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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.

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 “stink” 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.

This article will primarily review fermented fish processing, quality parameters of fermented fish, nutritional and functional evaluation of fermented

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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).

Table 1. Source and type of fish used for fermentation

Country	Source: Artisanal Fisheries (%)	Industrial Fisheries (%)	Cold Stores (Frozen Fish) (%)	Filleting Factories (%)	Fish Species Processed
Burundi	90	10	0	0	*Limnothrissa* sp., *Stolothrissa* sp., Tilapia, Nile perch
Chad	100	0	0	0	*Alestes* sp., Tilapia, Nile perch, *Hydrocynus* sp.
Ivory Coast	60	25	10	5	Tuna, bonito, shark, ray, octopus, sole, seabream, catfish, croaker, meagre, skate, triggerfish, mullet
Gambia	85	10	5	0	Same as for Ivory Coast
Ghana	70	20	10	0	Same as for Ivory Coast
Mali	100	0	0	0	Tilapia, *Clarias* sp., *Schilbe* sp., *Alestes* sp., *Hydrocynus* sp.
Senegal	70	15	10	5	Same as for Ivory Coast
Sudan	95	5	0	0	Same as for Chad
Uganda	95	0	5	negligible	Tilapia, Nile perch, *Bagrus* sp., *Rastrineobola argenta*, *Haplochromis* sp.

(Source: Adapted from Essuman 1992).

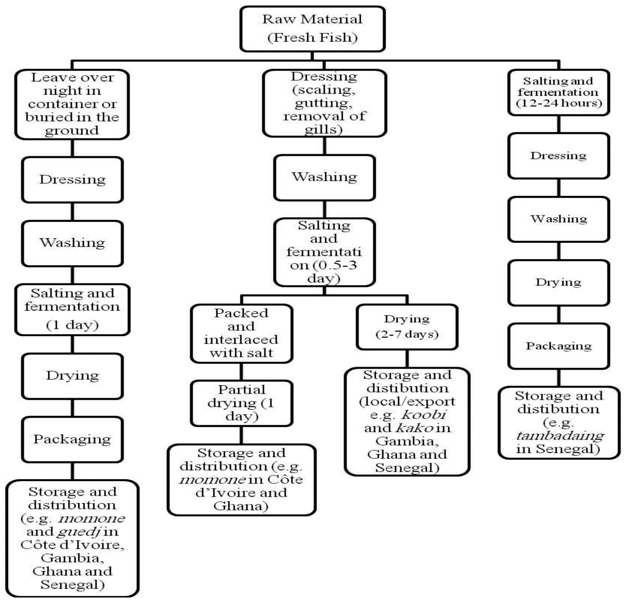

Figure 1. African traditional methods of fish fermentation with salting and drying (Source: Essuman 1992)

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

Table 2. Proximate composition of some raw and fermented fish

Type of Fish	Energy in Calories	Moisture %	Protein %	Fat %	Ash %
Cassava Croaker (*Pseudotolithus senegalensis*)					
Fresh	104	78.6	18.4	2.8	1.0
Fermented (*momone*)	134	57.6	26.2	2.4	14.6
Grey Snapper (*Lutjanus agennes*)					
Fresh	101	76.4	14.4	1.5	1.1
Fermented (*momone*)	-	64.9	18.2	1.4	-
Tilapia					
Fresh	123	73.4	16.6	5.8	6.8
Salted, fermented, sun-dried (*koobi*)	189	39.9	38.1	0.6	16.1
Unsalted, fermented, sun-dried	357	12.6	71.9	3.1	6.8
Triggerfish (*Balistes* sp.)					
Raw	-	79.1	19.4	0.3	1.4
Salted, fermented, dried	196	40.1	40.7	2.5	22.5

(Source: Adapted from Eyeson and Ankrah 1975).

fresh batches of fish with microorganisms (Essuman, 1992).

Drying

It is generally observed that fish is often dried on the ground except in commercial practices where raised drying racks are used. Drying fish on the ground is a source of contamination with sand and microorganisms (UNIFEM, 1988).

