

STUDIES ON SMOKING OF EEL FILLETS

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A procedure has been worked out to (hot) smoke eel fillets. Some of the important factors such as size of the fillets, brining, predrying, source of smoke, smoking period, final drying etc have been studied. Best quality of smoked product is obtained on smoking eel fillets with a mixture of coconut-husk and sag saw-dust in 1:1 proportion for 15 hours. Optimum moisture level of the final product was fixed in the range of 30 to 35% and it had a storage life of about 8 months at room temperature.

INTRODUCTION

4000 to 5000 tonnes of marine eels are landed every year by trawls as well as gill nets in the north western coast of India (Rao, 1967) *Muraenesox Talabonoids* is the dominating species among marine eels. It grows up to about 2 meters in length, weighing about 14-15kg. Even though eels are mostly consumed in fresh condition, the price fetched by this fish is very poor. At present eel fish is not utilized to prepare any product on large scale in India. Cutting (1951) has described a method to prepare a smoked product which could withstand warm climatic conditions; but no such process has been found in literature regarding preservation of eel fillets in tropical countries. A method worked out at this substation for preparation of smoked eel fillets is described in this paper.

MATERIALS AND METHODS

Absolutely fresh eels of medium size

weighing about 2.5 to 5 kg and 120-150cm length were brought in ice from fishing ground to the laboratory. The surface of the fish was rubbed with coarse salt and thoroughly washed with fresh water until surface became clean and completely free of slime. After removing the bladder and guts and washing, fillets (with skin on) of the appropriate size were prepared and several experiments were conducted as follows.

Filleting:

Fillets of 16 cm x 2 cm, 16 cm x 2.5cm, 16 cm x 3 cm, 18 cm x 4 cm and 20 cm x 5 cm were salted in 20% brine for 30 minutes, dried for 30 minutes and then smoked under identical conditions. The final drying periods required to obtain products with desirable level of moisture and appearance were observed. The thickness of fillets varied according to the size of the eel, usually about 2 to 3.5 cm for medium size eels.

Salting:

(a) *Dry salting:* Fillets of uniform size were dry salted for 4 hours in the ratio 1:5, rinsed in self-brine, dried for 30 minutes and then smoked.

(b) *Brining:* Fillets of uniform size were dipped in 5%, 10%, 15%, and 20% brine for 30 mts., followed by pre-drying, smoking and final drying.

(c) *Brining period:* Fillets of uniform size were kept in 20% brine for periods of 15 min, 30 min, 45 min, 1 hr, 1½ hr, 2 hrs and 3 hours and salt absorption by the fillets studied.

Pre-drying period:

Brined eel fillets of uniform size were dried in sun for 15 min, 30 min, 45 min, 1 hr and 2 hours followed by smoking.

It is preferable to press the cut sides of brined fillets before drying, either with hands or against the sides of the tray to get the surface smooth. Also it was found convenient to hang the brined fillets on pointed galvanised iron rods for pre-drying and subsequent smoking in kiln.

Smoke kiln:

An asbestos smoke kiln (a vertical box type, traditional kiln) fabricated in this Institute was used for the study as it was less expensive and easy to operate. (Size of kiln: 2.45 m x 0.61 m x 0.61 m).

Source of smoke:

Smoke was generated by burning saw dust in an earthen pot having a narrow hole at the bottom for air passage. The saw dust was filled in two layers, bottom (thick) layer having about 20% moisture and the top layer with 26% moisture in the ratio 3:1. Fire was introduced in the bottom layer near the hole. Uniform dense smoke was obtained by this method.

Saw dust:

Various types of saw dust were collected from saw mills. Normally it

contained about 10% moisture and water was sprinkled on it to adjust the moisture level in the range of 20 to 26%.

Coconut husk:

Both green and dried husk were procured, split into small chips and dried to a moisture content of about 20%.

Every kind of wood produces smoke with its own definite characteristics (Freixo, 1958). So with a view to finding out the most suitable combination to produce the best quality smoke, fresh saw dust of different types of wood such as 'Sag' (teak), 'Sajad', 'Acacia', 'Mango tree' etc and coconut husk were tried individually as well as mixed in different proportions.

