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Proximate Composition of Freshwater Mussels (*Unio Pictorum*, Linnaeus 1758) in Karasustream, Sinop

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A R T I C L E I N F O

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The effects of environmental factors and reproductive activities on proximate composition of freshwater mussels, *Unio pictorum*, was investigated from February 2013 to February 2014 in Sinop, Turkey. Environmental parameters including total particulate matter, inorganic matter and organic matter, chlorophyll-a and temperature were determined monthly during the experimental period. Mean protein, lipid, moisture and meat yield were 56.03±0.79%, 4.42±0.31%, 82.19±0.21% and 21.75±0.91%, respectively. The obtained data indicate that the proximate composition of mussels is highly correlated with environmental factors and reproduction cycle. In conclusion, freshwater mussel based protein should be evaluated an alternative source of protein for the feed industry.

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Introduction

Freshwater bivalves represent a wide range of distribution in the world. These mussels have a great value because of biological filtration activity for the freshwater ecosystem. They provide a trophic link between primary production and higher trophic species (Vaughn & Hakenkamp 2001). Also, these bivalves provide high-quality food with all the dietary essential amino acids, low-fat and high-protein (King et al. 1990). Whereas they are not preferred as a food item in European Countries, these species are traditionally used for human consumption only in some Asiatic countries (Chakraborty et al. 2008; Chandra et al. 2015). Even though freshwater molluscs are less preferred as food by a human, their high protein content has led to many studies on the utilization of a mussel meal in fish feed for aquaculture (Folkek et al. 2000; Gatlin et al. 2007) and in pet nutrition (Sicuro et al. 2010).

Proximate composition illustrates the nutritional quality of the body. Proximate properties of mussels often depend on phytoplankton availability in the environment and reproduction activities (Karayücel and Karayücel 1997; Okumus and Stirling 1998; Orban et al. 2002; Karayücel et al. 2003). Lipids are high caloric content when compared to other biochemical sources of mussels. Glycogen is the main source during reproductive activities when lipids are not available (Robledo et al. 1995). The largest proportion belongs to protein among other biochemical parameters, and it may be used as an alternative energy resource during gonadal development (Galap et al. 1997).

Turkey has large inland water bodies and large-sized freshwater mussels (Bivalvia: Unionidae Rafinesque 1820) are commonly found in freshwater resources of Turkey. The proximate composition (protein, lipid and moisture levels) and condition indices of the freshwater mussels related environmental factor and gonadal development were investigated.

Material and Method

The experiment was carried out at Karasu Stream (coordinate: N 41°57'20" E 35°01'12") from February 2013 to February 2014 in Sinop, Turkey. Karasu Stream extends to Erfelek district acting in south north direction, and it empties into the Black Sea from 8 km west of Sinop province. Freshwater mussels (*Union pictorum*) with an average length of 55.02 ± 0.16 mm, shell width of 27.36 ± 0.08 mm, shell height of 18.68 ± 0.67 mm and live weight of 20.58 ± 0.27 g were used in the study. The mussels were monthly collected with digger which was specially designed for catching mussels (Figure 1).

On each sampling date, total particulate matter (TPM), particulate inorganic matter (IM), particulate organic matter (OM), water temperature and chlorophyll-a (CH) were observed. Water samples were taken from the study site. Water temperature was measured *in situ* using a probe (YSI 6600, YSI Inc., Yellow Springs, OH, USA). In the laboratory, triplicate water samples (3 L) were filtered onto Whatman GF/C filters to determine TPM mgL^{-1}, IM mgL^{-1}, OM mgL^{-1} and CH μgL^{-1} (Stirling 1985).

Monthly sampling was performed and all sampled mussels were measured and counted during the study period. The wet meat index (CIV) was determined by measuring the volume of the shell cavity and the volume of meat. The dry weight condition index (CID) was determined after drying wet meat using the following equations (Austin et al. 1993):

$$\text{CID}=\frac{\text{Weight of dry tissue (g)}}{\text{Volume of shell cavity (ml)}}\times 100$$

Meat yield was estimated from the following formula:

$$\text{Meat yield (\%)}=\frac{\text{Wet meat weight (g)}}{\text{Total weight (g)}}\times 100$$

Triplicate dry meat samples were analysed for lipid (L), moisture (M) and protein (P) according to the AOAC (1990) methods.

A variance analysis (ANOVA) and correlation matrix were used to find the relationships between all measured parameters. Statistical analyses were carried out using MINITAB 19 software (Minitab Inc., State College, PA, USA).

