Significant effects of dietary intake of fish towards optimal growth and development of humans

ABSTRACT

In conquest to attain the goal of zero hunger as well as tackling the problem of malnutrition worldwide, fish proves to be one of the best functional food to humans. Along with the sense of good taste to humans, it ensures great nutritional value at an affordable price. Fish food plays an active role in supplementing the body with the nutrients that are directly involved in metabolic activities. It is enriched with high quality protein containing all the essential amino acids, omega-3 polyunsaturated fatty acids including eicosapentanoic acid and docoxahexanoicacid and wide variety of micronutrients involving vitamins (fat soluble vitamins and several members of vitamin B complex) and minerals. Also, these have significant protective effects against the occurrences of several diseases such as cancer, cardiovascular diseases, inflammatory diseases, retinopathy, diabetes, arthritis and some other acute or chronic diseases. The bioactive peptides from fish food are reported for their positive effect on humans. Therefore, fish is an optimal choice of food to humans as it helps in their growth, development and maintenance of good health. However, care should be taken during processing of fish or fish products as the inappropriate handling can deteriorate the nutritional quality of the food.

Keywords: Amino acids, Fish, Human health,Nutritional value, Omega-3 polyunsaturated fatty acids

Comment [T1]: Supplementing? Kindly use a word like PROVIDING.

Comment [T2]: Is it Docoxahexanoic OR Docosahexaenoic acid?

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INTRODUCTION

With the continuous rise in the world population in recent decades, the demands of food are also increasing exponentially and malnutrition is becoming the most serious problem globally despite enormous technical progress over the past 50 years. FAO(2018) has estimated nearly 11% of the total population of the world encounters the sufferings of poverty and does not have access to enough nutritious food optimum for proper growth and human health. The present plans are framed to boost the food supply by adopting sustainable agricultural techniques and other food systems which could ensure the continuous supplies by 2030.

Theconcerns are not only about undernutrition, in fact over nutrition and obesity is also a rising problem. WHO (2020) has reported tripled number of obese people since 1975 which accounts for 13% of the total adult population of the world. Also, the occurrence of cardiovascular diseasesrelated ailment to obesity and malnutrition has increased globally to 17.8 million deaths every year by 2017.

It has been predicted that the population size will rise by 2.4 billion people in developing countries of Sub-Saharan Africa and South Asia by 2050 (Lipper *et al*., 2014). The majority of the population in these regions thrive on agricultural produce, however several problems like desertification, salinization, improper rainfall pattern and excessive exploitation of natural aquatic resources put a limitation on sustainable production (Godfray*et al*., 2010). The sustainable optimum nutritious supply could only be possible by adopting the innovative techniques which boost the production and cause lesser stress on natural resources.

Aquaculture is regarded as an efficient source of food supply, even in lesser developed nations (Belton *et al*., 2016). In 2013, the World Bank in its report "Fish to 2030: Prospects for Fisheries and Aquaculture" estimated that aquaculture will provide nearly 62% of the total fish for human consumption by 2030. Fish is regarded as good sources of food supply and very beneficial for the human health (Figure 1). The most commonly cultured species will include carps, catfish and air breathing fish, tilapia. To achieve this goal, global yield from aquaculture is estimated to increase to 7.3 million tons by 2030. Presently, fish is a source of nearly 20 percent of average per capita consumption of total animal protein intake to 3.2 billion people (FAO, 2018).

Biochemical composition of the fish

Fish is a supreme quality food due to its great nutritional value. For determining the nutritional quality of fish, proximate analysis of different fish is carried out by many different researchers worldwide reporting minor discrepancies in them because of the differences in their feeding habits, surrounding temperature, age, season and sex. It is reported that fish provides high quality protein containing all essential amino acids, polyunsaturated omega-3 fatty acids and several micronutrients, including vitamins and minerals (Figure 2) (Marques *et al*., 2019). In general, the fish muscles have a great content of proteins, lipids and water which together constitute approximately 98 percent of the total weight (Table 1).Small fish which can be consumed wholly like *Amblypharyngodonmola* are a great source of calcium (Roos*et al.*, 2007).

BENEFITS OF FISH AS A FOOD SOURCE

The deficient supply of high quality protein diet to the children of young age is becoming a major source of stunting in them (Semba*et al*., 2016). This generates more human interest to acknowledge animal source based diet and fish is a great source for it. The preference to fish or other seafoods as a food source is a much healthier choice than other terrestrial meat based products to diminish the problem of malnutrition. In 2017, these lie on the third position to supply dietary protein to the humans, the first two being cereals and milk (FAO, 2020). Fishmeal has been utilized as a supreme ingredient in the feeds for different animals because of its rich content of protein of high quality, sufficiently high amount of essential polyunsaturated fatty acids and micronutrients constituting vitamins and minerals (Merino *et al.*, 2012).

