02[b]	0.56 ± 0.03[a]	s
C21:0	0.19 ± 0.01[b]	0.09 ± 0.00[a]	s
C22:0	0.73 ± 0.04[b]	0.58 ± 0.02[a]	s
C23:0	0.25 ± 0.01[a]	ND	
C24:0	0.24 ±0.03[a]	ND	
∑SFA	41.76 ± 0.03[b]	36.25 ± 0.07[a]	s
Monounsaturated (MUFA)			
C16:1n-7	4.43 ± 0.10[b]	3.77 ± 0.06[a]	s
C18:1n-9(cis-)	17.95 ± 0.06[a]	30.83 ± 0.08[b]	s
C18:1n-9(trans-)	2.79 ± 0.02[a]	ND	
C20:1n-9	0.31 ± 0.01[a]	3.05 ± 0.03[b]	s
C22:1n-9	0.16 ± 0.01[a]	ND	
∑MUFA	25.64 ± 0.01[a]	37.65 ± 0.01[b]	s
Polyunsaturated (PUFA)			
C18:2n-6(9,12)	4.95 ± 0.02[a]	ND	
C182n-6(9,11)	0.77 ± 0.03[a]	ND	
C182n-6(6,9)	ND	0.77 ± 0.01[a]	
C18:3n-6	ND	0.28 ± 0.01[a]	
C18:4n-3	ND	0.67 ± 0.03[a]	
C20:2n-6	0.29 ± 0.04[a]	0.72 ± 0.02[b]	s
C20:3n-9	0.24 ± 0.02[a]	1.21 ± 0.05[b]	s
C20:4n6	ND	1.24 ± 0.06[a]	
C20:5n-3 (EPA)	ND	1.09 ± 0.03[a]	
C22:6n-3 (DHA)	ND	1.12 ± 0.04[a]	
C22:4n-6	ND	0.25 ± 0.01[a]	
C22:5n-9	ND	0.51 ± 0.01[a]	
∑PUFA	6.25 ± 0.01[a]	7.86 ± 0.08[b]	s
∑n-3	ND	2.88 ± 0.02[a]	
∑n-6	6.01 ± 0.01[b]	3.77 ± 0.04[a]	s
∑n-6/∑n-3	6.01 ± 0.01[b]	1.30 ± 0.00[a]	s
Others	26.35 ± 0.04[b]	18.24 ± 0.14[a]	s

Values are represented as mean ± SD. Means within the same row having different superscripts are significantly different ($p<0.05$). ND=not detected, s=significant.

Table 4: Fatty acid profile in the dorsal region of Ice-packed and fresh *Pangasius pangasius*.

Fatty acids	Ice-packed	Fresh	Significant difference
Saturated (SFA)			
C12:0	ND	0.12 ± 0.00[a]	
C14:0	3.74 ± 0.05[a]	6.34 ± 0.06[b]	s
C15:0	2.97 ± 0.03[b]	0.72 ± 0.04[a]	s
C16:0	19.30 ± 0.12[a]	22.58 ± 0.10[b]	s
C17:0	2.15 ± 0.02[b]	1.01 ± 0.01[a]	s
C18:0	7.70 ± 0.05[b]	7.31 ± 0.07[a]	s
C19:0	0.27 ± 0.01[b]	0.24 ± 0.01[a]	s
C20:0	0.45 ± 0.03[a]	0.95 ± 0.05[b]	s
C21:0	0.11 ± 0.00[a]	0.17 ± 0.00[b]	s
C22:0	ND	0.66 ± 0.03[a]	
C23:0	ND	0.16 ± 0.02[a]	
C24:0	ND	0.23 ± 0.01[a]	
∑SFA	36.69 ± 0.03[a]	40.49 ± 0.02[b]	s
Monounsaturated (MUFA)			
C16:1n-7	3.85 ± 0.05[a]	6.01± 0.03[b]	s
C18:1n-9 (cis-)	19.58 ± 0.06[b]	17.88 ± 0.08[a]	s
C18:1n-9 (trans-)	ND	0.10 ± 0.00[a]	
C20:1n-9	0.35 ± 0.00[b]	0.17 ± 0.00[a]	s
C22:1n-9	ND	0.07 ± 0.00[a]	
C24:1n-9	ND	0.05 ± 0.01[a]	
∑MUFA	23.78 ± 0.01[a]	24.28 ± 0.03[b]	s
Polyunsaturated (PUFA)			
C18:2n-6 (9,12)	8.54 ± 0.05[b]	3.38 ± 0.08[a]	s
C18:2n-6 (6,9)	ND	0.98 ± 0.04[a]	
C18:2n-6 (9,11)	ND	0.06 ± 0.00[a]	
C18:3n-3	0.65 ± 0.04[a]	ND	
C18:3n-6	ND	0.17 ± 0.01[a]	
C18:4n-3	1.11 ± 0.01[b]	0.82 ± 0.01[a]	s
C20:2n-6	1.12 ± 0.03[a]	1.08 ± 0.02[a]	ns
C20:3n-9	1.18 ± 0.05[a]	1.36 ± 0.01[b]	s
C20:4n-6	1.54 ± 0.03[b]	1.34 ± 0.02[a]	s
C20:5n-3 (EPA)	1.34 ±0.01[a]	1.60 ± 0.01[b]	s
C22:5n-9	0.82 ± 0.03[b]	0.62 ± 0.02[a]	s
C22:6n-3 (DHA)	1.66 ± 0.02[b]	1.20 ± 0.02[a]	s
C22:4n-6	0.23 ± 0.01[a]	0.30 ± 0.01[b]	s
∑PUFA	18.19±0.03[b]	12.91±0.01[a]	s
n-3	4.76 ± 0.01[b]	3.62 ± 0.03[a]	s
n-6	12.25 ± 0.03[b]	7.93 ± 0.04[a]	s
n-6/n-3	2.57 ± 0.01[b]	2.18 ± 0.01[a]	s
Others	21.34 ± 0.07[a]	22.31 ± 0.01[b]	s

