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Production of quality dried small indigenous fish species products using low cost solar tunnel drier

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Abstract
A low cost solar drier was constructed using locally available materials. The size of the drier was 20′ x 3.6′ x 3′ having drying capacity of 80 kg of SIS (w/w). Optimization of moisture content was observed for mola, dhela, chapila, chanda and puti at temperature ranges between 40-45°C and 50-55°C in solar tunnel drier. There was little or no change in moisture content at temperature below 40°C during the first 3 hours. Then the moisture content declined gradually with the increase of drying period. On the other hand, at temperature between 50-55°C, moisture content started to decline after 2 hours of drying. The moisture content of the sample reached at about 16% after 26 hours of sun drying at 40-45°C and 20 hours at 50-55°C. The optimum temperature for producing high quality dried products was 45-50°C in solar tunnel drier. The temperature and relative humidity outside and inside the dryers (with fish) at various locations were recorded from 8.00 AM to 4.00 PM. The normal atmospheric ambient temperature was recorded in the range of 25-37 °C from at 8:00 AM to 4:00 PM. During the same period the atmospheric relative humidity recorded was in the range of 30-58 %. On the other hand, the maximum temperature inside the dryers was recorded in the range of 28 - 65°C. The lowest temperature recorded was 28°C in the morning and at 13.00 PM the highest temperature 65°C was recorded. The maximum relative humidity 58 % found in the afternoon and minimum of 28 % at noon. There was inverse relationship between temperature intensity of sunshine and humidity which decreased as sunshine increased. In total, it took around 26 hours of drying to reduce the moisture level to about 16 %.

Key words: Small Indigenous Fish Species, Solar tunnel drier

Introduction

Most of the traditional sun dried products available in the market are not satisfactory for human consumption due to various reasons. There are frequent complaints from the consumers about the quality of the products and the major problems associated with sun drying of fish are the infestations of the products by house fly and insect larvae. Generally, two major infestation damage the products, i. larvae (maggots) of several

species of fry (*Diptera*) infestation during the early stage of drying; and ii. beetle (both larvae and adults) and mite infestation during storage and distribution (FAO 2005). And also the poor handling and sanitation and improper processing that often lead to contamination and spoilage of the products. One of the problems markedly evident is indiscriminate use of various types of insecticides such as DDT, Nogos, Rubral, etc. in the raw material or products to prevent infestations. Sun dried fish treated with insecticides may create wide spectrum of health hazards in this country. The present-day, consumers have become more health conscious and interested in convenient food. The changing pattern of the life style and increasing number of households in the rural area have an impact on market demand since consumers now-a-days insist that the product should be acceptable in terms of both quality and safety. For the products of required quality a solar fish drying could be an alternative to the traditional sun drying. However, an effective model of such dryer should be designed and developed considering the common men's accessibility, operational suitability as well as output, quality, economic sustainability and social acceptability of the product.

A *Hohenheim* type solar dryer developed in Germany in the early sixties was recently field tested in Bangladesh in order to assess its suitability in drying mangoes, pineapples and fish (Bala and Hossain 1998, Bala and Mandal 2001). The quality of the dried fish produced by the *Hohenheim* type dryer was good in view of reducing infestations and contaminations, as it has been reported earlier by many authors (Ahmed *et al.* 1979, Islam 1982, Nowsad 2003). But the cost of the drier is extremely high for both large- or small-scale operations. A tunnel structure of about 20 meter long, that can dry a maximum of 150 kg fish at a time, required about Tk. 80,000, which seems to be too costly to replace a traditional elevated rack in commercial *Killa*-based fish drying operation that can dry as large as 400 kg fish at a time within the identical time period, costing only Tk.2000 for its construction. It is, therefore, felt very significant to minimize the cost of the solar dryer by improving the designs and nullifying the importance of two fans (as their use did not create any impact).

Materials and methods

A low cost solar tunnel drier was constructed using locally available bamboo and wood materials (Plates 1-6). The sizes of the drier was 6.10x1.10 x 0.91 meters having drying capacity of 80 kg of fishes (w/w). The drying activities started from the middle of October'02. The cost of the each drier was in the range of 6-7 thousand taka.

