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Nutritional aspect of crustaceans especially freshwater crabs of India

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Abstract

Lipids play important roles in the metabolism and reproduction of decapods crustaceans. Indian prospect is no better where epidemic of coronary heart disease (CHD) and diabetes is ongoing with no signs of a recession. Edible crustaceans, such as crab, shrimp, prawn, crayfish and lobster constitute one of the major sources of nutritious food for human being. The nutritive values of crustaceans depend upon their biochemical composition, such as protein, amino acids, lipid, fatty acids, carbohydrate, vitamins and minerals. Being very cheap, freshwater crabs constitute a great food potential for human in India, where they occur in almost every freshwater habitat, yet even fundamentals such as their biochemical composition of body flesh and hepatopancreas (these two parts are eatable by human) are yet to be determined and correlated with nutritional aspects for Indian population. This review addresses stimulating interest in this fascinating group of animal by summarizing what little we do know about freshwater crabs in India comparing with other edible crustacean found in different parts of the world. This will help in promoting freshwater crab culture in India. Freshwater crabs are neglected in various parts of world as well as in India also. But they have good quality proteins and fatty acids in their edible part. In this article, occurrence of major lipid and fatty acids were addressed. Among fatty acids, SFA especially C_{16} total and C_{18} total; MUFA, PUFA, linoleic acid (18:2ω6), linolenic acid (18:3ω3), EPA (20:5ω3) and DHA (22:6ω3) were compared in body flesh of various edible crustaceans. It was observed that Indian freshwater crab have a high content of MUFA and PUFA which makes them nutritionally attractive. The fatty acid profile exhibit a greater percentage of EPA and DHA of total fatty acids. The n3/n6 ratio maintains less than 1% in the body flesh of crabs. So, they are highlighted as a source of dietary supplement for human who need precautionary measure for CVD and may be consumption of freshwater crabs would help to prevent nutritional deficiencies in future.

Keywords: Crustacea, CVD, freshwater crab, lipid, fatty acid, n3/n6 ratio.

Introduction

Animal uptake all sorts of nutrients through their food source not for our consumption but for their own physiological requirement. We explore carbohydrate, protein and lipid contents of an animal because of utilization of those components for our betterment i.e. resource utilization for health. Thus, human exploit and incorporate many such animals in their food chain.

The population of India constitutes more than one third of the developing world and among them more than half live below poverty level, can't be called a health conscious group. The common Indian seems to be aware of their food for keep them fit and well to work hard. They are very familiar with the protein for make them wealthy but fat or lipid or fatty acids seem to be technical and usually avoided by them in food and nutrition. People are more concerned these days about the intake of protein value and diet chart contains less fat for less calorie ingestion. Health conscious public recognizes the importance of lipid as a vital dietary component because of the role of lipid and fatty acid content in the diet for cardiovascular impairment. A high caloric diet and least physical activity contribute to the modern day health problems like dyslipidemia, obesity, etc. All of these increase the risk of cardiovascular disease (CVD). Indian prospect is no better where epidemic of coronary heart disease (CAD) and diabetes is ongoing with no signs of a recession (Enas *et al*., 2003). According to them, Indians should increase the MUFA intake to 20% with the total fat intake to 35% of the energy because of the beneficial effects on High Density Lipid (HDL) and Triacylglycerols (TAG). Edible crustaceans, such as crab, shrimp, prawn, crayfish and lobster constitute one of the major sources of nutritious food for human being. Among seafood, prawns and shrimps contribute about 20% by volume of the world seafood market. Seafood in general, prawns and shrimps in particular, are highly nutritious with good source of protein and amino acids.

The nutritive values of crustaceans depend upon their biochemical composition, such as protein, amino acids, lipid, fatty acids, carbohydrate, vitamins and minerals. Being very cheap freshwater crabs constitute a great food potential for human in India. A large part of these shell fish species from cultivated farms. So there is growing need for information about the biochemical composition of these shell fishes. For the cultivation of these shellfishes some important characteristics, such as nutritional properties, biochemical structure and growth conditions need to be identified. Human consumption of freshwater crabs has been recorded from various parts of Africa, including *Sudanonautes aubryi* in Ivory Coast (Bertrand, 1979) and *S. africanus* and *S. kagoroensis* in Nigeria (Okafor, 1988; Cumberlidge, 1991). In Liberia, the dwarf river crab *Liberonautes nanoides* is caught in large numbers during the dry season using basket traps, and sold in local markets for human consumption (Sachs and Cumberlidge, 1991). In Nigeria, *Sudanonautes africanus* is commonly sold in markets and roadside stalls, either fresh or smoked (Okafor, 1988). Crab consumption in this region tends to increase when economic decline reduces the availability of other protein sources (Udonzi, 1987); economic austerity will therefore lead to increased prevalence of paragonimiasis among susceptible human populations. Recently in India few works were done on freshwater crabs. Radhakrishnan and Natrajan (1979) investigated the lipid content in *Podopthalmus vigil* (Fabricius); Manhas *et al*. (2013) studied water and lipid distribution pattern in female *Paratelphusa masoniana* (Henderson), an edible freshwater crab from Jammu region of J&K; Jadav (2013) observed, impact of mercuric chloride on lipid in the freshwater crab, *Barytelphusa guerini*; Das *et al*. (2015) reported major lipid classes and their fatty acids in the flesh and hepatopancreas of an edible freshwater crab *Varuna litterata* (Fabricius 1798). However, freshwater crabs are strangely neglected component of the world's inland aquatic ecosystems. Despite their wide distribution throughout the tropical and warm temperate zones of the world, and their great diversity, their role in the ecology of freshwater is very poorly understood. Similar situation prevails in India, where crabs occur in almost every freshwater habitat, yet even fundamentals such as their biochemical composition of body flesh and hepatopancreas (these two parts are normally consumed by human) are yet to be determined and correlated with nutritional aspects for Indian population. This review will attempt to stimulate interest in this fascinating group of organisms by summarizing what little we do know about lipids and fatty acids of freshwater crabs in India.

