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# Comparative Study of the Nutritional Composition of Wild and Farmed White-Spotted Conger, *Conger myriaster*

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**Authors' Contribution**
**YMZ and YYW performed the experiments, analyzed the data, wrote the manuscript. XHG, AHS and HD prepared the wild fish samples. PQH prepared the farmed fish samples. JJ and SHZ analyzed the composition of samples. XFS and YYW conceived and designed the project.**

**Key words**
***Conger myriaster*, Fatty acid, Essential amino acid, Nutrition value, Heavy metals, Farmed fish, Wild fish, Polyunsaturated fatty acids, Docosahexaenoic acid, Eicosapentaenoic acid**

**ABSTRACT**

The proximate composition, amino acid, fatty acid and mineral elements of wild and farmed *Conger myriaster* muscle were compared. Results indicated that the lipid content of farmed fish was significantly higher, while moisture content was significantly lower than that of the wild fish ($P$<0.05). The contents of all essential amino acids (EAA), half essential amino acids (HEAA) and Tyr, Asp, Glu were significantly higher in farmed *Conger myriaster* than that in wild fish ($P$<0.05). The ratios of the $W_{EAA}/W_{TAA}$ (39.92% *vs* 39.77%) and $W_{EAA}/W_{NEAA}$ (84.29% *vs* 82.37%) were similar in farmed and wild *Conger myriaster* ($P$>0.05). n-3 polyunsaturated fatty acids (PUFAs), n-6 PUFAs and total PUFAs content were lower in wild than that in farmed *Conger myriaster* ($P$<0.05). Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) were higher in farmed than wild *Conger myriaster* ($P$<0.05). Farmed fish showed significant high content in K and Mg but low in Hg, As and Pb compared to wild fish ($P$<0.05). In a word, farmed *Conger myriaster* under investigation have high nutritional qualities and positive health benefits, it is a potentially healthier alternative to the wild *Conger myriaster*.



## INTRODUCTION

Fish and fishery products are considered as valuable healthy products for human, because it has high quality protein, high long-chain n–3 polyunsaturated fatty acids (PUFAs) such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), liposoluble vitamins and mineral elements levels (Venugopal and Shahidi, 1996; Nakamura *et al*., 2007; Jensen *et al*., 2013; Kalantzi *et al*., 2013; Marengo *et al*., 2018). Quality of fish flesh involving various parameters such as texture, chemical composition, fat content, amino acid and fatty acid composition, mineral content and others (González *et al*., 2006; Fuentes *et al*., 2010), and muscle tissue is the main edible portion of fish and responsible of their nutritional value (Periago *et al*., 2005). Changes in muscle composition of fish may have consequences for marketing (Grigorakis, 2007). Amino acids in seafood proteins are usually the primary determinant of nutritional quality of protein. It serves as precursors for synthesis of a wide range of biologically important substances including nucleotides, peptide hormones, and neurotransmitters. Moreover, it also plays important roles in cell signaling, nutrient transport, prevention and treatment of metabolic diseases and metabolism in animal cells, and innate and cell-mediated immune responses (Mohanty *et al*., 2014; Wu, 2013). Generally, the EAA profile of fish tissue has been used as the fastest and most cost-effective method to estimate the fish amino acid requirements (Saavedra *et al*., 2006; Monentcham *et al*., 2010). Moreover, n-3 PUFA not only have an important impact in human nutrition and health promotion, but also have preventive effects on cardiovascular diseases and inflammatory conditions (arthritis, asthma, bowel diseases, etc.) (Gogus and Smith, 2010). On the other hand, some essential trace elements

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in fish have therapeutic effects toward the prevention of particular diseases.

