Mini Review

African fermented fish products in scope of risks

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Abstract

Post-harvest losses in African artisanal fisheries may thus be lower than often assumed. Fermentation of fish is especially used in situations where drying of fish is not possible because the climate is too wet and where cooling and sterilization of the product is too expensive. Fermented fishery products in Africa are usually whole or in cut pieces, and are not a paste or sauce. Sanitary conditions of fermented fish production were generally found to be poor and processing methods were not standardized. This article will primarily review fermented fish processing, quality parameters of fermented fish, nutritional and functional evaluation of fermented fish products, microbiology and biochemistry of fermented fish, safety of fermented fish, and the famous fermented fishery products in Africa. To the best of our knowledge, there is no review article on the fermented fishery products in Africa in scope of risks.

Keywords
Fermented fish
Traditional methods
Quality evaluation
Africa

Introduction

Fishing industry is vital to Africa; supporting annual exports worth about $3 bn. Fish is also crucial to the health of 200 million Africans, providing a source of inexpensive protein (BBC, 2005). However, fish also has the disadvantage that if it is not salted, dried, smoked or preserved in some way or other, it will quickly spoil. In warm region such as tropical countries, access to fresh fish can be a problem mainly in rural areas owing to the shortage of ice and lack of refrigeration (Anihouvi et al., 2007). Fermentation is the most important way of preserving fish. Fermented fish have, for many years, been considered as a Southeast Asian product. These products are highly salted and fermented until the fish flesh is transformed into simpler components. Fish fermentation in the Southeast Asian sub-region normally lasts for several months (three to nine months) and the fish flesh may liquefy or turn into a paste (Huss and Valdimarson, 1990). Some of these products include nuoc-mam of Vietnam and Cambodia, nam-pla of Thailand, sushi of Japan and patis of the Philippines. No African fermented fishery products are mentioned in the FAO Fisheries Report No. 100 on fermented fish (FAO, 1971); however, feseekh from Egypt and Sudan is mentioned as a Mediterranean product.

In Africa salting and drying of fish for preservation is accompanied by fermentation, but the period is short (a few days) and the product is not transformed into a paste or sauce. The products are all characterized by a strong odour and, for this reason; various authors have described the product as “sink” fish. In Ghana fermented fish is called momone, an Akan word which literally means stinking. The “sink” fish of Sierra Leone has been described, as fish which had developed a strong odour within 24 hours of capture and was salted for about four days and then dried (Watts, 1965). Watanabe (1982) described the fermented fishery products of Senegal as highly salted and semi-dried fishery products with an obnoxious odour and a cheesy but rich fishy flavour reminiscent of kusaya from Japan. The characteristic smell of fermented fish is the result of enzymatic and microbiological activity in the fish muscle. Zakhia and Cuq (1991) suggest that the organic acids produced during the fermentation of fish in Mali are mainly acetic acids, whereas it would appear that in Asia mainly lactic acid is produced. Fermented fish is, therefore, any fishery product which has undergone degradative changes through enzymatic or microbiological activity either in the presence or absence of salt.

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fish products, microbiology and biochemistry of fermented fish, safety of fermented fish, and the famous fermented fishery products in Africa. To the best of our knowledge, there is no review article on the fermented fishery products in Africa in scope of risks.

**Fermented fish processing**

Many consumers in Africa prefer fish in the fresh state; however, a considerable proportion of the landed catch is preserved by artisanal methods. The principal fish processing methods in Africa include smoking, salting, sun-drying, fermentation, grilling and frying. The predominant type of fishery product in any particular country is, however, closely related to the food habits and purchasing power of the population. Specific types of fishery products are best suited as the local staple food. Furthermore, due to the lack of a good transport infrastructure for the transportation of fresh fish to remote towns and villages, cured fish is the most convenient form in which fish can be sent to such areas.

Africa is endowed with numerous lakes, rivers and seas. These water bodies constitute a rich source of numerous species of fresh fish for many people. Over 80% of the fish landings in West Africa come from the Atlantic Ocean. The remainder comes from freshwater sources such as River Niger, Lake Chad, Lake Volta and River Shari. Fish from these lakes is normally salted, fermented and dried for consumption within the locality and also for export (Table 1).

