Biological Times

Volume No. 4 | Issue No. 3 | Pages 35-38

The Vital Role of Fish in Nutrition, Income, Employment and Ecosystem

Javed Khan*

Fisheries and Aquaculture Lab. Zoology Department. University of Peshawar

*Corresponding Author: **javedkhanbio71@gmail.com**

ABSTRACT

Fish play an important role in human diet, income, employment and a major component of ecosystem. Fish is good source of animal proteins, Fats (omega-3-fatty acid), vitamins (A&D) and minerals (Fe, Zn, Se etc.) which is vital for human health and physical growth. Fisheries and aquaculture provide millions of jobs through out of the words, fisheries is handy sector and source of income that boost the economy of the countries. Fish trade globally is worth US$ 51 billion per year and around 200 million employees directly and indirectly depend on fisheries and aqua culture for their lively hood. Additionally, fish play a crucial role in maintaining and balancing ecosystems. Fish is a major component of the food web and food chain. Fish eat the larvae of insects to maintain their numbers, fish act as indicator species which alarm the environmental change. Fish fauna face numerous problems and threats including over fishing, pollution, climatic change and habitat loss. This study emphasizes the conservation and management of fish to protect this valuable source.

Keywords: Vitamins, Aquaculture, Fisheries, Climatic changes, Food chain, Habitat loss

To cite this article: Khan J. The Vital Role of Fish in Nutrition, Income, Employment and in Ecosystem. Biological Times. 2025. March 4(3): 35-38.

Introduction

Freshwater is a prime biome that provides countless advantages which includes clean drinking water, algae, grass, fish and birds which are consumed by humans and other animals [1]. Fresh water provides habitat for fish, birds and other aquatic animals and also play a role in agriculture and maintain ecosystem to reduce pollution and climatic change [2]. Fish is a necessary diet that contains large amounts of nutrients i.e., proteins, omega-3-fatty acids, minerals, oils and vitamins [3].

Fish is a source of Lysine amino acid and protein

Fish is rich and a single source of protein, according to FAO report more than 16% fish protein is consumed worldwide [4]. Fish provide high quality protein and more than one third of population depend on fish as primary source of protein [5].

Fish body contains more than 20% proteins, which supplies 16% animal protein to Africa, 12% to Europe and North America and Europe, 22% to China and 28% to Asia [5]. FAO calculated that more than a billion people globally use fish as a first source in diet to get protein [6].

Fish flesh has highly biological value similar to chicken meat that easily digests and broken down inside the stomach. Fish meat contains 16 to 24 % protein contents and is rich in energy providing 80-90% energy [7].

According to nutrients date base USAD, the fish with highest proteins contents in four ounce meat are Yellow tail (contain 212 calories energy and 34g proteins), Tuna (contain 225 calories energy and 33g proteins), Anchovy (contain 378 calories energy and 52g proteins), Coho salmon (contain 209 calories energy and 31g proteins), Trout (215 calories energy and 30g proteins), Tilapia (contain 11 calories energy and 23g proteins), Blue fish (contain 180 calories energy and 29g proteins), Pollock (contain 134g calories 28g protein) and Sardine (contain 236 calories energy and 28g proteins) [7].

Lysine amino acid is the most important essential amino acid that our body cannot synthesize it, and we acquired it from secondary sources. Lysine is sulpher amino acid that found in fish meat only while missing in cereals, fruits and vegetables. Fish meat has highly biological values and is rich in lysine amino acid [9]

Lysine amino acid is necessary for normal body functioning that helps to promote tissue growth and recover the damaged organs. It helps to make antibodies, stimulate the immune system, increase the formation of collagen proteins, synthesize hormones and enzymes i.e., lipase and proteinase to digest lipids and portions. Lysine amino acid also stimulates intestine to absorb Zinc, Calcium and Iron [10, 11].

The deficiency of lysine amino acid can cause hair loss, anemia, nausea, fatigue, red eyes, anorexia, poor concentration inhibit growth and damage the reproductive system. Fish meat is full of lysine, approxemetly it has 9.21% lysine amino acids. Salmon tuna, sardines, cod and mackerels' fish are rich sources of lysine amino acid [12].

Fish is a source of Fats

Lipids (Fats) is major component of plasma membrane, sex hormones, vitamins, signaling molecules and rich source of energy. It is stored inside the body muscles, below the skin, connective tissue liver and mesentery [13].

