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THE COVID-19 EFFECT ON FISHERIES AND AGRICULTURE

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The worldwide COVID-19 pandemic had a major impact on various sectors, including agriculture, horticulture as well as fish and shrimp farming business. The corona pandemic will interrupt fisheries operations and supply in a variety of ways, including crop harvesting, processing, procurement, as well as marketing. Imports and exports are growing more slowly, and in some cases have stopped entirely. COVID-19's spread had both direct and indirect implications on worldwide economic development.

The World Health Organization (WHO) proclaimed the Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2) and COVID-19 pandemics in March 2020. Since its discovery, the virus has spread fast and widely, killing millions of people (Guan *et al*., 2020). The COVID-19 pandemic has a long-term impact on the four major dimensions of food security: availability, accessibility, use, and stability (Laborde *et al*., 2020). The corona outbreak will interrupt fisheries operations and supply in a variety of ways, including harvesting crops, processing, procurement, and marketing. March through June is the prime season for fish farming and shrimp farming, which will be affected by a lack of migrant workers. A lack of fish seed, fertilizer, and other inputs may also impede the required level of output. Reduced supply, transportation difficulties, and the closure of various restaurants and shopping establishments will have a significant impact on suppliers and manufacturers. Due to the failure of supply networks, many farmers are unable to sell their crops correctly, resulting in enormous losses.

The COVID-19 prevention

In those civilizations, COVID-19 preventative measures like lockdown, stay-at-home orders, mass quarantine, and transportation halt are extremely difficult. Imports and exports are moving more slowly, and in some cases have ceased entirely. Because of the lockdown imposed in numerous countries, the transport sector has also ceased operations, disrupting the supply chain for vital items, including food (Reardon *et al*., 2020) and humanitarian supplies supplied by various organizations.

Food Sectors

Agriculture, fisheries, and aquaculture have already experienced serious economic consequences and job losses as a result of decreased production capability and disturbed distribution channels (FAO and CELAC 2020). Food insecurity, like the virus, will disproportionately impact disadvantaged groups; thus, potential disruptions to food production and supply networks remain a major concern (Gregory *et al*. 2005).

Impacts on the Fisheries Sector

The fisheries sector employs about 14 million people in India, with the COVID-19 epidemic affecting the livelihoods of over 9 million active fishers, 80 percent of whom are small-scale fishers. The nationwide lockdown has had a significant impact on both the capture as well as culture fisheries sectors. Transportation, migrant labour, and trade disruptions have all had an impact on the supply chain for aquaculture and aqua-food products. Due to transportation constraints, shrimp seeds were scarce, feeds, liming material, and related aquaculture materials (e.g. aqua drugs). Restrictions and closures of national and international markets, as well as the foodservice sector, including restaurants, hotels, catering services, and school/office canteens), led to a dramatic drop in the market, consumer preferences, and the post-harvesting processing sector. This circumstance has a significant impact on the majority of women working in the post-harvest economy. Small-scale fisherman confronts grave danger in coastal India, where a day's catch buys that night's dinner (Mohanty *et al*., 2020).

Impacts on the Agriculture Sector

Normal life has been severely disrupted as a result of the country-wide lockdown, with approximately 50–60% of all agricultural activity halting. More than half of India's

workforce works in agriculture, fishery, and related industries. Food systems present a risk, and agricultural expansion may slow in the medium and long run. Due to social distance standards, agricultural labourers were unable to continue work and were obliged to reverse their journey. With fewer than 2 hectares of land, about 85% of Indian farmers are small and marginal, relying primarily on seasonal crops. In most parts of India, the summer/rabi crops were ready for harvest when phase-I of the lockdown brought everything to a halt. Plantation crops like bananas, coffee, and pepper were harvested at this time. The harvest of summer/rabi crops was postponed due to COVID-19 and the lockdown, mostly due to a lack of workers, machinery (tractors, harvesters, threshers, etc.), social-distancing norms, and travel/movement restrictions. Farmers who produce perishable items like fruits, flowers, and vegetables, in particular, suffered massive losses.

Conclusion

The nationwide shutdown has had a significant impact on both the catch and culture fisheries sectors. Agriculture employees were unable to return to work due to social distancing conventions, forcing many to reverse migrate. Transportation barriers and worker movement limitations will have a direct impact on the farming and processing industries. The global pandemic of COVID-19 has had a particularly devastating effect on food supply chains. COVID-19's spread had both direct and indirect implications on worldwide economic development.

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ADVANTAGES AND DISADVANTAGES OF OXYTOCIN INJECTION IN MILCH ANIMALS

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As a developing country, India depends mostly on agriculture and its livestock population. In India the livestock sector employs about 8 percent of the total population. India ranks one in terms of total livestock population as well as total milk production in the world. India contributes about 22 percent of the total global milk production. The increase in the demand for milk, has resulted in rampant use of various exogenous chemicals. One such incidence is the increase in the oxytocin supplementation. Oxytocin has been derived from the Greek word, which means quick birth. It is a peptide hormone synthesized in magnocellular-neuro-secretory-cells in supraoptic and paraventricular hypothalamic nuclei and stored in the posterior pituitary lobe then released in the blood as a result of a neuroendocrine reflex. It is transferred to the posterior pituitary after proteolytic processing and disulphide bond assembly Oxytocin is packaged in granules, then transported down with posterior-pituitary-gland axon and excreted to the systemic circulation with carrier protein, the neurophysin. Oxytocin, a neuropeptide, has 125 amino acid precursor. Apart from brain, Oxytocin is also synthesized in various other tissues and organs, including the uterine epithelium, ovary, testis, vascular endothelium and heart. It is now known that Oxytocin elicits its biological actions by binding to G-protein coupled receptor. In structural terms, oxytocin is a nano-peptide wherein the first cysteine residue is disulphide bonded to the 6^{th} cysteine, thus creating partial cyclic peptide. The disulphide bridge in Oxytocin is essential for its interaction with the receptor and thus for biological activity.

