


Review Article


Nutritional composition of small indigenous species of fishes of Northeast India: A systematic review

Amrit Pegu 


Department of Zoology, Gauhati University, Guwahati- 781014, Assam, India; Postgraduate Department of Zoology, Darrang College (Affiliated to Gauhati University), Tezpur- 784001 (Assam), India

Rekha Kalita 

Department of Zoology, Gauhati University, Guwahati- 781014, Assam, India; Postgraduate Department of Zoology, Darrang College (Affiliated to Gauhati University), Tezpur- 784001 (Assam), India

Pankaj Das 

Department of Zoology, Gauhati University, Guwahati- 781014, Assam, India; Postgraduate Department of Zoology, Darrang College (Affiliated to Gauhati University), Tezpur- 784001 (Assam), India

Chittaranjan Baruah* 

Postgraduate Department of Zoology, Darrang College (Affiliated to Gauhati University), Tezpur- 784001 (Assam), India

*Corresponding author. E-mail: chittaranjan.baruah@gmail.com

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Abstract

Northeast India has various water bodies including the tributaries of the Brahmaputra and Barak river systems, wetlands, lakes and beels. These water bodies support the diversity of many fish species. Seasonal changes in the number of fish species in the SIS category were also observed and they are most abundant during the winter and least abundant during the monsoon season. Many researchers collected fish data from Assam's rivers and wetlands, particularly small indigenous species (SIS). Small Indigenous Species (SIS) of fish are a vital and conveniently accessible source of rare protein, vitamins, and minerals in traditional diets. The present study aimed to review Assam's small indigenous fish species and their nutritional worth. The sources of the review article were Google Scholar, Web of Science, ScienceDirect, and PubMed for SIS nutrition composition, fish nutritional profile, and fish proximate composition. Northeast India's rural inhabitants get their sustenance from fish SIS. The SIS of Northeast India fish species contain proteins, lipids, vitamins, minerals, and vital macro- and micronutrients. The protein content of SIS range from 12.49% to 18.30% (12.49–18.30g/100 g), lipid content from 0.7% to 19.63% (0.7–19.63g/100 g), moisture content from 65.88% to 82.8% (65.88–82.8g/100 g), and ash level from 2% to 6.8% (2–6.8g/100 g). This review suggests SIS has adequate nutritional benefits because it is an excellent source of proteins, lipids, vitamins, minerals, and omega-3 fatty acids necessary for optimal health. Northeast India's impoverished region might achieve their nutritional demands by eating more SIS of fish.

Keywords: Nutritional profile, Northeast India, Proximate composition, SIS fish

INTRODUCTION

Fish is a nutritious diet high in micronutrients, high-quality animal proteins, and polyunsaturated fatty acids, particularly omega-3 eicosapentaenoic and docosahexaenoic acids. Moreover, compared to other sources of animal proteins, fish is more readily available and less expensive in tropical nations (Mohanty *et al.*, 2019; Mohanty *et al.*, 2022; Sinha *et al.*, 2022). More than half of

India's population eats fish, and in certain areas, such as Assam, Arunachal Pradesh, Goa, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Sikkim, Tripura, and West Bengal more than 90% of the population eats fish (Sankar *et al.*, 2010; Debnath *et al.*, 2014; Sobczak *et al.*, 2021). Fish contain proteins and nitrogenous substances other than protein, minerals, iodine, selenium, taurine, vitamin D, and a small quantity of carbohydrates (Chen *et al.*, 2007; Sankar *et al.*, 2010;

Achionye-Nzeh *et al.*, 2011; Moniruzzaman *et al.*, 2021). Fish is also a known source of such amino acids, which are not produced by the human body itself, specifically lysine, which is also found in less amounts in cereals (Jabeen and Chaudhry, 2011; Abdulkarim *et al.*, 2017). Therefore, protein from fish can be used to supplement a mixed diet's amino acid profile and overall protein quality (FAO, 2005). When compared to other protein sources such as goat and chicken meat, it is also known to be a safer, healthier, and higher quality protein in terms of both amino acid content and ease of digestion (Ogundiran, *et al.*, 2014). Unsaturated fatty acids, fat-soluble vitamins, and energy are all made from fats (Sarkar *et al.*, 2017). Fish consumption has gained popularity in recent years (Supartini *et al.*, 2018; Lee and Nam, 2019; Krittanawong *et al.*, 2021; Krešić *et al.*, 2022) due to its high level of polyunsaturated fatty acids, particularly omega-3 fatty acids such as docosahexaenoic acid (C22:6) and eicosapentaenoic acid (C20:5), as they cannot be synthesis by human body (Alam *et al.*, 2016). These acids have been shown to have a role in the formation of nerve cells in developing children, as well as having antithrombic and atherosclerosis actions. Vitamins A, D, and E, as well as Thiamin, Riboflavin, and Niacin, are abundant in fish. Vitamin A obtained from fish is more easily absorbed by the body than vitamin A obtained from plant sources (Sankar *et al.*, 2010).

Northeastern India comprises eight states: Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Tripura, Nagaland, and Sikkim. These states are known for

their many different ethnic groups and bioresources (Kaushik and Bordoloi, 2016; Borah, 2019). The region's rural and tribal peoples rely heavily on biological resources for their food, shelter, medical care, and cultural needs because of the area's favourable climate and a wide variety of plants and animals, many of which have their own biological benefits (Sarkar *et al.*, 2017). This review article aimed to review the diversity of Small Indigenous Species (SIS) of fish and their nutritional and nutraceutical significance.

This study analysed the literature with a focus on fish species that are underrepresented in global databases to fill the knowledge gap regarding the nutrient composition data of fish and other aquatic species (Byrd *et al.*, 2021). A systematic literature survey was conducted using ScienceDirect, Web of Science, PubMed, Scopus, Google Scholar, and other online sources. The information on the nutritional make-up of Small Indigenous Species of fish found in various parts of the globe was from the articles surveyed.

DIVERSITY OF SMALL INDIGENOUS FISH OF NORTHEAST

Rivers, beels (wetlands), and other bodies of water, as well as wetlands, are abundant in Assam. Assam has a variety of wetlands, including lakes, ponds, Ox-Bow Lakes, marshy areas, etc. These freshwater bodies' fish populations are seriously threatened by environmental degradation and other issues (Taran *et al.*, 2023). It is now widely accepted that environmental

