



Quality Characteristics of Two Freshwater Fishes Smoked under Traditional and Mechanical Methods

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Abstract

The study deals with comparison of quality characteristics between two freshwater fishes smoked by two different methods. Two commercially important smoked fish products of Manipur viz., smoked *Amblypharyngodon mola* and *Puntius sophore* were collected from the markets of Manipur and assessed the biochemical, microbiological and sensory qualities and were compared with the mechanically smoked *A. mola* and *P. sophore*. Moisture content of the mechanically smoked products was less than the market samples. Ash and protein content were more in mechanically smoked samples than market samples. Values of freshness parameters like TVBN, AAN, PV, FFA were less in mechanically smoked products than market products indicating better quality of the former. Bacteriological count was within the acceptable limits and no visible fungal colonies were detected in any of the products. Mechanically smoked products showed better organoleptic characteristics than traditionally smoked products. The study revealed that mechanically smoked fish products were better in all quality aspects for both the fishes in comparison to traditional smoked products of Manipur. So, mechanical method of smoking can be preferred over traditional one.

Keywords: Smoked fish, traditional smoking, mechanical smoking, *Amblypharyngodon mola*, *Puntius sophore*, cured products

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Introduction

Fish is one of the perishable food items due to its higher moisture content. Therefore, processing and preservation of fish is necessary immediately after harvesting. Different processing and preservation methods like salting, drying, smoking and fermentation prevail in the north-eastern states. Among these, smoking using wood and saw dust is cheaper and one of the commonly used methods by the north-eastern people. Fish smoking is a traditional method of processing globally; it accounts for about 3% of the world's catch and also increases the shelf-life of the fish (Olowoniyi et al., 1998; Gupta & Gupta, 2006). The flesh of smoked fish is delicate, succulent and delicious and can readily be consumed without further processing (Olowoniyi et al., 1998; Eyo, 2001). The main purpose of smoking is to impart attractive appearance and flavour. This process provides some antimicrobial action but during subsequent refrigerated storage, the surviving microflora multiplies and causes spoilage (Gonzalez-Rodriguez et al., 2002). Smoked form of small variety fishes like *Amblypharyngodon mola*, *Puntius sophore*, *Colisa fasciata*, *Mystus gulio* etc. have good demand in the markets of Manipur. These small freshwater fishes spoil easily due to faster onset of rigor mortis than the bigger fishes. The fish are preserved by partially drying and then smoking by traditional methods in Manipur.

Market samples are generally smoked by traditional methods in open condition by paddy husk, wood etc. and chances of contamination from sand, dust, insects and microbes are high. Mechanical smoking method is carried out in a smoking kiln under controlled temperature and humidity conditions and the products remain safe from dust, sand, insects etc. In the present study, fresh fishes *Amblypharyngodon mola* and *Puntius sophore* hot smoked in mechanical smoking kiln by using saw

dust and wood was compared with the smoked fish samples of same species procured from the markets of Manipur.

Materials and Methods

Traditional smoked fish products *viz.*, smoked *A. mola* and *P. sophore* were collected from the markets of Manipur in sterile polythene bags (100 gauge) and were brought to laboratory of Department of Fish Processing Technology, College of Fisheries, CAU, Tripura under hygienic conditions and stored at ambient temperature. For smoking in mechanical smoking kiln, fresh samples of *A. mola* and *P. sophore* were collected from the local markets of Tripura and packed in ice (1:1) in insulated box and brought to the laboratory. In the laboratory, fish were first made free of faecal matter by squeezing abdomen followed by thorough washing with potable water. The average size and weight of the fish were 6.21 cm & 1.92 g and 7.37 cm & 4.66 g respectively for *A. mola* and *P. sophore*. The medium size fishes were smoked after dressing (removing the gut) whereas the small sized fishes were smoked whole. Fishes were then exposed to flame in a traditional kiln briefly to burn the skin and then fishes were smoked in mechanical smoking kiln (Suan Scientific Instrument). The time and temperature of smoking were standardized by several trials and evaluating sensory qualities. The fishes were spread on a wire mesh tray inside the kiln. Smoke is generated from wood or by burning saw dust in smoke generation chamber. Temperature was maintained constant (70°C) throughout the process by electric or steam heaters which are thermostatically controlled. The warm smoke was circulated by a fan at an even speed over the fish kept inside the smoking kiln in wire mesh trays. Fish were smoked till desired golden brown colour and characteristic smoky flavour was obtained. The approximate duration of smoking for small fish *A. mola* was around 2.5 to 3 h and for *P. sophore* around 3.5 h. After smoking, smoked fish products were cooled at room temperature and packed in polythene packs of 100 gauges by heat sealing. The products were then analyzed for different quality parameters.