The Fats such as highly unsaturated fatty acid (HUFA) has two major types including Docossahexaenoic acid (DHA) and Eicosapentaenoic acid (EPA). Eicosanoid hormones (EH) are made from these fats [13]. These hormones were isolated from fish which is used for the treatment of cancer, hypertension, diabetes, arthritis, stroke and heart diseases [14]. Fish obtained this fatty acid by consuming phytoplankton and algae [15].

Fish oil contains a high amount of omega-3 fatty acid. It is good fat, and our body cannot synthesize such fats. Bad fats such as omega-6-fatty acid are mostly found in red meat or poultry and cattle, while absent or low in fish meat. Omega-3 fatty acid provides number of health benefits that help to regulate blood pressure, stop blood clotting, maintain cardiovascular disorders and prevent blood vessels contraction [16].

The omega-3-fatty acid is also vital for post anal and parental neurological development. It is also used to treat arthritis and cure the inflammation of tissue. In aged people it is used for treatment of loss of memory, depression and faltering [17].

According to Mozaffarian, (2006) Sardines, Arctic char, Tuna, Wild salmon, Rainbow trout and mackerel and are rich in omega-3 fatty acid [18]. Nutritionally, Omega 3 fatty acid is very vital for human health and isolated from Rays, Shark and Skate liver. On the availability of fat, fish have three major types i.e., fatty fish, mudfish and lean fish. Fatty fish consist of large amounts of fat contents more than 10% such as sardines, herring, salmon and mackerels. Lean fish have very little fat contents from 3-5% that include tuna, cod, sole and haddock fish. While mid fish have moderate fat, which is 6-10% sword fish, blue fish, rainbow trout and catfish [19].

Cod fish, also known as white fish, have very little fat, only 2 %. While mackerel is high amount of fats which is more the 16% fat. Globally, more than 20,000-tons of oil is isolated from Cod fish every year [20]. Salmon fish store fats inside muscle while cod fish deposit it in liver [21].

Fish is a source of vitamins

Vitamins have a crucial role in our body. Fish body contains various vitamins i.e. vitamins A, B1, B12, K and D. Fish is a rich source of vitamins, we obtained 14% of the vitamins from fish [3].

Vitamin A (Retinol)

Vitamin A is commonly known as Retinol. It is an unsaturated organic compound composed of Beta-carotene and Opsin protein. Carotene is necessary for retina and Opsin help to form rhodopsin protein that helps in low light vision [22]. Other important functions of vitamin A are to develop the immune system, initiate body growth, formation of teeth and repaired mucosal membrane and epithelial cells [23]. Sever vitamin A deficiency can cause blindness and death of Childs. [24].

Cod fish contains 3334% RDA of carotene that help in synthesis of vitamin A. Cod fish and Mackerel are considered vitamin A richest fishes in the world [25, 26]). The small, wild and indigenous fish contain 40 % of vitamin A. Annually, 60-90% small fishes are consumed in Cambodia, Philippine and Bangladesh [27].

Vitamin D (Ergocalciferol)

Ergocalciferol is fat soluble vitamin that synthesize in skin in the presence of light and attached with intestine reabsorbed phosphate calcium and magnesium to blood from food [28].

Inside the skin epidermis vitamin D_3 is present which is converted to mature form by exposure of light [29, 30]. The major function of Vitamin D is to control metabolism, bone formation, control prostate and breast cancer, help in muscle contraction and act as a neurotransmitter [31].

Due to insufficient sunlight exposure, it is roughly calculated that more than one million people have Vitamin D deficiency. Our body needed 1,000 IU

of vitamin D in the absence of sunlight [32]. Vitamin D deficiency may lead to many disorders including osteoporosis, rickets, bone softening and poor development of tooth [33].

Fatty fishes i.e. Herring, Tuna, Mackerel and Salmon fish have high contents of vitamin D. 25% vitamin D contents are only present in Salmon fish and make it richest source of vitamin D. Naturally large amount of vitamin D present in the flesh of fish. There are 10.2µl of vitamin D stored in 140g flesh of fatty fish. 450 IU of vitamin D is stored in one teaspoon (4.5g) oil of cod fish liver [34].