Period of smoking:

Brined fillets were smoked for different periods and colour, appearance and odour were observed. In another experiment seven petri-dishes of uniform area with 100 ml of water in each dish were exposed to smoke in the smoke kiln and were taken out for phenol estimations at different intervals of smoking. Smoke was produced from a mixture of sag saw dust and coconut husk (1:1). The loss in volume was noted in each sample and after making upto the original volume they were used for the total phenol (in terms O. D./100cm²) estimation.

Final drying period and storage:

The fillets (size 16 cm x 3 cm x 2.5 cm) were brined in 20% salt solution for 30 minutes, pre-dried for 30 minutes and smoked for 15 hours with the mixture of sag saw dust and coconut husk (1:1). The smoked product was dried in sun for different periods and analysed for moisture and salt contents.

All the above samples with different moisture levels were packed in polythene bags after trimming the samples to remove

pointed bones, loose muscle and fragments of skin. The packets were kept at room temperature for storage study. In the final experiment the eel fillets were smoked according to the procedure perfected from the previous experiments and a through analysis was carried out at different stages of processing and storage.

Analysis for moisture, salt, ash and fat was carried out according to the method of A. O. A. C. (1960). Total and non-protein nitrogen were estimated by Micro-kjeldahl method. TMA and TVB were estimated by Convey's micro-diffusion method (1947). α -amino nitrogen was estimated by the method of Pope and Stevens (1939). The method of Foster and Simpson (1961) was followed for the estimation of phenol using 4-amino-antipyrine, but the values in mg were obtained from the optical density of solutions with reference to standard curves.

RESULTS AND DISCUSSION

Filleting:

The fillets of bigger size (20 cm x 5 cm; 18 cm x 4 cm etc.) retained more moisture after smoking and took much longer time for final drying (more than 10 hours in sun) to bring down the moisture content to a desirable level (30-35%). So during this prolonged drying period the spoilage of inner muscle proceeds unchecked, seriously affecting the quality of the final product. Another defect of smoking bigger size fillets was deformation in shape. Fillets of 16 cm x 3 cm x 2.5 cm and 16 cm x 2.5 cm x 2.5 cm were most suitable and they required only 4 to 5 hours of final drying to get the required moisture level. The product obtained was uniformly smoked and dried.

Salting:

Salting makes the flesh firm and it is essential for the development of surface gloss or 'pellicle' during subsequent drying and smoking. Salt also contributes to the

overall flavour of the finished products and exerts a pronounced preservative effect against mould and bacteria at a level of 8 to 10% in the fish (Empey, 1959). Shewan (1940) also has stated that a salt concentration of 9 to 15% definitely affects the flora, killing off or keeping in check many of the putrifactive types normally found in fresh fish. Hence proper salting of fish fillets prior to smoking is of prime importance.

After dry salting for 4 hours in the ratio 1:5, the fillets showed moisture and salt contents of 69.4% and 12.7% respectively. The final product obtained after smoking exhibited an ugly appearance due to rupturing of the cut surface during dry-salting and salt encrustation on the surface of the finished product. Fillets treated with 5% and 10% brine for 30 minutes and then smoked were readily spoiled by insects and mould after 3-4 weeks of storage with the evolution of strong off odour whereas those treated with 15% and 20% brine were in good condition upto 5 months and 8 months respectively (Table I). It is found from Fig 1 that

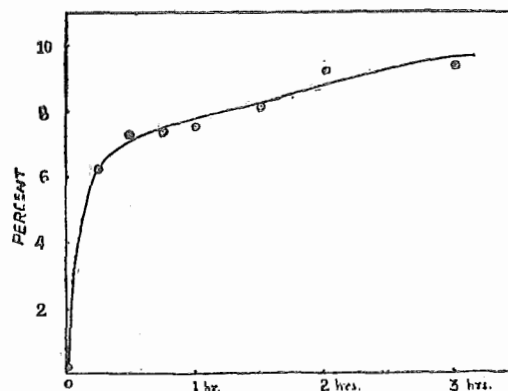


FIG. 1. SALT PICK-UP BY EEL FILLETS ON BRINING IN 20% BRINE FOR DIFFERENT PERIODS OF TIME.

by dipping in 20% brine for 30 minutes the fillets picked up about 7% salt (O.W.B.). This left about 13-14% salt in the final product which appeared to be the optimum level from the point of view of appearance and colour. The rate of salt absorption after 30 minutes was very

TABLE I OBSERVATION AND ANALYSIS OF SMOKED AND DRIED EEL-FILLETS, PRETREATED WITH 15% AND 20% BRINE FOR 30 MINUTES DURING STORAGE.