The proximate composition and non-protein nitrogen (NPN) of the smoked fish was determined according to AOAC, (2000) and the salt soluble nitrogen (SSN) by Dyer et al. (1950). The total volatile base nitrogen (TVB-N) was estimated by Conway's micro diffusion method (Conway, 1947) and alpha amino nitrogen (AAN) was determined

by Pope & Stevens (1939) method. The peroxide value (PV) of the samples was determined by the method of Jacobs, (1958) free fatty acid (FFA) according to the method described by Nambudiri (1985) and pH in a digital pH meter (Sartorius Make Basic pH meter PB-20) by homogenizing 10 g of sample with 50 ml of distilled water.

The microbial quality of the smoked fish products was determined by following standard methods outlined in USFDA (2001) and APHA (1976). Total plate count was assessed by pour plate technique. Enumeration of yeasts and moulds was carried out on Potato Dextrose Agar. *Escherichia coli*, faecal *Streptococci* and *Staphylococcus aureus* determination was carried out in Tergitol-7, Kenner Faecal (KF) Agar and Baired Parker (BP) Agar respectively. For enumeration of *Salmonella* pre-enriched and selective enriched samples were streaked on Bismuth Sulphite Agar, Xylose Lysine Deoxycholate Agar and Brilliant Green Agar separately and incubated at 37°C for 48 h.

Sensory evaluation of smoked fish products was judged for appearance, colour, taste, texture, odour and overall acceptability following Lilabati et al. (1999).

Results and Discussion

Proximate composition of both market samples and mechanically smoked samples of *A. mola* and *P. sophore* are given in Table 1. The moisture content for market samples and mechanically smoked samples of *A. mola* was 11.56 and 8.8% and of *P. sophore* was 15.17 and 10.8% respectively. The higher moisture content in market samples may be due to post-processed absorption of water during traditional processing and retailing. Comparatively lower moisture content in mechanically dried products can be attributed to hot smoking and controlled temperature and humidity condition inside the smoking kiln. This observation is in agreement with the findings of Salan et al. (2006) and Kumolu-Johnson & Ndimele (2001) which reported that spoilage of fish resulting from the action of enzymes and bacteria can be slowed down by the addition of salt as well as reduction in moisture through sun drying or smoking. Moisture plays an important role in the spoilage of fish and fish products as lowering of moisture retards the spoilage (Stansby, 1963). A moisture content of 56.96% was reported by Mathias et al. (2003) in case

Table 1. Proximate composition of traditionally smoked and mechanically smoked *Amblypharyngodon mola* and *Puntius sophore*

Parameters	Product type	<i>Amblypharyngodon mola</i>	<i>Puntius sophore</i>
Moisture (%)	Traditionally smoked	11.56±0.32	15.17±0.46
	Mechanically smoked	8.8±0.6	10.8±0.35
Ash (dry wt basis) (%)	Traditionally smoked	10.61±0.45	12.22±0.5
	Mechanically smoked	11.91±0.54	21.57±0.72
Crude protein (dry wt basis) (%)	Traditionally smoked	65.46±0.7	60.59±0.85
	Mechanically smoked	69.18±0.53	61.46±0.79
Lipid (dry wt basis) (%)	Traditionally smoked	15.43±0.24	12.33±0.67
	Mechanically smoked	16.47±0.87	11.9±0.5

of hot smoked trout fillets. Daramola et al. (2007) studied the moisture content in the five smoked fish species such as *Heterotis niloticus*, *Labeo coubie*, *Parachanna obscura*, *Oreochromis niloticus* and *Clarias gariepinus* which ranged between 10.41 and 10.62%.