Generally, people believed wild fish to be healthier, better quality, more nutritious and have a better taste compared to farmed fish. However, such beliefs are unsubstantiated (Claret *et al*., 2014). In addition, wild fish has potential risks of parasite and marine environmental pollution, especially the accumulation of heavy metals (e.g. mercury, cadmium, lead and arsenic) in fish may pose a potential risk to human health (Medeiros *et al*., 2012). Thus, there is a growing interest in wild fish safety with regard to the potential accumulation of these elements. In intensive production conditions, farmed fish have the advantage of being reared and harvested under controlled conditions, so that the hazards associated with fish consumption could be more easily controlled (Fuentes *et al*., 2010). However, intensive aquaculture production could cause crowding stress, disease outbreaks and overuse of antibiotics, so it has raised concerns over the nutritional quality of farmed fish in comparison with wild fish (Vidal *et al*., 2012). Therefore, the assessments of the quality of farmed fish and how the quality can vary and compare to the wild fish is central to ensuring aquaculture produced fish and products meet consumer and regulatory requirements (O'Neill *et al*., 2015). Misconceptions and unsubstantiated consumer belief currently exist with regard to the nutritional quality and sensory characteristics between farmed and wild fish and many comparative research has been conducted to date (O'Neill *et al*., 2015), however obtained opposite conclusions (Alasalvar *et al*., 2002; González *et al*., 2006; Kaya and Erdem, 2009; Fuentes *et al*., 2010; Rodríguez-Barreto *et al*., 2012). These contradictions could be due to differences in fish species, size and sexual maturity (Norambuena *et al*., 2012), diet type and nutrients, season, geographical region, temperature and salinity (Fuentes *et al*., 2010; Rasmussen *et al*., 2011). Therefore, the farmed *vs* wild fish quality evaluation is essential in order to correctly inform the farming industry and consumers on nutritional composition and sensory variation.

White-spotted conger (*Conger myriaster*) is one of the most important commercially valuable marine fishes, which naturally distributed from the East China Sea to the waters of Korea and Japan (Bae *et al*., 2018). The species presents a great potential for fish farming because of its excellent taste and high market value, and has been increasingly raised in the coastal area of China. Studies for the feeding habits and ecology, biological characteristics, early life history characteristics, genetic homogeneity and culture technique of this species have been reported (Yang *et al*., 2020). However, information on nutritional requirements of farmed *Conger myriaster* was limited, and there are no commercially available feeds specifically formulated for *Conger myriaster* so far. Marine fish feed and iced-fresh fish were used when this fish reared under farm conditions, which limited the development of this species reared in aquaculture. Therefore, the present study was conducted to compare the muscle proximate composition, amino acid, fatty acid profile and minerals of wild and farmed *Conger myriaster*, and to determine whether differences exist between wild and farmed fish in nutritional composition, and this study is of interest to both retailers and consumers.

## MATERIALS AND METHODS

*Sample preparation*

In present study, nine farmed *Conger myriaster* were obtained from Shandong Rongsense Group, China (119.427687E, 35.305356N) in May 2021. The fish were cultured in indoor recirculating aquaculture system, and the flow rate of water was maintained at 3.2 L $min^{-1}$, each cement pond was provided with continuous aeration to maintain the dissolved oxygen level above 6 mg/L, temperature was 25~26.6°C, salinity was 28.5-30‰, pH was 7.14~7.54, nitrite-N was 0.05~0.10 mg/L, ammonia-N was 0.29~0.35 mg/L, the light intensity was poor light. Farmed fish were fed minced trash fish and a commercial diet (crude Protein 53%, crude lipid 11.6%, lysine 3.2%, total phosphorus 1.1%) three times daily. Nine wild *Conger myriaster* were caught from the Yellow Sea (119.304201E, 35.042783N) in May 2021. From the time of capture until arrival at the laboratory, the fish were stored in box with ice pellets. Body weight and body length were measured, then fish muscles were collected and homogenized in a meat grinder. Mashed muscle sample of each group (three fish) was mixed and stored in a plastic bag, and then kept in refrigerator at -20°C until analysis (within 7 days). The body weight, body length and condition factor (CF) of fish were shown in Table I.

*Proximate composition analyses*

Muscle moisture, crude protein, crude lipid and ash were analyzed according to procedures of the Association of Official Analytical Chemists methods (AOAC, 1995). Moisture was analyzed by drying to a constant weight in an oven at 105°C for 24 h. Ash was analyzed by placing the samples in a muffle furnace at 550°C for 6 h. Crude protein was analyzed using an Auto Kjeldahl System (Kjeltec 8200; FOSS, Sweden) after acid digestion. Crude lipid was analyzed by ether extraction using a Soxhlet extraction system (SZF-06A; Xinjia Electronic Co., Ltd, Shanghai, China). The lipid extracted from muscle was stored in -20°C for fatty acid analysis.