Different traditional processing techniques are employed in fish fermentation from one region to another. This is greatly influenced by factors such as availability of salt and the food habits of the local people. Three main techniques have clearly emerged as methods commonly practiced in many African countries. These are:

a) Fermentation with salting and drying;
b) Fermentation and drying without salting; and
c) Fermentation with salting but without drying.

Figure 1 illustrates African traditional methods of fish fermentation with salting and drying. Processing practices for fermented fish products constitute health hazards to consumers, processors and the environment. These practices relate to dressing, washing, salting/fermentation, drying and waste disposal of the fish, as well as the use of poor quality salt and curing containers (Essuman, 1992).

**Dressing**

It was observed in African countries such as Ghana and Senegal that fish may be held under the foot on the ground during dressing. This practice can cause microbial contamination of the fish and injury to the processor either from the spines of the fish or by the knife (Essuman, 1992).

**Washing**

This is a very essential stage in fish processing. In most of the processing sites potable water is often not available. Therefore, water from lagoons, rivers, lakes or seas is used to wash the fish. These water bodies are often polluted by domestic waste, making them a possible source of chemical and microbial poisoning (Essuman, 1992).

**Salting/Fermentation**

The non-use of salt results in uncontrolled fermentation. Under such conditions, the fish muscle becomes ideal for the growth of pathogenic organisms and the product may decay within a short period. Such products could pose a health hazard to consumers. The reuse of salt may also lead to contamination of
Nutritional Evaluation of Fermented Fish Products

The primary objectives of curing fish in many African countries are to preserve the fish and develop a desirable flavour. However, processing sometimes tends to affect the nutritional value of food products. Table 2 shows the proximate analysis of different types of fresh and fermented fishery products. Considering fish as a major source of protein, a general observation of Table 2 indicates that fermentation does not adversely affect the crude protein content of fishery products. The moisture content of fermented fish varies from about 13% in fermented Tilapia to 65% in fermented Cassava Croaker fish (momone).

The protein content of fermented fish ranges from about 18% to nearly 72% depending on the water content. This makes the product a good source of animal protein. Thus, if fermented products are consumed on a large scale as food fish in the diet, they make a substantial contribution to the total protein intake. However, where only small quantities are used as a condiment to prepare sauces, their contribution is of minor importance.

Quality Parameters of Fermented Fish

The quality of fermented fish is assessed subjectively by visual and/or organoleptic inspection. The main quality parameters are texture, colour, odour and fragility (Essuman, 1992).

Texture

Two main types of textural characteristics were identified in the study. Fermented fish intended to be used as food fish is hard dried or semi-dried but firm. This was the main type of fermented product found in many African countries (e.g., guedj, koobi, ewule). Due to the firm texture it remains whole in the sauce after cooking. In Côte d’Ivoire, the Gambia, and Ghana and also in the Sudan, fermented fishery products with a soft texture are produced. These products are commonly added to soups and sauces in small quantities as a condiment. Feseekh is used both as a food fish and condiment. It is minced, mashed before adding to the vegetable sauce or broken up completely during cooking (Essuman, 1992).

Colour

The colour of the product depends on the species of fish used as well as the processing method. For whole products such as feseekh, a silvery appearance close to the fresh product is considered high quality. Poorly fermented products tend to be grayish or dark fermented products which are split and dried are usually light brown in colour. Long storage and further drying darkens the product. Yeet, for instance, becomes dark brown after weeks of exposure to the sun (Essuman, 1992).

Odour

The odour of fermented fishery products varies from mild to very pungent. Soft, semi-dry products usually have a strong smell but very dry fermented fishery products have a mild odour.