Ash content was found to be 10.61 & 12.22% and 11.91 & 21.57% for market samples and mechanically smoked products of *A. mola* and *P. sophore* respectively. Relatively higher ash contents in *P. sophore* may be due to use of whole fish for analysis. Salan et al. (2006) opined that the increase in ash content when fish are smoked is due to loss of humidity while Doe et al. (1983) reported that smoking resulted in concentration of nutrients like crude protein and fat. Karthikeyan et al. (2012) reported almost similar values of ash content for *A. mola* and *P. sophore* for smoked fish products available in the markets of Manipur. The crude protein content was 65.46 & 60.59% and 69.18 & 61.46% for market samples and mechanically smoked products of *A. mola* and *P. sophore* respectively. Johnson et al. (2010) reported almost similar values of crude protein for smoked *Clarius gariepinus* from a fish pond and market in Lagos, Nigeria. Karthikeyan et al. (2012) reported almost similar values of crude protein content for the same smoked fish products from the markets of Manipur. However, in the present study relatively higher content of crude protein was found in mechanically smoked product. The lipid content was found to be 15.43 & 12.33% and 16.47 & 11.9% for market samples and mechanically smoked products of *A. mola* and *P. sophore* respectively. As a result of moisture loss during smoking and drying process, the relative lipid content was found to be higher in the fish products (Eyabi & Eyabi, 1988). The results of

proximate compositions are in agreement with the results of the work done on some smoke-dried hill stream fishes from Manipur by Abdul Hei & Sarojnalini (2012). Agbabiaka et al. (2012) also reported fat content of about 20.19% in smoked catfish.

The values for salt soluble nitrogen (SSN) and non-protein nitrogen (NPN) of the smoked fish products are given in Table 2. The solubility of proteins and quantity of non protein nitrogen gives an index of the changes taking place in meat during smoking and drying. The lower value of SSN indicates denaturation of protein and formation of high molecular weight protein aggregates during smoking and subsequent drying process. Tadokoro & Watanabe (1928) reported decrease in salt soluble proteins and increase in insoluble and non protein nitrogenous compounds due to denaturation of proteins during smoke-drying. The present study revealed higher NPN content of smoked fish products collected from markets which may be due to higher proliferation of microbes and more protein denaturation due to longer exposure in open condition. However, SSN value was low and NPN value was high for mechanically smoked *A. mola* which may be due to the initial quality of raw material. But the difference in NPN and SSN value of market and mechanically smoked samples of *A. mola* was negligible. Karthikeyan et al. (2012) also reported similar values of SSN and NPN for smoked fish products from the markets of Manipur.

The values of protein degraded compounds like TVBN and AAN for both the products are given in Table 2. This high value of TVB-N of smoked fish might be attributed to the release of volatile bases

Table 2. Bio-chemical quality characteristics of traditionally smoked and mechanically smoked *Amblypharyngodon mola* and *Puntius sophore*

Parameters	Product type	<i>A. mola</i>	<i>P. sophore</i>
pH	Traditionally smoked	6.70	6.60
	Mechanically smoked	5.99	5.92
TVBN (mg %)	Traditionally smoked	26.6±2.8	21.4±0.81
	Mechanically smoked	23.1±0.42	10.6±0.43
NPN (%)	Traditionally smoked	1.42±0.17	1.97±0.04
	Mechanically smoked	1.44±0.03	1.35±0.18
AAN (mg %)	Traditionally smoked	7.25±1.13	35.76±0.11
	Mechanically smoked	3.21±0.14	29.21±4.19
SSN (% of TN)	Traditionally smoked	15.15±2.78	18.98±1.99
	Mechanically smoked	12.84±0.34	25.66±1.06
PV (mEq peroxide O ₂ kg ⁻¹ fat)	Traditionally smoked	39.0±0.52	11.46±0.42
	Mechanically smoked	36.39±0.69	9.85±0.32
FFA (% as oleic acid)	Traditionally smoked	5.51±0.49	0.96±0.14
	Mechanically smoked	0.61±0.04	0.38±0.04