Means within the same row having different superscript are significantly different ($p<0.05$). ND= not detected, s=significant, ns=not significant.

Table 5: Fatty acid profile in the ventral region of Ice-packed and fresh *Pangasius pangasius*.

Fatty acids	Ice-packed	Fresh	Significant difference
Saturated (SFA)			
C13:0	0.70 ± 0.01a	ND	
C14:0	4.39 ± 0.06a	5.34 ± 0.08b	s
C15:0	3.99 ± 0.03b	0.37 ± 0.01a	s
C16:0	17.69 ± 0.12a	22.42 ± 0.14b	s
C17:0	4.15 ± 0.06b	0.63 ± 0.01a	s
C18:0	6.88 ± 0. 07a	8.60 ± 0.10b	s
C19:0	0.42 ± 0.01b	0.19 ± 0.00a	s
C20:0	0.78 ± 0.02b	0.64 ± 0.01a	s
C21:0	0.18 ± 0.00b	0.10 ± 0.01a	s
C22:0	0.65 ± 0.02b	0.46 ± 0.01a	s
C23:0	0.23 ± 0.03b	0.12 ± 0.00a	s
C24:0	0.21 ± 0.01b	0.13 ± 0.00a	s
∑SFA	40.27 ± 0.15b	39.00 ± 0.12a	s
Monounsaturated (MUFA)			
C16:1n-7	6.45 ± 0.08b	3.89 ± 0.05a	s
C16:1n-9	ND	0.60 ± 0.01a	
C17:1n-7	0.79 ± 0.03a	ND	
C18:1n-9 (cis-)	22.43 ± 0.11a	32.61 ± 0.14b	s
C20:1n-9	0.59 ± 0.01a	3.07 ± 0.06b	s
C22:1n-9	0.17 ± 0.01a	ND	
C24:1n-9	0.10 ± 0.00a	ND	
∑MUFA	30.51 ± 0.16a	40.16 ± 0.18b	s
Polyunsaturated (PUFA)			
C18:2n-6 (9,12)	0.27 ± 0.01a	ND	
C18:2n-6 (6,9)	ND	0.76 ± 0.02a	
C18:3n-3	0.80 ± 0.01a	ND	
C18:3n-6	ND	0.23 ± 0.01a	
C18:4n-3	ND	0.57 ± 0.02a	
C20:4n-6	0.96 ± 0.03a	0.91 ± 0.01a	ns
C20:5n-3 (EPA)	1.75 ± 0.02b	1.00 ± 0.00a	s
C20:3n-9	0.12 ± 0.00a	1.08 ± 0.01b	s
C20:2n-6	1.13 ± 0.02b	0.72 ± 0.01a	s
C22:5n-6	ND	0.38 ± 0.00a	
C22:6n-3 (DHA)	1.09 ± 0.02b	0.87 ± 0.01a	s
C22:4n-6	0.21 ± 0.00b	0.18 ± 0.01a	s
C22:5n-3	1.03 ± 0.01a	ND	
∑PUFA	7.36 ± 0.08b	6.70 ± 0.02a	s
n-3	4.67 ± 0.03b	2.44 ±0.01a	s
n-6	2.57 ± 0.06a	3.18 ± 0.04b	s
n-6/n-3	0.54 ± 0.01a	1.30 ± 0.01b	s
Cyclopropaneoctanoic acid 2-hexyl	0.16 ± 0.00a	ND	
Others	21.70 ± 0.13b	14.14 ± 0.08a	s

