MEASUREMENT OF MOISTURE IN DRY CURED FISH BY INFRARED IRRADIATION

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Heating conditions have been standardised for measurement of moisture in dry cured fish using infrared irradiation source of 150 W. Results obtained are comparable to those obtained from standard air oven method (drying to a constant weight at 102°C), the mean deviation being less than 2 units. The method works equally well for fresh fish muscle.

INTRODUCTION

As moisture content is one of the limiting factors in deciding the storage life of cured fishery products, its quantitative determination is absolutely essential in any quality control programme for such products. Estimation of moisture content in fresh fish muscle is also important in all routine research work connected with the technology of fish processing. In India about 50% of the fish catches is cured by the traditional methods of salting and sun-drying and a sizeable portion of the cured products is exported to Ceylon and other Far Eastern countries. Our export of dry fish and prawns in 1966 was 7.7 million kgs., earning foreign exchange equivalent to Rs. 18 million. However, strict quality control measures are needed in order that we may get better market for such products in other countries. The Government of India have recently introduced preshipment inspection on a limited scale for export of dried fish products to Ceylon. Very soon it is likely to be made cumpulsory for all exports of dried fish as it has been done with frozen and canned prawns and frozen frog legs. When this is done, large number of samples will have to be handled the same day which may practically be impossible by the conventional air oven method as it is relatively a slow process taking 4 to 5 hours for each determination. Hence work was initiated with a view to evolving a quick method for determining moisture content in cured fishery products.

New sophisticated methods are available for measuring moisture contents in food materials using principles of magnetic resonance by hydrogen nuclei (Shaw, Elsken & Kunsman 1953), (Stitt, 1958) and microwave attenuation (Ince & Turner, 1965). But these methods besides requiring expensive and imported instruments, have not been fully investigated in the case of fishery products. Instruments based on electrical properties of moist materials viz; conductivity, dielectric constant, loss or dispersion etc. used for timber, textiles, soil etc. are severely limited in their use in cured fishery products due to interference by the salt, minerals and fat present in the material.

Infrared irradiation technique has been applied for determining moisture contents in tobacco, grains, oil seeds, smoked fish etc. (Ramachar, Allabakshi & Tirumal Rao, 1966) (Levieva 1960). However in these works, much attention has not been paid for standardisation of drying conditions viz; temperature of the material being dried, sample size etc. So much so samples have attained temperatures higher than 100°C which is not desirable in case of fishery products. Also the heating time and the height of bottom surface of the bulb from material had to be adjusted according to moisture content of the sample (low 8–10% or high 16–30%) which are rather cumbersome for routine analysis.

Materials and Methods

The method was applied to dry prawns and cured sardines, mackerel and lactarius as well as fresh prawn and sardine muscle. Samples of dry prawn were prepared by cooking peeled and deveined prawns in 7% brine followed by drying in laboratory hot air tunnel dryer to moisture levels varying from 20 to 58%. In the case of other fish they were eviscerated, cleaned and treated with salt (6:1) overnight, excess salt rinsed off and dried as in the case of cooked prawns. In all the cases the material was homogenised in a waring blender and a weighed aliquot was spread uniformly in a petridish of 100 mm. diameter and dried under an infrared lamp (150 W/230 V A/C), approximate wave length of rays being 1/1000 mm. The lamp was provided with a heat resistant red bulb which had its rear end coated with a reflective layer to exit an even concentrated beam of rays. It was connected to the mains through an electronic timer switch which cut off the source from supply at the end of preset time interval. Temperatures ($\pm$ 0.2°C) were recorded at two points in the sample by means of 36 SWG iron constantan thermocouples over a millivolt recorder throughout the heating cycle to ensure that no overheating of the sample took place. Weighings of the samples were done in a physical balance to an accuracy of $\pm$ .005 g After drying in the infrared light and recording the loss in weight, the samples were further dried to a constant weight in an air oven at 102° $\pm$ 2°C for comparison. 100°C was taken as the maximum limit to which the sample could be heated without causing heat damage.

Results and Discussion

Table I shows the effect of distance of the heating infrared source from the material under test on the efficiency of drying.