Lipids

Crustaceans use lipid for numerous biological structures and processes (Allen, 1976). The most studied decapod crustaceans in terms of lipid concentrations and ovarian maturation are penaeid shrimp (Kulkarni and Nagabhushanam, 1979; Middleditch *et al*., 1980; Read and Caulton, 1980; Castille and Lawrence, 1989; Mourente and Rodgiguez, 1991; Lubzene *et al*., 1995). Lipids play important role during the development of decapods crustaceans, not only as energy source, but also as essential nutrients (Kanazawa *et al*., 1985). In crustaceans, the hepatopancreas is generally regarded as a major lipid storage organ. In the case of female crustaceans, ovaries also contain higher levels of lipid than other organs and this suggests that lipids are important for maturation of ovaries (Ando *et al*., 1977; Teshima and Kanazawa, 1983), as well as precursor of gonadal steroids. The hepatopancreas is the main lipid storage organ, triglycerides and phospholipids being its major lipid components, while the muscle contained mainly phospholipids (Muriana *et al*., 1993; Chanmugam *et al*., 2006; Das *et al.*, 2015). Therefore, prawns and other sea foods are preferred by the consuming communities. Lipids also form a major component of yolk in decapod crustaceans. The majority of lipids stored in oocytes are derived from extraneous sources, particularly the hepatopancreas (Varadarajan and Subramoniam, 1982). Lipids are the precursors of steroidal hormones. The higher quantity of total lipid and fatty acids recorded in the adult female prawns may be necessitated for performing certain specific physiological activity related to reproduction. It has been reported that incorporation of essential fatty acids in the diet produced better growth rate and survival in aquaculture (Read, 1981; Sargent *et al.*, 1999; Bell and Sargent, 2003). Lipids are extremely important in maintaining structural and physiological integrity of cellular and sub- cellular membranes. Lipids are the best source of energy producers of the body through metabolism. They provides a source of indispensable nutrients and act as carriers of certain non fat nutrients, notably the fat soluble vitamins like A, D, E and K (New, 1986; Richardo *et al*., 2003). The proximate body composition including moisture, fat, protein and ash are good indicators of physiological condition of an organism. The greater the protein and lipid content represents higher the energy density (Dempson *et al*., 2004). However, quantities of these constituents vary considerably within and between species, size, sexual condition, feeding season and physical activity (Rosa and Nunes, 2003; Nargis, 2006).

Fatty acids

Lipids and fatty acids play important roles in the biochemistry, metabolism and reproduction of decapod crustaceans. Neutral lipids, particularly triacylglycerols, are a major energy source, and the predominant form of energy storage in the adult, egg and pre feeding larvae (Middleditch *et al*., 1979; Teshmina and Kanazawa, 1983 and Clarke *et al*., 1985). Phospholipids and sterols have important function as cytoplasm and membrane constituent of cells, affecting structural and physiological properties. Polyunsaturated Fatty Acids (PUFA) are important component of lipids and are essential for marine fish and crustaceans (Sargent *et al*., 2002). Apart from being a major role of metabolic energy and main form of energy storage, lipids also supply essential fatty acids needed for the maintenance and integrity of cellular membranes and serve as precursor of steroid and molting hormones (Middleditch *et al*., 1980; Harrison, 1990). Lipids play significant role during gonadial growth, maturation and development of decapod crustaceans. They are very important food reserves in the oocytes (Gallager *et al*., 1986; Le Pennee *et al*., 1988). The high lipid content observed in spring and post-monsoon could be attributed to active feeding and optimum availability of food, as algal blooms and plankton are reported to acquire maxima during this period (Sharma, 2005). It is well known that marine animals generally contain large amounts of polyunsaturated fatty acids with a long carbon chain, whereas terrestrial animals involve relatively large amounts of saturated C_{16} and C_{18} acids. As to the crustaceans, many reports have been presented about the fatty acid composition of lipids from different parts of world; for example, mysids, *Neomysis interger* (Linford, 1965); *Jasus lalandii* (de Koning and McMullan, 1966); shrimps, *Pandalus borealis* (Ackman and Eaton, 1967); *Homarus americanus* (Brockerhoff et al., 1968); *Euphausia* sp. (Saiki *et al*., 1959; Jeffrey *et al*., 1966; euphausids, *Meganyctiphanes* norvegica (Ackman and Eaton, 1967) and copepods (Ackman andHooper, 1970; Morris, 1971); prawn, crabs, *Pleuroncodes planipes* (Pierce *et al*., 1969; Van der Veen *et al*., 1971); *Euphausia superba* (Hansen, 1969); *Thysanoessa inermis* (Ackman *et al*., 1970); *Cancer magister* (Allen, 1971); *Xiphosura* (Limulus) *polyphemus* (van der Horst *et al*, 1973); *Crangon septemspinosus* (Ackman and Hooper, 1973); lobsters, *Penaeus japonicas* (Guary, 1973).