Values within the same row having different superscripts are significantly different ($p<0.05$). ND= not detected, s=significant, ns=not significant.

In Table 6, total lipid content was found positively correlated with MUFA and n-6/n-3 with correlation coefficient of 0.684 and 0.259 and negatively correlated with SFA, PUFA, n-3, n-6 and EPA+DHA respectively. SFA have positive correlation with n-6/n-3 and negatively correlated with MUFA, PUFA, n-3, n-6 and EPA+DHA. MUFA showed negative correlation with PUFA, n-3, n-6, n-6/n-3 and EPA+DHA. PUFA showed positive correlation with n-3, n-6 and EPA+DHA with correlation coefficients 0.604, 0.919 and 0.597 respectively and negatively correlated with n-6/n-3. n-3 showed positive correlation with n-6 and EPA+DHA with correlation coefficients 0.256 and 0.974 respectively and negatively correlated with n-6/n-3. n-6 showed positive correlation with n-6/n-3 and EPA+DHA with correlation coefficients 0.352 and 0.234 respectively. And n-6/n-3 showed negative correlation with EPA+DHA.

DISCUSSION

Proximate Composition

Significantly higher moisture content in the dorsal and ventral regions of ice-packed fish might be due to absorption of water from the ice-packed by the muscle tissues. Joseph *et al.*[22] also found increasing value of moisture during ice-packed storage. The overall less protein content in the ice-packed fish might be due to degradation of muscle protein during ice-packed storage and leaching out of water-soluble protein from the body due to hydrolysis. The protein value of fresh *P.pangasius* was found in agreement with the value reported by Sokamte *et al.*[23] in *Pangasius hypophthalmus*. In this study, the lipid content in the ventral region of fresh *P. pangasius* was significantly higher ($p<0.05$) than ice-packed *P. pangasius.* The reason might be due to improper handling which leads to autolysis of fish tissues in ice-packed fish and leakages of insulated boxes resulting into oxidation of lipids. A decrease in lipid content during ice-packed storage was likely to be due to the degradation of lipid by endogenous lipases or lipid oxidation.[24] It was also well recognised that various parts of the fish body contained different lipid contents, leading to varied degree of lipid oxidation during ice-packed storage.[25] Ash content in the dorsal region of both ice-packed and fresh *P. pangasius* were in similar range as reported by Kothandaperumal *et al.*[26] in *Pangasius* fillets. The proximate composition of this study was in agreement with Sankar *et al.*[27]

Fatty Acid Composition

Fatty acid composition was found varied in both the samples. The ratio of n-6/n-3 was found as: 6.01 in the

Table 6: Pearson's correlation among lipid and fatty acid contents.

	Total lipid	SFA	MUFA	PUFA	n-3	n-6	n-6:n-3	EPA+DHA
Total lipid	1							
SFA	-0.014	1						
MUFA	0.684	-0.342	1					
PUFA	-0.743	-0.428	-0.609	1				
n-3	-0.777	-0.462	-0.116	0.604	1			
n-6	-0.567	-0.240	-0.747	0.919**	0.256	1		
n-6:n-3	0.259	0.463	-0.520	-0.042	-0.756	0.352	1	
EPA+DHA	-0.729	-0.500	-0.040	0.597	0.974**	0.234	-0.806	1

