Research Article

Proximate composition and amino acid profile of the whole body of juvenile Persian sturgeon (*Acipenser persicus*)

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Abstract

The main objective of the current study was to analyze the proximate composition and the amino acid profile of the Persian sturgeon (*Acipenser persicus*). Forty-eight fish (with an initial weight of 96.60± 7.45 g) were randomly sampled from a local sturgeon farm in Mazandaran, Iran. The proximate analysis of the fish body showed 24.38 ± 1.62 g/100g ww of dry matter, 61.52 ± 1.65 g/100g dw of crude protein, 10.53 ± 0.18 g/100g dw of lipid, 16.48 ± 1.3 g/100g dw of ash, 0.94 ± 0.03 % of NH3, and 2.45 ± 0.18 % of phosphorus. The essential and non essential amino acid composition provided the following values: Methionine: 1.57 ± 0.06 %, Threonine: 2.34 ± 0.08 %, Tryptophan: 0.56 ± 0.02 %, Arginine: 3.37 ± 0.12 %, Histidine: 1.32 ± 0.02 %, Isoleucine: 2.35 ± 0.05 %, Leucine: 4.27 ± 0.32 %, Lysine: 4.34 ± 0.27 %, Valine: 2.71 ± 0.09 %, Phenylalanine: 2.22 ± 0.07 %, Glycine: 5.12 ± 0.17 %, Serine: 2.43 ± 0.05 %, Proline: 3.11 ± 0.06 %, Alanine: 3.85 ± 0.09 %, Cysteine: 0.53 ± 0.15 %, Asparagine: 5.08 ± 0.2 %, and Glutamine: 7.63 ± 0.16 % dry weight. Compared to a number of international standards for evaluating sturgeon body composition and amino acid profile, the present study showed identical results in sturgeon farms to those released by FAO in 2011. Overall, the Persian sturgeon is not only an invaluable source of protein (i.e., essential and non-essential amino acids), but it can also assist farmers and researchers in formulating fish diets based on their real nutrition needs.

Keywords: Proximate composition, Essential amino acid, Non-essential amino acid, Persian sturgeon, Nutritional value

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Introduction

The proximate composition is a term usually used in the field of nutrition, mainly for components including moisture, protein, fat, ash, and carbohydrates, which are expressed as content percentage (Hussain *et al.,* 2018; Hosseini Shekarabi *et al*., 2020). The proximate composition and amino acid profile of fish should be evaluated to enhance the health status of the animal during the culturing period, while they are also necessary to determine the processing suitability of the final product (Hussain *et al.,* 2018). Numerous studies have demonstrated a relationship between the whole-body amino acids and an amino acid pattern for different fish species (Borlongan and Coloso, 1993; Mambrini and Kaushik, 1995; Mente *et al.*, 2002; Hosseini Shekarabi *et al*., 2021). A positive correlation between the concentration of essential amino acids in the fish body and tissues and that of the feed regime was suggested by Cowey (1994), who conducted a similar study on this topic. These nourishing ingredients play an important role in the synthesis, the metabolism, and the immune response. For instance, glutamine performs a very important function in detoxification and excretion of toxic metabolites (Ip and Chew, 2010). In addition, methionine is one of the most important essential amino acids, which plays a key role in stimulating protein synthesis, preventing the green liver syndrome, increasing cell survival, and improving digestibility and growth (Espe *et al*., 2008). Furthermore, leucine can increase resistance against diseases, especially under stressful conditions, such as during the breeding seasons, migration periods, and artificial cultivation (Machado *et al*., 2019). Therefore, the evaluation of both essential and non-essential amino acids can assist farmers and researchers in formulating a balanced diet, which meets the majority of the nutritional requirements of the fish (Wu *et al*., 2013).

