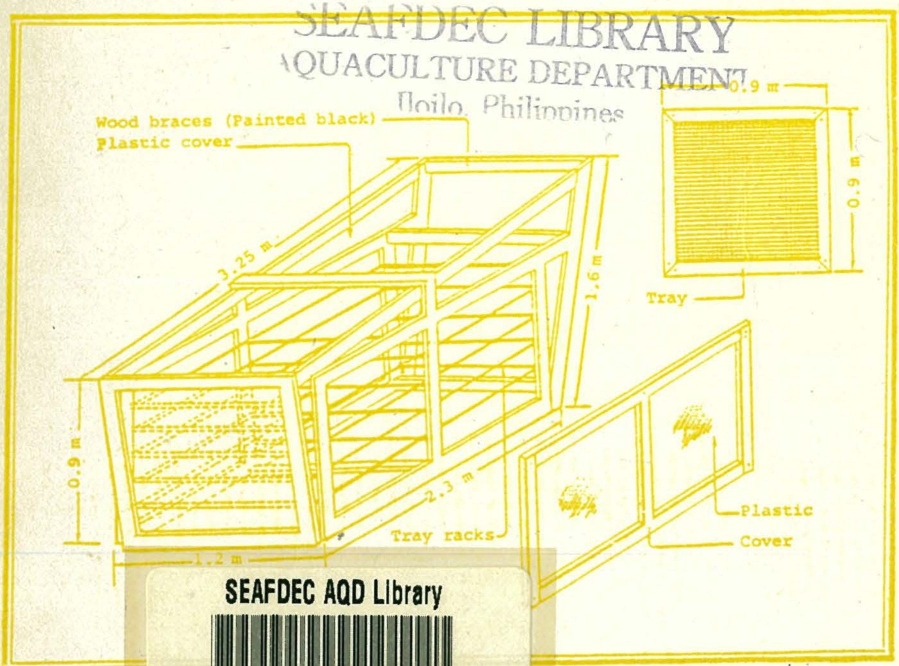
Southeast Asian Fisheries Development Center
in cooperation with the
ernational Development Research Centre

SAFIS Extension Manual Series No. 18, 1985

THE USE OF THE TRADITIONAL DRYING METHOD AND SOLAR DRIER FOR CROAKER, MULLET AND HERRING



by
Jasmin Espejo-Hermes
Marceliano B. Nieto
and
Rosita E. Lapitan

SEC/SM/ 18 SAFIS Manual No. 18

THE USE OF THE TRADITIONAL DRYING METHOD AND SOLAR DRIER FOR CROAKER, MULLET AND HERRING

by

Jasmin Espejo-Hermes
Marceliano B. Nieto
and
Rosita E. Lapitan
College of Fisheries and Institute of Fisheries
Development and Research
University of the Philippines in the Visayas

The Secretariat
Southeast Asian Fisheries Development Center
February 1985

THE USE OF THE TRADITIONAL DRYING METHOD AND SOLAR DRIER FOR CROAKER, MULLET AND HERRING *

by

Jasmin Espejo-Hermes
Marceliano B. Nieto
and
Rosita E. Lapitan
College of Fisheries and Institute of Fisheries Development and Research
University of the Philippines in the Visayas

INTRODUCTION

The current emphasis on the application of appropriate fish processing technology includes the use of solar driers. The sun's rays have been used since the early days for drying foodstuffs such as fish and fishery products. Sun drying or traditional drying consists in spreading out the fish on racks and exposing them to the sun for several hours. This drying method is, therefore, highly dependent upon environmental conditions. Moreover, the dried products are frequently of low quality owing to exposure to the elements, slow drying rate, high moisture content or maggot

* This study is part of the research on Appropriate Technology in Fish Processing, financially supported by the National Science Development Board (now NSTA) from 1978-1981.

infestation. To minimize these drawbacks and yet fully utilize the sun's potential, solar driers have been developed.

Drying, in other words dehydration, is one of the most practical methods for preserving fishery products, the main advantage being that the products do not require refrigeration during transportation and storage. Moreover, costs relating to transportation and storage are considerably reduced by the substantially lower weight of the dried products.