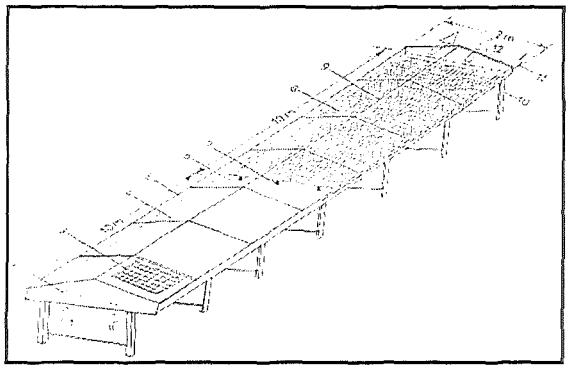

Plate 1. Model of solar tunnel drier

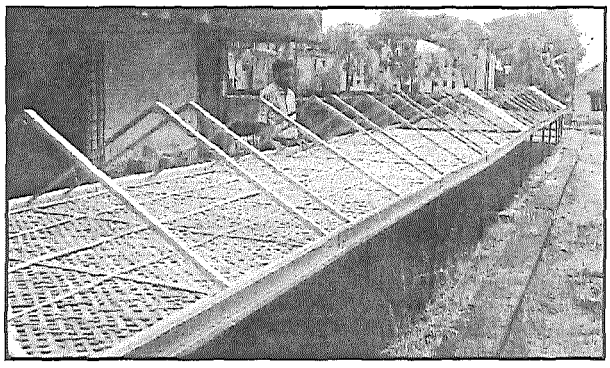

Plate 2. Original solar tunnel drier

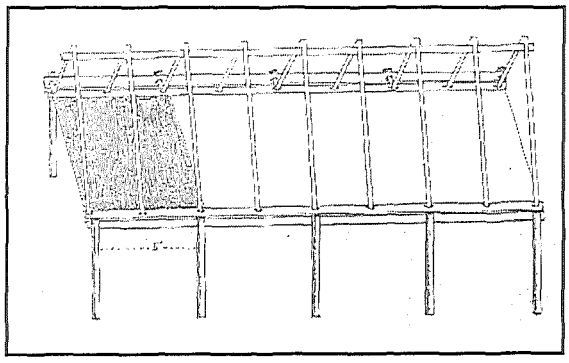

Plate 3. Modified design of drier

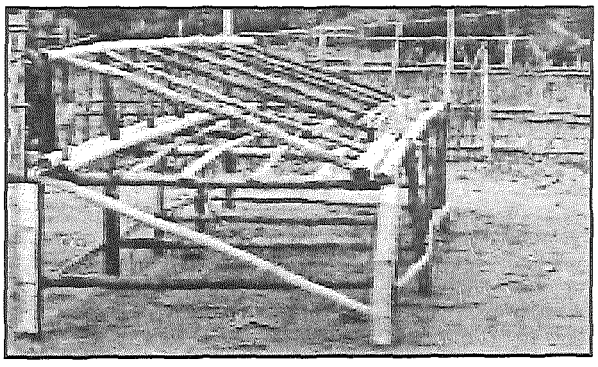

Plate 4. Picture of modified drier

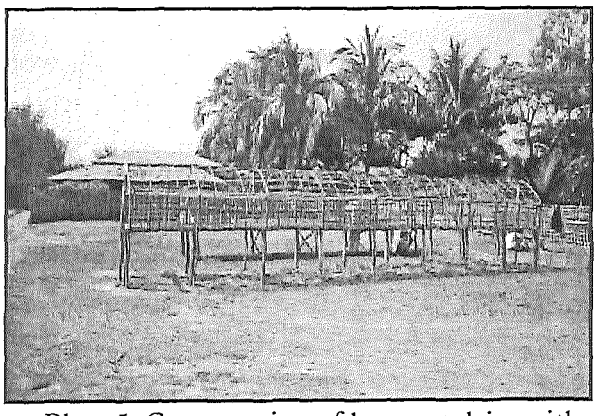

Plate 5. Construction of low cost drier with locally available materials

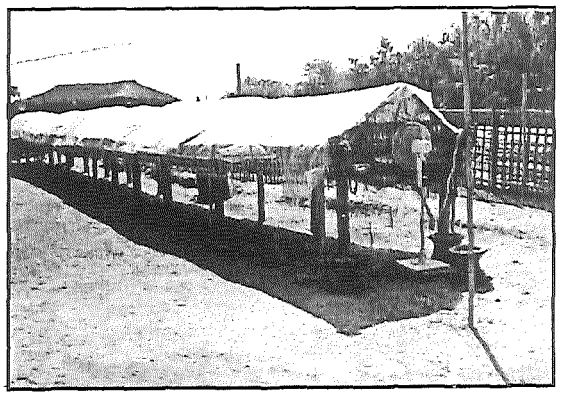

Plate 6. Drier in operation

Processing techniques for production of dried fish in solar tunnel drier

Collection of raw materials: Raw materials were purchased directly form the local market of Mymensingh and were transported to Faculty of Fisheries, BAU. Fresh raw fishes were purchased for processing into solar tunnel dried products.