The higher levels of EPA and DHA would increase stress tolerance and membrane permeability (Watanabe *et al*., 1989; Watanabe, 1993). The arachidonic acid (n-6) is a precursor of prostaglandin hormone, which is essential for reproduction and vitellogenesis (Tamaru *et al.*, 1997, Tamaru and Ako, 2000; Bell and Sargent, 2003). The interaction and balance between ω-3, ω-6 and ω-9 fatty acids are crucial for maintenance of good health (VonSchacky *et al.*, 1999; Christensen *et al.*, 2001). The ω-3 fatty acids have anti-inflammatory and anti-coagulant properties as well as many other important health benefits. The DHA is important for pregnant and nursing mothers and in young children for healthy development of the brain and vision. The EPA can be considered the most important for everyone else as it is necessary for continuation of the efficient functioning of the brain and body at the cellular level. The ω-6 fatty acids have their own role in female reproductive cycle. The ω-9 fatty acids help to reduce the risk of arteriosclerosis, cardiovascular disease and stroke. In Egypt, Flower (1931) reported that crabs were actively sought and eaten by childless women, in the belief that this would cause them to become pregnant. In India Das *et al.* (2015) extensively investigated the detail lipid components and their fatty acids from the flesh and hepatopancreas of a freshwater crab, *Varuna litterata*, and suggested that this freshwater crab have good source of lipids and fatty acids and this species can be used as marine counterpart. Since freshwater crabs containing considerable amounts of PUFA it can provide a healthy choice of daily diet.

Other nutritional aspects

Crustacean muscles also contain high concentration of free amino acids, such as arginine, glycine, proline, glutamine and alanine (Cobb *et al.,* 1975). The free amino acids have been shown to function in osmoregulation (Fang *et al.,* 1992) and have major contribution to the flavor of sea food (Thompson *et al.,* 1980). The amino acid, tryptophan plays an important role in the brain as a precursor of the neurotransmitter, serotonin, which has a major effect on the feeding behavior of animals (Mullen and Mortin, 1992). Valine is involved in many metabolic pathways and is considered indispensable for protein synthesis and optimal growth (Wilson, 2002). Histidine is also an indispensable amino acid involved in many metabolic functions including the production of histamines, which take part in allergic and inflammatory reactions. It plays a very important role in maintaining the osmoregulatory process and is related to energy production or is used in other metabolic pathways during certain emergencies/ harsh conditions (Abe and Ohmama, 1987).

Crabs are put to various medicinal uses. One of the most interesting is the role of *Potamonautes raybouldi*, the tree hole crab of the East Usambara Mountains in Tanzania and the Shimba Hills in Kenya (Bayliss, 2002; Cumberlidge and Vannini, 2004). Here it is not the crab itself that is important, but the water from the tree hole in which it lives. Tree hole crab water is administered to pregnant women, and particularly those with a history of miscarriages. The value of this water may relate to the behavior of the crab, which neutralizes the naturally acidic water in tree holes by capturing snails and adding their crushed shells to the water, raising the pH but also enhancing levels of dissolved calcium (Bayliss, 2002).

Crabs may play a valuable role as indicators of pollution. *Potamonautes warreni* has the misfortune of being large-bodied, easy to capture with bait, and common in the Orange River, which drains much of the heavily polluted mining region of northern South Africa. Therefore it has been intensively investigated as a possible bioindicator of metals in sediments (e.g. van Eeden and Schoonbee, 1991; Sanders *et al*., 1999; Shuwerack *et al*., 2001). One species, *Potamonautes lirrangensis* (‘Malawi blue crab’), which occurs in Lake Malawi and in rivers in the upper Congo catchment, can be found for sale as an aquarium species (often under the name of P. *orbitospinus*).

