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A REVIEW ON FERMENTED FISH: MICROBIOLOGY, CHEMISTRY AND HEALTH BENEFITS

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Abstract:
Traditional food preservation techniques like fermentation are frequently employed to increase food safety, shelf life, and organoleptic and nutritional qualities. Fish that has been fermented is produced, eaten, and an essential component of many food traditions across the world. Additionally, fish fermentation is a major industry in many nations and a source of fascinating bacteria. This review tries to update microbiology, chemistry and health benefits of fermented fish.

Keywords: *Bioactive compounds, fermentation, fish paste, fish sauce, gut microflora, health benefits, probiotics*

Introduction:

Fermented foods and beverages are those that have undergone controlled microbial development as well as enzymatic conversion of food components. Recent popularity of fermented foods is largely due to their alleged health benefits **(Dimidi *et al*., 2019).**

Dimidi *et al*. (2019) noted that there are countless types of fermented meals thanks to the microorgansms, nutritional components, and environmental factors that all play a role in the fermentation process. Because the production of antimicrobial metabolites (such as bacteriocins, organic acids and ethanol) lowers the danger of contamination with pathogenic bacteria, food fermentation has historically been used as a preservation technique. Fermentation is used to improve the organoleptic properties since some foods, like olives, are inedible without it because it removes the bitter phenolic compounds (e.g., taste and texture).

Foods are fermented using one of two main techniques. First, foods can naturally ferment; these processes are frequently referred to as "wild ferments" or "spontaneous ferments," and they involve

using microorganisms that are already present in the raw food or processing environment. Examples of such foods include sauerkraut, kimchi, and several fermented soy products. Second, by adding starter cultures, also referred to as "culture-dependent ferments," to foods, such as kefir, kombucha, and natto, meals can be fermented **(Rezac *et al*., 2018)**.

This review article will discuss about fermented fish. Unless a treatment is used to halt the bacteria that cause spoilage, fish quickly spoils or goes bad. A technique that combats the capacity of microbes to ruin fish is fermentation. This is accomplished by raising the acidity of the fish muscle; bacteria typically stop growing when the p^H falls below 4.5 **(Alzamora *et al*., 2000)**.

Nearly 20% of the world's population's daily average animal protein intake comes from fish and fish products, which are also good providers of polyunsaturated fatty acids, vital minerals, and vitamins **(Tacon and Metian, 2018; Zang *et al*., 2018)**. Products of historical, regional, and cultural significance include fermented fish. Fish fermentation is a centuries-old practise, and evidence from Japan's Yayoi period (300 BCE to 300 CE) implies that the practise was common **(Beddows, 1998)**.

Different process for fish fermentation:
Three distinct types of products have been produced as a result of the employment of various procedures in fish fermentation **(Giyatmi & Irianto, 2017)**:
1) Products that essentially keep the fish in its original shape (whole fish).
2) Fermented fish pastes **(Giri *et al*., 2010)**.
3) Fish sauce.

Fish Pastes and Sauces of the World
Fish proteins are prodded by enzymatic breakdown in the presence of high salt concentrations to produce both fish sauces and pasts **(Kristinsson and Rasco, 2000)**. In the instance of fish sauce, the fish tissue is extensively liquefied, and the fluid portion that results is then collected as the sauce **(Majumdar, 2016)**. The paste products are made similarly to sauces, although the fermentation process often takes less time, and the finished product contains solid fish components. There are two forms of fish pastes: pounded paste and ground paste, in which the fermented fish is ground or pounded into paste. Fish or shrimp are combined with salt and then ground or crushed to create ground fish paste, which is then sun-dried, placed in dosed containers, and given time to develop. Different Asian nations have a wide variety of traditional fish sauce and paste items, some of which are listed below **(Saisithi, 1994)**. There are changes in the choice of raw materials and the fish-to-salt ratio, even though the basic procedure for all fermented goods requires the use of large amounts of salt. length of fermentation and addition of additional source materials while fermentation is taking place. Each fermented product as a result has a distinct flavour and flavour **(Kumar and Nayak, 2015)**.

