Fish. Technol. (1979) **16**, 47-52

Studies on Smoke Curing and Preservation of Oil Sardine *(Sardinella longiceps)*

T. C. CHANDRASEKHAR, T. M. RUDRA SETTY and K. S. UDUPA
A. I. C. R. P. on Utilisation of Trash Fish (ICAR), College of Fisheries, Mangalore-575 001

A method is reported for smoke curing of oil sardine *(Sardinella longiceps)* by dry salting in the ratio of 1:6 (salt to fish), followed by smoking in the traditional smoke chamber in two stages, (1) at 45°C for 3 h and (2) at 75°C for 2 h with smoke generated from coconut husk, wood shavings and saw dust in 2:2:1 proportion. The product obtained had good odour, flavour, golden yellow colour and a shelf-life of 8 weeks at room temperature (26 to 28°C)

Oil sardine constitutes about 30 per cent of total marine fish landings of our country and the most abundant and commercially important species on the west coast. Due to lack of preservation facilities, a considerable quantity of it is converted into fertiliser. One method of avoiding such wastage of high quality fish is to preserve them by smoke curing, which is very simple and popular in the Far East and continental countries, where a variety of cold and hot smoked products are prepared and marketed. Unlike in India, extensive studies have been carried out on various aspects of this method of curing in those countries. Although some work (Anon, 1966, 1968; Solanki *et al.*, 1970; Kandoran *et al.*, 1971) has been reported on the preservation of lean and medium fatty fishes by hot smoking process, a satisfactory method for smoke curing of fatty fish like oil sardine, suited to the Indian conditions has not been developed. Moorjani & Vasantha (1972) have reported a method for hot smoking oil sardines, but the shelf-life of the product was only 2 to 3 days at room temperature. Muraleedharan *et al.* (1976) have recommended the use of sodium propionate to enhance the shelf-life and butyl hydroxyanisole (BHA) to control the rancidity in smoked products. The present paper reports a method to prepare acceptable smoked oil sardine without chemicals.

Materials and Methods

Fresh oil sardines of length 13–14 cm were obtained from the landing centre at Mangalore. A traditional vertical smoke chamber fabricated was used for the experiment. The chamber made of mild steel sheet was provided with an asbestos lining inside and facilities for generating smoke, reading temperature, metallic rods for hanging the fish and gas exhaust. Relative humidity was read from a wet bulb thermometer fixed inside the chamber. Saw dust, wood shavings and coconut husk in the ratio 1:2:2 were spread as bed, 30 cm deep, and burnt without flame to generate the smoke. Additional quantity of wood was used during smoking process to maintain the desired temperature of smoke. The fish were washed to remove any adhering dirt, gutted, cleaned, split ventrally and black peritonial membrane removed. They were then salted in the ratio 1:6 (salt to fish) and stacked in salting tanks overnight. Topmost layer of fish was covered by a layer of salt to avoid exposure to air. Cured fish was then rinsed in fresh water to remove excess salt, hung on clean metallic rods and drained for 15 min. The fish were then loaded into the smoke chamber and smoked in two stages, (1) at 45 °C for 3h and (2) at 75 °C for 2 h, keeping the relative humidity inside the chamber at 60 to 70%. The fish attained a characteristic golden yellow colour and flavour and moisture content fell below 40%. The product was cooled, sealed in coloured polythene bags and stored at room temperature for assessing the shelf life. The yield was 18 to 20%. Salted and sundried oil sardines also were stored

Table 1. *Effect of smoking on dry salted oil sardine at 45°C for 5 hours*
(Period of salting: 12 h)

Sample	Ratio of salt to fish	Moisture %	Sodium chloride % (OWB)	Storage period (days)	Overall acceptability (odour, flavour and colour)	Symptoms of spoilage
1	1:2	49.41	9.10	15	Uncooked taste internally and smoky externally. Not acceptable	Mould growth and rancid flavour
2	1:3	47.12	9.80	18	-do-	-do- With change of colour from golden yellow to dark brown and oozing of oil
3	1:4	48.27	10.30	16	-do-	-do-
4	1:5	46.10	11.08	17	-do-	-do-
5	1:6	45.50	11.19	19	-do-	-do-