Fish based food is rich in high quality protein which has a greater digestibility that may exceed 90%. These also contain high levels of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), the polyunsaturated fatty acids (PUFA) having longer chain length. Human body can only synthesize these fatty acids by elongating the fatty acids of shorter chain length such as alpha-linolenic acid but the level of production is not sufficient to meet the bodily requirements and thus these should be supplemented through diet. These omega-3 PUFA are known for their greater health benefits such as optimally enhanced cognitive development during pregnancy, lowering risk of early preterm birth and reduction in the chances of coronary heart disease and myocardial infarction. However, there have always been some heterogeneity in these results (Zheng *et al*., 2012). There is rising importance of fish for its micronutrient content (which includes fat soluble vitamins, Vitamin B_{12}, Folic acid, Choline, Coenzyme Q10, and minerals like Calcium, Selenium, Copper, Magnesium, Zinc, Iron, Iodine and trivalent Chromium) to minimize the deficiency at an affordable cost. However, the content of micronutrients in a fish depends on several factors such as the species of fish, its immediate environment, whether farmed or wild caught and certain other factors (Hicks *et al*., 2019). Some other benefits provided by the fish food include appropriate neurodevelopment in infants, lesser chances of diabetes (Wallin*et al*., 2012) and reduction in the chances of occurrence of thyroid cancers, especially in women (Michikawa*et al*., 2012). Therefore, fish and seafood suitably present as an optimal food source to meet the nutritional requirements of the world (Tacon&Metian, 2013).

FISH FOOD - A SOURCE OF HIGH QUALITY PROTEIN

Proteins are one of the most important structural and functional component of the cells in the body and are essentially required to retain the integrity and functionality of the cells. Fish or fish based products are a very rich source of high quality protein and there are many evidences suggesting their beneficial effects on human health (Vildmyren*et al*., 2018).

There are several factors that determine the nutritional value of the proteins present in the food such as the composition of amino acids in the protein, its susceptibility to enzymatic digestion, amount of essential amino acids and the chemical changes that accompany the processing methods. A high quality protein is the one that have higher amount of the essential amino acids and fish based foods are enriched with all the essential amino acids, especially leucine and lysine; and thus are one of the best source of protein supplementation. The non-essential amino acids such as alanine, glutamic acid and aspartic acid and taurine, which is an amino-acid derived organic acid are also present in the fish based protein sources (Ross *et al*., 2017). It has been determined that among the common food fishes, the content of aspartic acid and lysine is higher in coldwater fishes, leucine in marine fishes, and glycine and glutamic acid in carps and catfishes (Mohanty*et al*., 2019).

Health benefits of amino acids

The amino acids could be classified as essential and non-essential amino acids based on their necessary supplementation in the diet. There are nine essential amino acids that are necessarily required through supplementation and includes histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. The body can synthesize several amino acids *de novo* and these amino acids are considered non-essential because of no need of external supplementation by the human body. However, all the amino acids are necessary for the maintenance of proper functioning of the cells (Novelli& Tasker, 2008). Many fish are reported which are rich in specific type of the amino acid (Figure 3).

Taurine

Taurine is among the highly abundant free amino acids and not incorporated directly in the proteins, however it is greatly required for several essential functions in the body (Jacobsen & Smith, 1968; Hayes &Sturman, 1981). It is present in greater amounts in the heart, platelets, blood cells, retina, and brain. It acts as an antioxidant and also helps in boosting the action of insulin and increasing the glucose tolerance. It is an organic acid based amino acid and plays an efficient role in modulating the neurotransmission, and the development of central nervous system (Jacobsen & Smith, 1968; Hayes &Sturman, 1981).

Health benefits of Fish collagen peptides

Fish collagen is a Type-1 collagen and highly abundant in human body. It has greater absorption capacity and bioavailability than other animal collagen peptides because of its smaller particle size. Type-1 collagen peptides are well known for providing strength to bones and connective tissue, and beautiful skin. The collagen from fish food is a complex structural protein that is rich in glycine, proline, and hydroxyproline. It helps to maintain the flexibility and strength of bones, muscles, ligaments, tendons and skin. Also, it helps in wound-healing, anti-aging, and healing and regeneration of bones (Axe, 2018).

Potential effects of bioactive fish-derived peptides

Bioactive peptides are generated by the microbial or enzymatic action on the ingested proteins in the gut or can directly be consumed as a supplement in food. These generally consist of 2-20 amino acid residues and several different bioactive peptides contain different types of amino acids in them (Figure 4). These type of peptides can alter various metabolic pathways and thus, may contribute towards prevention of diseases. Some of the effects shown by bioactive peptides include inhibition of dipeptidylpeptidase-4 and angiotensin converting enzyme and enhanced conjugation of bile acid to taurine which results in improved glucose metabolism, reduced blood pressure and improved microbiota composition of gut respectively (Dale *et al.*, 2019).