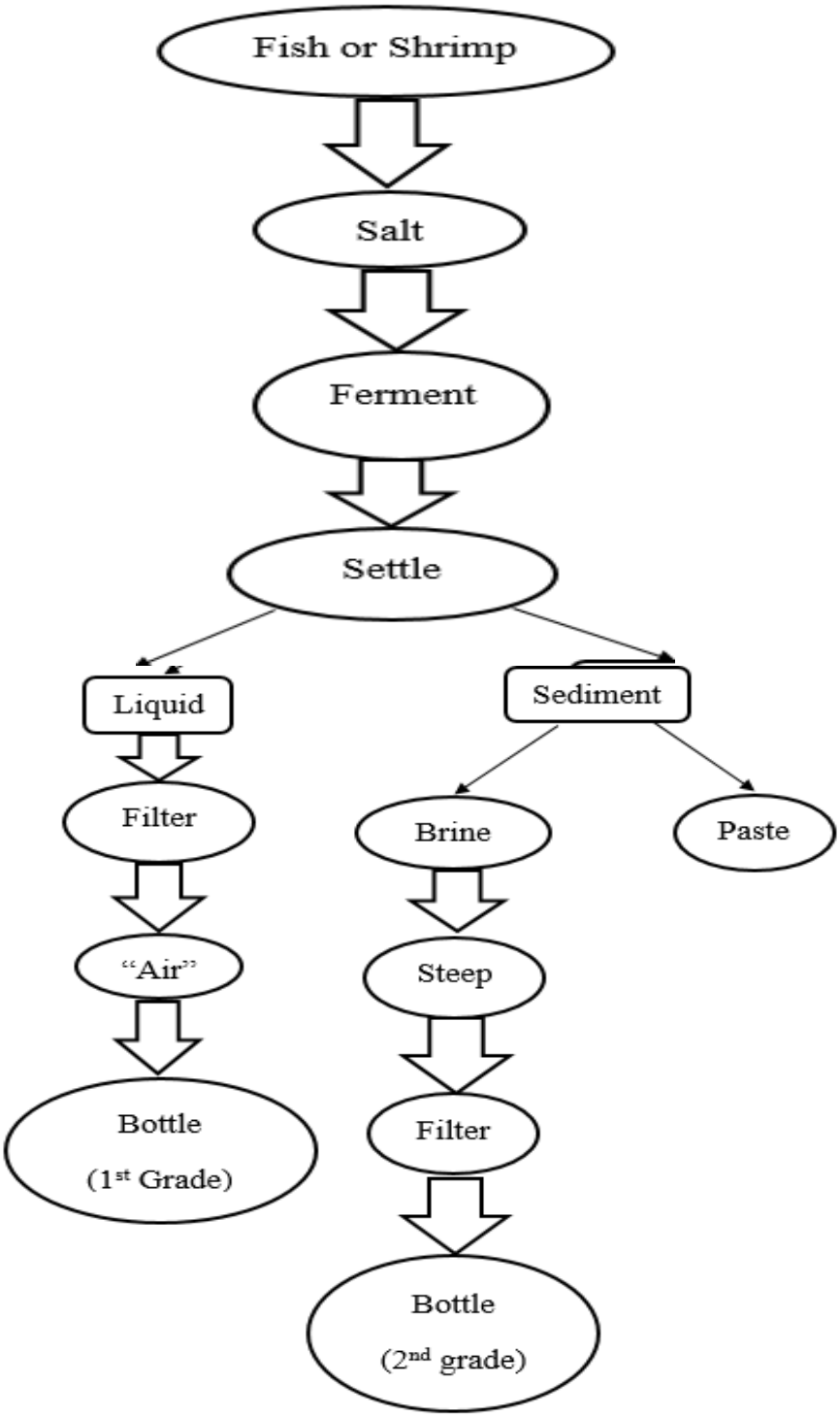
- ***Fish paste:***

Nearly all of South-east Asia consumes Fermented Fish Paste as a dipping sauce for rice dishes. It is typically made using shrimp or tiny fish. The paste is made by mixing it with salt (10-l5 %), drying it in the sun, kneading it into a paste, and then fermenting it at room temperature for a few weeks. Fish, salt, and the environment all include microorganisms that cause fermentation. Since many microorganisms have amino acid decarboxylases, the fermented fish paste is probably going to have amines in it **(Fardiaz & Markakis, 1979)**.