Fragility

When fermented fish is dried to very low moisture content, it tends to break up during packaging and storage. Soft or semi-dry products become flaky especially if the raw fish is putrid or fermentation is

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Table 2. Proximate composition of some raw and fermented fish

<table>
<thead>
<tr>
<th>Type of Fish</th>
<th>Energy (kcal)</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava Croaker (Pseudolithos senegalensis)</td>
<td>76.4</td>
<td>9.4</td>
<td>2.8</td>
<td>16.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Fresh</td>
<td>101</td>
<td>6.6</td>
<td>14.4</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Fermented (momone)</td>
<td>134</td>
<td>6.7</td>
<td>16.2</td>
<td>2.4</td>
<td>14.6</td>
</tr>
<tr>
<td>Grey Squirrel (Lepidotrigla momone)</td>
<td>104</td>
<td>7.6</td>
<td>14.4</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Fresh</td>
<td>111</td>
<td>7.6</td>
<td>14.4</td>
<td>1.5</td>
<td>1.1</td>
</tr>
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<td>16.2</td>
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<td>14.6</td>
</tr>
</tbody>
</table>

(Source: Adapted from Eysom and Ankrah 1973).
Microbiology and biochemistry of fermented fish

Most fermented fishery products are made from fatty fish. Lean fish has sometimes been noted to give a less acceptable texture and flavour. The role of fats in the fermentation process has not, however, been studied in any detail. Fish oils are highly unsaturated and hence very prone to oxidation. Certain pro-oxidants, such as haem, in the proteins catalyze the oxidation reaction. Similarly, iron impurities in the crude solar salt used for curing also accelerate auto-oxidation (Saisithi, 1969). Oxidized fish oils have a characteristic taste and paint-like smell, but the acceptability of products having the typical taste and flavour of oxidized fats depends very much on local preferences. The products of fat oxidation take part in further reactions especially with amines (Saisithi, 1969) and with other decomposition products of proteins (Bal and Dominova, 1967) to produce coloured compounds as well as substances with odour (Jones, 1966). Lipases present in the fish flesh also hydrolyze the lipids (Lovern, 1962), but the extent is dependent on the level of salting and fermentation (Amano, 1962; Lee et al., 2008).

Microbiology

Fish in its natural environment has its own micro-flora in the slime on its body, in its gut and in its gills. These microorganisms, as well as the enzymes in the tissues of the fish, bring about putrefactive changes in fish when it dies. Furthermore, the microorganisms generally present in the salt used for salting also contribute to the degradative changes in the fish. Figure 2 shows the relation between the growth ranges of microorganisms and water activity (A_w). Microorganisms require water in an available form for growth and metabolism. Figure 2 shows that all microbial growth is inhibited at water activity (A_w) below 0.60. Halophiles grow optimally at high salt concentrations but are unable to grow in salt-free media. Halotolerant organisms grow best in concentrations higher than that of sea water. Xerophiles are those organisms which grow rapidly of 0.85 but can also grow in concentrations higher than that of sea water. Osmophiles can grow under high osmotic pressure. Most food-borne bacterial pathogens are associated to the fermentation of lanhouin. The microbial population of lanhouin consisted of a variety of Gram-positive and Gram-negative bacteria. Most Bacillus isolates were identified as Bacillus subtilis, Bacillus licheniformis, Bacillus megaterium, Bacillus

Microbiological Shelf life

The shelf-life of fermented fish is an important quality characteristic. At high moisture content or low salt levels, insects tend to lay eggs on the product which eventually develop into maggots and destroy the fish. Very dry fermented fish without salt is easily infested by dermestes species. Dry fish can be stored for nearly six months, but the soft or semi-dry ones have a shelf life of up to three months (Essuman, 1992).

Shelf-life

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Table 3. Growth of microbial content in fermented fish

