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# PROXIMATE BIOCHEMICAL COMPOSITION AND CALORIC POTENTIAL IN THE RAFT-GROWN GREEN MUSSEL *PERNA VIRIDIS*

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ABSTRACT

The biochemical components of the mussel tissue, cultured on the raft were estimated. The range of variation in the content of moisture, protein, carbohydrates, lipid, organic carbon and ash were 66.8 - 90.1; 46.2 – 67.4; 11.7 – 18.6; 2.9 – 7.4; 19.5 - 34.2 and 3.1 - 21.2 % respectively. Major biochemical constituents were found to be influenced by phytoplankton abundance and were also found to vary with maturation and spawning cycle. The caloric potential in the raft-grown mussel varied from 3.33 to 4.9 K cal. $g^{-1}$. The maximum value of total energy was found to coincide with higher values of protein, indicating significant contribution by protein to the total energy. The relationship between biochemical constituents and spawning cycle is discussed.

## INTRODUCTION

EDIBLE BIVALVES especially mussels being filter feeders exhibit high conversion efficiency and consequently have high food value and elevated contents of the major biochemical constituents of body tissue in terms of quality and quantity. Earlier studies (Qasim *et al.* 1977; Parulekar *et al.* 1982) suggest that seasonal variation in biochemical composition follow different pattern depending on geographical areas, which are strongly influenced by temperature and productivity. These variations in biochemical constituents do exist with the progression of maturity (Nagabhushanam and Mane, 1978). The information on biochemical composition is essential as it reflects directly on the nutritive value, thereby enabling to suggest an ideal time to implant and subsequent harvest of the crop.

The present paper deals with results of an investigation on the proximate biochemical composition of the raft-grown green mussel *Perna viridis* L. Attempts are also made to study the growth variation in relation to reproductive cycle and the impact of environmental parameters on the biochemical constituents of the body tissue.

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## MATERIAL AND METHODS

Mussel samples were collected for a period of one year from October 1987 to September 1988 at fortnightly interval from an experimental raft floating in Dona Paula Bay, Goa 15° 27′N-73° 48′E). The mussel tissue was removed and weighed after removing the excess moisture. Later, wet biomass was dried (Borrero and Hilbish, 1988) in an oven at 80°C until the

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difference between two successive weighings remained near 0.1 mg. The dried mussel tissue samples were powdered in mortar and pestle and used for the analysis of biochemical constituents *viz.* protein, carbohydrate, lipid, total organic carbon and ash.

Protein was estimated following the method described by Herbert *et al.* (1971) using a mixed Carbonate - Tartarate - Copper solution and Folins Ciocalteau reagent. Carbohydrate analysis were conducted by using Phenol – Sulfuric acid method (Hitchcock, 1977). Estimation of lipid content was done by following the standard method (Parsons *et al.* 1984). Total organic carbon in the dried mussel tissue was determined by wet oxidation method (Parsons *et al.* 1984). All the estimated values are expressed as percentages. However, after taking the averages of two fortnightly values, monthly values are presented.

The caloric potential was computed using the conversion factors 5.7, 4.0 and 9.3 K cal.$g^{-1}$ for protein, carbohydrate and lipid respectively.

## Results and Discussion

The variation in major biochemical constituents are depicted in Fig. 1.

*Moisture :* Moisture content in the present study varied from 66.0 to 90.1%. The maximum and minimum moisture content were observed in July and March respectively. Nagabhushanam and Mane (1978) reported variation in the water content in the range of 79.33 to 81.17 % with lower value coinciding with summer and higher value with monsoon. For the high percentage of moisture recorded in monsoon, the possible

