

Food and Nutrition Security in The Context of COVID-19 and The Potential Role of Tilapia Aquaculture

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Submission date: 06-Apr-2023 11:48PM (UTC+0700)

Submission ID: 2057695231

File name: Bhujel_2021_IOP_Conf._Ser._Earth_Environ._Sci._695_012023.pdf (857.53K)

Word count: 8443

Character count: 43110

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To cite this article: R C Bhujel and I Suharman 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **695** 012023

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Food and Nutrition Security in The Context of COVID-19 and The Potential Role of Tilapia Aquaculture

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Abstract. Millions of people lost their jobs due to COVID-19 creating critical problems of food and nutrition insecurity. It has added 130 million in addition to 821 million hungry people [1]. Over 690 million people are malnourished. Fish is the best medicine of malnutrition and the most efficient food production system; tilapia is the most suitable one. It became the most widely farmed species due to availability of inputs, equipment, technologies and human resources. To solve the shortages of seed, AIT developed a technique capable of producing millions of mono-sex seed. It is spreading from Fiji through Asia, Africa to Brazil. Tilapia is grown in low input ponds to highly intensified cages and tank systems. China produces over 1.5 million ton annually, followed by Indonesia and Egypt. Globally about 7 million mt of Nile tilapia along with its hybrids, is produced annually which is the highest amongst the species. Tilapia is available in the street as well as supermarkets in Asia and frozen fillets are popular in USA and Europe. It has great scope to create millions of jobs and generate income in addition to ensuring food and nutrition security if it could be aggressively promoted worldwide.

1. Introduction

1.1. Background

In 2015, United Nations have established 17 Sustainable Development Goals (SDGs) to be achieved by 2030 [2]. These goals are broad categories of all critical problems encountered by the humankind, their surrounding environment and overall earth's ecosystem. Each goal has its own destination along with milestones or indicators and also plan of actions. Amongst the problems the most important ones are poverty, hunger and malnutrition or unhealthy conditions. Therefore, goals 1, 2, and 3 are to reach to zero poverty, zero hunger and good health and well-being in about a decade's time. Similarly, other important goals are associated with access to education, gender equality, employment for all, conservation of natural resources and so on. Poverty is the main cause of all the other problems; therefore, the Goal 1 states that "end poverty of all forms everywhere". According to UN, over 2 billion people are poor who can't access to safe, nutritious and sufficient food, nearly 1 billion people are at the risk of starvation and 0.8 billion extremely poor in the world, regardless of where they live, even the richest countries do have poverty. Therefore, poverty reduction has been always the main goal of any program.

1.2. Food and Nutrition Insecurity

The SDG Goal 2 is "Zero-hunger" to be achieved by 2030; however, according to [1], 821 million people became hungry in 2017 as compared to 804 million in 2016. Similarly, 24% more people became severely food insecure in 2017 than in 2015 indicating that current efforts are not adequate towards achieving the goals. [1] has also alarmed that 22% i.e. 151 million children under-5 are still stunted [3]. Most countries in Asia are suffering from stunting problem of under-5 children. For example, Pakistan (45%), India (38.7%), Bangladesh (36%), Indonesia (36%), Nepal (36%) and others. On the other hand, obesity problem, caused by the habits of over-eating or eating unhealthy food items, is increasing in adults i.e. 13.2% from 11.7%, as well as in children i.e. 5.6% from 5.4%. Shortages of knowledge about health and nutrition is common even among educated people. Limited



availability, accessibility and affordability of food cause malnutrition and poor health and wellbeing of people. Food and nutrition security largely depend on poverty and employment.

1.3. Overall Impacts of COVID19

Covid19 pandemic has affected every walks of life directly or indirectly all over the world (Figure 1). So far it has infected over 40 million people and caused deaths of over 1 million people as of October 20th 2020. Sudden closure of country boarders, cancellation of international as well as domestic flights and transport systems, restrictions on group activities, shut down of businesses including markets, restaurants, hotels, tours, entertainment places and so on have resulted in massive food shortages, job losses and worst economic crisis which has given stress to the billions of people resulting in social unrest, suicidal cases and so on. It has brought big change as people have to either find mitigating actions or adapting new and stressful conditions so that their actions will again help to creating jobs and solving the food and economic crisis which are looming the world.

