PRELIMINARY INVESTIGATIONS ON THE PIT CURING OF FISH IN INDIA

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Introduction

Among the methods adopted for the curing of fish in India the practice of pit curing common in certain parts of the Madras State and the neighbouring region of Travancore is of considerable interest for several reasons. Broadly speaking the method consists in burying the fish after salting in mat lined pits for varying periods ranging from a few days to a fortnight or more before marketing in a partially dried condition without any further washing or drying. The products possess a distinct flavour and taste much appreciated by some sections of the public in the eastern parts of Madras State. However the process is mainly adopted by private curers outside the Government curing yards and the quality of the commercial samples leaves much to be desired due to their unwholesome appearance and commonly observed infestation with maggots (Krishna Pillai *et al.*, 1956). Since pit curing forms one of the main methods of curing around Mandapam, it was considered desirable to undertake a comprehensive investigation of the local practices relating to this cure and the keeping quality of the products. A knowledge of the biochemical changes occurring during maturation under semi-anaerobic conditions which constitute the basis of this cure is necessary for obtaining a better product by this method.

Survey of the Existing Methods

A study of the pit curing methods practised in different localities has indicated considerable variations in detail. At Akkaraikuppam and Vadakkammapatnam (Tanjore Dist.) the fish after washing and gutting, are rubbed with salt and placed in mat lined pits dug close to the landing grounds. Salt is thickly sprinkled between each layer as also on the top and the whole is covered with a mat. They are then covered with sand and buried under pressure. The next day the pits are opened and the fish is well rubbed with salt and transferred to the same pits. They are left in the pits for 3 to 4 days till the salt is completely dissolved. At some places like Sethu-

bhavachatram and Malliapatnam (Tanjore Dist.) they are transferred to fresh pits after the first day (Govindan, 1916). Private enquiries have revealed that curers at Periapatnam (Ramnad Dist.) transfer the fish to fresh pits after a 3-day cure and the whole process lasts for 6 days. Fishermen around Mandapam follow a 3-day cure without interruption. Gutting of the fish is not universal, *e.g.*, *Chirocentrus* are pit cured immediately on landing after giving a few longitudinal cuts and rubbing with salt without the guts being removed as was observed at Dhanushkodi. Much longer periods for the duration of the cure are reported from Travancore (John, 1948) lasting up to four weeks. Salt is applied in the ratio of 1 : 5 or 1 : 6 for large fish and in much lower ratios upto 1 : 16 in case of the smaller varieties. However it was reported at Kilakarai (Ramnad Dist.) that pit curing requires more salt than other types of cure.

Plan of the Experiment

Mackerel was chosen for the study in view of its commercial importance. Freshly caught mackerel (*Rastrelliger kanagurta*) landed off Mandapam by shore-seines, about 20 cm. long, were employed for experimental curing. After washing with tap water, the fish were split on the dorsal side from the point of the head to the tail cutting deep on the upper side of the vertebral column so that the fish could be laid flat with the backbone lying on one of the sides. The guts and gills were carefully removed and the gutted fish were washed again free from traces of blood. They were then salted in the ratio of 1 : 5 on palmyra mats by applying salt uniformly for each fish and the fish were folded after introducing the remaining salt in the belly cavity and in between the different layers of fish. The mats were then made into compact bundles which were placed in three pits two feet wide and one and half feet deep dug in sandy soil close to the laboratory. They were covered with sand and buried under pressure by trampling. Wet salting according to the procedure followed at Malpe on the west coast as described by Nicholson (1930) was also carried out with a different lot from the same material simultaneously for a comparative study. Salt ratio of 1 : 3 was adopted for wet salting but only half of the requisite quantity of salt was applied on the first day. The remainder was again applied on the second and third day in equal amounts. After rubbing with salt as described previously the fish were stacked in layers in such manner that the self brine formed drains out freely into a basin placed below. Samples were taken from each pit successively on the next three days and they were analysed along with the wet cured product on each day. It was thus possible to follow the changes during the curing period apart

from providing samples pit cured for varying periods. The cured products were subjected to taste panel studies soon after removal from the pits. Their keeping quality was studied by chemical analysis at fortnightly intervals. Pit cured samples were stored after packing in mats and the wet salted fish were left in the stacked condition. Room temperature during the period of storage upto nine weeks ranged from 21·1° C. to 28·3° C. inclusive of diurnal variation. Relative humidity fluctuated between 60 to 87% being generally lower in the later half of the period under observation.

