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Smoke curing: A simple method of product development and value addition to low cost fish, *Gudusia chapra,* Clupeidae, from Hirakud Reservoir, India

M. M. PRASAD[1*], J.K. BANDYOPADHYAY[1] and PREM KUMAR[2]

[1]Central Institute of Fisheries Technology, Burla Research Centre,
Burla, Sambalpur, Orissa, India. PIN-768 017

[2]Experimental Fish Farm and Field Center, NRC CWF, Collectorate Road,
Champawat, Uttaranchal, India. PIN-262 523.

Abstract

Hirakud Reservoir is located in between Latitude $20^0$31'N to $21^0$45'N and Longitude 83^0 E to $85^0$10'E and covers a vast area of 74,592 hectares. It is also a source of high ichthyic diversity. Small sized low cost fish such as *Gudusia chapra,* Clupeidae, and *Rohtee cotio,* Cyprinidae, are sold in the local markets at cheaper price or preserved by curing. The small sized fish do not fetch any price to fishermen resulting in waste of time, energy, and under utilization. In an effort to improve the utilization of low cost fish for sustainable development, *Gudusia chapra* was used in the present study in which commercial and experimental smoke cured fish were subjected to quality analyses. The bacteriological, physical, biochemical, and sensory characteristics of *Gudusia chapra* smoke cured by hygienic and scientific methods using community fish smoking kiln (CoFiSmKi) designed and developed as a part of this study, are superior to same variety of commercial smoke cured fish. The CoFiSmKi's were installed in different remote fishing villages adjoining Hirakud Reservoir and fishers were given training cum demonstration on hygienic preparation of smoke cured fish.

Introduction

Hirakud, the largest Reservoir on Mahanadi River System, was taken up on the theme of Tennessee Valley project of America to control the devastating flood in Orissa due to Mahanadi River, power generation, and irrigation. Total area of the Hirakud reservoir quoted by Jhingran (1983) and Raghavachari and Rao (1984) is 74,592 hectares and 71,400 hectares, respectively. Geographically, Hirakud is situated in between Latitude $20^0$31'N to $21^0$45'N and Longitude 83^0 E to $85^0$10'E.

Most of the fish catches of Hirakud Reservoir are consumed as fresh, sold in the

*Corresponding Author. Tel: +91-891-2567856
Email : prasadmothadaka@yahoo.com

local market at cheaper price, and all small sized commercially important as well as low cost varieties are dry/smoke cured by traditional methods (Prasad et al. 2005). The small sized low cost varieties of fish do not fetch any price to fishermen resulting in waste of time, energy, and under utilization of the fish catch. In any effort to improve utilization of low cost fish, it is important to study quality aspects such as physical, biochemical, microbiological, and sensory characteristics of fish processed by smoke curing and sold at different locations of Hirakud Reservoir. In the present study, a low cost variety fish namely *Gudusia chapra*, Clupeidae, smoke cured in different locations of Hirakud Reservoir was selected for quality assessment and was compared with the same variety smoke cured under controlled conditions. The aim was to find ways to improve quality so as to facilitate better utilization of low cost fish that is available as a product in lean season of fish catches, render fishermen to venture into reservoir to catch all varieties of fish, meet the protein requirements, and also to generate sustainable income to economically under privileged fisher folk. The community fish smoking kiln (CoFiSmKi) designed and developed as a part of this study was installed in different remote fishing villages adjoining Hirakud Reservoir. The purpose of this was to impart training cum demonstration to fishers on hygienic preparation of smoke cured fish for better utilization of low cost fish species.

Materials and Methods

Sample collection and location

Smoke cured *Gudusia chapra* was collected for analytical purpose from three different areas where smoke curing is prevalent: they include upper, middle, and lower reaches of Hirakud Reservoir. The location selection is similar to the studies of Fu et al. (2003).

Fresh *Gudusia chapra* was collected from the landing centres for experimental purpose. Samples were smoke-cured using CoFiSmKi, designed and fabricated at Burla Research Centre of Central Institute of Fisheries Technology (Prasad 2007).

Quality analyses of commercial smoke cured Gudusia chapra

Bacteriological methods

The smoked *Gudusia chapra* samples were collected from different locations of Hirakud Reservoir in self-locking new polythene bags (200 gauge, 500 g capacity). The bags were opened just before the collection of the sample to prevent external contamination to the product. Sampling for bacteriological analyses was carried out immediately after bringing it to the laboratory. A 10 g–smoked fish sample was weighed

in aseptic condition and was cut into small pieces with sterilized scissors under sterile conditions. The sample was aseptically triturated in sterile mortar and pestle using part of 90 mL normal saline, which was later mixed with the rest.