Sun-dried products are, in general, easy to market; but when this is not the case, the occurrence of mould gives rise to problems. Mould on the product impairs its quality such as flavour and texture, and its appearance such as colour. Hence the saleability of the product is affected. When dried products are susceptible to pathogens and moulds, it may be due to unhygienic drying practices, or to insufficient drying, in particular during the rainy season.

In line with the present trend, this study aims to compare the efficiency of a solar drier with that of the traditional drying method, and to determine the time and temperature requirements for drying tiger-toothed croaker, mullet and herring under both methods.

REVIEW OF PREVIOUS STUDIES

In the last decade, more efforts have been devoted to designing suitable low-cost solar and other driers to produce dried seafoods with better storage life and consumer appeal. Viratchakul (1975) determined the drying rate of herring in a drier at various temperatures and different air velocities. He noted that the drying rate was dependent on both the drying temperature and air velocity, i.e., the higher the temperature and air velocity, the more rapid is the rate of drying.

In 1978, a low-cost fish drier for small-scale operation was designed and tested by Carpio. The drier was a 100 kg capacity recirculating type with a heat utilization efficiency of around 70 per cent. The burner efficiency of the direct heating system was more than 84 per cent. Carpio claimed that, with a drying temperature of 71.1°C and 173 m/min air velocity, anchovy, herring and mackerel can be dried with 20 per cent moisture content within 9.1 hrs, 10.5 hrs, and 14.3 hrs respectively.

Guevarra *et al.* (1978) made a study comparing the efficiency of cabinet drying with that of sun drying. They noted that cabinet-dried milkfish are of better quality than the sun-dried products in respect to microbial load and physical appearance. Likewise, Santos *et al.* (1978) conducted an investigation using fish meal as the raw material. They noted that, as far as process efficiency is concerned, no difference between the drying methods was demonstrated except for the inherent limitations of sun drying. They claimed, however, that differences in the quality of the product were detected. The sun-dried lot was darker in colour than the cabinet-dried batch. Furthermore, the peroxide value of the sun-dried lot was always higher than that of the cabinet-dried samples at any given sampling period.

More recently, Kampitan (1981) made a comparative study of the efficiency of two types of polythene tent driers and a traditional drier using round scad as raw material. The study showed that the drying time of the sample is affected by the kind of drier used. The samples dried in one type of polythene tent drier were of better quality than those dried by the traditional method and inside the other type of drier.

Much of the earlier work on solar and other drying methods was done by foreign researchers. Legendre (1955 and 1961) worked on the mechanical drying of lightly salted cod and fish species found in Cambodia. He discussed the effects of temperature, relative humidity, air velocity, etc., on the drying rate, and he also described the design of a commercial drier used for fish in Cambodia.

In India, pioneering work on mechanical dehydration of some locally available fish was done by Prabhu in 1963, Swaminathan in 1964 and Balachandran in 1969. The latter established the optimum drying conditions for some Indian fish: a temperature of 45-50°C, a relative humidity of 55-65 per cent and air velocity of 100-120 m/min.

In 1978, Chakraborty developed a design for tunnel and solar driers for fish. He claimed that both drying processes were much superior to conventional sun drying in terms of the quality of the product. Tunnel drying, moreover, is more advantageous than solar drying since it is not dependent on weather conditions.

Another group of researchers led by Doe in 1977, made a study on the efficiency of two types of solar tent driers. They noted that the small drier (2 m x 2.6 m) was more efficient than the larger drier (1.9 m x 9.1 m). They also claimed that solar tent driers could reduce infestation and shorten drying time.

Similarly, Richards (1981) made a comparative test using box and tent driers for tilapia fillets. He noted that, in all trials, the tent drier proved to be superior to the box drier and to simple sun drying in terms of temperatures obtained and drying rate of the fillets.

The present study aims to determine the effects of traditional drying methods and solar driers specifically on the proximate composition, drying rate, rehydration capacity and storage stability of dried mullet, croaker and herring.

MATERIALS AND METHODS

Fresh, newly-caught tiger-toothed croaker *(Otolithes ruber)*, mullet *(Mugil caeruleomaculatus)* and herring *(Sardinella fimbriata)* were purchased and kept in ice prior to processing. A solar drier of the trapezoidal type (see Fig. 1) and a traditional drier were built at Castillo, Cabusao, Camarines Sur, Philippines.