Vitamin E (Alpha-Tocopherol)

Vitamin E is commonly known is Alpha-Tocopherol is fat soluble vitamin have two major types such tocotrienol (alpha, beta, delta and gamma) and tocopherol (alpha, beta, delta and gamma) The most important for human body id tocopherol (alpha) [35].

Vitamin E perform various body functions, it controls various cardiovascular and heart disease. It helps to prevent thrombus formation in blood vessels to reduce stroke and heart attack. Vitamin E is most power full antioxidant. It oxidizes the free radicals and prevents the cell damage to perform their normal function. Vitamin E have key role in cancer it stops the breast and prostate cancer) [36, 37] Vitamin E can control Cataracts (age-related vision), cognitive disorders i.e. Dementia, Alzheimer, development of peripheral nervous system and Parkinson) and also stimulate immunity of human [38, 39].

Vitamin E deficiency may lead to gastro-intestinal disorders including cystic fibrosis, pancreatitis and celiac. It also caused peripheral neuropathy, damaged retina, unable to move body and stop the immunity response [40].

There are 15 mg Vitamin E in USA is consumed per day is enough for elder peoples. Rainbow trout have 13.2% while Atlantic salmon have 14.5%, fish roe consist of 7.1% DV of vitamin E [41]. The RDA (recommended daily allowance) for vitamin E of Shellfish and salmon fish is 15% [42].

Vitamin B complex

Vitamin B complex is a group of water-soluble vitamins consisting of eight different vitamins including Cobalamin (B12), Folic acid (B9), Pyridoxine (B6), Pantothenic acid (B5), Niacin (B3) Riboflavin (B2) and Thiamin (B1) [43].

It is water soluble vitamin help to developed new skin cell brain cells, blood cells and other body tissue. Fish meat is a good source of vitamin B, the most important is vitamin B12 that is vital for DNA synthesis, Nerve function, and red blood cells. It is considered as food of brain, and its deficiency may lead to cognitive decline and impair the function of brain [44].

Salmon fish is the best source of vitamin B complex, in 100g Salmon fish meat has cobalamin (51% of RDI), niacin (50% of RDI), pyridoxine (47% of RDI), riboflavin (29% of RDI), pantothenic acid (19% of RDI) and thiamine (18% of RDI). Salmon fish have high contents of omega-3-fatty acid, selenium, proteins and lesser amount of mercury (Dietary guideline for American, 2010). Trout is also rich and the best source of vitamin B. 100g of meat of trout provides cobalamin (125% of RDI), thiamine (28% of RDI), niacin (29% of RDI), riboflavin (22% of RDI) and pyridoxine (12% of RDI) [43].

Fish are a source of minerals

Fish bodies store large amount of dietary minerals i.e. Zinc, Iodine, Selenium, calcium, zinc and iron. Salmon fish and trout are good sources of selenium, which is necessary for metabolism, immune response and for reproduction [7].

Calcium is vital to make healthy bones, act as neurotransmitter and help to contact muscles. Calcium deficiency leads to osteoporosis and rickets. Iron is necessary for the synthesis of hemoglobin in red blood cells which is responsible for transportation of oxygen. The deficiency of iron can cause poor learning, weakness of body, and anemia. Most of minerals found in the consumption small size fishes. The rich source of iron and calcium is White fish [45].

Fish as source of Income

Fisheries and aquaculture not only provide food security but also a source of income and employment. The most important reservoir of country is Inland capture fishery and aquaculture [46].

Fish play a crucial role in the second trophic level of the aquatic ecosystem [47]. Worldwide, fisheries provide a large scale of employment and boost the economy of many countries [48, 49].

Fish plays an important role in economic and social development, globally 40 million employees are directly related with fisheries and aquaculture. The net trade of fish around the world is 55 billion US$ per year [7].

According to FAO, it is roughly calculated that more than 200 million people use fisheries and aquaculture as primary [50].

The fishery sector not only creates employment and source of income but improves live hoods and 95% of developing countries depend on fisheries as source of income. Fisheries and aquaculture are considered as vital to reduce poverty and hunger of millions of people in developing countries like Indonesia, Nepal, Bangladesh, Pakistan and Philippine [25].

Scientific value of fish

Lobe fin fishes or lung fishes also known Dipnoi scientifically, especially zoological very important because of their anatomical features and discontinuous distribution. Lungs fish shows connecting links with Amphibians that indicate that amphibians are the updated form fishes [51].