In this article, total lipid content of some edible freshwater and marine water crustacean is to be observed (table 1). The content of total lipids is high in marine crustacean relatively to freshwater crabs. In most cases freshwater crabs shows less than 2% fat which makes them lean and good for cardiac patients. Table 2 provides SFA components of different edible crustaceans. It is seen that freshwater crab *V. litterata* has high SFA content followed by *S. dehaani*, a brackish water crab. Figure 2 shows a comparison in C-16total and C-18total of different edible crustaceans. The MUFA and PUFA components are also observed and table 3 and table 4 presents profiles of edible crustacean’s fatty acids. Both UFAs are dominated in marine crustaceans but freshwater individuals have remarkable presence of EPA and DHA (Fig.3), which makes them nutritionally attractive. The n-3/n-6 ratio in freshwater crustaceans (Table 5) mostly has little value when compared to that of marine or brackish water crustaceans.

Table 1. Comparative studies of total lipid content in different edible crustaceans (from available sources)

Edible crustacean	TL%	References
Cray fish (From semi finished canned products)	0.4-0.9%	Walkowiak,1979
P. vigil	16.8-31.9%	Radhakrishnan ,1979
I. crenata	5.4-15.6%	Thomas ,1985
M. rosenbergii	3.37%	Gopakumar, 1993
S. tranquebarica	1.8-2.7%	Gopakumar, 1993
S. serrata	0.21%	Gopakumar, 1993
Cray fish (from different habitats)	0.15-0.3-%	Wlasow, 2002
Cray fish (from polish waters,)	0.15-0.3%	Wlasow, 2005
M. rosenbergii (male)	3.35-5.35%	Bhavan *et al*., 2010
M. rosenbergii (female)	4.12-6.34%	Bhavan *et al*., 2010
Cray fish (Goplo lake, Poland)	0.92-1.10%	Stanek *et al*., 2011
P. mansonia	5.85%	Manhas *et al*., 2013
V. litterata	1.03%	Das *et al*., 2015

Table 2. SFA components of different edible crustaceans (from available sources).

Edible crustacean	SFA%	References
P. japonicus	26.90%	Teshima *et al.*,1976
H. tridens	28.00%	Teshima *et al.*,1976
S. dehaani	35.10%	Teshima *et al.*,1976
P. paucidens	17.40%	Teshima *et al.*,1976
S. serrata	23.25%	Anas *et al.*, 2009
O. limosus (Brda river, Poland)	21.26%	Stanek *et al.*, 2010
O. limosus (Goplo lake, Poland)	21.97%	Stanek *et al.*, 2011
V. litterata	41.10%	Das *et al.*, 2015

Table 3. MUFA components of different edible crustaceans (from available sources).

Edible crustacean	MUFA%	References
P. japonicus	25.10%	Teshima *et al.*,1976
H. tridens	27.80%	Teshima *et al.*,1976
S. dehaani	38.60%	Teshima *et al.*,1976
P. paucidens	40.50%	Teshima *et al.*,1976
S. serrata	25.80%	Anas *et al.*, 2009
O. limosus (Brda river, Poland)	29.05%	Stanek *et al.*, 2010
O. limosus (Goplo lake, Poland)	30.36%	Stanek *et al.*, 2011
V. litterata	29.70%	Das *et al.*, 2015

Table 4. PUFA components of different edible crustaceans (from available sources).

Edible crustacean	PUFA%	References
P. japonicus	47.90%	Teshima *et al.*,1976
H. tridens	44.10%	Teshima *et al.*,1976
S. dehaani	26.30%	Teshima *et al.*,1976
P. paucidens	42.00%	Teshima *et al.*,1976
Cray fish (From semi finished canned product)	34.70%	Walkowiak,1979
S. serrata	42.85%	Anas *et al.*, 2009
O. limosus (Brda river, Poland)	39.18%	Stanek *et al.*, 2010
O. limosus (Goplo lake, Poland)	48.38%	Stanek *et al.*, 2011
V. litterata	19.05%	Das *et al.*, 2015

Table 5. The n3/n6 ratio of different edible crustaceans (from available sources).

Edible crustacean	n-3/n-6 ratio	References
H. gammarus (female)	4.20%	Barrento *et al.*, 2009
C. pagurus	3.50%	Barrento *et al.*, 2010
O. limosus (Brda river, Poland)	0.72%	Stanek *et al.*, 2010
O. limosus (Goplo lake)	0.70%	Stanek *et al.*, 2011
V. litterata	1.58%	Das *et al.*, 2015

Discussion

Lipids are the principal storage forms of energy in many organisms including crabs and human. Different type of lipids, although present in relatively small quantities, play crucial roles as enzyme cofactors, electron carrier, light absorbing pigments, hydrophobic anchor for proteins, 'chaperons' to help membrane protein fold and emulsifying agents in digestive tract, hormones, and intracellular messengers. Lipids and their fatty acids are also used for locomotion, spawning, migration and also used as an energy source for reproduction and structural components of membrane which maintains the lipid homeostasis in the crabs.

