AN ACCELERATED METHOD OF HOT AIR DRYING OF FISH

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The effects of temperature and relative humidity on the rate of drying of split open fish and salted fish in a tunnel dryer have been studied at a constant air velocity. By a judicious combination of these two, the rate of drying could be considerably accelerated, 10 to 12 hours only being required for drying to moisture levels below 30% in the case of mackerel, lactarius, otolithes and kilimeen *(Nemipterus japonicus)*

INTRODUCTION

Drying has, perhaps, been the oldest method of preservation of fish practised extensively in the fishing villages of India and elsewhere. Sun drying of fish is practised even todate in more or less the traditional way with little or no modification to the process. Inspite of the rapid development of freezing and canning industries in our country in recent years, more than 40% of our fish landings is still preserved by either simple sun drying or salt-curing and drying. Being the cheapest means of preservation of surplus fish, drying is likely to stay, especially in a developing country like ours for quite a long time. Even though we are exporting considerable quantities of dried fish to the far eastern countries like Ceylon, Burma etc, very little of it is exported to the Western markets, because our products fail to conform to the quality specifications of those markets. This is mainly attributable to the fact that our fish drying industry is still being carried on in the traditional way. Even within the country there is a large demand for good quality dried fish which cannot be produced by the methods now in use.

Much of the earlier work done on mechanical dehydration of fish was confined to cooked minced fish. Later some attempts were made to dry whole fish. Legendre (1955, 1961) studied the drying characteristics of light salted cod fish and Cambodian fish in an artificial dryer where the effects of temperature, relative humidity, air velocity etc on the drying characteristics of these fish have been discussed. Prabhu *et al* (1963) studied the drying characteristics of some important commercial fishes of India in a laboratory tunnel dryer. In all these investigations the main difficulty encountered was the unduly long time required for drying, though in contrast to sun drying the time consumed was considerably less. To overcome this difficulty a method has been reported (Anon; 1963) where the fish was subjected to successive higher temperatures of drying during the falling rate period. This was achieved by passing the fish through different regions of progressively higher temperature over a conveyor belt in a tunnel of about 40′ length. This method has since been applied in the case of fish of temperate and cold countries. The present communication deals with the application of the above principle to tropical fish. By a detailed study of different factors like temperature and relative humidity and a combination of these, a method has been worked out for the accelerated dehydration of fish which is much faster than the methods reported earlier.

Materials and methods

The tunnel dryer reported by Prabhu *et al (loc cit)* was employed in these studies after effecting suitable modifications. Provisions were made for closer control of temperature and relative humidity where the wet bulb temperature was automatically controlled. Uniform air velocity inside the tunnel was ensured by making the ends of the dryer elliptical by providing suitable baffles. The air velocity was maintained constant at 130 linear m/min. Trays made of galvanized iron mesh were used to spread the fish while drying in the tunnel.

Marine fish caught by the trawlers operated by the Institute off Cochin as well as those landed near about Cochin by country fishing boats were used in these studies. Fish were kept well iced till used for experiment. The common commercial varieties like pallikora *(Otolithes argenteus)*, Kilimeen *(Nemipterus Japonicus)*, mackerel *(Rastrelliger kanagurta)*, and lactarius*(Lactarius lactarius)* were used.

Preparation of fish for drying.

The fish was cut open from the dorsal side, intestines and gills removed and washed clean of blood and slime. The split open fish was dried as such and when salted fish was employed for drying, salting was done in the ratio 1:5 (salt : fish) for 18 hours since maximum water loss for split fish occurred during this period (Sen *et at*, 1960). After salting; the fish was lightly rinsed with tap water to remove any adhering salt. In both cases (salted and unsalted) the fish were spread on the trays, flesh side upwards and loaded in the dryer whieh was operated at the desired conditions.

The loss in weight due to the removal of water was determined at regular intervals and the moisture loss curves obtained by plottlng the loss in kg per 100 kg of dry matter against time in hours.

Results and discussion

Several experiments were carried out at temperatures ranging from 40°C - 60°C keeping both R. H. and air velocity constant at 50% and 130 linear m/min respectively, the latter two being selected at random. Fig. 1 shows the effect of temperature on the drying rate of split open pallikora (Otolithes argenteus) (av. weight: 105 g). It can be seen from the figure that the moisture loss increased with increases in temperature. However, temperatures above 50°C resulted in cooking of the muscle resulting in brittleness of the end product.

Unsalted fish on drylng exhibited two distinct phases of drying, viz., the constant rate period, during which the loss of moisture per unit weight of dry matter per