Lung fish (Lobe finned fish) is a type of osteichthyes (bony fish) that fins are covered by flesh and lobe or paddle like. Such fishes are extinct more than 70 million years ago. In 1938, some South African fisher again caught them in net. Lobe-finned fish are scientifically very important because scientists hypothesize that the first land vertebrate such as amphibians are the advanced form this fish [52].

Lobe fin fish fresh water osteichthyes that belong to sub class Dipnoi found along the coast of Australia and South America. Lung fish have a unique respiratory system that consists of one or two lungs connected with larynx and pharynx without trachea [53].

Like alveoli, the lungs of such fish have many small sacs that increase the surface area of lungs to exchange gases that are similar to land vertebrate lungs such lungs help in breathing if water is not available [52].

Aesthetic valve of fish

Large numbers of fish are cultured in aquarium for beauty and grace full moments. Ornamental fishes are attractive and colure full fish species which can be kept in confined space like aquarium and garden pool with purpose of enjoy their beauty [54]. Next to photography the keeping of the ornamental fish is an emerging hobby [55, 56]. Globally there are 32000 freshwater fish species, in which more than 800 are Ornamental fish. Now a days these fishes are considered living jewel because of their economic importance [57] The most important ornamental and aquarium fishes are Cherry barb (*Puntius titteya*), Oscar Fish (*Astronotus ocellatus*), Sailfin Molly (*Poecilia latipinna*), Zebra Danio (*Danio rerio*), Goldfish (*Carassius auratus*), Neon Tetra (*Paracheirodon innesi*), Jack Dempsey (*Rocio octofasciata*), Guppi (*Poecilia reticulata*), Swordtails (*Xiphophorous hellerii*) and Kuhli Loach (*Pangio kuhlii*) [58].

According to FAO the trade of Ornamental fisheries has increased 14% since 1985. It is a major component of world trade and plays a crucial role in livehood and economic development. It is estimated that one third of developed countries trade ornamental fishery. In Kerela, India 114 freshwater fish species are exported for the ornamental trade, an Amazon (Brazil) 1,000 families directly depends upon ornamental fisheries [59].

In the USA imported ornamental fish worth 500 million per year. Approximately India trade Rs 160 lake ornamental fishes which is only 0.008% of the world trade. The most popular countries are India, Singapore, Indonesia, Taiwan, Sri Lanka, Philippines, Thailand, Malaysia and Hong Kong. USA is largest importer followed by Japan and Europe [60].

Fish for controlling diseases

Mosquitoes are type of arthropods that carries parasite of many diseases such as Filariasis, Zika, Dengue, Chikanguna, Yellow fever and malaria. These diseases are a serious health problem for the tropical and subtropical region of world [61].

The population of mosquitoes is controlled by using several techniques, i.e., physical chemical and biological methods are usually used. In all of these techniques the best one is biological control that uses larvaevorous fishe to control immature stage (larvae) and mature mosquitoes through out of the world [62].

There are seven genera and 316 larvivorous fish species reported by Dash and Ghosh (2007 [63].

The fish species such as *Puntius sophore, Cyprinus carpio Rivulus elegan, Pethia ticto* and *Labeo rohita* are larvivorous species that eat larvae, pupae and adult mosquitoes [64].

Fish by products

The fish by products are the organs which is not used as feed for human beings such as fish scales, tail, skin, intestine, stomach, liver, gonads, snout gills brains etc. these fish by products are used to make pearls, shagreen, fish oil, fish glue, and fish manure. [65].

Fish glue

Fish glue is adhesive substance that obtained from the cod fish and used as gum. Jelly-like product is isolated from cat fish, salon fish and perches air bladder that are used in the making of cement and purification of win and bear. Shark skins are used to make Shagreen. To polish wood and to make cover of sward and jewelry placoid scales of Rays fish are used. In France silvery bony scales are used in manufacturing of pearls (Technical information about fish leather).

Fish meal

After the oil extraction from fish, the remaining waste body is converted to fish meal. For this purpose, fish is dried in hot sunlight rays and used as feed

for poultry, cattle, pigs and birds. It is also used as manure in coffee, tea and tobacco fields. Sardines and Mackerels are not ideal to consume and use to make fish meal [66].

