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

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**ABSTRACT**

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.

**Keywords:**
Freshwater mussels, proximate composition, *Unio pictorum*, Chemical, Turkey

**A R T I C L E  I N F O**

**Research Article**

Received: 09/05/2020
Accepted: 07/09/2020

**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 mg L⁻¹, IM mg L⁻¹, OM mg L⁻¹ and CH µg L⁻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):

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

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 µg L⁻¹) as a result of spring algal bloom and decreased to the lowest value in November (0.22 µg L⁻¹), with a mean of 0.56±0.09 µg L⁻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 mg L⁻¹ (May) with a mean of 6.63±0.86 mg L⁻¹ while OM ranged from 1.33 mg L⁻¹ in March to 6.63 mg L⁻¹ in June with a mean of 2.78±0.38 mg L⁻¹ and IM ranged from 0.93 mg L⁻¹ in July to 9.20 mg L⁻¹ in May with a mean of 3.53±0.28 mg L⁻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 CH-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 Çiğ 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](image1)

![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](image2)

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) lipids 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 Sereflisan (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](image)

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   |
|-------|------|------|------|------|------|------|------|------|------|------|
| CIV   |      | 0.656| 0.664| 0.241| 0.453|      |      |      |      |      |
| MY    | 0.593|      | 0.691**| 0.756**| 0.693**|      |      |      |      |      |
| P     | -0.209| 0.241|      | 0.453|      |      |      |      |      |      |
| L     | 0.393| 0.691**| 0.756**|      |      |      |      |      |      |      |
| 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≤0.01, ***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= chlorophyll-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.

References

AOAC 1990. Official Methods of Analysis of the Association of Official Analytical Chemists (W. Horwitz, ed.) 15th Ed., Assoc. of Official Analytical Chemists, Arlington, VA. ISBN 0-93558-467-6

Austin H, Haven DS, Moustafa MS, 1993. The relationship between trends in a condition index of the american oyster, *Crassostrea Virginica*, and environmental parameters in three Virginia Estuaries, Estuaries, 16(2): 362–374.

Aydemir Ç, Taşdemir A, Yardım Ö, Yıldız P, 2016. The Dipteran Larvae (Insecta) of Karasu Stream (Sinop, Turkey). Gazi Osmanpaşa Bilimsel Araştırma dergisi, 12: 01-08.

Babar AG, Jayawant MS, Pawar SP, 2017. Nutritional profile of the freshwater edible bivalve *Lamellidens corriatus* (Lea 1834) and its Relation to water quality in the Bhatsa River, India. Asian Fisheries Science, 30: 52–69.

Baker SM, Hornbach DJ, 2001. Seasonal metabolism and biochemical composition of two unionid mussels, *Actinonaias ligamentina* and *Amblema plicata*. Journal of Molluscan Studies, 67: 407–416.

Chakraborty S, Ray M, Ray S, 2008. Sodium arsenite induced alteration of hemocytic density of *Lamellidens marginalis* an edible mollusk from India. Clean, 36:195-203.

Chandra BM, Magare VN, Kulkarni CP, 2015. Biochemical Studies to investigate the nutritional content of the freshwater mussel *Parreysia corrugata*. International Journal of Pure & Applied Bioscience, 3(4): 265-270.

Çoşkun T, Qarajani A, Doğankaya L, 2019. Sinop Karasu Çayı Tatlısu Midyelerinin (Unio crassus, Philipsson, 1788) Bazı Biyomikr. Parâmetrelerinin Değerlendirilmesi. Journal of Anatolian Environmental and Animal Sciences. 4(2):174-181.

Díaz S, Rontani JS, Elcasi M, Durán A, 2007. Seasonal variation in weight and biochemical composition of the Pacific oyster, *Crassostrea gigas* in relation to the gametogenic cycle and environmental conditions of the Bizert lagoon, Tunisia. Aquaculture, 263: 238–248.Ersoy B, Sereflisan, H, 2010. The Proximate Composition and Fatty Acid Profiles of Edible Parts of Two Freshwater Mussels. Turkish Journal of Fisheries and Aquatic Sciences 10: 71-74.

Folke C, Lubchenco J, Mooney H, Troell M, 2000. Effect of aquaculture on world fish supplies. Nature, 405:1017.

Galap C, Lebouleguer F, Grillot JP, 1997. Seasonal variations in biochemical constituents during the reproductive cycle of female dog cockle *Glycymeris glyceris*. Marine Biology, 129: 625–634.

Gatlin DM, Barrows FT, Brown P, Dabrowski K, Gaylord TG, Hardy RW, Herman E, Hu G, Krogdahl A, Nelson R, Overturf K, Rust M, Sealey W, Skonberg D, Souza EJ, Stone D, Wilson R, Wurtele E, 2007. Expanding the utilization of sustainable plant products in aquafeeds: a review. Aquaculture Research, 38:551.

