QUALITY AND SAFETY ISSUES ASSOCIATED WITH FERMENTED FISHERY PRODUCTS

Devananda Uchoi and Pankaj Kishore
ICAR-Central Institute of Fisheries Technology, Cochin
uchoidev514@gmail.com

Introduction

Fermented fishery products (FFPs) are consumed by people from different parts of the world and are more popular in South-east Asian countries. The FPPs possess a unique blend of aroma and flavour which contributes to achieved its characteristics taste. The FPPs are reported with several health benefits owing to beneficial microbes, nutraceutical and functional molecules (Paredes and Harry, 1988). Food Safety and Standard Regulations, India (FSSR, 2011) defined fermented fishery products as any fishery product that has undergone degradative changes by the action of enzymes or microbes either with or without salt. Non-traditional products manufactured by accelerated fermentation, acid ensilage and chemical hydrolysis also belong to this category. The popular ethnic FFPs in India are *hentak, ngari, tungtap, puthi shidal, lona ilish, phasa shidal, hidal,* etc. (Thapa *et al*., 2004). The categories of various FFPs in South-east Asian countries, African countries, American countries and European countries are presented in Table 1. Some of the popular FFPs in South-east Asia are *nam-pla* and *pla-ra* in Thailand, *phu quoc*, *shiokara* and *narezushi* in Japan, *budu* and *belacan* in Malaysia, *patis* and *buro* in Philippines, *nuoc-mam* and *mams-ca* in Vietnam, *makassar* and *trassi* in Indonesia and *ngapi* in Myanmar. While *feseekh*, *momone*, *lanhouin*, etc. are popular FFPs in African countries. However, it is essential to understand that the health beneficial aspects of FFPs can be limited if potential food safety hazards and other quality issues are not considered. Therefore, in this chapter the quality issues in fermented fishery products and the corresponding mitigation measures were discussed.

Significance of fermented fishery products

Fermented fish are rich source of essential fatty acids such as omega-3 fatty acids (EPA, DHA) & omega-6 fatty acids (AA, linoleic acid); essential amino acids and micronutrients such as cobalt, chromium, copper, iron, manganese, nickel, zinc, boron, selenium, calcium, magnesium, etc. Fermented fish are potential diet for improving nutritional security particularly in developing countries. Certain FFPs possess probiotic microbes such as lactic acid bacteria (LAB). Commonly isolated LAB from FFPs are *Lactobacillus acidipiscis, L. versmoldensis, L. plantarum, L. Alimentarius, Lactococcus lactis ssp. lactis, Tetragenococcus halophilus, T. muriaticus,*

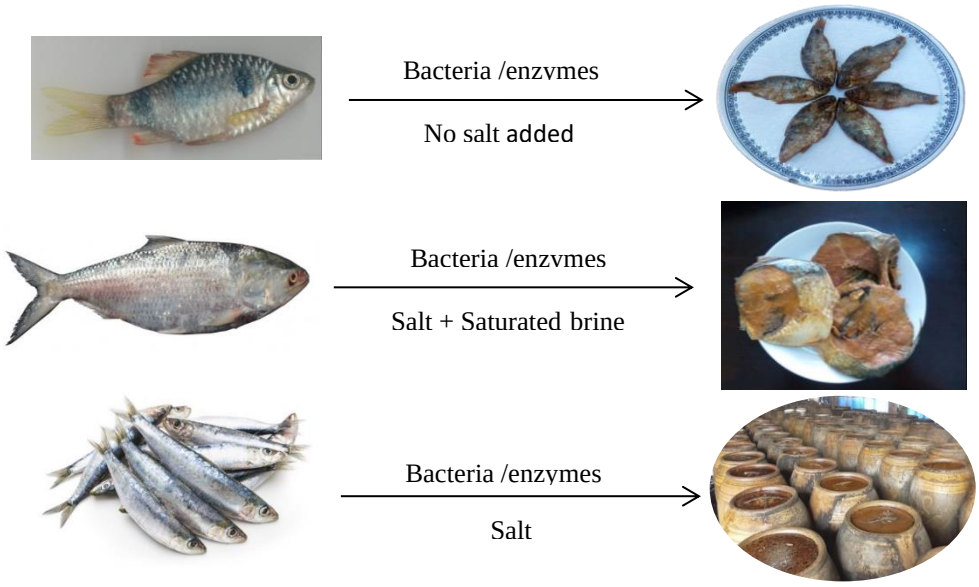
Pediococcus pentosaceus, P. acidilactici, etc. Ingestion of probiotic yogurt has been reported to stimulate cytokine production in blood cells and enhance the activities of macrophages (Solis and Lemonnier, 1996). Similar effect can be anticipated from LAB associated with FFPs. Bioactive peptides isolated from FFPs are reported to inhibit Angiotensin-I-converting enzyme (ACE) and control hypertension. Fermented products produced by lactic and bifids have potential anticarcinogenic activity (Goldin and Gorbach, 1977). The consumption of fermented foods containing viable cells of *Lactobacillus acidophilus* decrease β-glucuronidase, azoreductase, and nitroreductase (which catalyze the conversion of procarcinogens to carcinogens), thus possibly removing procarcinogens and activating the immune system of consumers, it is also anti-hypertensive (Goldin and Gorbach, 1984).