Storage period —>	Initial		3 months		5 months		8 months	
Treatment —>	I	II	I	II	I	II	I	II
Moisture %	34.85	34.5	32.08	33.2	36.52	37.05	38.15	39.0
Salt %	8.04	13.84	8.16	13.95	7.71	12.28	7.64	11.93
TMAN mg %	3.96	4.0	6.11	5.6	15.45	10.03	21.23	14.30
TVBN mg %	53.4	52.5	112.0	95.25	153.6	147.8	193.6	161.8
SPC/g.	8.84×10^4	7.486×10^4	4.72×10^5	2.05×10^5	8.1×10^5	3.87×10^5	3.46×10^6	8.6×10^5
Colour	red	red	brownish red	brownish red (salt on surface)	dark brown	brownish red	very dark brown	brownish red
Odour	pleasant smoked odour	pleasant smoked odour	pleasant	pleasant	smoked odour masked	smoked odor is slightly less	slight off odour	smoked odor very less
Flavour	very palatable	very palatable	palatable	palatable	slight unpleasant after-taste	palatable	slight unpalatable taste	slight unpalatable after-taste
Texture	firm	firm	very firm	very firm	slight soft	slight soft	soft	soft

I: Pre-treated with 15% brine II: Pre-treated with 20% brine

low. Hence salting of eel fillets in 20% brine for 30 minutes is suggested as the optimum brining period for preparing the smoked eel fillets.

Pre-drying:

Shewan (1945) and Empey (1959) recommended surface drying prior to smoking of fish in order to get 'tacky' surface for the development of good colour and 'gloss'. Drying aids in 'pellicle' formation which is quite important in securing a smoked product of good quality. (Anderson & Pedersen, 1947). To find out an appropriate pre-drying period, brined fillets were dried for different periods of time. The fillets dried for more than 45 minutes gave smoked product with unsatisfactory colour and odor. This might be due to the over hardening of the surface during prolonged drying. If the pre-drying was effected for less than 30 minutes the fillets appeared to be not sufficiently dried and also increased the humidity level inside the smoke kiln which lowered the rate of drying during smoking. A relative humidity higher than 70% (inside the kiln) does not allow good drying (Freixo, 1958). In the light of these, an optimum pre-drying period of 30-45 minutes is suggested to get a product with 'pellicle' form and maximum smoke deposition. In this case the relative humidity in the smoke kiln during the initial stage of smoking did not go beyond 70%. The maximum temperature observed was 50°C to 62°C inside the kiln.

Source of smoke:

The active constituents of wood smoke result from the destructive distillation and/or partial oxidation of wood. Complete combustion of wood gives only carbon dioxide and water (Nicol, 1960). Hence addition of some extra water in saw-dust was essential for the partial oxidation of saw dust in commercial type smoking. The smoke constituents and

and hence the flavour and appearance of the cure vary with the type of wood used (Shewan, 1945). The effect of different saw dust samples on colour, odour and flavour of smoked product of eel fillets is shown in Table II.

A very attractive smoked product with red colour was obtained by smoking with sag saw dust but the odour and flavour were considerably acrid and unpleasant. Smoking with saw dust of sajad, acacia and mango tree did not give satisfactory product with respect to odour and flavour because of the resinous nature of soft woods and further they had a tendency to impart acrid flavours and odours to smoked products (Sidaway, 1944). In our investigation coconut husk alone gave a very good product with respect to odour and flavour but the colour was pale yellow. However the best results were obtained with a mixture of coconut husk and sag saw dust in equal weights. The fillets smoked by this mixture had a very rich golden yellow colour which turned to reddish during subsequent drying. The product had a very palatable taste without any undesirable after-taste.