Greseth SL, Cope WG, Rada RG, Waller DL, Bartsch MR, 2003. Biochemical composition of three species of *Unio* mussels after emersion. Journal of Molluscan Studies, 69: 101-106.

Gündoğdu A, Gülepe E, Carlı U, 2018. Determination of Anionic Detergent Concentration of Karasu Stream in Sinop (Turkey). Turkish Journal of Agriculture Food Science and Technology, 6(1): 112-123.

Karayücel S, Karayücel I, 1997. Influence of environmental factors on condition index and biochemical composition in *Mytilus edulis* L. in cultivated raft system, in two Scottish Sea lochs. Turkish Journal of Marine Science, 3(3): 149–166.

Karayücel S, Kaya Y, Karayücel I, 2003. Effect of environmental factors on biochemical composition and condition index in the Mediterranean mussel (*Mytilus galloprovincialis* Lamarck, 1819) in the Sinop Region. Turkish Journal of Veterinary and Animal Science, 27: 1391–1396.

Lachowicz ŁS, 2005. Population biology of mussels (*Aulacomya maoriana*, *Mytilus galloprovincialis* and *Perna canaliculus*) from rocky intertidal shores in Wellington Harbour. PhD Dissertation. Victoria University of Wellington, New Zealand.

Magoulis DD, Lewis LC, 2002. Predation on exotic zebra mussels by native fishes: effects on predator and prey. Freshwater Biology, 47:1908.

Narvaez M, Freites L, Guevara M, Mendoza J, Guderley H, Lodeiros CJ, Salazar G, 2008. Food availability and reproduction affects lipid and fatty acid composition of the brown mussel, *Perna perna*, raised in sus pension culture. Comparative Biochemistry and Physiology, Part B 149: 293–302.

Orban E, Di Lena G, Nevigato T, Casini I, Marzetti A, Caproni R, 2002. Seasonal changes in meat content, condition index and chemical composition of mussels (*Mytilus galloprovincialis*) cultured in two different Italian sites. Food Chemistry, 77: 57–65.

Oktamas I, Stirling HP, 1998. Seasonal variations in the meat weight, condition index and biochemical composition of mussels (*Mytilus edulis* L.) in suspended culture in two Scottish Sea lochs. Aquaculture, 159: 261–294.

Panini E, Sicuro B, Daprá F, Forneris G, 2008. Preliminary considerations for freshwater mussel reproduction and possible application for extensive rearing in Italy. J. Conch. 59:124.

Ramesha MM, Thippeswamy S, 2009. Allometry and condition index in the freshwater bivalve *Parreysia corrugata* (Muller) from river Kemphoule, India. Asian Fisheries Science, 22: 203-214.

Robledo JAF, Santarem MM, Gonzalez P, Figueras A, 1995. Seasonal variations in the biochemical composition of the serum of *Mytilus galloprovincialis* Lmks. and its relationship to the reproductive cycle and parasitic load. Aquaculture, 133: 311–322.

Shafakatullah N, Krishnamoorth M, 2014. Nutritional Quality in Freshwater Mussels, *Parreysia spp.* of Periyar River, Kerala, India. Research Journal of Recent Sciences, 3:267-270.

Shetty S, Tharavathy NC, Lobo RO, Shafakatullah N, 2013. Seasonal changes in the biochemical composition of freshwater bivalves, *Parreysia spp.* from Tungabhadra River, Karnataka, International Journal of Pharma Sciences and Research, 4: 94–99.

Santhiyya N, Ramasamy M, Gayathri M, 2016. Seasonal changes in the biochemical composition of Freshwater bivalve *Parreysia corrugata* (Muller 1774) of lower Anicut Reservoir, Tamilnadu. International Journal of Scientific Engineering and Applied Science (IJEAS), 2(11): 85-99.

Sicuro B, Mioletti S, Abete C, Amedoe S, Panini E, Forneris G, 2010. Potential utilisation of farmed freshwater mussels (*Anodonta anatina* and *Unio mancerus*) in Italy. Cuban Journal of Agricultural Science, 44(4): 409-411.

Strohmeier T, Duinker A, Strand Ø, Aare J, 2008. Temporal and spatial variation in food availability and meat ratio in a longline mussel farm (*Mytilus edulis*). Aquaculture 276: 83–90.

Stirling HP, 1985. Chemical and biological methods of water analyses for aquaculturists, Stirling, Scotland: University of Stirling, Institute of Aquaculture. ISBN 0-90163-662-2.

Vaughn CC, Hakenkamp CC, 2001. The functional role of burrowing bivalves in freshwater ecosystems. Freshwater Biology, 46:1431–1446.