Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(1):1211 – 1219 (2024)
www.ejabf.journals.ekb.eg

Biochemical Composition and Meat Yield of Three Commercial Bivalves Harvested from Lake Timsah, Suez Canal, Egypt

Mahmoud Sami*, Saad Z. Mohammad, Deyaaedin A. Mohammad
Department of Marine Science , Faculty of Science, Suez Canal University, Egypt
***Corresponding Author:** Mahmoud_Sami@science.suez.edu.eg

ARTICLE INFO

Article History:
Received: Dec. 29, 2023
Accepted: Jan.17, 2024
Online: Feb. 4, 2024

Keywords:
Bivalve,
Meat yield,
Protein,
Organoleptic qualities,
Suez Canal

ABSTRACT

Clams are one of the important varieties of shellfish and perhaps the most versatile seafood in the world. This study aimed to compare the meat yields and biochemical composition of some commercial bivalves harvested from Lake Timsah. Specimens were purchased from clam collectors working at Lake Timsah in January 2015. The nutritional composition of clams was analyzed at the Regional Center for Food and Agriculture (RCFA) and Agriculture Research Center (ARC), Giza, Egypt. This study revealed that the highest meat yield was recorded in *Ruditapes decussatus* compared to other species (*Paphia undulata* and *Venerupis pullastra*). The highest protein was recorded in *Paphia undulata*, while the highest lipid was detected in *Venerupis pullastra*.

INTRODUCTION

Clams are one of the important varieties of shellfish and perhaps the most versatile seafood in the world. These edible bivalves are filter feeders; thereby have high conversion efficiency and consequently high levels of biochemical constituents. Clams are high in protein, and the nutritive value of several species of clams has been estimated **(Dincer, 2006; Moschino *et al*., 2023)**. Shellfish meat, particularly clam meat, have been recommended in several dietary regimes for their high protein content, low calorific values, low fat/ cholesterol profile and lower proportions of saturated fat, as well as the presence of good lipids, significant amounts of omega- 3-fatty acids, dietary essential amino acids, vitamin B12 and several important minerals (as iron, zinc and copper) **(Krzynowek *et al*., 1989; Dong, 2001)**. Various factors affecting the proximate composition in shellfish, such as fecundity **(Durve, 1964; Litaay & Sena, 2003)**, spawning season **(Durve, 1964; Moschino *et al*., 2023)**, depth of culture area **(Ngo *et al*., 2006)** have been investigated **(Qasim *et al*., 1977; Nagabhushanam & Mane, 1978; Rivonker & Parulekar, 1995)**.

Lake Timsah is the main water body of the commercial production of clam species in Egypt. This lake is one of three lakes that are connected to the Suez Canal in Egypt. The lake bottom is mainly muddy or sandy, and it forms the habitat of a wide range of ecological and economical important taxa such as the clams of family Veneridae **(Gabr & Gab-Alla, 2008)**. Among these clams are *Ruditapes decussatus* (Linnaeus, 1758), *Venerupis pullastra* (Montagu, 1803) and *Paphia undulata* (Born, 1778) that have been collected intensively on a commercial scale. **Yassien *et al*. (2009)** documented the fisheries statistics in the region and mentioned that *R. decussatus* makes up about 25% of the clam fisheries in Lake Timash. The authors also showed that there was an increase in the total clam catch from 499t in 1999 to 2088t in 2006, and then declined in 2008 to 1793t. According to GAFRD statistics, the fisheries of gastropods and bivalves in the Suez Canal and its lakes declined from 1669t in 2003 to 836t in 2012, with a maximum value recorded in 2006. *R. decussatus* is attaining the highest marketable price overall clam species in Egypt during all seasons with high demands.

The objective of the current study was to compare the nutritive values among the commercial clam species in the Suez Canal (particularly, Lake Timsah, Ismailia) that is considered the main area for the collection of these clams. These comparisons include the meat yields and the nutritional characteristics.