Table 1. Different categories of fermented fishery products in the world

Countries	**Sauce**	**Paste**	**Whole/slice**
Japan	Phu Quoc	Nukazuke, Shiokara,	Narezushi, Funazushi
Thailand	Nam-pla, pla-ra,		Plaa-som, som-fug
Indonesia	Makassar, bakasang, bud	trassi	
Malaysia	Budu, pekasam, belacan		
Philippines	Patis, buro,	bagoong (shrimp)	
Vietnam	Nuoc-mam,	Mams-ca	
Norway			Rakfisk (fermented salmo saithe
Ghana			Momone
Korea			Jeotgal (shrimp, oyster, fis Hongeo-hoe
Myanmar		Ngapi	
Bangladesh			Shutki, Lona ilish
India			Seedhal, ngari, Hentak, Lo ilish, etc.
Greece	Garam		Lekarda
Egypt			Feseekh (gray mullet)
Iceland			Hakarl (shark)
Sweden			Surstromming (herring)
China			Fermented silver carp

Sri Lanka			Columbo cured mackerel
Alaska			Igunaq
Canada			
Greenland			

Source: Tamang and Kailasapathy (2010)



Hongeo-hoe: Korea

Igunaq: Greenland, Alaska, Canada

Kusaya: Japan

Lekarda: Greece

Rakfisk: Norway

Feseekh of Egypt

Bakasang and Budu of Indonesia

Momone of Ghana

Nam pla of Thailand

Ngapi of Myanmar

Advantages of fish fermentation

- Simplest way of preserving fish during surplus catch
- Overcome scarcity of fishery products in times of fishing off-season
- Imparts unique aroma and characteristics taste to the products
- Nutrients enrichment of the product by the action of fermentative microflora during the process of fermentation
- Production of beneficial microbial enzymes in the products
- Value addition of the products
- Development of varieties in fishery products
- Economic and affordable technology by the fisher folks
- High end equipments are not required
- No high technical subject matters are involved
- Create business or entrepreneurship opportunity
- Provide livelihood to fisher's community

- Utilization of rest raw materials (silage, hydrolysate, etc.)
- Minimization of protein loss from fishery sector

Chemical changes during fish fermentation

The pH of fish decrease during fermentation due to production of organic acids, free amino acids and large acidic polypeptides by biochemical and microbial actions. These acids contribute to the flavour development of fermented fishery products. Microbial actions degrade protein which leads to the production of volatile compounds from amino acids and small peptides. Trimethylamineoxide (TMAO) undergoes reduction to produce trimethylamine (TMA) by bacterial action giving rise to fishy odour of fermented fish. However, not all microorganisms play roles in aroma development. In the degradative changes occurring during fermentation, no significant changes were reported in the amino-acids profile particularly the essential ones. The products of fat oxidation take part in further reactions especially with amines and other decomposition products of proteins to produce coloured compounds as well as odorous substances. Lipases present in the fish flesh also hydrolyse the lipids, but the extent is dependent on the level of salting and fermentation. The volatile bases particularly TMA, DMA and NH_3 are associated with changes in the organoleptic and textural quality of fish.

Composition and biochemical qualities of fermented fishery products

Parameter	**Range of values**
Moisture	35- 69%
Protein	30-40%
Lipid	10-15%
Ash	10-25%
pH	4.25 to 6.0
Salt content	5- 28% or nil in some products
Volatile nitrogen fraction	TVBN: 60- 450 mg/100g NPN: 2-3 g%
Lipid by-products	PV: 60-70 meqO_2/Kg lipid FFA: 30-50 (as % Oleic acid)
Water activity(a_w)	0.98 to 0.89

Common quality issues in fermented fishery products

- Histamine formation in favourable environment
- Mycotoxin formation in poorly stored raw materials and products

- Botulinum toxin production in favourable condition
- Contamination with foodborne pathogens when handled unhygienically
- Growth of parasites
- Production of very high volatile nitrogen compounds
- Development of rancidity
- Dehydration and dryness in poorly stored products
- Occurrence of sand particles
- Discolouration of the products

Potential food safety hazards in fermented fishery products

- Histamine - chemical hazard
- Pathogenic *Escherichia coli* - biological hazard
- Coagulase positive *Staphylococci aureus and its* enterotoxin - biological hazard
- *Salmonella* - biological hazard
- Botulinum poisoning - biological hazard
- Parasites (in low salted product)- biological hazard
- Heavy metals and chemical residues - chemical hazard
- Biotoxins (if marine reef fishes are used) - chemical hazard