Dietary lipids of man, which are at the focus of the investigation, are the structural and storage lipids of the animals and plants that form the food and the diet of man. It is a known fact that crab is one of the main sources of protein in the diet of the common Indian household. It is also rich in lipids and fatty acid especially the essential fatty acids that are required in minute amount but are not synthesized in the human body.

Now a day's people of India and other countries change their food habit from fish to different invertebrate like muscles and crustacean *viz*., crabs, shrimps, etc. Because the crabs are sweet, delicious and rich in fatty acids and protein, most importantly their market price is very cheap relative to beef, pork, fish etc. customer are so many in number. The main point is that crab being the most important food source of these vital nutrients for human, a long-lasting interest in crab lipids stem from their abundance and their uniqueness should be encouraged. The result presented in this article on lipid and fatty acid classes of crabs is discussed in comparison to other crustacean along with their basic biochemistry and importance in human nutrition.

The total lipid content from various crustaceans was observed (Table1) and it is seen that the value ranges from 0.21-31.9% among these; freshwater crab *V. litterata* shows 1.03% TL value which consider it as lean fish category. Whereas, it was seen that *P. vigil* , *M. rosenbergii* (Male); *M. rosenbergii* (female), *P. mansonia* have TL content of 4.12-6.34%, 3.35-5.35%, 16.8-31.9%, 5.85% respectively, reflecting that all of them have high lipid content. The importance of lipids in crustacean physiology is that it is one of the major organic sources other than protein. Lipids in body flesh are used as energy source for locomotion, stored and transported to gonads for reproduction and utilized during spawning migration and actual spawning. According to Ackman's data (1994 a, b) *Varuna litterata* can be judged as low fat lean crab and hence recommended as perfect count as low fat protein to the patients suffering from gastrointestinal difficulties and overweight (Das *et al.*, 2015).

Fatty acids are aliphatic monocarboxylic acids derived from, or contained in esterified form in an animal or vegetable fat, oil, or wax. Natural fatty acids commonly have a chain of 4-28 carbons (usually unbranched and even numbered), which may be saturated or unsaturated. Fatty acids exist free in the body (that is, they are unesterified) and also are found as fatty esters in more complex molecules, such as triacylglycerols. Low levels of free fatty acids occur in all tissues, but substantial amounts sometimes can be found on the plasma, particularly during fasting. Plasma free fatty acids (transported by serum albumin) are in route from their point of origin (triacylglycerols of adipose tissue or circulating lipoproteins) to their site of consumption (most tissue). Free fatty acids can be oxidized by many tissues particularly liver and muscle to provide energy. Fatty acids are also structural components of membrane lipids. Fatty acids are attached to certain intracellular proteins to enhance the ability of those proteins to associate with membranes. Fatty acids are also precursors of the hormone-like prostaglandins. Esterified fatty acids, in the form of triacylglycerols stored in adipose cells, serve as the major energy reserve of the body. It is seen that the all crustaceans in this observation have a no. of important fatty acids present in their edible part.

Palmitic acid ($C_{16:0}$) is probably the commonest saturated fatty acid and is found in virtually all animal and plant fats and oil. It is seen that among all crustaceans this is the predominant SFA and maximally found in *V. litterata*. Other crustaceans are ranged from 14.8-15.8% of total lipid. Ackman *et al*. (2000) remarked that palmitic acid is the prime fatty acid at all evolutionary as well as tropic levels. In fish, the defense mechanism against microbial infections performed particularly by palmitic acids through the pathogen-associated molecular pattern and T-cell signaling (Bergson, 2005). In the crustacean body palmitic acid may help to defense against protozoan infection. Thus it is found in every crustacean flesh as a remarkable amount.

Stearic acid ($C_{18:0}$) is also relatively common and may on occasion be more abundant than palmitic acid, especially in complex lipid. Palmitic acid is also high in the edible Indian freshwater crab *V. litterata*. The freshwater shrimp, *P. paucidens*, have lower stearic acid among all crustaceans. The combination of total C_{16} and total C_{18} are also compared among the crabs. Combination of these two fatty acid groups are favored as substrates for mitochondrial β- oxidation and catabolised via the TCA cycle to generate metabolic energy (Handerson *et al*., 1985) required in reproduction.