MATERIALS AND METHODS

Morphometric measurement and meat yield determination

Some commercial clam species *(Ruditapes decussatus*, *Venerupis pullastra* and *Paphia undulata* were found in the Suez Canal, Ismalia (Plate 1). Freshly caught clams were selected in the present study and purchased from the local market at Abo Adam village (Ismailia City) during January 2015. Collected clams were brought to the laboratory, cleaned to remove the adhered sediments and kept in seawater. In experimental analysis, a total of 50 individuals of different sizes from each clam species were used for estimating meat yield and its nutritional composition. Total body weight (TBW) and soft body weight (SBW) were recorded to the nearest 0.1g, while the shell length (SL) was measured by a digital Vernier caliper, with an accuracy of 0.01mm. The extracted meat was stored at 4°C until further analyses. Each clam individuals were dissected out to remove the meat from shell and partially dried by paper and weighed on an electronic digital balance (Sartorius, BL310).

Meat yield was determined by the standard method. The statistical formula for the meat yield was as follows:

Meat yield (%)= soft body weight (g)/total body weight (g) * 100

Plate 1. The commercial species in the Suez Canal showing: **(A)** *R. decussatus*, **(B)** *P. undulata*, and (C) *V. pullastra*

Nutritional composition of meat

Meat (flesh) from each individual was analyzed for the proximate composition using the guidelines of **AOAC (1990)**. The analysis was carried out at the Regional Center for Food and Agriculture (RCFA) and Agriculture Research Center (ARC), Giza, Egypt. Moisture content was determined by drying the meat in an oven at 85°C until a constant weight was reached. Moisture, crude protein and lipid were estimated according to the **AOAC (1990)** procedure. The results are presented as mean ± SD.

Random sample of intact individuals of the three clam species were obtained for testing the organoleptic qualities. Each clam species was separately cooked in boiling water. An evaluation of organoleptic qualities of clam's meat was performed by the aid of ten panelistis according to **Klein and Bardy (1984)**. The fresher, firmer, juicier and more acceptable meat was ranked higher in score. The score was divided into 10 points as follows: 9- 8 very good, 7- 6 good, 5- 4 fair, and 3- 1 poor.

Statistical analysis

All the results of meat yield and the proximate analysis were applied to test the significant difference between clam species in terms of meat yields and nutritional compositions by using one-way ANOVA. Pearson correlation among shell length, total body weight and soft body weight for each clam species was estimated, all of these statistical studies were studied at the 0.05 level of significance using the SPSS software version 22.

RESULTS

1. Morphometric measurement and meat yield determination

The shell length, total body weight, soft body weight and meat yield of the studied clams are given in Table (1). *R. decussatus* and *P. undulata* attained high values of these parameters than those found for *V. pullastra.* The shell length, the total body weight and the soft body weight were recorded for *R. decussatus* (ranged between 15.5- 39.8mm, 0.56- 8.4 and 0.26- 3.22g, respectively). The correlation relationship between shell length (SL), total body weight (TBW) and soft body weight (SBW) in all clam species were studied and are displayed in Table (2). High positive significant correlations were estimated for all species. Meat yield of the studied clam species varied significantly (F-ratio= 27.67, $P < 0.001$, Table 3). The highest meat yield percentage was determined for *R. decussatus* (42.1%± 5.1), while the other clams species recorded lower values of meat yield (Table 1).

Table 1: Meat yield and other measurements of the studied clam species

Clam species	Meat Yield (%)	Shell length (mm)		Total weight (g)		Soft body weight (g)	
		Min.	Max.	Min.	Max.	Min.	Max.
V. pullastra	36.1±5.1	8.4	28.4	0.48	2.39	0.12	0.83
R. decussatus	42.1±5.1	15.5	39.8	0.56	8.47	0.26	3.22
P. undulata	36.5±3	22.7	38	1.07	5.31	0.44	1.88

Table 2: Pearson correlation coefficient among SL, TBW and SBW and its significance value for each studied clam species.