TABLE 1. *Regression coefficient of various biochemical parameters showing the relationship along with correlation coefficient value (r) and level of significance*

| Relationship | a | ± | SE | b | ± | SE | r |
|---|---|---|---|---|---|---|---|
| Lipid/Protein | 13.86 | ± | 1.30 | -0.002 | ± | 0.12 | - 0.006 |
| Carbohydrate/Protein | 3.62 | ± | 0.83 | 0.024 | ± | 0.08 | 0.136 |
| Organic carbon/Protein | 42.45 | ± | 3.43 | - 0.294 | ± | 0.33 | - 0.375 |
| Water/Protein | 117.82 | ± | 3.94 | - 0.713 | ± | 0.38 | - 0.646* |
| Energy content/Protein | 0.89 | ± | 0.12 | 0.059 | ± | 0.01 | 0.924* |
| Carbohydrate/Lipid | 0.65 | ± | 1.06 | 0.321 | ± | 0.25 | 0.496+ |
| Organic carbon/Lipid | 32.03 | ± | 5.32 | - 0.511 | ± | 1.27 | - 0.183 |
| Water/Lipid | 83.19 | ± | 7.47 | - 0.336 | ± | 1.79 | - 0.135 |
| Energy content/Lipid | 3.46 | ± | 0.42 | 0.068 | ± | 1.01 | 0.292 |
| Organic carbon/Carbohydrate | 34.59 | ± | 4.65 | - 1.906 | ± | 1.82 | - 0.434** |
| Water/Carbohydrate | 87.19 | ± | 6.71 | - 2.255 | ± | 2.61 | - 0.365 |
| Energy content/Carbohydrate | 3.53 | ± | 0.37 | 0.172 | ± | 1.44 | 0.473* |
| Water/Organic carbon | 64.97 | ± | 4.50 | 0.434 | ± | 0.60 | 0.311 |
| Energy content/Organic carbon | 5.37 | ± | 0.24 | 0.039 | ± | 0.03 | - 0.484+ |
| Energy content/Water | 7.48 | ± | 0.22 | - 0.441 | ± | 0.02 | - 0.700* |

* Significant at 1%; + Significant at 5%; ** Significant at 10%

cause may be that salts in the mussel tissue might have been replaced by the moisture content as reported earlier (Galtsoff, 1964). Parulekar *et al.* (1982) also reported similar type of relationship between salinity and water content in the raft-grown green mussel and stated that these mussels develop an iso-osmotic internal medium to compensate for considerable lowering of salinity during monsoon season. Furthermore, it was reported that this compensation is achieved by dilution of body fluids, resulting in higher water content in tissues. Regression analysis (Table 1) indicate that water content showed negative correlation with protein and energy content, whereas with other parameters the correlation was not significant.

*Proteins :* Protein content was observed to be generally high except in the second half of the monsoon season, just prior to the termination of the experiment. Higher values of protein were mainly because of increased food availability and secondly it happened to be just prior to the spawning period. Further, this increased protein content may be a mechanism of storage of reserves to meet spawning requirements (Nagabhushanam and Mane, 1978; Wafer *et al.* 1976). Another possible reason for elevated protein content could be the increased feeding efficiency associated with food availability thereby resulting in proper assimilation of food and better metabolic conditions at that time (Qasim *et al.* 1977). Initially protein values were low, with a marked increase in November and followed by gradual increase during postmonsoon upto January. During premonsoon season, the protein values were higher and ratio of increase in protein content was correspondingly high during the early part of premonsoon season especially in February and March (62.07 to 68.58%) and further remained high till May. An increase in protein content during the premonsoon season was observed to coincide with maturation of gonads. Similar observations have been reported earlier (Nagabhushanam and Mane, 1978; Wafer *et al.* 1976). Wherein, it was inferred that increased protein content during pre-spawning season could be a mechanism of storage of reserves to meet spawning requirements.