From the figures in the table, it could be seen that distances less than 60 mm. cause overheating of the sample while at longer distances the time required for drying is unduly prolonged as indicated by larger differences of moisture values from those obtained by the air oven method. At a distance of 60 mm. the difference is minimum (1.5 to 1.8) the maximum temperature attained during drying remaining fairly low (90 to 94.5°C). Hence for all further experiments the distance of the lamp from the material was fixed at 60 mm. Results obtained by increasing the wattage of lamp to 250 and using supplementary heating from bottom

TABLE I EFFECT OF DISTANCE OF INFRARED IRRADIATION SOURCE (150 W) FROM MATERIAL ON THE EFFICIENCY OF DRYING.

Sample size : 10 ± 0.2 g.

Initial moisture content 40.5% W. W. B.

Distance of infrared source from drying sample.	Duration of drying minutes	Maximum temperature attained by fish at the end of drying.	Variation of moisture content from air oven method (Negative)
25 mm	10 – 12	102 – 104°C	8.6 – 10.4
50 mm	20	100 – 102.5°C	3.7 – 4.2
60 mm	30	90 – 94.5°C	1.5 – 1.8
75 mm	30	92°C	2.4 – 3
90 mm	30	90°C	4.0 – 4.2

TABLE II EFFECT OF SOURCE AND SUPPLEMENTARY HEATING ON THE EFFICIENCY OF DRYING.

Sample size ... 10 ± 0.5 g

Moisture content 40.5% W. W. B.

Distance of infrared source from drying sample.	Duration of drying minutes.	Maximum temperature attained by the sample at the end of drying	Variation of moisture content from air oven method (Negative)
250 W. Source			
75 mm.	10 – 15	100°C	4.5 – 5.0
100 mm.	16 – 20	102°C	5.5 – 6.0
125 mm.	20	—	6.2
	30	98°C	2.1
150 mm.	25	93.5°C	3.2 – 3.7
	30	—	2.8
150 W. Source + 18 W. supplementary heating.			
100 mm.	12 – 15	97 – 102°C	6.1
150 mm.	30	105°C	1.1 – 1.6

TABLE III RATE OF DRYING WITH VARIATION IN SAMPLE SIZE (Distance of infrared lamp from sample: 60 mm)

Weight of sample taken.	Drying period minutes	Difference from air oven method in units (– ive for samples with initial moisture contents)	
		57.8%	37.9%
5 ± 0.2 g	20	—	0.7
7.5 ± 0.2 ,,	20	—	1 – 2
	30	1.0	—
10 ± 0.5 ,,	20	—	1.0 – 1.1
	30	1.8 — 2.0	—
12.5 ,,	30	3.0	—
15 ,,	30	5.5	4.5