Smoking period:

As the muscle of eel fish is white in colour less than 10 hours of smoking could not impart the required level of red colour. Moisture content also could not be brought down sufficiently by this period. Smoking for 15 hours gave the best result. Figs 2 and 3 show the total phenol absorbed in terms of optical density per 100 cm² and % loss of water / 100 cm² respectively when water was exposed to smoke for different periods. It has been reported by Foster and Simpson (1961) that if water and surface of wet fish of the same area were exposed to smoke under identical conditions the rates of absorption of smoke phenols were almost the same. So in order to get some idea about the rate of

TABLE II PHYSICAL OBSERVATION OF SMOKED AND DRIED EEL FILLETS,
SMOKED WITH DIFFERENT VARIETIES OF SAW DUST

Materials use to generate smoke	Observations of smoked product		
	Colour	Odour	Flavour
'Sag' (teak) saw dust	Very rich red colour	acid smoke odour	slight unpalatable after-taste
'Sajad' saw dust	reddish yellow	-do-	-do-
'Acacia' saw dust	rich red	slightly more acrid and penetrating	unpalatable and bitter after-taste
Mango wood saw dust	reddish yellow (very dull appearance)	very acrid	tarry and unpleasant
'Sag' wood chips	very pale yellow	acid	unpalatable and slightly sour
Coconut husk (alone)	Pale yellow	Pleasant and appealing	very palatable and pleasant after-taste
75% Coconut husk + 25% sag saw dust	very rich yellow	pleasant	palatable and liking
50% coconut husk + 50% sag saw dust	rich golden yellow colour	pleasant	palatable
25% Coconut husk + 75% Sag saw dust	rich red	mild pleasant	slightly acrid

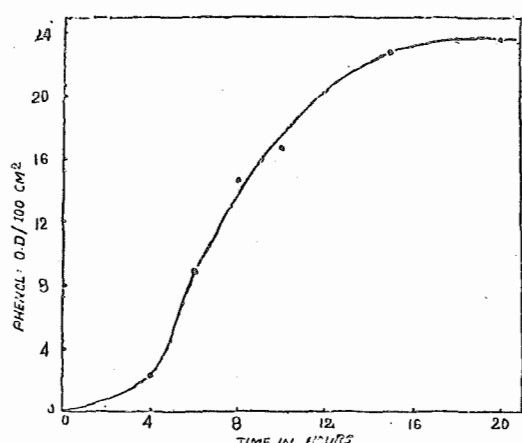


FIG. 2. PHENOL ABSORBED BY THE SAMPLES OF WATER DURING DIFFERENT INTERVALS OF SMOKING.

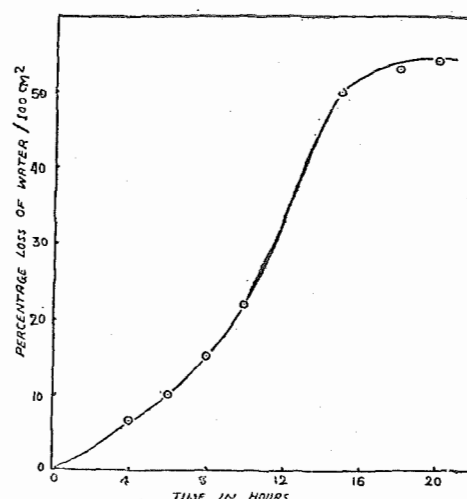


FIG. 3. PERCENTAGE LOSS OF WATER IN PETRIDISH DURING SMOKING

absorption of phenol and rate of evaporation of water samples, this experiment was carried out. From the figures it is observed that most of the phenol is deposited during the first 10 hours of smoking and about 21% water was lost by evaporation during the same period. From 10 to 20 hours the phenol content did not increase considerably but about 54% loss in water was observed. This reveals that

the rate of absorption of phenol might be higher during the initial ten hours of smoking and rate of evaporation of moisture might be higher after this period. These results are quite comparable with those of smoking of eel fillets where smoking and drying took place to the required level within 15 hours of smoking.

Final drying:

The moisture content of smoked eel fillets (smoked for 15 hours) was in the range 56–60%. Further drying was necessary for the proper preservation of the product. Fig 4 shows the course of drying of smoked eel during sun drying. It took about 5 hours to bring down the moisture to 30–35%.

