Preparation and Keeping Quality of Hot Smoked Mackerel*

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A method has been standardised for the production of smoke cured mackerel by dry salting in the ratio of 1:8 salt to fish followed by smoking in a traditional smoke chamber at 70 ± 5°C for 5 h. The smoke was generated by burning moist coconut husk and saw dust. The product obtained by this method had shelf-lives of 105, 95 and 6 days in chilled storage (0 to 2°C) refrigerated storage (10 ± 2°C) and at room temperature (29 ± 2°C) respectively.

Indian mackerel *(Rastrelliger kanagurta)* is a commercially important species constituting about 8% of the total marine fish landings of our country. At present its utilization is limited to consumption in fresh condition and production of salted and dried products. It is necessary to introduce diversified products from mackerel having appealing characteristics and reasonably good shelf-life to increase its utilization. Though extensive studies have been conducted on smoke curing of fish in various countries, only limited work has been carried out in India (Chandrasekhar *et al.*, 1979; Mathur & Bhatia, 1967; Moorjani & Vasantha, 1972; Muraleedharan & Valsan, 1976) and the product is yet to gain popularity. The present paper reports the method of preparation and storage of hot smoked mackerel.

Materials and Methods

Mackerel *(Rastrelliger kanagurta)*, average length 20 cm, caught by purse seine at Mangalore were used for the study. The fish were stored at –20°C till they were used for the experiments. Good quality crystal salt, dried saw dust *(Accacia* sp./*Mangifera indica)* and coconut husk *(Coccos nucifora)* were obtained from the local market. A vertical type traditional fish smoke chamber was used to generate smoke (Chandrasekhar *et al.*, 1979). A wooden vat of 25 kg capacity was used for salt curing.

Frozen fish were thawed in running water and dressed in butterfly style leaving the head and the belly intact. It was further washed in chilled water to remove the adhering dirt, peritonium membrane and blood. They were salted in the ratio 1:6, 1:7 and 1:8 (salt: fish) and stacked in the wooden vat for 1, 2 and 3 h. The top most layer of fish was covered by a layer of salt to avoid exposure to air. The self brine liberated was drained out through the outlet. The cured fish was rinsed in freshwater, hooked and hung on clean metallic rods and allowed for pre-drying under fan at room temperature for 10 min. The smoke chamber was prepared by spreading dried saw dust and coconut husk in the ratio 2:1 (V/V) as a bed (30 cm deep) and burnt to generate smoke. The burning temperature of the wood during the generation of smoke was controlled to around 400°C by the addition of 20–30% of water in instalments during the process. Fish were smoked at 70±5°C for 5 h, cooled, packed in polythene bags and stored in chilled storage (CS: 0 to + 2°C), refrigerated storage (RS: 10±2°C) and at room temperature (RT: 29±2°C) for assessing the quality.

Proximate composition (Table 1) of the smoke cured mackerel was determined by the methods outlined in AOAC (1975). pH of the suspension was measured using pH meter (Horiba). Peroxide value (PV) and thiobarbituric acid (TBA) values were determined by modified method of Hills & Thiol (1946) and Sinnhuber & Yu (1963) method respectively. Free fatty acid (FFA) was estimated according to AOAC (1975). Total volatile basic nitrogen (TVBN) and trimethyl amine nitrogen (TMAN) were

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determined by the procedure described by Beatty & Gibbons (1937). Phenol content of the smoked product was estimated according to Foster & Simpson (1961). Microbiological analysis was carried out for total plate count (TPC) and moulds as per the methods given in APHA (1976). The products were evaluated for quality, immediately after production and during storage.

Results and Discussion

The proximate composition of fresh and smoked fish stored at different temperatures

Table 1. *Proximate composition of the meat of fresh and smoke cured mackerel*

Samples	Moisture %	Protein %	Fat %	Ash %	NaCl %
Raw material (frozen)	70.39	21.80	7.03	1.25	0.38
a) Smoke cured fish before storage	44.88	35.28	13.72	7.00	4.92
b) After storage in CS for 14 weeks	37.54	38.48	15.99	7.10	4.98
c) After storage in RS for 10 weeks	41.40	37.17	14.20	7.23	4.72
d) After storage at RT for 6 days	42.09	35.09	15.70	7.40	4.92

Table 2. *Effect of different concentrations of salt and time of salting on the quality (acceptability) of smoke cured products*

Ratio of salt to fish	Time of salting h	Temperature and time of smoke curing	Quality
	1	70 ± 5°C for 5 h	Low salt content and high moisture
1:6	2	,,	Salty, bitter taste, slight tough texture
	3	,,	Salty, tough texture, strong smoky flavour
	1	,,	High moisture content
1:7	2	,,	Salty, tough texture
	3	,,	Salty, firm texture
	1	,,	Low salt content
1:8	2	,,	Good taste, colour, texture and flavour
	3	,,	Slightly salty, texture tough with increased smoky flavour.