Clam species	SL vs TBW	TBW vs SBW	SL vs SBW
V. pullastra	0.858, 0.001*	0.936, 0.001*	0.812, 0.001*
R. decussatus	0.93, 0.001*	0.985, 0.001*	0.92, 0.001*
P. undulate	0.943, 0.001*	0.975, 0.001*	0.905, 0.001*

Significance level: * P<0.05

2. Nutritional composition of meat

The percentages of crude protein, lipid and moisture of the soft tissues of the three clam species are presented in Table (4). The crude protein percentages and lipid percentages were varied significantly among species except the moisture percentage values (Tables 3, 4). The soft body tissues of *R. decussatus* was attained the least values for both crude protein and the lipid percentage values. In regard to the moisture contents in the studied clams, slight differences were found among species and ranged between 78.78% in *P. undulata*, and 79.20% in *V. pullastra* (Table 4).

Table 3: One way ANOVA between the studied clam species in terms of their meat yield %, Crude protein %, lipids and moisture %

Parameter	F ratio	*P* value
Meat yield %	27.67	0.000**
Crude Protein %	218.259	0.000**
lipid%	4401	0.000**
Moisture %	**944.354**	**0.6 NS**

Significance level:** = *P*<0.01 & NS= non-significant.

Table 4: Averages of crude protein %, lipids % and moisture % in samples

Clam species	Crude Protein %	lipids %	Moisture %
V. pullastra	9.49	1.21	79.20
R. decussatus	9.30	0.45	79.74
P. undulate	11.10	0.95	78.78

Table (5) illustrates the organoleptic qualities for the studied clam species after cooking. The results of the test showed that *R. decussatus* was the highest in organoleptic qualities in comparisons with the other two species, which had lower status. The analysis of variance (one way ANOVA) revealed significant differences between all organoleptic quality parameters of the studied clam species (Table 6). However, the organoleptic qualities of *V. pullastra* and *P. undulata* attained similar values.

Table 5: Organoleptic qualities of the studied clam species

Organoleptic quality /Clam species	*V. pullastra*	*R. decussatus*	*P. undulata*
Aroma (10)	7.5±1	8.8±1.2	7.4±1.3
Texture (10)	7.2±1.2	9±1.3	7.2±1.5
Taste (10)	7±1	9±1.1	6.2±1
Acceptability (10)	7.1±1.1	9.2±1.2	6.5±1.1
Total acceptability (40)	28.8±4.5	36±4.9	27.3±4.8

Table 6: One way ANOVA between the studied clam species in terms of their organoleptic qualities

Source of variation	Sum of Squares	df	Mean Square	F ratio	P value
Aroma	3.500	2	1.750	7.000	0.027*
Texture	8.000	2	4.000	12.000	0.007**
Taste	10.409	2	5.204	40.034	0.008**
Acceptability	10.692	2	5.348	45.838	0.000**
Total acceptability	278.020	2	139.000	69.5000	0.000**

Significance level: * = $P < 0.05$, ** = $P < 0.01$

DISCUSSION

The studied clams constitute the main bivalve fisheries in the Suez Canal area. *R. decussatus* and *V. pullastra* have high popularity among consumers in the Suez Canal regions than *P. undulata*. The popularity of the latter species started in the last decade due to the decline of fisheries for the former clam species. The present study analyzed the meat yield and nutritional composition of the common clam species in the Suez Canal region, showing the major characters of these species that might give a good feature for the consumers and to determine the basis, on which the consumers are building their superiority in choosing among these clams and which species should be taken a lot of attention in terms of seed production and farming.