Fish flour

Fish flour is globally demanded, in the last few decades (25 years) their production increased 400%. Wheat and maize flour are added with fish flour which is easily digestible and rich source of proteins. 10% fish flour is added with other flour to change their taste and lesser amount of fish flour cannot change their taste [67, 68].

Fish silage

Fish silage is made when fish meat is treated with fumic acid and hydrochloric acid, fish silage is used as meal is rich in vitamins (A&D) and have high nutritional value. During oil extraction sometimes water-soluble liquid is isolated from the fish body. Which is rich in vitamin B complex and proteins that are used for animals as diet [69].

In Philippine and China, many industrial products such as soap, shoes, jackets and handbags are made from the skin of Shark and rays' fish. In the presence of large number of vitamins and amino acid fish are used in synthesis of glue and fibers [70].

Fish roe

Fish roe is the external mass of released eggs and fully ripe internal eggs of ovaries obtained from sturgeons, hake, salmon, lump sucker and mackerel and some other aquatic animals i.e., scallops, sea urchins and shrimp [71].

Fish roe is rich in omega-3-fatty acid, proteins and vitamin B complex that is popular for human consumption [72, 71, 73].

Fish oil

Fish contains two types of oil i.e., body oil and liver oil. The liver oil is isolated from Cod and Shark fish liver. Liver oil has many therapeutic properties that are rich in vitamin D and Vitamin A which recovered their deficiency. The fish body oil is isolated from hearing, pilchard and sardine. The body oil is rich in poly saturated particles (n-3 PUFA) that are vital for cardiovascular diseases. Tuna fishes are rich in decosahexaenoic acid that are highly demanded used for thrombotic and chronic heart problems [74].

Conclusion

Fish play an important role in supporting humans and the ecosystem of our planet. Fish is not only source of income and employment of millions of people but also maintains a healthy ecosystem of the globe. Fish is a rich source of protein and also provide omega-3- fats, crucial vitamins and minerals to build the human body. Fisheries and aquaculture are handy sectors, billions of people use fisheries as source of income. Fish is a major component of food web and food chain to build balance ecosystem. Now a days, fish fauna suffered several environmental threats including overfishing, pollution, habitat loss, climatic change, and desertification. We need fish management and conservation to protect fish fauna for future generations.