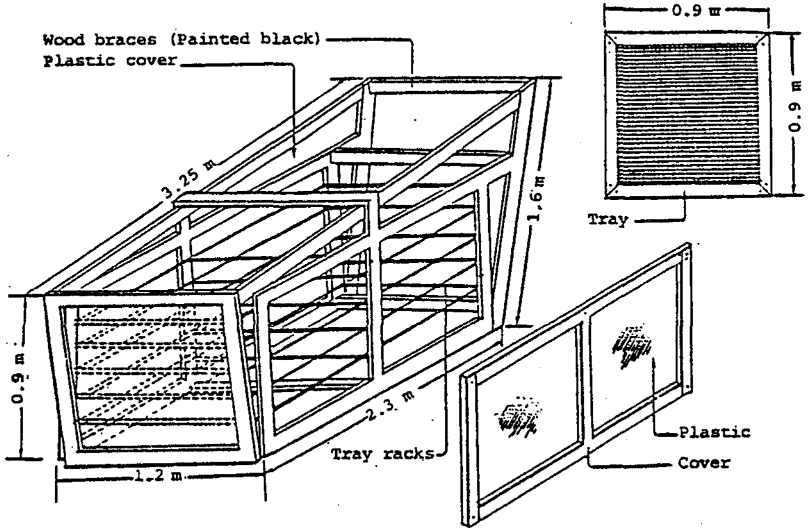


Fig. 1. Solar Dryer (Trapezoidal type)

__Brining time requirements of croaker, mullet and herring__

This was conducted to determine the most suitable soaking time for croaker (16.9-22.5 cm, SL*), mullet (14-14.2 cm, SL) and herring (13-14 cm, SL). Brine concentration of 1:3 salt to water ratio (approximately 64.2 ppt) was used for soaking split croaker and mullet, and whole herring. The split mullet was divided into three lots and each lot was soaked for 15, 25 and 35 minutes. For the split croaker, the three lots were soaked for 15, 25 and 35 minutes, respectively. For whole herring, the soaking time was 35, 45 and 60 minutes.

__Drying Procedures for Mullet, Croaker and Herring__

The flowsheets of drying procedures for the three species under study are given in Figs. 2 and 3 below.

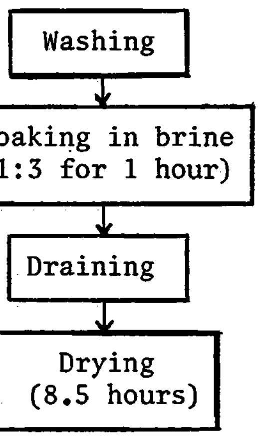


Fig. 3. Flowsheet for Herring

---

* SL = Standard Length

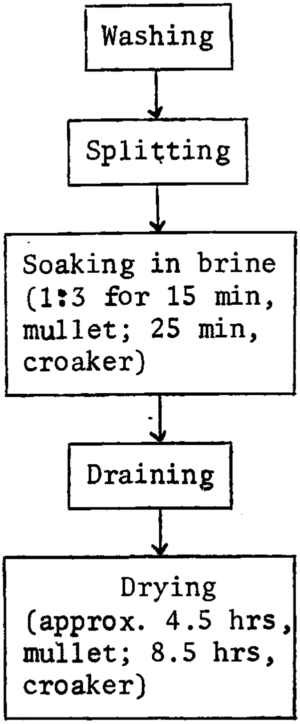


Fig. 2. Flowsheet for Mullet and Croaker

Each species was divided into two lots. One lot was dried inside the solar drier (30-57°C) and the other in the traditional manner (30-39°C). The drying rate was checked at regular time intervals and the moisture content (wet and dry basis) was computed for each time interval using the following formula:

$$\% \ Md = \frac{MoWo - Wo + Wd}{Wd} \times 100$$

where:

$\%\ Md$ = percent moisture content at a given time interval
Wd = weight of sample at a given time interval
Wo = weight of fresh sample
Mo = initial moisture content

$$Md\ (\text{dry basis}) = \frac{MdWd}{Wo - MoWo}$$

The temperatures in the driers were also recorded at regular time intervals.

