

THE NUTRITIONAL PROFILE OF INDONESIAN SALMON
VAN JAVA MAHSEER *T. SORO* SPECIES*Ekowati Chasanah, Diini Fithriani, Achmad Poernomo, Mohammad Halim Jeinie, Nurul Huda*

ABSTRACT

T. soro, in Indonesia called salmon van Java is of high economic value, and due to high demand, its culture has been intensively studied and developed. This study aimed to assess the nutritional value of wild and cultured *T. soro*. The fish's proximate compositions, minerals, as well as amino and fatty acid profiles were analyzed. A t-test analysis was used to identify differences between treatments. Results showed that the fat content of wild *T. soro* was higher than that of cultured fish, but the protein, water, and ash contents between the two groups were not significantly different ($p > 0.05$). *T. soro* was considered a lean fish with higher concentrations of PUFAs (polyunsaturated fatty acids) than MUFAs (monounsaturated fatty acids). The amino acid profile was dominated by lysine, phenylalanine, and allo-isoleucine. Both groups of fish were a good source of macro- (Na, K, Ca) and micronutrients (Zn, Fe), except for selenium (Se). The two groups were not significantly different ($p > 0.05$) in $\omega 3$, $\omega 6$, and PUFAs, indicating that culturing *T. soro* in proper ways could substitute for wild *T. soro*.

Keywords: amino acid and fatty acid profile; Indonesian *T. soro*; minerals; proximate composition

INTRODUCTION

In some parts of the world, especially in developing countries, fish has been a major protein source in diet. The latest FAO data have shown that fish contributes 17% of animal protein consumption and 6.7% of total protein consumption globally. As food, fish offers a unique combination of high-quality protein and vital micronutrients such as vitamins and minerals. Fish can improve the quality of dietary proteins by providing certain essential amino acids that may be deficient in other foods. Vitamins and minerals in fish include B-complex vitamins, vitamin D, vitamin A (especially in oily fish), selenium, zinc, iodine, and iron. All vitamins and minerals as micronutrients are important for development and health maintenance. Small fish with bones is an important source of calcium in human diets. Fish is also a good source of certain fatty acids (omega 3 and omega 6) that are as vital to normal brain development in unborn babies and infants as they are vital to adult due to the roles of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in lowering the risk of coronary heart disease (CHD) mortality (Abouel-Yazeed, 2013; Thilsted et al., 2014). These fatty acids cannot be produced by the human body and must be supplied by food. Fish is reported to be the only natural source of EPA and DHA (Philibert et al., 2006).

Fish consumption in Indonesia is as high as 43.9 kg/capita/year (Ministry of Marine Affairs and Fisheries, 2017), and it contributes up to 51% to animal protein consumption. In addition to saltwater fish, Indonesia

is also blessed with numerous freshwater fish species that play important roles in the food security and livelihood of communities living close to freshwater areas. One of the freshwater fish is Tor fish. Some are endemic to Indonesian waters, and some are commonly found in the lakes and rivers in Aceh, West Java (Kuningan, Sumedang, Majalengka), East Java (Blitar, Senggaring), South, Central, and West Kalimantan, West and South Sumatera, and Jambi (Arifin et al., 2019). The genus *Tor*, called true mahseer, is reported to represent 16 valid species so far (Pinder et al., 2019). These species are related to high religious and cultural significance throughout South and Southeast Asia, including Indonesia. They live in clean, strong-current rivers as well as in lakes. The fish are usually found in lowland and warm habitats, but one species of *Tor* (*Tor putitora*) is also found in Himalayan rivers and lakes (Sarma et al., 2015). There are 6 species of the mahseers found in Indonesia, 4 from the genus *Tor* and 2 from the genus *Neolissochilus*. The genus *Neolissochilus* is endemic to Toba Lake, North Sumatera, and currently included on the International Union for Conservation of Nature (IUCN) list as an endangered fish species (Arifin et al., 2019).

The *Tor* species found in Indonesia are *T. tambroides*, *T. soro*, *T. douronensis*, and *T. tambra*, of which the morphology has been described by Haryono and Tjakrawidjaja (2006). *Tor soro* is locally known as Kanca or Dewa in West Java, Pedih in Aceh, Jurung in North Sumatera, Sirang in Lampung, and Kelah in Kalimantan. It