TABLE IV RATE OF DRYING OF SAMPLES WITH DIFFERENT MOISTURE CONTENTS

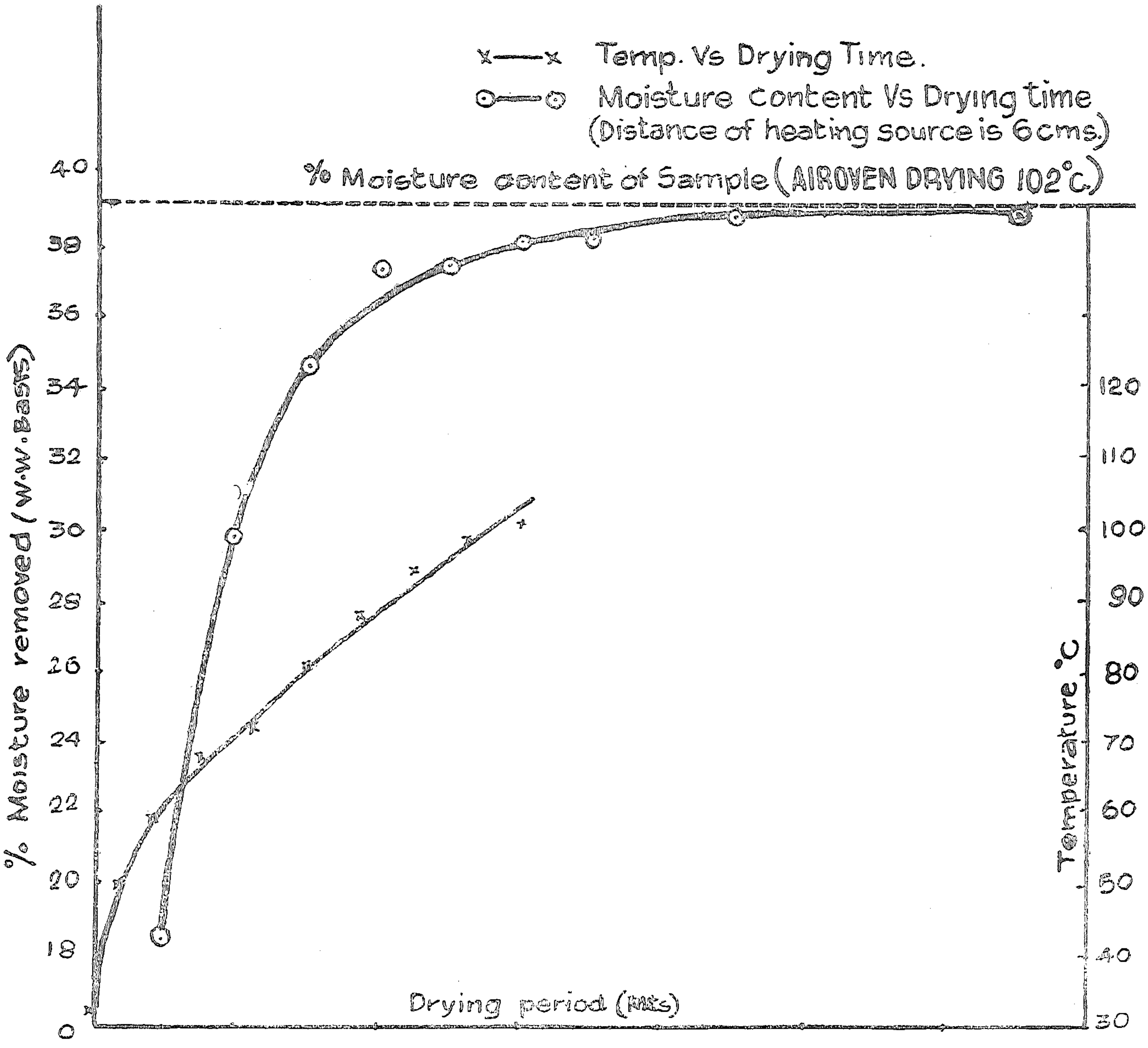
(Distance of infrared source from drying sample is 60 mm)

% Moisture content (W.W.B.) as determined by air oven method	Weight of sample taken	Drying period minutes	Maximum temperature attained by the sample at the end of drying	Difference (Negative) from air oven method
Dry Cured Fish				
1) 21.8 ± 0.1%	10 ± 0.1 g	30	92 — 94.5°C	1.2 — 1.8
2) 29.4 ± 0.2%	10 ± 0.05,,	30	—	1.0 — 1.4
	6.9 ± 0.2 ,,	20	—	0.8 — 1.2
3) 40.5%	10 ± 0.2 ,,	30	92 — 94.5°C	1.5 — 1.8
4) 42.7%	10.4 ± 0.5 ,,	30	95.5 — 97°C	2.2 — 2.5
5) 46.4 ± 0.2%	10 ,,	30	99°C	0.7 — 1.4
6) 53.6%	10 ± 0.2 ,,	30	97°C	1.6 — 1.8
7) 57.8%	10 ± 0.2 ,,	30	92°C	1.8 — 2.0
	7.2 ± 0.2 ,,	30	98 — 99°C	1.0
Fresh Fish				
8) 72.6%	7.5 ± 0.2 ,,	30	93 — 98°C	2.0 — 2.2
	9.26 ,,	45	96 — 102°C	0.7
9) 76.6%	10.46 ,,	45	97 — 99°C	0.8
	7.32 ,,	30	84 — 86°C	2.0

TABLE V EFFECT OF SIZE OF PARTICLE ON THE RATE OF DRYING

(Distance of heating source from material is 60mm. and initial moisture content of sample is 29.5%)