**Table I. Nutrient components of wild and farmed *Conger myriaster.***

| | Wild | Farmed |
|---|---|---|
| Body weight (g) | 540±118 | 450±50 |
| Body length (cm) | 67.33±3.98 | 62.53±1.54 |
| Condition factor (g/cm³) | 0.17±0.01 | 0.18±0.01 |
| Moisture (g/100g, wet weight basis) | 72.00±2.50[a] | 62.87±1.96[b] |
| Protein (g/100g, wet weight basis) | 14.60±0.57 | 15.57±0.38 |
| Lipid (g/100g, wet weight basis) | 8.20±1.84[b] | 19.43±1.63[a] |
| Carbohydrate (g/100g, wet weight basis) | 4.16±0.16 | 3.97±0.58 |
| Chloride (g/100g, wet weight basis) | 0.13±0.01 | 0.12±0.01 |

Data are expressed as mean ± S.D; Mean with different superscripts in the same row are significantly different ($P$<0.05).

*Amino acids analyses*

The contents of amino acids were determined by high-performance liquid chromatography (HPLC). About 0.2 g of each muscle sample was weighed into the hydrolysis tubes, and 20 mL HCl (6mol/l) was added, then oxygen was expelled by passing nitrogen gas into the samples. The hydrolysis tubes were sealed with an alcohol blast burner and put into an oven for 22 h at 110°C. After that, the tubes were allowed to cool. The hydrolysate was then filtered by qualitative filter paper into 25 ml colorimetric tube, and diluted with deionized water. 50 µl filtrate was then evaporated to dryness at 60°C for 2 h in a vacuum drying oven. Accurately added 50 µl derivative agent (ethanol: phenyl isothiocyanate: $H_2O$: triethylamine=7:1:1:1), and derived for 30 min at 25°C. Next, 0.45 ml buffer (pH 6.5) was added and mixed. Finally, samples were analysed by HPLC (Agilent 1260, American Agilent Company). As acid hydrolysis oxidizes and breaks down tryptophan and cystine, their results were not reported. Amino acid quantification was done using standard curve given by a mixture of amino acid standard (Sigma Chemical Co., St. Louis, MO, USA). Standard curves were constructed for free amino acids; qualitative analysis was made on the basis of retention time and peak area of standard compounds.

*Fatty acid analyses*

The fatty acid compositions of muscle samples were determined according to a slightly modified protocol of Liu *et al*. (2019). The dried lipid extracts were added 2 mL methanolic NaOH (2%) and bathe in water at 85°C for 30 min. 3 mL $BF_3$-$CH_3OH$ (14%) was added for FAMEs derivatization, and the mixed liquid was heated at 85°C for 30 min. After adding 1 mL of hexane (for HPLC, >95%), extracted for 2 min and placed stably for 1 h. Afterwards, 100 µl of the upper layer (fatty acid methyl esters) were transferred to a 1 mL vial, diluted with hexane, and quantified using an Agilent 7890A gas chromatograph (American Agilent Company) with a fused silica capillary column (HP-88, American Agilent Company) and a flame ionization detector. The column temperature was programmed to rise from 130°C up to 240°C at a rate of 4°C min$^{-1}$, and keep for 30 min. Injector and detector temperature was 250°C, respectively.

*Mineral analyses*

Mineral elements composition from fish muscle was measured by high performance liquid chromatography-inductively coupled plasma mass spectrometry (HPLC-ICP-MS) (Agilent 7800, Agilent Technologies, Santa Clara, CA, USA). Sample mineralization was carried out by Kjeldahl method using nitric and sulphuric acid (2:1, w/w) as previously described (Alasalvar *et al*., 2002). Phosphorus was analyzed using UV-Spectrophotometer at a wavelength of 700 nm. Each sample was analyzed in triplicate and quantified by using external standards analysis. Samples were remeasured whenever the relative standard deviation of internal standards was higher than 10%.