is utilized as food and ornamental fish. In North Sumatera, *T. soro* is used as a substitution for Batak fish (*Neolissochilus thieenmanni*) for cultural ceremonies. As this fish grows slowly, a high level of utilization has led to overfishing. Tor fish has become less common due to the degradation of its habitats. Fortunately, there are places where Tor fish is considered sacred and kept in sanctuary ponds, for example, in Kuningan in West Java, Telaga Rambut Monte, Gandusari, Blitar in East Java, Aek Sirambe in North Sumatera, and Lubuk Larangan in West Sumatera. Studies and trials to culture Tor fish have been conducted (Kristanto, Asih and Winarlin, 2007; Gustiano et al., 2013; Radona et al., 2015; Muchlisin et al., 2017). This effort is intended to save the fish from extinction, and nowadays, the culture of *T. soro* has been developed in Indonesia. Culture development not only helps Indonesia on the fish extinction but also to use this fish as alternative protein sources for the needy population. Character comparison such as the nutritional value of the cultured fish to the wild fish is very important to improve the culture technique of this fish.

The chemical composition of freshwater fish, including the Tor fish from cold-water environments, has been reported elsewhere (Abouel-Yazeed, 2013; Sarma et al., 2011; Skibniewska et al., 2013; Basumatary et al., 2017). However, the information regarding this tropical freshwater fish has been limited. The objective of this study was to assess the chemical composition and to provide information on the nutritional value of Indonesian *T. soro*. As the cultivation of *T. soro* has been developed, in the current study, cultured *T. soro* was included in the analysis for comparison.

Scientific hypothesis

Due to the similar characteristics and living environment, the chemical composition and nutritional value of wild and cultured Indonesian *T. soro* were not significantly different.

MATERIALS AND METHODS

Sample

This study used *T. soro* fish in consumable size. Wild *T. soro* was caught by fishermen from the Cipunagara River, Subang (West Java), Indonesia, in size of 36 ± 3.6 cm in length and 535.5 ± 24.2 g in weight (Figure 1). Identification was conducted by the Research Institute for Inland Water Fisheries. The 33.3 ± 1.5 cm and 343.7

± 34.4 g cultured fish were from the Research Institute for Inland Water Fisheries' ponds in Cijeruk, West Java, Indonesia. The cultured fish was fed with commercial feed (SINTA pakan ikan), composing of the protein content of 32%, fat content of 5%, dietary fiber of 6%, ash content of 12%, and moisture content of 12%. The feed was applied at 2% per day per total biomass since the fish attained a weight of 200 grams at 10 months. The fish was cultured with a stocking density of 15 fish per cubic running water. The fish was harvested at 10 months old.

Chemicals

The Chemical used in this study were Merck-based HCl, NaCl, HNO₃, Na₂SO₄, KOH, methanol, hexane, and isopropyl alcohol. Amino acid standard testing kit KG0-7167 and AG0-7184 (Phenomenex) were also used in this experiment.

Instruments

The equipment used in this study were inductively coupled plasma optical emission spectrometry (ICP-OES) Agilent 720 (US), Gas Chromatography equipped with flame ionization detector (FID) (Perkin Elmer Technologies, US), centrifuge, microwave, vortex, oven, furnace, and freezer.

Description of Experiments

Sample Preparation

T. soro fish used in this study was consumable size. Wild *T. soro* was caught by fishermen from the Cipunagara River, Subang (West Java), Indonesia, in size of 36 ± 3.6 cm long and 535.5 ± 24.2 g. The cultured fish in size of 33.3 ± 1.5 cm and 343.7 ± 34.4 g were collected from Research Institute for Inland Water Fisheries, Cijeruk, West Java, Indonesia. The fishes were brought alive to the Research Center for Marine and Fisheries Product Processing and Biotechnology (BBRP2BKP) and were killed by immersing them in iced water and filleted as soon as the fish died.

Each group of fish (15 wild and 15 cultured *T. soro*) was divided into 3 sub-groups, filleted, minced, and homogenized using a domestic food processor (Panasonic, Indonesia). The homogenate (25 g) was then put into several small sterile plastics and stored at -20 °C before laboratory analysis. For fatty acid analysis, the homogenate was added with liquid nitrogen and stored at -80 °C before being analyzed in the following day. All analyses were conducted in triplicate.



Figure 1 Wild (left) and Cultured (right) Indonesian Masheer *T. soro*

Chemical Composition (Proximate and Mineral Analysis)

Proximates (protein, fat, ash, and moisture contents) were assessed according to the **AOAC (2000)**. Protein was assayed by the Kjeldahl method, fat content by the Bligh and Dyer method, and ash and moisture contents by gravimetry.