Analyses of the finished products

(a) Rehydration and rehydration coefficient ratios

The rehydration and rehydration coefficient ratios of the dried products were determined by boiling in distilled water for 30 minutes. The ratios were determined as follows:

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated fish}}{\text{Weight of dried fish}}$$

$$\text{Rehydration coefficient ratio} = \frac{\text{Weight of rehydrated product}}{\text{Weight of fresh sample}}$$

(b) Proximate Analysis

The protein content of the samples was determined by the Kjeldahl method, the moisture content by oven method, ash content by incineration in a furnace, fat content by the Soxhlet extraction method and salt determination by the Volhard method (Kramlich, 1973).

(c) Sorption Isotherm Studies

The sorption isotherms of the samples were determined to ascertain the stability of the dried products when stored under various environmental conditions, using Wink's equilibrium method.

RESULTS AND DISCUSSION

Drying Process

The range in temperature was wider in the solar drier than in the traditional drier (Table I). The temperature in the solar drier ranged from 30-57°C, while in the traditional drier the temperature ranged from 30-39°C. Relatively higher temperatures were recorded in the solar drier than in the traditional drier at given time intervals.

The drying time requirement of each species varied. For croaker, both samples were dried for 8.5 hours (Fig. 4). The solar dried samples yielded a moisture content of 1.43 g water/g solid (dry basis). The same length of drying was required for herring (Fig. 5).

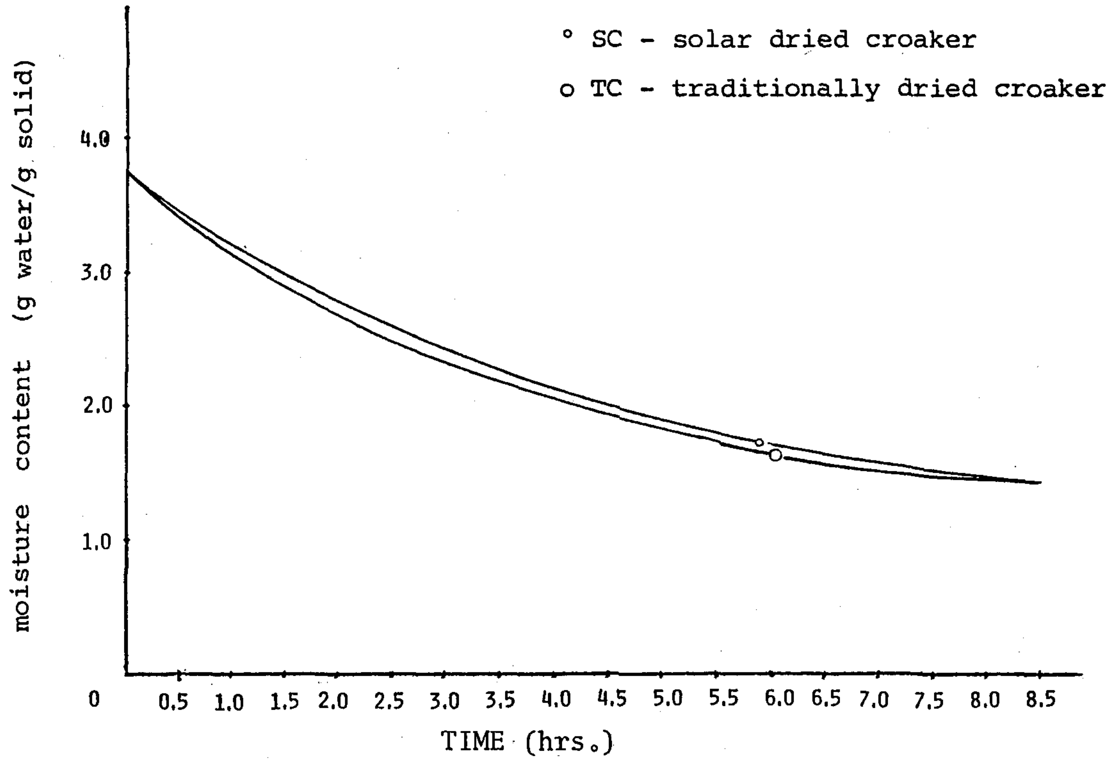


Fig. 4. Drying time curves of traditionally and solar dried croaker (*Otolithes ruber*)