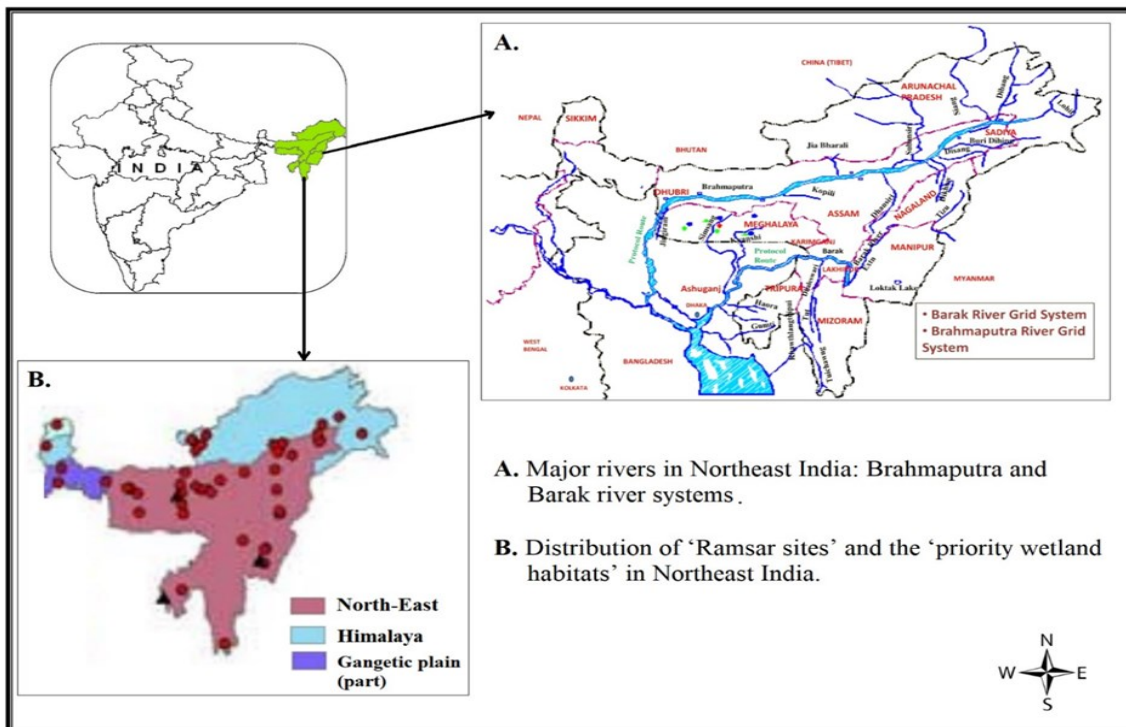


Fig. 1. Map of North-east India showing water bodies. A. Major rivers in Northeast India; B. Distribution of “Ramsar sites” and the conservation “priority wetland habitats” in Northeast India (Vijayan *et al.*, 2004; Nagabhatla *et al.*, 2010)

deterioration has harmed biodiversity, including plants and animals (Duarah and Das, 2019; Mohanty et al., 2022; Sinha et al., 2022).

Locally available in tiny water resources like wetlands, canals, streams, etc., the small indigenous fish (SIF), with a length of around 25 cm, is also cheap to the poor (Sinha et al., 2022). Diverse fish species, including SIS, have been found in rivers and wetlands, according to a number of workers. Two hundred sixteen species of Small Indigenous fishes have been found in Northeast India (Goswami et al., 2012; Duarah and Das, 2019; Mohanty et al., 2022) (Table 1). In another study, 18 species of fish belonging to 15 genera and 10 families were in the Brahmaputra River and its tributaries in Assam. Most of the species they studied and recorded were economically important for food, medicine, leisure, and aesthetics. (Das & Antoney, 2010). From Jorhat, Assam, approximately 27 SIS from 5 orders, 17 genera, and 13 families were reported. (Duarah and Das, 2019). Fifty-two SIS fish in total, representing 15 families and 33 genera, were found over the entire upper side of the Brahmaputra River. With 22 species (42.31%), the Cyprinidae family was reported to be the most abundant, followed by the Bagridae family with 9 species (17.31%) and the Cobitidae family with 4 species (7.69%). They also recorded *Botia lohachata* from this area, which had not before been recorded (Bora and Sarma, 2014; Duarah and Das, 2019). Another study conducted in Divalibeel, Kokrajhar, Assam, identified 67 fish species, including 4 exotic species, in 49 genera, 25 families, and 8 orders (Singha et al., 2017).

NUTRITIONAL PROFILE OF SMALL INDIGENOUS FISH

Due to an increase in consciousness of human health, an increase in food security in developing countries (India, Bangladesh, Pakistan, Nepal) and restoration of the ecological diversity of the various species of fish around the world, there has been an increase in the interest of research in biochemical composition and extensive studies in the impact of fish for health and diseases of the mankind when consumed.

One of the best sources of nutrients, including the proteins, lipids, carbohydrates, vitamins, and minerals needed to maintain a healthy human body, is fish (Sarkar et al., 2017). Protein, fat, and carbohydrate, which are known as macronutrients and are present in large amounts, make up the high energy-yielding component among these compositions. While vitamins and minerals, which do not produce energy, are known as micronutrients (Fig. 2).

Proximate composition of small indigenous species (SIS) of fish

Determining the moisture, protein, fat, and ash concen-

trations of fish is part of determining its "proximate composition," which accounts for 96%–98% of the total components of the fish's body (Ahmed et al., 2022). The small indigenous fish *Puntius sophore*'s proximate composition, amino acid, fatty acid and micronutrient profiles have been studied (Mahanty et al., 2014). The moisture, crude fat, crude protein, and ash with values of 72.02, 3.55, 16.2, and 5.36%, have been estimated, respectively. They also stated that compared to other food fishes like large catfish and Indian major carps, small indigenous species (SIS) of fishes provided higher-quality animal protein for human nutrition.

The mean value of protein, moisture, fat and ash content in *C. batrachus*, *H. fossilis*, *A. testudineus*, *N. nothopterus*, *C. punctatus* and *M. vittatus* was found in the range of 14.87±0.63 to 19.63 ± 0.5 (protein), 69.27 ± 1.04 to 76.06 ±2.24 (moisture), 3.45 ± 0.92 to 7.90 ± 1.91 (fat) and 3.15 ± 0.25% to 6.81 ±0.94% (ash) respectively (Kamal et al., 2007; Sinha et al., 2022). Considering the result of their studies, they concluded that all the species are rich in food value.

The proximate composition of ten small indigenous species (SIS) viz., *Parambassis nama*, *Puntius sophor*, *P. ranga*, *Trichogaster fasciata*, *Amblypharyngodon mola*, *Botia dario*, *Esomus danricus*, *Magrognathus pancalus*, *Mystus vittatus*, *Lepidocephalichthys guntea* were analysed to evaluate their nutritive value (Chalamaiah et al., 2012; Jena et al., 2018; Manoharan et al., 2019). They reported that the protein content varied between 12.89% and 16.75%, with *A. mola* and *M. pancalus* having the highest protein content and *E. danricus* and *Parambassis nama* having the lowest. In the same way, the lipid content ranged from 1.84% (*A. mola*) to 6.19% (*P. sophore*). Other nutrients such as moisture content show a discrepancy from 70.65% (*P. sophore*) to 76.95% (*P. ranga*), carbohydrate content from 0.68% (*P. ranga*) to 7.13% (*C. nama*) whereas, the ash content varied from 1.93% (*A. mola*) to 4.29% (*P. sophore*) indicating that the SIS are the good sources of macronutrients thereby safeguarding both nutritional as well as livelihood security.

The proximate composition of some small indigenous fish species i.e., *Gudusia chapra*, *A. mola*, *P. chola*, *Pseudeutropius atherinoides*, *P. nama* and *Ailia coila* have been reported (Mazumder et al., 2008). Different species were reported to have different proximate compositions. The reported protein content of *A. mola* is 18.46 %, *G. chapra* is 15.23 %, *P. chola* is 14.08%, *Parambassis nama* is 18.26%, *Pseudeutropius atherinoides* is 15.84% and *A. coila* is 16.99% respectively. Likewise, the fat content of those SIS was reported as 4.10%, 5.41%, 3.05%, 1.53%, 2.24% and 3.53%, respectively. *A. coila* had the lowest moisture content (65.88%), while *P. nama* had the highest (78.62%) and ash content ranged from 1.55 percent in *G. chapra* to 3.92 percent in *P. nama* as per their report (Table 2).

