Fatty acid profiles of *Tominanga sanguicauda* and *Tominanga aurea* in Lake Towuti, South Sulawesi, Indonesia

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Abstract. Endemic fish is a fishery resource with important economic and ecological value. The objective of this study was to investigate the fatty acids in *Tominanga sanguicauda and Tominanga aurea* endemic fish species in the Lake Towuti, South Sulawesi, Indonesia. The sampling was conducted on July 2024. The trap net was used to obtain the samples from the research location in the Lake Towuti, and gas-liquid chromatography was applied to determine the chemical composition of the fatty acids. Subsequently, a descriptive technique was employed to analyze the data. The results showed an extensive overall content of *T. aurea* saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), compared to *T. sanguicauda*. Moreover, the compositions of docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and arachidonic acid (AA) in *T. aurea* were 0.03327%, 0.00875% and 0.00402%, respectively. Furthermore, the proportions of omega 3, 6 and 9 fatty acids in *T. aurea* were greater, compared to *T. sanguicauda.*
Key Words: endemic fish, saturated fatty acid, long chain polyunsaturated fatty acid, mono unsaturated fatty acid.

Introduction. Fish serves as an important nutrient source for human consumption. Indonesia is an archipelago country with strategic value and also plays a significant role as a habitat for various aquatic resources. The country is host to a massive abundance of fish species, estimated at 8,500, and a total of 1,300 species are living in freshwater (Kottelat & Whitten 1996). Indonesia has a total of 440 endemic freshwater fish species, with a fourth global position, after Brazil (1,716 species), China (888 species) and the United States (593 species), as well as above 140 marine species (FAO 2020). Unfortunately, adequate endemic fish production data have not been reported, despite the decline in several lakes across the nation.

Lake Towuti is among the ancient waters and is classified as oligotrophic lake, with a maximum depth of 203 m and an altitude of 293 m above the sea level (Haffner et al 2001). This particular source is an important habitat for over 17 endemic fish species in Indonesia (Hadiaty 2018). The endemic fish is a major marine resource with sufficient economic and ecological values. Lake Towuti is a biodiversity hotspot, the inherent abundance of biota species requiring conservation management (Parenti & Ebach 2013; Stelbrink et al 2014). The biota of Towuti waters is constantly exploited by the surrounding communities, as a tasty protein source, in particular the endemic fish species, such as of *T. sanguicauda* and *T. aurea* (known as pangkilang fish by the local population) (Jayadi et al 2024). Residents around the lake catch endemic fish for consumption, ornamental purposes and animal feed ingredients (Kartamihardja 2014).

The varieties *T. sanguicauda* and *T. aurea* living in the Lake Towuti are considered threatened species (Kottelat et al 1993; Kottelat & Whitten 1996) and are included on the Red List of Threatened Species (IUCN) under the record numbers: e. T21979A90980310 for *T. aurea* fish (Lumbantobing 2019a) and e. T21980A90980344 in *T. sanguicauda* (Lumbantobing 2019b). Currently, both varieties require adequate attention, in terms of sustainability of their exploitation, as well as in terms of preservation of their natural habitat. They are endangered by the human activity, particularly by indigenous fishermen engaging in overfishing activities. Information on *T. sanguicauda* and *T. aurea* is limited to taxonomic status and description (Said & Hidayat 2015), as ichthyofauna of the endemic fish in Lake Towuti (Hadiaty 2018; Jayadi et al 2021). Information on biological aspects, including condition factors and food habits of *T. sanguicauda* have been reported (Jayadi et al 2024), but information regarding the nutritional composition of endemic fish in Lake Towuti does not exist. The chemical composition of the freshwater species is fundamental in providing baseline information on nutrition for human intake. The objective of this study was to investigate the fatty acid profiles of *T. sanguicauda* and *T. aurea* in the Lake Towuti, Luwu Timur District, South Sulawesi, Indonesia.