Table 2. *Effect of smoking on dry salted oil sardine at 75°C for 5 hours*
(Period of salting: 12h)

Sample	Ratio of salt to fish	Moisture %	Sodium chloride % (OWB)	Remarks
1	1:2	34.10	17.81	Oozing of fat and poor acceptability due to development of dark colour, salty taste, tough texture, precipitation of salt.
2	1:3	33.00	16.92	
3	1:4	34.85	17.52	
4	1:5	34.92	17.82	
5	1:6	33.08	18.72	

Table 3. *Effect of smoking on dry salted oil sardine at 45°C for 3 hours and 75°C for 2 hours*
(Period of salting: 12 h)

Sample	Ratio of salt to fish	Moisture %	Sodium chloride % (OWB)	Storage period (days)	Overall acceptability (odour, flavour, colour)
1	1:2	37.30	12.22	25	Acceptable
2	1:3	37.11	15.30	49	-do-
3	1:4	36.89	16.17	60	-do-
4	1:5	36.12	16.89	60	-do-
5	1:6	36.78	15.07	61	-do-

Table 4. *Analyses before and after salting of oil sardine (1:6)*

Stage at which analysed	pH	Moisture %	Nacl % (OWB)	Peroxide value (milli-moles of O_2/kg of fat)	FFA %	TMAN mg/100g	TVN mg/100g	Plate count/g
Before salt curing	6.2	66.00	0.64	Negligible	0.01	—	6.0	25×10^5
After salt curing	6.1	58.00	5.49	2.12	0.62	1.42	16.60	12×10^3

under the same conditions as reference samples.

Estimations of moisture and sodium chloride were carried out according to AOAC (1950) methods. Oxidative rancidity was determined by organoleptic evaluation and peroxide values (Tarr, 1947). Free fatty acids (FFA) were estimated by the method of Dyer & Morton (1956). Total volatile nitrogen (TVN) and trimethylamine (TMA) were estimated on a trichloroacetic acid extract (Beatty & Gibbons, 1936) and phenolic content of smoked product by the method of Foster & Simpson (1961). Total viable count was determined by using nutrient agar medium and incubating at ambient temperature for 48 h. The presence of *E. coli,* faecal *streptococci,* coagulase positive *styphylococci,* salmonella and aerobic spore-formers was tested using standard media as recommended by APHA (1966). Subjective evaluation of the product (meat portion separated from skin and bone) was carried out by a taste panel of ten members using a Hadonic scale: A=like very much (10 marks); B=like much (8 marks); C=like (6 marks) ; D = neither like nor dislike (4 marks) and E=do not like (2 marks). Instead of trying the acceptability on individual attributes, overall acceptability of the product was judged statistically following the method of analysis of variance of Krammer & Twigg (1970), as modified by Udupa & Jayaram (in press). The rate of dehydration was determined by drawing samples during smoking process at intervals of one hour and estimating the moisture content.

Results and Discussion

The proximate composition of oil sardine used for the experiment was protein, 16.38%; fat, 16.20%; moisture, 66.00% and ash, 1.42%. The results of preliminary experiments to determine the optimum conditions of smoking are presented in Tables 1, 2 and 3. It may be seen from Table 1 that dry salting in ratios of 1:2 to 1:6 and smoking at 45°C for 5 h could preserve the product for 15 to 19 days only before spoilage, mainly due to mould growth. Reduction in moisture content was comparatively less and there was no oozing of fat in this process. The products were not acceptable because of uncooked (raw fish) taste.