*Statistical analysis*

All data were subjected to one-way ANOVA after homogeneity in variance was tested using SAS 9.12 for Windows. When a significant treatment effect was observed, Duncan's multiple range test was used to compare means. Data are expressed as means ± standard deviation. A significant level of $P < 0.05$ was employed in all cases. Each sample was performed in triplicate.

## RESULTS AND DISCUSSION

*Proximate composition*

Fish are a protein source rich in amino acids, fat-soluble vitamins, and minerals (Polak-Juszczak and Podolska., 2021). The results of proximate composition of farmed and wild *Conger myriaster* are shown in Table I. No statistically significant differences were observed in muscle protein, carbohydrate and chloride contents between farmed and wild *Conger myriaster* ($P$>0.05). Similar results had been reported for sea bass (*Dicentrarchus labrax*) (Alasalvar *et al*., 2002), turbot (*Psetta maxima*) (Martinez *et al*., 2010), rainbow trout (*Oncorhynchus mykiss*) (Fallah *et al*., 2011), Atlantic salmon (*Salmo salar*) (Jensen *et al*., 2012), yellowtail (*Seriola lalandi*) (O'Neill *et al*., 2015) and common sole (*Solea solea* L.) (Parma *et al*., 2019). In contrast, higher protein content in wild fish compared to farmed fish have been observed for yellow perch (*Perca flavescens*) (González *et al*., 2006), sea bass (*Dicentrarchus labrax*) (Fuentes *et al*., 2010) and *Pseudoplatystoma fasciatum* (Sant'Ana *et al*., 2010). Surprisingly, according to Periago *et al*. (2005) and Jensen *et al*. (2013), farmed fish had significantly higher protein content than wild fish.

In this study, the lipid content of farmed *Conger myriaster* (19.43%) was significantly higher ($P$<0.05), while moisture content (62.87%) was significantly lower ($P$<0.05) when compared to wild *Conger myriaster* (8.20%, 72.00%). These results were similar to some fish varieties such as Pacific bluefin tuna (*Thunnus orientalis*) (Nakamura *et al*., 2007), salmonids (Kaya and Erdem, 2009; Jensen *et al*., 2012), sea bass (Alasalvar *et al*., 2002; Fuentes *et al*., 2010; Lenas *et al*., 2011; Vidal *et al*., 2012) and other fish species (González *et al*., 2006; Martinez *et al*., 2010; Parma *et al*., 2019). It was determined that higher fat contents and water-holding capacity had an impact on flesh texture rendering it juicier and palatable (Fallah *et al*., 2011). Higher lipid content in farmed fish could be due to a variety of factors such as rearing conditions, development phase, feeding strategy, availability and type of food, dietary lipids and carbohydrate, higher energy consumption by the farmed fish compared with wild fish (Alasalvar *et al*., 2002; Grigorakis, 2007; Fallah *et al*., 2011). In addition, the high lipid content of farmed fish is may cause by the restricted activity of the farmed fish (Nakamura *et al*., 2007). However, farmed seabass had significantly lower fat content than wild fish (Periago *et al*., 2005), and no significant differences in lipid contents were found when comparing wild and farmed yellowtail (O'Neill *et al*., 2015) and cod (Jensen *et al*., 2013). A number of factors, such as species, age, environment conditions (e.g. temperature and salinity), the type and the availability of food, feeding regimes and season, are believed to be important factors contributing to these variations in the nutritional value of fish.