Functions of Oxytocin

The oxytocin acts as the primary hormone for the ejection or let down of milk. Oxytocin is also involved in the process of parturition and in the management of post parturient uterine prolapse. It is used for the management of inevitable abortions and for the

induction of abortions therapeutically. It is used for the treatment of cases like breast engorgement and mastitis, in the cases of agalactia and retention of fetal membrane. The release of oxytocin during suckling is to reinforce maternal behaviour. Oxytocin has insulin-like activity in that it stimulates lipogenesis and increases pyruvate dehydrogenase activity. Oxytocin released during milking or suckling is to increase peripheral concentrations of lipids as part of a mechanism designed to replenish the lipids "lost" during milking or suckling. Moreover, prolactin and oxytocin are released during suckling and milking, and both prolactin and oxytocin have been implicated in regulation of fluid and osmotic balance.

Exogeneous Oxytocin Analogues

In order to duplicate the hormone and create an artificial drug Oxytocin (Syntocinon) was developed in 1953 by Vincent du Vigneaud. Other analogues used are Pitocin, carbetocin etc. The dose rate for Oxytocin in case of cattle for uterus inaction, milk ejection, mastitis, uterus involution is 40IU(I.M./S.C.) or 2.5-10 IU(I.V.). While in case of sheep and goat , exogenous oxytocin is used for milk ejection and uterus involution at the dose rate of 10-20 IU (I.M./S.C.) or 0.5-2.5 IU(I.V.), and in the case of uterus inaction, it is 10-20 IU (I.M./S.C.) or 0.5-2.5 IU(I.V.).

Milk Production and Oxytocin

Lactation consists of two phases: milk secretion or synthesis, which is controlled inpart by a hormonal complex originating in the anterior pituitary, and milk removal or (ejection), which is controlled primarily by oxytocin release from the posterior pituitary.

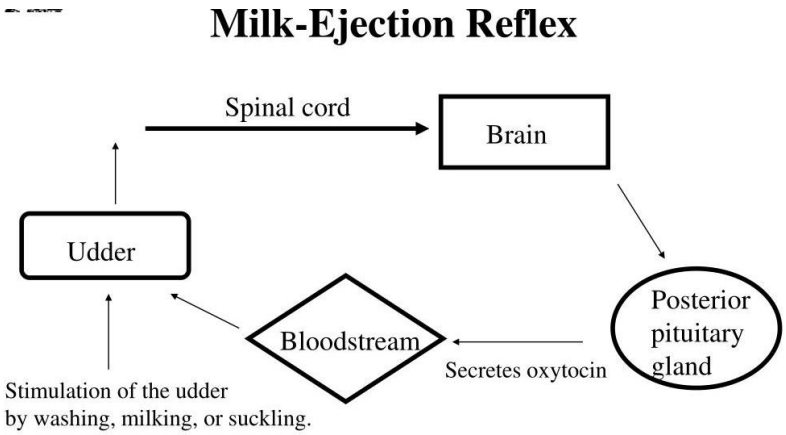

Fig 1: Milk Ejection Reflex

The receptors for oxytocin are present in the smooth muscle cells and myoepithelial cells. The contraction of the myoepithelial cells result in the ejection of milk from mammary ducts. The receptors for oxytocin are also present in the myometrium and endometrium which gets activated at the end of pregnancy. The half-life of oxytocin is given by 2-8 minutes.

Basal concentrations of oxytocin decreased from early to middle lactation, increased from middle to late lactation, and further increased from late lactation to the dry period.

Advantages of Oxytocin Injection

Effect on milk production: There is an increase in milk production. There is increased gland milk output rather than residual milk removal. It is obvious that total evacuation of the udder during milking so that there is no-residual milk reduced production-losses which occur when using once a day milking, while ↑ the rate of milking was found ineffective in reduction of losses. Exogenous oxytocin injections at non-milking times ↑ the milk yield and improved galactopoiesis (maintainance of milk production). Thus, oxytocin influences cell maintenance and mammary metabolism in addition to its traditional role of facilitating milk let-down. The use of oxytocin to promote milk let-down, in particular when the glands are engorged with milk, can prevent udder damage and promote udder health.

Effect on milk composition: Chronic oxytocin administration has also been shown to increase electrical conductivity and SCC of milk as well as lactose and K levels in the systemic circulation.

Effect on reproductive health: Oxytocin is related to the reproductive process causing the womb to contract. Similarly, an oestrogen dominated myometrium such as is found at ovulation and at parturition, seems more responsive to oxytocin, and as a result, it causes greater contraction of the uterus. The release of oxytocin at that time is associated with subsequent myometrial contractions and appropriate stimuli that assist the transportation of sperm to the oviduct at copulation and helps in the expulsion of the foetus at parturition; hence plays an important role in the completion of the fertilization and parturition process. Oxytocin is also secreted into the blood in both females and males also at the sexual orgasm.

