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Nutritional Analysis and Overall Diet Quality of Fresh and Processed (Sun-dried and Fermented) *Puntius sophore*

SANCHARI GOSWAMI and KUNTAL MANNA *

Department of Pharmacy, Tripura University (A Central University),Suryamaninagar, Tripura, India.

Abstract

Puntius sophore (*P. sophore*), a small indigenous fish, belonging to family Cyprinidae is an important source of micronutrients. But as it may be considered as one of the most perishable among all foodstuffs therefore, their preservation becomes necessary for future use. Fermentation and sun-drying process have been used for the processing of *P. sophore.* Both fresh and processed (fermented and sun-dried) *P. sophore* is very popular among the common people of Tripura, Northeastern part of India. So, the aim of the present study was to analyze the nutrient content of raw and processed *P. sophore* and evaluate the overall diet quality of them. In this study, proximate composition, minerals, amino acids, fatty acids analysis for raw and cooked sample of fresh and processed (fermented and sun-dried) *P. sophore* were performed as the cooking process lead to changes of certain nutrients. The changes in the amount of fat and ash content were found to be higher in fried fish sample. Mineral content such as Na, K, Fe, Cu, Mn, Se was increased in processed sample whereas Ca and Mg was reduced. The amino acid profile showed that aspartic acid was the major component of fish protein. But after cooking amino acid content was reduced. The analysis of fatty acid composition showed that saturated fatty acids were the most abundant in both fresh and processed *P. sophore* which was increased through frying. In the present experiment, frying process was found to be good for health.

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Keywords

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Proximate composition.

Introduction

Fish are very highly nutritive food in the human diet. They not only the important sources of protein but also have many other essential nutrients like minerals, polyunsaturated fatty acids (PUFA) especially Eicosa Pentaenoic acid (EPA) and Docosa Hexaenoic Acids (DHA). PUFA plays an important role to reduce the risk factors that has been associated with several cardiovascular diseases.[1] India is one of the mega biodiversity countries where among 765 freshwater fishes 450 are small indigenous fishes.[2] They serve as the richest source of vitamin A, iron, protein and lipid.[3] But fish may be considered as one of the most perishable of all

CONTACT Kuntal Manna k_manna2002@yahoo.com Department of Pharmacy, Tripura University (A Central University), Suryamaninagar, Tripura, India.

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foodstuffs therefore, their preservation becomes necessary for future use.[4] Fermentation has been used for the preparation of flavored fish which can contribute greatly to the general nutrition of large populations.[5] Sun-drying is also one of the most important traditional methods which has been used for centuries for preserving fish.[6]

Puntius sophore, commonly known as pool barb belonging to family Cyprinidae, order Cypriniformes. It is widely distributed in India, Bangladesh, China, Bhutan, Nepal, Pakistan, Myanmar.[7] It is a small indigenous fish species of Bangladesh which is an important source of micronutrients in the diet of rural small scale farmers.[8-10] Fermented and sun-dried *P. sophore* is very popular among the common people of Tripura, Northeastern part of India. So, comparison between the nutritional value of fresh and processed (fermented and sun-dried) *P. sophore* is very important. On the other hand, fresh and processed (fermented and sun-dried) *P. sophore* is not normally consumed in raw form. Various cooking methods such as boiling, frying, roasting are applied to prepare them which have numerous effects on their nutrient content and organoleptic properties.[11] The suitable cooking method minimizes the nutrient loss and also improves the digestibility of food.[12]

Thus, concomitant nutrient analysis of both raw and cooked form of fresh and processed (sun-dried and fermented) *P. sophore* was performed to evaluate the overall diet quality of processed (sun-dried and fermented) *P. sophore*.