Analytical Methods

Fish muscle alone separated from two of the experimental samples was thoroughly minced in a mortar and used for chemical analysis. Moisture content was determined by drying at 105° C. to constant weight. Salt was determined after ashing and titrating the aqueous extract of the same with standard $AgNO_3$. Total Volatile Basic Nitrogen was estimated by steam distillation in a microkjeldahl employing an extract of the fish muscle in 95% alcohol. The same extract was used for determining Trimethylamine by Conway's microdiffusion technique (Beatty and Gibbons, 1937). For the determination of Formol Titratable Nitrogen, Sorensen's method as modified by Effront was employed using however Bromothymolblue for adjusting the pH to 7·0 before the final titration (Westenberg, 1950). Amino acid Nitrogen was computed by subtracting the T.V.N. value from Formol Nitrogen, no correction being applied for the error due to trimethylamine content. Rancidity development was followed by determining Peroxide Values on the lines of the procedure described by Tarr (1947).

Results

After the fish were removed from the pits, yellowish discoloration was observed in all the samples and they were also slimy to touch as against the firmness shown by wet salted products. The flesh of pit cured mackerel was of a deep red tint and was quite soft. Smell of ammonia was noticed in all the samples. Their appearance showed marked deterioration during storage. Taste panel studies have indicated that pit cured mackerel after cooking were very soft as compared with the toughness of texture and 'stringy' feeling expressed with regard to the wet salted fish. The flavour and taste of the products obtained by pit curing for 2 or 3 days were relished unanimously by all the observers, but the products removed from the pit after only 24 hrs. had a putrid odour and unpalatable taste in spite of the softness of the flesh. Wet salted mackerel were definitely inferior from the organoleptic point of view.

Chemical changes observed during the cure by both pit curing and wet salting are recorded in Table I and data from the studies on the keeping quality of the products tabulated in Table II. Desiccation by the action of salt is complete within two days in both cases though pit cured fish gain some moisture on the third day. Final salt content on dry weight basis was 31·5% for wet salting and 27·2% for pit curing. In order to obviate the influence of the increase in salt concentration during the curing process, results of investigation have been expressed on moisture-salt-free basis. Increase in Amino acid Nitrogen was observed to be much higher in pit curing, reaching more than double the original level. Levels of trimethylamine were fluctuating during wet salting, while in pit curing these showed a steady increase from the second day. Total Volatile Basic Nitrogen increased steadily during pit curing from 58·3 to 181·4 mgm.% while there was no appreciable rise in wet salted mackerel. Peroxide Values were nil during the curing period in both cases.

Data from the analyses during storage reveal a marked difference in Total Volatile Basic Nitrogen between the two cures. Pit cured samples were characterised by a much faster rate in the development of volatile bases and values more than 500 mgm. N% (on moisture-salt-free basis) were recorded in about 2 weeks. The values increased still further till the fourth week ranging from 803·9 to 994·5. Wet salted mackerel showed a gradual increase from 80·2 to 551·8 during the 9 weeks of keeping. Rise in trimethylamine content consisted of a mild initial peak followed by gradual lowering. Peroxide values reached high levels on keeping though the values appeared to be fluctuating.

Bacteriological work during the investigation was confined to the enumeration of the plate counts at different stages. Fresh fish muscle was sterile. In pit curing bacterial count expressed as log. no. of bacteria/gm. increased to 4·64 in 3 days. However the final counts after 9 weeks' storage showed a general reduction in the case of the pit cured fish the converse being true for wet salted fish. The data have been presented along with the results of the chemical analyses.

Discussion

Previous observations on the chemical quality of pit cured fish have been limited to the anlaysis of the marketed samples (Velankar, 1952; Krishna Pillai *et al.*, 1956). Results of the present investigation indicate that pit curing promotes pronounced chemical changes which improve the quality of the products as revealed by taste panel studies in the laboratory.

TABLE I

Chemical changes during the curing process

(Constituents other than moisture and salt expressed on moisture-salt-free basis)

Type of cure	Period of curing in days	Moisture %	Salt %	T.V.B. Nitrogen mgm. %	Trimethyl-amine mgm. N%	Formol Nitrogen mgm. %	Amino acid Nitrogen mgm. %	Log. No. of bacteria/gm. of muscle
Fresh sample ..	..	73·87	0·1	58·3	4·86	288·9	230·6	nil
Wet salting ..	1	65·37	3·6	85·7	7·89	354·2	268·5	3·40
..	2	53·06	13·4	61·4	5·26	352·7	291·3	..
..	3	54·04	14·5	80·2	6·83	408·6	328·4	3·90
Pit curing ..	1	63·43	6·6	89·6	4·72	351·7	262·1	4·43
..	2	57·84	8·5	106·6	8·19	509·3	402·7	..
..	3	62·37	10·2	181·4	16·71	780·5	599·1	4·64