FUNCTIONAL ROLE OF POLYUNSATURATED FATTY ACIDS FROM FISH FOOD IN HUMAN NUTRITION

Prior to the proliferation of agriculture, the main food sources to humans were fruits, nuts, berries, honey, fish, shellfish and meat. The diet was thus rich in n-3 PUFA and contained lesser amount of n-6 PUFA than present diets. After the revolutionary rise of agriculture, intake of cereals increased greatly leading to higher amount of n-6 PUFA in human diets, consequently leading to the alteration in the balance of n-6/n-3 PUFA in human body (Simopoulos, 2002).

Alpha-lenolenic acid (ALA) is the most abundantly found PUFA that is derived from oils of several plant and animal based sources. However, the main beneficial effects to human health are due to the long chain omega-3 polyunsaturated fatty acids, DHA & EPA which are gained mainly through fish food (Ellulu*et al*., 2015). The humans cannot synthesize a specific group of fatty acids- n-3 and n-6 PUFA. However, it can modify the parental fatty acids, ALA (18:3) to form EPA and DHA but the level is not sufficient for the human body (Rubio-Rodriguez *et al.*, 2010). Therefore, their intake is recommended for the proper growth and well-functioning of the body (Ganesan*et al.*, 2014). Fish oil is a great source of EPA and DHA and therefore fish such as tuna, salmon, trout, sardine and sturgeon are exploited for their oil (Siriwardhana*et al.*, 2012).

There are several evidences for the benefits of n-3 long chain PUFA on human health(Figure 5). These play important role in growth and maturation of fetus and infants. The n-3 PUFA from fish oil are well documented to reduce the risk of cardiovascular ailments and also reduce the chances of inflammation (Figueras*et al.*, 2011). Daily dose of 140-600 mg per day DHA and EPA is recommended for optimal human growth and development (Ganesan*et al*., 2014).

Physiological effects of n-3 PUFA

*Triglycerides***:**

It has been established that long chain n-3 PUFA from fish oil have hypotriglyceridemic properties. The dose-response relationship is present between n-3 PUFA supplementation and serum triglyceride concentration lowering in the human body. Harris (1997) demonstrated that serum triglyceride levels lowered by 25% - 30% with the supplementation of n-3 fatty acids from fish oil at a rate of 4g/day. The optimal dose of n-3 fatty acids effective for human body ranges from 3 to 5 g/day and can be achieved through supplementation. Both EPA and DHA may lead to the lowering in triglyceride levels (Grimsgaard*et al*., 1997).

Blood Pressure:

Hypotensive effects also seem to be associated with the supplementation of long chain n-3 PUFA, however the degree of response depends on the degree of hypertension. In a meta-analysis, it has been found by Morris *et al*. (1993) that the blood pressure reduced significantly by 3.4/2.0 mm Hg by supplementing 5.6 g/d of n-3 PUFA to the hypertensive subjects. Similarly, Appel *et al*. (1993) observed the decrease in blood pressure levels by 5.5/3.5 mm Hg with the supplementation of 3g/d n-3 PUFA to the hypertensives. Also, it has been suggested that DHA is more effective in lowering the blood pressure than EPA (Mori *et al*., 2000).

Thrombosis and Haemostasis:

The n-3 PUFA can delay the aggregation of platelets and results in increase of bleeding times to a modest level (Mori *et al*., 1997). It has been suggested that the supplementation of fish oil leads to the enhanced fibrinolysis (Barcelli*et al*., 1985). A study revealed that 5.1 g/d supplementation of n-3 PUFA to the coronary patients for 6 months resulted in lessened level of von Willebrand factor and thrombomodulin (Johansen *et al*., 1999). The long chain n-3 PUFA have clear effects on collagen-induced aggregation of platelets (thus affecting hemostasis), however their effect on thrombosis is not much clear.

FISH AS AN IMPORTANT SOURCE OF MICRONUTRIENTS (VITAMINS & MINERALS)

Micronutrients acquire their name because of their requirement in human body in only minimal amounts. However, these are essential as their deficiency can lead to growth retardation, poor immunity, perinatal and maternal mortality, child mortality and other cognitive defects. It has been analyzed that approximately 17% of the world population is having the deficiency of zinc and around one-fifth of the global population of pregnant women is encountering the deficiency of iron leading to anemia and one-third of them are deficient in vitamin-A (Black *et al.*, 2013).It has been demonstrated that small fish are a very good source of micronutrients, if consumed wholly. This is because most of the micronutrients in the fish body are concentrated in the head, bone and viscera region (Kawarazuka& Bene, 2011). Several fish species rich in particular micronutrients have been enlisted in table 2.