<table>
<thead>
<tr>
<th>Water Activity (A_w)</th>
<th>NaCl (%)</th>
<th>Microorganisms Growing Pathogens</th>
<th>Spoilage Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.98</td>
<td>&lt; 5.5</td>
<td>All known food-borne pathogens</td>
<td>Xerophilic moulds</td>
</tr>
<tr>
<td>0.98-0.93</td>
<td>3.5-10</td>
<td>Bacillus cereus, Clostridium botulinum, Salmonella sp., Staphylococcus</td>
<td>Lactic acid bacteria, Halophilic bacteria, yeasts, moulds</td>
</tr>
<tr>
<td>0.93-0.85</td>
<td>10-17</td>
<td>Mycotoxic, xerophilic moulds (no mycotoxin produced at A_w less than 0.80)</td>
<td>Yeasts, moulds (dun = Wallenia sebi)</td>
</tr>
<tr>
<td>0.85-0.60</td>
<td>&gt; 17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Adapted from Essuman 1992)
mycoides and Bacillus cereus; Staphylococcus species consisted mainly of Staphylococcus lentus and Staphylococcus xylosus (Table 4). Similarly to lanhouin, various species of microorganisms including Bacillus, Lactobacillus, Pseudomonas, Pediococcus, Staphylococcus, Klebsiella, Debaryomyces, Hansenula and Aspergillus involve in the fermentation of momone (Nerquaye-Tetteh et al., 1978; Yankah, 1988; Oronsaye, 1991; Essuman, 1992; Sanni et al., 2002) (Table 4). In contrast, the recent work carried out by Koffi-Nevry et al. (2011) on adjuevan a fermented fish from Côte d’Ivoire showed that the fermentation is dominated by lactic acid bacteria, and the genera and species isolated and identified were Leuconostoc lactis, Lactobacillus fermentum, Pediococcus sp. and Streptococcus sp.. A study by Abd-Allah (2011) reported that the microbial load was detected of Egyptian fermented salted Mugil cephalus fish (feseekh) consisted of Staphylococcus equorum, Bacillus subtilis, Lactobacillus sp., Teratogenococcus halophilus, Clostridium bifermens, Clostridium sp., Clostridium butyricum and Clostridium cochlearium.

Pathogens rarely multiply at high salt concentrations; however, Karnop (1988) demonstrated that Pediococcus halophilus is able to produce histamine during long storage at ambient temperatures of 20 to 25°C. Toxins produced by Clostridium botulinum in poor quality fish before salting may be stable in the salted product (Huss and Rye-Petersen, 1980).

Biochemistry

Physico-chemical characteristics of some of the African fermented fish products discussed in this review are summarized in Table 5. For example, the pH values of lanhouin are generally above (Beaumont, 2002; Anihouvi et al., 2006; Anihouvi et al., 2007). Similar higher values of pH were reported on momone (Nerquaye-Tetteh et al., 1978; Yankah, 1988; Abbey et al., 1994; Sanni et al., 2002). In contrast for adjuevan, pH values ranging between 5.2 and 6.10 were reported by Koffi-Nevry et al. (2011) and for feseekh the pH ranged from 6.4 to 6.9. No literature on the recommended pH range of African fermented fish products is available.

Several studies have been carried out to study the biochemical pathways followed during the degradation process of fish fermentation (Essuman, 1992). Pearson (1970) identified the following five chemical changes in deteriorating fish:

a) Enzymatic degradation of nucleotides and nucleosides in the flesh leading to the formation of inosine, hypoxanthine, ribose.

b) Bacterial reduction of trimethylamine oxide (TMAO), a non-volatile and non-odoriferous compound, to volatile trimethylamine (TMA) which has an ammoniacal smell.

c) Formation of dimethylamine (DMA).

d) Breakdown of protein with subsequent formation of ammonia (NH₃) indole, hydrogen sulphide.

e) Oxidative rancidity of the fat.

In the degradative changes occurring during fermentation no significant changes were observed in the amino acids particularly the essential ones. The degradation process, however, brings out certain characteristic flavours which are essential for the quality of the final product.

Table 4. Some African traditional fish products and micro flora involved in their production