In bivalve, meat yield depends on species, reproducive season, feeding regime and environment like other invertebrates. Meat yield of the studied clams showed variations among species. In this section, the meat yield of clam species were determined during the same month (January) and ranged between 36.1 and 42.1%. These values are within the range recorded in previous studies, where the meat yield in the clam species ranged between 27 and 46% throughout the year **(Lagade *et al.*, 2014)**. **Lagade *et al.* (2014)** found that the meat yield in three estuarine clam species ranged between 34 and 43% in January; these findings are in accordance with the results of the studied clam species in the present study. Many authors found that the variation in the meat yield of bivalve were influenced apparently by the maturation stages and the spawning period of these organisms **(Lagade *et al*., 2014; Berik *et al*., 2017)**.

According to literature, the percent edibility (or meat yield) among bivalves varied seasonally and geographically, depending on food availability and the timing of the gametogenic cycle **(Okumus & Stirling, 1998; Orban *et al*., 2002, 2007; Del gado *et al*., 2004; Ojea *et al*., 2004)**. **Mohite *et al*. (2009)** noted a decrease in the edibility during the spawning period **(Gozler & Tarkan, 2000)**, while the percentage edibility enhances as gametogenesis advances **(Anibal *et al*., 2011)**. Bivalves discharge their gonads into their mantle cavities and then out to the surrounding water during their spawning activity, resulting in a considerable loss of meat weight **(Okumus & Stirling, 1998; Yildiz *et al*., 2011)**. Hence, the percentage of meat yield has an important role concerned with the cultivation and harvesting strategy **(Okumus & Stirling, 1998)**.

Organic elements or substances, viz. proteins, lipids and glycogen are the basic building blocks of living organisms **(Yildiz *et al*., 2011)**, determining their nutritional value **(Orban *et al*., 2007)**. The biochemical composition, percentage edibility and condition index of bivalve and clams are significantly affected by both internal and external factors **(Orban *et al*., 2002, 2007; Delgado *et al*., 2004; Ojea *et al*., 2004; Zrncic *et al*., 2007; Gullian & Aguirre-Macedo, 2009; Moschino *et al*., 2023)**.

With respect to the biochemical composition of the edible parts of the clam species, protein contents usually attained the highest percentages with ranges between 9.3 and 11.1% (based on the wet weight tissue of the studied clams) among the clam species in the present study. These values coincide with those of **Lagade *et al*. (2015**) who found that the protein contents in some estuarine clams ranged between 6 and 16%, corresponding to the edible organ in these species and seasons.

Regarding lipid content in the soft tissues of the studied clam species, low contents percentages of lipid were determined and ranged between 0.45 and 1.21% in January; these findings are in line with the results of **Lagade *et al*. (2015)**. These authors found that the lipid contents in clams were the least contents and declined in winter seasons (ranged between 0.7 and 2%). **Martinez (1991)** reported that the variation of lipid content is principally related to gamete development. From the result of this survey, it seems clear that the highest level of lipid in clams occurs when the gonads are mature. Lipids also play a vital role in the energy metabolism, after protein **(Camacho *et al*., 2003)**. In mature bivalves, lipids are stored mainly in gonads and constitute the major element of reproduction **(Gabbott, 1975)**. According to **Wolowicz *et al*. (2006)**, the protein and lipid content in the mytilid *Mytilus trossulus* increased during gametogenesis and declined after spawning. **Anibal *et al*. (2011)** stated that lipids are more influenced by the seasonal reproductive cycle due to their relationship with gonad maturation. According to these findings, variations in the percentage of lipid contents among the three studied clams might be due to the variation in gonad maturation and spawning period for each species.

Finally, the organoleptic quality analyses revealed that the *R. decussatus* attained higher values than the other clams in terms of aroma, texture, taste, acceptability and total acceptability. This can explain the higher popularity of this species for consumers, particularly in the Suez Canal region, which encourages researches to pay more attention in terms of aquaculture practices for this clam species.

REFERENCES

Anibal, J.; Esteves, E. and Rocha, C. (2011). Seasonal variations in gross biochemical composition, percent edibility and condition index of the clam *Ruditapes decussatus* cultivated in the Ria Formosa (South Portugal). J. Shellfish Res., 30: 17-23.