References

[1] Baron JS, Poff NL, Angermeier PL, Dahm C, Gleick PH, Hairston NG, Jackson RB, Johnston CA, Richter BD, Steinman AD. Sustaining healthy freshwater ecosystems. Water Resources Update. 2004 Feb; 127:52-8.
[2] Lira-Noriega A, Aguilar V, Alarcón J, Kolb M, Urquiza-Haas T, González-Ramírez L, Tobón W, Koleff P. Conservation planning for freshwater ecosystems in Mexico. Biological Conservation. 2015 Nov 1; 191:357-66.
[3] Eyo, A. A. Fish processsing technology in the tropic (403 p). New Bussa: University of Ilorin press. 2001.
[4] FAO. Technical Guidelines for Responsible Fisheries. No.4. Fisheries management. 1997.
[5] Béné C, Macfadyen G, Allison EH. Increasing the contribution of small-scale fisheries to poverty alleviation and food security. Food & Agriculture Org.; 2007.
[6] FAO. The state of world fisheries and aquaculture. Room. 2000.
[7] FAO. Food and Agriculture organization. The state of world fisheries and aquaculture. Fisheries report.N0.702. Room. 2010
[8] Kita P. Best meals ever: we rifled through all the recipes in our 35-year history to find the ones that offered the most flavor and nutrition. Men's Health. 2023 Oct 1;38(7):80-8.
[9] Wilson RP. Amino acids and proteins. InFish nutrition 2003 Jan 1 (pp. 143-179). Academic press.
[10] Civitelli R, Villareal DT, Agnusdei D, Nardi P, Avioli LV., Gennari C. Dietary L- lysine and calcium catabolism in human. Nutrition.1992;8(6):400-5
[11] Miles RD, Chapman FA. The concept of ideal protein in formulation of aquaculture feeds–Department of Fisheries and Aquatic Sciences. University of Florida. USA [Internet]. 2008.
[12] Zuraini A, Somchit MN, Solihah MH, Goh YM, Arifah AK, Zakaria MS, Somchit N, Rajion MA, Zakaria ZA, Jais AM. Fatty acid and amino acid composition of three local Malaysian Channa spp. fish. Food Chemistry. 2006 Aug 1;97(4):674-8.
[13] Lecerf JM, De Lorgeril M. Dietary cholesterol: from physiology to cardiovascular risk. British Journal of Nutrition. 2011 Jul;106(1):6-14.
[14] Drevon CA. Fatty acids and expression of adipokines. Biochimica et Biophysica Acta (BBA)-Molecular Basis of Disease. 2005 May 30;1740(2):287-92.
[15] Falk PG, Hooper LV, Midtvedt T, Gordon JI. Creating and maintaining the gastrointestinal ecosystem: what we know and need to know from gnotobiology. Microbiology and molecular biology reviews. 1998 Dec 1;62(4):1157-70.
[16] Rizos EC, Ntzani EE, Bika E, Kostapanos MS, Elisaf MS. Association between omega-3 fatty acid supplementation and risk of major cardiovascular disease events: a systematic review and meta-analysis. Jama. 2012 Sep 12;308(10):1024-33.
[17] Hegarty B, Parker G. Fish oil as a management component for mood disorders–an evolving signal. Current opinion in psychiatry. 2013 Jan 1;26(1):33-40.
[18] Mozaffarian D, Rimm EB. Fish intake, contaminants, and human health: evaluating the risks and the benefits. Jama. 2006 Oct 18;296(15):1885-99.
[19] Daschner A. Risks and possible health effects of raw fish intake. InFish and fish oil in health and disease prevention 2016 Jan 1 (pp. 341-353). Academic Press.
[20] Sabry JH. Nutritional Aspects of Fish Consumption: A report prepared for the National Institute of Nutrition on behalf of the Economic and Commercial Analysis Directorate of the Department of Fisheries and Oceans. National Institute of Nutrition; 1990.
[21] Norwegian Food Safety Authority (NFSA). Mattilsynets Arbeid med Dyrevelferd—Årsrapport 2018 (Animal Welfare Work. Norwegian Food Safety Authority—Annual Report 2018); Norwegian Food Safety Authority: Oslo, Norway, 2018.
[22] Wolf ER. Pathways of power: building an anthropology of the modern world. Univ of California Press; 2001 Jan 3.
[23] Tanumihardjo SA. Vitamin A: biomarkers of nutrition for development. The American journal of clinical nutrition. 2011 Aug 1;94(2):658S-65S.
[24] Akhtar S, Ahmed A, Randhawa MA, Atukorala S, Arlappa N, Ismail T, Ali Z. Prevalence of vitamin A deficiency in South Asia: causes, outcomes, and possible remedies. Journal of health, population, and nutrition. 2013 Dec;31(4):413.
[25] FAO. World Health Organization. Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. World Health Organization; 2003 Apr 22.
[26] Borel P, Caillaud D, Cano NJ. Vitamin D bioavailability: state of the art. Critical reviews in food science and nutrition. 2015 Jul 29;55(9):1193-205.
[27] Roos N, Mazharul Islam M, Thilsted SH. Small fish is an important dietary source of vitamin A and calcium in rural Bangladesh. International Journal of Food Sciences and Nutrition. 2003 Jan 1;54(5):329-39.
[28] Holick MF. High prevalence of vitamin D inadequacy and implications for health. InMayo Clinic Proceedings 2006 Mar 1 (Vol. 81, No. 3, pp. 353-373). Elsevier.
[29] Holick MF Vitamin D. deficiency. N Engl. J. Med. 2007; 357:266-81.
[30] Clavo B, Gutiérrez D, Martín D, Suárez G, Hernández MA, Robaina F. Intravesical ozone therapy for progressive radiation-induced hematuria. Journal of Alternative & Complementary Medicine. 2005 Jun 1;11(3):539-41.
[31] Brasky TM, Neuhouser ML, Cohn DE, White E. Associations of long-chain ω-3 fatty acids and fish intake with endometrial cancer risk in the Vitamins And Lifestyle cohort. The American journal of clinical nutrition. 2014 Mar 1;99(3):599-608.
[32] Angeline ME, Gee AO, Shindle M, Warren RF, Rodeo SA. The effects of vitamin D deficiency in athletes. The American journal of sports medicine. 2013 Feb;41(2):461-4.