Waste disposal

At most of the processing sites in the countries of the survey, and indeed in many other African countries, there are no efficient of disposing of offal and other waste matter. These items are indiscriminately thrown away, thus polluting the environment and the available water body as well as serving as suitable breeding grounds for flies and mites which eventually infest the cured fishery product (Essuman, 1992).

Salt quality

Solar salt which is predominantly used for curing is often dirty and stored in heaps or in sacks on the bare ground without being covered. Solar salt is a major source of halophilic bacteria which causes poor quality fermented fishery products notably "pink" (Brennan, 2006).

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

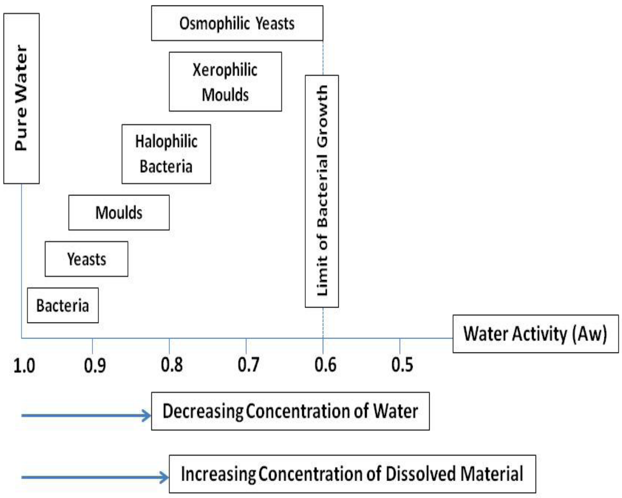

Figure 2. Growth ranges of microorganisms with respect to water activity (A_w) (Parry and Pawsey 1973)

unduly prolonged. *Momone*, for example, breaks up if poorly cured.

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).

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).

Table 3. Growth of microbial content in fermented fish

Water Activity (A_w)	NaCl (%)	Microorganisms Growing	
		Pathogens	Spoilage Organisms
0.98	< 3.5	All known food-borne	Most micro-organisms pathogens of concern in foods particularly the gram negative rods
0.98-0.93	3.5-10	*Bacillus cereus* *Clostridium botulinum* *Salmonella* sp. *Clostridium perfringens Vibrio parahaemolyticu*	*Lactobacilliaceae*, *Enterobacteriaceae*, *Bacilliaceae*, *Micrococcaceae*, moulds
0.93-0.85	10- 17	*Staphylococcus*	Cocci, yeasts, moulds
0.85-0.60	> 17	Mycotoxic, xerophilic moulds (no mycotoxin is produced at A_w less than 0.80)	Halophilic bacteria, yeasts, moulds (dun = Wallemia sebi)

(Source: Adapted from Essuman 1992).

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 without significant amounts of salt but can also grow in concentrations higher than that of sea water. Xerophiles are those organisms which grow rapidly under relatively dry conditions or below A_w of 0.85 while osmophiles can grow under high osmotic pressure. Most food-borne bacterial pathogens are not able to grow in an A_w range of 0.98 - 0.93, Table 3) (Essuman, 1992).

Lactic acid bacteria (LAB) are also found as the dominant microorganisms in many fermented fish products (Paludan-Müller *et al.*, 2002). The primary role of LAB is to ferment the available carbohydrates and thereby cause a decrease in pH. The combination of low pH and organic acids (mainly lactic acid) is the main preservation factor in fermented fish products.