AOAC (1990). Official methods of analysis of the Association of Official Analytical chemists. Association of the official Analytical Chemists, Arlington.

Berik, N.; Cankiriligil, E and Gul, G. (2017). Meat yield and shell dimension of smooth scallop (*Flexopecten glaber*) caught from Cardak lagoon in Canakkale, Turkey. J. Aquac. mar. biol., 5(3): 82-85.

Camacho, A.P.; Delgado, M.; Fernández-Reiriz, M.J. and Labarta, U. (2003). Energy balance, gonad development and biochemical composition in the clam *Ruditapes decussatus*. Mar. ecol. Prog. Ser., 258: 133-145.

Delgado, M.; Camacho, A.P.; Labarta, U. and Fernandez-Reiriz, M.J. (2004). The role of lipids in the gonadal development of the clam *Ruditapes decussatus* (L.). Aquac., 241: 395 - 411.

Dincer, T. (2006**).** Differences of Turkish clam (*Ruditapes decussates*) and Manila clam (*R. philippinarum*) according to their proximate composition and heavy metal contents. J. Shellfish Res., 25 (2): 455-459.

Dong, M. F. (2001). The nutritional value of shellfish. www.wsg.washington.edu., p. 1-8.

Durve, V.S. (1964). Preliminary observation on the seasonal gonadal changes and spawning in the clam *Meretrix casta* (Chemnitz) from the marine fish farm. J. Mar. Biol. Ass. India, 6(2): 241- 248.

Gabbott, P.A. (1975). Storage cycles in marine bivalve molluscs: an hypothesis concerning the relation between glycogen and gametogenesis. In: Barnes, H. (Ed.), Proceedings of the Ninth Eur. Mar. Biol. Symp., Aberdeen Univ. Press, Aberdeen, Scotland, pp. 191– 211.

Gabr, H. and Gab-Alla, A. (2008). Effect of transplantation on heavy metal concentrations in commercial clams of Lake Timsah, Suez Canal, Egypt. Oceanol. 50: 83-93.

Gözler, A.M. and Tarkan, A.N. (2000). Reproductive biology of *Ruditapes decussates* (Linnaeus, 1758) in Çardak Lagoon, Dardanelles Strait. Turk. J. Mar. Sci., 6(2): 175-198.

Gullian, M. and Aguirre-Macedo, L. (2009). Seasonal variation of physiological parameters in the eastern oyster *Crassostrea virginica* from a tropical region of the Gulf of Mexico. J. Shellfish Res., 28: 439 - 446.

Klein, B.P. and Bardy, P.L. (1984). Experimental Foods. Department of Food Nutrition, University of Illinois, USA.

Krzynowek, J.; D'entremont, D. and Murphy, J. (1989). Proximate composition and fatty acid and cholesterol content of squid *Loligo pealei* and *Illex illecebrosus*. J. Food Sci., 54(1): 45-48.

Lagade, V.; Taware, S. and Muley, D. (2014). Seasonal variations in meat yield and body indices of three estuarine clam species (Bivalvia: Veneridae). Indian. J. Mar. Sci., 43(8): 1586-1893.

Lagade, V.; Taware, S. and Muley, D. (2015). Seasonal variation in the biochemical constituents, percentage edibility and condition index of estuarine clam, *Soletellina diphos* (Linnaeus, 1771) (Mollusca: Bivalvia: Veneroida: Psammobiidae). Int. J. Zool. Res., 11 (4): 127-139.

Litaay, M. and Sena De Silva, S. (2003). Spawning season, fecundity and proximate composition of the gonads of wild-caught blacklip abalone (Haliotis rubra) from Port Fairy waters, south-eastern Australia. Aquat. Living, Resour., 16: 53–361.

Martínez, G. (1991). Seasonal variation in biochemical composition of three size classes of the Chilean scallop *Argopecten purpuratus* Lamar, 1819. The Veliger 34: 335-343.