*Amino acid composition*

The amino acid composition is one of the most important nutritional qualities of protein (Iqbal *et al*., 2006). As shown in Table II, a total of 16 kinds of amino acids were identified in the muscles of farmed and wild *Conger myriaster*, including 7 kinds of essential amino acids (EAA) (Ile, Leu, Lys, Met, Thr, Phe, Val), 2 kinds of half essential amino acids (HEAA) (Arg, His) and 7 kinds of non-essential amino acids (NEAA)(Tyr, Pro, Ala, Asp, Gly, Glu, Ser). The content of all EAA, HEAA and some NEAA) (Tyr, Asp, Glu) was significantly higher in farmed *Conger myriaster* than in wild fish ($P$<0.05), and other amino acid contents did not vary between fish ($P$>0.05). Glu was the most abundant amino acid in both farmed (24.76 mg/g) and wild (20.91 mg/g) *Conger myriaster* muscle protein, followed by Lys, Asp, Leu, Arg, Gly, Ala, Val in decreasing amounts, with Met (1.54%) in both farmed (4.66 mg/g) and wild (3.90 mg/g) being the lowest. Glu is the most abundant free amino acid in the body. As a donor of nitrogen in the synthesis of purines and pyrimidines, Glu is essential for the proliferation of cells. *Conger myriaster* protein is also rich in lysine, which is the limiting amino acid in cereal-based diets of children in developing countries. The lysine in fish can supplement the corresponding deficiency in plant proteins.

**Table II. Amino acids composition in muscle of wild and farmed *Conger myriaster* (mg/g).**

| | Wild | Farmed |
|---|---|---|
| **EAA** | | |
| Isoleucine (Ile) | 5.76±0.08[b] | 7.14±0.33[a] |
| Leucine (Leu) | 11.18±0.12[b] | 13.48±0.54[a] |
| Lysine (Lys) | 13.62±0.06[b] | 16.13±0.58[a] |
| Methionine (Met) | 3.90±0.06[b] | 4.66±0.18[a] |
| Phenylalanine (Phe) | 5.33±0.07[b] | 6.52±0.27[a] |
| Threonine (Thr) | 5.53±0.05[b] | 6.61±0.36[a] |
| Valine (Val) | 6.37±0.09[b] | 7.92±0.36[a] |
| **HEAA** | | |
| Arginine (Arg) | 10.56±0.23[b] | 13.13±0.68[a] |
| Histidine (His) | 4.96±0.05[b] | 6.74±0.33[a] |
| **NEAA** | | |
| Aspartic acid (Asp)* | 13.21±0.18[b] | 16.05±0.66[a] |
| Glycine (Gly) | 7.15±0.69 | 8.07±1.04 |
| Glutamic acid (Glu)* | 20.91±0.15[b] | 24.76±1.04[a] |
| Alanine (Ala) | 6.60±0.22 | 7.81±0.49 |
| Serine (Ser) | 5.30±0.07 | 6.23±0.35 |
| Proline (Pro) | 5.00±0.24 | 5.70±0.54 |
| Tyrosine (Tyr) | 4.65±0.03[b] | 5.59±0.18[a] |
| Cys | ND | ND |
| Trp | ND | ND |
| $W_{TAA}$ | 130.03±3.41[b] | 156.53±13.31[a] |
| $W_{EAA}$ | 51.70±0.43[b] | 62.45±2.61[a] |
| $W_{NEAA}$ | 62.81±1.42 | 74.22±4.19 |
| $W_{DAA}$ | 47.86±1.15 | 56.70±3.14 |
| $W_{EAA}/W_{TAA}$ | 39.77±0.44 | 39.92±0.41 |
| $W_{DAA}/W_{TAA}$ | 36.80±0.38 | 36.20±0.29 |
| $W_{EAA}/W_{NEAA}$ | 82.37±1.64 | 84.29±1.59 |

Data are expressed as mean ± S.D; Mean with different superscripts in the same row are significantly different ($P$<0.05); $W_{TAA}$ is total amino acids (TAA), $W_{EAA}$ is total essential amino acids (EAA), $W_{HEAA}$ is total half-essential amino acids (HEAA), $W_{NEAA}$ is total nonessential amino acids (NEAA), $W_{DAA}$ is total delicious amino acids (DAA); *means delicious amino acids (DAA). ND, none detected.