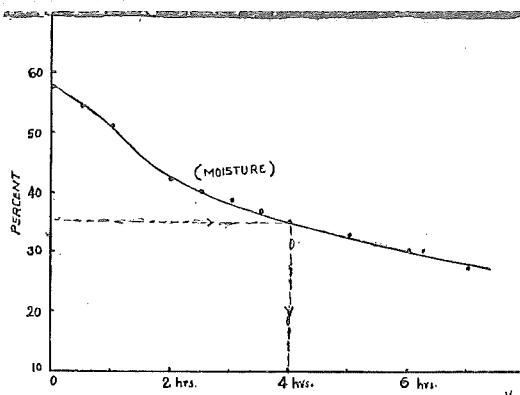


FIG. 4. MOISTURE CONTENT OF SMOKED EEL FILLETS DURING SUN DRYING.

optimum moisture level:

In Table III the storage behaviour of smoked samples having different moisture

contents is given. Smoked products having moisture content above 50% were attacked by moulds and spoiled within 3 to 4 days of storage at room temperature and those having 37 to 40% moisture had storage life of only 2–4 months after which they spoiled gradually. Samples with moisture content between 30 and 35% remained good for more than 6 months without any significant spoilage. However no mould attack was observed up to 8 months of storage. Below 30% moisture level the product tended to acquire toughness and pronounced shrinkage on the surface. Moreover the “pellicle” form was lost within a short storage period. No other significant spoilage was noted even after 8 months of storage. It may be concluded from these results that the smoked product with moisture content between 30–35% and salt content about 13% has the best appearance as well as shelf life.

The analytical data of the smoked fillets prepared under the optimum

TABLE III OBSERVATION OF THE SMOKED EEL FILLETS WITH DIFFERENT INITIAL CONCENTRATIONS OF SALT AND MOISTURE CONTENTS.

Moisture %	Salt (O.W B.) %	Observation
57.8	8.23	Product had very good appearance but mould attacked after two days of storage.
54.52	8.80	Mould attack after three days.
51.02	9.37	„ „ „ five „
42.32	11.56	„ „ „ three weeks.
40.25	11.80	„ „ „ 2½ months.
39.00	12.06	No mould attack upto 3 months but gave out slight off odour.
37.18	12.70	Gave out slight ammonical smell after 4 months. No mould attack. No salt crystallisation on the surface.
35.20	13.20	Colour turned to more brownish red after six months. Salt appeared on the surface after two months. No mould attack even after 8 months of storage. Smoke odour was masked after this time.
30.50	14.15	} Fillets became very tough, salt appeared on the surface in the form of white powder and also in crystal form. Smoke odour was considerably less, but no off odour was noted. No other significant spoilage was noted even after 9 months of storage.
27.81	14.23	
21.30	14.52	

conditions suggested above are given in table IV. About 86.7% reduction in the

TABLE IV ANALYSIS OF THE EEL FILLETS PRIOR TO AND AFTER SMOKING AND DRYING

Contents	Analysis before smoking	Analysis after smoking and drying
Moisture %	77.54	33.78
Salt (as NaCl) %	4.60	12.74
Ash %	6.23	17.20
Fat %	0.58	1.86
TN %	2.88	7.52
NPN %	0.21	1.06
TMAN: mg %	2.90	4.32
TVBN: mg %	23.40	58.92
∞ -amino N: mg %	98.60	187.00
SPC/g.	3.98×10^5	5.39×10^4
Phenol	...	i). Steam volatile 30.5 mg % ii). Steam non-volatile 10.0 mg. %

initial bacterial load was noted on smoking and drying. In 'hot' smoking (Shewan 1949) most of the organisms are killed and apart from the occurrence of a few resistant micrococci or spore formers, the smoked product as it is taken from the kiln, is nearly sterile. Shewan (1945) also stated that aldehydes, phenols and fatty acids jointly accounted for most of the bactericidal properties of smoke. About 30.5 mg/100 g steam volatile and 10 mg/100 g steam nonvolatile phenols were present in the final smoked product. It is believed that the deposited phenols are responsible for the formation of the colour of smoked products (Linton and French, 1945). Simpson and Cambell (1960) emphasised that analysis for phenols in smoked fish appeared to provide a more useful index of smokiness than the estimations of formaldehyde, total carbonyls and volatile acids.

Yield:

The proximate yield of fresh fillets and final smoked product from the original weight of whole fish is:

- (a) Fillets : 60-62%
- (b) Final (smoked and dried) product : 25-22%

SUMMARY

The effect of various factors such as source of smoke, the size of fillets, concentration of brine, period of brining, pre-drying, smoking and final drying on the quality of smoked product was studied in detail and from the results obtained, a method was suggested for the preparation of an excellent smoked product from eel fish. The smoked product prepared by the above method had attractive reddish colour, pleasant odour and very palatable flavour and had a storage life of about 8 months at room temperature.

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