Vitamins

Vitamins are a group of organic substances required essentially by the body to maintain the normal functioning of the cells, their growth and development. The deficiency of these substances in the human body can cause several health problems. Fish food contains abundant amount of vitamins (Erkan&Ozden, 2007), mainly fat-soluble vitamins and some vitamins of B-complex. Fish food contains more readily available vitamin A as compared to the plant sources. Oily fishes are well known for their rich content of vitamin D (Spiro &Buttriss, 2014).

Vitamin A:

Vitamin A is essentially important for the human body as it performs several important roles such as vision, growth and immune function (HHPS 2009; NIH, 2020). Yellow and orange vegetables or fruits have good quantities of provitaminA carotenoid. Humans can convert these into retinol, however the conversion depends on many factors such as the method of food preparation, food matrix, dietary fat consumption and the genetic factors (Olson, 1989). On the other hand, the foods of animal origin contain the preformed retinol which have higher absorption capacity and bioavailability; and are thus preferable (Kwasek*et al.*, 2020). Small fish species that are consumed wholly have greater content of vitamin A (Roos*et al.*, 2003).

Vitamin D:

The sunlight action on human skin leads to the formation of vitamin D in body but with today's lifestyle, the supplementation of vitamin D is becoming increasingly important due to the human preference for less exposure to outdoor environment. It is crucial to the body as it helps in the absorption of calcium and phosphorus from the gut, thereby maintaining the optimum level of calcium in the blood. It therefore, promotes mineralization of the bones and aids in teeth formation(HHPS 2009; NIH, 2020). The form of vitamin Dfound in fish,that is cholecalciferol is three times more potent than the form of vitamin D found in mushroom, that is ergocalciferol (Holick, 2008). Moreover, the content of vitamin D is affected by different processing methods and it has been reported that wild salmon have lesser content of vitamin D than farmed salmon (Lu *et al.*, 2007).

Vitamin E:

Vitamin E is greatly known for its antioxidant properties, by which it protects the cell from the highly reactive free radicals which otherwise may lead to the oxidative damage to the cell or results in any other associated chronic disease such ascancer, cognitive decline, Alzheimer's disease, eye disorders, and cardiovascular diseases. It also plays key role in regulating immune system, inhibiting aggregation of platelets and anti-inflammatory reactions (HHPS 2009; NIH, 2020).

The content of fat soluble vitamins is greater in fish species such as *Anabas testudineus*, *Puntius sophore*,*Amblypharyngodonmola*,*Sardinellalongiceps*,*Tenualosailisha*and*Epinephelus* spp. (Mohanty*et al.*, 2019).

Vitamin B_{12}:

Vitamin B_{12} aids in proper formation of blood cells, DNA synthesis and several neurological functions. Its supplementation may result in decline in the risk of cardiovascular diseases and decreased homocysteine levels and better cognitive development (HHPS 2009; NIH, 2020).

Minerals

Calcium (C) :

Calcium is among the most abundant essential micronutrients in the human body. Most of it (about 99%) is present in the bones and soft tissues. In growing children, the deficiency of calcium can cause rickets because of inadequate calcification of the bones and in adults, it can lead to osteomalacia and osteoporosis (Hays, 1985). Also, the deficiency of calcium can impact the dentition of organisms. Thus, the supplementation of calcium is beneficial for pregnant, growing and lactating women due to the greater demand of calcium and phosphorus.

Small fish that are consumed wholly along with the bones are a great source of calcium (Kawarazuka& Bene, 2011). Its bio-availability is also high like that of milk calcium, in fact the concentration is even higher (approximately eight times) as compared to the milk (Larsen *et al.*, 2000). It has been resulted in a study that average daily consumption of edible part of small fish at a rate of 65g/person can complete the 31% of the average requirement on a daily basis (Roos*et al.*, 2007). Therefore, small fish is an optimal complementary food when milk and other rich sources are not available.

Phosphorus (P) :

Phosphorus is an important constituent of the adenosine triphosphate (ATP) molecules, nucleic acids, phosphorylated metabolic intermediates, bones and teeth. In the living cells, the exchange of energy is associated with the formation and breakage of the bonds with high energy that are in the form of phosphorus oxides (Hays, 1985). Phosphorylation of signaling molecules is the utmost step in cell signaling. The deficiency of phosphorus can result in rickets, osteomalacia and De Toni-Fanconi Syndrome. It has been reported that fish and sea food are the superior source of phosphorus than other land animals' based sources (Tacon&Metian, 2013).