Appropriate dilution of the samples in sterile normal saline water were surface plated on plate count agar, violet bile salt glucose agar, Kenner Fecal or KF streptococcal agar and Baird-Parker agar for the enumeration of mesophilic aerobes, coliforms, faecal *streptococci* and *staphylococci* by following the standard procedures (ICMSF 1978; Mossel et al. 1978). Inoculated plates were incubated at 37^0C for 24 to 96 h, according to the type of enumerating bacteria. Colonies formed on the plates were counted and expressed as $\log_{10}$ CFU g^{-1} of the sample. Further, suspected colonies of *Staphylococcus aureus* were confirmed by coagulase positive test using rabbit plasma (Sanjeev and Surendran 1996).

Throughout the study, sterile normal saline (0.85% NaCl) was used as diluent. Chemicals and dehydrated media used in this study were of Qualigens (India) and Hi Media (India) make.

Physical and biochemical methods

The moisture, fats, and μNH_2 (alpha amino nitrogen) in smoked fish samples were estimated following AOAC (1995) methods. The total volatile nitrogen (TVN) in the cured fish samples was estimated by standard method (Conway 1947).

External quality of the smoke cured Gudusia chapra

The smoke cured *Gudusia chapra* samples collected from three different locations of Hirakud Reservoir were screened for percentage of miscellaneous fish (MF), percentage of extraneous material (EM) such as small parts of fire wood material used for smoking, small molluscs, by sieving and insect infestation and by manual methods using magnifying lenses. The MF or EM in smoked cured fish was assessed by standard method (Prasad et al. 2007),

$$\frac{\text{Total weight of MF/ EM}}{\text{Total weight of the specific sample}} \times 100 = \text{Percentage of MF/EM}$$

Sensory evaluation

The smoke cured *Gudusia chapra* were kept separately and evaluated for overall acceptability by a panel of 15 experienced panelists using a Ten-point Hedonic scale. The same panel was used throughout the study. The mean panel scores of each product were taken into consideration while assessing the quality. The quality of value added fish product collected from three regions of Hirakud Reservoir was assessed from the mean over all acceptability scores on source basis, assuming the Hedonic score 'Two'

to be the limit, below which the product was not acceptable.

Results and Discussion

Post-harvest Utilization

Most of the fish catches are consumed fresh but small sized fish and the other species that are commercially undervalued are sold at very low price or are smoke cured by traditional methods. As a part of better utilization of these groups of fish the commercial smoke cured *Gudusia chapra* samples collected from three different regions of Hirakud Reservoir *viz.*, upper, middle, and lower reaches and the same variety of fish smoke cured in controlled conditions were assessed. The various tests were conducted for bacteriological, physical, biochemical, external quality, and sensory characteristics. In tropical countries, annual losses of cured fish due to bacterial spoilage amount to two to three million tonnes (Clucas and Ward 1996). Hence, it is important to minimize the losses that can lead to better utilization of different varieties of fish that otherwise go waste.

Bacteriological quality of the smoked Gudusia chapra

Bacterial counts from all the smoked *Gudusia chapra* samples collected from different sources with mean values are shown in Table 1.

Table 1. Bacterial load in Low cost value added *Gudusia chapra* and their in comparison with same variety of fish processed under controlled conditions. All bacterial counts are expressed in log CFU g^{-1} of sample.

Source of smoke cured *G. chapra*	Total Viable Bacteria (TVB)	Coliforms	Faecal streptococci	Grouap D fecal streptococci	Total Staphylococci
Upper reaches of Hirakud Reservoir	5.67 (4.30 to 7.44)	2.63 (<1 to 4.15)	2.42 (<1 to 5.11)	1.90 (<1 to 5.30)	4.96 (3.10 to 6.86)
MID reaches Hirakud Reservoir	3.61 (3.15 to 5.53)	3.11 (<1 to 5.33)	3.29 (<1 to 7.12)	3.32 (<1 to 5.83)	3.87 (2.00 to 7.20)
Lower reaches of Hirakud Reservoir	6.08 (5.78 to 6.56)	0.23 (2.00 to 3.51)	3.26 (2.53 to 4.20)	2.81 (1.54 to 3.95)	4.78 (4.62 to 5.04)
Smoke cured under controlled conditions	2.48 (2.30 to 3.42)	<1	<1	<1	2.45 (1.94 to 2.95)

Mean and data given in parentheses are range of occurrence. When the occurrence of particular group of bacteria is not detected in the sample, the data is given as <1 taking into consideration experimental limitations. From each area an average of 15 fish samples were tested for comparison with fish processed under controlled conditions for value product development.