Various authors have reported a large range of microorganisms involved in fish fermentation in African regions. According to Anihouvi *et al.* (2006, 2007), a large number of microorganisms 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*

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

Types of fish	Products local name	Country	Ferme-ntation duration	Microflora involved	References
Catfish, barraccuda, seabream, threadfin, croaker, grouper, bonito, mackerel, herrings, squid, octopus, bumper, snapper, ribbon fish	Momone	Ghana	Over-night to 3 days with salting	*B. subtilis, B. licheniformi, B.megaterium, B. cereux, B. mycoides, Micrococcus luteus, Staphylococcus* sp, *Lactobacillus, Pseudomonas, Pediococcus, Klebsiella, Debaryomyces, Hansenula, Aspergillus*	Nerquaye-Tettch *et al.* (1978), Yankah (1988), Oronsaye (1991), Essuman (1992), Sanni *et al.* (2002)
Bouri fish (*Mugil cephlus*)	Feseekh	Egypt	Low salt type 15-20 days, high salt type 3 months	*Staphylococcus equorum*, *Bacillus subtilis*, *Lactobacillus* sp, *Teratogenococcus halophilus*, *Clostridium bifermentans*, *Clostridium* sp, *Clostridium butyricum*, *Clostridium cochlearium*	Abd-Allah (2011)
Cassava croaker/Cassava fish, kingfish	Lanhouin	Benin	3 - 8 days with salting	*B. subtilis, B. licheniformis, B.megaterium, B. cereux, B. mycoides, Micrococcus luteus, Staphylococcus lentus, Staphylococcus xylosus, Streptococcus, Corynebacterium* sp	Anihouvi *et al.* (2007)
Catfish, croaker, meagre, shark, mullet, skate, rays, triggerfish, horse mackerel, octopus, tuna, sole, Spanish mackerel, seabream, herring,	Adjuevan/ Adjonfa	Ivory Coast	6 hours to 3 days with salting	Lactic acid bactria *Leuconostoc lactis*, *Lactobacillus fermentum*, *Pediococcus* sp, *Streptococcus* sp	Nerquaye-Tetteh *et al.* (1978), Essuman (1992), Koffi-Nevry *et al.* (2011)

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 bifermentans*, *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 amoniacal smell.

c) Formation of dimethylamine (DMA).

d) Breakdown of protein with subsequent formation of ammonia (NH_3) 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 5. Physico-chemical and nutritional composition of main African fermented fish products

Product name	Content/ 100g sample (wwb)									pH	A_w	References
	Moist	Prot	FFA	NaCl	TVN (mg)	Hist (mg)	Ca (mg)	Fe (mg)	P (mg)			
Momone	54.8	25.2	30.8	5.8	336.1	143	-	-	-	7.8	0.73	Essuman (1992), Abbey*et al.* (1994), Anihouvi*et al.* (2006)
Feseekh	64.8	72.2	20.3	14	-	462	-	-	-	6.4-6.9	-	El-Sebaiy and Metwalli (1989), Abdalla (1989), Aslan and Hamed (2012)
Lanhouin	56.6	24.6	31.9	5.2	374.5	33.1	-	-	-	7.6	0.77	Essuman (1992), Abbey*et al.* (1994), Anihouvi*et al.* (2006)
Adjuevan	70.6	25.6	-	1.7	-	-	5.3	-	4.1	5.7	-	Koffi-Nevry*et al.* (2011)

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 NH_3, 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 cephlus*). 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 chrysurus.* 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 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.

References

Abbey, L. D., Hodari-Okae, M. and Osei-Yaw, A. 1994. Studies on traditional processing and quality of fermented fish *momone*, Artisanal Fish processing and Applied Research Report, Ed. Food Research Institute, Accra-Ghana, 48

Abdalla, M. T. 1989. Microbiology and biochemistry of *fessiekh* fermentation. Khartoum, Sudan: University of Khartoum, MSc thesis.

Abd-Allah, S. M. S. 2011. Bacterial-flora of Egyptian salted Mugil cephalus fish (*fessiekh*) PCR-identification. Assiut Veterinary Medical Journal 57(130): 116-137.

Adams, M. R. 1986. Fermented flesh foods [sausages, fish products]. Progress in Industrial Microbiology 23: 159-198.

Amano, K. 1962. The influence of fermentation on the nutritive value of fish with special reference to fermented fish products of Southeast Asia. In Heen, E. and Kreuzer, R. (Eds). Fish in Nutrition, p. 180-200. London: Fishing News (Books) Ltd.