Materials and Methods

Samples Preparation

Fresh and processed (sun-dried and fermented) sample of *P.sophore* had been collected from the local market of Battala, Tripura and kept in a plastic container. Fresh samples of *P.sophore* were washed with potable water for cleaning. The internal organs were removed and the fish was washed to remove the residual blood. The fish fillet was obtained by cutting the fish lengthwise along the backbone to obtain the maximum amount of flesh without including the backbone. The fillet was then cut into small pieces and thus prepared for cooking. In case of processed (sun-dried and fermented) *P.sophore*, the samples were washed with potable water and cut into small pieces. Subsequently, the fillet of the sample was boiled in distilled water for about 20 minutes until the pieces were well cooked and tender. Deep-frying of all the samples was done using vegetable oil in a pot on an open flame at 240^{0}C for 15 minutes with occasional turning.

Analytical Procedures

Proximate Composition Analysis

Proximate composition analysis of cooked and raw sample of fresh and processed (sun-dried and fermented) *P.sophor*e was done in triplicate for moisture, protein, lipid and ash contents. Moisture content was determined by oven drying method at 105^{0}C to a constant weight. The crude protein content was determined micro-Kjeldahl method using Kjeltec machine (Tecator Kjeltec System 1026).[13] Total lipid was extracted by chloroform: methanol (2:1) solvent system.[14] The lipid content was gravimetrically analyzed. Ash content was determined by ignition of samples in a muffle furnace at 550 – 600^{0}C for 16 hours.[15]

Mineral Analysis

For mineral analysis, fish samples were kept overnight in a hot air oven at 120^{0}C and then the dried samples were powdered in a mixer grinder and stored in aluminium foils. A microwave-assisted digestion procedure was carried out in order to achieve a shorter digestion time. 0.5 g homogenized powder were weighed and dissolved with 3 mL of 65% w/v conc HNO_3 to microwave digestion under controlled pressure. After digestion, samples were cooled and diluted to 50 ml with Milli-Q water and stored in a refrigerator. Mineral analysis was carried out by inductive coupled plasma mass spectrometry (ICPMS) (Thermo Fisher X Series 2) and inductive coupled plasma atomic emission spectrometry (ICP-AES) (ICP spectrometer, iCAP 6300 Radial, Thermo Scientific).[16]

Amino Acid Composition Analysis

For estimation of amino acid composition, Fish samples were homogenized, hydrolyzed with hydrochloric acid 6N solution at 110^{0}C under anaerobic condition for 24h. The hydrolyzed samples were neutralized with NaOH 6N solution and were derivatized using a kit (AccQ-Fluor Reagent, WAT052880, waters). The derivatized samples were injected in High-performance liquid chromatography (HPLC) (Shimadzu LC 10AS) equipped with

a C18 RP column and fluorescence detector (2475, waters).[17] For the tryptophan analysis, minced meat was digested with 5% (w/v) NaOH solution for 24h and neutralized to pH 7.0 with a solution of HCL 6N. Tryptophan content was measured spectrophotometrically at 530 nm.[18]

Fatty Acid Composition Analysis

Total lipid of fish sample was extracted by chloroform: methanol (2:1) solvent system.[14] Fatty acid methyl esters (FAME) were prepared by transesterification with boron trifluoride (BF3) in methanol from lipid fraction.[19] The FAME was analyzed by injecting 1µl (30: 1split ratio) into GC-MS20. The fatty acids were identified and quantified using a GC (Trace GC Ultra, Thermo Scientific) equipped with a capillary column (TR-FAME, 30m×0.25mm, 0.25µm film thickness) and an MS (ITQ 900, Thermo Scientific) attached to it. The individual constituents detected by GC were identified and quantified by comparing the retention times and peak areas to those of standards (ME-14-KT and ME-19-KT, SUPELCO Analytical).

Statistical Analysis

Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS) v. 16.0 for Windows (SPSS, SAS Institute Inc. Cary, USA). The data were analyzed to determine the descriptive statistics such as Standard Error of Mean (SEM), Standard Deviation (SD), Statistic Mean, Minimum and Maximum value and Ranges of variables. One way ANOVA and Duncan multiple test were done to test the significance using 5% level of significance.