The smoke cured fish samples collected from lower reaches of Hirakud Reservoir harboured more number of total viable bacteria (TVB) in comparison with the other two groups. Fish or shellfish containing 8 log cycles g^{-1} are unfit for human consumption (Almas, 1981) and the TVB in the present study are within limits (Table 1). The occurrence of faecal *streptococci* in more numbers and from more sources than coliforms suggests that they are better indicators of hygienic conditions prevailing in postharvest handling and smoke curing places (Table 1). This corroborates findings of other works (Prasad and Seenayya, 1998; Prasad et al. 2007).

Consumption of fish and fishery products often results in staphylococcal food poisoning (Sanjeev and Surendran 1996). Though the mean staphylococcal counts were between 3 and 4 log CFU g^{-1}, in the range of occurrence in the samples of middle and upper reaches of Hirakud Reservoir it is slightly higher than the threshold level (6 log CFU g^{-1}) (Table 1) and is a potential health hazard (Bergdoll 1979). Sporadic occurrence of *staphylococci* from a wide variety of environmental sources has been reported (Kloos et al. 1992). In comparison with counts of different groups of bacteria in commercial samples of smoke cured *Gudusia chapra*, the one cured in controlled conditions harboured very less number, which indicates advantage of hygienic and scientific methods of curing the fish.

Physical and biochemical quality of smoke cured Gudusia chapra

Moisture is one of the important factors that determine the quality of smoke cured fish. In the present study, the mean moisture content of all the samples ranged from 5.7 to 15.9% (Table 2). In commercial smoke cured fish the mean fat content ranged from 7.6 to 13.7%, TVN from 73.6 to 153 mg %, αNH_2 from 183.6 to 295.6 mg % and peroxide values from 48.5 to 114.2 meq Kg^{-1}.fat. High TVN values were reported to correlate with high bacterial activity (Vanderzant et al. 1978). In the present study the commercial samples showed more TVN than that of experimental sample.

External quality of the smoked fish

The results of external quality of commercial smoke cured fish revealed that the presence of MF ranged from 0.69 to 5.5% in the samples. The MF identified included *Xenontodon cancilla* (Gourchana-Oriya name), *Pama pama* (Patharmundi-Oriya name), *Rohitee cotio* (Chilanti-Oriya name), *Ambasis nama* (Patponia-Oriya name) and *Puntius spp*. More than 50% of the samples contained EM ranging from 1.24 to 6.57 %. The presence of MF in commercial smoke cured samples is similar to the observations made

Table 2. Physical and biochemical quality of commercial smoke cured *Gudusia chapra* in comparison with same variety of fish smoke cured under controlled conditions.

Source of smoke cured *G. chapra*	H_2O (%)	PV (meq Kg^{-1}.fat)	Alpha NH_2 (mg%)	TVN (mg%)	Fat (%). DWB
Upper reaches of Hirakud Reservoir (n=15)	15.93±10.8 (5.46 to 21.69)	114.2±60.99 (43.1 to 215.5)	295.6±131.64 (126.71 to 555.13)	153.00±56.36 (96.00 to 243.20)	7.58±2.57 (4.7 to 12.69)
Mid reaches Hirakud Reservoir (n=15)	5.72±1.80 (3.74 to 9.26)	86.22±57.11 (43.1 to 150.85)	251.33±169.99 (96.54 to 555.13)	104.00±25.16 (64.00 to144.00)	13.70±5.70 (6.01 to 18.21)
Lower reaches of Hirakud Reservoir (n=15)	5.98±1.05 (5.04 to 7.46)	48.46±27.07 (21.55 to 86.1)	183.6±94.91 (102.58 to 313.77)	73.6±9.05 (60.80 to 80.00)	10.57±7.76 (3.5 to 21.33)
Smoke cured under controlled conditions	8.46±1.13 (6.48 to 9.16)	35.63±18.88 (20.14 to 64.43)	146.23±78.45 (96.87 to 278.63)	59.35±7.22 (52.31 to 68.74)	12.95±4.97 (7.54 to 18.64)

Mean ± Standard deviation. Data given in parentheses are ranges. From each area an average of 15 fish samples were tested for comparison with fish processed under controlled conditions for value added product development.