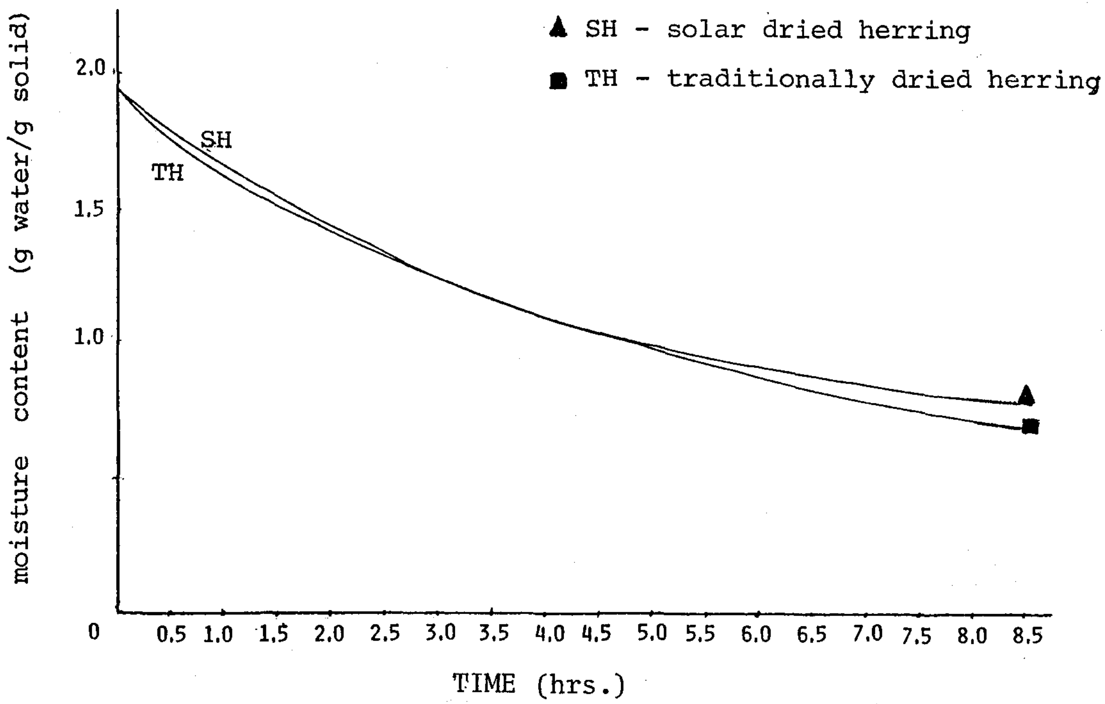


Fig. 5. Drying time curves of traditionally and solar dried herring *(Sardinella fimbriata)*