Fish possess high levels of total protein, essential amino acids, and fatty acids, and they are one of the most important sources of animal protein in the world (Okland *et al*., 2005; Suvitha *et al*., 2014; King *et al*., 1990; Desai *et al*., 2018;). While fish are considered as a reliable source of these nourishing ingredients, they differ from species to species in terms of the quality and quantity of such amino acids. The difference can be ascribed to age, the feeding regime, the species, environmental conditions, the hunting season, and sex (FAO, 2002; Suvitha *et al*., 2014). Amino acids act as the building blocks of proteins, and as an intermediate in metabolism; hence, it is necessary to supplement the diet with sufficient protein to improve growth, survival, development, and reproduction, and to maintain health (Suvitha *et al.,* 2014). The composition of amino acids in fish and shellfish is not only important as an indicator for determining their nutritional value, but it is also important for the amelioration of both the quantity and the quality of these substances in fish products. However, free amino acids belong to non-protein nitrogen parts in crustaceans and fish, which are used as an index to evaluate the taste of fish and bivalves (Ikeda, 1980; Konosu and Yamaguchi, 1982). Some peptides and free amino acids function as flavoring materials (Kato *et al*., 1989), many of which, such as alanine, glycine, and glutamic acid, are responsible for the taste of the food (Yamanaka and Shimada, 1996). Extensive research has been conducted to determine the proximate composition and the amino acid profile of various fish species (Osibona *et al*., 2006; Nurnadia *et al.,* 2013; Shirai *et al.,* 2002; Mol and Turan, 2008; Gunlu and Gunlu, 2014; Costa *et al.,* 2018); however, very limited data is available on sturgeons' amino acids profiles. The Persian sturgeon (*Acipenser persicus*) inhabits the southern and southwestern parts of the Caspian Sea, and it is one of the most important species because of its unique ecological and biological features (Afraei *et al.,* 2006). The fish has recently been introduced as a new cultivable species (Agh *et al*., 2013). However, the morbidity and mortality of cultured fish can be high, which requires focusing on the nutritional requirements of the fish (Folorunso *et al*., 2017; Shefat, 2018). Since there is no comprehensive report on the proximate composition of the Persian sturgeon, such research can provide nutritional data and fundamental information for the improvement of the health status of artificially-cultivated fish, and the compound feeding of this essential commercial fish. Hence, the present study investigates the proximate composition and amino acid profile of the whole body of the Persian sturgeon.

Materials and methods Fish samples

A total of 48 Persian sturgeons (96.60 ± 7.45 g and 31.36 ± 0.91 cm) were randomly selected from 24 pools (2 fish per pool) in the Qhareh-Boron Sari Cultivation Center in Hossein Abad, Mazandaran, Iran. In terms of the physicochemical parameters of the water, its temperature was determined in the range of 18.2 to 18.6 C, its dissolved oxygen was measured near saturation at 8.5 mg/L, its pH was shown to be in a neutral range of 7.47 to 7.56, its electrical conductivity (EC) was measured at 760.66 µS/cm, and $NH3$, $NH4$, $NO3$, and $NO2$ were not significant. The fish were kept on ice with a ratio of 2:1 (w/w) and transferred to the Zakariya-Razi Laboratory, Tehran, Iran.

Proximate composition analysis

Proximate composition analysis was carried out according to the AOAC (1995) procedure. The fish were minced separately and dried in an oven (ED 115, Binder, Germany) for 24 hours at 60 °C. The dried samples were reweighted and kept in a freezer at -20 °C until the quantitative analysis of the lipids and proteins. The defined fractions of the proximate composition (i.e., protein, total lipid, ash, phosphorus, and $NH3$) were measured using transmission spectra from a FoodScan NIR spectrophotometer (FOSS NIRSystems, Hillerød, Denmark) (Fontaine *et al.,* 2001), and the data were expressed as 91% dry matter.

Amino acids profile

Transmission spectra from a FoodScan NIR spectrophotometer (FOSS NIRSystems, Hillerød, Denmark) were used to analyze the amino acid profile of the samples (Fontaine *et al.,* 2001). In summary, after the extraction of lipids from the oven-dried samples, the extraction mixture was centrifuged at 14560 g for 20 minutes at 30 °C to separate the lipids. Then, the

FoodScan NIR spectrophotometer was calibrated, and the amino acids were measured through scanning and radiation at different wavelengths in the near-infrared range. The spectrum was matched with the calibration result of the high-performance liquid chromatography (HPLC; Evonik, Germany).

