STORAGE BEHAVIOUR OF SALTED AND DRIED FISH IN RELATION TO HUMIDITY CONDITIONS

By S. V. Suryanarayana Rao,* A. P. Valsan, M. K. Kandoran and M. R. Nair

(Central Institute of Fisheries Technology, Ernakulam)

Humidity conditions play very important role in governing the storage life of cured fish products, since mould growth and red halophile attack depend on the moisture content of the product which varies with changes in relative humidity (R.H.). An additional factor is contributed by salt, if used for curing, which by lowering the equilibrium vapour pressure in fish muscle to 76 per cent. R.H. helps the products to absorb moisture, when the humidity is above this level. Sen *et al.* (1961) studied the storage characteristics of dry-cured mackerel under controlled humidities. However, they have employed various packaging materials during the storage period. Since the industry in India has not taken to modern method of packing, it was felt necessary to study the behaviour of salted and dried fish during storage without any packaging at high humidity levels as are experienced in tropical areas. Sen *et al.* have recommended 37·5 per cent. as the optimum moisture level for dry salted mackerel, assuming that this would correspond to equilibrium moisture content at 70 per cent. R.H. Since Cooper (1938) had earlier reported that the equilibrium moisture level at 70 per cent. R.H. is only 19·5–20·5 per cent. for dry salted cod at temperature range 15–35° C., it has been decided to reinvestigate the equilibrium moisture content of salted and dried fish in the critical range of 70–80 per cent. R.H. together with the storage studies on salted mackerel.

Experimental

Dry salted mackerel, fully split and salted in 1 : 6 ratio were employed for storage study. The fish were placed in petri dishes and left in desiccators containing solutions which would maintain constant R.H. as recommended in *International Critical Tables*. Small size catfish (16–18 cm.) salted in 1 : 6 ratio (eviscerated but not fully split open) were also employed to study the equilibrium moisture content in the range 70–80 per cent. R.H., maintained by sulphuric acid solutions. In view of the observations made by Loesecke

* Present Address: Central Food Technological Research Institute, Mysore.

(1955) that the rate of change of moisture content with temperature is quite small, which also agrees with Cooper's observation, the above studies were carried out at room temperature. Apart from the continuous observation of the organoleptic condition of the products, changes in weight were noted every fortnight and equilibrium moisture curve plotted, when all but the sample at 80 per cent. R.H. reached constant weight. Chemical analyses were conducted by the usual procedures.

Results and Discussion

In Tables I and II are presented the results of the storage studies on mackerel and catfish respectively. It may be observed that the shelf life of

TABLE I

Effect of humidity conditions on the storage of dry salted mackerel

Factor studied (original moisture basis)	Initial value	After 10 weeks storage at graded relative humidity (R.H.) levels		
		75% R.H.	87% R.H.	97% R.H.
Moisture % ..	36·78	43·98	46·72	53·15
Salt % ..	12·28	..	..	..
Total volatile nitrogen mg. N % ..	58·15	117·6	151·2	257·6
Appearance ..	..	Slightly moist	Moist	Highly moist
Odour ..	..	Fair	Slightly spoiled	Strong ammoniacal odour
Mould growth* ..	..	Slight	++	++++

* Colour of the moulds whitish and grey at 97% and bluish-black at 87% R.H. levels.

the dry salted mackerel is limited to a little over two months at R.H. levels above 75 per cent., mould growth being the main cause of spoilage. Although Frank and Hess (1941) have shown that the halophilic moulds grow best at 75 per cent. R.H. with a range of 70–85 per cent. R.H., it is of interest to observe that heavy mould growth occurred at 97 per cent. R.H. on dry salted mackerel in the present experiment. It is, however, plausible

TABLE II

Data relating to equilibrium moisture content and chemical characteristics of catfish (dry salted) at controlled relative humidity levels in the range 70–80 per cent.

Relative humidity %	Condition after 10½ weeks of storage				Condition after 23 weeks			
	Moisture %	Salt %	T.V.N. mg. N %	Mould growth	Moisture %	Salt %	T.V.N. mg. N %	Mould growth*
70% R.H. ..	23·60	13·46	Nil	..	23·32	13·24	70·0	..
72·5% R.H. ..	..	12·24	Nil	+	29·11	11·23	182·0	+++
75% R.H. ..	31·05	12·38	Nil	+	36·08	11·50	102·7	++
80% R.H. ..	35·84	13·55	Nil	++	39·77	12·0	265·1	+

Initial analysis of sample: Moisture 30·21%, salt 15·13%, T.V.N. 41·1 mg. N% (o.m.b.).

* Red halophiles observed in sample under 80% R.H. after 23 weeks.

that these might be facultative types, since salt concentration is lowered at the surface by moisture uptake. The colour of the moulds was however lighter at this high humidity level contrary to observation made by Frank and Hess. The second experiment showed that the mould growth occurred at 72·5 per cent. R.H. Although it may appear from Table II that mould growth was less at 80 per cent. R.H., it may be mentioned that the onset as well as maximum growth occurred at 80 per cent. R.H. in the initial period of storage. Mould growth was observed to subside after reaching maximum in all cases followed by the appearance of red halophiles. The results of the present study have indicated that the mould growth is major cause of spoilage at all humidity levels above 70 per cent. R.H. Mould growth is also found to occur when the moisture level of the product reaches above 25 per cent.

Red halophiles were observed on dry salted mackerel only at the end of five months' storage. The observation that maximum growth occurred at 75 per cent. R.H. but none at 97 per cent. R.H. agree with Hess's (1942) findings rather than with earlier report by Lloyd *et al.* (1929).