Type of sample taken.	Weight of sample	Duration of drying minutes	Difference from air oven method (Negative)
			Units
1. Finely powdered in waring blender	10 g.	30	1.0 — 1.4
	6.9 ± 0.2 ,,	20	0.8 — 1.2
		30	1.04
2. Cut into coarse particles of 2 to 3 mm. thickness	10 g.	30	1.8
	6.8 ,,	30	1.2
	7.15 ,,	30	1.15



Heating characteristics of 7·5 gm. powdered fish sample exposed to Infrared irradiation (150 W.).

of the sample in case of 150 W lamp are shown in Table II. The maximum supplementary heating that could be applied without overheating the sample was 18 watts (15V at 1.2A) and in both cases the safe distance of the lamp from the material had to be increased to 125–150 mm. This is undesirable as it will unnecessarily increase the size of any compact equipment that could be improvised on this principle.

Figure I shows the course of drying of 7.5 g sample with an initial moisture content of 39.3% W.W.B. at a distance of 60 mm. from 150 W infrared lamp.

At intervals of 20, 30 and 60 minutes the differences of moisture contents from the air oven method were 1.8, 1.2 and 0.2 units. Hence 30 minutes were fixed as a reasonable period of drying as a fair amount of accuracy was also obtained.

Results obtained in experiments conducted with a view to determining the optimum sample size to be used for drying are shown in Table III.

The greater the sample size, the more it represents the lot. But as seen from the table, increasing the sample size beyond 10g results in less removal of moisture in the fixed time of 30 minutes. For sample sizes of 10 ± 0.5g, maximum removable moisture was obtained in 30 minutes and this sample size is large enough for a fair representation of the lot as evidenced by the standard methods of analysis. Hence sample sizes upto 10 ± 0.5g can be used in the present method with a fair amount of accuracy.

Table IV gives the results obtained from drying experiments conducted with cured samples containing different moisture levels (21.8% to 57.8% W.W.B.) and fresh fish muscle (72.6% to 76.6%).

For a 10g cured sample at as high a moisture level as 57.8% the error is more or less same (1.8 to 2.0 units) as for those at lower moisture levels of the order of 21.8%. This should be expected as the removal of moisture from the sample, as a result of infrared irradiation depends to a large extent on the medium of communication of heat, the emissivity of the surface, distance of the lamp from the sample, power of the source and thickness of the sample. In the present study since all the factors excepting the last are constant the course of dehydration is mainly dependant on the thickness of the sample. Obviously thickness of same weight of samples spread over the same areas will be inversely proportional to their moisture contents. Hence even though the amount of moisture to be removed in case of samples with higher moisture contents is more than that in samples with less moisture contents, the rates of drying in all cases are approximately same due to their differences in thicknesses. The method therefore works equally well for both cured products at different moisture levels as well as for fresh fish muscle with comparatively high moisture level (76.6%). There was also a little variation in the maximum temperatures attained by fish samples at the end of drying period, which could be attributed partly to the uneven distribution of samples.

The effect of size of particles on the rate of drying was studied and the results are shown in Table V.

The rate of drying was found to be approximately same irrespective of the size of particles. This may be true as long as the thickness of particles does not exceed that occupied by the same weight of finely ground sample spread over the same surface area.

Summary

Infrared drying technique can be successfully applied for quick determination of moisture contents in cured as well as fresh muscle. The time required for drying a sample of 10g is 30 minutes, with an infrared source of 150 W kept at a distance of 60mm. from the sample. The error in this method is less than 2 units from the conventional method. Increasing the wattage of the lamp to 250 and decreasing the distance of lamp from the sample, cause overheating of the sample. This method is universally applicable to all types of fish viz; fresh, salted or unsalted and dried. This is particularly suitable for quick determination of moisture contents in cured fish samples, especially when a large number of samples have to be analysed the same day as in the case of preshipment inspection, for which purpose the method has been investigated in detail.

Acknowledgement

The authors are grateful to Dr. A. N. Bose, Director of the Institute for the guidance and encouragement given during the course of the work and to Dr. V. K. Pillai, Senior Research Officer (Processing) for going through the manuscript and offering valuable suggestions.

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