Table 5. *Rate of fall in moisture contents in relation to relative humidity and temperature of smoking*

Smoking time h	Temperature °C	Relative humidity %	Moisture content %
1	45	60	53.8
2	45	65	50.2
3	45	65 to 70	46.0
4	75	70	40.0
5	75	65 to 70	37.4

Initial moisture : 58.0%

Samples salted in the same ratios and smoked at 75°C for 5 h showed very high salt content, tough texture, reduced moisture contents and dark discolouration (Table 2). Oozing of fat during smoking was very high. The products were not acceptable and hence not preserved to study their storage quality. But the samples smoked at 45°C for 3 h and subsequently at 75°C for 2 h (total 5 h)

Table 6. *Storage characteristics of smoked oil sardine*

Characteristics	Immediately after preparation		One week		Two weeks		Three weeks	Four weeks	Five weeks	Six weeks	Seven weeks	Eight weeks
	1	2	1	2	1	2	2	2	2	2	2	2
pH	5.80	5.70	5.90	6.00	5.80	5.90	6.00	6.00	5.80	5.70	5.70	5.80
Moisture %	37.12	37.30	36.91	37.23	36.56	36.12	35.24	35.44	35.74	36.40	36.83	35.82
Nacl % (OWB)	15.90	16.78	16.12	16.73	15.02	15.69	14.80	14.67	13.96	14.12	13.82	13.69
Peroxide value (millimoles O_2/kg fat)	40.12	14.71	91.01	17.60	120.00	20.12	26.66	32.09	25.60	21.44	20.19	21.09
FFA % (as oleic acid)	5.72	1.49	8.11	2.60	16.00	2.90	8.14	14.40	16.00	5.60	14.12	12.00
TMAN mg/100g	5.17	0.92	—	1.26	—	2.00	2.66	5.12	8.12	5.10	11.14	10.12
TVN mg/100g	20.08	10.20	37.08	15.28	—	20.00	21.28	21.18	26.32	40.04	56.12	60.12
Organoleptic evaluation	A	A	ASR	A	UHRR	A	A	A	A	A	A	LA
Plate count/g	<300	$12x10^1$	—	$17x10^1$	—	$40x10^2$	$38x10^2$	$56x10^2$	$42x10^3$	$21x10^3$	—	$30x10^2$

1—Control (salted and sundried)
2—Salted and smoked

A : Acceptable
ASR : Acceptable, slightly rancid
UHRR : Unacceptable, highly rancid and rusty
LA : Less acceptable due to loss of flavour and colour

showed promising results (Table 3). The products remained in acceptable condition for 25 to 61 days with golden yellow colour, flavour and odour. Hence salting in the ratio of 1:6 and smoking for 3 h at 45 °C and 2 h at 75 °C were fixed as the optimum conditions which were adhered to in further experiments. The results of chemical analysis and counts for aerobic microorganisms before and after salt curing of oil sardines in 1:6 ratio are presented in Table 4. The rate of fall in moisture content in relation to relative humidity and temperature of smoking for 5 h (at 45 °C for 3 h and 75 °C for 2 h) is presented in Table 5. The changes occurring in the smoked products during storage at room temperature are presented in Table 6.

It may be seen from Table 6 that controls deteriorated quickly with development of both free fatty acids (FFA) and peroxides, dark brown discolouration and rancid flavour within two weeks and became unacceptable, while the experimental samples remained well at room temperature for 8 weeks before losing original flavour, colour and acceptable texture. The samples showed salt encrustation, but no mould growth. TMAN increased gradually in storage. Moisture and sodium chloride contents were about 37 and 16% respectively. The phenolic content was 11.2 mg/100 g of steam volatile and 4.5 mg/100 g of steam non-volatile phenols.

The samples did not show presence of *E. coli,* faecal *streptococci* and coagulase positive *staphylococci* and salmonella either during processing or storage. However, aerobic spore-formers were encountered. There was no growth of mould during the period of 8 weeks of storage. The total counts were of the order of 10^1 to 10^4 which were appreciably low.

Statistical analysis showed that there is significant difference between the 4 attributes (colour, texture, taste and flavour) on their acceptability. When least significant difference based on 't' test ($lsd_{to.05}$) is calculated to isolate the differences among attributes, it was found that there was no difference between colour and texture, and also between flavour and taste. In other words, product is most acceptable with regard to colour or texture, but not so with regard to flavour or taste. The mean scores per panelist are 7.80, 7.55, 5.40 and 5.35 respectively for colour, texture, flavour and taste. Further, Table 7 shows that the effect of extraneous factors on the acceptability of smoked fish are of lesser importance.