Initial grading: After receiving the raw materials in the processing site, fishes were graded according to size. The graded fishes were then washed with tap water to remove any kind of undesirable materials attached with the fish body.

Dressing: The abdomen of fish was cut open using knives, and the entire viscera was removed. Scales were removed using steel made brush.

Washing: Scaled fish were washed with fresh water to remove blood and other dusty materials.

Drying: The fishes were then dried in solar tunnel drier. The time for drying was 20- 26 hours and it mainly depended on weather. Bamboos made platforms, which were about 1m high from the ground, were used for sun drying.

Grading: The dried fishes were then finally graded according to size, broken products or any other abnormalities.

Packing: After grading, the processed products were packed in polythene bag.

Optimization of drying process in low cost solar tunnel drier over a wide rang of temperature, humidity and moisture content

Experimental design: Five species of fresh SIS, mola (*Amblypharyngodon mola*), puti (*Barbodes sarana*), dhela ((*Osteobrama cotio cotio*), chapila (*Gudusia chapra*) and chanda (*Chanda nama*) were collected from local market of Mymensingh. Experiments were conducted using solar tunnel drier facility developed and installed at the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The tests on solar tunnel drying of fish were carried out during the months of October - December 2002.

Temperature and humidity measurement: Important parameters affecting the performance of the drier were measured. The relative humidity of air inside the drier was determined using relative humidity meter recorded by a data logger. To measure the temperature of air at various locations of the collector and dryer, thermometers were installed at various points along the length and breadth of the solar tunnel drier. Drying temperature and time for each five fish species were optimized on the basis of relative humidity and temperature of the solar tunnel drier. The data of optimization of solar tunnel drier for each five SIS were collected at 2 temperature ranges such as at 40-45°C and 50-55°C. Four thermometers at 3 meter intervals were used to measure the drying air temperature along the flow direction of the air inside the drier. A thermometer and relative humidity meter were used inside the tunnel to measure the ambient temperature and relative humidity during the study period.

The drying procedure was started after completion of loading, usually at 8 AM and the drying was discontinued at 4 PM for each day. The samples were kept in

desiccator/deep freeze until next morning when the samples were used for drying again until desired moisture content was obtained. Representative samples of each five fish species were collected in aluminium foil after 1-hour interval of drying. These samples were carried to the laboratory of Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh for measurement of moisture content and water reconstitution properties.

Determination of moisture content: Moisture content was determined by placing an accurately weighed known amount of ground sample in a pre-weighed porcelain crucible in an electric oven at 105°C for about 24 hrs until constant weight was obtained. The loss of moisture was calculated as percent moisture.

Determination of water reconstitution properties: Water reconstitution properties is one of the most important physical parameter to assess the quality of the dried products. For the determination of reconstitution properties of the dried products of each five species produced at 40-45^{0}C and 50-55^{0}C, recommended amount (100 g) of representative samples were soaked in water at the temperature of 40^{0}C, 60^{0}C and 80^{0}C for one hour and weights were taken after every 15 minute intervals.

Results and discussion

The temperatures were recorded from 8 AM to 4 PM everyday and after 4 PM the samples were taken out in aluminium foil and kept in desiccator/deep freeze until next morning when the samples were used for drying again.

Optimization of moisture content

As shown in the Figs. 1. and 2. for all the species, there was little or no change in moisture content at temperature between 40-45°C during the first 3 hours. Then the moisture content declined gradually with the increase of drying period. On the other hand, at higher temperatures between 50-55°C, moisture content started to decline after 2 hours of drying. The moisture content of the sample reduced to about 16% after 26 hours of sun drying at 40-45°C and 20 hours at 50-55°C.

During air drying, moisture is removed from the surface of the fish; water then moves from the deeper layers to the surface. Drying takes place in two phases. In the first phase, when the surface of the fish is wet, the rate of drying depends on the condition (velocity, relative humidity, etc.) of the air surrounding the fish. If these conditions remain constant, the rate of drying will remain constant; this phase is called the 'constant rate period'. Once all the surface moisture has been carried away, the second phase of drying begins; this depends on the rate at which moisture from within the body can be brought to the surface of the fish. As the concentration of moisture in the fish falls, the rate of movement of moisture to the surface is reduced and the drying rate becomes slower; this phase is called the 'falling rate period'.