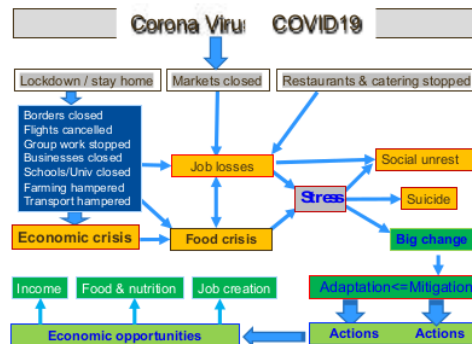


Figure 1. Impacts of COVID19

More specifically COVID19 pandemic is dramatically skyrocketing the above-mentioned figures/indicators of SDGs since early 2020 creating dismal situation. More information is yet to come but it has already added over 130 million to the previously estimated 821 million hungry people in 2017 [1] pushing about a billion people to go hungry by the end of 2020. Yet, no one knows how far COVID19 will go and what extent the problem will reach. However, the COVID19 has made clear to everyone is that food security is by far the most important to tackle. No matter how rich some countries, they might be not prepared to cope with the food shortages when such crises occur. Most poor countries might be more resilient in terms of food security because people try to produce almost everything, they need growing by themselves as buying from outside cost a lot. In the same way, within each country, poorer families in the rural areas might be more resilient as they tend to produce food by themselves with the need of limited amount of food to purchase. Therefore, COVID19 has taught the people that they need to find some ways to produce food at home; either in a backyard garden, at balcony or on the roof wherever is possible or nearby land. More importantly, each country or state needs to plan and explore various ways to produce adequate food for its people within the country or region to ensure accessibility and affordability of food. COVID19 pandemic has created a situation in which Goal 2 i.e. Zero hunger is the most critical as people around the globe are struggling to survive. Many solutions have been tried in different places and countries.

1.4. Impacts of COVID19 on Seafood Industry

Seafood plays tremendous role in food security as it is the staple food of over 3 billion people. Seafood industry engages over 60 million people and 85% of them are in Asia [1]. Globally, it is the no. 1 item among the animal protein sources. Approx. 156.4 million tons of seafood is consumed annually followed by chicken which is estimated at 133.6 million mt in 2019 [4]. According to the Food Outlook report of [4], over 37% of the seafood produced globally is traded valued at US\$164 billion across the borders in 2019 which was the highest amongst all types of food items traded. That was almost four times that of poultry or pig, and over 2.5 folds of that of bovine meat. and it was

doubling every decade in the past three decades. More importantly, out of the total trade volume, nearly 90% of the seafood export is from Asia. As seafood is the highest trading item, it has been affected the most by COVID19. Some countries are gaining but most countries are suffering from negative growth in trade due to COVID19 and often misunderstandings or wrong information spreading all over the world such as virus can spread via seafood, which has been proved to be wrong. Those wrong messages are spreading as the virus first started appearing in people working in seafood market of Wuhan, China. While many government and industry officials were trying hard to clarify, viruses were found in Salmon in Beijing as a result import of Salmon from Norway was halted. Even though, it was not the case and later found that virus was not from salmon but from the people who were handling it, Salmon industry worldwide lost over US\$4.3 billion [5]. Similarly, the top exporter of shrimp, Ecuador could not sustain its shrimp industry because of ban on export to China after COVID19. Similarly, India, the second exporter of shrimp to China is also struggling to find domestic consumption and markets.

Many fishermen stopped to catch wild fish because they could not sell to the markets. Markets were closed and also no vehicles were allowed to deliver. Several seafood restaurants around the world including UK, USA and other countries collapsed due to lack of customers and delivery of food items during the COVID19 pandemic. Many more forms of negative impacts on seafood value chain are occurring and more information is yet to come. On the other hand, retail sales of seafood are increasing as the most families prefer seafood as safer than terrestrial animal meats e.g. in the UK [6]. Nevertheless, all of these have clearly indicated that shortages of seafood in many countries and communities are really critical. It has big impacts on the health and immunity of the people to combat COVID19 as well as many other diseases. Therefore, seafood industry needs rethinking of local production, processing, marketing and consumption instead of depending too much on export markets.