Iron (Fe) :

Iron is essential for a wide range of activities involving growth, immunity and healing. The deficiency of iron is a very common nutritional disorder among human population across the world (Blanco-Rojo& Vaquero, 2019). It may lead to low oxygen delivery to the tissues which may result in fatigue, lower work capacity, difficulty in concentrating, weakness, tiredness and lower cognitive efficiency (Camaschella, 2015). The plant based iron sources and fish based iron sources are different in the way that fish based iron source contains large amount of heme iron which is not present in the plant based sources.

Zinc (Zn):

Zinc is essential for synthesis and digestion of proteins, metabolism of nucleic acids and wound healing. Human diet generally constitute the staple food which contains lesser amount of zinc (Kawarazuka& Bene, 2011). Additionally, it cannot be stored in the body of humans and therefore, daily supplementation of zinc is necessary in the human diet. Small fish is a great source of zinc as compared to the other animal based zinc source and thus it should be supplemented with the staple food which will also compensate for the low bioavailability due to the phytate present in the staple food (Kawarazuka& Bene, 2011).

Selenium (Se) :

Selenium is essential to the body as it helps in the antioxidant activity and also boosts the immunity, thereby keeps the body healthy. It is necessary for the fertility in both males and females, and also known to lower the risk of certain diseases such as thyroid diseases and cancer (NIH, 2020).

FACTORS AFFECTING NUTRITIONAL COMPOSITION OF FISH FOOD

There are different factors which affect the nutritional value of the fishes (Figure 6)

Processing methods

Different methods of processing which are essential to prevent the fish food from spoilage can alter the biochemical composition of fish food. The effects on proteins include its denaturing, altered digestibility and other changes in physical and chemical properties. The denaturation or altered structure of a protein can be a result of heating or freezing which is an essential step during the processing of fish. These processing methods are needed to increase the shelf life of the fish food or to make the fish attractive to the consumer and may be done at lower temperature (freezing, chilling and canning) or higher temperature (sun drying, frying, smoking and grilling) or a combination of both (Abraha*et al.*, 2018). Different modes of processing differently affect the nutritional status of the fish food.

Drying:

The solar drying method can be applied for the preservation of the fish as it helps in reducing the content of water and also kills or stops the proliferation of microorganisms. When allowed for the natural sun drying, the protein content is reported to decrease and the moisture content does not properly vanish which leads to the hardness of flesh. Also, lipid oxidation is reported to increase during prolonged exposure to sunlight. All these changes lead to the decline in nutritional composition of the fish that may affect the health status of consumers (Smida*et al.*, 2014). The extent of changes accompanied with sun drying depends on two factors which includes the temperature and time of exposure to sunlight (Abraha*et al.*, 2018). Roos*et al.* (2003) has demonstrated that prolonged exposure of small fish to sunlight leads to loss of almost whole of vitamin A.

Cooking:

It involves the heating process and can leads to the protein denaturation and loss of certain essential amino acids or other beneficial nutrients. The water holding capacity of the fish reduces after heating that leads to excess dehydration from the fish muscle making it difficult to consume (Smida*et al.*, 2014).

Smoking:

The process of smoking is basically of two types, cold smoking and hot smoking. The processing with cold smoking involves the smoking process to be done below 33°C. But, it does not involve killing of the harmful microbes which creates a need for further processing. On the other hand, hot smoking involves the smoking process at higher temperatures reaching upto 70-80°C which could effectively kill the microbes. However, it results in the decreased bioavailability of the essential amino acids such as lysine, methionine and tryptophan (Belitz*et al.*, 2009).

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Freezing:

Freezing is the most commonly used method for the preservation of fish. However, it may lead to deterioration in the nutritional status of the fish. The extent of loss in the quality of fish depends on several factors including the rate of freezing, rate of thawing and the fluctuations in temperature. In this process,the denaturation of proteins may occur which can lead to the altered water holding capacity, texture and flavor of fish muscles and results in toughened texture of fish muscle. Boonsumrej*et al.* (2007) observed that the deterioration in quality is mainly due to oxidation, sublimation, recrystallization of ice crystals and denaturation of proteins.

Feed

In recent decades, a significant rise is reported in utilization of fish for direct consumption by humans which has reached to 88% in 2016 (FAO, 2016). Rest of the 12% is utilized for the production of fish oil and fishmeal (FAO, 2018). Fishoil is highly digestible and major ingredient in fish feed due to its high nutritional value (Merino *et al.*, 2012). It has been observed that fish fed with plant protein based diet experience reduced biosynthesis of protein as compared to fishmeal fed fish. This may be due to the non-availability of essential amino acids in the plant source based diet (Richard *et al.*, 2011) or inefficiency of fish liver to metabolically adapt with the high plant protein levels (Panserat*et al.*, 2009).