Statistical analysis

Data analysis was performed in SPSS (version 20). All findings are expressed in the form of mean ± standard deviation (SD). The Kolmogorov–Smirnov test was used to assess the normality and homogeneity of the data. Significant differences were determined using one-way ANOVA, followed by Duncan's test to compare the differences between the experimental fish groups. Differences were considered statistically significant when $p < 0.05$.

Table 1. Body composition, NH3 and Phosphorus of Persian sturgeon, *Acipenser persicus*

	Dry matter (g/100 g ww)	Crude protein (g/100 g dw)	Ether extract (g/100 g dw)	Ash (g/100 g dw)	NH_3 (%)	Phosphorus (%)
1	25.90±0.08	62.53±0.67	10.20±1.41	16.13±0.14	0.94±0.002	1.26±1.75
2	27.20±2.88	57.84±1.98	13.04±2.47	16.72±0.67	0.91±0.01	2.48±0.12
3	25.29±1.18	61.41±2.64	10.80±1.32	16.29±1.28	0.97±0.05	2.39±0.02
4	26.36±2.28	59.62±2.27	12.45±0.10	16.95±0.12	0.92±0.05	2.47±0.14
5	27.20±3.71	61.54±1.19	10.32±0.49	16.39±0.10	0.98±0.03	2.42±0.25
6	22.12±2.30	62.91±0.30	9.40±0.07	16.18±0.02	1.04±0.06	2.28±1.32
7	26.17±0.53	62.36±1.07	11.10±0.49	16.03±0.55	0.98±0.04	2.32±0.17
8	25.66±4.10	63.02±0.78	10.48±1.06	15.70±0.004	0.98±0.03	2.32±0.04
9	24.37±0.97	61.13±1.12	9.82±0.42	15.66±1.32	0.96±0.002	2.42±0.26
10	25.78±1.12	62.23±1.72	10.30±1.97	15.72±0.47	0.98±0.01	2.21±0.28
11	24.05±3.27	60.38±2.47	10.38±0.21	17.07±0.87	1.00±0.07	2.39±0.12
12	26.24±0.35	61.58±0.38	9.13±1.34	16.59±1.41	0.98±0.033	2.53±0.28
13	21.41±2.95	62.36±0.007	9.60±2.89	16.76±2.03	0.97±0.009	2.35±0.19
14	22.55±2.42	62.44±1.67	9.10±0.84	17.02±2.07	0.95±0.06	2.47±0.35
15	23.51±1.47	61.27±0.40	10.15±0.28	16.73±0.66	1.01±0.05	2.56±0.06
16	24.24±0.35	61.74±1.10	9.21±0.70	17.38±0.16	0.94±0.03	2.46±0.10
17	26.17±1.29	60.98±1.12	10.91±0.56	16.17±1.17	0.95±0.03	2.46±0.28
18	25.39±0.64	61.34±1.56	11.03±1.62	16.37±0.62	1.00±0.009	2.40±0.13
19	29.54±1.38	61.04±1.08	11.80±1.20	16.14±0.06	1.01±0.04	2.39±0.12
20	26.24±0.29	58.30±3.11	11.13±0.11	16.43±0.24	0.97±1.01	2.40±0.08
21	22.22±2.54	62.82±0.53	10.30±0.63	15.94±1.17	0.98±0.07	2.35±0.20
22	26.88±1.37	62.32±4.36	11.53±4.59	15.88±1.28	0.96±0.04	2.32±0.22
23	27.69±2.82	58.97±5.35	10.43±0.11	15.80±0.35	0.92±0.07	2.33±0.07
24	28.90±2.14	57.99±4.35	12.82±0.12	15.94±0.49	0.94±0.05	2.32±0.05

w.w. = wet weight; d.w.= dry weight.
Results are presented as means±SD (n=2), SD = Standard Deviation. Similar letters in the same column show no significant difference between results for each treatment (P>0.05).