Table 1. Understudied SIS fish diversity in Northeast India (Goswami et al., 2012; Duarah and Das, 2019; Mohanty et al., 2022)

	Species	Family	Economic Importance	Present Status
1	<i>Notopterus notopterus</i> (Pallas, 1769)	Notopteridae	Fd	EN
2	<i>Gonialosa manmina</i> (Hamilton, 1822)	Anguillidae	Fd	VU
3	<i>Gudusia chapra</i> (Hamilton, 1822)	Anguillidae	Fd	VU
4	<i>Gudusia variegata</i> (Day, 1870)	Clupeidae	Fd	DD
5	<i>Nematalosa nasus</i> (Bloch, 1795)	Clupeidae	Fd, Or	DD
6	<i>Setipinna phasa</i> (Hamilton, 1822)	Engraulidae	Fd, Or	LC
7	<i>Amblypharyngodon mola</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
8	<i>Aspidoparia jaya</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
9	<i>Aspidoparia morar</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
10	<i>Aspidoparia ukhrulensis</i> (Selim & Vishwanath, 2001)	Cyprinidae	Fd, Or	DD
11	<i>Barilius bakeri</i> (Day, 1865)	Cyprinidae	Fd, Or	VU
12	<i>Barilius bendelisis</i> (Hamilton, 1807)	Cyprinidae	Fd, Or	VU
13	<i>Barilius barnoides</i> (Vinciguerra, 1890)	Cyprinidae	Fd	LC
14	<i>Barilius vagra</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
15	<i>Barilius chatricensis</i> (Selim & Vishwanath, 2002)	Cyprinidae	Fd, Or	VU
16	<i>Barilius dimorphicus</i> (Tilak & Husain, 1990)	Cyprinidae	Fd	VU
17	<i>Barilius dogarsinghi</i> (Hora, 1921)	Cyprinidae	Fd, Or	VU
18	<i>Barilius gatensis</i> (Valenciennes, 1844)	Cyprinidae	Fd	LC
19	<i>Barilius ngawa</i> (Vishwanath & Manojkumar, 2002)	Cyprinidae	Fd, Or	VU
20	<i>Barilius radiolatus</i> (Günther, 1868)	Cyprinidae	Fd, Or	DD
21	<i>Barilius tileo</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
22	<i>Barilius barila</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
23	<i>Barilius barna</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
24	<i>Barilius shacra</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
25	<i>Barilius laiokensis</i> (Arunkumar & Tombi Singh, 2000)	Cyprinidae	Fd	LC
26	<i>Crossocheilus latius</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
27	<i>Danio rerio</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
28	<i>Devario aequipinnatus</i> (McClelland, 1839)	Cyprinidae	Fd, Or	LC
29	<i>Esomus danricus</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
30	<i>Garra annandalei</i> (Hora, 1921)	Cyprinidae	Fd, Or	NT
31	<i>Garra gotyla</i> (Gray, 1830)	Cyprinidae	Fd, Or	VU
32	<i>Garra lamta</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
33	<i>Chela laubuca</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	DD
34	<i>Oreichthys cosuatis</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	DD
35	<i>Osteobrama cotio</i> (Hamilton, 1822)	Cyprinidae	Fd	NT
36	<i>Puntius chola</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
37	<i>Puntius conchonius</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
38	<i>Dawkinsia filamentosus</i> (Valenciennes, 1844)	Cyprinidae	Fd, Or	VU
39	<i>Puntius fraseri</i> (Hora & Misra, 1938)	Cyprinidae	Fd, Or	VU
40	<i>Puntius gelius</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
41	<i>Puntius guganio</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
42	<i>Puntius jayarami</i> (Vishwanath & Tombi Singh, 1986)	Cyprinidae	Fd	EN
43	<i>Pethia ornatus</i> (Vishwanath & Laisram, 2004)	Cyprinidae	Fd, Or	LC
44	<i>Puntius javanicus</i> (Bleeker, 1855)	Cyprinidae	Fd	NE
45	<i>Pethia khugae</i> (Linthoingambi & Vishwanath, 2007)	Cyprinidae	Fd, Or	NE
46	<i>Pethia phutunio</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	NK
47	<i>Pethia yuensis</i> (Arunkumar & Tombi Singh, 2003)	Cyprinidae	Fd	VU
48	<i>Systemus sarana</i> (Hamilton, 1822)	Cyprinidae	Fd	VU
49	<i>Puntius shalynius</i> (Yazdani & Talukdar, 1975)	Cyprinidae	Fd, Or	VU
50	<i>Puntius puntio</i> (Hamilton, 1822)	Cyprinidae	Or	NK
51	<i>Puntius sophore</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	NK
52	<i>Puntius terio</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	NK
53	<i>Pethia ticto</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	NK
54	<i>Rasbora daniconius</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC

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55	<i>Chela cachius</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
56	<i>Laubuka fasciata</i> (Silas, 1958)	Cyprinidae	Fd, Or	LC
57	<i>Chela khujairokensis</i> (Arunkumar, 2000)	Cyprinidae	Fd	LC
58	<i>Danio dangila</i> (Hamilton, 1822)	Cyprinidae	Or	VU
59	<i>Danio jaintianensis</i> (Sen, 2007)	Cyprinidae	Or	VU
60	<i>Devario annandalei</i> (Chaudhuri, 1908)	Cyprinidae	Or	LC
61	<i>Devario acuticephala</i> (Hora, 1921)	Cyprinidae	Or	EN
62	<i>Devario aequipinnatus</i> (McClelland, 1839)	Cyprinidae	Or	LC
63	<i>Devario assamensis</i> (Barman, 1984)	Cyprinidae	Or	LC
64	<i>Devario devario</i> (Hamilton, 1822)	Cyprinidae	Or	NT
65	<i>Devario horai</i> (Barman, 1983)	Cyprinidae	Or	NT
66	<i>Devario naganensis</i> (Chaudhuri, 1912)	Cyprinidae	Or	VU
67	<i>Devario regina</i> (Fowler, 1934)	Cyprinidae	Or	LC
68	<i>Devario yuensis</i> (Arunkumar & Tombi Singh, 1998)	Cyprinidae	Or	LC
69	<i>Esomus danrica</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	VU
70	<i>Garra rupecula</i> (McClelland, 1839)	Cyprinidae	Fd, Or	LC
71	<i>Garra annandalei</i> (Hora, 1921)	Cyprinidae	Or	LC
72	<i>Garra compressus</i> (Kosygin & Vishwanath, 1998)	Cyprinidae	Or	LC
73	<i>Garra flavatra</i> (Kullander & Fang, 2004)	Cyprinidae	Fd, Or	DD
74	<i>Garra gotyla</i> (Gray, 1830)	Cyprinidae	Fd, Or	VU
75	<i>Garra kempfi</i> (Hora, 1921)	Cyprinidae	Or	VU
76	<i>Garra kalpangi</i> (Nebeshwar, Bagra & Das, 2012)	Cyprinidae	Or	NK
77	<i>Garra maclellandi</i> (Jerdon, 1849)	Cyprinidae	Or	LC
78	<i>Garra notata</i> (Blyth, 1860)	Cyprinidae	Or	LC
79	<i>Garra lissorhynchus</i> (McClelland, 1842)	Cyprinidae	Fd, Or	VU
80	<i>Garra litanensis</i> (Vishwanath, 1993)	Cyprinidae	Or	NT
81	<i>Garra manipurensis</i> (Vishwanath & Sarojnalini, 1988)	Cyprinidae	Or	NK
82	<i>Garra naganensis</i> (Hora, 1921)	Cyprinidae	Or	VU
83	<i>Garra nasuta</i> (McClelland, 1838)	Cyprinidae	Or	LC
84	<i>Horlabiosa joshuai</i> (Silas, 1954)	Cyprinidae	Fd	VU
85	<i>Megarasbora elanga</i> (Hamilton, 1822)	Cyprinidae	Fd	VU
86	<i>Neolissochilus blythii</i> (Day, 1870)	Cyprinidae	Fd	LC
87	<i>Oreochthys cosuatis</i> (Hamilton, 1822)	Cyprinidae	Or	DD
88	<i>Osteobrama cotio</i> (Hamilton, 1822)	Cyprinidae	Fd	NT
89	<i>Rasbora ornata</i> (Vishwanath & Laisram, 2005)	Cyprinidae	Or	LC
90	<i>Rasbora rasbora</i> (Hamilton, 1822)	Cyprinidae	Or	LC
91	<i>Salmostoma bacaila</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	DD
92	<i>Salmostoma sardinella</i> (Valenciennes, 1844)	Cyprinidae	Fd	DD
93	<i>Salmostoma sladoni</i> (Day, 1870)	Cyprinidae	Fd	DD
94	<i>Salmostoma phulo</i> (Hamilton, 1822)	Cyprinidae	Fd, Or	LC
95	<i>Psilorhynchus arunachalensis</i> (Nebeshwar, Bagra & Das, 2007)	Psilorhynchidae	Or	NK
96	<i>Psilorhynchus balitora</i> (Hamilton, 1822)	Psilorhynchidae	Or	VU
97	<i>Psilorhynchus gracilis</i> (Rainboth, 1983)	Psilorhynchidae	Fd	NK
98	<i>Psilorhynchus homaloptera</i> (Hora & Mukerji, 1935)	Psilorhynchidae	Fd	VU
99	<i>Psilorhynchus microphthalmus</i> (Vishwanath & Manojkumar, 1995)	Psilorhynchidae	Fd	NK
100	<i>Psilorhynchus sucatio</i> (Hamilton, 1822)	Psilorhynchidae	Or	LC
101	<i>Aborichthys garoensis</i> (Hora, 1925)	Balitoridae	Or	NK
102	<i>Aborichthys elongatus</i> (Hora, 1921)	Balitoridae	Or	LC
103	<i>Aborichthys kempfi</i> (Chaudhuri, 1913)	Balitoridae	Or	VU
104	<i>Acanthocobitis botia</i> (Hamilton, 1822)	Balitoridae	Or	VU
105	<i>Paracanthocobitis zonalternans</i> (Blyth, 1860)	Balitoridae	Or	DD
106	<i>Balitora brucei</i> (Gray, 1830)	Balitoridae	Or	VU
107	<i>Balitora burmanica</i> (Hora, 1932)	Balitoridae	Or	VU
108	<i>Homalopteroides modestus</i> (Vinciguerra, 1890)	Balitoridae	Or	NK
109	<i>Schistura reticulofasciata</i> (Singh & Banarescu, 1982)	Balitoridae	Or	DD
110	<i>Neonoemacheilus assamensis</i> (Menon, 1987)	Balitoridae	Or	DD
111	<i>Neonoemacheilus labeosus</i> (Kottelat, 1982)	Balitoridae	Or	VU
112	<i>Physoschistura elongata</i> (Sen & Nalbant, 1982)	Balitoridae	Or	EN

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Table 1. Contd.....