** Correlation is significant at the 0.01 level (2-tailed).

head, 2.57 in the dorsal and 0.54 in the ventral regions of ice-packed *P. pangasius* and 1.30 in the head, 2.16 in the dorsal and 1.30 in the ventral regions of fresh *P. pangasius*. The ideal ratio of n-6/n-3 was 4.0 at maximum recommended by the UK department of health.[28] Values higher than 4 are harmful to health.[29] In this study, the n-6/n-3 ratio was found below the maximum limit except in the head of ice-packed *P. pangasius.* The proportions of SFAs, MUFAs and PUFAs were also different for different body regions of ice-packed and fresh *P. pangasius*. In the head and ventral regions of ice-packed *P. pangasius*, the amount of SFAs were higher than the unsaturated fatty acids (MUFAs and PUFAs) and in the fresh *P. pangasius*, the amount of unsaturated fatty acids were higher in the head and ventral regions. The mean percentage of saturated fatty acids were higher than unsaturated fatty acids in case of ice-packed *P. pangasius* and the mean percentage of unsaturated fatty acids were higher than SFAs in case of fresh *P. pangasius*. The reduction of MUFA and PUFA was due to lipid oxidation during ice-packed storage. The increase in SFA was likely to be due to the degradation of MUFA and PUFA, which in turn increased the proportion of SFA.[30] Among the fatty acids, SFAs were the most dominant followed by MUFAs and then PUFAs, which agrees with the results in Ho and Paul[31] in the fillets of *Pangasius hypophthalmus* from Vietnam. Main SFAs present in the head, dorsal and ventral regions of ice-packed and fresh *Pangasius pangasius* were palmitic and stearic acid which is in agreement with Sokamte *et al.*[23] in *Pangasius hypophthalmus.* Palmitic acid is one of the main contributors to increase the level of total blood cholesterol, particularly LDL cholesterol, which is involved in the incidence and high risk of death from coronary heart disease. Consumption of food rich in MUFA, particularly oleic acid, is associated with the reduction of LDL cholesterol, therefore, helps in reducing the risk of death from coronary heart disease. Oleic acid is found rich in *P. pangasius*. The alpha-linolenic acid (ALA) was detected only in the dorsal and ventral regions of ice-packed *P. pangasius*. ALA plays a significant role in regulating body homeostasis of inflammation and anti-inflammation, vasodilatation and vasoconstriction, bronchoconstriction and bronchodilation, and platelet aggregation and anti-aggregation.[32] Gamma- linolenic acid was detected only in the head, dorsal and ventral regions of fresh *P. pangasius*. The reason might be due to differences in the sources of feed and feeding regimens. Moreover, a Cyclopropane ring fatty acid namely Cyclopropaneoctanoic acid 2-hexyl was detected only in the ventral region of ice-packed *P. pangasius* with 0.16% of the total fatty acids. It was not recorded so far in other fish. These ring fatty acids have been recorded in plants, bacteria, parasites, sponges and ascidia.[33-35] Cyclopropane fatty acids are produced by intestinal bacteria.[36] So, presence of this cyclic fatty acid might help in deterioration of ventral region of ice-packed *P. pangasius* that leads to higher autolysis and more lipid oxidation. Cyclopropaneoctanoic acid 2-hexyl accounts for approximately 0.4% of the total fatty acid in human adipose tissue, both from the visceral and subcutaneous depots, and about 0.2% of the total fatty acid in the serum.[37]

CONCLUSION

The study concluded that the proximate composition and fatty acids profile in different body regions of fresh and ice-packed *Pangasius pangasius* have significant values. A significantly higher value of lipid was found in the ventral region of fresh fish. Among PUFAs, alpha-linolenic acid was found only in the ice-packed fish and γ-linolenic acid was found only in the fresh fish. n-3 fatty acids were not found in the head portion of ice-packed fish. The present finding shows that different body regions have different nutritional values. So, in terms of proximate composition and fatty acids profile, the fresh *P. pangasius* have better nutritional values than ones. Moreover, the head region of fresh fish also has good source of lipid, protein and essential fatty acids. So, it can be recommended as a source of essential nutrients for human health.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

ALA: Alpha- Linolenic Acid; **AOAC:** Association of Official Analytical Chemists; **DHA:** Docosahexaenoic Acid; **EPA:** Eicosapentaenoic Acid; **FAME:** Fatty Acid Methyl Ester; **LA:** Linoleic Acid; **LDL:** Low-Density Lipoprotein; **MUFAs:** Monounsaturated Fatty Acids; **PUFAs:** Polyunsaturated Fatty Acids; **SFAs:** Saturated Fatty Acids; **NIST:** National Institute of Standards and Technology.

SUMMARY

Proximate composition and fatty acids profile in different body regions of fresh and imported ice-packed *Pangasius pangasius* have significant values. The present finding shows that in terms of proximate composition and fatty acids profile, the fresh *P. pangasius* have better nutritional values than ice-packed ones. The main reason behind the less nutritional quality in imported ice-packed fishes is lipid oxidation. Moreover, the head region also has good sources of lipid, protein and essential fatty acids.

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