Table 2. Whole body essential amino acid concentration (% dry weight) profile Persian sturgeon (*Acipenser persicus*)

	Methionine	Threonine	Tryptophan	Arginine	Histidine	Isoleucine	Leucine	Lysine	Valine	Phenylalanine	Sum
1	1.63±0.01	2.42±0.02	0.59±0.008	3.52±0.02	1.40±0.01	2.39±0.02	4.28±0.05	4.56±0.06	2.86±0.03	2.27±0.03	25.96
2	1.52±0.02	2.22±0.06	0.53±0.02	3.24±0.15	1.28±0.09	2.17±0.03	3.84±0.09	4.11±0.21	2.58±0.04	2.03±0.06	23.56
3	1.60±0.10	2.34±0.14	0.56±0.04	3.43±0.13	1.31±0.02	2.34±0.19	4.14±0.32	4.48±0.31	2.76±0.20	2.18±0.15	25.18
4	1.50±0.01	2.27±0.04	0.53±0.004	3.35±0.05	1.30±0.02	2.24±0.08	3.99±0.16	4.16±0.16	2.68±0.11	2.11±0.07	24.18
5	1.53±0.04	2.33±0.05	0.54±0.01	3.42±0.13	1.31±0.007	2.33±0.06	4.13±0.13	4.37±0.05	2.77±0.09	2.16±0.06	24.94
6	1.60±0.07	2.35±0.06	0.56±0.01	3.33±0.16	1.29±0.06	2.38±0.03	4.22±0.07	4.46±0.18	2.82±0.03	2.21±0.04	25.26
7	1.62±0.04	2.41±0.08	0.57±0.01	3.54±0.21	1.35±0.08	2.39±0.03	4.25±0.08	4.49±0.19	2.84±0.03	2.23±0.05	25.73
8	1.61±0.00	2.42±0.01	0.58±0.006	3.53±0.07	1.39±0.009	2.40±0.02	4.28±0.03	4.55±0.04	2.85±0.01	2.26±0.01	25.92
9	1.56±0.03	2.32±0.06	0.53±0.02	3.47±0.01	1.26±0.04	2.31±0.06	4.10±0.12	4.34±0.08	2.75±0.07	2.15±0.05	24.82
10	1.59±0.002	2.37±0.04	0.57±0.008	3.43±0.13	1.31±0.06	2.38±0.06	4.24±0.08	4.43±0.21	2.84±0.04	2.22±0.05	25.43
11	1.52±0.13	2.29±0.15	0.53±0.05	3.32±0.24	1.23±0.10	2.30±0.17	4.07±0.29	4.18±0.45	2.76±0.15	2.15±0.14	24.39
12	1.51±0.02	2.29±0.006	0.55±0.008	3.31±0.07	1.31±0.02	2.31±0.01	4.09±0.03	4.31±0.08	2.76±0.04	2.16±0.01	24.64
13	1.61±0.03	2.37±0.05	0.56±0.03	3.49±0.003	1.32±0.05	2.36±0.05	4.19±0.10	4.48±0.03	2.81±0.07	2.21±0.03	25.44
14	1.62±0.05	2.40±0.07	0.57±0.03	3.56±0.01	1.36±0.00	2.38±0.15	4.23±0.24	4.56±0.13	2.83±0.16	2.39±0.10	25.78
15	1.53±0.02	2.26±0.05	0.54±0.002	3.28±0.21	1.30±0.03	2.26±0.004	4.01±0.03	4.31±0.09	2.67±0.01	1.12±0.01	24.31
16	1.57±0.02	2.35±0.01	0.55±0.03	3.49±0.02	1.32±0.04	2.31±0.04	4.13±0.06	4.40±0.04	2.80±0.03	2.19±0.01	25.13
17	1.54±0.02	2.33±0.05	0.56±0.03	3.41±0.06	1.34±0.02	2.32±0.07	4.12±0.14	4.36±0.007	2.76±0.11	2.17±0.08	24.95
18	1.58±0.06	2.34±0.04	0.55±0.02	3.41±0.02	1.28±0.009	2.34±0.09	4.13±0.16	4.31±0.22	2.79±0.07	2.18±0.08	24.94
19	1.56±0.01	2.29±0.009	0.54±0.002	3.32±0.01	1.29±0.001	2.32±0.04	4.09±0.06	4.36±0.07	2.75±0.04	2.13±0.09	24.69
20	1.46±0.05	2.20±0.12	0.53±0.02	3.10±0.25	1.25±0.04	2.19±0.13	3.90±0.23	4.00±0.26	2.63±0.16	2.04±0.14	23.33
21	1.60±0.02	2.40±0.02	0.58±0.009	3.48±0.17	1.35±0.02	2.39±0.04	4.26±0.05	4.48±0.06	2.86±0.04	2.25±0.02	25.69
22	2.24±0.13	2.83±0.13	4.60±0.31	4.27±0.23	2.41±0.11	1.37±0.03	3.53±0.23	0.58±0.02	2.42±0.11	1.65±0.05	25.94
23	1.53±0.10	2.26±0.20	0.54±0.04	3.28±0.31	1.30±0.04	2.24±0.23	3.97±0.42	4.20±0.40	2.65±0.29	2.09±0.22	24.11
24	1.53±0.11	2.24±0.19	0.54±0.04	3.24±0.33	1.27±0.68	2.22±1.13	3.92±0.59	4.14±0.43	2.63±0.80	3.42±2.11	23.21

