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An Integrated Approach on Interconnected Effects between Selected Environmental Parameters and Fatty Acid Composition in Mollusks

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ABSTRACT

This study presents results of study on some of the important marine environmental parameters on fatty acid composition in mollusks. Lipids are main source of metabolic energy and necessary material for the formation of cell and tissue membranes. They are very important in the physiology of marine organisms. Animals only have a limited capacity to synthesize and modify fatty acids; the fatty acid composition of their lipids is markedly influenced by taxonomic relations, diet, reproductive status, habitat, environmental parameters and etc. Furthermore, the relative ease with which lipids can be assimilated, in comparison with other classes of macromolecules, means that lipid storage is a relatively direct process, allowing rapid accumulation when foods rich in lipids are consumed. In this study, we review some of the rules of fatty acids in mollusk.

Key words: Biomarker, lipid, energetic, mollusks, fatty acids

INTRODUCTION

Many studies have emphasized the significance of fatty acids, especially polyunsaturated fatty acids (PUFA) in food and health of bivalve (Caers *et al*., 2000). Fatty acids act as precursors of bioactive molecules (e.g., prostaglandins) and have structural and functional role in organisms, affecting processes such a reproduction, osmoregulation and stress response (Makoto *et al*., 1989). The importance of the n-3 fatty acids DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid) has been highlighted in the molluscan paper (Marty *et al*., 1992). Lipid biochemistry of many gastropods, bivalves and cephalopods has been described in details. The pioneering studies on the fatty acids of mollusks, mostly bivalves and gastropods were carried out in the 1970 (Gardner and Riley, 1972; Ackman and Hooper, 1973; Ackman *et al*., 1974). Lipid and fatty acid compositions of different classes of Mollusca have been reviewed by Joseph (2003). Fatty acids have been found to differ for mollusk species and are influenced by taxonomic relations and environmental conditions and also depend on nutrient habits and food availability and also physiological conditions.

In recent decades, some reports have been published on decline of mussel communities in different marine areas (Salimi *et al*., 2009). This phenomenon might be due to environmental parameters and their changes in the world which in turn may produce physiological and molecular variations in these organisms. One of the most important outcomes of biochemical variations in the cellular and molecular level might result in changes in energetic of the organism which in turn could be studied trough fatty acid compositions in mussels during a temporal study. There are some related reports about temporal studies on effects of environmental parameters on chemical composition of fatty acids in mollusks (Pernet and Tremblay, 2004; Sajjadi *et al.*, 2009a, b). This article reviews the results of these studies as well as a comparison with similar reports on effects of environmental parameters on fatty acid composition in mussels in an upwelling area (Heilman *et al.*, 2008) which provide a diverse food regime for the mussels.

Biochemical and physiological responses to environmental factors has been used in recent decades in order to assess the health and status of biological organisms in marine environment (Eghtesadi-Araghi, 2005; Karami-Varnamkhasti *et al.*, 2008). We have also discussed application of these responses as biomarkers in the aquatic ecosystems.

Fatty acids and temperature: Temperature is a crucial determinant of the bio-geographical distribution and the performance of marine ectotherms. Temperature alters the velocity of chemical and enzymatic reactions, rates of diffusion, membrane fluidity and protein structure (Hochachka and Somero, 2002). The thermal sensitivity of membrane processes is due to the strong effect of temperature on the physical properties of membrane lipids that in turn have a major influence on associated proteins. A decrease in temperature usually reduces membrane fluidity, which can lead to membrane dysfunction. Ectotherms usually counteract this temperature effect by remodeling membrane lipids, a phenomenon known as homeoviscous adaptation (HVA), via changes in phospholipid head groups, fatty acid composition and cholesterol content to compensate the effect of temperature on membrane structure (Hazel, 1995). Many intertidal organisms, which commonly withstand variations in temperature of 20-30°C on a daily basis and encounter even wider thermal ranges on a seasonal basis, are able to regulate their membrane fluidity in response to temperature changes. According to previous reports, unsaturation of fatty acids in the tissues of marine organisms increases with low environmental temperatures while saturation, increases with high environmental temperatures (Lewis, 1962).

Fatty acids and food: Many studies have shown that the levels of fatty acids in bivalves reflect the phytoplankton eaten by filter feeders. Phytoplankton is the major food source of bivalves as well as being the major source of these fatty acids in marine food webs. Similarly significant negative correlation between silicate and nitrate with linoleic acid can be explained by the fact that in high temperatures a decrease occurs in silicate and nitrate availability and highly saturated fatty acids, which will increase unsaturated ones (Mortensen *et al.*, 1988). Similar results had been reported before with a silicate deprivation diet in which 18:2n-6 fatty acid increased in fatty acid composition of sea Scallop Placopecten magellanicus larvae (Pernet and Tremblay, 2004).

Fatty acids and reproduction: Seasonal variations in lipid and fatty acid composition have been reported for several marine mollusks and are generally related to the growth-maturation cycle: in the summer when the growth phase takes place, reserves of lipids are build up and stored and these are later mobilized for gametogenesis in the maturation phase (often autumn or winter), being normally lost during spawning.