Histamine content and associated histamine formers

Fermented fishery products such as fish sauce and fish paste are reported to possess high content of histamine. Sanceda *et al.* (1996) reported histamine level of 430 ppm in *nampla* and 1380 ppm in Korean anchovy sauce. Kirschbaum *et al*. (2000) also reported histamine at 721 to 757 ppm in anchovy fish sauce. The majority content of histamine in 549 commercial fish sauces in Thailand was in the range of 200-600 ppm (Brilliantes and Samosorn, 2001). Fermented fishery products are usually consumed in small amounts, so higher concentrations of histamine could possibly be tolerated in these products. Yatsunami and Echigo (1993) identified halotolerant *Staphylococcus* spp., *Vibrio* spp., and *Pseudomonas* spp. as histamine formers from fermented salted sardine (nukazuke) products. *Tetragenococcus muriaticus*, a moderate halophilic and lactic acid coccus,

is a histamine-forming bacterium in salted and fermented fish products and it possess histidine decarboxylase gene (Kobayashi *et al*., 2004). These suggest that accumulation of histamine in salted and fermented fishery products may be affected by their histidine content and composition of halophilic histamine forming bacterial flora. Levels of above 200 mg/kg have been associated with human illness. However, levels as low as 50 mg/kg have known to cause illness, but this is uncommon. Most cases of illness caused by histamine in fish and fishery products have been above 200 mg/kg, and often above 500 mg/kg.

Preventive measures for histamine formation

Use fresh raw material transported at chilled condition. Gutting and gilling of susceptible fish. Refrigerated storage and freezing of unused raw martial. Using suitable starter cultures and/or their enzymes. When fresh fish was used for ripening, histamine formation in anchovy products did not occur (Herrero *et al.*, 1999). FSSR (2011) notified for fermented fishery products that out of 9 samples only 2 samples may have 200 mg/kg histamine and no sample should possess equal to or more than 400 mg/kg histamine.

***Clostridium botulinum* and botulinum toxin formation**

Toxins produced by *Clostridium botulinum* under favourable condition in fish before salting can be stable in the salted product. Abdalla (1989) reported that in *fessiekh* processing the pH of about 6.4 to 6.9 and the salt level of 6-7% offers favorable conditions for the growth of *C. botulinum* and other proteolytic bacteria. This could possibly be the reason for fatalities involving the consumption of *fessiekh* in Egypt where the uncooked product is a delicacy among some people. Botulinum toxin have a lethal dose of 1.3–2.1 ng/kg in humans.

Preventive measures for botulinum toxin

Maintaining pH 4.5 or below, or having NaCl content of 15% and above would prevent growth of *C. botulinum* and formation of toxin. Therefore, the low level of incidence of *C. botulinum* poisoning in fermented fishery products may be mainly attributed to the high level of salt usage, activities of proteolytic enzymes and cooking before consumption.

Foodborne pathogen in fermented fishery products

Foodborne pathogenic bacteria such as pathogenic *E. coli*, coagulase positive *Staphylococci* and *Salmonella* may be present in fermented fishery products if cross contamination occurs through contaminated water, contaminated surfaces and unhygienic handling.

Preventive measures

Adoption of effective Good Manufacturing Practises (GMP) and Sanitation Standard Operating Procedure (SSOP) in the manufacturing unit will prevent the cross contamination of the fermented fishery products with foodborne pathogenic bacteria. Examples such; Food handlers must wash hand thoroughly after using the lavatory. Food handlers must maintain personal hygiene, etc.

Biotoxin (Ciguatera)

Biotoxin occurs in fishes of tropical and subtropical area, particular in reef fishes such as snapper, barracuda, grouper, etc. The toxins accumulate in fish when they feed on marine algae, where the toxins are present in sub-lethal state. The use of such contaminated fishes as raw material for production of fermented fishery products might cause serious consumer illness. Therefore, selection of appropriate fish species as raw material for preparation of fermented fishery products is very crucial.

Prevention measures

To ensure that incoming fish have not been caught in an area for which there is a CFP advisory or for which there is knowledge that CFP is a problem.