earlier (Prasad et al. 2005). The composition of EM consists of large mud particles, small sticks, snails and burnt particles of algae. Insects were seen in four samples. All the samples contained broken pieces of fish. The percentage of other small fish in the product indicates inadequate care taken in postharvest handling. The percentage of EM indicates that care taken was insufficient during the smoking process and the level of insect infestation indicates the improper storage methods after product preparation, but prior to marketing (Prasad et al. 2007). On the contrary, the fish samples cured by scientific method, following good manufacturing practices, using CoFiSmKi are free from these problems. The results indicate the need for improvement in all quarters of postharvest handling till the product reaches the consumer. This is possible through training cum demonstration programmes.

Sensory Characteristics

The results of sensory evaluation of commercial and experimental smoke cured *Gudusia chapra* samples are shown in Table 3.

Asian Fisheries Science **22** (2009): 511-519

Table 3. Sensory evaluation of commercial smoke cured *Gudusia chapra* in comparison with same variety of fish smoke cured under controlled conditions.

S. No.	Source of smoke cured *G. chapra*	Sensory evaluation scores*			
		Appearance	odour	Texture	Taste
1	Upper reaches of Hirakud Reservoir	6.65±0.29 (6.46 to 6.98)	6.57±0.40 (6.27 to 7.03)	6.51±0.18 (6.31 to 6.58)	6.65±0.07 (6.58 to 6.73)
2	Mid reaches Hirakud Reservoir	6.60±0.49 (6.23 to 71.5)	6.41±0.42 (6.08 to 6.88)	6.14±0.09 (6.04 to 6.19)	6.94±0.40 (6.58 to 7.38)
3	Lower reaches of Hirakud Reservoir	6.18±0.55 (5.85 to 6.81)	6.03±0.59 (5.35 to 6.42)	6.05± 0.36 (5.77 to 6.46)	6.20±0.36 (6.0 to 6.62)
4	Smoke cured under controlled conditions	9.26±0.31 (9.0 to 9.6)	9.0±0.26 (8.7 to 9.2)	9.4±0.36 (9.1 to 9.8)	9.6±0.44 (9.1 to 9.9)

Mean ± Standard deviation. Data given in parentheses are ranges. *The data represents the average of the sensory evaluation of 15 panelists who participated throughout the study. All the samples tested belonged to one variety of fish (*Gudusia chapra*) and had uniform shelf life of 7 days.

The overall mean score of 15 panelists of the commercial smoke cured samples are (~ six levels) good. However, it is excellent (nine) for the same variety of fish smoke cured in controlled conditions.

The present study indicates the need for improvement in postharvest handling of the product to upgrade overall quality, especially, the hygiene aspects in view of occurrence of *staphylococci* in high numbers to an extent hazardous to human health. In the present practice of smoke curing of fish, significant amount of firewood is collected from the forest that is resulting in deforestation (Mishra and Dash, 1984). After years of research the Burla Research Centre of Central Institute of Fisheries Technology has developed different models of CoFiSmKi's, which could be termed as Green kilns, that support not only the conservation of biodiversity of flora of Hirakud Reservoir area but also better utilization of fish. These kilns were installed in fishing hamlets adjoining Hirakud Reservoir and other parts of Orissa (Table 4).

Table 4. Details of installation of Community Fish Smoking Kiln (CoFiSmKi) in different remote fishing hamlets in Orissa

S.No	Location of CoFiSmKi (Burla Model) installation		Year of installation
	Fishing hamlet	District	
1	Sapne*	Sambalpur	2005
2	Rampaluga*	Jharsuguda	2005
3	Pujaripali* (Jhampali)	Jharsuguda	2005
4	Kurumkhel*	Bargarh	2005
5	Thebra*	Jharsuguda	2005
6	Mohammadpur*	Sambalpur	2006
7	Jagipali*	Sambalpur	2006
8	Sonutikara*	Sambalpur	2006
9	Balbuspur*	Sambalpur	2006
10	Jhikimiki sahi I.*	Deogarh	2006
11	jhikimiki sahi II.*	Deogarh	2006

*. Fishing hamlets under CIFT adoption.

In the same fishing villages, training cum demonstration programs were conducted on "Hygienic preparation of smoke cured freshwater fishes and prawns & use of eco-friendly fishing gear for sustainable fisheries". In the Green kilns the firewood used is very less in quantity in the initial stages of smoking and in the remaining period of fish curing, firewood is replaced with paddy husk or saw dust to generate smoke.

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