Disadvantages of Exogenous Oxytocin

Effect on milk production: Milk let-down without administration of oxytocin seems to be difficult in the animals which regularly exposed to oxytocin injections as they become habitual to the drug. While repeated administration of oxytocin injections therefore interferes with the normal mammary epithelium milk secretary activity thus inhibits the normal milk ejection process and affect reproductive health. Thus a disadvantage of oxytocin injection was that its continuous usage could lead to addiction and lack of response to normal milk ejection stimuli.

Effect on reproduction: It is believed that the prolonged use of oxytocin injections also causes fertility disorders like poor oestrus signs, reduced lactation period, lower conception rate and high embryonic mortalities. Delayed puberty, lower conception rates, increased abortion rates, lower pregnancy chances, delays in the duration of placenta expulsion, ovulation interval, shortened postpartum oestrus interval and calf death soon after the delivery because of poor quantity and quality of milk have also been observed.

Effect on human health: Oxytocin produces its desired effects in minutes and then is readily metabolized in inactive products. It is mostly secreted and ingested along with the milk, it is efficiently degraded by gut enzymes so can't reach the blood circulation in biologically active form. However ,it has been believed to have harmful effects when milk with oxytocin is consumed by humans. For example, oxytocin in milk and dairy products, the age at which girls attain menarche has come down drastically from 16 years of age to 10 years of age. Gynaecomastia (breast enlargement) is diagnosing even in boys due to oxytocin affects. Due toIt is clear to have imbalance hearing and weak eyesight in children due to oxytocin. Pregnant women should avoid such milk or don't use milk without proper boiling. The use of such milk by the pregnant women may lead to abortion. And babies may born with deformities and low immunity levels. Use of such milk also increases the risk of haemorrhage in mothers after birth.

Conclusion

Since oxytocin is mostly known for let-down of milk , extensive use of oxytocin to increase the milk yield has let to harmful effects on the animals. There has been reduction in response to natural stimuli for let -down of milk. Moreover, the action of hormone causes the uterus of the cattle to contract, causing immense pain. Due to these reasons of extensive

unethical use of oxytocin injection, Oxytocin is **banned under Section 12 of the Prevention of Cruelty to Animals Act (1960)**. According to Food and Consumable Substances Adulteration Act and the Drug Control Laws cannot be sold without a prescription from a registered medical practitioner. Thus, judicious use of exogeneous oxytocin supplements with proper consultancy can be helpful in terms of milk production as well as animal health.

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CURRENT AND FUTURE CONCERN OF GHOST FISHING GEAR TOWARDS THE SUSTAINABLE MARINE ECOSYSTEM

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Ghost fishing refers that derelict fishing gear (DFG), either lost or abandoned, remains their capture function in water and continue inducing mortality of aquatic organisms without human control. Commercial fishing nets that have been lost, abandoned, or dumped at sea are known as ghost fishing. Every year, they entangle or trap millions of marine species, including sharks, rays, bony fish, turtles, dolphins, whales, crustaceans, and birds, and kill them. Ghost nets entangle living coral, suffocate reefs, and introduce parasites and exotic species into reef habitats, causing more damage.

According to the United Nations (2009), approximately 650000 tonnes of fishing equipment are discarded in the ocean each year, including fishing nets, lines, cages, crayfish traps, and gill nets. At a rate of one tonne per minute, accounting for 10% of all plastic waste in the ocean and sea worldwide, according to UNEP. Ghost gear kills an estimated 5-30% of global harvestable fish stocks each year (depending on fishery/geography), making it a massive threat to global food security. In the oceans, ghost gear accounts for up to 58 percent of all macro-plastics (those greater than 5mm) and 70 percent of all floating macro-plastic pollution.

"Ghost fishing" is a form of marine detritus that impacts marine animals and the ecosystem. Derelict fishing gear (DFG) is lost or discarded fishing gear that is no longer under a fisherman's control and can continue to trap and kill fish, crabs, marine mammals, sea turtles, and seabirds. Gillnets and crab pots/traps are the most prevalent DFG to ghost fish, while longlines and trawls are less likely (Werner, *et al.*, 2016). Ghost fishing has several negative consequences, including the ability to kill both target and non-target creatures,

including endangered and protected species, damage to underwater environments like coral reefs and benthic fauna and contribution to marine pollution. It continues to kill for many years, even decades, and it has stopped capturing for human consumption. With the usage of synthetic materials, the extent and impact of ALDFG debris have expanded dramatically due to increases in the scope of fishing operations and technologies utilized in recent decades.

Causes of the fishing net becoming ghost fishing gear that might be poor weather conditions, gear conflicts with other vessels or bottom topography, gear abuse, and too much gear are all factors leading to gear becoming DFG. When misplaced gear continues to catch and destroy marine life, it is known as ghost fishing. The state of the equipment at the time of loss is crucial. For example, lost nets may operate at optimum efficiency, resulting in high ghost fishing catches (Macfadyen,2009). ALDFG is also a source of concern because it can become a navigational hazard in coastal and offshore locations, posing safety concerns.

Fishing Gear- More Prone To Become a Ghost Fishing Gear

There are many different types of fisheries, which are usually classified by the target species they are attempting to catch and the size of the operation. Industrial and commercial fisheries operate on a big scale, necessitating large vessels and a large amount of equipment. Small-scale fisheries, such as artisanal or recreational/sport fisheries, use smaller vessels and fewer gear. Whatever type of fishery you're in, you're at risk of having your gear become DFG. The most commonly stated types of DFG for ghost fishing are, in order of prevalence and amount of information available (Shomura and Godfrey, 1990). Since gillnets and pots have been the most well-documented ghost fishing gear types to far, this research focuses on their loss rates, species mortalities, and mitigation attempts.