2. Farming businesses

As any other problems, COVID19 pandemic has given some opportunities or even made compulsion to explore solutions through rethinking and reshaping the seafood industry, especially the ways to do the followings:

- plan for the production of food at home or nearby
- identify right species of choices among the hundreds of fish/shellfishes available for production
- choose the practical and most efficient method of production
- process, add value and extend shelf life of the products
- smart marketing and delivery
- formulate a plan to disseminate on a mass scale
- create awareness and technical supports to engage more people
- organize series of trainings to as many people as possible
- network and exchange/share experiences and ideas

Even before COVID19 pandemic, the countries which were producing enough food, over emphasis on commercialization driven by profits was making food unsafe to eat due to the use of haphazard use of chemicals and antibiotics during the process of production, value addition, transportation and storage. It was already an issue before COVID19. This situation was encouraging people to produce food by themselves in home gardens. COVID19 has pushed further and made almost clear that they need to do it. Therefore, enabling people in producing nutritious and safe food at home or nearby wherever they live should be the main strategy to solve the problem of food and nutrition insecurity so that they have access at any time they want. Growing vegetables at backyard gardens are quite common. However, they are not adequate to meet the requirements of macro- and micro-nutrients and demand for animal protein. Therefore, farming of fish integrating with vegetables recycling the water between them could be the best option. Fish is the best medicine for malnutrition as they are rich in protein, lipids, vitamins and minerals [7]. Depending upon the body size and activities, approximately 60-100 g would be adequate to fulfill the daily needs. Most of the fishes can be easily produced using small spaces and little inputs in combination with vegetables, rice and others. There are a number of ways,

people can use to produce either fish only or in combination with vegetables, fruits and other crops or even livestock.

2.1. Aquaponics

Aquaponics is one of the best solutions to the produce a varieties of food items including fish and shellfishes. It is system of growing fish and vegetables together in water reusing the wastes and uneaten food of fish by vegetables as sources of nutrients or fertilizers. Water from the fish tank comes with wastes to the plant growing area which is up taken by plants filtering the water to go back to the fish tanks again and again. Growing only vegetables in water without the use of soil is hydroponics which requires chemical fertilizers or mineral solutions as external inputs which adds to the cost. Whereas in aquaponics, wastes from fish tanks can serve as fertilizers. In a simple aquaponic system, in an average 2-3 kg vegetables per m² is possible to produce and whereas about 20 kg fish can be produced in 1 m³ of water volume i.e. 1,000 L [8]. Production depends on the fish species and the vegetable type. Suitable species of fish which can grow well at high densities is tilapia, pangasius, catfish, common carp, trout, shrimp/prawn. Among them, tilapia i.e. Nile tilapia (*Oreochromis niloticus*) and its hybrids such as red tilapia. Over a hundred of vegetable species can be grown such as basil, eggplant, lettuce, Chinese kale, tomatoes, and immunity boosting spices such as ginger, garlic, garlic, mint, coriander, and so on. Figure 2 shows the system which can be installed in a small space in backyard garden, balcony or on rooftop where electricity is available 24 hours along with a backup DC generator. Simple tap water can be used to fill at first and top up 10% weekly to compensate the losses. There is need to understand fully to run this system. More descriptions are available in FAO manual by [8].

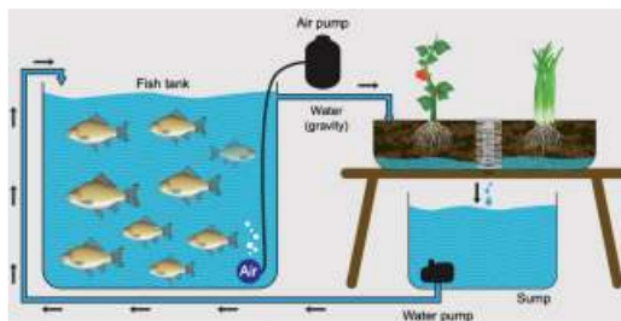


Figure 2. Simple aquaponic system (source: Somerville, 2014) [8]

2.2. Recirculatory Aquaculture System (RAS) and Biofloc Technology (BFT)

Where water is scarce, fish can be cultured in tanks with limited water recirculating after filtration which involves includes separation of coarse materials by gravel and sand filtration and also conversion of toxic ammonia (NH_3) into nitrite (NO_2) and then to non-toxic nitrate (NO_3) through with the help of nitrosomonas bacteria and nitro-bactor respectively. In this system, water has to be replaced by new water after certain intervals when nitrogen waste builds up at high level in the whole system. This means, all nitrogen remains as waste, unutilized and thrown away as sludge (Figure 3, left). In this system, complete feed is given to the fish to fulfil its requirements. It can be costly. Therefore, recently, biofloc system has been developed in which the nitrogenous wastes are utilized to produce microbial protein by adding starch or carbohydrate sources (C:N ration 1:10-1:20) so that bacteria can grow and gradually, microbes form consuming bacteria. They clump together in the water which is called biofloc that is the natural food for fish. Biofloc technology should be; therefore, cost effective as nitrogenous wastes are converted into microbial protein (Figure 3, right and Figure 4). In this system, water is not necessary to change.