Salinity and temperature of water

The temperature of water significantly affects the nutritional status of fish. It has been reported that with the decrease in temperature, the concentration of polyunsaturated fatty acids, especially docosahexaenoic acid increases and the fatty acid synthetases continually adjust their activity with the change in temperature. Further, it has been analyzed that at higher temperature of water, the bioconversion capacity of fatty acids is altered in the liver and intestine due to the reduced expression of fatty acid desaturase-2 (Norambuena*et al.*, 2016). In a study on Chirostomaestor reared at different salinities (0ppt, 5ppt, and 15ppt), Fonseca-Madrigal *et al*. (2012) reported that the synthesis of long chain n-3 polyunsaturated fatty acids was higher in fish group exposed to higher salinity conditions (15ppt).

Conclusion

Fish are highly nutritious food source and performs several structural and functional roles in the body such as supplying construction material for the formation of genetic material (DNA or RNA). It supplies most of the essential nutrients to the body such as essential amino acids, n-3 polyunsaturated fatty acids and micronutrients, comprising vitamins and minerals. The protein from fish food is highly digestible and is of superior quality, thus have great biological value. Fish food is highly recommendable during early growth of children. Also, it helps to prevent the onset of several diseases which also makes it a good food source. Fish is a great functional food and is highly delicious to human taste. The variations in fish food quality depends on several factors such as species, temperature, habitat, and feeding habits. Some other factors like harvesting, processing and storage effects can also affect the fish food quality.

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Comment [T7]: Check the authors' guideline for the proper way to do the references.

Table 1: The general chemical composition of fish body (Holma &Maalekuu, 2013)

Comment [T8]: Use a better style of table, please. These are too basic.

Nutrient	*Percentage* (%)
Water	70-84
Protein	15-24
Lipid	0.1-22
Minerals	1-2
Carbohydrate	0.1-1

Table 2: Fish species rich in particular micronutrients (Mohanty*et al.*, 2016)

Micronutrient	*Fish species*
Vitamins	
Vitamin A	*Epinephelusspp., Amblypharyngodonmola, Sardinellalongiceps*
Vitamin D	*Puntius sophore, Amblypharyngodonmola, Epinephelusspp.*
Vitamin E	*Sardinellalongiceps, Epinephelusspp., Tenualosailisha*
Vitamin K	*Puntius sophore, Amblypharyngodonmola, Epinephelusspp.*

Minerals	
Calcium	*Xenentodoncancila, Ailiacoila, Gudusiachapra, Puntius sophore*
Iron	*Gudusiachapra, Puntius sophore, Amblypharyngodonmola*
Phosphorus	*Xenentodoncancila, Epinephelusspp., Gudusiachapra*
Zinc	*Stolephoruswaitei, Stolephoruscommersonii, Xenentodoncancila*
Selenium	*Neolissochilushexagonolepis, Clariasbatrachus, Labeorohita*