Table 7. *Analysis of variance*

Source of variation	df	ss	ms	F
Between attributes	3	53.225	17.741	37.037*
Error	36	17.250	0.479	
Total	39	70.475		

* Significant at 5% level
$(lsd)_{t\ 0.05}=0.6284$

Smoked products are stable only if they are sufficiently dehydrated or if the salt content is sufficient to lower the water activity to a level which would not support microbial activity (Chan *et al.,* 1975). Probably the reason for the slow rate of development of PVand FFA is the anti-oxidant property of wood smoke (Banks, 1952), particularly its phenolic content, which must have also contributed to the good taste,flavour and colour.

The low bacterial loads of the samples observed may be attributed to the bactericidal properties of smoke (Hess, 1929; Gibbons *et al.,* 1954). The early spoilage of control samples by rancidity can be due to the high salt content, which have accelerated the oxidation of fat during storage. According to Castell (1965), high salt content causes rancidity with unpleasant odour. But the catalytic effect of almost the same amount of salt is not prominent in the smoked fish product due to the inhibitory action of the smoke. Use of wood smoke with its antioxidant properties is more ideal than synthetic chemicals for controlling rancidity.

The authors wish to express their sincere thanks to Dr. K. Krishnamurthy, Director of Research, University of Agricultural Sciences, Bangalore, Dr. N. L. Lahiry, Professor of Fish Processing Technology and Prof. H. P. C. Shetty, Director of Instruction, College of Fisheries, Mangalore and Shri M. R. Nair, Project Co-ordinator of AICRP, Central Institute of Fisheries Technology, Cochin for their keen interest in the work and to ICAR for financial help.

References

Anon (1966) *Fish. Technol. Newsletter.* **7**, 1

Anon (1968) *Fish. Technol. Newletter,* **9**, 2

AOAC (1950) *Official Methods of Analysis* (Henry A. Lepper, Ed.) Association of Official Agricultural Chemists, Washington

APHA (1966) *Recommended Methods for the Microbiological Examination of Foods* American Public Health Association, New York.

Banks, A. (1952) *J. Sci. Fd. Agric.* **3**, 250

Beatty, S. A. & Gibbons, W. E. (1936) *J. biol. Bd. Can.* **3**, 77

Castell, C. H. (1965) *Metal Catalysed Rancidity in Ground Fish. The Technology of Fish Utilization. Contribution from Research* (Rudolf *Kreuzer,* Ed.) p. 98 Food and Agricultural Organization.

Chan, W. S., Toledo, R. T. & Denj, J. (1975) *J. Fd. Sci.* **40**, 240

Dyer, W. J. & Morton, M. L. (1956) *J. Fish. Res. Bd Can.* **13**, 569

Foster, W. W. & Simpson, T. H. (1961) *J. Sci. Fd Agric.* **12**, 363

Gibbons, N. E., Rose, D. Z. & Hopkins, J. W. (1954) *Fd Technol.* **8**, 155

Hess, E. A. (1929) *Can. Biol Fish* (N. S) **4**, 29

Kandoran, M. K., Solanki, K.K. & Venkataraman, R. (1971) *Fish. Technol.* **8**, 98

Kramer, A. & Twigg, B. A. (1970) *Quality Control for the Food Industry.* 3rd edn., Vol. 1, p. 135, AVI Publishing Company, Connecticut

Moorjani, M. N. & Vasantha (1972) *Sea Fd Export J.* **4**, 25

Muraleedharan, V. & Valsan, A. P. (1976) *Fish. Technol.* **13**, 146

Solanki, K. K., Kandoran, M.K. & Venkataraman, R. (1970) *Fish. Technol.* **7**, 169.

Tarr, H. L. A. (1947) *J. Fish. Res. Bd. Can.* **7**, 137

Udupa, K. S. & Jayaram, M. G. *Curr. Res.* (in press)