[33] Brown J, Sandmann A, Ignatius A, Amling M, Barvencik F. New perspectives on vitamin D food fortification based on a modeling of 25 (OH) D concentrations. Nutrition Journal. 2013 Dec;12:1-2. [34] Dierkes J. Supplementation für alle?. Trillium-Diagnostik. 2019 Jul 1;17(3).
[34] Wang X, Quinn PJ. Vitamin E and its function in membranes. Progress in lipid research. 1999 Jul 1;38(4):309-36.
[35] Wang L, Sesso HD, Glynn RJ, Christen WG, Bubes V, Manson JE, Buring JE, Gaziano JM. Vitamin E and C supplementation and risk of cancer in men: posttrial follow-up in the Physicians' Health Study II randomized trial. The American journal of clinical nutrition. 2014 Sep 1;100(3):915-23.
[36] Klein EA, Thompson IM, Tangen CM, Crowley JJ, Lucia MS, Goodman PJ, Minasian LM, Ford LG, Parnes HL, Gaziano JM, Karp DD. Vitamin E and the risk of prostate cancer: the Selenium and Vitamin E Cancer Prevention Trial (SELECT). Jama. 2011 Oct 12;306(14):1549-56.
[37] Chong EW, Wong TY, Kreis AJ, Simpson JA, Guymer RH. Dietary antioxidants and primary prevention of age related macular degeneration: systematic review and meta-analysis. Bmj. 2007 Oct 11;335(7623):755.
[38] Kamat CD, Gadal S, Mhatre M, Williamson KS, Pye QN, Hensley K. Antioxidants in central nervous system diseases: preclinical promise and translational challenges. Journal of Alzheimer's disease. 2008 Oct 24;15(3):473-93.
[39] Wu Y, Zu K, Ni J, Yeh S, Kasi D, James NS, Chemler S, Ip C. Cellular and Molecular Effects of-Tocopheryloxybutyrate: Lessons for the Design of Vitamin E Analog for Cancer Prevention. Anticancer research. 2004 Nov 1;24(6):3795-802.
[40] Arnarson, A. 20 foods that high in vitamin E. Health line.2017.
[41] Khawaja R, Munir T, Hassan U, Shah SS. Type 2 diabetes mellitus: antioxidant status in patients with variation in duration. The Professional Medical Journal. 2015 Jan 10;22(01):143-8.
[42] McCulloch N. OUR BLOG 2018.
[43] Brasky TM, Lampe JW, Potter JD, Patterson RE, White E. Specialty supplements and breast cancer risk in the VITamins And Lifestyle (VITAL) Cohort. Cancer epidemiology, biomarkers & prevention. 2010 Jul 1;19(7):1696-708.
[44] Mohanty BP, Ganguly S, Karunakaran D, Chakraborty K, Sharma AP, Mohapatra PK, Nayak NR. Maternal fish consumption and prevention of low birth weight in the developing world. National Academy Science Letters. 2012 Oct;35:433-8.
[45] Sinha RK. An alternative to dolphin oil as a fish attractant in the Ganges River system: conservation of the Ganges River dolphin. Biological Conservation. 2002 Oct 1;107(2):253-7.
[46] Dubey AK, Shukla SK, Verma H. Ichthyo-diversity of banisagar Dam at Chhatarpur Madhya Pradesh, India. International Journal of Fisheries and Aquatic Sciences. 2012;2:157-61.
[47] Khan MA, Hasan Z. A preliminary survey of Fish fauna of Changhoz Dam, Karak, KPK, Pakistan. World Journal of Fish and marine sciences. 2011;3(5):376-8.
[48] Nagabhushan CM, Hosett BB. Diversity of Ichthyo fauba I relation of physio-chemical characters of Tungabhadrareservoir. Hospet. Wetlands. Biodiversity and climatic change. 2010;1-9.
[49] Garcia SM, Newton C. Current situation, trends and prospects in world capture fisheries. FAO, Fisheries Department; 1995 Jun.
[50] Nelson JS. Fishes of the World, 4th Ed. John Wiley & Sons, Inc, New York; 2006:p.601.
[51] Clack JA. Gaining ground. The origin and evolution of Tetrapods. Bloomington and Indianapolis. 2002.
[52] Farmer C. Did lungs and the intracardiac shunt evolve to oxygenate the heart in vertebrates?. Paleobiology. 1997 Jul;23(3):358-72.
[53] Mukherjee M, Singh S, Mondal SK. Live feed–the life line of ornamental fish industries in west bengal a livilihood study. InNational Seminar on (Vol. 17, p. 49).
[54] Das T, Pal AK, Chakraborty SK, Manush SM, Sahu NP, Mukherjee SC. Thermal tolerance, growth and oxygen consumption of Labeo rohita fry (Hamilton, 1822) acclimated to four temperatures. Journal of Thermal Biology. 2005 Jul 1;30(5):378-83.
[55] Singh AK, Ahmed SH. Ornamental fish culture in Bihar: prospects as a cottage industry. Fishing Chimes. 2005;25(6):9-18.
[56] Nelson JA. Pickled fish anyone? The physiological ecology of fish from naturally acidic waters. InExtremophile fishes: Ecology, evolution, and physiology of teleosts in extreme environments 2014 Dec 22 (pp. 193-215). Cham: Springer International Publishing.
[57] Walster C. The welfare of ornamental fish. Fish welfare. 2008 Jan 1;16:271-90.
[58] Tlusty MF, Dowd S, Raghavan R. Saving forests through the fisheries: ornamental fisheries as a means to avoid deforestation. Ornamental Fish International Journal. 2008;56:21-5.
[59] Tlusty MF, Rhyne AL, Kaufman L, Hutchins M, Reid GM, Andrews C, Boyle P, Hemdal J, McGilvray F, Dowd S. Opportunities for public aquariums to increase the sustainability of the aquatic animal trade. Zoo biology. 2013 Jan;32(1):1-2.
[60] Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, Drake JM, Brownstein JS, Hoen AG, Sankoh O, Myers MF. The global distribution and burden of dengue. Nature. 2013 Apr 25;496(7446):504-7.
[61] Walton WE. Larvivorous fish including Gambusia. Journal of the American Mosquito Control Association. 2007 Jul;23(sp2):184-220.
[62] Ghosh SK, Dash AP. Larvivorous fish against malaria vectors: a new outlook. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2007 Nov 1;101(11):1063-4.