Proximate analysis was conducted at BBRP2BKP Chemical lab. Minerals (Ca, Na, K, Zn, and Fe) were assayed at PT SIG Saraswanti's laboratory according to the method of **AOAC (2000)**. A total of 0.5 g of sample was added with 10 ml of HNO₃ and then destructed at 190 °C for 20 minutes. The sample was introduced into a flask and added with aquabidest until 50 mL in volume, and then filtered. Determination of mineral content was assayed using inductively coupled plasma optical emission spectrometry (ICP-OES) Agilent 720 at each wavelength of minerals.

Amino Acid Analysis

Amino acid analysis was conducted at BBRP2BKP's instrumentation laboratory. The fish sample (20 mg) was hydrolyzed according to **Csapo et al. (1997)**. That is, the sample was hydrolyzed with 1 ml of 6N HCl and heated using a microwave at 180 °C for 60 min. The hydrolysate (100 µL) was then analyzed for amino acid content using EZ, the fast amino acid testing kit Phenomenex (KG0-7167), against essential and non-essential amino acid standards (Phenomenex AG0-7184). An analysis of amino acids was conducted in duplicate using a gas chromatography flame ionization detector (GC-FID).

Fatty Acid Analysis

Fatty acid analysis was conducted at PT SIG Saraswanti's laboratory, Bogor, Indonesia. A Five-gram sample was weighed into a clean quencher tube, added with 4 mL of isopropyl alcohol, and shaken for 1 minute. Six mL of hexane was added. Then, vortexing was conducted for 1 minute, followed by centrifuging for 3 minutes (12.370 RCF) to completely dissolve the extract. The upper layer with hexane phase was removed into a screw tube. For a methylation process, about 1 mL of hexane extract was removed into a tube, added with 1.5 mL of 0.5 M KOH methanol, heated at 100 °C for 20 minutes, and cooled at room temperature. After that, it was added with 1.5 mL of 20% BF₃ in methanol and heated again at 100 °C for 20 minutes. The solution was cooled and shaken until the temperature decreased to 30 °C. It was then added with 3 mL of NaCl and 2 mL of hexane before being subjected to vortexing for 2 minutes. After cooling and formation of

two phases, one of which containing fatty acid methyl ester (FAME), the mix was transferred into a tube and dried with 0.1 – 0.2 g of anhydrous sodium sulfate (Na₂SO₄). The FAME solution was removed into a vial and injected into GC-FID. FAME was identified and measured by Perkin Elmer Technologies Gas Chromatography equipped with flame ionization detector (FID) with SP TM -2560 column of 100 m having a 0.35 mm ID and 0.20 µm film thickness, 0.5 µL split, and 100:1 injection. The initial oven temperature was set and held at 100 °C for 3 minutes before being increased to 240 °C at a rate of 2.5 °C/minute and held at that temperature for 23 minutes. The carrier gas was helium at a total flow rate of 18.0 cm/second with a column length of 100 m. The detector temperature was set at 240 °C, and the injector temperature at 224 °C.

Statistical Analysis

All analyses were conducted in triplicate. The results are reported as mean value ± standard deviation (SD). Differences between treatments for each parameter were tested for significance using t-test analysis.

RESULTS AND DISCUSSION**Proximate composition and minerals**

The *T. soro* studied, both wild and cultured, were considered low-fat fish as the fat content of both was less than 2%. As shown in Table 1, except for fat, Ca, and Na, the proportions of all components were not different between wild and cultured *T. soro* ($p > 0.05$). Wild *T. soro* contained higher Ca, Na, and fat contents than the cultured ones ($p < 0.05$).

Studies on the proximate composition of wild and cultured fish of the same species have been conducted in many parts of the world. Inconsistent results in terms of the composition of the two groups were reported by different authors. Some reported that wild fish contained a higher content of certain chemical contents such as protein and fat, while others reported the opposite. Concerning protein content, wild fish were reported to be higher in the cases of yellow perch (*Perca flavescens*) (**Gonzales et al. 2006**), Nile tilapia (*Oreochromis niloticus*) (**El-zaeem et al. 2012**), and native fish *Dormitator latifrons* (**López-Huerta et al., 2018**). Contrary results were reported on freshwater giant prawn (*Macrobrachium rosenbergii*), shrimp (*Penaeus monodon*) (**Islam et al., 2017**), and sea bass (*Dicentrarchus labrax*) (**Alasalvar et al., 2002**), in which case the cultured ones were reported to have higher protein and fat contents

Table 1 Chemical compositions of wild and cultured *T. soro* compared with *T. Putitora*.