TABLE II

Chemical changes during storage of the cured products

(Values expressed on moisture-salt-free basis)

Sample	Period of storage in weeks				
	0	2	4	7	9
			Moisture %		
Wet cure ..	54·04	52·05	53·02	49·16	45·91
Pit cure I* ..	63·43	58·60	54·83	51·57	49·10
Pit cure II ..	57·84	56·22	54·66	51·87	48·84
Pit cure III ..	62·37	58·86	55·43	51·25	49·80
			Total Volatile Basic Nitrogen mgm. %		
Wet cure ..	80·2	125·4	213·5	353·5	551·8
Pit cure I ..	89·6	686·4	919·1	1042·0	984·5
Pit cure II ..	106·6	449·0	803·9	1005·0	913·9
Pit cure III ..	181·4	620·4	994·5	1110·0	1257·0
			Trimethylamine Nitrogen mgm. %		
Wet cure ..	6·83	17·31	27·27	28·15	33·11
Pit cure I ..	4·72	29·30	27·04	25·83	34·76
Pit cure II ..	8·19	19·82	23·10	22·96	44·08
Pit cure III ..	16·71	30·90	32·67	22·31	25·50
			Formol Nitrogen gm. %		
Wet cure ..	0·409	0·537	0·506	0·512	0·801
Pit cure I ..	0·352	1·759	1·715	1·505	1·121
Pit cure II ..	0·509	1·135	1·480	1·690	1·621
Pit cure III ..	0·781	1·232	1·586	1·511	1·379
			Peroxide Value (ml. N/500 $Na_2S_2O_3$ per gm. of fat)		
Wet cure ..	nil	83·0	133·9	296·1	144·0
Pit cure I ..	nil	nil	167·9	180·5	113·1
Pit cure II ..	nil	14·4	nil	277·5	40·3
Pit cure III ..	nil	nil	nil	327·7	nil

* Pit cure I, II and III denote samples obtained by curing for 1, 2 and 3 days respectively.

This may perhaps be attributed to the process of maturation or ripening under mild anaerobic conditions obtaining in the pits which hasten the proteolytic breakdown and oxidation of fat. These biochemical changes

constituting the process of maturation in primitive indigenous methods like pit curing are of considerable interest. Though dry salting and wet salting along with sun drying form the major methods of curing in India, a variety of fish products like fish sauces, fish pastes and partially dried salt fish are prepared in other South-East Asian countries which owe their characteristic flavours to partial decomposition by microbial and autolytic agencies. That pit curing depends essentially in maturation under semi-anaerobic conditions can be inferred from the fact that wet salted fish also acquire the characteristic softness and flavour by controlling the conditions of salting, packing and storage. It is of interest to mention that though pit curing is not practised on the west coast, fish intended for Madurai, Ramnad and Tanjore Districts are wet salted in a special manner. After stacking with salt for 24 hrs. fish are packed in cadjan bundles without washing or drying. They become soft and develop a putrid smell resembling the pit cured products of the east coast (Govindan, *loc. cit.*). This type of cure corresponds in a way to the preparation of 'Pedah Siam' of Thailand wherein careful packing of partly dried salted fish (*Scomber neglectus* and *S. kanagurta*) helps in promoting maturation to yield a highly valued product in Indonesia (Van Veen, 1953).

Rate of penetration of salt is accelerated during pit curing due to the application of pressure which results in a more efficient utilisation of the salt. Final salt content in pit cured mackerel is 27·2% as against 32·0% in wet salted fish (on dry weight basis) though the salt ratios employed are 1 : 5 and 1 : 3. Although pit cured fish were more moist and slimy in appearance, no maggots have been found in the present instance and it is therefore evident that maggot infestation in commercial samples is mainly due to the insanitary conditions under which curing is conducted. Bacterial counts recorded during pit curing were however considerably higher than the levels observed in wet salting, the trend being more pronounced during the first 24 hrs. On the other hand, there occurred a significant increase in the log. bacterial count of wet salted fish during storage from 3·90 to 4·21 while pit cured fish (3-day sample) showed appreciable reduction from 4·64 to 3·91 (log. bac. counts).

During the first 24 hrs. of the curing process proteolytic changes appear to be similar for both methods as the values for Total Volatile Nitrogen and Amino acid Nitrogen show similar levels. During the next 2 days in the pits a marked rise in both the forms of nitrogen is observed indicating active proteolysis. It is possible that a considerable time lag exists for the attainment of the optimum conditions for the process of ripening.