113	<i>Schistura beavani</i> (Günther, 1868)	Balitoridae	Or	EN
114	<i>Schistura cincticauda</i> (Blyth, 1860)	Balitoridae	Or	EN
115	<i>Schistura corica</i> (Hamilton, 1822)	Balitoridae	Or	LC
116	<i>Schistura devdevi</i> (Hora, 1935)	Balitoridae	Or	EN
117	<i>Schistura kangjupkhuensis</i> (Hora, 1921)	Balitoridae	Or	LC
118	<i>Schistura manipurensis</i> (Chaudhuri, 1912)	Balitoridae	Or	VU
119	<i>Schistura minuta</i> (Vishwanath & Shanta Kumar, 2006)	Balitoridae	Or	NK
120	<i>Schistura multifasciata</i> (Day, 1878)	Balitoridae	Or	VU
121	<i>Schistura nagaensis</i> (Menon, 1987)	Balitoridae	Or	EN
122	<i>Schistura prashadi</i> (Hora, 1921)	Balitoridae	Or	LC
123	<i>Schistura reticulata</i> (Vishwanath & Nebeshwar Sharma, 2004)	Balitoridae	Or	EN
124	<i>Schistura savona</i> (Hamilton, 1822)	Balitoridae	Or	LC
125	<i>Schistura scaturigina</i> (McClelland, 1839)	Balitoridae	Or	LC
126	<i>Schistura sikmaiensis</i> (Hora, 1921)	Balitoridae	Or	EN
127	<i>Schistura vinciguerrae</i> (Hora, 1935)	Balitoridae	Or	EN
128	<i>Acanthopoma multistigmatus</i> (Vishwanath & Laisram, 2005)	Cobitidae	Fd, Or	LC
129	<i>Botia dario</i> (Hamilton, 1822)	Cobitidae	Or	VU
130	<i>Botia histrionica</i> (Blyth, 1860)	Cobitidae	Or	VU
131	<i>Lepidocephalichthys berdmorei</i> (Blyth, 1860)	Cobitidae	Or	EN
132	<i>Lepidocephalichthys guntea</i> (Hamilton, 1822)	Cobitidae	Or	VU
133	<i>Lepidocephalichthys annandalei</i> (Chaudhuri, 1912)	Cobitidae	Or	LC
134	<i>Neoeucirrhichthys maydelli</i> (Bănărescu & Nalbant, 1968)	Cobitidae	Or	LC
135	<i>Pangio pangia</i> (Hamilton, 1822)	Cobitidae	Fd	VU
136	<i>Somileptus gongota</i> (Hamilton, 1822)	Cobitidae	Or	VU
137	<i>Batasio batasio</i> (Hamilton, 1822)	Bagridae	Or	NK
138	<i>Batasio fasciolatus</i> (Ng, 2006)	Bagridae	Fd, Or	LC
139	<i>Batasio niger</i> (Vishwanath & Darshan, 2006)	Bagridae	Fd, Or	NT
140	<i>Batasio spilurus</i> (Ng, 2006)	Bagridae	Fd, Or	LC
141	<i>Batasio tengana</i> (Hamilton, 1822)	Bagridae	Fd, Or	LC
142	<i>Chandramara chandramara</i> (Hamilton, 1822)	Bagridae	Fd, Or	VU
143	<i>Mystus armatus</i> (Day, 1865)	Bagridae	Fd	VU
144	<i>Mystus bleekeri</i> (Day, 1877)	Bagridae	Fd, Or	VU
145	<i>Mystus falcarius</i> (Chakrabarty & Ng, 2005)	Bagridae	Fd, Or	LC
146	<i>Mystus montanus</i> (Jerdon, 1849)	Bagridae	Fd, Or	VU
147	<i>Mystus pulcher</i> (Chaudhuri, 1911)	Bagridae	Fd, Or	LC
148	<i>Mystus rufescens</i> (Vinciguerra, 1890)	Bagridae	Fd, Or	LC
149	<i>Mystus tengara</i> (Hamilton, 1822)	Bagridae	Fd, Or	LC
150	<i>Mystus vittatus</i> (Bloch, 1794)	Bagridae	Fd, Or	LC
151	<i>Olyra kempfi</i> (Chaudhuri, 1912)	Bagridae	Or	VU
152	<i>Olyra longicaudata</i> (McClelland, 1842)	Bagridae	Or	VU
153	<i>Olyra burmanica</i> (Day, 1872)	Bagridae	Fd	LC
154	<i>Rama rama</i> (Hamilton, 1822)	Bagridae	Fd	LC
156	<i>Ompok bimaculatus</i> (Bloch, 1794)	Siluridae	Fd	EN
157	<i>Ompok pabda</i> (Hamilton, 1822)	Siluridae	Fd	VU
158	<i>Ompok pabo</i> (Hamilton, 1822)	Siluridae	Fd	EN
159	<i>Pterocryptis berdmorei</i> (Blyth, 1860)	Siluridae	Fd	LC
160	<i>Pterocryptis indica</i> (Datta, Barman & Jayaram, 1987)	Siluridae	Fd	LC
161	<i>Pterocryptis gangelica</i> (Peters, 1861)	Siluridae	Fd	NK
162	<i>Ailia coila</i> (Hamilton, 1822)	Schilbeidae	Fd	VU
163	<i>Ailiichthys punctata</i> (Day, 1872)	Schilbeidae	Fd	VU
164	<i>Pachypterus atherinoides</i> (Bloch, 1794)	Schilbeidae	Fd	LC
165	<i>Amblyceps apangi</i> (Nath & Dey, 1989)	Amblycipitidae	Or	VU
166	<i>Amblyceps arunachalense</i> (Nath & Dey, 1989)	Amblycipitidae	Or	VU
167	<i>Amblyceps laticeps</i> (McClelland, 1842)	Amblycipitidae	Or	LC
168	<i>Amblyceps cerinum</i> (Ng & Wright, 2010)	Amblycipitidae	Or	NE
169	<i>Amblyceps mangois</i> (Hamilton, 1822)	Amblycipitidae	Or	EN
170	<i>Exostoma berdmorei</i> (Blyth, 1860)	Sisoridae	Or	LC
171	<i>Exostoma labiatum</i> (McClelland, 1842)	Sisoridae	Or	LC
172	<i>Exostoma stuarti</i> (Hora, 1923)	Sisoridae	Or	LC
173	<i>Exostoma vinciguerrae</i> (Regan, 1905)	Sisoridae	Or	LC
174	<i>Gagata cenia</i> (Hamilton, 1822)	Sisoridae	Or	NT
175	<i>Gagata dolichonema</i> (He, 1996)	Sisoridae	Or	LC
176	<i>Gagata sexualis</i> (Tilak, 1970)	Sisoridae	Or	NT
177	<i>Glyptothorax botius</i> (Hamilton, 1822)	Sisoridae	Or	LC

Contd.....

Table 1. Contd.....

178	<i>Glyptothorax conirostris</i> (Steindachner, 1867)	Sisoridae	Or	LC
179	<i>Glyptothorax platypogonides</i> (Bleeker, 1855)	Sisoridae	Or	VU
180	<i>Glyptothorax chindwinica</i> (Vishwanath & Linthoingambi, 2007)	Sisoridae	Or	VU
181	<i>Glyptothorax granulus</i> (Vishwanath & Linthoingambi, 2007)	Sisoridae	Or	LC
182	<i>Glyptothorax manipurensis</i> (Menon, 1955)	Sisoridae	Or	LC
183	<i>Glyptothorax ngapang</i> (Vishwanath & Linthoingambi, 2007)	Sisoridae	Or	LC
184	<i>Glyptothorax striatus</i> (McClelland, 1842)	Sisoridae	Or	VU
185	<i>Glyptothorax telchitta</i> (Hamilton, 1822)	Sisoridae	Or	VU
186	<i>Glyptothorax ventrolineatus</i> (Vishwanath & Linthoingambi, 2006)	Sisoridae	Or	VU
187	<i>Glyptothorax indicus</i> (Talwar, 1991)	Sisoridae	Or	NT
189	<i>Glyptothorax gracilis</i> (Günther, 1864)	Sisoridae	Or	LC
190	<i>Glyptothorax chintuipuiensis</i> (Anganthoibi & Vishwanath, 2010)	Sisoridae	Fd	NK
191	<i>Gogangra viridescens</i> (Hamilton, 1822)	Sisoridae	Or	LC
192	<i>Nangra assamensis</i> (Sen & Biswas, 1994)	Sisoridae	Or	LC
193	<i>Nangra nangra</i> (Hamilton, 1822)	Sisoridae	Or	NK
194	<i>Nangra robusta</i> (Mirza & Awan, 1973)	Sisoridae	Or	LC
195	<i>Parachilognis hodgarti</i> (Hora, 1923)	Sisoridae	Or	LC
196	<i>Aplocheilus panchax</i> (Hamilton, 1822)	Aplocheilidae	Or	LC
197	<i>Microphis deocata</i> (Hamilton, 1822)	Syngnathidae	Or	VU
198	<i>Monopterus hodgarti</i> (Chaudhuri, 1913)	Synbranchidae	Fd	LC
199	<i>Macrogathus pancalus</i> (Hamilton, 1822)	Mastacembelidae	Fd,Or	NK
200	<i>Heteropneustes fossilis</i> (Bloch, 1794)	Clariidae	Fd	VU
201	<i>Xenentodon cancila</i> (Hamilton, 1822)	Belontiidae	Or	VU
202	<i>Chanda nama</i> (Hamilton, 1822)	Chandidae	Or	LC
203	<i>Parambassis baculis</i> (Hamilton, 1822)	Chandidae	Or	LC
204	<i>Parambassis lala</i> (Hamilton, 1822)	Chandidae	Or	LC
205	<i>Parambassis ranga</i> (Hamilton, 1822)	Chandidae	Or	LC
206	<i>Parambassis tenasserimensis</i> (Roberts, 1995)	Chandidae	Or	LC
207	<i>Johnius coitor</i> (Hamilton, 1822)	Sciaenidae	Fd	NK
208	<i>Badis assamensis</i> (Ahl, 1937)	Nandidae	Or	NK
209	<i>Badis badis</i> (Hamilton, 1822)	Nandidae	Or	NK
210	<i>Badis blosyrus</i> (Kullander & Britz, 2002)	Nandidae	Or	LC
211	<i>Badis kanabos</i> (Kullander & Britz, 2002)	Nandidae	Or	NK
212	<i>Badis tuivaiei</i> (Vishwanath & Shanta, 2004)	Nandidae	Or	LC
213	<i>Nandus nandus</i> (Hamilton, 1822)	Nandidae	Or	NK
214	<i>Anabas testudineus</i> (Bloch, 1792)	Anabantidae	Fd	VU
215	<i>Trichogaster fasciata</i> (Bloch & Schneider, 1801)	Osphronemidae	Or	NK
216	<i>Trichogaster lalius</i> (Hamilton, 1822)	Osphronemidae	Or	LC
217	<i>Trichogaster labiosa</i> (Day, 1877)	Osphronemidae	Or	NK
218	<i>Channa bleheri</i> (Vierke, 1991)	Channidae	Fd	EN

Abbreviations: LC, Least Concern; EN, endangered; VU, vulnerable; NK, not known; NT, Near Threatened, DD; data deficient; Or, Ornamental; Fd, Food

These findings revealed that *A. mola* had the highest protein content (18.46%), but *G. chapra* had the highest fat content (18.46%). They concluded that the overall nutritional content of the small native fish they examined was comparable to or even greater than that of larger fish species.