Fatty acids and immune system: Fewer studies have investigated the impact of nutrition on immune responses of bivalves. Recently, Delaporte *et al.* (2003) have demonstrated that feeding Pacific oysters Crassostrea gigas and Manila clams Ruditapes philippinarum with cultures of the microalgae Chaetoceros calcitrans (a diatom) led to increases in hemocyte numbers, phagocytosis and reactive oxygen species production. These authors suggested that the FA composition of Chaetoceros calcitrans, characterized by high proportions of EPA (17.8%) and ArA (2.0%), may be responsible for the changes observed in immune responses of both species, as demonstrated for vertebrates and fishes fed on different oils Similarly, Hegaret *et al.* (2004) showed that immune parameters of the Eastern oyster Crassostrea virginica were modulated by the quality of the algal diet. Nonetheless, no specific PUFA could be clearly identified as responsible for those changes. Lastly, dietary conditioning using lipid emulsion was used to assess the impact of EPA on hemocyte parameters of the oyster *C. gigas* (Delaporte, 2005).

Fatty acids and habitat: Comparative studies of fatty acids in marine, brackish and freshwater mollusks were reported in many publications. In a comparative study of composition fatty acids, in particular gastropod species and other invertebrates and fish, it is often difficult to determine which of various factors influences the content: diet, water temperature or salinity, wave action and/or physiological status.

Fatty acids as biomarker: In the last two decades the use of lipids as biomarkers has been established as a tool to investigate the feeding ecology. Diets can be investigated by various techniques, including gut content analyses, fatty acid profiles and stable isotopes. Stable isotopes are especially hard to interpret when used to identify diets at higher trophic levels or for organisms that nourish on a wide selection of food types. Analyses of gut content are relatively easy and inexpensive to conduct, but they only supply information on the food ingest and not what is assimilated. Adversely, assimilated food types can be provided from fatty acid profiles and stable isotopes record; however they cannot identify specific consumed food items. Useful dietary information for groups with known and unequivocal lipid biomarkers may be provided from fatty acid profiles, but these are not available for many taxa. Fatty acids are carbon-rich compounds that are used in all organisms and rather easy to metabolize. According to the fact that they are transferred from primary producers to higher trophic levels without change once incorporated in the organism and their biological specificity, make fatty acids suitable for use as biomarkers. (Alfaro, 2008). It has been shown that marine detritus contains significant quantities of saturated fatty acid between C14:0 and C18:0 carbons (Ackman *et al.*, 1968; Perry *et al.*, 1979). This result may be related to the higher amount of saturated fatty acids found in bivalves, residing in organic detritus-rich environments with a rich bacterial load (Galap *et al.*, 1999). As reported by Sargent *et al.* (1990), photosynthetic organism's biosynthesize both n-3 and n-6 PUFAs readily, initially by converting newly biosynthesized 16:0 and 18:0 to 16:1n-7 and 18:1n-9, respectively. Unlike animals, plants can continue the further desaturation of the 18:1n-9 to 18:2n-6 and 18:3n-3 fatty acids. Falk-Petersen *et al.* (2002) have shown that the lipids of copepods contained 20:1n-9 and 20:1n-11, which together constituted 60% of their total fatty acids. When ingested by predators, the long-chain monoenes partially accumulate in the predators' tissue lipids (Raclot *et al.*, 1998). The use of zooplankton as food has also been reported in the oyster Ostrea edulis (Knox, 1986).

Due to the fact that marine molluscs cannot synthesize essential fatty acids de novo, the quality and the quantity of algal lipids is very important in the diet of marine animals and algae are reported to be their main sources of these acids (Sukenik *et al.*, 1993). Diatoms (Bacillariophycea) are rich sources of EPA, ARA and to a lesser extent of C16 PUFA. Dinoflagellates (Dinophycea) are richer in DHA. Green algae (Chlorophycea) tend to be rich in C16 and C18 (n-3) PUFA, especially 18:4(n-3) and deficient in both C20 and C22 PUFAs. Red algae (Rhodophyta), besides being rich in (n-3) PUFA, mainly EPA, may have considerable amounts of ARA. Finally, brown algae tend to be rich in ARA and EPA but significant levels of C18 (n-3) PUFA are also found. Thus the occurrence of the fatty acids 20:5n-3 and 20:4 n-6 indicate Diatoms, Red algae and brown algae (macroalgals) in food webs.

We did not observe C22 PUFA in our results (Sajjadi *et al.*, 2009a, b) this is consistent with previous studies (Chuecas and Riley, 1969) in which, C22 PUFA is not reported to be present in high levels in all groups of microalgae.

Some bacteria capable to produce 20:4(n-6) and other PUFA (Russell and Nichols, 1999). It is possible that bacterial input to the diet may also be responsible for the levels of 20:4 (n-6) within mollusks.

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