Anihouvi, V. B., Ayernor, G. S., Hoounhouigan, J. D. and Sakyi-Dawson, E. 2006. Quality characteristics of Lanhouin: A traditionally processed fermented fish product in the republic of Benin. African Journal of Food, Agriculture, Nutrition and Development 6(1): 1-15.

Anihouvi, V. B., Sakyi-Dawson, E., Ayernor, G. S. and Hounhouigan, J. D. 2007. Microbiological changes in naturally fermented cassava fish (*Pseudotolithus* sp.) for *lanhouin* production. International Journal of Food Microbiology 116(2): 287-291.

Bal, V. V. and Dominova, S. R. 1967. Changes of fish fat during curing. II. Interaction of fish lipids and protein decomposition products. Isv Vyssh Uched Zaved Pishch Tekhnol 2: 36.

BBC 2005. African fish industry ‘in crisis’. BBC NEWS Web. Downloaded from *http://news.bbc.co.uk/go/pr/fr/-/2/hi/business/4172280.stm* on 22/08/2005.

Beaumont, M. 2002. Flavouring composition prepared by fermentation with *Bacillus* spp. International Journal of Food Microbiology 75(3): 189-196.

Beddows, C. G. 1985. Microbiology of Fermented Foods. In Wood, B. J. B. (Ed). Fermented fish and fish products (Vol 2), p. 1-39. London: Elsevier Applied Science.

Brennan, J. G. 2006. Food Processing Handbook, 602 p. Weinheim: Wiley-VCH, Verlag GmbH & Co, KGaA.

El-Sebaiy, L. A. and Metwalli, S. M. 1989. Changes in some chemical characteristics and lipid composition of salted fermented Bouri fish muscle (*Mugil cephalus*). Food Chemistry 31(1): 41-50.

El-Tahan, M. H., Hassan, S. A., El-Awamry, Z. K. and Hamza, A. S. 1998. Studies on microorganisms contaminated salted fish in Egypt. Central Laboratory for Food & Feed (CLFF), Agricultural Research Central, Cairo, Egypt. Journal of Union Arab Biologists 6(B): 339-352.

Essuman, K. M. 1992. Fermented fish in Africa: A study on processing, marketing and consumption. FAO Fisheries Technical Paper. No. 329, FAO, Rome, 80.

Eyeson, K. K. and Ankrah, E. K. 1975. Composition of foods commonly used in Ghana. Accra, Ghana, Food Research Institute (CSIR), 1-39

FAO, 1971. Food and Agriculture Organization, Fermented fish products. FAO Fishery Report, Mackie, I. M., Hardy, R. and Hobbs, G. (Eds), FAO, Rome, 54.

Hiltz, D. F., Lall, B. S., Lemon, D. W. and Dyer, W. J. 1976. Deteriorative changes during frozen storage in fillets and minced flesh of silver hake (*Merluccius bilinearis*) processed from round fish held in ice and refrigerated seawater. Journal of the Fisheries Research Board of Canada 33(11): 2560-2567.

Huss, H. H. and Rye-Petersen, E. 1980. The stability of *Clostridium botulinum* type E toxin in salty and/or acid environment. Journal of Food Technology 15(6): 619-627.