Material and Method

Collection of fish samples. The fish samples were collected from Lake Towuti, Luwu Timur district, South Sulawesi, Indonesia, using a trap net. The sampling was conducted in July 2024. The samples (1.5 kg) were packaged in separate labeled polythene bags and stored in a cool box with ice to keep the temperature cool during their transportation to the laboratory, at the Faculty of Fisheries and Marine Science, Muslim University of Indonesia. Furthermore, the samples were cleaned with water and dried in the sun for ±12 hours (the estimated moisture content was <10% depending on the intensity of the sun) (Hasnidar & Tamsil 2020). The water content determination of samples was carried out by weighing the fish after drying (fish sample weight after drying from 1,500 to 750 g). The frozen dried powder meat samples were stored until used to detect fatty acid characterization.

Fish fatty acid composition analysis. The steps in the fatty acid analysis are as follows: (1) 20 mg of the fat extract is placed into a tube with a Teflon lid, and heated for 20 minutes. (2) The resulting substances are added to a solution of BF3 20% to achieve a 2 ml volume with an internal standard of 5 mg mL^{-1}, followed by further heating for 20 minutes. (3) Subsequently, the cooled 2 ml of saturated NaCl is then added, including 1 ml of isoocan, and the mixture is continuously agitated to attain uniformity. (4) The obtained isoocan layer is transferred into a tube containing 0.1 g of anhydrous Na_2SO_4, using a dropper and left for 15 minutes. (5) The resulting liquid phase is separated, while the oil phase is extracted up to 1 μL, and immediately injected into the GC instrument. Prior to injection of 1 μL, the melted substance was first mixed with a solution of FAME (Supelco 37 component fatty acid methyl ester mix) (Abdullah et al 2013).

Data analysis. The data of fatty acids of *T. sanguicauda* and *T. aurea* were analyzed descriptively.

Results and Discussion. Fish is a potential source of proteins, fatty acids and essential amino acids. Fatty acids are important nutritional compounds with significant influence on human health (Suvitha et al 2014). Tables 1, 2, and 3 represent the profiles of the fatty acid content, saturated fatty acid (SFA), long chain polyunsaturated fatty acids (PUFA) and mono unsaturated fatty acid (MUFA) in *T. sanguicauda* and *T. aurea*. In addition, the most occurring fatty acid content in *T. sanguicauda* were SFA (0.83979%)>PUFA (0.52861%)>MUFA (0.19772%), while *T. aurea* contained SFA (0.97223%)>PUFA (0.67066%)>MUFA (0.24912%). The SFA, PUFA and MUFA were higher in *T. aurea*, compared to *T. sanguicauda,* and the amount of these content in each fish species varies (Ahmed et al 2020). The difference in fish fatty acid composition is caused by species type, survival rate, sex, seasonal changes and fat content (Nielson et al 2011) and the diversity is influenced by several factors, including species type, feed, geographic location, age and size (Ozogul et al 2012), as well as the genetic indicators in muscles (Bayir et al 2006). Table 1 shows that the major SFA in *T. sanguicauda* and *T. aurea* is C16:0 (palmitic acid). Palmitic acid appeared dominant in various fish species, based on reports by Osibona et al (2009), Cengiz et al (2010), Citil et al (2014), Priatni et al (2018), Ahmed et al (2020), and is also known to increase blood cholesterol (Ibhadon et al 2015).

Table 1
Profiles of saturated fatty acid in *Tominanga sanguicauda* and *Tominanga aurea* from the Lake Towuti

Saturated fatty acid composition	*T. sanguicauda (%)*	*T. aurea (%)*
C4:0 (butyric acid)	0.00122	0.00122
C6:0 (caproic acid)	0.00127	0.00127
C8:0 (caprylic acid)	0.00144	0.00144
C10:0 (capric acid)	0.00158	0.00158
C11:0 (un decanoic acid)	0.00162	0.00162
C12:0 (lauric acid)	0.00167	0.00167
C13:0 (tridecanoic acid)	0.0017	0.0017
C14:0 (myristic acid)	0.0608	0.0814
C15:0 (pentadecanoic acid)	0.0158	0.0237
C16:0 (palmitic acid)	0.4462	0.5482
C17:0 (heptadecanoic acid)	0.0472	0.0583
C18:0 (stearic acid)	0.1838	0.2243
C20:0 (arachidic acid)	0.0073	0.0097
C21:0 (heneicosanoic acid)	0.0034	0.0066
C22:0 (acid behenat)	0.0073	0.0090
C23:0 (trichosanoic acid)	0.00143	0.00143
C24:0 (lignoseric acid)	0.0448	0.0577
∑SFA	0.83979	0.97223