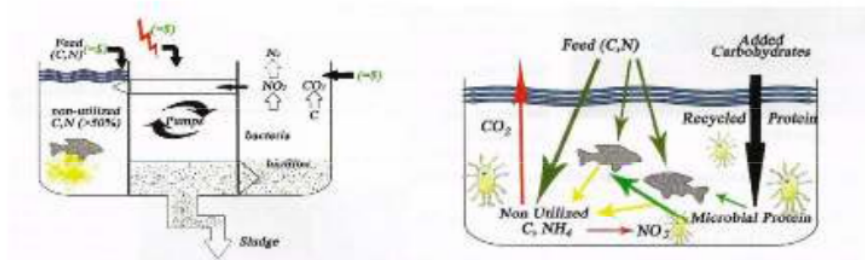


Figure 3. Schematic diagram of RAS (left) and Biofloc (right) systems (Adapted from Avnimelech et al 2014 [35])



Figure 4. Tilapia in a Biofloc system Iran

2.3. Cage culture

Cage culture of fish can be very useful where natural or communal water bodies are available such as lakes, canals, rivers, reservoirs and so on (Figure 5). As it does not require purchase of expensive if the water bodies are available for leasing to the farmers. In most of the cases, landless people, especially traditional fishermen, are given opportunities to raise fish as occupation [9]. Suitable species of fish to culture at high densities are tilapia, pangasius, carps and others. As tilapia grows fast and can tolerate high density, also utilize natural food, it has been widely used for cage culture around the globe. Most farmers use standard size of cages either 5m x 5m or 6m x 4m with 2m in depth. They stock about 2,000 juveniles (30-40g)/cage. Farmers harvest about 1 ton in 5-6 month with the size ranging from 0.6 to 1 kg. A cage gives approximately one ton of fish and US\$1,000 net profit/crop [10]. More recently, with the increasing demand for tilapia and its expansion of farming, there is an increasing trend of using large and circular cages extensively used for salmon to produce in large volumes such as in Indonesia, Malaysia, Zambia, Zimbabwe and others. These cage diameters often reach over 20m and production up to 100 tons per cage.



Figure 5. Series of cages in Mekong River (left) and in a reservoir (right) in Thailand

2.4. Pond culture

Tilapia can be easily cultured in ponds where land is available without any input to harvest less than 1 ton per year. If pond is fertilized making water green (Figure 6) with chicken or [22] manures at the rate of 1 ton/ha once at the beginning productivity can be increased to 1-2 ton fish ha⁻¹.year⁻¹. Weekly addition of urea (60 kg.ha⁻¹) and triple superphosphate or diammonium phosphate (30 kg.ha⁻¹) in addition to manures, tilapia [16] production can be increased to 3-4 ton.ha⁻¹ [11]. It is possible to produce 5-6 ton.ha⁻¹ per year by feed at the rate of 1-2% of the fish biomass d [23] as supplemental feeding especially later part of grow-out [12]. For these increased productivities, stocking densities have to be increased from 1 to 5 fingerlings.m⁻² with the gradual increased in inputs from zero inputs to more fertilizers and feeds. Stocking density could be raised twice with emergency aeration (early morning 3-6 am and 1-4 pm) to achieve 3-4 times higher productivity if electricity is available at lower costs or subsidized by the government. More intensive farming can be done in ponds with continuous or 24 hours aeration with higher rate of feeding 4-6% biomass daily to harvest 40-50 ton per ha; however, input costs have to be worked out.



Figure 6. Small-scale pond fish culture in Nepal

2.5. In-pond raceway system (IPRS)

Productivity of pond can be further enhanced by creating a raceway system within a pond. A corner of a pond is modified in a series of 3 or more parallel narrow concrete tanks depending upon the target production (Figure 7) [13, 14]. A small pond of 0.4 ha can have four raceway tanks of 12.2 m x 3.1m x 1.2 m which receive the water by a pump of 2.5 HP for each raceway tank. Two more 1.5 HP pumps are needed to move the water at the two corners of the pond. Based on a study by Aranna et al, [14], when 17,000 tilapia fingerlings of 18g size were stocked in each of the concrete tanks of 150 m³ (25m x 5m x 1.2m), it was possible to harvest 57 kg.m⁻³ space of race way tank in about 125 days. The size of pond may range from 0.5-2 ha.