Regulatory guidelines for fermented fishery products (FSSR, 2011)

PARTICULARS	**ORGANISM & TEST METHOD**	**SAMPLING**		**LIMITS**		**STAGE WHERE CRITERION APPLIES**
		n	*c*	*m*	*M*	
Hygiene Indicators (cfu/g)	*Coagulase positive Staphylococci* **Testing:**	5	1	1×10^2	1×10^3	End of Manufacturing process

	ISO : 6888-1 or ISO : 6888-2					
	Yeast &mold count **Testing:** IS:5403/ISO: 21527	5	0	100		End of Manufacturing process
Biogenic amine (mg/kg)	*Histamine* **Testing:** ISO : 19343: 2017	9	2	200		400
Safety Indicators	*Escherichia coli (cfu/g)* **Testing:** IS: 5887 Part 1 or ISO: 16649-2	5	2	4	40	-
	Salmonella **Testing:** IS: 5887 Part 3/ ISO: 6579	10	0	**Absent/25g**		-
	Clostridium botulinum **Testing:** IS: 5887, Part 4 or ISO: 17919	Absence of viable spores or vegetative cells of *Clostridium botulinum* and absence of botulinum toxin.				-

PARTICULARS	**HAZARDS**	**LIMITS**
Toxic Heavy Metals	*Arsenic (As)*	76 mg/Kg
	Cadmium (Cd)	0.3 mg/Kg
	Mercury (Hg)	0.5 mg/Kg

	Lead (Pb)	0.3 mg/Kg
	Chromium (Cr)	12 mg/Kg
General parameters for fish sauce	pH	5.0 – 6.5 (Traditional Product) > 4.5 (If ingredients used to assist fermentation)
	Total Nitrogen Content	>10g/ L
	Amino Acid Nitrogen Content	> 40% of total nitrogen content
	NaCl	> 200g/L

Where,

n = Number of units comprising a sample

c = Maximum allowable number of units having microbiological counts above m

m = Microbiological limit that may be exceeded number of units c

M = Microbiological limit that no sample unit may exceed

Conclusion

Fermented fishery products can be thus regarded as a nutrients rich diet where essential fatty acid and amino acids, mineral and vitamins are present in significant percentage. Fermented fishery products are potential diet for improving nutritional security in the society. However, the quality of the products differs from region to region. The GMP and SSOP need to be in place for hygienic fermented fishery products. Effort needs to be taken by the processors to comply the quality parameters of the regulatory guidelines. All category of hazard needs to be controlled by elimination or minimizing to an acceptable limit for safe consumption of the products.

References

Abdalla, M. T., 1989. Microbiology and biochemistry of fessiekh fermentation. A thesis submitted in partial fulfillment of requirements for the degree of M.Sc. in Food Microbiology. Faculty of Agriculture, University of Khartoum.

Brilliantes, S., and Samosorn, W., 2001. Determination of histamine in fish sauce from Thailand using a solid phase extraction and high performance liquid chromatography. *Fish. Sci*., 67: 1163-1168.

FSSR. 2011. *Food Safety and Standards (Food Products Standards and Food Additives) Regulations*. Delhi.

Goldin, B. R. and Gorbach, S. L., 1984. The effect of milk and *lactobacillus* feeding on human intestinal bacterial enzyme activity. *American Journal of Clinical Nutrition,* 39: 756–761.

Goldin, B., & Gorbach, S. L. 1977. Alterations in fecal microflora enzymes related to diet, age, lactobacillus supplements, and dimethylhydrazine. *Cancer*, *40*(S5), 2421-2426.

Hernandaz-Herrero, M. M., Roig-Sauges, A. X., Lopez-Sabater, E. I., Rodriguez- Jerez, J. J., and Mora-Ventura, M. T., 1999. Total volatile basic nitrogen and other physiochemical and microbiological characteristics as related to ripening of salted anchovies, *J Food Sci*, 64(2): 344-347.

Kirschbaum, J., Rebscher, K., and Bruckner, H., 2000. Liquid chromatographic determination of biogenic amines in fermented foods after derivatization with 3,5-dinitrobenzoyl chloride. *Journal of Chromatography* A, 881, 517–530.

Kobayashi, T., Kajiwara, M., Wahyuni, M., Hamada-Sato, N., Imada, C. and Watanabe, E., 2004. Effect of culture conditions on lactic acid production of *Tetragenococcus* species. *Journal of Applied Microbiology, 96,* 1215–1221.

Sanceda, N. G., Kurata, T., and Arakawa, N., 1996. Accelerated fermentation process for the manufacture of fish sauce using histidine. *Journal of Food Science,* 61, 220–225.

Solis, P. and Lemonnier, D., 1996. Induction of human cytokines by bacteria used in dairy foods. Nutrition Research, 13: 1127–1140.

Tamang, J. P. and K. Kailasapathy., 2010. Fermented foods and beverages of the world. Boca Raton, CRC Press/Taylor & Francis.

Yatsunami, K., Echigo, T., 1993. Changes in the number of halotolerant histamineforming bacteria and contents of nonvolatile aminesin sardine meat with addition of NaCl. Nippon Suisan Gakk. 59, 123–127.

Thapa, N., Pal, J. and Tamang, J. P., 2004. Microbial diversity in ngari, hentak and tungtap, fermented fish products of Northeast India. *World Journal of Microbiology and Biotechnology*, 20(6): 599–607.

***