**Table III. Fatty acid composition of wild and farmed *Conger myriaster* (g/100 g sample).**

| Fatty acids | | Wild | Farmed |
|---|---|---|---|
| SFA | C14:0 | 0.42±0.06 | 0.66±0.07 |
| | C15:0 | 0.04±0.01$^{b}$ | 0.07±0.01$^{a}$ |
| | C16:0 | 2.78±0.44 | 3.30±0.39 |
| | C17:0 | 0.05±0.01 | 0.05±0.00 |
| | C18:0 | 0.52±0.03 | 0.68±0.07 |
| | C20:0 | 0.04±0.01 | 0.03±0.01 |
| | C22:0 | 0.01±0.00 | 0.01±0.00 |
| | C24:0 | 0.01±0.00 | 0.01±0.00 |
| | Total SFA | 3.87±0.55 | 4.81±0.54 |
| MUFA | C14:1 | 0.01±0.01 | 0.01±0.00 |
| | C16:1n-7 | 1.02±0.05 | 1.30±0.14 |
| | C18:1n-9 | 4.24±0.26 | 4.34±0.33 |
| | C20:1 | 0.29±0.03$^{b}$ | 0.60±0.04$^{a}$ |
| | C22:1n-9 | 0.07±0.02 | 0.12±0.02 |
| | C24:1 | 0.06±0.01$^{b}$ | 0.12±0.02$^{a}$ |
| | Total MUFA | 5.71±0.36 | 6.50±0.53 |
| PUFA | C20:3n-3 | 0.02±0.01$^{b}$ | 0.05±0.00$^{a}$ |
| | C20:5n-3 (EPA) | 0.62±0.05$^{b}$ | 1.05±0.12$^{a}$ |
| | C22:6n-3 (DHA) | 1.50±0.06$^{b}$ | 2.47±0.22$^{a}$ |
| | Total n-3 | 2.14±0.10$^{b}$ | 3.57±0.34$^{a}$ |
| | C18:2n-6c | 0.08±0.01$^{b}$ | 0.19±0.01$^{a}$ |
| | C20:2 | 0.04±0.01 | 0.05±0.00 |
| | C20:3n-6 | 0.01±0.00 | 0.01±0.00 |
| | C20:4n-6 | 0.22±0.02$^{b}$ | 0.56±0.02$^{a}$ |
| | Total n-6 | 0.31±0.03$^{b}$ | 0.76±0.03$^{a}$ |
| | Total PUFA | 2.49±0.13$^{b}$ | 4.39±0.37$^{a}$ |
| | TFA | 12.07±0.97 | 15.70±1.44 |
| | n-3/n-6 | 7.07±0.63$^{a}$ | 4.64±0.27$^{b}$ |
| | PUFA/SFA | 0.67±0.09 | 0.92±0.03 |

Data are expressed as mean ± S.D; Mean with different superscripts in the same row are significantly different ($P$<0.05). MUFA, monounsaturated fatty acids; ND, none detected; NSA, no significant amount (<0.01); PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

In present study, the total amino acids ($W_{TAA}$) and total essential amino acids ($W_{EAA}$) contents in farmed *Conger myriaster* were significantly higher ($P$<0.05) than those in wild fish. The ratios of the $W_{EAA}/W_{TAA}$ (39.92% *vs* 39.77%) and $W_{EAA}/W_{NEAA}$ (84.29% *vs* 82.37%) were similar in farmed and wild *Conger myriaster* ($P$>0.05), and this result indicated that the ratios of the $W_{EAA}/W_{TAA}$ and $W_{EAA}/W_{NEAA}$ were comparable to the reference values of 40% and above 60% recommended by FAO/WHO (1991), it proves that the protein in *Conger myriaster* muscle was well-balanced in essential amino acid composition and is of high quality. The differences in the amino acids profile could be caused by diet type, rearing environment (salinity and temperature) or storage time (Gomes and Rosa, 2000; González *et al*., 2006; Jensen *et al*, 2013).