[63] Chandra G, Bhattacharjee I, Chatterjee SN, Ghosh A. Mosquito control by larvivorous fish. Indian Journal of Medical Research. 2008 Jan 1;127(1):13-27.
[64] Shaikh HM, Kamble SM, Renge AB. The study of ichthyofauna diversity in upper Dudhna project water reservoir near Somthana in Jalna district (MS) India. Journal of Fisheries and Aquaculture. 2011 Jan 1;2(1):8.
[65] Jacobs A. China's appetite pushes fish stocks to brink. New York Times. 2017 Apr;30.
[66] Levin E. Fish flour and fish meal by azeotropic solvent processing. Food Technol. 1959 Feb;13(2):132-5.
[67] Sure B, Easterling L, Dowell J, Crudup M. The Addition of Small Amounts of Defatted Fish Flour to Milled Wheat Flour, Corn Meal and Rice: Influence on Growth and Protein Efficiency. The Journal of Nutrition. 1957 Apr 1;61(4):547-54.
[68] Abdullah J. Utilization of bycatches for the production of fish silage [Malaysia]. Philippine Journal of Veterinary and Animal Sciences (Philippines). 1983;9(1-4).
[69] FAO. The state of world fisheries and aquaculture. Room. 2000
[70] Rao PP, Balaswamy K, Jyothirmayi T, Karuna MS, Prasad RB. Fish roe lipids: composition and changes during processing and storage. InProcessing and Impact on Active Components in Food 2015 Jan 1 (pp. 463-468). Academic Press.
[71] Higuchi T, Shirai N, Suzuki H. Effects of herring roe on plasma lipid, glucose, insulin and adiponectin levels, and hepatic lipid contents in mice. Journal of nutritional science and vitaminology. 2008; 54(3):230-6.
[72] Shirai N, Higuchi T, Suzuki H. Analysis of lipid classes and the fatty acid composition of the salted fish roe food products, Ikura, Tarako, Tobiko and Kazunoko. Food chemistry. 2006 Jan 1;94(1):61-7.
[73] Masson L. 13 Phenolic Acids as Natural Antioxidants. Phytochemicals of Nutraceutical Importance. 2014 Feb 28:196.