SIFs were reported to contain moisture 75-81%, Ash 1.95-4.31%, protein 13-15%, fat 1.18-5.78%, energy 52.14-114.02 Kcal/g, Potassium 78.29-501.47mg/100g, Sodium 124.85-581.92mg/100g, Calcium 76.59-1984.32 mg/100g, Magnesium 81.55-148.16 mg/100g, iron 0.31-15.95 mg/100g, zinc 13.15-27.06mg/100g, Manganese -0.02-6.34mg/100g. Since the ethnic people of the region typically consume these fish along with their head, bones, and viscera, they can be a convenient source of important nutrients, including vitamins, calcium, iron, and other minerals (Borah, 2019).

Amino acid composition of small indigenous species of fish

Amino acids are organic molecules with side chains (R groups) unique to each amino acid as well as amine (-NH₂) and carboxyl (-COOH) functional groups. The main constituents of an amino acid are carbon (C), oxygen (O), nitrogen (N), and hydrogen (H), though some amino acids also contain other elements in their side chains. There are around 500 naturally occurring amino acids, but only 20 of these, known as proteinogenic amino acids, are found in proteins.

Mohanty *et al.* (2014) had reported on amino acid compositions of 27 food fishes out of which 4 food fishes, i.e., *Amblypharyngodon mola*, *Anabas testudineus*, *Puntius sophore* and *Heteropneustes fossilis* are small indigenous fish. They reported that lysine and glutamic acid is the most abundant amino acid in *Hetero-*

pneustes fossilis in comparison to other SIS. They further reported that Histidine is present in significant proportions in the SIS *Puntius sophore* and *Amblypharyngodon mola*. According to their analysis, marine fishes have leucine, small indigenous fishes contain histidine, and carps and catfishes contain glutamic acid and glycine.

The amino acid composition of 10 SIS fishes (*A. mola*, *Macrogathus pancalus*, *Trichogaster fasciata*, *Xenentodon cancila*, *Channa punctatus*, *Barilius vagra*, *N. maydelli*, *Parambassis nama*, *C. gachua*, *Rasbora daniconius*) was recorded by Chakraborty in (2018). They showed that *Barilius vagra* had a fair amount of glutamic acid. *T. fasciata* had the greatest concentration of the essential amino acid (EAA) histidine (10%), while *C. nama* had the second-highest concentration (8.36%). Methionine, another EAA was highly quantified in *C. gachua* (9.42%), followed by *N. maydelli* (6.8%) and *X. cancila* (5.75%), in that order. Another NEAA (non-essential amino acid), threonine was present in high concentration in *C. gachua* (8.67%), *M. pancalus* (7.07%), *R. daniconius* (6.51%) and *X. cancila* (5.18%), respectively. According to data from Romharsha et al. (2014), *S. manipurensis* has the greatest quantity of glutamic acid (20.04%) compared to the other two investigated fish species, *L. pangusia* and *N. stracheyi*. Some researchers have estimated the amino acid composition of *Systomus clavatus*, *Gagata dolichonema*, *Garra abhoyai* and *Opsarius barnoides* (Ambily and Nandan, 2017; Singh, 2020). All the EAA—Histidine, Isoleucine, Lysine, Leucine, Methionine, Phenylalanine, Threonine, and Valine—are found in the highest concentration in *Systomus clavatus* (Table 3).

Fatty acid composition of Small Indigenous Species of fish

The ability of fatty acids to minimize a wide range of medical conditions, including cancer, cardiovascular disease, and many others, is broadly established. Additionally, it plays a significant role in many facets and newborn brain development. Due to their role in supplying high-energy molecules and the necessary nature of particular fatty acids, lipids are a vital part of a fish's diet. As a result of the presence of polyunsaturated fatty acids (PUFAs), fish oil is essential for maintaining human health.

There are primarily three groups of fatty acids, namely SFAs (saturated fatty acids), MUFA (monounsaturated fatty acids) and PUFA (poly-unsaturated fatty acids). SFAs and MUFAs can be synthesized by the human body, but PUFAs cannot be produced by humans; as a result, it must be received from food. Fish oils are substantial sources of essential fatty acids including alpha - linolenic acid, eicosapentaenoic acid, and docosahex-

anoic acid, which are the significant n-3 polyunsaturated fatty acids. These fatty acids may be found in fish eggs from small and big fish as well as oily fish. These omega -3 fatty acids are another name for these n-3 fatty acids.

Mohanty et al. (2019) reported that most of the fatty acids in the SIS viz, *Amblypharyngodon mola*, *Anabas testudineus*, *Puntius sophore* and *Heteropneustes fossilis*, were unsaturated fatty acids (UFA) like oleic acid and linolenic acid. They also reported a high ω -3 fatty acid content in *P. sophore* and a high ω -6 fatty acid content in *Amblypharyngodon mola*. The ω -3 / ω -6 ratio indicates the fat's quality since higher levels of -6 fatty acids enhance the pathogenesis of many diseases, including cancer, inflammatory diseases, and autoimmune diseases, whereas higher levels of -3 PUFA exert inhibitory effects (Simopoulos, 2002). Therefore, it is preferable to have more omega-3 fatty acids and a higher ratio of omega-3 to omega-6 (Mohanty et al., 2019). A recent study has reported that seasonal variations can affect fatty acid composition and nutritional profiles of fish (Souza et al., 2020).

Vitamin contribution of Small Indigenous Species of fish

Vitamins are chemical compounds that organisms require in little amounts for normal metabolic processes. In all forms of life, these molecules have virtually identical tasks. Higher animals have lost their ability to synthesise them and must thus receive them through eating. Vitamins are categorized as either water-soluble or fat-soluble based on their solubility. Vitamin C and the vitamin B series are water-soluble vitamins. Vitamin deficiency is a serious public health issue in many underdeveloped countries, particularly in children and women of reproductive age (West, 2002). According to studies, children under five with a high vitamin A level had a lower death rate. Some regularly consumed small indigenous freshwater fish species have greater levels of preformed vitamin A in retinol and dehydroretinol isomers, with the relative quantities varying between species (Roos et al., 2002). *Amblypharyngodon mola* is an SIS fish that is nutritional dense; it is high in vitamin A and also high in haemi, zinc, and, notably, calcium (Kongsbak et al., 2008). Other small indigenous species with high vitamin A content include *Gudusia chapra*, *Botia dario*, *Chela cachius*, *Osteobrama cotio cotio*, *P. ranga*, *Esomus danricus*, *Parambassis baculis*, *Channa punctatus*, *P. nama* and *Mystus vittatus* (Islam et al., 2023; Bogard et al., 2015). In order to determine the dietary contribution of calcium and vitamin A from fish in rural Bangladesh, Roos et al. (2003) conducted research. There were 44 fish species reported in the diet and 84% of the entire fish intake came under small indigenous fish.