An attempt has been made to compare the equilibrium moisture contents obtained during this study with the equilibrium curve described by Canadian workers. It is observed (*see* Fig. 1) that the equilibrium moisture contents for the non-fatty fish like catfish at 70 and 72·5 per cent. R.H. levels

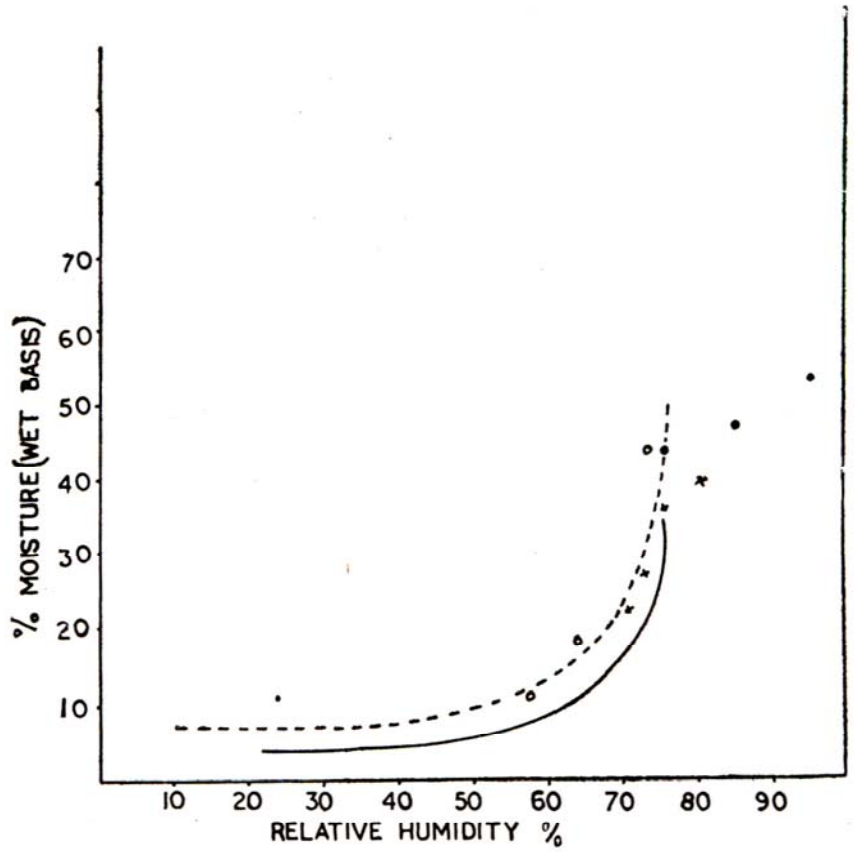

FIG. 1. Dotted line refers to equilibrium moisture curve reproduced from Dingle (1952) for light salted cod at 10° and 20° C. The lower line is taken from Cooper (1938) for heavily salted fish. Present observations for catfish (marked ×) and mackerel (marked ●) are plotted in relation to above. Values described by Sen *et al.* (1961) at 25·5° C., are also reproduced here (marked ●).

lie on the same curve for light salted cod (Dingle, 1952). Salt ratio employed by us is almost the same, though the final salt contents are slightly lower. Values reported by Sen *et al.* (*loc. cit.*) for dry salted mackerel are also seen to lie close to the same curve at 73, 64 and 57 per cent. R.H. levels. However the value 37·5 per cent. obtained by them for 70 per cent. R.H. presumably by extrapolation, is rendered doubtful in view of the close agreement by both sets of findings with Dingle's observations. Equilibrium moisture content at 70 per cent. R.H. for dry salted fish may therefore lie around 25 per cent. moisture level, as observed by us for catfish. Although Sen *et al.* have employed a slightly more fatty fish like mackerel equilibrium, moisture content can only be lowered by presence of fat. Possibility of any hysteresis in the curve has to be considered. But mere extrapolation may not be justified.

The above results also indicate that the moisture equilibrium curve does not differ widely even under tropical temperature conditions. No difference was observed by Dingle at 10 and 20° C. Although equilibrium moisture contents at 75 per cent. R.H. were found to differ widely in the case of catfish and mackerel in the present study, Cooper (*loc. cit.*) have already stated that the values above 75·3 per cent. R.H. are indeterminate because of the direct condensation of water on the product. At 75 per cent. R.H. level and above, initial moisture level appears to attain significance and some general relationship is observed in the case of moisture levels during storage at high humidity levels.

Based on Christensen's (1951) opinion, Sen *et al.* (*loc. cit.*) have stated that the initial moisture content of the dry salted mackerel should be below 37·5 per cent. before packaging. The results of the present study which deals with the actual determination of the equilibrium moisture content at 70 per cent. R.H. level instead of extrapolation indicate that more intensive drying of salted fish to 25 per cent. level would be necessary if mould growth is to be prevented by the use of latest packaging material, without the use of any antifungal agents.

Summary

Apart from studying the general keeping quality of dry salted fish stored under different relative humidities with particular reference to the onset of spoilage caused by moulds and red halophiles, an attempt has been made to determine the equilibrium moisture curve of the samples under these conditions. It has been found that the equilibrium moisture curve obtained for dry salted catfish is comparable with that obtained by Canadian workers for light salted cod. Earlier report by Indian workers recommending the moisture level of 37·5 per cent. for efficient packaging of cured fish appears to need revision in the light of the authors' findings which reveal that extensive drying up to moisture level of 25 per cent. would be necessary to prevent attack by moulds.

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* Not seen in original.