Mohite, S.A.; Mohite, A.S. and Singh, H., (2009). On condition index and percentage edibility of the short neck clam *Paphia malabarica* (Chemnitz) from estuarine regions of Ratnagiri, west coast of India. Aquac. Res., 40: 69-73.

Moschino, V.; Rizzo, G.; Marĉeta, T.; Cernigai, F.; Masiero, L.; Da Ros, L. and Marin, M.G. (2023). Biochemical composition and reproductive cycle of the clam *Chamelea gallina* in the Northern Adriatic Sea: an after-10-year comparison of patterns and changes. Front. Mar. Sci., 10: 1158327

Nagabhushanam, R. and Mane, U.H. (1978). Seasonal variations in the biochemical composition of *Mytilus viridis* at Ratnagiri, on west coast of of India. Hydrobiol., 57: 69-72.

Ngo, T. ; Sang-Gyun, K.; Do-Hyung, K.; Patrick, S. and Kwang-Sik, C. (2006). Effect of culture depth on the proximate composition and reproduction of the Pacific oyster, *Crassostrea gigas* from Gosung Bay, Korea. Aquac., 253: 712-720.

Ojea, J.; Pazos, A.J.; Martínez, D.; Novoa, S.; Sánchez J.L. and Abad M. (2004). Seasonal variation in weight and biochemical composition of the tissues of *Ruditapes decussatus* in relation to the gametogenic cycle. Aquac. 238: 451-468.

Okumuş, İ. and Stirling, H.P. (1998). Seasonal variations in the weight, condition index and biochemical composition of mussel (*Mytilus edulis*, L.) in suspended culture in two Scottish sea lochs. Aquac. 159 (3 - 4): 249–261.

Orban, E.; Lena, G.D.; Nevigato, T.; Casini, I.; Caproni, R.; Santaroni, G. and Giulini, G. (2007). Nutritional and commercial quality of the striped venus clam, *Chamelea gallina*, from the Adriatic sea. Food Chem., 101: 1063-1070.

Orban, E.; Lena, G.D.; Nevigato, T.; Casini, I.; Marzetti, A. and Caproni, A. (2002). Seasonal changes in meat continent and chemical composition of mussels (*Mytilus galloprovincialis*) cultures in two different Italian sites. Food Chem., 77: 57-65.

Qasim, S.Z.; Parulekar, A.H.; Harikantra, S.N.; Ansari, Z.A. and Nair, A. (1977). Aquaculture of green mussel Mytilus viridis L. cultivation on ropes from floating rafts. Ind. J. Mar. Sci., 6: 18-25.

Rivonker, C.U. and Parulekar, A.H. (1995). Proximate biochemical composition and calorific potential in the raft grown green mussel *Perna viridis*. J. Mar. Biol. Ass. India, 37(1 - 2): 231-236.

Wolowicz, M.; Sokołowski, A.; Bawazir, A.S. and Lasota, R. (2006). Effect of eutrophication on the distribution and ecophysiology of the mussel *Mytilus trossulus* (Bivalvia) in Southern Baltic Sea (the Gulf of Gdansk). J. oceanol. Limnol., 51: 580-590.

Yassien, M.H.; El-Ganainy, A.A. and Sallam, W.S. (2009). Age, growth and mortality rates of the venerid clam *Venerupis aurea* in Timsah Lake, Suez Canal, Egypt. Egypt. J. Aquat. Res. 35: 317-324.

Yildiz, H.; Berber, S.; Acarli, S. and Vural, P. (2011). Seasonal variation in the condition index, meat yield and biochemical composition of the flat oyster *Ostrea edulis* (Linnaeus, 1758) from the Dardanelles, Turk. J. Anim. Sci., 10: 22-26.

Zrncic, S.; Oraic, D.; Mihaljevic, Z. and Zanella, D. (2007). Impact of varying cultivation depths on growth rate and survival of the European flat oyster *Ostrea edulis*, L. Aquac. Res., 38: 1305-1310.