Figures

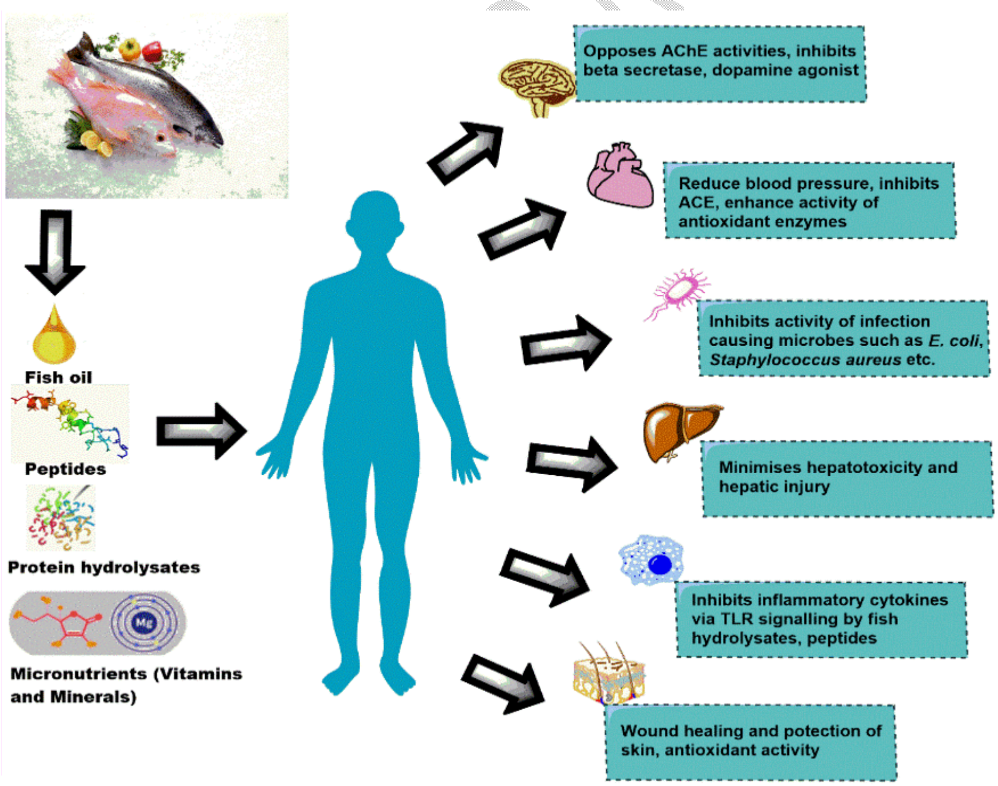

Figure 1:Beneficial effects of fish food on human health

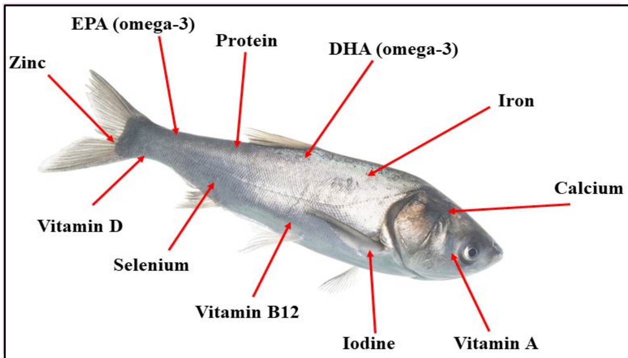

Figure 2. Some important constituents in fish food

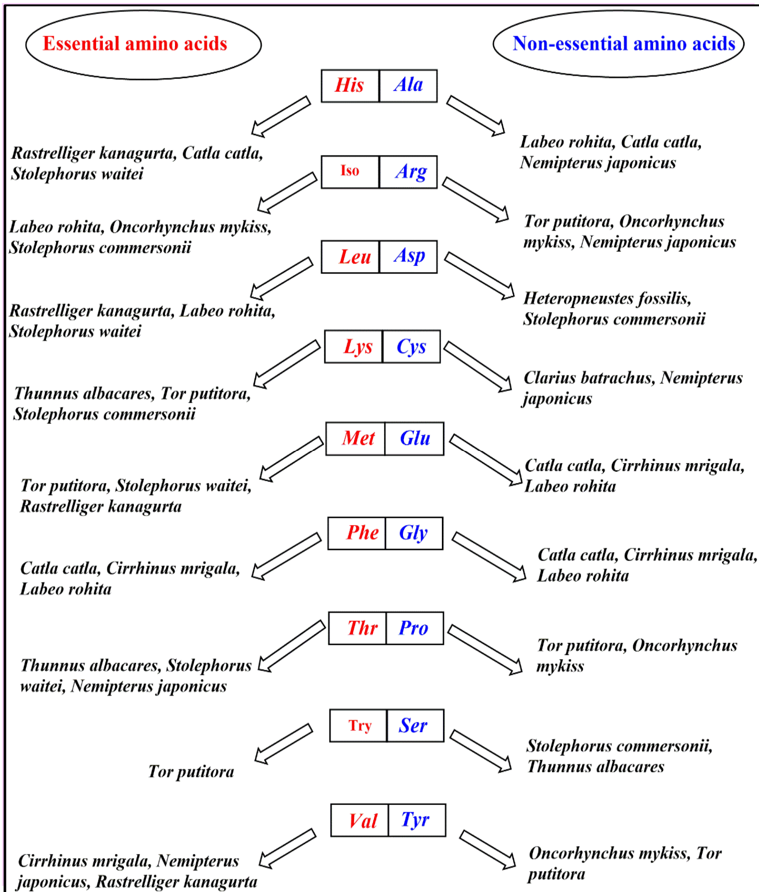

Figure 3: Richness of specific amino acids in different types of food fishes (Mohanty*et al.*, 2019