Results and Discussion

Proximate Composition

The proximate composition of fresh, sun-dried and fermented P. sophore and the effects of boiling and frying on their nutritional value are presented in Table 1. Significantly higher protein content (12.88%) was found in boiled sample of fermented P. sophore followed by 12.54% and 12.44% in boiled sample of sun-dried and fresh P. sophore ($p < 0.05$). Significantly higher fat content (33.21%) was observed in fried sample of fresh *P. sophore* followed by fried sample of sun-dried and fermented *P. sophore* 32.61% and 27.64% ($p < 0.05$). Moisture content was found to be higher in fresh sample of *P. sophore* which was reduced after sun-drying and fermentation process. It was found to be increased after boiling process. Increased ash content was noticed after processing of fish such as sun-drying and fermentation. It was reduced after boiling and further increased through frying process ($p < 0.05$).

Proximate composition was performed to evaluate the nutritional value of fresh, sun-dried and fermented *P. sophore*. The increase in protein content after boiling may be due to solubilization of some nitrogenous compounds.[21] Fat content was found to be increased in fried sample of both fresh and processed (sun-dried and fermented) *P. sophore.* This may be due to absorption of oil on the fish sample as water is partially lost through frying.[22] Ash content was found to be higher in processed (sun-dried and fermented) sample may be due to remaining inorganic content as ash after the removal of organic matter by incineration.[23] But through boiling because of volatility of the mineral elements at high temperature ash content was reduced.[24] Water losses during sun-drying and fermentation process resulted in higher protein content of processed *P. sophore*.[25] On the other hand, fat content was found to be reduced after fermentation process may be due to lipid oxidation which can cause degradation of fatty acids.

Mineral Composition

Minerals participate in human metabolism. Lack of essential minerals such as sodium, potassium, calcium, iron lead to improper enzyme-mediated metabolic functions and results in organ malfunctions, chronic diseases and ultimately death.[26] The concentration of minerals are shown in Table 2. Sodium, potassium, calcium, iron, magnesium, copper, manganese, selenium were detected in fresh, sun-dried and fermented *P. sophore* both in raw and cooked form. Higher level of Ca and Mg content was found in fresh *P. sophore* as these minerals may be released due to fish processing such as sun-drying and fermentation.[27] On the other hand, processed (sun-dried and fermented) *P. sophore* contained higher amount of Na, K, Fe, Cu, Mn, Se and this can be attributed because of increased dry matter.[28] But cooking had some effects on mineral content which was observed in the present experiment. After boiling mineral content was found to be reduced, may be due to leaching of minerals into the boiling water but reverse was observed after frying. In fried sample of both fresh

and processed (sun-dried and fermented) *P.sophore* mineral content was increased as dry matter content was high in fried sample.

Amino Acid Composition

The method used in this study allowed the analysis of 15 essential amino acids and 3 nonessential amino acids. The amino acid profile of fresh and processed *P. sophore* and the effects of boiling and frying on their amino acid content are presented in Table 3. The major component of fish protein was aspartic acid in fresh *P. sophore* followed by serine in sun-dried and fermented *P. sophore.* Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tyrosine, Valine, Tryptophan, Cysteine, Glutamic acid, Glycine and Proline were present as

Table 1: Proximate composition

	Puntius sophore **(Fresh)**	***Puntius sophore*** **(Fresh)-Boiled**	***Puntius sophore*** **(Fresh)-Fried**	***Puntius sophore*** **(Sun-dried) boiled**	***Puntius sophore*** **(Sun-dried)-fried**	***Puntius sophore*** **(Sun-dried)-**	***Puntius sophore*** **(Fermented)**	***Puntius sophore*** **(Fermented) -Boiled**	***Puntius sophore*** **(Fermented) -Fried**
Moisture %	78.42	76.52	55.41	64.32	68.7	59.36	67.21	73.54	65.23
Protein %	9.85	12.44	9.88	11.45	12.54	9.87	11.6	12.88	10.23
Fat %	22.35	20.11	33.21	26.46	23.54	32.61	18.94	17.68	27.64
Ash %	5.66	5.12	7.75	8.77	6.52	8.99	7.65	6.33	8.41

The moisture contents (%); protein contents (%); Fat contents (%); and Ash (%) of individual fish samples analyzed in triplicate. Significance level is $p < 0.05$.