Table 2 indicates the MUFA profile (mono unsaturated fatty acids) of the two fish species, with C18:1W9C (c-oleic acid) and C16: 1 (palmitoleic acid) reaching the highest concentrations. The *T. aurea* contained 10.1407% C18:1 W9C (c-oleic acid) and 0.0724% C16:1 (palmitoleic acid), while C18:1 W9C (c-oleic acid) and C16:1 (palmitoleic acid) in *T. sanguicauda* were estimated at 0.1143% and 0.0568%, respectively.

Table 2
Profiles of mono unsaturated fatty acid in *Tominanga sanguicauda* and *Tominanga aurea* from the Lake Towuti

Mono unsaturated fatty acid composition	*T. sanguicauda* (%)	*T. aurea* (%)
C14:1 (miristoleic acid)	0.0080	0.0122
C15:1 (penta decanoic acid)	0.0044	0.0055
C16:1 (palmitoleic acid)	0.0568	0.0724
C17:1 (heptadecenoic acid)	0.0052	0.0076
C18:1 W9C (c-oleic acid)	0.1143	0.1407
C18:1 W9T (t-oleic acid)	0.00151	0.00151
C20:1 (eicocyanic acid)	0.0044	0.0061
C22:1 (erucic acid)	0.00147	0.00147
C24:1 w9 (nervonic acid)	0.00164	0.00164
∑MUFA	0.19772	0.24912

Table 3 shows that the PUFA contents in *T. aurea* and *T. sanguicauda* were 0.67066 and 0.52861%, respectively. The highest concentrations in PUFA profiles for *T. sanguicauda* and *T. aurea* were reached by C18:2 W6 (linoleic acid/w6), C18:2 W6C (c-linoleic acid), C22:6 W3 (docosahexaenoic acid), C20:4 W6 (arachidonic acid) and C18:3 W3 (linolenic acid/w3). PUFAs play an important role in human health, ranging from embryonic development to the prevention and treatment of certain diseases, including arthritis and inflammation, autoimmune disease, diabetes, hypertension, kidney and skin disorders, as well as cancer in children and adults (Taşbozan & Gökçe 2017). Furthermore, polyunsaturated fatty acids (PUFAs) are considered as essential fatty acids, due to the inability to be synthesized by humans, and are therefore obtained from diet or supplements (Kris-Etherton et al 2002).

Table 3

Profiles of long chain polyunsaturated fatty acid (%) in *Tominanga sanguicauda* and *Tominanga aurea* from the Lake Towuti

Long chain polyunsaturated fatty acid composition	*T. sanguicauda (%)*	*T. aurea (%)*
C18:2 W6(linoleic acid/w6)	0.0052	0.0695
C18:2 W6C (c-linoleic acid)	0.0462	0.0695
C18:2 W6T(t-linoleic acid)	0.00164	0.00164
C20:2 (eicosadienoic acid)	0.00147	0.00147
C22:2 (docosadienoic acid)	0.0031	0.00155
C18:3 W3 (linolenic acid/w3)	0.0345	0.0429
C20:3 w3 (eico satrienoic acid/w3)	0.0042	0.0065
C20:3 w6 (eico satrienoic acid/w6)	0.0096	0.0102
C18:3 W6 (linolenic acid/w6)	0.0052	0.0070
C20:4 W6 (arachidonic acid)	0.0763	0.0875
C20:5 W3 (eico sapentaenoic acid)	0.0379	0.0402
C22:6 W3 (docosahexaenoic acid)	0.3033	0.3327
∑PUFA	0.52861	0.67066