Results are presented as means±SD (n=2), SD = Standard Deviation. Similar letters in the same column show no significant difference between results for each treatment (P>0.05).

Table 3. Whole body non-essential amino acid concentration (% dry weight) profile Persian sturgeon (*Acipenser persicus*)

	Glycine	Serine	Proline	Alanine	Cysteine	Asparagine	Glutamine	Sum
1	5.11±0.03	2.52±0.01	3.15±0.05	3.93±0.05	0.56±0.01	5.41±0.08	7.94±0.14	28.64
2	4.94±0.30	2.34±0.05	2.99±0.16	3.68±0.18	0.49±0.01	4.86±0.22	7.14±0.32	26.47
3	5.09±0.18	2.49±0.12	3.12±0.05	3.90±0.007	0.55±0.04	5.21±0.36	7.67±0.49	28.03
4	5.16±0.08	2.40±0.06	3.15±0.09	3.79±0.12	0.52±0.02	4.98±0.12	7.62±0.15	27.41
5	5.19±0.12	2.48±0.05	3.22±0.02	3.87±0.007	0.54±0.02	5.14±0.11	7.62±0.15	28.08
6	4.97±0.13	2.46±0.07	3.07±0.09	3.94±0.03	0.55±0.02	5.22±0.19	7.73±0.73	27.97
7	5.13±0.30	2.56±0.09	3.19±0.13	3.88±0.10	0.55±0.005	5.31±0.22	7.79±0.29	28.44
8	5.09±0.05	2.54±0.04	3.18±0.02	3.93±0.07	0.56±0.01	5.37±0.01	7.89±0.07	28.59
9	5.27±0.17	2.51±0.03	3.20±0.05	3.85±0.04	0.54±0.01	5.12±0.11	7.57±0.18	28.10
10	5.01±0.22	2.49±0.04	3.12±0.15	3.90±0.10	0.55±0.01	5.25±0.16	7.79±0.20	28.14
11	4.97±0.06	2.40±0.16	3.10±0.05	3.74±0.17	0.54±0.03	5.02±0.41	7.43±0.54	27.21
12	5.14±0.21	2.40±0.01	3.18±0.05	3.90±0.05	0.54±0.001	5.09±0.07	7.57±0.10	27.85
13	5.16±0.29	2.52±0.30	3.17±0.08	3.93±0.05	0.55±0.003	5.28±0.05	7.80±0.05	28.45
14	5.25±0.33	2.54±0.04	3.24±0.09	3.95±0.01	0.56±0.02	5.35±0.14	7.87±0.19	28.80
15	5.14±0.28	2.37±0.10	3.10±1.32	3.89±0.06	0.52±0.01	5.01±0.13	7.42±0.19	27.49
16	5.27±0.05	2.49±0.05	3.23±0.007	3.90±0.04	0.55±0.008	5.22±0.04	7.74±0.10	28.43
17	5.05±0.32	2.45±1.32	3.14±0.12	3.82±0.01	0.54±0.01	5.15±0.08	7.59±0.14	27.76
18	5.03±0.02	2.48±0.04	3.15±0.02	3.81±0.14	0.54±0.02	5.13±0.17	7.56±0.27	27.73
19	5.00±0.009	2.42±0.02	3.07±0.01	3.81±0.04	0.52±0.00	5.05±0.04	7.41±0.05	27.32
20	4.70±0.23	2.28±0.10	2.93±0.18	3.63±0.16	0.51±0.03	4.75±0.33	7.07±0.48	25.90
21	5.11±0.33	2.51±0.07	3.17±0.11	3.92±0.03	0.55±0.01	5.32±0.07	7.58±0.09	28.46
22	5.04±0.45	2.52±0.11	3.10±0.26	3.91±0.30	0.55±0.04	5.38±0.36	7.89±0.64	28.45
23	4.91±0.23	2.38±0.20	3.01±0.22	3.75±0.25	0.51±0.07	4.94±0.51	7.27±0.78	26.80
24	4.79±1.12	2.63±0.60	2.95±0.16	3.64±0.18	0.50±0.05	4.88±0.49	7.16±0.66	25.65