Table 3. *Changes in the chemical parameters, TPC and mould count during preparation of the product*

Sample	FFA (% as oleic acid)	TBA (mg malonaldehyde/kg extracted oil)	PV (m mole O_2 per kg extracted oil)	TVBN mg/100 g	TMAN mg/100 g	TPC/g	Mould/g
Raw material (frozen fish)	0.46	34.29	1.31	9.20	0.20	3.5×10^3	0.4×10^2
Salted fish	0.65	89.05	2.08	13.80	1.00	6.0×10^4	0.8×10^2
Smoked fish	2.28	41.30	4.06	19.60	1.40	1.4×10^2	0.3×10^2

Table 4. *Changes in chemical parameters, TPC, mould count and pH during storage of smoked mackerel at different temperatures*

Storage conditions	Days of storage	FFA (as % oleic acid)	TBA (mg malonaldehyde per kg extracted oil)	PV (m mol oxygen per kg extracted oil)	TVBN mg/100g	TMAN mg/100g	Steam volatile phenols mg/100g	Steam non-volatile phenols mg/100g	TPC/g	Mould/g	pH
Chilled storage	0	2.28	41.30	4.06	19.0	1.40	16.22	4.08	1.4×10^3	0.4×10^2	5.80
	15	3.26	49.75	5.08	23.00	3.80	15.02	4.00	0.9×10^2	0.35×10^2	5.75
	30	4.20	55.52	8.26	29.84	6.30	14.82	3.94	0.4×10^2	0.3×10^2	5.70
	45	4.32	63.99	10.06	30.69	7.00	14.20	3.90	0.3×10^2	0.2×10^2	5.70
	60	4.48	70.77	9.12	34.20	9.80	13.80	3.80	0.6×10^2	0.1×10^2	5.65
	75	5.87	75.14	8.82	46.80	11.20	12.90	3.85	5.5×10^3	1.6×10^2	5.65
	90	6.10	84.45	9.28	46.80	14.00	10.00	3.40	8.0×10^3	1.8×10^2	5.60
	105	7.02	96.87	7.16	55.00	16.80	8.13	3.03	1.4×10^4	1.9×10^3	5.30
Refrigerated storage	0	2.28	41.30	4.06	19.00	1.40	16.22	4.08	1.4×10^3	0.4×10^2	5.80
	15	2.60	52.85	4.06	25.00	7.00	15.80	4.60	0.7×10^2	0.2×10^2	5.70
	30	2.80	60.93	10.24	30.40	8.40	14.20	3.81	0.2×10^2	0.2×10^2	5.65
	45	3.90	69.65	12.26	39.40	15.40	12.02	3.69	0.6×10^2	0.2×10^3	5.50
	60	4.60	77.14	10.52	50.90	16.10	10.43	3.42	1.0×10^4	1.0×10^2	5.50
	75	6.80	109.30	9.18	63.82	18.20	11.43	3.50	6.6×10^4	1.0×10^4	5.45
Room temperature	0	2.28	41.30	4.06	19.0	1.40	16.22	4.08	1.4×10^2	0.4×10^2	5.80
	2	3.85	58.40	6.57	27.40	4.60	15.50	4.73	0.8×10^2	0.35×10^2	5.75
	4	5.20	62.08	7.16	37.70	7.80	14.18	3.40	0.4×10^2	0.3×10^2	5.60
	6	6.48	63.54	6.26	42.50	10.30	12.28	3.00	1.5×10^2	3.5×10^3	5.65

is presented in Table 1. Results of preliminary experiments to determine the optimum conditions of salting and smoke curing are presented in Table 2. It is seen from the Table that the dry salting in the ratio 1:6 and 1:7 for different periods and smoking at 70±5°C for 5 h did not give an acceptable product. Fish salted in the ratio of 1:8 for 1 and 3 h and smoked at 70±5°C for 5 h also did not yield acceptable product. However, fish salted in the ratio 1:8 for 2h and smoked at 70±5°C for 5 h gave an acceptable product with golden yellow colour, good taste, texture and flavour. Hence, salting in the ratio 1:8 for 2 h and smoking at 70±5°C were selected as optimum conditions for further experiments.

The results of chemical analysis and counts for microbes for the raw material, salted mackerel and smoked mackerel are presented in the Table 3. The bacterial and chemical changes occurring during storage at different temperatures are presented in Table 4. The Table shows that product stored at RT deteriorated quickly with growth of moulds after 6 days and became unacceptable, while the product stored at CS and RS remained in acceptable condition for 105 and 75 days respectively. The products were unacceptable after these storage periods due to the development of rancidity. Both TMAN and TVBN increased gradually during storage. The sodium chloride concentration was about 4.9% and did not show any significant change during the period of storage as seen from Table 1. According to Bannerman (1980) 3% salt concentration in the final smoked product has been found effective for hot smoked fish. According to him, this concentration was enough to inhibit the growth of any food poisoning organisms present, particularly *Clostridium botulinum,* without making the product unpleasantly salty to eat. In the present experiment final salt concentration is just above the minimum level in the product (Table 1) and the product is acceptable. The volatile phenol content which was 16.22 mg/100 g and nonvolatile phenol content 4.08 mg/100g at the time of storage showed gradual reduction in all the samples, which might be due to the volatile characteristics of smoke. *Escherichia coli, Streptococcus,* staphylococci and *Salmonella* were absent in all samples. However aerobic spore formers were noticed in the sample. The total plate counts were appreciably low.

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