during smoking and the subsequent biochemical changes in fish muscle. TVB-N does not affect the organoleptic qualities of smoked samples (Lilabati & Vishwanath, 2001). Akiba et al. (1967) reported that amino and volatile basic nitrogen contents of the fish increased during smoking process. The higher values of TVBN and AAN indicate denaturation and higher enzymatic or microbial degradation of protein. However, comparatively lower values of TVBN and AAN was obtained in mechanically smoked samples in the present study indicating less degradation of protein due to controlled handling and smoking condition. The reason for higher AAN values in both the samples of smoked *P. sophore* may be due to initial high content of AAN in the raw material.

Primary lipid-oxidised product PV was found comparatively higher in market-smoked samples of both the fishes (Table 2). Higher PV value indicates more oxidation of lipid. The oxidative deterioration of fat results from smoking and exposure to oxygen during subsequent drying and storage (Bhuiyan et al., 1986). Oduor-Odote & Obiero (2009) reported a similar study of PV in three marine smoked fishes viz., *Gerres oyena* (Chaa), *Lutjanus argentimaculatus* (Red snapper) and *Valamugil seheli* (Mullet) as 21.48±0.44, 112.86±0.19 and 76.55±0.49 mEq kg⁻¹ respectively. The phenolic substances in wood

smoke are often credited with providing some protection against oxidation (FAO, 1981). The Lipid hydrolysed product FFA was 5.51%, 0.96% and 0.61%, 0.38% for market sample and mechanically smoked product of *A. mola* and *P. sophore* respectively. The hydrolysis of lipid during smoking and subsequent drying and storage of fish results in the formation of free fatty acids (Huss, 1994). The percentage FFA content for the five smoked freshwater fish species *H. niloticus*, *L. coubie*, *P. obscura*, *O. niloticus* and *C. gariepinus* was reported to range between 0.91-1.96% (Daramola et al., 2007). However, the lower values of FFA in the mechanically smoked products of the present study indicate less enzymatic hydrolysis of lipid due to controlled smoking.

pH of fish tissue drops due to smoking generally to 6.5 or less and lower pH values in smoked fish might be attributed to the effect of phenolic /acidic constituents deposited on the fish muscle during smoking (Doe et al., 1998). Karthikeyan et al. (2012) also reported similar pH value range in smoked fish samples of Manipur market. A pH value of smoked buckling (6.1- 6.7), dog fish (6.1- 6.2), halibut (6.7-6.9), mackerel (6.4-6.7), ocean perch (6.7-6.9), sprats (6.4-6.5) and trout (5.4-6.1) was reported by Kleickmann & Schellhass (1979). The lower pH of the smoked fish makes it a less favourable environ-

ment for most bacteria. Relatively lower pH (Table 2) value was found in case of mechanically smoked sample which indicates that product is less favourable for bacterial attack.

Microbial characteristics of both the samples are given in Table 3. Comparatively higher load of bacterial count was found in the market samples. It may be due to unhygienic processing, handling and keeping in open conditions for long time which makes it susceptible for bacterial attack. However, the low bacterial load of the smoked samples observed may be attributed to the bactericidal properties of smoke (Huss, 1994; Gibson et al., 1994). Smoking of fish is reported to impart a degree of microbiological stability to the product which is a function of reduced water activity, heating and smoking (Eklund et al., 1988). According to Schulze & Zimmermann (1983) the highest acceptable values for total counts in smoked mackerels, indicating significant loss of sensory quality, should be 10^6 per gram and for *enterobacteriaceae/pseudomonas/aeromonas* are 10^4 per gram.