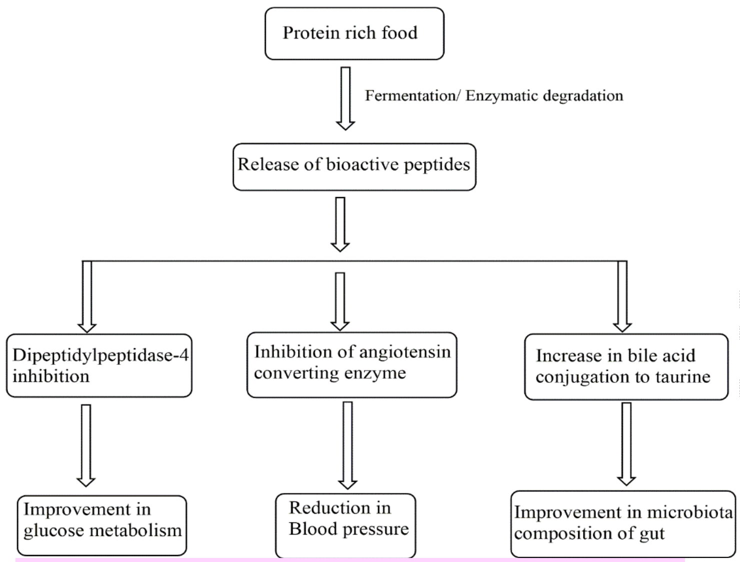

Figure 4: Several potential effects of fish-derived bioactive peptides

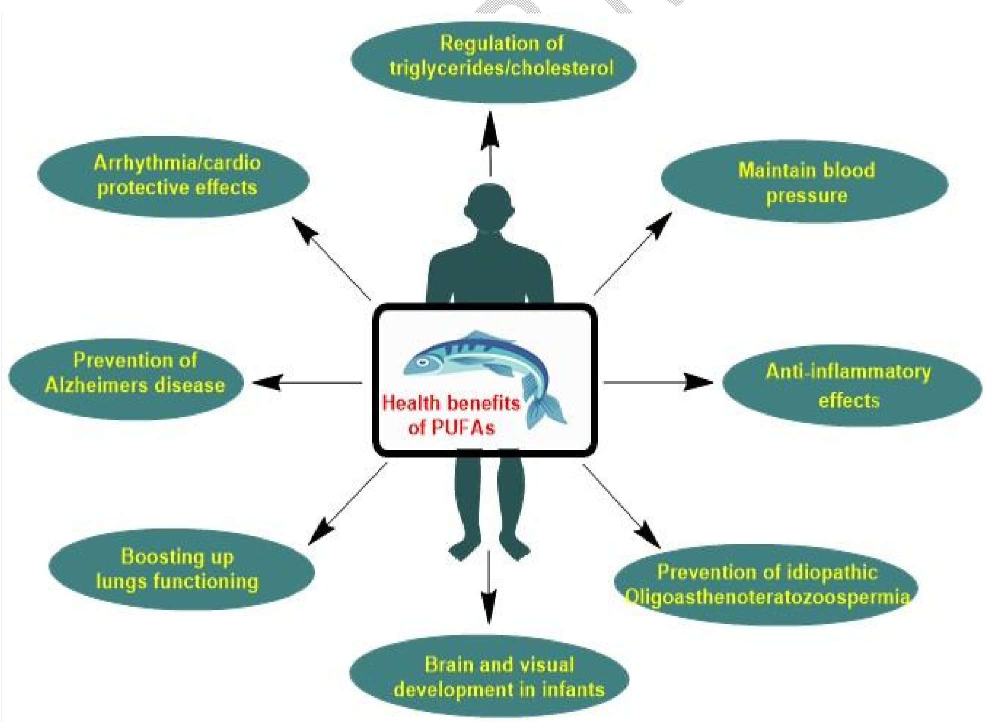

Figure 5: Several health benefits of polyunsaturated fatty acids (PUFAs)

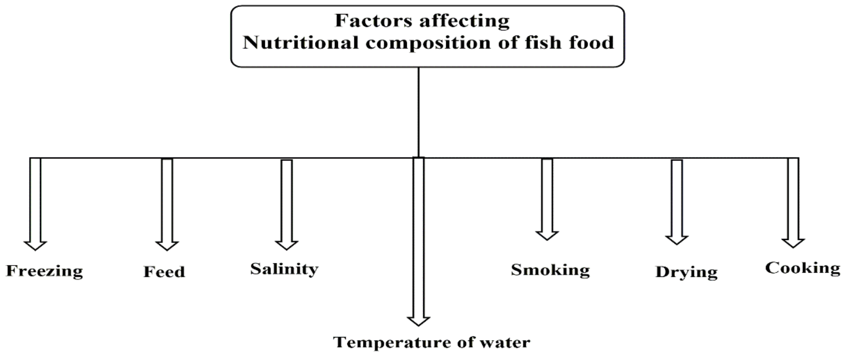

Figure 6: Factors affecting the nutritional value of the fish

Comment [T9]: Check the authors' guideline. "Tables & figures should be placed inside the text".

Why then do you have your tables and figures after references? Kindly fix up.