Table 2: Mineral composition

	Puntius sophore **(Fresh)**	***Puntius sophore*** **(Fresh)-Boiled**	***Puntius sophore*** **(Fresh)-Fried**	***Puntius sophore*** **(Sun-dried)**	***Puntius sophore*** **(Sun-dried)-boiled**	***Puntius sophore*** **(Sun -dried)-fried**	***Puntius sophore*** **(Fermented)**	***Puntius sophore*** **(Fermented)-Boiled**	***Puntius sophore*** **(Fermented)-Fried**
Na	57.8± 4.5	55.2± 11.0	57.0± 7.1	76.6± 11.2	75.5± 9.8	75.7± 10.4	68.3± 9.7	66.6± 10.2	67.4± 12.8
K	197.9± 28.9	195.0± 12.1	197.4 ± 16.8	206.2 ± 17.4	205.6 ± 22.2	206.7 ± 19.0	187.6 ± 14.3	184.2 ± 10.1	186.7 ± 13.7
Ca	944.6 ± 55.4	940.3 ± 24.9	942.7 ± 26.3	841.3 ± 32.4	838.8 ± 12.1	840.1 ± 22.6	684.5 ± 19.5	679.3 ± 22.2	681.6 ± 18.7
Mg	37.8 ± 1.1	36.6 ± 2.5	37.3 ± 3.8	32.1 ± 9.1	31.2 ± 3.7	31.9 ± 6.4	28.8 ± 4.6	27.6 ± 9.2	28.7 ± 6.6
Fe	11.6 ± 3.6	11.2 ± 2.0	11.4 ± 0.3	76.6 ± 11.2	75.5 ± 9.8	76.2 ± 6.4	68.3 ± 9.7	67.6 ± 10.2	68.0 ± 8.8
Cu	0.1 ± 0.0	0.1 ± 0.0	NDL	0.1 ± 0.0	NDL	NDL	NDL	NDL	NDL
Mn	1.1 ± 0.7	1.1 ± 0.4	1.0 ± 0.0	0.7 ± 0.1	0.7 ± 0.7	0.8 ± 0.4	0.8 ± 0.6	0.7 ± 0.2	0.8 ± 0.6
Se	0.6 ± 0.0	0.5 ± 0.0	NDL	0.8 ± 0.7	NDL	NDL	0.5 ± 0.2	0.4 ± 0.0	0.5 ± 0.1

*NDL: Not Detectable Level

The values are expressed as mg/100g wet weight. Values are reported as mean ± standard deviation of individual fish samples analyzed in triplicate. Significance level is $p < 0.05$.

essential amino acid (EAA). More specifically leucine a prominent EAA and its content was (7.1±0.7) in fresh *P. sophor*e, (6.1±0.1) in sun-dried *P. sophore*, (5.8±0.6) in fermented *P. sophore.* On the other hand, Alanine, Aspartic acid and Serine are considered nonessential amino acid (NEAA). Aspartic acid was the highest (11.4±2.1) in fresh P. sophore, (9.6±1.2) in sun-dried *P. sophore* and (10.9±2.2) in fermented *P. sophore*.