Results are presented as means±SD (*n*=2), SD = Standard Deviation. Similar letters in the same column show no significant difference between results for each treatment (*P*>0.05).

Result

The proximate composition of the Persian sturgeon demonstrated no significant difference between the fish breeding ponds ($p>0.05$). The dry matter, total protein, ether extract, ash, NH3, and phosphorus contents showed the values in the range of 24.38±1.62 g/100g ww, 61.52 ± 1.65 g/100g dw, 10.53 ± 0.18 g/100g dw, 16.48 ± 1.3 g/100g dw; 0.94 ± 0.03 %; and 2.45 ± 0.18 %, respectively (Table 1).

The highest and lowest concentrations of the essential amino acids showed for Methionine 1.57 ± 0.06 %, Threonine 2.34 ± 0.08 %, Tryptophan 0.56 ± 0.02 %, Arginine 3.37 ± 0.12 %, Histidine 1.32 ± 0.02 %, Isoleucine 2.35 ± 0.05 %, Leucine 4.27 ± 0.32 %, Lysine 4.34 ± 0.27 %, Valine 2.71 ± 0.09 %, Phenylalanine 2.22 ± 0.07 %, Glycine 5.12 ± 0.17 % dry weight (Table 2). Moreover, non-essential amino acids exhibited a range of concentrations in Persian sturgeon as follows: Serine 2.43 ± 0.05 %, Proline 3.11 ± 0.06 %, Alanine 3.85 ± 0.09 %, Cysteine 0.53 ±0.15 %, sparagine 5.08 ± 0.2 % and Glutamine 7.63 ± 0.16 % dry weight. (Table 3).

Discussion

The whole body composition of the fish is investigated to evaluate their survival in nature, determine their nutritional requirements, and measure the nutrients (Jobling, 1980; Hung *et al.,* 1987). The nature and quality of the nutrients in most animal carcasses, such as fish, depend on their diet and habitat (Adewoye and Omotosho, 1997). Considering the significant role of amino acids in protein synthesis, Phillips and Brockway (1956) showed that the nutritional value of proteins in the diet depended on their amino acid profile. Proteins and the amino acid composition of the fish are quite similar to those of terrestrial animals; however, fish muscles possess less structural fibers than the muscles of terrestrial animals (Hultin, 1985).

The proximate analysis of the fish body showed 24.38 ± 1.62 g/100g ww of dry matter, 61.52 ± 1.65 g/100g dw of crude protein, 10.53 ± 0.18 g/100g dw of lipid, 16.48 ± 1.3 g/100g dw of ash, 0.94 ± 0.03 % of NH_3, and 2.45 ± 0.18 % of phosphorus. The essential and non-essential amino acid composition provided the following values: Methionine: 1.57 ± 0.06 %, Threonine: 2.34 ± 0.08 %, Tryptophan: 0.56 ± 0.02 %, Arginine: 3.37 ± 0.12 %, Histidine: 1.32 ± 0.02 %, Isoleucine: 2.35 ± 0.05 %, Leucine: 4.27 ± 0.32 %, Lysine: 4.34 ± 0.27 %, Valine: 2.71 ± 0.09 %, Phenylalanine: 2.22 ± 0.07 %, Glycine: 5.12 ± 0.17 %, Serine: 2.43 ± 0.05%, Proline: 3.11 ± 0.06 %, Alanine: 3.85 ± 0.09 %, Cysteine: 0.53 ± 0.15 %, Asparagine: 5.08 ± 0.2 %, and Glutamine: 7.63 ± 0.16 % dry weight.