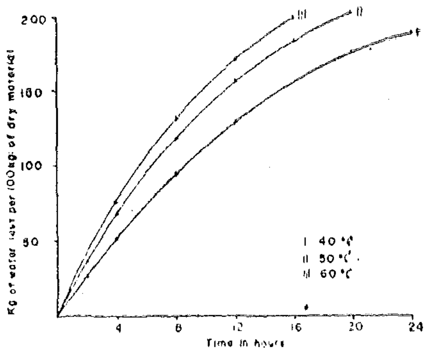

Fig 1 EFFECT OF TEMPERATURE ON DRYING RATE

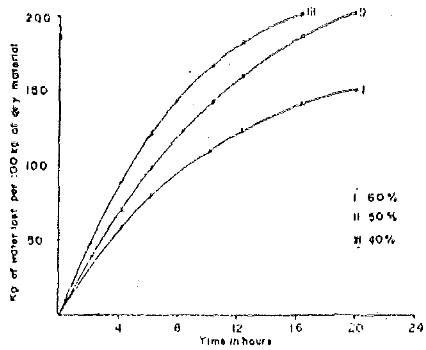

Fig 2 EFFECT OF R H ON DRYING RATE

unit time remained constant and the falling rate period, during which the loss gradually decreased (Prabhu *et al*, *loc cit.*) Drying rate of fish at the constant rate period is equal to that from a saturated surface of the same shape (Jason, 1958). It is the falling rate period that determines the extent or duration of drying. Legendre (*loc cit)* has observed that relative humidity (RH) influences drying during the early periods of drying and has recommended a higher RH for the later stages of drying. It is needless to say that any such increase in RH will automatically result in the lengthening of the drying period since, evidently at higher RH the moisture up take by the circulating air will be lessened. In order to make up for the slow moisture loss during this period, the temperature can be slowly stepped up to accelerate the diffusion of moisture from the interior to the surface from where it can be evaporated at the same rate.

Drying characteristics of Otolithes (105g av.wt., split open unsalted) as affected by RH is represented in Fig. 2. the temperature being maintained at 50°C and the air velocity at 130 linear m/min. The curves indicate that the duration of drying is highly influenced by RH. The higher the RH, the more the time required for drying. During a period of 20 hours the amount of water lost per 100 kg of dry matter was 150 and 202 kg respectively at 60% and 50% RH, but at 40% RH 200 kg of water are lost even in 16 hours, However, the phenomenon of case hardening was conspicuous at this RH. Even some cracks appeared on the surface of the fish at the later stage of drying at this RH resulting in poor appearance of the of the material. Even at 50°C, higher RH of the order of 60% and above caused certain amount of cooking of the flesh in the case of certain fishes.

R. H. influences the drying rate as long as the surface remains wet. Once the surface of the fish gets dried up, further drying is largely governed by the mechanism of diffusion of water from inside the muscle which can be accelerated by increasing the temperature of the circulating air. But an unregulated increase in drying temperature and reduction in RH aggrevates the phenomenon of case hardening. Curve II in fig. 3 shows the effect of phased drying of Otolithes (105 g av. wt., split open, unsalted) by increasing the temperature slowly as drying progressed, the RH and air velocity remaining constant at 50% and 130 linear m/min. Curve I shows the course of drying of the same fish at constant temperature of 50°C, keeping other conditions unchanged.

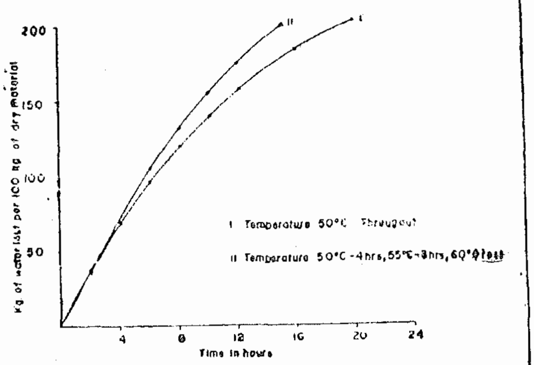

Fig 3 EFFECT OF PHASED DRYING

By increasing the temperature of the air slowly after the constant rate period (4 hours as shown by the straight line portion of the curve) it was found possible to accelerate the moisture loss considerably thereby effecting substantial saving in the drying time. The phenomenon of cooking of muscle did not take place during this process. Since considerable amounts of moisture evaporate in the initial stages of drying and the latent heat required for this is taken from the circulating air, the temperature of the muscle does not rise to any appreciable extent. At the later stages when much of the water has been removed from the fish, increase in temperature does not affect the muscle as at the earlier stages of drying, since the residual water content is not sufficient to cause cooking of the muscle.

Since the above technique effects considerable reduction in drying time, the method was extended to the dehydration of salted fish also. The results of some experiments carried out with different varieties of fish are represented in fig. 4. Salted fish did not exhibit any constant rate period. The initial high rate of drying suddenly fell and slow drying proceeded (Prabhu *et al loc cit*). From the figure it can be seen that this fall in rate can be compensated to a large extent by the in-

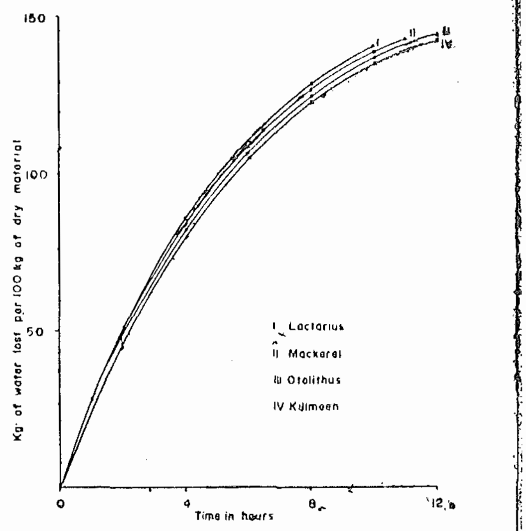

Fig 4 PHASED DRYING OF SALTED FISH

crease in temperature as observed with unsalted fish. The time taken by different fishes to dry to moisture contents of 30% or below varied from 10–12 hours depending upon size.

Summary

High temperature accelerated the drying of fish considerably, but temperatures above 50°C caused a certain amount of cooking of the muscle. The lower the RH, the higher the rate of moisture loss. But RH below a certain level resulted in case hardening. Unduly high RH values increased the duration of drying. By increasing the temperature of drying after the constant rate period, the drying time could be considerably reduced without sacrificing the product quality. Extension of this method of drying to salted fish worked well in substantially reducing the drying time.

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