Results and Discussion

In the present study, the temperature ranged from 6.57°C in December to 24.20°C in June with a mean of 14.10±1.70°C. CH was the highest value in March (1.43 μgL^{-1}) as a result of spring algal bloom and decreased to the lowest value in November (0.22 μgL^{-1}), with a mean of 0.56±0.09 μgL^{-1}. In general, CH concentration was lower in winter and higher in spring ($P<0.05$, Figure 2). TPM was between 2.60 mg L^{-1} (September) and 11.73 mgL^{-1} (May) with a mean of 6.63±0.86 mgL^{-1} while OM ranged from 1.33 mgL^{-1} in March to 6.63 mgL^{-1} in June with a mean of 2.78±0.38 mgL^{-1} and IM ranged from 0.93 mgL^{-1} in July to 9.20 mgL^{-1} in May with a mean of 3.53±0.28 mgL^{-1}. At the beginning of spring, increasing water flow rate in the stream increased TPM and IM rate in the water. In the following month, an increase was observed in the ratio of OM and Chl-a which is important nutrition for mussels. Many studies on the Karasu Stream showed that seasonal trends did not change much over the years (Coşkun et al. 2019; Gündoğdu et al. 2018; Aydemir Çil et al. 2016). Then, it can be argued that freshwater mussels live under relatively stable conditions resulted in a less stressful environment.

Figure 1. Specially designed digger

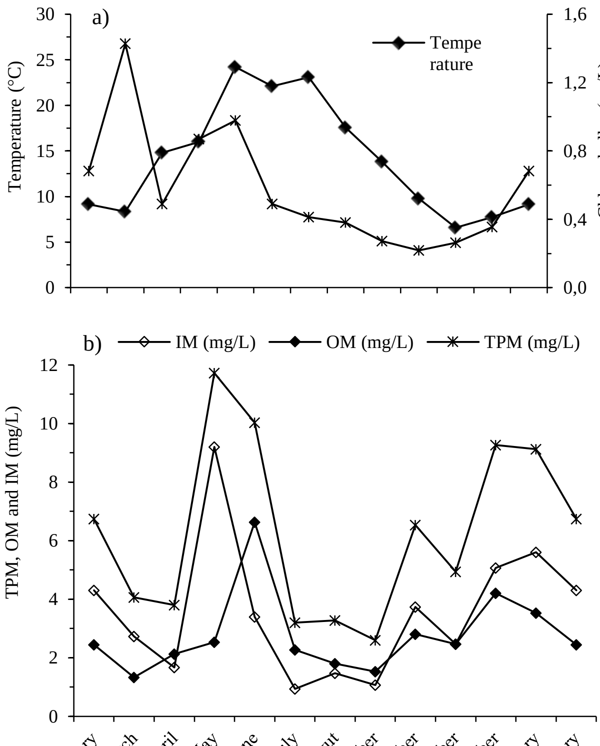

Figure 2. Monthly distribution of mean temperature, chlorophyll-a (CH), OM: organic matter, IM: inorganic matter, TSM: total suspended matter (c) from February 2013- February 2014

In the present study, CID, CIV and MY displayed similar patterns with peak values occurring in March. Wet meat volume condition index (CIV), dry meat weight condition index (CID), and meat yield (MY) varied between 25.73% (April) and 35.19% (March), 5.02% (July) and 7.99% (March), and 18.52 (July) and 29.87% (March), respectively (Figure 3) Mean CIV, CID, and MY were 28.32 ± 0.69%, 6.19 ± 0.20%, 21.74 ± 0.91%, respectively. The condition index and meat yield of *U.*

pictorum were found highest due to the mature gonads filled with eggs and sperm in March which could be named first reproduction season. In April, the gamete release might result in a rapid decrease in meat yield and condition indices. Mussels rapidly regained their condition with the increasing rate of OM and CH in May. In the following October, mussels might enter into a new reproduction period again, but no intense as compared to Spring months, which could be named second reproduction season of the same year (Figure 3). Parallel observations are reported in the literature that the maximum meat yield of mussels (*Parreysia corrugata*) was determined in the reproductive stage (Ramesha and Thippeswamy 2009). The high meat yield and condition index corresponds with gonadal development of *Lamellidens corrianus* in Vasind, India (Babar et al. 2017). Okumuş and Stirling (1998) reported that low meat yields and conditions were observed during the spawning period of mussels (*Mytilus edulis*) cultured in two Scottish sea lochs. The high meat yield and condition index corresponds with gonadal development of *Lamellidens corrianus* in Vasind, India (Babar et al 2017). Okumuş and Stirling (1998) reported that low meat yields and conditions was observed during the gamete release of mussels.