<table>
<thead>
<tr>
<th>Types of fish</th>
<th>Product local name</th>
<th>Country</th>
<th>Fermentation duration</th>
<th>Microflora involved</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>seabream, threadfin,</td>
<td>Feseekh</td>
<td>Egypt</td>
<td>Low salt type 15-20 days, high salt type 3 months</td>
<td>Staphylococcus equorum, lacticina numb, Lactobacillus sp., Teratogenococcus halophilus, Clostridium bifermens, Clostridium sp., Clostridium butyricum, Clostridium cochlearium</td>
<td>Abd-Allah (2011)</td>
</tr>
<tr>
<td>croaker, kingfish</td>
<td>Lanhouin</td>
<td>Benin</td>
<td>3 - 8 days with salting</td>
<td>B. subtilis, B.licheniformis, B. megaterium, B. cereus, B. mycoides, Micrococcus luteus, Streptococcus sp., Streptococcus, Corynebacterium sp.</td>
<td>Anihouvi et al. (2007)</td>
</tr>
<tr>
<td>Catfish, croaker,</td>
<td>Adjuevan/Adjouba</td>
<td>Ivory</td>
<td>6 hours to 3 days with salting</td>
<td>Lactic acid bacteria, Leuconostociciax, Lactobacillus fermentum, Pediococcus sp., Streptococcus sp.</td>
<td>Nequaye-Tetteh et al. (1978), Essuman (1992), Koffi-Nevry et al. (2011)</td>
</tr>
</tbody>
</table>
**Table 5. Physico-chemical and nutritional composition of main African fermented fish products**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Moist (%)</th>
<th>Prot (mg)</th>
<th>FFA (mg)</th>
<th>NaCl (mg)</th>
<th>TVN (mg)</th>
<th>Hist (mg)</th>
<th>Ca (mg)</th>
<th>Fe (mg)</th>
<th>P (mg)</th>
<th>pH</th>
<th>A_w</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Momone</td>
<td>54.8</td>
<td>25.2</td>
<td>30.8</td>
<td>5.8</td>
<td>336.1</td>
<td>143</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.8</td>
<td>0.73</td>
<td>Essuman (1992), Abbeyet al. (1994), Anihouvi et al. (2006)</td>
</tr>
<tr>
<td>Feseekh</td>
<td>64.8</td>
<td>72.2</td>
<td>20.3</td>
<td>14</td>
<td>-</td>
<td>462</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6.4</td>
<td>6.9</td>
<td>El-Sebaiy and Metwalli (1989), Abdalla (1989), Anslan and Hamed (2012)</td>
</tr>
<tr>
<td>Lanhouin</td>
<td>56.6</td>
<td>24.6</td>
<td>31.9</td>
<td>5.2</td>
<td>374.5</td>
<td>33.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.6</td>
<td>0.77</td>
<td>Essuman (1992), Abbeyet al. (1994), Anihouvi et al. (2006)</td>
</tr>
<tr>
<td>Adjuevan</td>
<td>70.6</td>
<td>25.6</td>
<td>-</td>
<td>1.7</td>
<td>-</td>
<td>-</td>
<td>5.3</td>
<td>4.1</td>
<td>5.7</td>
<td>-</td>
<td>-</td>
<td>Koffi-Nevry et al. (2011)</td>
</tr>
</tbody>
</table>

Wet weight basis; Moist: moisture; Prot: protein; FFA: free fatty acids; TVN: total volatile nitrogen base; A_w: water activity; Hist: histamine; P: phosphorus; Ca: calcium; Fe: iron

Hiltz et al. (1976) reported that the volatile bases particularly TMA, DMA and NH₃, are associated with changes in the organoleptic and textural quality of fish. Adams (1986) noted that microorganisms play little or no part in aroma production. Beddows (1985) isolated halotolerant organisms, Bacillus sp. and used them in pure culture but none of them produced the typical fish sauce aroma.

**The Main African Traditional Fermented Fish**

**Momoni**

In Ghana one type of fermented fish product, momoni is popularly used as condiment for preparing sauces for the consumption of yam, cocoyam and apetum (boiled unripe plantain). For the preparation of momoni, different types of freshwater fish can be used; usually African jack mackerel (Caranx hippos) is employed. They can be scaled and gutted followed by washing in tap water and salting (294 - 310 g/kg) is done with the gill and gut regions being heavily salted. The fish are arranged in baskets covered with aluminium trays or jute bags and fermentation is allowed for 1 - 5 days. Before retailing, the fermented fish are washed in brine water, rubbed with salt and cut into small pieces. The cut pieces are sun-dried on a wooden tray in the open air for a few hours. Momoni is a solid product that is added to boiling stew consisting of ground red pepper, tomato, onion and little quantity of palm oil. The finished product is usually of low quality with a high salt concentration and deteriorates rapidly during retailing and storage (Sanni et al., 2002).