Gillnets

Gillnet are antagonists of Ghost fishing's gears. The rate of loss is determined by where and how they are used. Those who contact the ground, for example, are more likely to be lost, as are those who are left unattended. Similarly, gillnets used in shallow coastal waters (under 200 meters) have a lower loss rate and are easier to recover, whereas gillnets used in deep sea (over 500 meters) are the most problematic due to enormous net lengths, longer soak durations, and gear stress. In 1992, the United Nations (UN) banned huge drifting gillnets with a length of more than 2.5 kilometres from international waters. Deep-water fisheries in

the northeast Atlantic were responsible for more than 25,000 of the 33,038 gillnets reported lost in 2005 research (Brown et al., 2007).

Pots /Traps

Pots and traps are examples of passive gear. Trap gear frames used to be constructed of wood, so that if it became derelict, the string would rot and allow the door to open, releasing any trapped animals, but nowadays they are usually made of metal or covered with a plastic resin. This makes the trap gear considerably more durable and long-lasting, which is good for the fishers, but it also means that lost gear has a larger chance of ghost fishing for longer periods if not retrieved. Traps for lobsters and crabs, for example, become dislodged from their ropes and/or buoys during a storm, or are cut off by boat propellers, or are lost owing to poor trap maintenance. Trapped animals starve and die, or are devoured by other predators or scavengers, while ghost traps continue to catch them until they degrade significantly. Fishers in Florida have recorded annual trap losses of 10–20 percent of their total traps, equating to 50,000–100,000 lost traps in recent years. Lewis et al. (Lewis *et al.*, 2009).

Long line

In comparison to gillnets and trap gears, ghost fishing mortality and gear loss for derelict bottom trawl, longline, jigging, and fish weir gears are negligible. When trawl nets are used in regions with a rocky substrate or coral reefs, they become lost. Although this gear does not catch as many fish as other gear, it can nevertheless trap octopus and crabs.

Fish Aggregating Devices

Artificial drifting fish aggregating devices (FADs) are used by purse seine vessels targeting tropical tuna to attract fish. FADs are rafts built of natural and manmade materials that have long pieces of old fishing nets, ropes, and plastic ribbons suspended 40–100 meters beneath them to impede their progress across the water. This approach is mostly employed to catch skipjack tuna, but it also takes young yellowfin and bigeye tuna, as well as other marine life, resulting in 2.8 to 6.7 times more non-target species, including endangered sharks.

The reasons Why Fishing Gear Has Turned into a Ghost Net

There is a different reason why fishing gear is abandoned, lost, or discarded, but overcrowded fisheries, excess fishing capacity, and illicit, unreported, and unregulated fishing all contribute to the ghost gear problem (IUU).

- Severe weather events
- Snagging on the seabed (rocks, corals, wrecks, and seamounts)
- Entanglement with other fishing gear is some of the specific variables that can occur, sometimes in combination (often conflict between towed and static gear types)
- Theft and vandalism
- Gear breakage and tracking malfunction
- Inadequately maintained or outdated gear
- Willful abandonment and discarding

The volume, distribution, and impacts of ghost gear have increased as fishing has spread to practically every corner of the globe, and the industry produced a wide range of synthetic, robust, and buoyant gears. Since the 1980s, abandoned, lost, and discarded fishing gear has been recognized as a major problem, and it's likely that the problem is worsening, though it's difficult to quantify given incomplete reporting of how much fishing gear is involved, the wide variety of gear types, and the difficulty in monitoring or retrieving ghost gear.

Impacts of Ghost Gear

Marine environments and biodiversity, particularly sensitive habitats and endangered species, are threatened by ghost fishing gear. Ghost gear is a major source of litter in marine environments, but it has a greater impact than other trash since it has the potential to entangle and trap marine creatures indefinitely.

1. Taking life from sea creatures

The negative impact of ghost fishing on fish species is difficult to quantify because it is dependent on several different factors, including the rate of gear loss, the catching efficiency of different types of gear, the materials used in construction and the rate at which the gear breaks down once abandoned, lost, or discarded, and the susceptibility of the animals in the area. Ghost gear, on the other hand, can catch both commercial and non-target species for months, years, or even decades after it has been lost or abandoned. Snared fish die of

starvation or are eaten by predators. Scavengers are drawn to dead animals, and some of them are caught, giving a steady supply of food.

2. **Endangering habitats**

Ghost gear poses a serious threat to maritime environments and biodiversity, particularly in sensitive areas and for endangered species. Ghost gear, like any other accumulation of marine litter, has the potential to affect and degrade marine environments by causing physical harm such as abrasion, shearing, or suffocation, as well as changing the physical and chemical composition of marine sediments. Physical degradation to marine ecosystems degrades the quality of the environment and can jeopardize vital feeding regions and breeding grounds (such as turtle and seabird nesting sites).

3**. Economic and other consequences**

Aside from environmental consequences, lost and abandoned fishing gear has substantial socioeconomic consequences for both fishermen and the general public. By tangles with other fishing gear, ghost gear can cause further damage and loss of fishing gear and catches. Replacing lost gear can be expensive, albeit it is occasionally abandoned when snagged to minimize the direct expenses of potential vessel damage or loss of other components of the gear, or when retrieving gear will limit fishing time and increase fuel expenditures, as is the case with FADs. The removal of entangled gear from propellers or engines, repairs, fuel, lost profits, and emergency services necessary when it causes breakdown are all substantial costs.