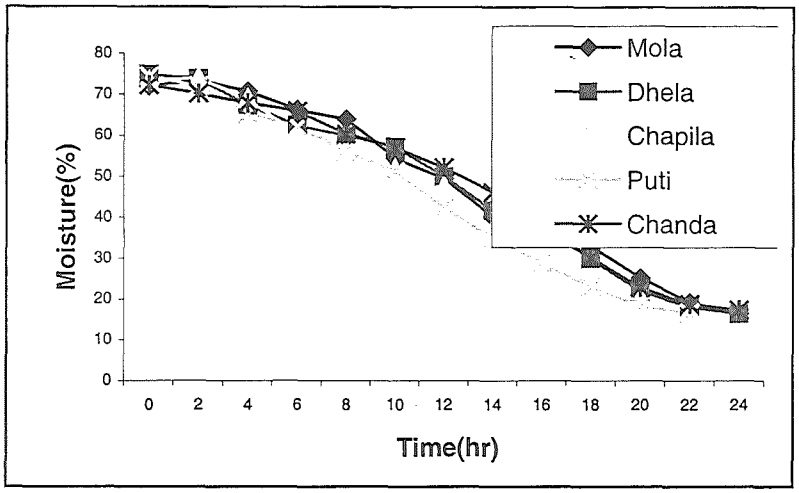

Fig. 1. Moisture content of SIS with time of drying at 40-45°C.

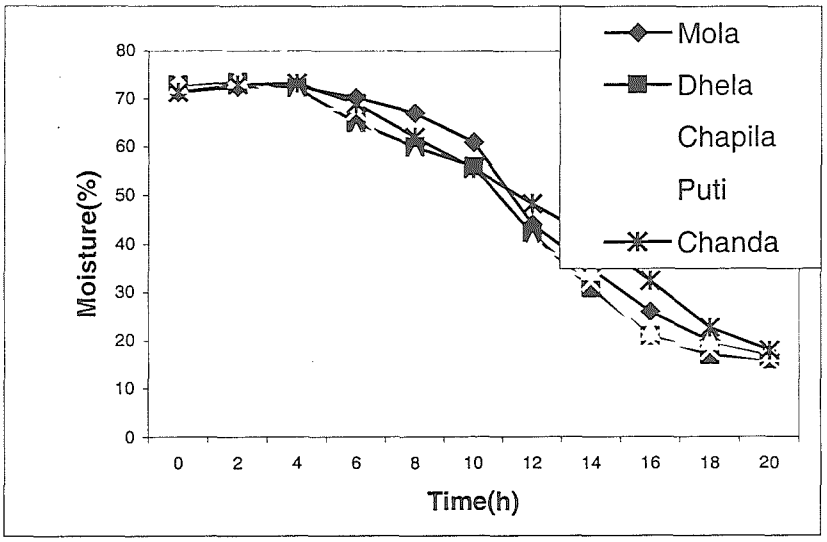

Fig. 2. Moisture content of SIS with time of drying at 50-55°C.

In case of all five SIS, the moisture content started to decline after 2-3 hours of drying in two temperature ranges studied. Then moisture content declined rapidly between 14 -16 hours. After that, moisture content gradually decreased with the increase of drying time.

The pattern of changes in moisture content during drying period can roughly be divided into four phases, corresponding to period of 0-3, 4-12, 12-18 and 18-20/26 hours. In phase one, the moisture content was more or less static and there was little or no change in moisture content. In phase two, the decrease in moisture content was rapid and in phase three and four, moisture content decreased more slowly in both the

temperature ranges under study. The changing pattern of moisture content of all species during drying process was more or less similar. Moisture content reached to 16% in 24-26 hours at temperature 40-45°C and in 20 hours at 50-55°C for all the five species.