In monsoon *i.e.* from June onwards, a decreasing trend of protein content was observed registering its lowest values in September (45.76%) which coincided with the end of monsoon and beginning of postmonsoon season. Low protein values in mussels from natural beds, especially during post-spawning season have earlier been reported (Gabbot and Bayne, 1973). However, we observed higher value (53.25%) which indicates that much of the energy contributed by protein was used for maturation and spawning. Secondly, the energy values were low and marked loss in contribution to the total energy was mainly due to protein component. Gabbot and Bayne (1973) reported decrease in total energy during spawning and found that protein accounted for about 75% of the loss. They reported that fall in protein content of the body tissue was accompanied by increase rate of ammonia excretion. Further, gonad conditions indicated that the gametogenesis was initiated in January and the maturation lasts till May. In raft-grown mussels, first gametogenesis occurs at a size group of 15 mm and above. From the present study it appears that the spawning was continuous from June to end of the experimental period. This species is known to breed continuously throughout the year. During this period three stages of gonadal condition *viz.* maturing, mature and spent were found. The re-occurrence of maturing stages of gonads during July-September could mainly be due to

intermittent spawning of these mussels. The contribution of protein to total energy varied from 2.58 to 3.87 K cal $g^{-1}$ dry wt. during the period of study, coinciding with minimum and maximum values of protein in the respective months. This highlights that protein forms a major source of contribution to the total energy production. The percentage contribution by this constituent to the total energy production was from 77.45 to 79.09. Protein, a source of energy reserve in bivalve plays an important role as compared to glycogen and other intermediary carbohydrate metabolism. The contribution of protein to total caloric potential showed a positive correlation with a high degree of significance ($r$ - 0.924; $P < 0.001$).

*Carbohydrate :* The pattern of variation in carbohydrate content registered its higher values in the initial period of growth. At this time the chlorophyll *a* and phytoplankton biomass was observed to be high, thus indicating that metabolic energy demands were met by phytoplanktonic biomass (Parulekar *et al.* 1982) and with an enhancement of growth the carbohydrate content decreased gradually. Soon after, the carbohydrate content decreased and remained steady till May - June suggesting that during spawning season, energy requirements are met by protein and lipid to a large extent as compared to carbohydrate content. In monsoon (June - September) low values in carbohydrate levels were observed which were mainly due to low temperature and unfavourable conditions causing stress to the cultured mussels. An earlier study (Gabbot and Bayne, 1973) stated that stress in cultured mussels results in utilization of carbohydrate reserve and a decline in the rate of secretion of ammonia - N. Carbohydrate serves as index of high glycogen metabolism during the period of high environmental stress in monsoon season (Parulekar *et al.*, 1982). In general, results of carbohydrate analysis indicated that there was no marked variation in relation to annual cycle, except slightly higher values in May.

During monsoon, low values of carbohydrate coincided with low values of protein and statistical inferences highlight a positive relationship among these constituents. The contribution of carbohydrate to the total energy content was upto the tune of 0.44 to 0.81 K cal $g^{-1}$ dry wt. during February and October respectively. The percentage contribution from biochemical constituent was from 9.9 to 18.2% to the total energy production in the raft-grown green mussel. This makes it obvious that carbohydrates do not contribute significantly for the total energy production (Table 1). During pre-spawning period, coinciding with peak monsoon period high carbohydrate content was observed. However, during spawning season, carbohydrate values were low. Totally, carbohydrate content was high in immature mussels and reduced in mature mussels.

*Lipid :* The lipid content was observed to decrease gradually from the beginning to the end of study period (Fig. 1). Higher values of lipid in the initial stages were mainly due to increased feeding efficiency. Venkataraman and Chari (1951) correlated high lipid level with intensive feeding and storage of fat before spawning. The range of variation in lipid content during the study period was from 61.62 to 74.23 $mg.g^{-1}$ dry wt. This was followed by low values of lipid content upto June. The low values were mainly due to utilization of accumulated lipid for building up of tissue material. Further, low lipid values were