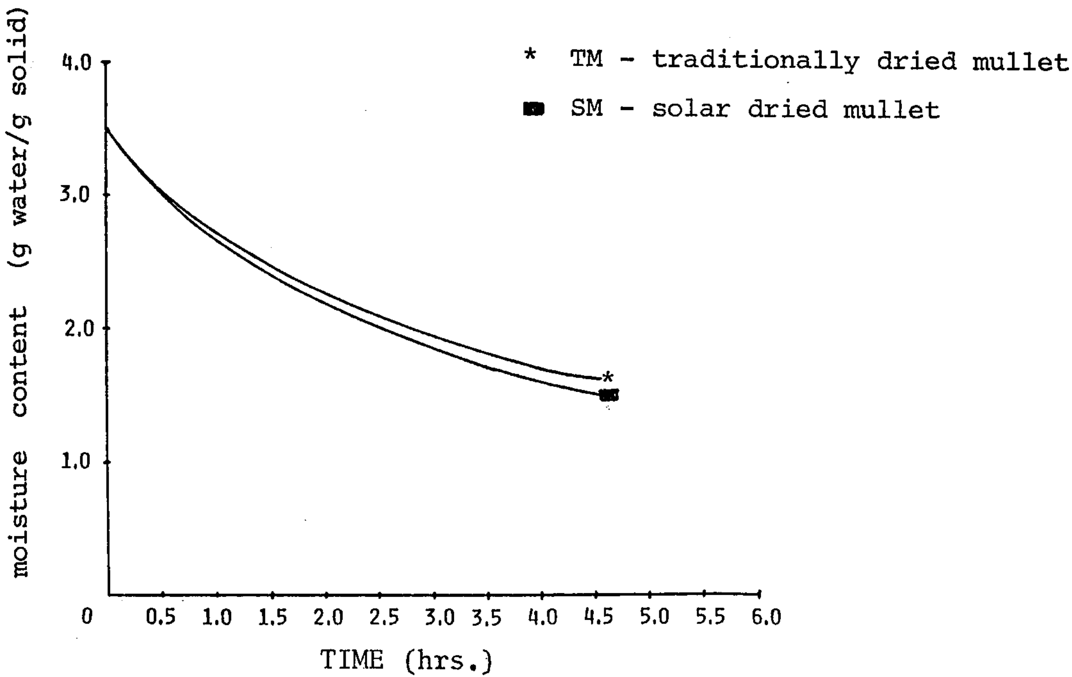


Fig. 6. Drying time curves of traditionally and solar dried mullet (*Mugil caeruleomaculatus*)

The solar dried product had a moisture content of 0.699 g water/g solid (dry basis), while the traditionally dried sample gave 0.78 g water/g solid (dry basis). In the case of mullet, the samples required 4.5 hours of drying (Fig. 6), yielding moisture contents of 1.43 g water/g solid (dry gasis) and 1.56 g water/g solid (dry basis) for the solar dried and traditionally dried samples respectively.

Table I. Temperatures in solar traditional driers

Time Taken	Temperature °C Solar Drier	 Traditional Drier
10:35 am	37	35
10:50 am	37	35
11:15 am	40	39
11:40 am	40	35
12:05 pm	39	35
12:45 pm	45	38
1:25 pm	43	35
2:45 pm	38	35
2:45 pm	38	35
3:25 pm	37	32
4:05 pm	30	30
9:45 pm	45	39
10:25 pm	48	36
11:00 pm	47	38
11:40 pm	55	38
12:15 am	57	39
1:25 am	54	35
2:49 am	48	33

The drying rate curves of each species were constructed from the drying time curves. The curves exhibited two distinct phases: the constant rate phase where the drying rate is constant, followed by the falling rate phase where the drying rate progressively falls off with time.

In the case of croaker (Fig. 7), the traditionally dried samples had a faster drying rate than the solar dried samples. It will be noted that during the constant rate period, a greater amount of water was removed in the traditionally dried fish, i.e., approximately 0.64 g water/hr/g solid, than in the solar dried samples, i.e. 0.56 g water/hr/g solid. This can be ascribed to the higher air velocity in the traditional drier which increased the amount of moisture removed. During the falling rate phase, however, the amount of water removed was lower in the traditionally dried samples. The possible explanation for this is that the higher drying temperatures in the solar drier speeded up the rate of moisture removal during the falling rate phase. The length of the drying phases were similar in both samples. The constant rate phase of both products ended after about one hour, which is relatively shorter in proportion to its falling rate period, which took around seven and a half hours.