A Worldwide Solution for Ghost Fishing

Through collaborations between governments, fishers, NGOs, researchers, ports, and intergovernmental organizations, we must take tangible steps to limit the implications of ghost gear. Members' collaborative goals to solve the issue of ghost gear in a holistic and cyclical manner, with a focus on:

Reducing the amount of gear lost or abandoned in the oceans,

- Removing existing gear,
- Recycling recovered or end-of-life gear,
- Rescuing animals caught in the gear.

Good Practice for Avoidance of Ghost Fishing

To strengthen the management of fishing gear and reduce the risk of damage or loss, gear use limits, such as limited lengths of gillnet fleets, trap strings, and so on, are implemented.

For static gear like gillnets and traps, set soak time limits. Longer soak times increase the chance of losing gear, so anglers will strike a compromise between catching fish and retrieving gear fast.

Good connection with other anglers, especially between segments – for example, between static and mobile operators in common fishing grounds.

To decrease snagging and associated gear loss, data about the seabed and local currents should be shared.

Ghost Gear Management and Mitigation

Notify the appropriate fisheries department/authorities of any misplaced fishing gear.

- Retrieval of lost fishing equipment; fishermen should have well-trained crew members and retrieval equipment on board for safe retrieval.
- Engage with government representatives to obtain more information about ghost gear and learn the methodologies to mitigate it.
- Share expertise to prevent fishing gear loss; the authority can train new fishers to avoid fishing gear loss and raise awareness about ghost gear's environmental impacts.
- Interact with fishing equipment manufacturers and users to demonstrate the issue of ghost gear.
- Inventing and producing traceable and recyclable fishing gear.
- Design and fabricate gear made from biodegradable materials that will not affect the environment if lost.

Conclusion

Ghost gear has a negative impact on the marine environment and poses a threat to marine biodiversity. We need to determine the fundamental causes of gear loss so that we can build effective ways to prevent it. Local and global policies can play a critical role in avoiding and minimizing ghost fishing through voluntary measures. Preventive and

mitigation actions must be implemented, as well as the usage of biodegradable materials and raising awareness at the local, regional, and worldwide levels.

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NEOTERIC TECHNOLOGIES IN FISH PROCESSING AND FISHERY PRODUCTS: A REVIEW

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Fish is the cheapest source of animal protein constitutes a major share in the global food basket. World fish production sector facings the challenges to boost the production to alleviate the hunger and mal nutrition in the future. From the post-harvest handling, to the transportation of fish, through the processing line packaging and storage certainly require a proper care, in order to maintain the quality and nutritional attributes and preventing post-harvest losses. During the year 2018 about 88 percent (156 million tonnes) of world fish production was utilized for direct human consumption. The remaining 12 percent (22 million tonnes) was used for non-food purposes, of which 82 percent (or 18 million tonnes) was used to produce fishmeal and fish oil. The proportion of fish used for direct human consumption has increased significantly from 67 percent in the 1960s. Live, fresh or chilled fish still represented the largest share (44 percent) of fish utilized for direct human consumption as being often the most preferred and highly priced form of fish. It was followed by frozen (35 percent), prepared and preserved fish (11 percent) and cured at 10 percent. (FAO, 2020). Few of the emerging technologies that have application in fish processing are High Pressure Processing, Irradiation, Microwave Processing, Radio frequency, Ultrasound, etc. Packaging technologies like Modified Atmosphere, active and intelligent packaging also plays an important role in fish preservation (Fellows, 2000; Da-Wen, 2005).

High Pressure Processing

High pressure processing is an effective methods for preservation of foods. In which the food is placed in a pressure vessel which is capable to sustain the required pressure and

the food is submerged in a liquid, which acts as the pressure transmitting medium, such as water, castor oil, ethanol or glycol etc. These liquids protect the inner vessel surface from corrosion. HPP preserving food by combining elevated pressures (up to 900 Mpa or good atmosphere) and moderate tem (up to 120 ^{o}C) over a short period. So many advantages in this technology like uniform pressure, minimum heat, minimum damage to food and properties of foods. Effects of HPP on microorganisms shown that fungi showed highest sensitivity at 300 Mpa to 400 Mpa fungi showed highest sensitivity to HPP followed by gram bacteria. HPP treatment of 250 Mpa and 200 Mpa enhanced shelf life of Indian white prawns (H. Milne Edwards, 1837) and yellowfin tuna chunks respectively (Hugas *et.al*. 2002, Hogan *et.al*. 2005).