Cysteine was not detectable in both boiled and fried sample of fresh and processed (sun-dried and fermented) *P. sophore* because of heating process that causes excessive denaturation of protein and destruction of amino acid.[29]

Different types of fish processing techniques such as drying, fermentation, sun-drying leads to the formation of different inter and intra-molecular bonds. As a result, protein chains unfold and free carboxylic and amino groups are exposed.[30]

On the other hand, there was a progressive reduction in the amino acid content was observed from raw to boiled and raw to fried. In case of fried sample of both fresh and processed fish sample of *P. sophore*, Maillard reaction may take place which leads to an interaction between the carbonyl group of a reducing sugar and the free amino group from an amino acid or protein. The resulting condensation product is then converted to 1-deoxy-2 ketosyl compound.[31]

Fatty Acid Composition

In case of fatty acid content, it was observed that after boiling fatty acid content reduced and through frying fatty acid content was increased ($p<0.05$). Fatty acid composition of fresh and processed *P. sophore* and effects of boiling and frying on them are represented in Table 4-6. Most abundant fatty acids present in both fresh, sun-dried and fermented *P. sophore* were saturated fatty acids (SFA) 36.1mg/100g, 35.2mg/100g, 35.9mg/100g followed

Table 3: Amino Acid Composition

	***Puntius sophore* (Fresh)**	***Puntius sophore* (Fresh)-Boiled**	***Puntius sophore* (Fresh)-Fried**	***Puntius sophore* (Sun-dried)**	***Puntius sophore* (Sun-dried)-boiled**	***Puntius sophore* (Sun-dried)-fried**	***Puntius sophore* (Fermented)**	***Puntius sophore* (Fermented)-Boiled**	***Puntius sophore* (Fermented)-Fried**
Arg	4.6±0.6	4.2±0.2	4.0±0.1	3.6±0.2	2.5±0.8	1.7±0.4	3.3±0.7	2.6±0.2	1.4±0.8
His	4.1±0.5	4.0±0.1	3.4±0.8	2.2±0.4	1.6±0.2	1.0±0.0	2.6±0.3	2.2±0.1	1.7±0.7
Iso	5.4±0.4	5.3±0.9	4.7±0.3	4.3±0.4	3.8±0.1	2.1±0.6	3.5±0.5	2.3±0.2	1.6±0.7
Leu	7.1±0.7	6.6±0.5	5.3±0.8	6.1±0.1	5.9±0.7	4.2±0.4	5.8±0.6	4.6±0.2	2.7±0.6
Lys	2.6±0.0	2.0±0.7	1.4±0.3	3.8±0.7	2.1±0.2	1.4±0.8	3.5±0.2	2.1±0.8	1.2±0.3
Met	2.1±0.2	2.0±0.7	1.4±0.3	2.8±0.7	2.0±0.2	1.6±0.6	2.5±0.2	2.1±0.8	1.2±0.3
Phe	4.6±0.6	4.0±0.7	3.4±0.3	2.8±0.7	2.4±0.2	1.7±0.8	2.5±0.2	1.1±0.8	0.7±0.3
Thr	5.2±0.7	5.0±0.4	4.4±0.3	4.8±0.7	4.2±0.2	3.4±0.2	4.5±0.2	3.1±0.2	0.7±0.3
Tyr	4.6±0.6	4.2±0.0	2.0±0.1	3.6±0.2	2.5±0.8	1.7±0.4	3.3±0.7	1.6±0.2	0.4±0.0
Val	4.1±0.0	3.0±0.1	2.4±0.8	3.2±0.4	2.6±0.2	1.0±0.0	3.6±0.3	2.2±0.1	0.7±0.0
Trp	5.4±0.4	4.3±0.5	2.7±0.3	4.3±0.2	3.8±0.1	2.1±0.6	4.5±0.5	2.3±0.2	0.6±0.0
Cys	1.1±0.2	NDL	NDL	0.9±0.1	NDL	NDL	0.8±0.0	NDL	NDL
Glu	3.1±0.2	3.0±0.1	2.4±0.8	2.2±0.4	1.6±0.2	0.7±0.0	2.6±0.3	1.2±0.1	0.7±0.0
Gly	4.1±0.2	4.0±0.1	2.4±0.4	3.2±0.2	2.1±0.3	0.7±0.0	3.6±0.2	1.2±0.1	0.4±0.0
Pro	2.1±0.3	2.0±0.1	1.4±0.6	1.2±0.4	0.6±0.2	0.9±0.0	1.6±0.3	1.2±0.2	0.5±0.0
Ala	5.9±1.5	5.2±1.2	4.4±1.1	6.3±0.6	5.7±1.0	5.6±0.9	7.4±1.8	6.2±1.7	5.2±0.8
Asp	11.4±2.1	10.7±0.8	8.8±1.6	9.6±1.2	8.2±1.2	7.7±0.7	10.9±2.2	7.2±2.1	4.2±0.9
Ser	6.4±1.4	4.2±0.8	3.8±0.3	7.2±0.4	6.6±1.3	5.3±0.6	8.5±1.5	8.8±2.0	7.6±0.8