While the changes in Amino acid Nitrogen are not prominent in wet salting large amounts of this fraction of nitrogen are released during pit curing due to a partial decomposition of the protein; however the ratio of Volatile Basic Nitrogen to Formol Nitrogen is fairly low indicating the predominant role of autolysis as against bacterial action (Boury, 1938). The characteristic flavour of 'Pedah Siam' has been ascribed by Van Veen (*loc. cit.*) to the presence of methyl ketones and odoriferous aldehydes. Preliminary investigations on the carbonyl compounds in pit cured mackerel have revealed their presence in appreciable quantities.

Studies on the keeping quality of the cured samples reveal that pit cured products undergo rapid deterioration and the T.V.N. values exceed 500 mgm.% (moisture-salt-free basis) after a fortnight. Values as high as 1·26 gm. N% are encountered after 6 weeks of storage. Duration of curing has no appreciable influence on the rate of increase in volatile bases. It has been reported by previous workers (Krishna Pillai *et al.*, 1956; Velankar, 1952) that T.V.N. values were low in the market samples examined by them. Wet salted mackerel were in a good condition up to 2 months and the T.V.N. values were also lower. Total Volatile Nitrogen therefore appears to be a useful index of spoilage in these products though pit cured mackerel show a slow increase after the first 4 weeks. This is in conformity with the observations reported by Velankar (*loc. cit.*) suggesting a limit of 200 mgm.% for T.V.N. (original moisture basis) in salt fish. Notwithstanding the upward trend observed in pit curing as also in the initial stages of storage in wet salted fish, the usefulness of Trimethylamine index appears to be of limited significance in cured fish.

Formol Titratable Nitrogen shows a general tendency to increase in the initial stages followed by some reduction after 4 weeks of storage. Rise in F.T.N. is observed in wet salted mackerel only after prolonged storage. Amino acid Nitrogen follows a similar pattern but the gradual reduction during storage is more obvious. Although Lafont (1951) has advocated the usefulness of Formol Nitrogen in salted and dried fish, neither of the above two forms of Nitrogen appears to provide a satisfactory index for the assessment of fish spoilage according to the results of the present investigation and the same may hold good for products obtained by other curing methods as well judging from the preliminary studies conducted at this laboratory. However the changes during storage of the T.V.N./F.T.N. ratio reveal a general increase and may prove to be of considerable interest in studying the progress of spoilage. Peroxide values in wet salted mackerel show a gradual increase up to 7 weeks and get reduced subsequently in the

later stages as observed by previous workers. Changes in the peroxide value of pit cured products are rather abrupt and inconclusive.

In conclusion it can be stated that the results of the present study show that pit cured mackerel have a storage life not exceeding 2 weeks on the basis of the observed high T.V.N. values. Wet salted mackerel keep well till about 2 months. However pit curing confers a characteristic flavour and taste and if the process is conducted in a hygienic manner the products may prove to be more popular. The process of ripening for acquiring the desired softness and flavour is found to be mostly complete in 2 days in the case of pit cured mackerel. Results of the chemical analysis conducted during curing also suggest that the period of curing may be limited to 2 days. Estimation of the Total Volatile Nitrogen is useful in the assessment of the quality of the products.

Summary

A study of the process of pit curing of fish which is practised mainly on the east coast of the Madras State was undertaken to determine the optimum conditions for the cure, keeping quality of the cured products and to evaluate the different chemical tests for the detection of spoilage during storage. Mackerel was chosen for the investigation which also included observations on the more common method of wet salting. Pit curing improved the organoleptic properties by imparting a characteristic flavour and softness to the flesh. However their appearance was rather unfavourable and their keeping quality limited to a few weeks after the cure. Wet salted mackerel on the other hand were found to keep in a good condition up to 2 months.

The beneficial effect of maturation or ripening under semi-anaerobic conditions in pit curing was reflected in the release of large amounts of free amino acid nitrogen during the cure. However the levels of Total Volatile Basic Nitrogen which had also increased during the curing period reached more than 500 mgm.% (moisture-salt-free basis) after two weeks of storage. The optimum period for the cure was found to be two days in the case of gutted mackerel salted in 1 : 5 ratio. A comparative study of the changes in T.V.B. Nitrogen, Trimethylamine, Formol Nitrogen and Peroxide Value during storage revealed the usefulness of T.V.B. increase as a test for the assessment of quality.

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