Components	<i>Tor soro</i>		<i>Tor putitora</i> *	<i>Channa striata</i> **	
	Wild	Cultured	(Golden Mahseer)	Wild	Cultured
Moisture (%)	77.7 ± 6.3	79.4 ± 0.6	76.24 – 79.24	78.88 ± 0.29	76.90 ± 0.99
Ash (%)	1.3 ± 0.4	1.2 ± 0.2	1.23 – 1.55	1.23 ± 0.09	1.44 ± 0.12
Protein (%)	17.8 ± 0.9	18.6 ± 0.6	15.59 – 17.29	19.85 ± 0.59	19.71 ± 0.28
Fat (%)	1.4 ± 0.2 ^a	0.9 ± 0.1 ^b	0.62 – 1.52	0.44 ± 0.19	2.65 ± 0.83
Ca (mg, 100 g ⁻¹)	182.5 ± 6.4 ^a	253 ± 2.8 ^b	1400 – 1600	12.15 ± 2.33	73.23 ± 36.86
Na (mg, 100 g ⁻¹)	90.9 ± 7.0 ^a	26.7 ± 3.6 ^b	200	18.35 ± 3.04	34.82 ± 2.65
K (mg, 100 g ⁻¹)	378 ± 12.7	370 ± 0.0	1400 – 1600	283.00 ± 18.38	398.83 ± 17.37
Zn (mg, 100g ⁻¹)	0.5 ± 0.0	0.4 ± 1.9	1 – 1.4	0.36 ± 0.003	0.45 ± 0.02
Fe (mg, 100 g ⁻¹)	0.6 ± 0.0	0.6 ± 0.0	0.6 – 1.3	0.17 ± 0.01	0.45 ± 0.02

Note: Values with a different word in a row means significant difference ($p < 0.05$). Source: *Sarma et al. (2015); **Chasanah et al. (2015).

compared to the wild sources. Feeds, habitats, seasons, and sex were the factors considered as most responsible. In fish culture, feeding is usually controlled for feed composition and feeding time to achieve certain targets such as weight, protein content, fat content, or color of the fish.

In this study, cultured *T. soro* were not significantly different from wild *T. soro* in moisture, protein, and ash content ($p > 0.05$), but significantly different in fat content and minerals ($p < 0.05$). Wild *T. soro* contained higher fat content and minerals compared to the cultured *T. soro*. This result was supported by previous studies conducted by **Nettleton and Elmhurst (2000)** and **Job et al. (2015)**. **Nettleton and Elmhurst (2000)** found that among 3 fishes studied, the fat contents in cultured and wild rainbow trouts were not significantly different, while **Job et al. (2015)** found that the fat content of wild tilapia was higher than that of cultured tilapia. The cultured *T. soro* used in this study were harvested from ponds and were fed with 2% of total biomass per day of commercial feed (**Kristanto, Asih and Winarlin, 2007**). The commercial feed had a protein content of $32.70 \pm 0.34\%$, moisture of $9.47 \pm 0.01\%$, fat content of $7.76 \pm 0.16\%$, and ash content of $14.61 \pm 1.16\%$. Meanwhile, the wild *T. soro* harvested from the Cipunagara River, Subang (West Java, Indonesia) consumed natural feed available in the river water. Tor fish is reported to be an active swimmer, fast-moving fish which eats a variety of foods available in the river. This means that the river from where the *T. soro* were harvested might be rich in natural feed containing high-fat content, which was not only used as an energy source but also conserved in the body. The main diet of wild *T. soro* is algae, detritus, insects, or

smaller fish (**Haryono and Tjakrawidjaja, 2006**). The study reported by **Sarma et al. (2015)** on the proximate composition of the Himalayan mahseer *T. putitora* showed comparable results with those of the warm water *T. soro* used in this study. Fat content is highly dependent on the species as well as fish ontogeny, feed, and environmental waters. In cold water environments, like Himalayas, the composition of fish was reported maximal during the monsoon season and lesser during the summer and winter seasons (**Sharma and Singh, 2020**).

The microelement (Zn) and macroelements (Ca, Na, K) in *T. soro* flesh were in general lower compared to those in golden mahseer (*T. putitora*) flesh, but the Fe contents of the two species were comparable. The *T. soro* studied, both wild and cultivated in ponds, were poor in micromineral selenium (Se) (Table 2). Microelement Se (selenium) was reported to be used as an important, and good, antioxidant against aluminum toxicity (**Iordache et al., 2011**). Himalayan mahseers, which live in the cold water of Himalaya, provide better sources of micro- and macroelement compared to *T. soro* which live in warm tropical water. However, compared to local fish *Channa striata*, *T. soro* was superior in terms of Ca, Na, Fe and comparable in terms of Zn and K contents. Therefore, *T. soro*, especially the wild ones, could be used as a good source of macrominerals. Potassium, calcium, and sodium are macrominerals essential to human health and involved in biological systems, while microminerals are involved in normal tissue metabolism and maintaining the health of the human body (**Sharma and Singh, 2020**). The results of this study are different from those of the study conducted by

Table 2 Amino acid profile of wild and cultured *T. soro* compared to *T. putitora*.