Fresh fish meat contains up to 80% water, while the average moisture content of fatty fish is about 70%, and the highest amount of moisture has been measured in *Harpadon nehereus* (about 90%). Moisture in breeding sturgeon (*Acipenser spp.*) ranges from 65.93% to 77.59% (Badiani *et al.*, 1996), while the moisture content in young breeding sturgeon (*Acipenser transmontanus*) has been reported between 72.1 and 79.4% (Hung *et al.,* 1987). Similar findings were reported by Song *et al.* (2014), who measured the moisture in the muscle (72.07%) and bone (78.4%) tissues of female Chinese sturgeons (*Acipenser sinensis*). The present study shows that the amount of dry matter in the Persian sturgeon varies from 21.49% to 29.54%.

The fat content of the fish depends on their species and catch season. It should be noted that fish meat contains less fat than red meat, and the fat content in the fish body varies from 0.2% to 25%. The higher the amount of fat, the lower the amount of water content expected in the fish body. These fish- based nutrients play vital roles in the prevention of human diseases (Simopoulos, 1997). By comparison with the published data for a wide range of fish species, lipid content is slightly more important as 100 g of sturgeon flesh can provide high levels of energy. Badiani *et al.* (1996) categorized the sturgeon species as a medium-fat fish since fat only accounts for 5-15 percent of the fish weight. The present study showed that the fat content of the Persian sturgeon was in the range of 9.06%-

13.04% dry weight. The results of the current study corroborate the findings of a great number of previous works in this field. For example, the fat content for inbreeding sturgeon species, including *Acipenser spp.* and *Acipenser transmontanus*, was reported about 2.66-15.31 and 3.4-7.4 g kg^{-1} of fresh fish, respectively (Badiani *et al*., 1996; Hung *et al.,* 1987). Moreover, the composition analysis of the Siberian sturgeon indicated 12.57% fat in the fish muscles (Pyz-Lukasik and Paszkiewicz, 2018).

In the present study, the Persian sturgeon showed an ash content of 15.70 to 17.38% in dry weight. In line with this finding, previous studies have reported ash contents of 0.80-0.21 and 4.5-2.5 g per 100 g wet weigh in white sturgeon (*Acipenser transmontanus*) (Hung *et al.,* 1987) and female Chines sturgeon (*Acipenser sinensis*) (Song *et al.,* 2014), respectively.

The protein content of the fish muscles usually ranges from 16 to 21 percent wet weight (Alam, 2007); however, values lower than 16% or higher than 28% have also been reported for some species (Pyz-łukasik and Paszkiewicz, 2018). The amino acid composition and digestibility of the fish protein range from about 85 to 95%. In addition to their high nutritional value, fish proteins have proper functional properties, such as water retention capacity, gel ability, emulsion, and tissue properties for products such as surimi. Among these properties, the water retention capacity and the gel ability are among the most important qualitative characteristics (Venugopal, 1995). According to the results of the current study, the amount of protein in the body of the Persian sturgeon was 57.63-84.02% of dry weight. Pyz-Lukasik and Paszkiewicz (2018) reported the protein content in Siberian sturgeon muscle as 15.69% by wet weight. With regard to the total protein content, the Persian sturgeon showed high levels, and this finding is close to the results reported for the breeding sturgeon (*Acipenser sp*p.; 17.60%- 17.01%) by Badiani *et al.* (1996). Many parameters, including species, body size, gender, food source, season, salinity, and temperature, can directly change the protein content and amino acid composition of the fish (Borresen, 1992).