MUFA or monounsaturated fatty acids also occur naturally in chain lengths from about C_{14} to C_{24} but, although they are characterized by having a single unsaturated bond, the position of the ethylene bond within the carbon chain can vary even within a specific chain length, so that there are considerably more species of monounsaturated fatty acids than those of saturated fatty acids. In all animal desaturation of fatty acids takes place in the endoplasmic reticulum of cells of particular tissues via an aerobic process utilizing Co-A linked substrates and requiring NADPH and O_2, catalyzed by multi-component systems comprising NADPH-cytochrome b_5 reductase, cytochrome b_5 and terminal desaturase enzymes (Brenner, 1974). This reaction is particular physiological importance in that the monounsaturated products formed (16:1ω7 and 18:1ω9) have markedly lower melting points (phase transition temperature) than their saturated precursors (16:0, 18:0). Hence, Δ9 fatty acid desaturase provides a means of regulating the viscosity of cell membranes by altering the phase transition temperatures of the fatty acids in their constituent phosphoglycerides. In this observation, among all edible crustaceans highest MUFA is found in freshwater shrimp *P. paucidens* have highest amount and prawn, *P. japonicus* have lowest MUFA. The mud crab *S. serrata* has 25% of MUFA but interestingly freshwater crab *V. litterata* has 29% value of MUFA. According to Muhamad and Mohamed (2012), MUFAs appeared to be the major fatty acid class in freshwater fishes.

Linoleic acid (18:2ω6) is the commonest and simplest fatty acid among dienes and found in most plant and animal tissues. It is an essential fatty acid in animal diet as it cannot be synthesized by the animal yet is required for growth, reproduction and healthy development (Holman, 1968). *C. sapidus*, a north east Mediterranean crab have less linoleic acid among all but freshwater crab *V. litterata* have highest, followed by the prawn, *P. japonicus* and mud crab, *S. dehaani*. Linolenic acid (18:3ω3) is a major component of plant lipids, particularly of the photosynthetic tissues, but it is a significant component of crab lipid. This is an extremely important as the primary source of other polyunsaturated fatty acids. It is seen that freshwater shrimp *P. paucidens* do not have linoleic acid where as mud crab *S. dehaani* and freshwater crab *V. litterata* shows high amount of linolenic acid (Fig. 3).

EPA (20:5ω3) and DHA (22:6ω3), in particular, are found in all marine animal tissues as major component. Fish take up the ω-3PUFA from their food, as essential nutritional components, which they cannot synthesize *de novo*. Along with simplified food chain, the animals can perform limited chain elongation and desaturation of the dietary ω-3PUFA (Figure1 shows the relation between dietary PUFA, Tissue PUFA and eicosanoid product). For this reason, the herbivores (e.g. abalone, oyster, mussels) and low order carnivore (e.g. crustaceans) tend to contain more EPA and less DHA than high order carnivores, which in turn contain less EPA than DHA (e.g. tuna, mackerel, shark, squid, octopus) (Dunstan *et al*., 1996,1999). Some crustaceans also show high amount of EPA and DHA, showing similarity with previous reports (Fig. 3). It is reported that, addition of 2g / Day of EPA to slandered antipsychotic therapy was superior to the addition of a 2g / day to DHA in decreasing residual symptoms (Stou *et al*., 1999). The authors conducted the study on 30 individuals, with bi-polar disorder consuming 6.2g / day EPA and 3.4g / day DHA, and they found significantly longer period of remission. The data on crustaceans compared in this article have sufficient amount of EPA and DHA especially *Varuna litterata* which shows more or less considerable amount of these important PUFAs. Thus intake of only two servings/week to minimize the symptoms of schizophrenia and regular use of this food may give advance protection to schizophrenia.

The n-3/n-6 ratio is also addressed in this article. It has been suggested that n-3/n-6 ratio of 1.1 to 1.5 would contribute to a healthy human diet (Osman *et al*., 2001) and recommendation by WHO is that the n-3/n-6 ratio in total human diet should be more than 1.5/day (Vojkovic *et al.*, 1999). It is seen that among the crustaceans under discussion the freshwater crab *V. litterata*, maintains the recommended ratio, making it as an important food source for human for an advanced protection of cardio vascular disease (CVD).