Amino Acids (%)	<i>Tor soro</i>		<i>Channa striata</i>		<i>Tor putitora</i> (Golden Mahser)***
	Wild	Cultured	River*	Swam water **(Merauke)	
Non-Essential					
Allo-isoleucine	7.14 ± 0.18 ^a	10.46 ± 0.26 ^b			
Alanine	3.01 ± 0.30	4.33 ± 0.43	3.35 ± 1.29	1.2	
Aspartic acid	2.88 ± 0.77	3.72 ± 1.0	2.93 ± 0.30	2.3	7.61
Proline	2.63 ± 0.14 ^a	3.39 ± 0.18 ^b	2.27 ± 1.07	0.5	6.68
Glycine	2.3 ± 0.18 ^a	3.59 ± 0.27 ^b	2.41 ± 0.91	0.7	7.46
Glutamine	1.18 ± 0.17	0.83 ± 0.12	1.13 ± 0.75	3.5	9.63
Asparagine	0.29 ± 0.06	0.18 ± 0.03	0.27 ± 0.25		
β-Aminoisobutyric acid	0.21 ± 0.03	0.31 ± 0.04	0.13 ± 0.11		
Tyrosine	0.17 ± 0.08	0.28 ± 0.06	0.62 ± 0.50	0.7	
α-Aminoadipic acid	0.13 ± 0.08	0.19 ± 0.12	0.18 ± 0.07		
Ornithine	0.09 ± 0.02	0.14 ± 0.04	0.12 ± 0.03		
Cysteine	0.08 ± 0.01 ^a	0.15 ± 0.02 ^b	0.11 ± 0.06	0.2	
β-Amino butyric acid	0.02 ± 0.01	0.03 ± 0.01	0.13 ± 0.11		
Essential					
Lysine	5.24 ± 0.17 ^a	7.32 ± 0.24 ^b	5.49 ± 0.12	2.5	9.41
Phenylalanine	4.21 ± 0.45 ^a	6.68 ± 0.71 ^b	3.63 ± 0.02		
Valine	2.28 ± 0.07 ^a	3.33 ± 0.3 ^b	1.82 ± 1.26	1.0	
Leucine			5.76 ± 2.59	1.6	7.59
Isoleucine	2.27 ± 0.19 ^a	3.62 ± 0.1 ^b	0.22 ± 0.15	0.9	
Histidine	0.91 ± 0.41	1.58 ± 0.71	0.83 ± 0.10	0.4	
Methionine	0.1 ± 0.02	0.16 ± 0.03	0.12 ± 0.05	0.9	
Tryptophan	0.1 ± 0.03	0.1 ± 0.03	0.15 ± 0.00	0.2	
Total amino Acid	35.25	50.39			

Note: Values with a different word in a row means significant difference ($p < 0.05$). Source: ***Chasanah et al. (2015)**; ****Susilowati et al. (2016)**; *** **Sarma et al. (2015)**.

Gonzales et al. (2006), who reported that both cultured and wild *Cichlasoma festae* living in tropical Ecuadorian rivers did not have significantly different values for K, Zn, and Fe, but did have significantly different values for P, Ca, and Mg, with the cultured fish having the higher values.

The value of Fe in *T. soro* flesh was following FAO's 2004 requirements for Fe content, that is, 0.23 – 2.1 mg.100g⁻¹ for human requirement (**FAO, 2004**). The macro- and micromineral contents in the fish were highly dependant on the water environment from where the fish is harvested, and this study supported earlier reports that different geographic areas influence the proximate composition and minerals in fish. Exogenous factors such as environment/geographic area from where the fish is harvested as well as indigenous factors such as species, age, and sex will affect the chemical composition of the fish, including minerals.

Amino acid profile

Table 2 shows the amino acid profiles of the cultured and wild *T. soro*, which indicate that the cultured fish had a higher amount than the wild ones. However, the amino acid patterns of both fish were similar. The orders of amino acids in terms of amount were not much different. The essential amino acids in *T. soro* flesh were mostly lysine and phenylalanine, with some addition of isoleucine and valine, while the non-essential amino acids were composed of allo-isoleucine as the most abundant as well as alanine, glycine, proline, and aspartic acid.