Irradiation

It is a physical treatment that consists of exposing foods to the direct action of electronic, electromagnetic rays to assume the innocuity of foods and to prolong the shelf life (Doyle, 1999). Irradiation of food can control insect infestation, reduce the number of pathogenic microorganisms and delay or eliminate natural biological processes such as ripening, germination or sprouting in fresh food. (Ahn *et al*. 2006) Three types of ionizing radiations are used to process products. Gamma rays, x-rays and accelerated electrons (Lecroix, 2005). Three types of ionizing radiation are used in commercial radiation to process products such as foods and medical and pharmaceutical devices (International Atomic Energy Agency (IAEA), radiation from high-energy gamma rays, X-rays, and accelerated electrons (Lacroix, 2005). Gamma rays, which are produced by radioactive substances (called radioisotopes). The approved sources of gamma rays for food irradiation are the radionuclides cobalt-60 (60Co; the most common) and cesium-137 (137Cs). They contain energy levels of 1.17 MeV and 1.33 MeV (60Co) and 0.662 MeV (137Cs). Electron beams, which are produced in accelerators, such as in a linear accelerator (linac) or a Van de Graaff generator at nearly the speed of light. Maximum quantum energy is not to exceed 10 MeV. X-rays or decelerating rays, which can be likewise produced in accelerators. Maximum quantum energy of the electrons is not to exceed 5 MeV**.** Irradiation doses of 2 kGy to 7 kGy can reduce important food pathogens such as Salmonella, Listeria, and Vibrio spp., as well as many fish spoilers' microorganisms such as *Pseudomonadaceae* and *Enterobacteriaceae* that can be significantly decreased in number (Lacroix, 2005)

Microwave Processing

The applications of microwave heating on different fish preservation methods include drying, pasteurization, sterilization, thawing, tempering, baking etc. Microwaves are electromagnetic waves whose frequency varies within 300 MHz to 300 GHz. Microwave heating is caused by the ability of the materials to absorb microwave energy and convert it into heat. Microwave heating of food materials mainly occurs due to dipolar and ionic mechanisms. Water content in the food material causes dielectric heating due to the dipolar nature of water.Microwave drying has advantage of fast drying rates and improving the quality of product. In microwave drying, due to volumetric heating, the vapors are generated inside and an internal pressure gradient is developed which forces the water outside. Thus shrinkage of food materials is prevented in microwave drying. One of the disadvantages of microwave drying is that excessive temperature along the corner or edges of food products results in scorching and production of off-flavors especially during final stages of drying. Microwave combined with other drying methods such as air drying or infrared or vacuum drying or freezedrying gave better drying characteristics compared to their respective drying methods or microwave drying alone (Chandrasekaran *et al*., 2013).

Radio Frequency

Radiofrequency heating refers to the use of electromagnetic waves of certain frequencies to generate heat in the material. Radiofrequency heating can be performed in any of the 3 frequencies (13.56 MHz ± 6.68 kHz; 27.12 MHz ± 160 kHz and 40.68 MHz ± 20 kHz). The advantages of RF heating are increased heating and processing speed, improved product quality and yield because of uniform heating, usage of only 1/3 of the floor space of conventional heating units, instant on/off and temperature change and higher energy savings up to 60 % to 70 %. Another important advantage claimed for RF heating is its 'self-limiting' property, which controls the consumption of RF energy according to the workload.

Ultrasound

Ultrasound (US) is defined as waves of a mechanical nature that require an elastic medium to propagate (Mason, 2002 andLempriere, 2013). Sounds and ultrasounds differ in frequency: sound waves propagate at frequencies audible to the human ear (from 16 Hz to 16–20 kHz), while US waves propagate at frequencies greater than 20 kHz (upper limit of audibility for the human ear) up to frequencies of 10 MHz, which then proceeds to the so-

called hypersonic region.Ultrasonic waves at this range are capable of causing physical, mechanical, or chemical changes inthe material leading to disrupting the physical integrity, acceleration of certain chemical reactions through generation of immense pressure, shear, and temperature gradient in the medium. Ultrasonic has been successfully used to inactivate *Salmonella* spp., *E. coli*, *L. monocytogenes*, *S. aureus* and other pathogens (Awad *et al*., 2012).This technique has potential advantages over other techniques including freedom from radiation hazards, which may appear in some of the existing non-destructive methods.

Retort Pouch Processing

As in canning, retort pouch food is sterilized after packing, but the sterilizing procedure differs. The pouches are processed in an overpressure retort. The time and temperature will be standardized depending on the product. With the availability of retort pouches, it can function as an excellent import substitute for metallic cans. Besides, cost reduction retort pouch packages have unique advantages like boil in bag facility, ease of opening, reduced weightand do not require refrigeration for storage. Processed food products can be kept for long periods at ambient temperature. The energy saving is more in processing in flexible pouches compared to cans. On a comparison, oftotal costs, including energy, warehousing and shipping, the pouch looks even more favorable. There is 30 % to40 % reduction in processing time compared to cans, solids fill is greater per unit, empty warehousing is 85 %smaller and weight of the empty package is substantially smaller.

Bio Preservation

Bacteriocins are a heterogeneous group of antibacterial proteins that vary in spectrum of activity, mode of action, molecular weight, genetic origin and biochemical properties various spices and essential oils have preservative properties and have been used to extend the storage life of fish and fishery products. Natural compounds such as essential oils, chitosan, nisin and lysozyme, bacteriocins have been investigated toreplace chemical preservatives and to obtain green label products (Stiles and Hastings, 1991).

Active and Intelligent Packaging

- **Active packaging (AP)**

Active packaging is defined by European regulation (EC) No 450/2009, AP systems are designed to "*deliberately incorporate components that would release or absorb*

substances into or from the packaged food or the environment surrounding the food." Active packaging materials are thereby "*intended to extend the shelf-life or to maintain or improve the condition of packaged food*." Although extensive research on AP technologies is being undertaken, many of these technologies have not yet been implemented successfully in commercial food packaging systems. Some of the active packaging systems include; Oxygen scavengers; Carbon dioxide emitters; Moisture regulators; Antimicrobial packaging, Antioxidant release; Release or absorption of flavors and odors; Carbon dioxide scavenger and Activepackaging systems with dual functionality (combination of oxygen scavengers with carbon dioxide and/or antimicrobial/antioxidant substances). Other active packaging systems that are expected to find increased attention in the future include colour-containing films, light-absorbing or regulating systems, subsectors formicrowave heating, gas permeable/breathable films, anti-fogging films, and insecticides repellant package (Labuza and Breene, 1989).