*Fatty acid profile*

Fatty acids participate in various biochemical and physiological processes related to cell growth and maintenance, and as a source of energy for cell signaling activities and other physiological functions. Fisheries products are the major source of fatty acids, especially HUFAs in the human diet (Ferreira *et al*., 2010). In present study, the fatty acid profiles of farmed and wild *Conger myriaster* are indicated in Table III, where they are grouped as saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and PUFA. The major SFA, MUFA and PUFA identified in both groups of *Conger myriaster* were C16:0 (palmitic), C18:1n-9 (oleic) and DHA, respectively. C15:0, C20:1, C24:1, C20:3n-3, C20:5n-3, C22:6n-3, C20:4n-6 was higher in farmed than wild *Conger myriaster* ($P$<0.05), while no significant differences were observed in other fatty acid in both groups ($P$>0.05). The percentage of linoleic acid (LA, 18:2n-6) was higher in farmed *Conger myriaster* (0.19 g/100g sample) than in wild fish (0.08 g/100g sample), and this may indicate that fish feed was composed of high level of vegetable oils in contrast to the natural feed of the wild fish (Alasalvar *et al*., 2002; Lenas *et al*., 2011; Jensen *et al*., 2012; Parma *et al*., 2019). Several studies have documented that dietary lipid contents influence the muscle fatty acid profile, particularly the LA (Martinez *et al*., 2010; Fallah *et al*., 2011; Jensen *et al*., 2012). However, Saglik *et al*. (2007) reported that fatty acid composition of farmed rainbow trout did not depend on that of feed.

The most advantageous aspect of seafood is its heart-healthy fatty acid profile that stems from the high levels of the two kinds of n-3 long-chain highly PUFAs, mainly EPA and DHA (Kris-Etherton and Hill, 2008), which provide many health effects, especially for persons with cardiovascular diseases, Alzheimer's and type 2 diabetes, moreover, DHA is essential for proper visual and neurological postnatal development (Castro-Gonzalez and Mendez-Armenta, 2008; Patel *et al*., 2021; Polak-Juszczak and Podolska, 2021). In this study, the levels of DHA and EPA were significantly higher in farmed *Conger myriaster* compared to wild fish (DHA, 2.47 and 1.50 g/100g sample; EPA, 1.05 and 0.62 g/100g sample, respectively). However, the DHA level was higher in wild compared to farmed sea bass (Alasalvar *et al.*, 2002), turbot (Martinez *et al*., 2010), Atlantic salmon (Jensen *et al*., 2012), cod (Jensen *et al*., 2013) and yellowtail (O'Neill *et al*., 2015). The difference in PUFA profile may come from season, habitat, environment and food web of each polychaete (Meunpol *et al*., 2005). The n-3 PUFA, n-6 PUFA and total PUFA content was lower in wild than that in farmed *Conger myriaster* ($P<0.05$). Numerous studies have suggested increasing dietary intake of long chain n-3 PUFAs and the n-3/n-6 ratio within the diet to be of benefit to human health (Simopoulos, 2000). However, there is no compelling scientific rationale for the recommendation of a specific ratio of n-6 to n-3 fatty acids, especially if intakes of n-6 and n-3 fats lie within the recommendations established in the report (FAO/WHO, 2008).

*Mineral elements*

Mineral components in seafoods tissues and organs (0.6–1.5% wet weight) are important for human nutrition (Erkan and Özden, 2007; Alvarez *et al*., 2009). Numerous reports showed that the accumulation of minerals in marine foods may be related to different factors such as feeding habits, fish species, size, sex, sexual maturity and life styles, area of catch, tissue site, food intake, seasonal and environmental conditions (water chemistry, salinity, temperature and contaminant etc.) (Alasalvar *et al*., 2002; Erkan and Özden, 2007; Uysal *et al*., 2008; Fallah *et al*., 2011; Kalantzi *et al*., 2013). Minerals contents of *Conger myriaster* are expressed in Table IV. Cd and Cr levels were not detected in this study. Farmed fish showed significant high content in K and Mg compared to wild fish ($P<0.05$) and low Na content ($P>0.05$), and no differences were obtained in the case of other minerals contents ($P>0.05$). As the results of marine fishes (González *et al*., 2006; Njinkoue *et al*., 2016), higher K and lower Na content were observed in farmed *Conger myriaster* and makes it a good meal for human health, especially in the case of cardiovascular disease prevention, the Na/K ratio in seafood should be less than 1. Trace metals are ubiquitously present in the environment and can be found at enhanced concentrations in coastal waters and inhabitant organisms (Ferreira *et al*., 2010).