Table 2. Gross chemical composition of important food fish species from India (in %) (Duarah and Das, 2019; Mohanty et al., 2022)

SI No	Species	Moisture (g/100 g)	Crude Protein (g/100 g)	Crude Fat (g/100 g)	Ash (g/100 g)	Reference
1	<i>Ailia coila</i> (Hamilton, 1822)	82.8 ± 0.2	12.9 ± 0.5	1.8 ± 0.0	2.0 ± 0.0	Mohanty et al., 2017
2	<i>Amblypharyngodon mola</i> (Hamilton, 1822)	76.2 ± 1.1	16.3 ± 0.8	4.3 ± 0.0	4.0 ± 0.9	Mohanty et al., 2017
3	<i>Anabas testudineus</i> (Bloch, 1792)	68.0 ± 0.7	16.9 ± 0.5	6.9 ± 0.6	5.3 ± 0.2	Mohanty et al., 2017
4	<i>Gudusia chapra</i> (Hamilton, 1822)	76.7 ± 0.3	14.1 ± 0.1	5.7 ± 0.0	2.9 ± 0.0	Mohanty et al., 2017
5	<i>Heteropneustes fossilis</i> (Bloch, 1794)	76.7 ± 1.1	16.3 ± 0.4	2.7 ± 0.5	2.6 ± 0.1	Mohanty et al., 2017
6	<i>Puntius sophore</i> (Hamilton, 1822)	75.7 ± 1.9	16.3 ± 0.9	4.9 ± 0.5	3.4 ± 0.1	Mohanty et al., 2017
7	<i>Xenentodon cancila</i> (Hamilton, 1822)	78.2 ± 0.7	15.7 ± 0.3	0.7 ± 0.0	3.6 ± 0.1	Mohanty et al., 2017
8	<i>Nandas nandas</i> (Hamilton, 1822)	75.75±0.78	16.09±2.66	7.34 ±0.49	5.19±.029	Kamal et al., 2007
9	<i>Mystus vittatus</i> (Bloch, 1794)	73.99±3.13	15.62± 0.32	7.53±1.10	6.50±0.63	Kamal et al., 2007
10	<i>Channa punctatus</i> (Bloch, 1793)	70.55±1.89	19.13±2.40	4.55±1.18	6.81±0.94	Kamal et al., 2007
11	<i>Notopterus notopterus</i> (Pallas, 1769)	72.68±1.08	18.30± 0.79	4.98 ±1.71	5.82±0.82	Kamal et al., 2007
12	<i>Parambassis nama</i> (Hamilton, 1822)	74.19±0.27	13.23±0.23	2.87±0.09	2.58±0.01	Jena et al., 2018
13	<i>Parambassis ranga</i> (Hamilton, 1822)	76.95±0.21	14.24±0.20	5.06±0.26	2.58±0.01	Jena et al., 2018
14	<i>Trichogaster fasciata</i> (Bloch & Schneider, 1801)	73.18±0.17	13.86±0.09	4.79±0.18	3.14±0.04	Jena et al., 2018
15	<i>Botia dario</i> (Hamilton, 1822)	72.92±0.71	14.59±0.26	6.15±0.17	3.13±0.03	Jena et al., 2018
16	<i>Esomus danrica</i> (Hamilton, 1822)	75.58±0.19	12.89±0.14	3.83±0.19	2.43±0.10	Jena et al., 2018
17	<i>Lepidocephalichthys guntea</i> (Hamilton, 1822)	72.80±0.27	14.10±0.14	5.81±0.10	3.29±0.18	Jena et al., 2018
18	<i>Macrogathus pancalus</i> (Hamilton, 1822)	75.12±0.40	16.53±0.06	3.02±0.13	3.58±0.05	Jena et al., 2018
19	<i>Puntius chola</i> (Hamilton, 1822)	65.88±3.00	18.26±2.50	1.53±0.25	3.92±0.54	Mazumder et al., 2008
20	<i>Pachypterus atherinoides</i> (Bloch, 1794)	73.32±2.98	15.84±1.50	2.24±0.40	3.29±0.68	Mazumder et al., 2008
21	<i>Setipinna phasa</i> (Hamilton, 1822)	69.31±0.54	15.65±0.78	13.23±0.25	3.46±0.06	Sarma et al., 2019
23	<i>Aspidoparia morar</i> (Hamilton, 1822)	77.42±0.36	16.71±0.70	4.96 ± 0.39	2.36±0.15	Sarma et al., 2019
23	<i>Mystus tengara</i> (Hamilton, 1822)	74.27±.07	16.96±.07	6.04±.06	2.67±.08	Farid et al., 2015

Over 99% of the calcium and vitamin A intakes from all fish were contributed by SIS. They also stated the availability and accessibility of SIS for the population in rural Bangladesh should be prioritised because it is a crucial and perhaps irreplaceable dietary source of calcium and vitamin A. (Mohanty et al., 2013).

The concentration of vitamin A in the mola's eyes was staggeringly high, at 62,200 RE/100 g (Roos et al., 2002). More than 50% of the vitamin A in the mola's eyes made up 2% of its wet weight. The viscera and eyes contain 90% of the vitamin A in mola. They also reported that Less than 2% of mola's total vitamin A content per 100 g of raw fish was present in *Labeo rohita*. Additionally, compared to bodily tissue and viscera, the eyes of *L. rohita* contain the highest concentration of vitamin A; however, this concentration is less than 2% of that of *mola*. This study explored the nutritional value of small indigenous species of fish that are found in Northeast India. Food fish have predominantly fulfilled the nutritional needs of human beings. Due to the declining fish population and rising demand for fish as food, production in the area requires additional study on the growth of technology for enhancing water quality, preventing sickness and producing wholesome stock. Campaigns to raise awareness of the SIS of fishes' abundance in fish protein, vital minerals, and n-3 polyunsaturated fatty acids like docosahexaenoic acid and eicosapentaenoic acid are being widely conducted. Additionally required for increasing the usefulness of fish are vitamins and amino acids, both in clinical and community nutrition. The conservation and sustainable use of the SIS of fish resources required environmental initiatives.