The smoked fish products of both categories were free from visible fungal growth. The degree of mould formation is higher in less smoked fish products and products with more moisture content

than in heavy smoked samples (Karnop, 1980). *E.coli* count was less than 10 cfu g^{-1} indicating that the products were safe from faecal coliform contamination. Both the products were free from faecal *Streptococcus*, *Salmonella* and *Vibrio* sp. which indicated that the products were free from pathogenic contamination.

The results of sensory characteristics of the samples are given in Table 4. Mechanically smoked products of both the species were found good in terms of all the sensory attributes. Overall acceptability was 7.5 for market sample of *A.mola* and *P.sophore*; whereas the value was 8.0 and 7.5 respectively for mechanically smoked products of both the species. It indicated that the mechanically smoked product was highly preferred by the panel members than the traditional one. Taste, flavour and colour of the smoked fishes are attributed to phenolic compounds deposited during smoking process. The colour characteristic of smoked fish depends not only on the pigmentation of the skin but also on the quantity and composition of the smoke deposits and their interactions with the tissue components (Sikorski et al., 1998). Karthikeyan et al. (2007) reported that mechanically smoked *Colisa fasciata* showed better sensory characteristics and enhanced shelf life than the traditional one.

Table 3. Microbiological quality characteristics of traditionally smoked and mechanically smoked *Amblypharyngodon mola* and *Puntius sophore*

Parameters	Product type	<i>A. mola</i>	<i>P. sophore</i>
TPC (cfu g ⁻¹)	Traditionally smoked	3.0×10^5	5.0×10^5
	Mechanically smoked	1.1×10^4	9.0×10^3
<i>E. coli</i> (cfu g ⁻¹)	Traditionally smoked	<10	<10
	Mechanically smoked	<10	<10
Yeast/mould (cfu g ⁻¹)	Traditionally smoked	3.0×10^2	5.5×10^2
	Mechanically smoked	<10	<10
<i>Salmonella</i> sp. (cfu g ⁻¹)	Traditionally smoked	ND	ND
	Mechanically smoked	ND	ND
Faecal <i>Streptococcus</i> (cfu g ⁻¹)	Traditionally smoked	ND	ND
	Mechanically smoked	ND	ND
<i>Vibrio</i> (cfu g ⁻¹)	Traditionally smoked	ND	ND
	Mechanically smoked	ND	ND
Visible fungal colonies (cfu g ⁻¹)	Traditionally smoked	ND	ND
	Mechanically smoked	ND	ND

*ND: Not detected

Table 4. Sensory quality characteristics of traditionally smoked and mechanically smoked *Amblypharyngodon mola* and *Puntius sophore*

Parameters	Product type	<i>A. mola</i>	<i>P. sophore</i>
Appearance	Traditionally smoked	8.0±0.71	7.62±0.74
	Mechanically smoked	8.0±0.53	8.0±0.0
Colour	Traditionally smoked	7.75±0.67	7.75±0.67
	Mechanically smoked	8.25±0.71	7.37±0.92
Texture	Traditionally smoked	7.5±0.53	7.5±0.53
	Mechanically smoked	7.75±0.71	7.2±0.84
Odour	Traditionally smoked	7.5±0.53	7.5±0.53
	Mechanically smoked	7.75±1.03	7.16±0.41
Taste	Traditionally smoked	7.10±0.5	7.25±0.5
	Mechanically smoked	7.62±0.52	7.14±0.89
Overall acceptability	Traditionally smoked	7.5±0.53	7.5±0.53
	Mechanically smoked	8.0±0.53	7.5±0.92

The study revealed that the method of smoking has effect on sensory quality of the products while no significant changes in proximate compositions were found. Overall, the product obtained by mechanical method of smoking was found more suitable than traditionally smoked market sample of *A. mola* and *P. sophore*. No pathogenic bacteria were found in both the products which indicated that these products were safe for human consumption.

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