*NDL: Not Detectable Level

The values are expressed as Xg of specific amino acid is present in 100g of protein sample. Values are reported as mean ± standard deviation of individual fish samples analyzed in triplicate. Significance level is $p < 0.05$

Table 4: Saturated Fatty Acid (SFA) Composition

	Puntius sophore **(Fresh)**	***Puntius sophore*** **(Fresh)-Boiled**	***Puntius sophore*** **(Fresh)-Fried**	***Puntius sophore*** **(Sun-dried)**	***Puntius sophore*** **(Sun-dried)-boiled**	***Puntius sophore*** **(Sun-dried)-fried**	***Puntius sophore*** **(Fermented)**	***Puntius sophore*** **(Fermented)-Boiled**	***Puntius sophore*** **(Fermented)-Fried**
C12	0.8±0.2	0.5±0.0	0.8±0.1	0.7±0.2	0.5±0.0	1.2±0.4	0.7±0.7	0.6±0.2	0.8±0.0
C13	1.1±0.1	1.0±0.2	1.4±0.6	1.1±0.4	1.0±0.2	1.7±0.0	1.2±0.3	1.2±0.1	1.7±0.7
C14	2.4±0.2	2.2±0.7	2.7±0.3	2.3±0.2	1.8±0.1	2.1±0.6	2.5±0.5	2.3±0.2	0.6±0.0
C15	1.0±0.2	1.0±0.5	1.3±0.8	0.9±0.1	0.9±0.3	1.2±0.4	0.8±0.0	0.6±0.2	0.7±0.1
C16	28.2±3.2	27.0±2.7	29.4±3.3	26.8±4.7	25.2±1.2	28.4±2.8	28.5±4.2	26.1±1.8	28.2±2.4
C17	1.2±0.4	1.0±0.4	1.4±0.1	1.6±0.2	1.2±0.2	1.8±0.4	1.5±0.2	1.1±0.8	1.2±0.3
C18	11.6±1.8	10.0±0.7	12.4±4.3	10.8±2.7	10.2±1.2	11.4±3.8	10.5±1.7	10.1±2.5	10.8±2.8
C19	0.6±0.0	-	0.8±0.1	0.4±0.0	0.2±0.0	0.7±0.4	0.3±0.0	-	0.4±0.0
C20	0.2±0.0	-	0.4±0.0	0.2±0.0	-	0.6±0.0	0.3±0.0	0.2±0.1	0.5±0.0
C22	0.6±0.0	0.5±0.0	0.7±0.3	0.3±0.0	0.2±0.1	0.4±0.1	0.5±0.0	0.3±0.2	0.6±0.3
ΣSFA	36.1	32.5	38.4	35.2	33.6	36.1	35.9	34.7	36.1

'-'represented not found any significant result

The values are expressed, as mg of specific fatty acid is present in 100g of fish sample. Values are reported as mean ± standard deviation of individual fish samples analyzed in triplicate. Significance level is $p < 0.05$.