The temperature and relative humidity in atmosphere and inside the dryers at various locations were recorded from 8.00 AM to 4.00 PM during fish drying (Fig. 3.). The ambient atmospheric temperature was recorded in the range of 25-37^{0}C from morning at 8:00 AM to the afternoon at 4:00 PM. During the same period the ambient atmospheric relative humidity recorded was in the range of 30-58 %. On the other hand, the temperature inside the dryers was recorded in the range of 28-65°C. In the morning, the lowest temperature recorded was 28^{0}C and at 13.00 PM, the highest temperature recorded was 65°C. The maximum relative humidity 58 % found in the afternoon and minimum of 28% during noon time. Temperature increased with increasing intensity of sunshine and humidity increased as sunshine decreased. In total, it took around 26 hours of drying to reduce moisture level at about 16 %. According to Bala and Islam (2001), drying air temperature to the collector outlet varied from 35.6°C to 52.4°C during February-March, 1999, 32.5°C to 53.5°C during November-December, 1999 and 29.5°C to 55.0°C during November-December, 2000. According to Reza (2002), among the temperature ranges investigated for optimization, the products produced at 45-50°C were found organoleptically excellent quality. Reconstitution rate was found to be faster in solar tunnel dried products produced at 45-50°C and comparatively slow in the rest of the products produced at 40-45°C and 50-55°C temperature ranges.

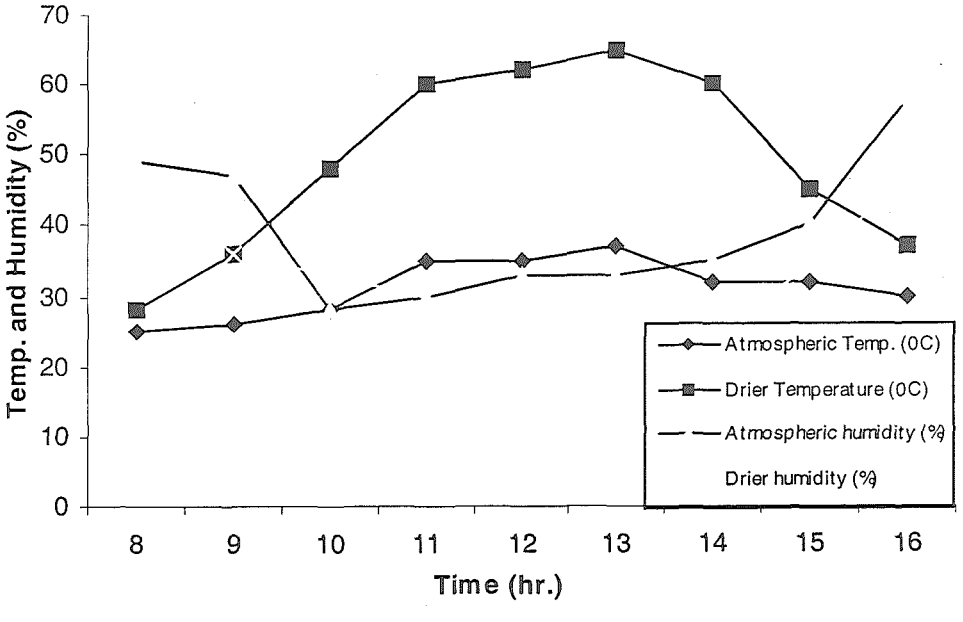

Fig. 3. Variation in temperature and humidity (%) with time of drying.

Studies were conducted to evaluate the influence of ice stored fish samples of mola, puti and chapila on the quality of the final dried products in solar tunnel drier by

organoleptic assessment (Table 1). The organoleptic characteristics such as colour, odour/smell, texture and presence of broken pieces judged by the panel members indicated that the raw material stored up to 4 days in ice produced excellent quality and as good as products from fresh fish. The products were tough and firm with good fishy odour and without any sign of infestation or broken pieces in any samples.

Table 1. Influence of ice storage period on the quality of the final dried mola, puti and chapila products in solar tunnel drier

Storage time	Name of species	Color	Texture	Broken piece	Infestation	Overall quality
0 day		Fresh	Tough and firm	Nil	No	Excellent
2 day	Mola Puti Chapila	Slightly brownish	Tough and firm	Nil	No	Excellent
4 day		Slightly brownish	Tough and firm	Nil	No	Good
6 day		Brownish	Fibrous	Present	No	Acceptable
8 day		Dark brownish	Soft and fibrous	Present	No	Poor quality

All the samples of SIS produced good quality of dried products up to 4 days of ice storage whereas acceptable quality of dried products was obtained even after 6 days of storage. On the other hand, products from 8 days in ice stored fishes were unacceptable due to their characteristics such as slight brown/brown, slight off odour and slight rancid or sometimes rancid and slightly soft or soft and fibrous texture.

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