In general, fish is well known as a prime nutrition source with a high quality of proteins. The essential amino acid composition in the *T. soro* studied, both wild and cultured, was dominated by lysine, followed by phenylalanine, valine, and isoleucine. Lysine was also reported as the dominant amino acid in freshwater fish from Indonesia, namely, *Channa striata* and *Osphronemus goramy* (**Chasanah et al., 2015; Susilowati, Sugiyono 2016**). While **Mohanty et al. (2014)** reported lysine and aspartic acid as key amino acids in the freshwater fish harvested from cold water, the mahseer from Himalaya was reported to contain lysine and leucine and dominant amino acids. Even though the protein contents of *T. soro* and Himalayan mahseer (*Tor putitora*) were comparable, the concentrations of lysine and leucine were higher in Himalayan mahseer. As an essential amino acid, lysine plays an important role in human nutrition since this amino acid is required to obtain optimal growth. Hence, consumption of the fish can be used as one strategy to combat malnutrition and prevent stunting in children (**Marinda et al., 2018; Ngaisyah and Rohman, 2019**). In this study, nonessential amino acid allo-isoleucine (7.14 ± 0.18%) in the wild group and 10.46 ± 0.26% in the cultured group) was dominant in *T. soro*, while the Himalayan mahseer flesh was dominated by glutamic acid, aspartic acid, and glycine. Allo-isoleucine was detected as a dominant amino acid in *T. soro*, but nonexistent in *Tor putitora* and other freshwater fish such as *Channa striata* (Table 2). Since it is non-essential, this amino acid could be formed from a precursor in the feed. On the contrary, leucine which is an essential amino acid was absent in the *T. soro* studied. Allo-isoleucine is branched-chain amino acids (BCAAs) required for muscle formation and proper growth, as are leucine, isoleucine, and valine. This BCAA was found low in chronic renal failure (CRF) patients on

hemodialysis (**Mohanty et al., 2014**). Allo-isoleucine is associated with MSUD (Maple syrup urinary disease) (**Merriam-Webster, 2020**), and it has been used as a pathognomonic marker of branched-chain keto acid dehydrogenase complex (BCKDC) disorders (**Olson et al., 2014**). *Tor soro*, both wild and cultured, are considered as sources of the functional amino acid (FAA) in human nutrition as it is rich in aspartic acid, glycine, proline, and glutamine. The non-essential amino acids glutamic acid, aspartic, and proline have participated in the healing process (**Sarma et al., 2015**). Aspartic acid regulates the secretion of important hormones and is the precursor of methionine, threonine, isoleucine, and lysine (**Mohanty and Singh, 2018**), while amino acid glycine is reported to be able to convert harmful materials in the body into harmless forms and to control gluconeogenesis and blood sugar. Meanwhile, glutamine plays an important role in regulating gene expression, intracellular protein turnover, nutrient metabolism, and oxidative defense (**Mohanty et al., 2014; Wu, 2010**).

Fatty acid profile

Table 3 presents the fatty acid profile of *T. soro*. It shows that wild *T. soro*, in general, had higher fatty acids than those in the cultured ones, except arachidic acid (C20:0), eicosenoic acid (C20:1), EPA (C20:5), and linoleic acid (C18:2). The wild fish was richer in saturated fatty acid (SFA), while the cultured fish contained more monounsaturated fatty acid (MUFA) ($p < 0.05$). The wild and cultured fish were not significantly different in PUFA, total n-3, n-6 contents ($p > 0.05$), with similar patterns in the dominant fatty acids, i.e., oleic acid (C18:1 n9), palmitic acid (C16:0), linoleic acid (C18:2), DHA (C22:6), stearic acid (C18:0), and arachidonic acid (C20:4).

Polyunsaturated fatty acids (PUFAs), especially n-3, contribute positively to human health. Consumption of n-3 fatty acids has been reported to reduce the incidence of coronary heart diseases, depression, stroke, blood pressure disorders, glycemic index, triglycerides, and cancer (**Taşbozan and Gökçe, 2017; Williams et al., 2017**). Among n-3 fatty acids, docosahexaenoic acid (DHA) 22:6 n-3 and eicosapentaenoic acid (EPA) C20:5 n-3 correlate to good health benefits (**Swanson et al., 2012; Mohanty and Singh, 2018**). Our results show that wild and cultured *T. soro* had insignificant differences in total n-3, total n-6, DHA, and total PUFA, but cultured *T. soro* had higher EPA (eicosapentaenoic acid C20:5 n-3) compared to the wild one. The ratio of n-6 to n-3 in the fish studied was around 2, i.e., 1.99 ± 0.06 and 2.17 ± 0.13 for wild and cultured *T. soro*, respectively. The n-6/n-3 ratio of 1:5 is considered a good diet, but 1:2 is not harmful to human health (**Ana et al., 2019**).