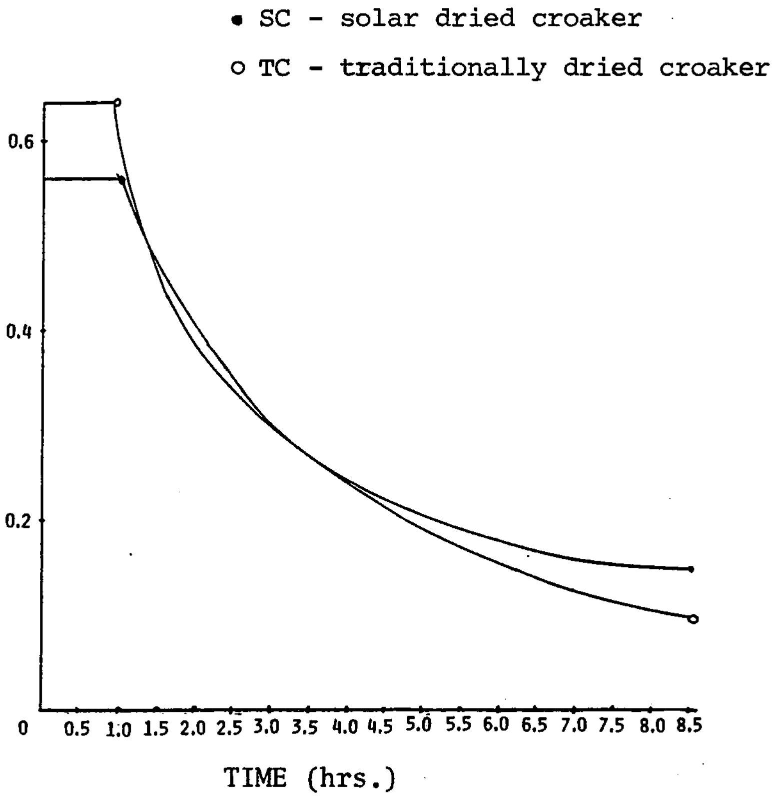


Fig. 7. Drying rate curves of traditionally and solar dried croaker *(Otolithes ruber)*.

Figure 8 shows a reverse trend for the mullet samples. The solar dried samples had a faster drying rate than those dried in the traditional manner. Approximately 1.02 g water/hr/g solid was removed initially from the former compared to 1.01 g water/hr/g solid removed from the latter. The constant rate phase was somewhat shorter in the traditionally dried samples. i.e., about 0.05 hour in contrast to 0.75 hour in solar dried mullet. On the other hand, the falling rate phase of both products was relatively longer than their constant rate phase.

In herring samples (Fig. 9) the rate at the initial stage of drying was faster in the traditionally dried samples with 0.75 g water/hr/g solid removed. Meanwhile, the solar-dried samples had an initial drying rate of 0.55 g water removed per hour per gram solid. The constant rate phase of the former was also shorter than that of the solar-dried samples. However, at the later stage of drying, the rate was faster in the solar-dried samples than in the traditionally dried samples.

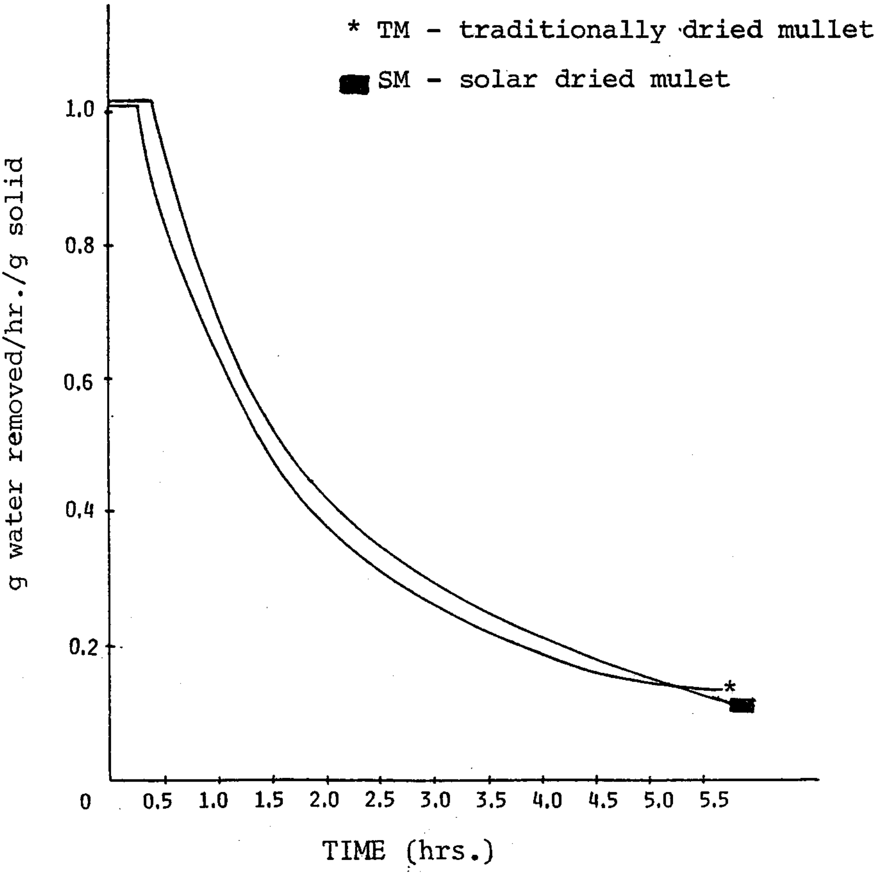


Fig. 8. Drying rate curves of traditionally and solar dried mullet *(Mugil caeruleomaculatus)*