Table 4 shows higher omega 3 fatty acids, omega 6 fatty acids, omega 9 fatty acids, arachidonic acid (AA), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) concentrations in *T. aurea*, compared to *T. sanguicauda*. The omega 3 fatty acids, omega 6 fatty acids, omega 9 fatty acids contents in *T. aurea* were 0.04224%, 0.01741%, and 0.01407% respectively. Meanwhile, the *T. aurea* species exhibited DHA, AA and EPA values of 0.03327%, 0.00875% and 0.00402%, respectively, while in *T. sanguicauda* there were recorded concentrations of 0.03033%, 0.00763% and 0.00379%, correspondingly. EPA and DHA fatty acids are very important in human health, in the prevention of coronary heart diseases. Also, DHA serves as a major component of the brain, retina and heart muscle, and is equally an essential factor for brain and eye development as well as maintains a healthy heart condition. However, EPA appears very useful in the treatment of brain disorders and cancer (Pratama et al 2018). These two fatty acids play vital roles in the development and functioning of an effective nervous system, photoreception and in reproductive health (Pirestani et al 2010). In addition, the substances are widely accepted as essential elements in a healthy and balanced diet, with several beneficial effects, particularly in the neural system (Innis 2007). Bowman & Rand (1980) reported the AA component as a precursor for prostaglandin and thromboxane, responsible for influencing blood clot and the attachment to the endothelia tissue during the wound healing process. Fatty acids, specifically EPA and DHA, are microelements with significant roles as stimulating transcription factors in hippocampus, including peroxisome proliferator activated receptors (PPARs), believed to regulate the synaptic plasticity level of neurons in the brain (Zulissetiana et al 2019). Based on World Health Organization (WHO) recommendations, the standard total intake of EPA and DHA occur in the range of 0.3–0.4 g day^{-1} (Hoseini et al 2013). Moreover, every fish contains EPA and DHA, but varies in quantity within the individual species, due to environmental variables, including diet and habitat, as well as being wild or farmed (Cengiz et al 2010).

Table 4 shows the extensive occurrence of PUFAs, including omega 3, 6 and 9 fatty acids, in particular linolenic, linoleic and oleic acids, in *T. aurea*, compared to *T. sanguicauda*. Omega-3s demonstrate diverse health benefits, due to the presence of anti-inflammatory and anti-clotting effects, with significant effectiveness at preventing heart diseases and cancer. These fatty acids are also good for the central nervous system, including brain development (Aryani et al 2017). Furthermore, the combination of omega 3, 6 and 9 is believed to greatly improve the cognitive function and visual abilities of infants (Nurasmi et al 2018).

Table 4
Profiles of fatty acid contents of *Tominanga sanguicauda* and *Tominanga aurea* from the Lake Towuti

Fatty acid composition	*T. sanguicauda*	*T. aurea*
Omega 3 fatty acids	0.03799	0.04224
Linolenic acid	0.0397	0.0498
Omega 6 fatty acids	0.01373	0.01741
Linoleic Acid	0.0462	0.0695
Oleic acid	0.1143	0.1407
DHA	0.03033	0.03327
Polyunsaturated fat	0.520	0.600
Unsaturated fats	0.710	0.840
Omega 9 fatty acids	0.01143	0.01407
AA	0.00763	0.00875
EPA	0.00379	0.00402
Mono unsaturated fat	0.190	0.240
Saturated fat	0.820	1.020

Conclusions. Fatty acid profiles of *T. aurea* and *T. sanguicauda* encompass SFA, MUFA and PUFA, which can have significant benefits to human health and fitness. In addition, the *T. aurea* species contain extensive concentrations of omega 3, 6 and 9 fatty acids, in particular DHA, EPA, and AA, compared to *T. sanguicauda*. The results of this study possibly provide adequate information to consumers and serve as an important reference for the sustainability of endemic fish populations in Lake Towuti. Further research is required to ascertain the nutritional and chemical contents of other endemic fish species in Lake Towuti.

Conflict of interest. The authors declare no conflict of interest.

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