The EPA and DHA contents of the fish were derived from the feed and their endogenous metabolism system. Being an omnivore, the wild *T. soro* derived the EPA and DHA from freshwater plankton and algae as natural feeds available in the river. On the other hand, the cultured *T. soro* consumed commercial feed. Consequently, the fatty acid profile of the fish was very dependent on the fatty acid in the feed. Commercial feeds are usually composed of a variety of alternative plant-based ingredients such as legume seeds, oilseed cakes, leaf meals, vegetable oils, and other materials. In the case of the cultured *T. soro* in this study,

Table 3 Fatty acid (FA) profile of wild and cultured *T. soro* compared with another freshwater fish, *C. Striata*.

Fatty acids (FA)	<i>Tor soro</i>		<i>Channa striata</i> *
	Wild (%)	Cultured (%)	
SFA			
C 4:0 (butiric acid)	0.17 ±0.03 ^a	0.06 ±0.01 ^b	1.5 ±0.3
C 12:0 (lauric acid)	0.52 ±0.00 ^a	0.14 ±0.06 ^b	
C 14:0 (miristic acid)	2.53 ±0.03 ^a	1.71 ±0.09 ^b	
C 15:0 (pentadecanoic acid)	0.34 ±0.01 ^a	0.27 ±0.01 ^b	
C 16:0 (palmitic acid)	24.52 ±0.58 ^a	21.07 ±0.66 ^b	23.3 ±0.3
C 17:0 (heptadecanoic acid)	0.36 ±0.04	0.29 ±0.01	
C 18:0 (stearic acid)	8.08 ±0.08	8.06 ±0.01	9.8 ±0.6
C 20:0 (arachidic acid)	0.18 ±0.01 ^a	0.26 ±0.01 ^b	
C 22:0 (behenic acid)		0.25 ±0.02	
C 24:0 (lignocerate acid)		0.12 ±0.04	
TOTAL SFA	36.69 ±0.57 ^a	32.20 ±0.81 ^b	38.4 ±0.8
C 14:1 (miristoleic acid)		0.08 ±0.01	
16:1 (palmitoleic acid)	2.25 ±0.10	2.62 ±0.13	3.1 ±0.3
C 20:1 (eicosenoic acid)	0.78 ±0.03 ^a	1.41 ±0.08 ^b	
C 18:1 n-9 (oleic/n-9 acid)	25.77 ±0.13 ^a	29.29 ±0.11 ^b	23.2 ±1.0
C 22:1 n-9 (erucic acid)		0.11 ±0.00	
C 24:1 (nervonic acid)		0.16 ±0.02	
TOTAL MUFA	28.80 ±0.00 ^a	33.65 ±0.07 ^b	34.2 ±1.7
C 20:2 (eicosadienoic acid)	0.57 ±0.04 ^a	0.45 ±0.04 ^b	
C 22:2 (docosadienoic acid)	0.27 ±0.16 ^a	0.18 ±0.03 ^b	
Omega 3			
C 18:3 (linolenic acid)	0.98 ±0.02	1.14 ±0.01	2.7 ±0.7
C 20:5 (EPA)	0.86 ±0.12 ^a	1.27 ±0.03 ^b	0.9 ±0.2
C 22:6 (DHA)	9.44 ±0.34	8.16 ±0.64	4.0 ±0.9
Total omega 3	11.27 ±0.44	10.57 ±0.66	11.3 ±0.2
Omega 6			
C 18:3 (linolenic acid)	0.32 ±0.00 ^a	0.21 ±0.00 ^b	0.5 ±0.1
C 18:2 (linoleic acid)	16.40 ±0.07 ^a	18.13 ±0.06 ^b	8.7 ±1.1
C 20:3 (eikosatrienoic acid)	1.57 ±0.05	1.20 ±0.01	0.4 ±0.1
C 20:4 (arachidonic acid)	4.12 ±0.13 ^a	3.43 ±0.09 ^b	6.0 ±1.3
Total omega 6	22.41 ±0.25	22.96 ±0.03	15.5 ±2.4
TOTAL PUFA	34.51 ±0.57	34.15 ±0.75	26.8 ±2.4
Ratio PUFA/SFA	0.94 ±0.03	1.06 ±0.05	
Ratio n-6 /n-3	1.99 ±0.06	2.17 ±0.13	
Ratio n-3 /n-6	0.50 ±0.01	0.46 ±0.03	0.8 ±0.1

Note: Values with a different word (superscript) in a row means significant difference ($p < 0.05$). Source: ***Jaya-ram et al. (2018)**.