Huss, H. I. and Valdimarson, G. 1990. Microbiology of

salted fish. FAO Food Technical News 10(1): 190.
Jones, N. R. 1966. Fish flavours. In Schultz, H. W., Day, E. A. and Libbey, L. M. (Eds). Chemistry and Physiology of Flavours, p. 267. Connecticut: AVI Publishing Company Inc.
Karnop, G. 1988. Verderb von salzsardellen durch histaminbildende Pediokokken. (Spoilage of salted sardine products by histamine forming pediococci.). Inf fur die Fischwirtschaft 1: 28-31.
Koffi-Nevry, R., Koussémon, M. and Aboua, F. 2007. Chemical and organoleptic properties of *Attoukpou* made from two cassava varieties. Journal of Food Technology 5(4): 300-304.
Koffi-Nevry, R., Koussémon, M., Nanga, Z. Y., Mobio, A. M., Kacou, C. and Tano, K. 2008. Évolution de la microflore et caractéristiques phyisico-chimiques d'un aliment traditionnel à base de manioc (*Manihot esculenta* Crantz) fermenté: le bêdêcouman. European Journal of Scientific Research 21(2): 259-267.
Koffi-Nevry, R., Ouina, T. S. T., Koussemon, M. and Brou, K. 2011. Chemical composition and lactic microflora of *Adjuevan*, A traditional Ivorian fermented fish condiment. Pakistan Journal of Nutrition 10(4): 332-337.
Lee, S. Y., Choi, W. Y., Oh, T. K. and Yoon, J. H. 2008. *Lentibacillus salinarum* sp. Nov., isolated from a marine solar salt in Korea. International Journal of Systematic and Evolutionary Microbiology 58(1): 45-49.
Lovern, J. L. 1962. The lipids of fish and changes occurring in them during processing and storage. In Heen, H. and Kreuzer, R. (Eds). Fish in Nutrition, p. 86-111. London: Fishing News (Books) Ltd.
Montet, D., Le Nguyen, D. D. and Kouakou, A. C. 2012. Determination of fish origin by using 16S rDNA fingerprinting of microbial communities by PCR-DGGE: An application on fish from different tropical origins. In: Muchlisin, Z. A. (Ed). Aquaculture, p. 93-108. Rijeka: InTech.
Nerquaye-Tetteh, G. A., Eyeson, K. K. and Tete-Marmon, J. 1978. Studies on momone, a Ghanaian fermented fish product. Ghana Journal of Agriculture Science 11: 21-26.
Oronsaye, J. 1991. An approach to Fish Processing and Preservation, Africa Bio-Science Network (ABN), 125
Paludan-Müller, C., Madsen, M., Sophanodora, P., Gram, L. and Møller, P. L. 2002. Genotypic and phenotypic characterization of garlic-fermenting lactic acid bacteria isolated from som-fak, a Thai low-salt fermented fish product. International Journal of Food Microbiology 73(1): 61-70.
Parry, T. J. and Pawsey, R. K. 1973. Principles of microbiology for students of food technology. p. 153. London: Hutchinson Educational.
Pearson, D. 1970. The Chemical Analysis of Food (6th Edn), p. 604. London: Churchill Publisher.
Rabie, M., Simon-Sarkadi, L., Siliha, H., El-seedy, S. and El Badawy, A. A. 2009. Changes in free amino acids and biogenic amines of Egyptian salted-fermented fish (*Feseekh*) during ripening and storage. Food Chemistry 115(2): 635-638.
Raslan, A. A. and Hamed, A. 2012. Estimation of biogenic amines in salted – fermented fish and some fish products in Cairo Markets with special references to its storage. Report and Opinion 4(6): 47-52.
Saisithi, P. 1967. Studies on the origin and development of the typical flavour and aroma of Thai fish sauce. USA: University of Washington, PhD Thesis.
Sanni, I., Asiedu, M., Ayernor, G. S. 2002. Microflora and chemical composition of *Momoni*, a Ghanaian fermented fish condiment. Journal of Food Composition and Analysis 15(5): 577-583.
UNIFEM 1988. The United Nations Development Fund for Women (UNIFEM) for Food Cycle Technology Source Book. Project GLO/85/W02, 9.
Watanabe, K. 1982. Fish handling and processing in tropical Africa. In proceeding of the FAO export consultation on fish technology in Africa, Casablanca, Morocco, June 7-11, 1982. FAO Fish Report 268: 18-25.
Watts, J. C. D. 1965. Some observation on the preservation of fish in Sierra Leone. Bulletin de mpani xxvill Sci of no. 1
Yankah, W. 1988. Studies on momone: a Ghanaian fermented fish product, in Department of Nutrition and Food Science, Ed. University of Ghana, Legon, 80
Zakhia, N. and Cuq, J. L. 1991. Traditional Methods of Fish Fermentation in Ghana proceedings of the FAO export consultation on fish Technology in Africa, Accra, Ghana