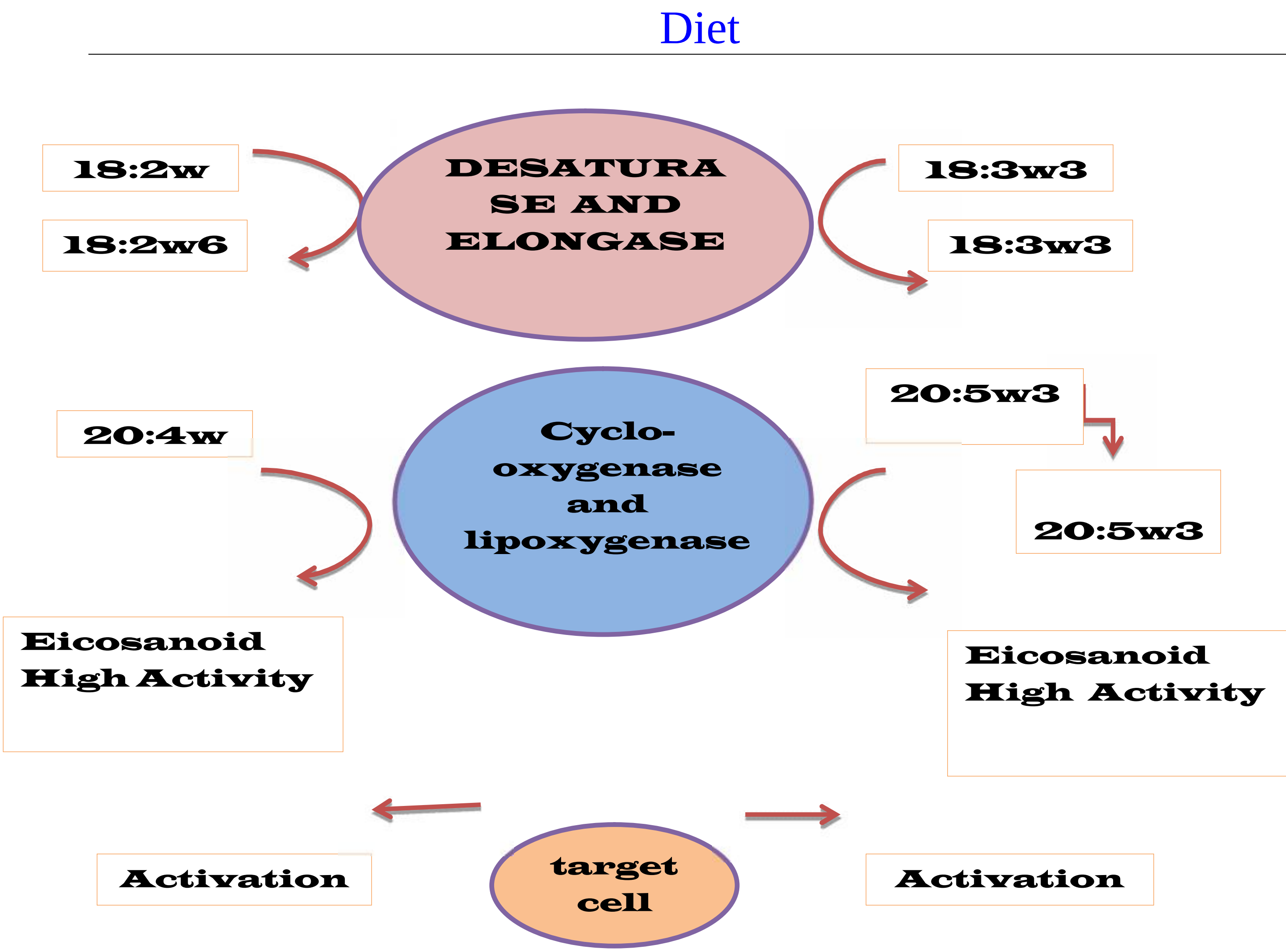

Figure 1. Relative links between dietary PUFA, tissue PUFA and eicosanoid product (modified after Tocher, 2003).

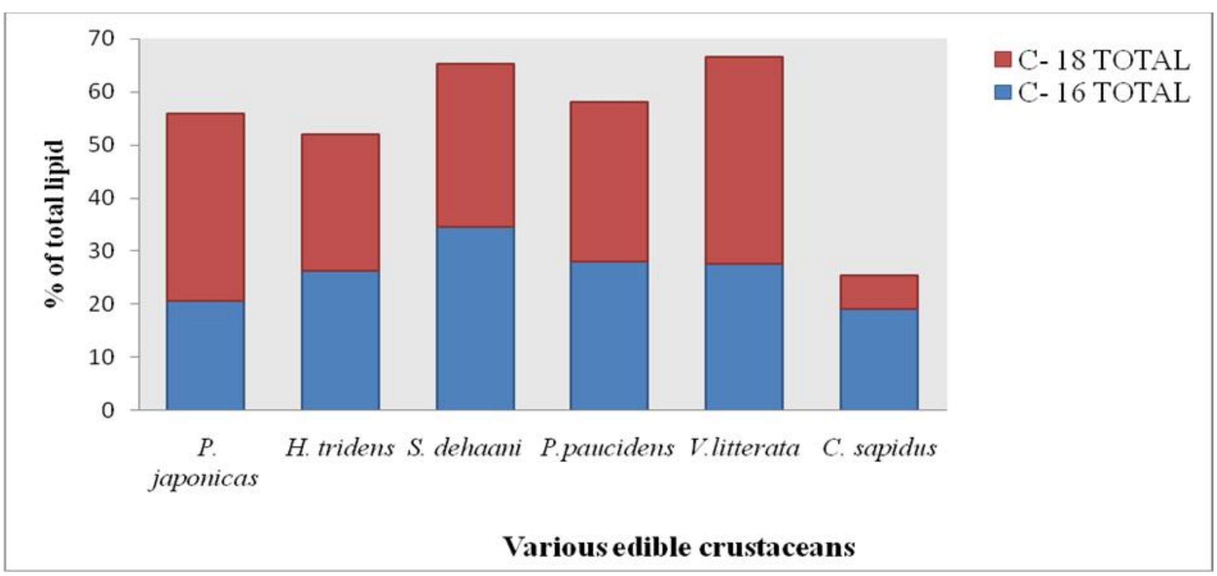

Figure 2. Comparison of total C_{16} and total C_{18} of different edible crustaceans.