Figure 7. IPRS adapted from Brawn et al [13]

2.6. Integrated farming

Rice is the staple food of Asia it is the main crop to grow. As most of the rice need water to grow, rice field can be good for fish as well. Traditionally fish are caught from the rice field especially during summer when fish migrate up streams for breeding reaching to rice fields. However, due to excessive chemicals and pesticide use in rice, fish may not survive in rice fields. Therefore, growing fish would help farmers to grow rice organically as they have to stop using them. At the same time, it will help produce fish for family consumption and also for sale. As shown in Figure 8, fish can be grown in trenches (1-1.5 m deep and 2-3 wide) dug around the rice field or simply installing hapa nets (10 m² or larger in size depending upon the need) at a corner where rice is not growing well [11]. In addition, vegetables and fruits can be grown on the dikes using the water from pond to irrigate them. At the same time, cattle, buffalo, goats and sheep can be raised to graze the grasses of the dikes (Figure 9).



Figure 8. Rice-fish integrated farming



Figure 9. Integrated farming in Vietnam (Courtesy Prof. Peter Edwards)

2.7. Comparison of systems

Among these production systems used for tilapia, pond culture is the cheapest and can be done using various degrees of inputs ranging from extensive to highly intensive system. However, requirement of a large area of land with sufficient water is a big constraint. Land is the limiting factor. It may not be available in most comfortable place. If it is available, its price can be prohibitively high if a person needs to purchase. Normally, land is available in rural areas, far away from road which creates problems of transportation for the inputs to bring in and also products to take to the markets for sale, lack of labour, and unwillingness of technical managers to work in remote areas. Therefore, alternative methods are needed to be explored that do not require any land at all, or if require small piece of land would be adequate. For example, land is not required for cage culture. It can be done in communal ponds, lakes, reservoirs and slow flowing rivers. Therefore, landless people can also raise tilapia installing cages. num However, government may arrange licensing or permit system. Relative advantages and disadvantages of each system against others are shown in Table 1

Table 1. Relative importance of various systems in terms of resources, inputs and outputs

Systems	Land required	Water use	Feed use	Wastes production	How cost	Productivity	Risk level	Power needed	Profit potential
Lake/sea	-	++++	-	-	+	+	-	-	+
Pond	+++	+++	+	+	+	+	+	+	+
Aquaponics	+	+	++	+	+++	++	++	++	+++
Cages	-	++++	+++	+	++	+++	++	-	+++
RAS	+	+	+++	++	+++	+++	+++	++	++
Biofloc	+	+	++	+	++	+++	++++	+++	+++
Aquamimicry	+	+	++	+	++	+++	+++	+++	+++
Raceway	++	+++	+++	++	++	++++	++	+	++
IPRS	++	++	+++	++	+++	++++	+++	+++	++
Rice+fish	++++	+++	+	+	+	+	+	+	+
Rice+animals	+++	++	+	+	++	++	++	+	+++

2.8. Tilapia for aquaculture

Although there are over 300 aquatic species farmed in different parts of the world; only few are commercially important ones with large scale production contributing food and nutrition security as they are consumed by people in producers and also traded globally. According to [1] and [15], major four species in terms of volume are tilapia (6.5 million mt), shrimp (4.45 million), salmon (2.6 million mt) and Pangasius (2.4 million mt). Global production of 6.5 million mt tilapia means only about 1 kg per capita. There is plenty of room to increase its consumption if its culture is expanded to produce more. As tilapia is relatively cheap, majority of produce is consumed where it is produced and also it is traded cross boarder contributing to food and nutrition security worldwide. Those countries which are producing more are having more consumption. Although, tilapia is considered aquatic chicken and it is following the same path as it becomes as common as chicken in terms of farming method, feeds and feeding, and its genetic improvement which have brought significant improvement in growth, reducing feed conversion and shortening culture period, its annual production (6.5 million ton) is still way behind as compared to the chicken production (133.6 million ton). Therefore, tilapia research and development (R&D) has a long way to go to compete. It can even grown in saline waters [16]. Its potential is still unexploited [17]. There is a need to increase the number of farmers and size of farms and the number of hatcheries to supply high quality seed.

2.8.1. Good price for nutrients

In various parts of the world tilapia is considered poor men's fish. It can be cheaply produced often less than a US dollar.kg⁻¹. Selling price is US\$1-3 kg⁻¹ of fresh tilapia. Cheap fish is good as many poor people can afford and also competitive price for export. Fish is cheap but it still contains the same level of protein, minerals and vitamins. It actually contains higher protein than salmon [7]. Only omega-3 is relatively low but still it can also be enhanced through feeding and growing in green water systems [18]. However, it also contains higher level of many other nutrients as compared to other species [7] e.g. 100 grams of tilapia contains 94 calories, 19 g protein, 2 g fat (but no saturated fats) and 0 carbohydrates. In addition to these, tilapia is rich in niacin, vitamin B12, potassium, selenium and Phosphorus.