the feed consumed contained more EPA than those consumed by the wild ones. Although freshwater fish has been known not to be as good as marine fish at providing PUFA essential fatty acids, including n-3 fatty acids, this study showed that *T. soro* in both groups could be a better source of DHA than other freshwater fish such as *Channa striata*. DHA is a primary structural component of the human brain, cerebral cortex, skin, and retina (**Swanson et al., 2012**). **Abouel-Yazeed (2013)** reported that the fatty acid compositions of marine and freshwater fish species from Egypt were comparable, indicating that fresh water could be used as the source of polyunsaturated fatty acids (PUFAs). Meanwhile, **Coutinho et al. (2019)** reported that *A. gigas*, a freshwater fish from Brazil's farm, was a great source of DHA (22:6 n-3) but had a low content of EPA

(20:5 n-3). This agrees with **Jaya-ram et al. (2018)**, who reported that the freshwater fish from Bukit Merah Reservoir contained considerable amounts of beneficial omega-3 PUFA, thus usable as a source of EPA and DHA.

The *T. soro* studied were rich in linoleic acid (C18:2 n-6), and this amino acid, along with α -linolenic acid (ALA C18:3 n-3), can be converted into the long-chain fatty acids EPA and DHA by freshwater fish body systems (**Thilsted et al., 2014**). The rates of conversion by endogenous metabolism are reported to vary between 1 and 10% by species (**Robert et al., 2014; Williams et al., 2017**). Therefore, it can be inferred that the essential fatty acids, EPA and DHA found in both groups studied were from either feed or endogenous conversion. Phytoplankton is the primary producer of these essential fatty acids. Therefore,

besides diet, the fatty acid composition and another nutritional status of the fish will be ruled by many factors like species and environmental factors like salinity, temperature, seasons, geographical location, and weather, and this applies to both the farmed or wild fish (Robert et al., 2014; Williams et al., 2017; Sarma et al., 2015).

CONCLUSION

The *T. soro* studied, both wild and cultured, contained high protein and low-fat values. The proximate contents were comparable with *T. putitora* from the cold water of Himalaya. However, allo-isoleucine was detected only in the *T. soro* studied here, with the cultured fish containing higher amounts than the wild fish. *T. soro* could be used as a good source of macrominerals and microminerals, except for Se (selenium). Wild *T. soro* contained more lipid than the cultured one. However, the cultured *T. soro* was as good as the wild one in terms of PUFA, n-3, n-6, and DHA. The ratio of PUFA to SFA of the *T. soro* met the optimal ratio of PUFA to SFA in food diets, i.e., 1.0 – 1.5. Based on this study, the cultured *T. soro* could provide nutrition as well as the wild one, but increasing leucine while reducing allo-isoleucine is important.

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Conflict of Interest:

The authors declare no conflict of interest.

Contact Address:

*Ekowati Chasanah, Research Center for Marine and Fisheries Product Processing and Biotechnology, Jl. KS Tubun, Petamburan 6, 10260, Jakarta, Indonesia, E-mail: ekowati.chasanah@kkp.go
ORCID: <https://orcid.org/0000-0002-5974-0690>
Diini Fithriani, Research Center for Marine and Fisheries Product Processing and Biotechnology, Jl. KS Tubun, Petamburan 6, 10260, Jakarta, Indonesia, E-mail: diinikkp@gmail.com
ORCID: <https://orcid.org/0000-0002-1482-6829>

Achmad Poernomo, State College of Fisheries, Jl. Raya Pasar. Minggu, RT.1/RW.9, Jati Padang, Kec. Ps. Minggu, Jakarta Selatan, Jakarta 12520, Indonesia,
E-mail: achpoer@yahoo.com

ORCID: <https://orcid.org/0000-0003-1845-2235>

Mohammad Halim Jeinie, Universiti Malaysia Sabah, Faculty of Food Science and Nutrition, Department of Food Service, 88400, Kota Kinabalu, Sabah, Malaysia,
E-mail: halimjeinie@ums.edu.my

ORCID: <https://orcid.org/0000-0001-6394-922X>

*Nurul Huda, Universiti Malaysia Sabah, Faculty of Food Science and Nutrition, Department of Food Science and Nutrition, 88400, Kota Kinabalu, Sabah, Malaysia; Universitas Sebelas Maret, Faculty of Agriculture, Department of Food Science and Technology, Jln. Ir. Sutami 36 A, Surakarta, Central Java, 57126, Indonesia;

E-mail: drnurulhuda@ums.edu.my

ORCID: <https://orcid.org/0000-0001-9867-6401>

Corresponding author: *