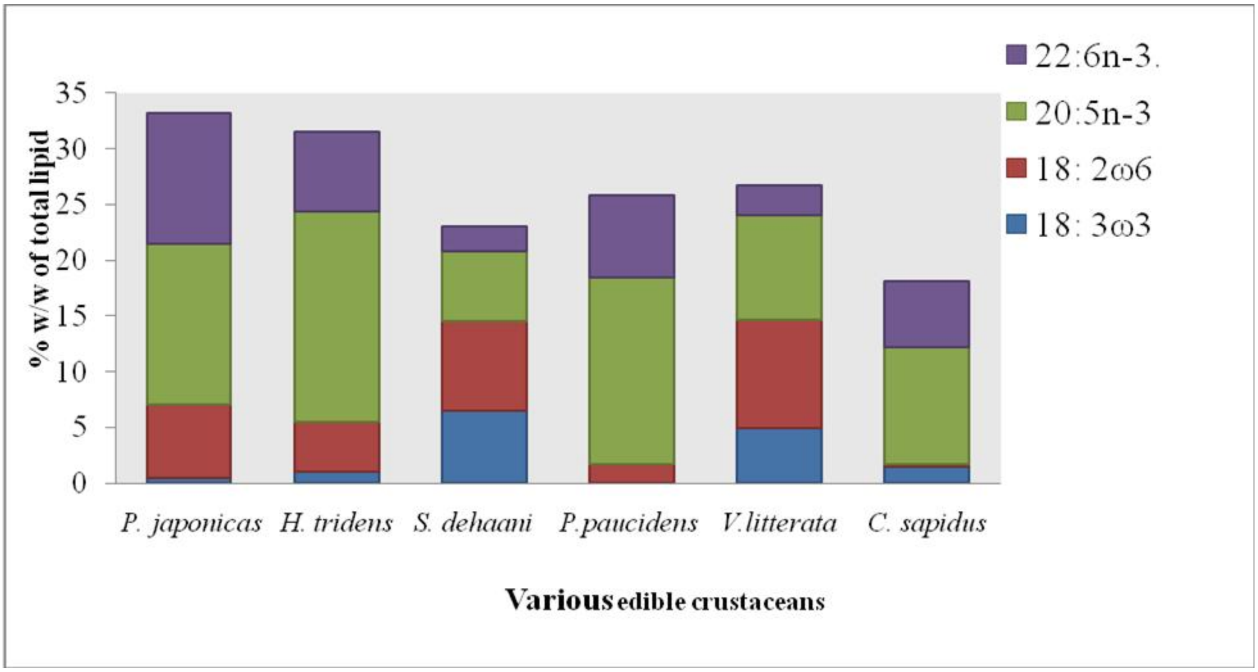

Figure 3. Comparisons of four valuable fatty acids for human in different edible crustaceans. The prawn, *P. japonicus*, was obtained from Darumaya-Sangyo Co., Kagoshima. The crabs, *H. tridens tridens* and *S. dehaani*, were collected in the marsh quite near brackish water at Ibusuki, Kagoshima; The crab, *H. tridens tridens*, was inhabiting in the wet mud of relatively shallow depths, whereas *S. dehaani* was found in the hole of relatively dry mud; The shrimp, *P. paucidens*, was harvested in the Lake of Ikeda (fresh water), Kagoshima (Teshima *et al*., 1976). *C. sapidus* a north east mediterranian crab (Celik *et al.*, 2004). *V. litterata*, an Indian freshwater crab (Das *et al*., 2015).

However, it can be concluded that freshwater crab possess no less nutritional quality than other edible crustacean like marine crab, prawn, shrimp, etc. They are equally important for human consumption and have sufficient nutritional value and therapeutic value for cardiac heart disease patients. Crustaceans especially flesh of fresh water crabs, like *Varuna litterata*, has good quality of lipids and remarkably valuable low fat type fatty acid makes them lean shellfish. Being very cheap these can be used as marine counterpart. A few research works is performed on freshwater crabs in India, so more attention should be given on Indian freshwater crabs. Conservation strategy should be undertaken for locally important shellfish such as *V. litterata*. Taking freshwater crab or other crustacean in daily diet may results in better and advanced protection against cardiac heart disease and other lifestyle related disease. Exploration of the nutritional quality of freshwater crab will encourage farmers to promote freshwater crab culture in India.

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