2.8.2. Low in food chain

Tilapia is easy to growth as it can grow well in a wide range of farming systems varying from very small ponds in backyard garden to highly intensive commercial feedlot systems with floating pellets [12, 19, 20, 21]. The required inputs such as seed, feed, equipment, technologies and human resources for tilapia are well-developed and easily accessible. More importantly, they graze on mostly phytoplanktons which are abundant in green water in fertilized ponds and are low in food chain [22,

23]. They are favored by the relatively poor farmers. They can also utilize commercial pellets and grow fast that enables farmers earn in a short period.

2.8.3. Improved broods

There are many types of genetic resources in case of tilapia [24]. It has many improved broods or gene pool developed using selective breeding. For example, Chitralada strain from Thailand promoted by the Late King of Thailand promoted after receiving from Japanese Emperor. Some of these have also been gifted to the Sultanate of Indonesia and the former King of Nepal. Similarly, genetically improved farmed tilapia (GIFT) was developed through genetic work crossbreeding of eight strains of tilapia by WorldFish (Former ICLARM) [25, 26]. Similarly, many other types have been produced by most large hatcheries. Some of these types are already running on nearly 15-20th generations, which have been improved growth and other desired traits each generation. Fast growing broods are easily available.

2.8.4. Seed production and technology

Availability of high-quality seed is the key to success. AIT developed model hatchery system that is capable of producing millions of fast-growing mono-sex fry monthly and has commercialized [27, 28]. It is now spreading all over the world from Fiji through to Mexico. Hundreds of such hatcheries have emerged which supply well over a billion fry annually in some countries e.g. Bangladesh and Thailand [29, 30]. Recent research and development on various aspects of farming such as production of monosex fry their feeding and others have contributed to the expansion of its farming [11, 31].

2.8.5. Tilapia aquaculture an expanding business

Tilapia farming is rapidly expanding business. Globally about 7 million mt tilapia, mainly Nile tilapia and its hybrid, is produced annually which is now the highest while considering individual species well ahead of Grass carp, Silver carp and Common carp. PR China produces over 1.7 million ton per year followed by Indonesia and Egypt. Indonesia overtook Egypt from where Nile tilapia originated and became the second largest producer in the world boosting its production to over 1 million ton annually. Remarkable success of new species introduction of Nile tilapia has been in Bangladesh and Thailand. Thailand, the Philippines, Myanmar, Vietnam, Laos are among the Asian countries. Colombia, Cote D'Ivoire, Ghana, Kenya, Uganda and Zambia are the major tilapia countries in Africa [32, 11, 33]. Tilapia has contributed a lot and has still more scope to contribute to the food and nutrition security [34].

Global production of Nile tilapia including its hybrids is almost tripling in each decade and expected to reach over seven million mt by the end of 2020. Its production has surpassed those of highly traded and high value species; namely, salmon and shrimp. Its production growth was fastest among the major commercial aquaculture species during the last three decades. It has become number one species while comparing individual species such as grass carp, silver carp, common carp and others [34]. Its growth took off after mid 90s especially when mass scale high quality monosex seed technology was commercialized. Although, tilapia is considered aquatic chicken [36] or an alternative to chicken, annual production of tilapia is way behind the annual production of chicken (133.6 million ton) [4]. Therefore, it has a plenty of space to growth further in terms of production and consumption.

3. Processing and value addition

Except some air-breathing aquatic animals which can survive for long and sold as live, most are perishable. In most of part of Asia, people like live and fresh fish. However, it can be costly to keep live and fresh for long. People struggle to keep them alive especially in local markets and restaurants. Vendors often sell live and fresh just harvested fish on the site or rush to the nearby market. Quite often, middlemen or women may order or buy larger fish on cash or even on loan so that they can carry them on head, by bicycle, motorbike or pick-ups and walk along the road in villages or towns selling fish. If they need to keep longer then they will keep on ice partially covered. However, if the items are processed, they can be kept for long which helps reduce wastages and also make it available to the people at any time they like to prepare and eat that ensures better food and nutrition security. During COVID19 lockdown period, people around the world stockpile the food items which they could for long such as frozen seafood, canned, dried, smoked and so on. Tilapia can be easily

processed using various traditional and modern methods [11] to make many products which are described in this section.