As the heavy metals accumulate along the food chain, it may pose a risk for human health when reaching higher concentrations (Castro-Gonzalez and Mendez-Armenta, 2008), the presence of pollutants in fish tissues can counteract the positive effects of the omega-3 fatty acids present and their beneficial effects on heart disease risk (Domingo *et al*., 2007). The concentration (wet weight) of Pb, Hg, total arsenic, and Sn were 0.11–0.15 mg/kg, 0.02–0.05 mg/kg, 1.99–3.65 mg/kg, and 0.03–0.04 mg/kg, respectively. These heavy metals content in wild and farmed fish muscle were below the maximum limits for the national food safety standards (GB 2762–2017), suggesting human consumption of wild and farmed *Conger myriaster* have no adverse health effects. The comparison between wild and cultured *Conger myriaster* showed that Hg, As and Pb concentrations were generally higher in wild fish. Similar results were found in yellow perch (*Perca flavescens*) (González *et al*., 2006), Gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) (Marengo *et al*., 2018). The level of heavy metal bioaccumulation in fish tissues is influenced by fish biological habitat, chemical form of metal in the water, water environment (temperature, pH, dissolved oxygen level, transparency), as well as by fish species and age, gender, body mass, physiologic conditions and different tissues (Has-Schön *et al*., 2006).



**Table IV. Muscle minerals composition of wild and farmed *Coilia nasus* (mg/kg).**

| | Wild | Farmed |
|---|---|---|
| Potassium (K) | 3610.33±98.10[b] | 4037.33±95.09[a] |
| Calcium (Ca) | 247.50±33.50 | 218.67±23.81 |
| Sodium (Na) | 655.33±35.80 | 562.67±41.24 |
| Magnesium (Mg) | 197.00±5.13[b] | 230.00±6.81[a] |
| Zinc (Zn) | 7.74±0.86 | 8.37±0.55 |
| Iron (Fe) | 3.13±0.20 | 3.81±0.26 |
| Copper (Cu) | 0.65±0.05 | 0.59±0.18 |
| Aluminium (Al) | 2.26±0.18 | 2.20±0.13 |
| Stannum (Sn) | 0.03±0.00 | 0.04±0.01 |
| Mercury (Hg) | 0.05±0.01[a] | 0.02±0.01[b] |
| Arsenic (As) | 3.65±0.21[a] | 1.99±0.30[b] |
| Selenium (Se) | 0.79±0.06 | 1.08±0.09 |
| Lead (Pb) | 0.15±0.01[a] | 0.11±0.01[b] |
| Chromium (Cr) | ND | ND |
| Cadmium (Cd) | ND | ND |

Data are expressed as mean ± S.D; Mean with different superscripts in the same row are significantly different ($P<0.05$). ND, none detected.

## CONCLUSIONS

The present study has provided novel nutritional information on farmed and wild *Conger myriaster* which can inform fish farmers and consumers. The farmed *Conger myriaster* has higher lipid content, total amino acids, EAA content, EPA, DHA, n-3 PUFA, total PUFA, compared to wild fish. The $W_{EAA}/W_{TAA}$ and $W_{EAA}/W_{NEAA}$ in both groups were comparable to the reference values of 40% and above 60% recommended by FAO/WHO (1991).

The concentration of mineral composition, especially for Pb, Hg, total arsenic, and Sn in both groups were below the recommended dietary allowance (GB 2762–2017), which indicated that both wild and farmed *Conger myriaster* could be considered safe for human consumption. Therefore, this study shows that the farmed *Conger myriaster* under investigation have high nutritional qualities and positive health benefits, it is a potentially healthier alternative to the wild *Conger myriaster*. Furthermore, the present data is available to determine the nutritive requirements, especially amino acid requirements and could be used to develop practical diets for *Conger myriaster*. Therefore, future studies should focus on improving *Conger myriaster* diet in order to enhance the overall nutritional composition.

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*Statement of conflict of interest*

The authors have declared no conflict of interest.



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