Table 5: Monounsaturated Fatty Acid Composition

	Puntius sophore **(Fresh)**	***Puntius sophore*** **(Fresh)-Boiled**	***Puntius sophore*** **(Fresh)-Fried**	***Puntius sophore*** **(Sun-dried)**	***Puntius sophore*** **(Sun-dried)-boiled**	***Puntius sophore*** **(Sun-dried)-fried**	***Puntius sophore*** **(Fermented)**	***Puntius sophore*** **(Fermented)-Boiled**	***Puntius sophore*** **(Fermented)-Fried**
C16:1	1.5±0.2	1.3±0.7	1.4±0.4	1.8±0.4	1.2±0.2	1.4±0.8	1.5±0.2	1.1±0.8	1.2±0.3
C17:1	0.6±0.1	0.5±0.0	0.8±0.3	0.6±0.0	0.4±0.2	0.8±0.1	0.5±0.2	0.4±0.0	0.7±0.3
C18:1	10.6±2.0	10.0±0.7	11.4±2.5	9.8±1.7	9.2±1.4	10.4±1.8	8.5±4.4	8.1±2.8	8.8±1.5
C20:1	0.6±0.0	0.4±0.0	0.7±0.1	0.6±0.2	0.5±0.1	0.7±0.4	0.5±0.3	0.5±0.2	0.8±0.1
C22:1	0.42±0.1	0.4±0.2	0.5±0.1	0.4±0.0	0.3±0.0	0.48±0.1	0.3±0.0	0.2±0.1	0.4±0.0
ΣMUFA	24.5	24.9	25.2	22.1	21.8	23.4	20.6	20.1	21.5

The values are expressed, as mg of specific fatty acid is present in 100 g of fish sample. Values are reported as mean ± standard deviation of individual fish samples analyzed in triplicate. Significance level is $p < 0.05$.

by polyunsaturated fatty acid (PUFA) 28.4 mg/100g, 23.3mg/100g, 22.5mg/100g and monounsaturated fatty acid (MUFA) 24.5mg/100g, 22.1mg/100g, 20.6mg/100g Palmitic acid ($C_{16:0}$) was the dominant fatty acid in saturated fatty acids. Results showed that MUFA was dominated by oleic acid in both fresh and processed *P. sophore*. The dominant fatty acid in the PUFA group are linoleic acid ($C_{18:2}$) as the omega-6 fatty acid. Results also showed that ω-3 content was higher than the ω-6 content in case of fresh, sun-dried and fermented sample of *P. sophore*. All the fatty acid content was found to be reduced after sun-drying and fermentation process. Extractability of the lipids may be affected by the changes in the protein-lipid complexes in the fish tissues which results in bound lipids being released as free lipids during processing.[32] On the other hand, boiling and frying had some effects on fatty acid content. After