3.1. Chilled and frozen items

Chilling is simplest way keeping fish at the temperature below 10°C. It can reduce microbial activities considerably so that the products are not rotten. It is quite common when aquatic products need to keep few days before selling using refrigerators during storage and especial modified vehicles as chillers for transportation. Fish can be stored in refrigerator (4-10°C) for a week or so. Therefore, it can't be for long. Using temperature 0°C at which almost all the chemical, enzymatic and bacterial activities drops to zero. Frozen seafood very popular as it can preserve for long without altering quality. Simply keeping in deep freezer part of refrigerator below 0°C helps to avoid rotting for a month or longer. However, there are many other methods and machines for commercial purposes e.g. blast freezing, which freezes the products within 10 second that can be stored up to 6 months or even more. As a result, it is possible to transport long distances or even across the globe. Whole frozen and fillet frozen tilapia are exported to US and Europe from Asia. Similarly, frozen shrimp, salmon and pangasius are sold worldwide.

3.2. Sun-dried fish

Tilapia can be easily dried keeping in open area under sun during sunny days where sun light is strong enough to evaporate the moisture. This traditional method can used when the fish can't be sold fresh. Improved methods are also found by special solar drier using box type or making tunnels covered with glasses or white plastics through which sun light passes and heat the air which can go out with slowly passing through the fish. It is possible to raise the temperature of 70–80°C using good solar drier.

3.3. Dry fish and snacks

Traditionally, drying along with smoking, is being done using simple firewood. Nowadays, electrical machines are available which can raise temperature to 100°C or higher to reduce the moisture to 8-12% that can limit the biological activities and chemical reactions. Skin of the fish is dried with some spices to produce crunchy fish skin snacks with desired tastes similar to potato chips utilizing the wasted products but still better in terms of nutrients as compare to potato chips.

3.4. Smoked fish

It is probably the most common but traditional method. Smoking raise temperature to 70–80°C which can kill most of the bacteria and viruses. Wet and unripe wooden can be used to produce plenty of smoke. It may destroy also the nutrients. Fats absorb flavor of smoke easily or quickly, but it also decreases fatty acids including omega-3s during the smoking process [37]. Cold smoking is less destructive as the smoke is passed through low temperature i.e. 28–32°C. Cold smoking also help maintain the freshness of products while reducing the food pathogens significantly.

3.5. Salting and marinated fish

Addition of salt, and other spices, help preserve foods as bacteria or virus can't survive at high concentration as the water content from their body is sucked out by reverse osmosis. Salted food can have long self-life. However, it can be too salty and need to consider while cooking.

3.6. Fermented fish

It is a traditional method of lowering the pH i.e. below 4.5 to stop the growth of lactic or acetic acid. The method is used to produce various types of pickles and pastes from aquatic animals in Asia. They often ferment whole fish, which produces normally putrid smell but some traditional communities in rural areas like it. It is one of the easiest methods for preserving food for long.

3.7. Canned

It is the safest method of food preservation. Well-cooked fish is kept inside the strong metal container called "can". This method is done at industrial scale as it requires sophisticated process involving preparation of raw materials, pre-cooking, filling, exhausting, sealing of the container and washing then heating. It is costly but well-prepared canned fish can be kept for a year or even longer and transported to any distance. Consumers can buy in bulk and enjoy any anytime they like that ensures food security.

3.8. Packaged products

Modified Atmospheric Packaged (MAP) Fish is becoming popular nowadays especially in superstores. In this method, fresh, processed or cooked fish is placed in air-tight enclosures or packets, mainly in plastic bags, foam boxes, glasses, metals etc. in modified gaseous environment by pumping out the oxygen (O₂) or adding nitrogen (N₂) and/or CO₂. Presence of oxygen helps micro-organisms survive and grow but its absence creates anaerobic condition whereas infusion of nitrogen or CO₂, either destroys micro-organisms or prohibits their growth.

3.9. Tilapia ice cream

In the Philippines, tilapia ice cream has been produced and sold [38]. As ice cream has limited protein, addition of soft and smell-less steamed tilapia meat can make the protein available to people especially children who need protein the most and they like the ice cream. Smart ideas like this could help minimize the child malnutrition and stunting which is required in some countries such as Pakistan, India, Bangladesh and Nepal where over one third of under-5 children are stunted.