- ***Fish sauce:***

In South-east Asia, where they have a long history of use, important side dishes and condiments are created by salt-pickling fish and small shrimp to create fermented fish sauces. In large part, the use of fermentation processes is what allows fish that is accessible throughout the season to be preserved throughout the region **(Mizutani *et al*., 1992)**.

Flow chart for fish Pastes and sauces Figure (Witono et al., 2014)



Microflora of fermented fish

The initial flora of fish utilised in fermentation is made up of the native microflora of fish and those introduced as contaminants at various stages of harvesting, handling, and processing as well as through the salt used in fish fermentation. Most of the bacteria that were initially discovered in fish, however, are unable to thrive in the high sodium chloride concentration and are progressively eradicated. In the later phases of fermentation, only halophilic and halotolerant bacteria survive. Such bacteria have been found in fermented fish items, according to several investigations. For instance, *Bacillus* spp., *Coryneform* spp., *Streptococcus* spp., *Micrococcus* spp., and *Staphylococcus* spp. were found in an investigation of a 9-month-old *nam pla* **(Saisithi *et al*., 1966)**. From *nam pla*, halophilic

bacteria like Halobacterium and Halococcus have also been identified **(Thongthai and Suntinanalert, 1991)**. *Bacillus* spp., *Pediococcus* spp., *Lactobacillus* spp., *Micrococcus* spp., *Sarcina* spp., *Clostridium* spp., *Brevibacterium* spp., *Flavobacterium* spp., and *Corynebacteriurn* spp. make up the bacterial ecology of shrimp paste belacan **(Karim, 1993)**. The majority of the species in the final product were high salt-tolerant.

Health benefits of fermented fish:

Linoleic acid and alpha-linolenic acid, two important fatty acids, are best found in fish **(Tewari *et al*., 2022)**. Because fermented fish and other aquatic products have distinctive sensory qualities and nutritional benefits, they are in high demand all over the world **(Ruddle & Ishige, 2010)**.

It is well recognised that fermentation has a significant role in maintaining nutrients and enhancing the flavour and texture of fish. This could mostly depend on the quality of the raw materials used and the kinds of fermentation procedures (spontaneous and non-spontaneous) used. The interaction of different native or selected microflora during fermentation has been linked to the enzyme activity, which produces a variety of bioactive chemicals. Some of these substances are referred to as "bioactive compounds" since they are known to have numerous health advantages. Additionally, it is recognised that these bioactive substances have a role in the prevention or treatment of a number of disorders **(Sharma *et al*., 2022)**.

Probiotics from fermented fish:

Live bacteria and yeasts known as probiotics are beneficial to human health, particularly the digestive system **(Tewari *et al*., 2019)**. Probiotics from fish and their products have the potential to be used to improve the nutritional content of human diets **(Prado *et al*., 2009)**.

Bacteria that are common in the aquatic environment can flourish in fish guts' hospitable habitat. Aerobes or facultative anaerobes make up the majority of the probiotic bacteria that have been isolated from fish guts. Fish has been consumed in a variety of ways all across the world. It has long been customary for some ethnic groups to dry and ferment fish to extend its shelf life. Freshwater fish has been fermented traditionally in the northeastern parts of India to create foods like Ngari, Hentak, and Utonga-kupsu. Workers have studied the bacterial communities in these products and isolated *Lactococcus lactis subsp. cremoris, L. plantarum, Enterococcus faecium, Lactobacillus fructosus, Lactobacillus amylophilus, Lactobacillus coryniformis, Bacillus subtilis and B. pumilus, B. cereus, Staphylococcus aureus* and *Enterobacteriaceae* population. Most of them fall within the probiotic category **(Thapa *et al*., 2004; Thapa, 2016)**.

Conclusion:

Research subjects related to fish fermentation are becoming more and more appealing. Around the world, fish is created in a variety of methods through fermentation. Numerous advantageous biological processes and chemicals have been discovered. The creation of unique fish products with enhanced sensory qualities, nutritional value, and health advantages has a great deal of promise with the use of fermented fish and fish products.

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