Table 6: Polyunsaturated Fatty Acid (PUFA) Composition

	***Puntius sophore* (Fresh)**	***Puntius sophore* (Fresh)-Boiled**	***Puntius sophore* (Fresh)-Fried**	***Puntius sophore* (Sun-dried)**	***Puntius sophore* (Sun-dried)-boiled**	***Puntius sophore* (Sun-dried)-fried**	***Puntius sophore* (Ferm-ented) Boiled**	***Puntius sophore* (Ferm-ented)-Fried**	***Puntius sophore* (Ferm-ented)-**
C18:2ω-6	11.1±1.5	10.6±2.5	11.3±3.8	10.1±4.1	9.9±3.7	10.2±6.4	9.8±4.6	9.6±3.2	10.7±2.6
C18: 3ω-3	1.6±0.0	1.5±0.3	1.7±0.4	1.8±0.7	1.6±0.2	1.8±0.8	1.5±0.4	1.2±0.2	1.4±0.3
C18:3ω-6	0.3±0.0	0.2±0.0	0.4±0.1	-	-	0.2±0.0	-	-	0.3±0.0
C18: 4ω-3	0.4±0.0	-	0.4±0.0	-	-	0.2±0.0	-	-	0.2±0.0
C20: 2ω-6	1.6±0.2	1.2±0.0	1.8±0.1	1.4±0.3	1.2±0.8	1.7±0.4	1.3±0.7	1.0±0.2	1.4±0.5
C20: 3ω-6	1.1±0.1	1.0±0.3	1.4±0.8	1.2±0.4	1.0±0.2	1.7±0.6	1.2±0.3	1.0±0.1	1.5±0.7
C20: 3ω-3	-	-	0.2±0.1	-	-	0.4±0.1	-	-	0.3±0.0
C20: 4ω-6	0.9±0.2	0.8±0.5	1.1±0.2	0.8±0.1	0.6±0.2	0.9±0.4	0.8±0.6	0.6±0.2	0.7±0.6
C20:5ω-3 (EPA)	1.8±0.1	1.3±0.7	1.4±0.3	0.8±0.0	0.5±0.2	0.9±0.3	1.5±0.2	1.3±0.4	1.6±0.3
C22:5ω-3	-	-	0.2±0.1	-	-	0.2±0.0	-	-	0.3±0.1
C22:6ω-3 (DHA)	1.1±0.0	1.0±0.5	0.8±0.3	0.8±0.2	0.7±0.1	0.6±0.3	0.5±0.2	0.4±0.0	0.4±0.3
ΣPUFA	28.4	28.0	28.7	23.3	23.2	24.1	22.5	22.0	22.8
Σω-3	8.6	8.2	8.0	7.5	7.2	7.0	6.2	6.1	5.9
Σω-6	6.7	6.5	7.2	6.8	6.4	6.9	5.8	5.8	5.9
ω-3/ω-6	1.3	1.3	1.1	1.1	1.05	1.02	1.07	1.05	1.00
DHA (mg/dl)	1.2	1.1	1.1	1.0	0.8	0.9	0.7	0.5	0.7
DHA+ EPA (mg/dl)	3.2	3.1	2.8	1.8	1.7	2.0	2.2	2.1	2.3
Chole-sterol (mg)	88.4±3.7	88.0±9.7	88.8±8.3	98.8±8.7	98.2±7.2	98.4±8.8	88.5±4.2	88.1±8.8	88.2±6.3

'-' represented not found any significant result

The values are expressed as mg of specific fatty acid is present in 100g of fish sample. Values are reported as mean ± standard deviation of individual fish samples analyzed in triplicate. Significance level is $p < 0.05$.

boiling level of fatty acids were decreased because of leaching of fat in water[32] but reverse was observed in fried sample because of oil penetration on the food after water is partially lost by evaporation.[33] The ratio of ω3/ω6 fatty acids has been suggested as a useful indicator of the relative nutritional values of fish oils.[34] According to current WHO recommendations, the daily ratio of total ω3/ω6 should not be higher than 1.5. In our present experiment, ω3/ω6 ratio in fresh, sun-dried and fermented P. sophore was 1.3, 1.1 and 1.07. But cooking method did not cause any significant effect in this ratio.

Conclusion

The increased amount of ash and protein content was observed in processed (sun-dried and fermented) *P.sophore*. On the other hand, fat content was reduced in fermented fish sample. Processed

sample of *P. sophore* (sun-dried and fermented) contained increased amount of minerals except Ca and Mg. Fish processing techniques such as sun-drying and fermentation has some effects on amino acid and fatty acid composition. Both were reduced after processing. On the other hand, cooking had considerable effects on nutritional value of *P.sophore*. Fried sample of fresh, sun-dried and fermented *P. sophore* sample contained more fat, ash, minerals, fatty acids than the boiled fish which play an important role in human health. Based on the results of proximate, minerals, amino acids and fatty acid composition frying process of fresh and processed (sun-dried and fermented) sample of *P. sophore* was found to be good for health.

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Conflicts of Interest
The authors declare no conflicts of interest.

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