In our study, the monthly values of lipid, protein and moisture of the mussels varied from 2.79 (August) to 6.75% (March) with a mean of 4.42±0.31%, 52.13 (July) to 61.46 % (April) with a mean of 56.03±0.79 % and 80.42 % (March) to 83.19 % (December) with a mean of 82.19±0.21 % in dry weight-based, respectively (Figure 3). Lipid showed a similar pattern with protein content as a maximum in spring and minimum in summer (P≤0.01, Table 1). Ersoy and Şereflisan (2010) reported that the protein and lipid in wet weight-based of freshwater mussel were 11.87% and 2.55% in *Unio terminalis*, those values were 11.97% and 1.05% in *Potamida littoralis*, respectively. Shafakatullah and Krishnamoorth (2014) found, protein values were ranging between 34.4%-59.0% in *Parreysia corrugata*, 36.0%-56.0% in *Parreysia corrugata sub spp. nagpoorensis* and lipid values were ranging between 3.8%-7.2% in *P. corrugate* 2.0%-8.8% in *P.corrugata sub spp. Nagpoorensis.* When the present study was evaluated according to biochemical composition results, the lipid was the main reserve when gonads were full. When MY and condition indices sharply decreased in April, and that time lipid also decreased while protein increased. Many researchers declared similar results related to reduction in lipid during spawning (Dridi et al. 2007; Narvaez et al., 2008). Lipid is the principal source that used in gametogenesis and is reduced during spawning in mussels (Karayücel and Karayücel 1997). In the present study, the results indicated that lipid and protein were not used for the same purpose. The results supported the studies of Babar et al. (2017) and Shetty et al. (2013) which found that protein and lipid varied depending on the reproduction period.

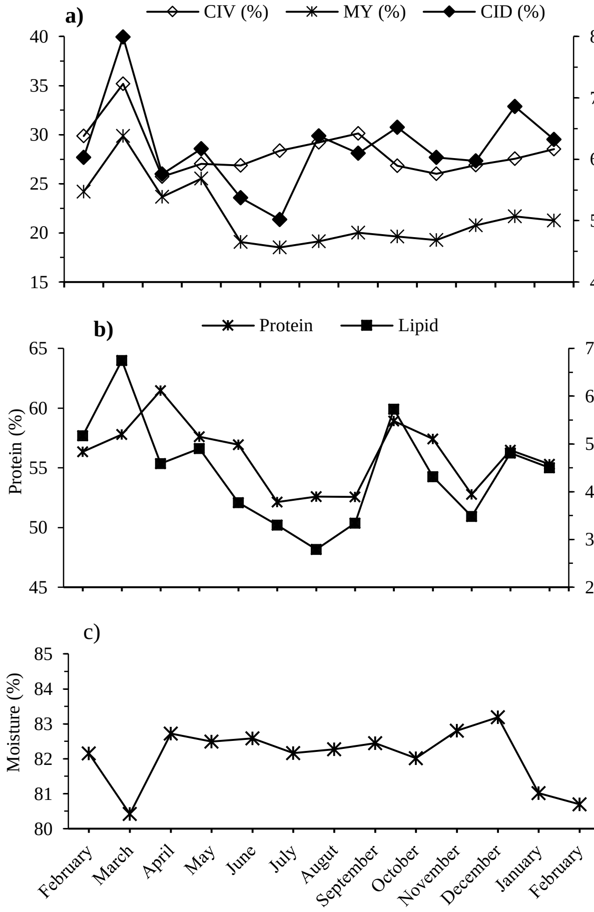

Figure 3. Monthly distribution of mean CIV: condition index volumetric, CID: condition index and MY: meat yield (a), protein and lipid (b) and moisture (c) from February 2013- February 2014

Table 1. Correlation matrix between CIV, CID, MY, P, L, M of freshwater mussels and environmental parameters

	CIV	CID	MY	P	L	M	IM	OM	TPM	CH
CID	0.656									
MY	0.593	0.664								
P	-0.209	0.241	0.453							
L	0.393	0.691**	0.756**	0.693**						
M	-0.348	-0.545*	-0.191	-0.041	-0.291					
IM	-0.214	0.178	0.355	0.230	0.330	0.003				
OM	-0.463	-0.393	-0.352	0.047	-0.211	0.177	0.275			
TPM	-0.380	-0.047	0.108	0.198	0.155	0.085	0.894	0.677		
CH	0.646	0.400	0.724**	0.249	0.515	-0.315	0.176	0.029	0.148	
T	-0.141	-0.539*	-0.454	-0.243	-0.558*	0.137	-0.371	0.178	-0.202	0.045

Significant levels: *P≤0.05; **P≤0.01; ***P≤0.001, CIV= condition index volume; CID= condition index dry; MY= meat yield; P=protein; L=lipid; IM= inorganic matter; OM=organic matter; TPM= total particulate matter; CH= chloprohyll-a; M=moisture

In conclusion, it is important to reach low-cost foods rich in good quality protein for not only human consumption but also for farmed animals and pet nutrition. Mussels have high protein content, which is comparable to the other food items of higher trophic levels. This situation reveals importance as a source of inexpensive animal protein. The present study suggested that freshwater mussel could be utilized for alternative protein source if mussel should be harvested during the non-reproduction period. Future studies need to be extended to be able to use freshwater mussels as an alternative protein source.

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