Amino acid profiling of the Persian sturgeon demonstrated the highest percentage for glutamic acid (7.63 ± 0.16 %), followed by aspartic acid (5.08 ± 0.2 %), glycine (5.12 ± 0.17 %), and lysine (4.34 ± 0.27 %). Similar results have been reported by Iwasaki and Harada (1985), who measured the highest levels of aspartic acid, glutamic acid, and lysine in the fish muscles. A further supportive study reported the highest levels of glutamic acid, glycine, aspartic acid, and lysine in the whole body of sturgeon (Ng and Hung, 1994). Such amino acids can not only increase the resistance of the fish against diseases, but they can also lead to an increased rate of breeding, survival, and maturation during all life stages, including larvae, fingerlings, juvenile, and adults (Mohanty *et al*., 2014).

Moreover, the amino acid glycine plays a vital role in metabolic regulation, increasing antioxidant activity and protein synthesis, and enhancing immunity and the treatment of metabolic disorders (Wang *et al.*, 2013). The highest level of tryptophan has been detected in the Putitor mahseer (*Tor putitora*), while the Persian sturgeon showed 0.53-0.55% of the amino acid. Although the content of tryptophan is usually less than those of other amino acids, it is nutritionally essential as a precursor of vital metabolites, such as serotonin and nicotinamide. In aquaculture, extensive research has been performed to regulate and create a balance among different levels of tryptophan to support neuroendocrine and the immune system with a range of 0.3 to 1.3 % protein in the diet (Hoseini *et al*., 2019). This evidence is in line with our findings, showing 0.56 ± 0.02 % dry weight tryptophan in the Persian sturgeon amino acid profile. Moreover, in the Persian sturgeon, histidine exhibited a range of 1.23-1.40, and the highest level of this amino acid was observed in *Catla catla* (5.3 g per 100 g protein). Histidine performs a function in protein metabolism, growth, tissue repair, hemoglobin synthesis, and the removal of pollutants, such as heavy metals (Nasset and Gatewood, 1954; Liao *et al*., 2013). Evidence shows that histidine plays an integral role in tissue formation and repair, as well as the maintenance of osmoregulation and myelin sheaths, which are critical for migratory fish, including the Persian sturgeon (A. Khan, 2018). Threonine was detected in the range of 2.2% to 20.42% in the Persian sturgeon. This amino acid is the second limiting one in the maintenance after the sulfur-containing amino acids (Said and Hegste, 1970; Fuller *et al.,* 1989). This essential amino acid can improve the antioxidant and immune capacities of the fish, as reported by Habte-Tsion *et al.* (2016), who conducted an experiment to modulate the immune response, the antioxidant status, and gene expressions of antioxidant enzymes and antioxidant-immune-cytokine-related signaling molecules in juvenile blunt snout bream (*Megalobrama amblycephala*) (Habte-Tsion *et al.,* 2016). These findings can be very crucial in fish nutrition, particularly for the Persian sturgeon since it always faces various challenging conditions in both natural and artificial cultivating environments.

The nutritional value of a protein depends on its similarity to the available amino acid profiles. Although this concept cannot be extended for the amino acids used for metabolic needs, it is a reasonable starting point for defining the requirements of essential amino acids in the diet (Gurure *et al.,* 2007). Determination of the essential amino acid requirements can help the animal to be more resistant to stressful conditions and infectious diseases. Since the Persian sturgeon is a new cultivable species, this data can provide a more practical and comprehensive view of the fish nutrient requirements, which will help researchers and farmers manage the health of the wild juvenile sturgeon stocks and farmed sturgeons under aquaculture conditions more efficiently and sustainably. Our findings also provided a new vision to show the importance of the balance in the process of diet formulation for the fish, especially for essential amino acids, whose role in synthesis and metabolism cannot be neglected.

According to the results of this study, the total protein of the Persian sturgeon is in a remarkable range compared to other fish, while the amino acid profile showed a rich source of nourishing ingredients for humans. FAO has already reported numerous findings pertaining to the high rate of protein in sturgeon, especially those who live in the Caspian Sea. Therefore, such findings confirm the results of the present study as the Persian sturgeon contains a large group of both essential and non-essential amino acids.

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Conflicts of interest

The authors have no actual or potential conflicts of interest to report.

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