- **Intelligent packaging**

Intelligent packaging also known as smart packaging, senses some properties of the food it encloses orthe environment in which it is kept and informs the manufacturer, retailer and consumer of the state of these properties. Intelligent packaging has been defined as 'Packaging systems which monitor the condition of packaged foods to provide information about the quality of the packaged food during transport and storage. These include Time temperature indicators, Leakage indicator, Freshness indicator, etc. Active andante lligent packaging systems contribute to the improvement of food safety and extend the shelf-life of the packagedfoods. However these are evolving technologies in the seafood area and many of these systems are in thedevelopmental stage (Kerry *et al*., 2006).

Conclusion

Aquatic foods can help with food and nutritional security, product diversity, value addition, increasing exports, and minimizing post-harvest losses, all of which can contribute to global economic growth and hunger reduction. Consumers prefer high-quality processed foods with little nutritional characteristics alterations. Recent thermal and non-thermal processing technologies will aid in increasing the shelf life of fish, maintaining nutritional characteristics, increasing convenience, reducing waste, facilitating exports and imports, and, most importantly, increasing economic value.

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"OMICS" DRIVEN INSIGHT TO SOIL MICROBIOME: THE FUTURE OF SUSTAINABLE AGRICULTURE

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Microorganisms play a pivotal role in the agriculture production system by inducing several nutrient cycling systems, pest and disease dynamics, and soil quality. Inthe last several decades, these potentials of microbes are continuously getting explored for even higher production and at the same time maintaining the soil and environmental health. Careful alteration of the microbial community can significantly improve the quantity and quality of production. The modern cutting-edge research revolves around the better understanding of microbes, their interaction with the environment, association with root zone, utilization of secondary metabolites and many more aspects. In recent times, comprehensive research has led to the production of several biofertilizers, which has significantly improved the soil health and crop yield, especially in challenged areas demonstrated at the controlled environment and field application. However, soil microbiota's enormous complexity and diversity have possessed immense challenges in this field. The major problem in this research area is that approximately only 1% of the total microbes can be culturedin vitro (in the lab), while the vast majority is still unculturable. Over the year, an alternative approach has been developed that is culture-independent and based on isolation identification and quantification of genomes isolated from the target soil. In the meantime, gene sequencing technologies has been astonishingly improved, resulting much faster and cheaper sequence of genomes. Simultaneous sequencing or next-generation sequencing has transformed the human capacity to better understand the genome and classify the microbes taxonomically and functionally, which has opened a way of better agriculture management tomorrow.

Nuts And Bolts of Soil Microbiome from Metagenomic Insight

Soil is immensely diverse based on its physicochemical and biological properties. The diversity is due to the inherent parent material or a complex interaction of mineralogy,

ecology, environmental, and anthropogenic factors. The soil itself is an autonomous system that wharves several elementary processes, including nutrient cycling, different moisture regimes and microbial actions. The various ecosystem services are primarily dependent on microbes. However, as mentioned above, the study on such soil microbes was minimal because in vitro culture was possible. The recent development of two "omics" tools, i.e., metagenomics and metatranscriptomics in system biology, has laid the foundation for more in-depth study. This has been further improved due to the improvement of bioinformatics tools, more powerful computing ability and incorporation of high-level programming languages like python.

16s rRNA Gene: The Heart of the Process

The 16S rRNA has been proved to be a brilliant genetic marker for bacterial taxonomy due to its higher conservation nature in the bacterial and archaea domain. The 16S rRNA gene is the DNA sequence corresponding to rRNA encoding bacteria, which exists in the genome of all bacteria. The 16s rRNA gene has nine hypervariable regions ranging from V1 to V9. The conserved region has a unique benefit, to be used as an anchoring region for amplifying the variable region. Meanwhile, the variable area provides the essential element later used as a taxonomic marker. The number of copies of 16S rRNA is currently also used as an index of microbial lite history; higher numbers translate to favourable conditions and rapid multiplication. The copiotroph organisms have a higher number of operon copies, while oligotrophs have a lower number of operons.

Fig 1: Picture of Illumina HiSeq 2500 system, which is used in metagenomic sequencing

A composite soil sample contains hundreds or even thousands of bacterial species in complex communities. The majority of them are not culturable. A single unit constitutes such a community known as a "**metagenome**". Once again, the study of a particular constituent like a single gene or operon or another component is called **"targeted metagenomics"**.

The 16S rRNA gene of the bacteria can be amplified using universal primers using PCR protocols. Subsequently, the sequence is later used as a biomarker to identify the taxonomic position of the microbe.

Among several regions,an extensive number of the literature suggests that the V3 and V4 region of 16s rRNA is the richest fragment for differentiating a large number of bacteria. As a result, the most popular high throughput sequencing platform company "Illumina" has adopted this region as a standard.