4. Major challenges

4.1. Acceptance of farming

There is a tendency of young and educated people look for job in cities in clean offices. Working in the field doing agricultural and fisheries related work are neither regarded as prestigious occupation nor they are considered as profitable businesses. Therefore, government have to promote and provide some incentive and supports.

4.2. Human resources and technical supports

Majority people who have lost jobs due to COVID19 are simple labourers or factory workers who may not have adequate knowledge and basic understanding of biological systems. Another target group should the newly graduates looking for jobs. The above-mentioned systems are highly technical; therefore, only well-planned and organized training can help them to set up and run the systems. At the same time, government officials or trainers have to have adequate knowledge to train them and also provide continuous supports on regular basis. Therefore, two types of trainings are needed; training of trainers (ToT) and training of farmers (ToF).

4.3. Financial supports

As most of the job losing people due to COVID19 pandemic may have financial hardships to invest on business, they will need capital investment. Government has to arrange low interest loan or interest free loan so that there wouldn't be a problem. At the same time, some of them may receive their accumulated allowances or privileges and may be willing to invest. The practical ideas described in this paper would be very useful.

4.4. Sustainability

Sustainability of the business start-ups will depend on the profitability and opportunity cost. In case, COVID19 crisis is over, they may be recalled and offered by their companies which they might have laid off. If they tend to return to their jobs, sustainability of these start-ups might have problems to sustain.

4.5. Consumer acceptance for tilapia

Many middle class and rich people did not or are not eating tilapia due to the mind-set that tilapia is cheap and poor man's fish. This notion is gradually changing as people will know gradually that it has even high level of protein content [7] and many other nutrients in the meat including that of salmon. Branding may help to boost its image e.g. Thapthim is a brand name of red tilapia in Thailand which has created its own market and fetches higher prices as common people do not consider it is actually a type of tilapia [11]. Recently, tilapia fin has been used to make a soup which is an effort to replace shark fin soup in Taiwan.

4.6. Markets and prices

Production cost of tilapia may vary from less than a US dollar kg⁻¹ to US\$1 or so and are sold normally at US\$1-3/kg of fresh tilapia. In some countries, consumers pay up to US\$7 for a kilo of fresh tilapia. Low price is good as it enables poor communities to afford nutritious food and makes it competitive for export. Even the price may be low, but it still contains the same level of protein, minerals and vitamins [7]. Only omega-3 is relatively low but still it can be enhanced through feeding

and growing in green water systems. A wide range of culture systems have been used to grow tilapia in cages, ponds, and tanks. Monosex culture has greatly contributed to high volume production.

4.7. Low omega-3 fish image

Questions have been raised about its low level of omega-3 fatty acids. However, the main purpose of producing and supplying fish is for the protein, which is the main concern in rural areas and the developing countries. It is common that all freshwater fish species have low in omega-3 fatty acids and higher in omega-6 fatty acids. Interestingly, tilapia grown in green water, which is common practice in developing countries, has relatively higher level of omega-3 fatty acids as compared to the ones grown in cages with complete feeds [18].

4.8. Off-flavour

Tilapia grown in excessively green, turbid or murky water with excessively high anoxic environment may develop muddy smell fish which is known as "off-flavor". The smell is from the presence of geosmin and other chemicals produced by blue green algae or cyanobacteria. Off-flavours are typically caused by geosmin (GSM) and 2-methylisoborneol (MIB) formed as secondary by products of bacterial metabolism [39]. If off-flavours occur, several multiple methods may be tried to remove or decrease GSM and MIB in tilapia which may include ozonation, advanced oxidation processes (AOPs) and adsorption removal from water using activated carbon and/or zeolites. For the time being, purging with clean water or 3 ppt saline water keeping them at least 16 days has recommended as efficient method by the farmers [40].

5. Conclusions and recommendations

COVID19 pandemic has tremendous negative impacts on food and nutrition security of the people around the globe due to job losses, obstruction in the group activities required for the production, processing, storage, and transportation of food items including seafood. This pandemic has given good signals that every family, community or the country needs to plan for food and nutrition security enabling to produce in backyard gardens or nearby home or within the districts/province and make food accessible at any time. Simple growing fish in rice fields and producing fish and vegetables using aquaponic system could have tremendous supports. Similarly, highly intensive but efficient and productive farming systems such as biofloc, IPRS and other forms of integrated farming could be good options which could be done locally re-cycling wastes to produce highly nutritious food. Among the protein source, tilapia and its farming could be aggressively promoted and expanded it could contribute greatly to the food and nutrition security of the people globally especially at a difficult time of COVID19 and in similar situation in the future occur time and again.

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