Therapeutic potential of SIS fishes

Omega-3 fatty acids are essential for proper growth and development as well as cognitive function. They minimize the chance of developing heart disease. Omega-3 fatty acids are also said to decrease inflam-

mation and may minimise the chance of developing chronic illnesses, including cancer, arthritis, and heart disease. Omega-3 fatty acids are important for cognitive (brain memory and performance) and behavioral function because they are heavily concentrated in the brain. In fact, babies who do not receive adequate amounts of omega-3 fatty acids from their mothers throughout pregnancy continue to risk developing visual and nervous system issues. Fatigue, poor memory, dry skin, heart issues, mood swings or sadness, and poor circulation are all omega-3 fatty acid insufficiency symptoms. The human body cannot generate these nutritionally essential n-3 fatty acids from scratch. Still, it can convert the eighteen-carbon n-3 fatty acid alpha-linolenic acid into 20-carbon unsaturated n-3 fatty acids (EPA) and 22-carbon unsaturated n-3 fatty acids (DHA). DHA and EPA compete for the enzyme cyclooxygenase with arachidonic acid. Platelet cyclooxygenase converts EPA to thromboxane A3, a relatively mild vasoconstrictor, as opposed to thromboxane A2, which is generated by the action of cyclo-oxygenase on arachidonic acid and is a significant vasoconstrictor (Choo et al., 2018). However, prostacyclin I3, generated from eicosapentaenoic acid (EPA) in the endothelium, is just as effective as prostacyclin I2, produced from arachidonic acid. As a result, an elevated dietary eicosapentaenoic acid: arachidonic acid ratio results in relative vasodilation and platelet aggregation inhibition (Singleton et al., 2000). *Channa punctatus* is a species of air-breathing fish native to different Asian nations. This species is popularly thought to have healing properties for wounds, postpartum depression, and various skin ailments. It has excellent amino acid and fatty acid contents, which are thought to be active components in the induction of wound healing (Zuraini et al., 2006). *Channa* spp. has a unique fatty acid composition in that it has extremely low quantities of eicosapentaenoic acid and relatively high levels of arachidonic acid, a precursor of prostaglandin. (Jais et al., 1994). *Monopterus albus* is a freshwater eel mostly found in Northeast India and Bangladesh. In recent years, there has grown in market demand and consumption of *Monopterus albus*. It is also thought to be an important part of the diet of anaemic and feeble persons. Traditional healers think consuming this species raises blood haemoglobin content and improves physical strength in sick people. Fish is excellent in nutritional content and has been believed to be a significant element in traditional therapies. (Neog and Konwor, 2023). Enhancement of the nutritional value of fish is now possible using an artificial intelligence approach (Sadhu et al., 2021).

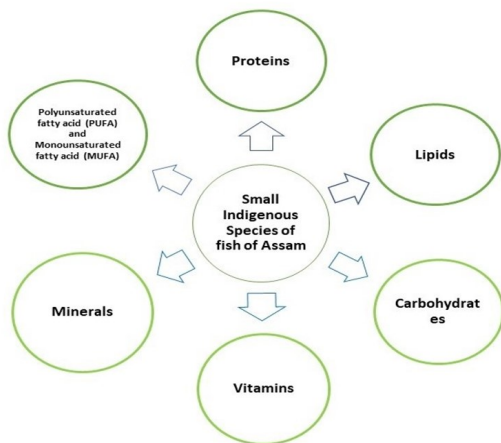


Fig. 2. Nutrients in SIS fish of Northeast India (Adopted from Acharya et al., 2018 with modifications)

Conclusion

Despite some variances in nutrient levels, SIS in Northeast India are nutrient-rich and can provide excellent

Table 3. Amino acid composition of SIS fishes from North east India

Amino acids (g/100g)	<i>Amblypharyngodon mola</i>	<i>Macrogynathus pancalis</i>	<i>Trichogaster fasciata</i>	<i>Xenentodon cancila</i>	<i>Channa punctatus</i>	<i>Barilius vagra</i>	<i>N. maydelli</i>	<i>Parambassis nama</i>	<i>Channa gachua</i>	<i>Rasbora daniconius</i>
L-Ala	0.37	0.09	1.43	0.30	0.26	1.13	1.34		0.14	0.88
L-Arg	ND	1.33	0.21	ND	0.72	0.39	3.76	0.16	ND	0.23
L-Asn	0.89	1.59	1.46	1.08	0.78	0.74	0.10	1.06	0.96	0.59
L-Asp	ND	ND	0.74	1.01	ND	1.56	2.11	0.08	1.05	0.96
L-Glu	0.43	1.19	ND	0.27	0.31	0.06	ND	ND	0.29	0.24
L-Cys	1.66	0.16	0.39	0.73	0.31	5.25	0.18	0.28	0.67	ND
L-Gln	ND	ND	ND	0.06	ND	0.45	0.77	ND	0.12	0.06
L-Gly	0.43	ND	ND	0.42	0.14	0.23	0.07	ND	0.36	0.28
L-Pro	1.66	0.11	0.24	ND	0.12	ND	ND	0.20	ND	ND
L-Ser	ND	0.41	0.11	0.58	0.47	ND	ND	0.65	0.54	0.35
L-Tyr	ND	0.75	0.47	0.33	ND	0.28	ND	0.33	0.62	0.86
L-His	0.16	ND	10.0	0.08	0.18	0.15	0.23	8.36	0.08	0.09
L-Ile	ND	0.19	0.51	ND	0.24	0.40	0.13	0.47	ND	ND
L-Leu	ND	0.73	0.45	0.75	2.68	0.99	0.57	0.29	0.72	0.54
L-Met	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
L-Lys	0.29	1.03	1.49	5.75	9.42	4.90	6.80	1.15	4.59	2.71
L-Phe	ND	0.46	0.15	0.60	0.30	0.10	ND	0.10	0.37	0.49
L-thr	0.17	7.07	ND	5.18	3.27	ND	ND	ND	8.67	6.51
L-Trp	0.07	ND	0.48	0.37	0.06	ND	0.63	0.37	0.20	0.21
L-Val	0.31	1.03	0.58	ND	0.23	0.56	0.70	0.39	0.27	0.21

Adopted from Chakraborty (2018), with modifications. ND= Not Detected

nutritional security. Small Indigenous fish species are the main food item among the rural population of the Northeast and have long been known to have medicinal uses for treating a variety of illnesses. SIS fish give the rural fishermen in those areas access to food, nourishment, and extra revenue. For the poor in rural areas, they provide a source of vitamins, proteins, calcium, and iron. Because even the poor can afford the purchase of little fish, they are the main source of necessary animal protein in rural and urban environments. The Northeast region of India is shown to have the highest SIS fish diversity. The SIS fish species more diverse in NE India are *Anabas testudineus*, *Amblypharyngodon mola*, *Gudusia chapra*, *Puntius sophore*, *P. chola*, *P. conchonius*, *Systemus sarana*, *Pethia ticto*, *Xenentodon cancila*, *Barilius barila*, *B. barana*, *Rasbora daniconius*, *Esomus danricus*, *Lepidocephalichthys guntea*, *Mystus bleekeri*, *M. cavasius*, *M. tengara*, *M. vittatus*, *Macrognathus aral*, *M. pancalus*, *Parambassis nama*, *Nandus nandus*. The threatened species of SIS fish are *B. dimorphicus*, *P. jayarami*, *Physoschistura elongata*, *Schistura beavani*, *S. cincticauda*, *S. devdevi*, *S. nagaensis*, *S. reticulata*, *S. sikmaiensis*, *S. vinciguerrae* and *Lepidocephalichthys berdmorei*. *Ompok bimaculatus*, *O. pabo*, and *Channa bleheri*. Various biochemical and nutritional studies on these freshwater fish species reveal that they contain four basic components—water, protein, fat, and ash in varying proportions, as well as other powerful elements such as vitamins and minerals, which are also abundant. Therefore, it is suggested that small indigenous fish species might be a good alternative for most of Northeast India's poor people to meet their daily nutritional needs.

Conflict of interest

The authors declare that they have no conflict of interest.

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