**Feseekh**

In Egypt, feseekh is a traditional name for the salted-fermented Bouri fish (Mugil cephalus). It is popular not only as an appetiser, but also as the main dish at some feasts in Egypt (El-Sebaiy and Metwalli, 1989). There are two types of feseekh on the Egyptian market, the first type having a low salt content and being suitable for consumption after 15 - 20 days of maturing, whilst the second has a high salt content and can be eaten after 2 - 3 months of storage. From the nutritional point of view, feseekh is a rich source of high quality protein, essential amino acids, vitamins and minerals (Rabie et al., 2009).

The traditional process of preparing it is to dry the fish in the sun before being preserved in salt. It has a distinctive stench to it that only its true lovers would appreciate. The process of preparing feseekh is quite elaborate; the information is passed from father to son in certain family. Feseekh is traditionally eaten during Sham El Nesem (“Smelling the Breeze”), which is a spring celebration in Egypt from ancient times. Some consider feseekh as a part of the good things of Egypt (El-Tahan et al., 1998).

**Lanhouin**

A fermented fish product is processed by spontaneous and largely uncontrolled fermentation. Disadvantages of this type of fermentation are that very little control can be exercised over the fermentation process and the product is often of variable quality with inherent risks of quality defects. Samples of lanhouin processed from cassava croaker/cassava fish (Speudotolithus sp.) or Spanish mackerel/king fish (Scomberomorus tritor), widely used as condiment in Benin, Togo and Ghana, were purchased from processors and retailers in the processing sites and markets respectively, for product characterization (Anihouvi et al., 2006).

**Adjuevan/Adjonfa**

Adjuevan, a traditional Ivorian naturally fermented fish prepared from the Atlantic bumper Chloroscombrus chrysura. This product is widely used and appreciated as a condiment in many types of flavourings and cuisines to season sauces for the consumption of yam, plantain, attieke, etc and not eaten as food fish because of the strong smell (Koffi-Nevry et al., 2007; Koffi-Nevry et al., 2008; Koffi-Nevry et al., 2011).

Adjuevan is a salted and fermented fish traditionally produced in the west coast of Ivory Coast. It is a traditional Ivorian naturally fermented fish prepared from the Atlantic bumper Chloroscombrus chrysura. This product is widely used and appreciated as a condiment in many types of flavourings and cuisines to season sauces for the consumption of yam, plantain, attieke, etc and not eaten as food fish because of the strong smell (Koffi-Nevry et al., 2007; Koffi-Nevry et al., 2008; Koffi-Nevry et al., 2011).
Coast at ambient temperature (28 - 30°C) following two traditional methods. First method of production took place in jars covered with plastics and stones for 5 days and second method followed the same fermentation process and then fish were dried on racks or nets for at least 10 days (Montet et al., 2012).

However, the uncontrolled fermentation process of during adjeuvan production could lead sometimes to a product with variable qualities with occasional public health hazards as indicated by Anihouvi et al. (2006).

Conclusion

Fermented fish products and manufacturing methods vary from country to country due to culture, social and geographical position and weather/temperature. In Africa, fermented fish is used both as a condiment and as food fish. In fermented fish products, the volatile bases particularly TMA, DMA and NH3, are associated with changes in the organoleptic and textural quality of fish. Unlike Southeast Asian products, fermented fishery products in Africa usually remain whole and firm after processing. This review covers the traditional methods of fish fermentation with salting and drying, factors affecting the quality of fermented fish, nutritional values of fermented fish, microbiological changes involved with fermentation, and flavor. We can conclude that as sanitary conditions of fermented fish production were generally found to be poor and processing methods were not standardized. The major issues of safety of fish as well as fermented fish products include microbiological and biochemistry changes (e.g., histamine poisoning, Salmonella and Clostridium poisoning, aflatoxin contamination). Targeting in short and long-term, the safety attributes will require more serious attention.

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