associated with faster growth rate in the mussels in the present study. Another probable cause for low lipid values could also be due to initiation of gametogenesis and utilization of energy reserves for development of gametes. Low values were correlated with low content of chlorophyll *a* and phytoplankton biomass at the site of raft culture. During this period the magnitude of change in lipid content was not high, although it showed an alternate increase. The low values of lipid content were inversely related to the protein content values. Since July, till the end of the study period, a gradual decrease in lipid content was observed. This decline in lipid content was observed to coincide with monsoon season. At this time water content was high thus indicating an inverse relationship between lipid and water content. The period of low lipid content coincided with post-spawning season in the cultured mussels (Qasim *et al.* 1977; Parulekar *et al.* 1982). Another noteworthy observation, was that higher values of protein were followed by higher values of lipid in the successive months. The contribution of lipid content to the total energy varied from 0.24 to 0.70 K cal $g^{-1}$. Percentagewise contribution from this component was from 7.2 to 15.6.

During maturation, the lipid content values were low as compared to early stages of life (60-70 mm size group). Lipid content was reported to be comparatively high during pre-spawning period. Soon after spawning, marked decline in lipid content was reported. Low values of lipid content during post-spawning could be attributed to depletion of energy resources for spawning activity (Qasim *et al.* 1977).

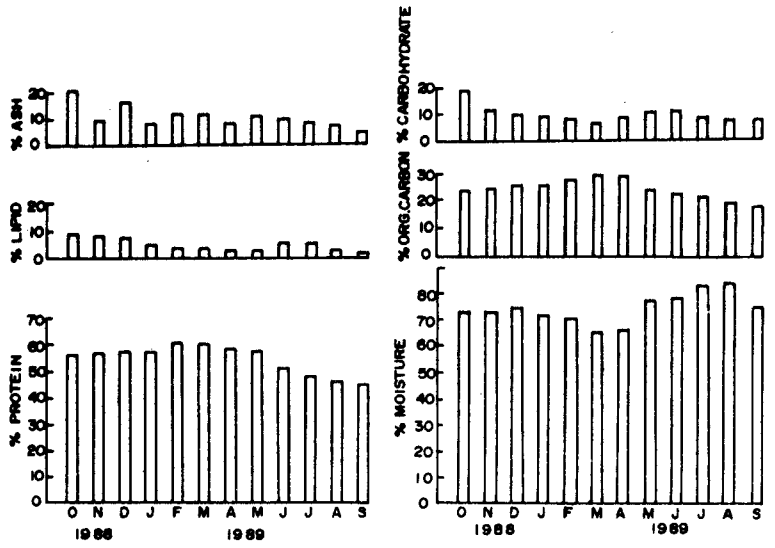


Fig. 1. Variations in proximate biochemical composition in the raft-grown green mussel *Perna viridis* L.

*Ash* : No definite pattern of variation was followed in the ash content during the present study (Fig. 1). The ash content during the complete period of study varied from 5.18 to 21.87%. In younger mussels, values of ash

content were higher inspite of large fluctuations. In general, during monsoon season *i.e.* after July, ash values reported a decreasing trend upto the end of the study period. During July – September, low values of ash were found to coincide with low values of lipid and protein, whereas, higher values of ash content coincided with higher values of carbohydrate during the early stages of growth.

*Organic carbon :* The minimum (18.24%) and maximum (36.97%) values were observed in March and August respectively (Fig. 1). The organic carbon content was low in the initial stages of the growth and increased upto December. Thereafter, the organic carbon content was stable upto February followed by a decline with lowest value in March. An increase upto May with stable values upto July was followed by further increase in August and subsequent decrease in September. The higher values were directly related to protein, carbohydrate, lipid and ash content. The results indicate that major biochemical constituents are greatly influenced by quality and quantity of food available, exogenous parameters such as temperature which influence metabolic level and reproductive cycle of cultivated mussels. The present study also revealed that the reproductive cycle to a large extent was associated with the proximate biochemical composition and thus affected the seasonal cycle.

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