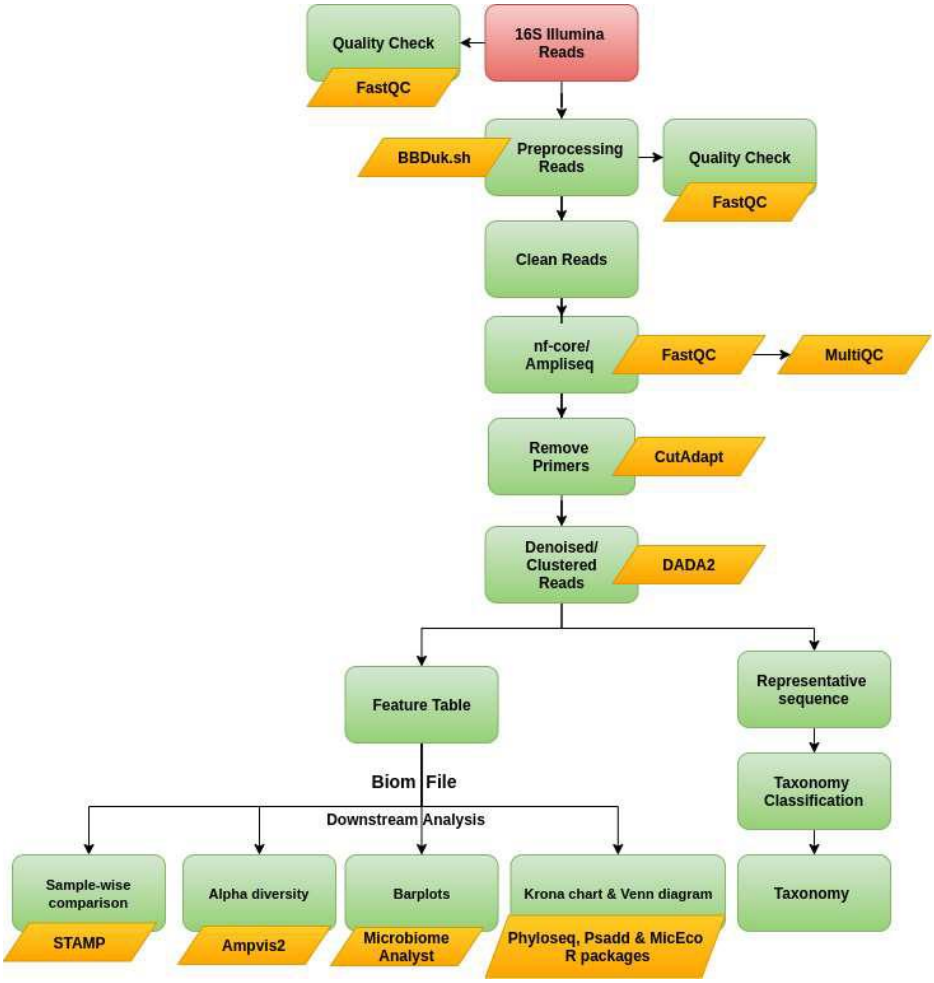

Fig 2: Exemplary workflow of 16s rRNA sequencing (V4 region) followed by identification, taxonomic classification and diversity analysis of bacterial community structure compost sample. (Source and copyright: authors of this article, agronomy section, ICAR-NDRI, Karnal)

Microbe Derived Biological Process and Its Impact on Modern Agronomy: How Can The Omics Help?

Since the last decade, bioinformatics tools have evolved so that 16S rRNA is not only used to identify the microbe. Instead,it can be used to assess several metabolic and biochemical processes. This phylogeny-driven metabolic prediction data is known as metabolic inference or functional potential.

The process can be understood from an angle of soil-borne pathogenic bacteria. An antibiotic is needed to suppress the bacterial disease in the plant. However, functional metagenomics can be used to determinethe chances of antibiotic resistance. A more targeted and efficient antibiotic/strategy can also be used to be environmentally friendly. The procedure will involve the identification of specific bacteria as well as antibiotic-resistant gene, their mechanism of action and the mechanism of disease infestation in the crop. Nonetheless, highly specialized tools and mechanisms will be required to deploy such a methodology.

From the plant nutrition point of view, different nutrient cycle and their association with solubilizing and fixing bacteria plays the most crucial role. Functional metagenomics will bring up the whole process to the genomic level, which will help modify the system at the micro-level with higher precision and not break the agro-ecosystem.

In modern agriculture, it is scientifically proven that adding organic matter via incorporating different compost is essential to achieve better soil physical, chemical and biological properties and achieve sustainability. The composting itself is a primarily microbe driven process. The composting process varies significantly based on source material, temperature, resource, and quantity. Omics, especially metagenomics, can help identify different compost friendly bacteria such as cellulose degrading bacteria and the class and type of bacteria that can survive under a particular temperature regime. Once the compost is applied to the soil, the omics tool is the most efficient way to assess if the existing microbial community is getting succeeded by the microbes that came with the compost itself. As a result, the synergism, antagonism and commensalism among microbes and plants will also be more clearly visible.

Conclusion

Despite such enormous advantages and scope of application of omics tools such as metagenomics and transcriptomics in agronomy; the research has yet to pick the momentum. The technology is a very recent one, and due to its sophisticated workflow, agronomists worldwide are taking their own time to replace conventional analytical procedures with molecular works.Moreover, the sequencing setup used for high throughput sequencing such as Illumina high seq is also costly and requires a highly skilled workforce. However, in the coming days, it is foreseeable that omics tools will replace the conventional methods for exploring the vast world of soil microbiology and its interaction with agronomic practices.

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