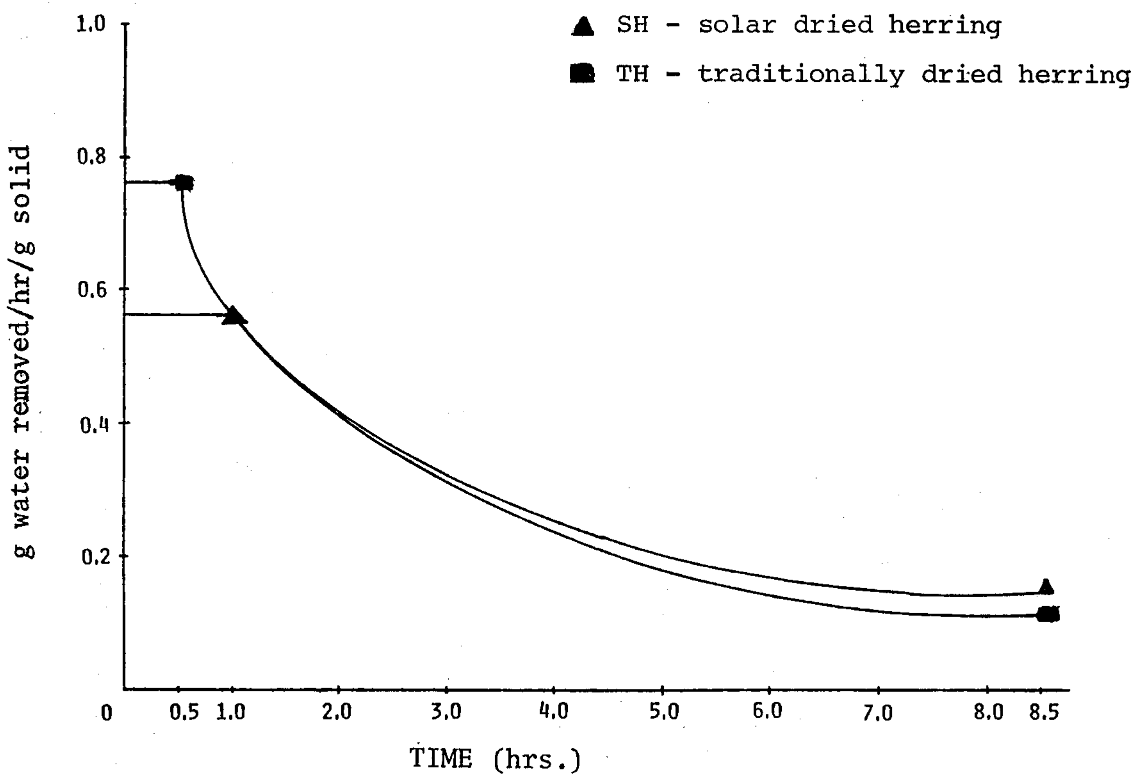


Fig. 9. Drying rate curves of traditionally and solar dried herring *(Sardinella fimbriata)*

Rehydration Capacity

Rehydration and rehydration coefficient ratios are given in Table II. The solar dried samples of croaker had a better reconstitution capacity than the traditionally dried samples as indicated by the higher rehydration and rehydration coefficient ratios. Similarly, the solar-dried mullet samples showed higher rehydration and rehydration coefficient ratios than the traditionally dried samples. The low rehydration ratio and rehydration coefficient ratio of the traditionally dried samples may be due to fat migration to the surface of the product which made it to some extent repellant to water upon rehydration. However, in the herring samples, the computed rehydration and rehydration coefficient ratios of the traditionally dried fish were higher than those of the solar-dried samples. This may be due to a decrease in the water holding capacity of the solar-dried samples brought about by protein denaturation. The denaturation of the protein might have been affected by heat treatment during drying.

Table II. Rehydration and rehydration coefficient ratios of traditionally and solar-dried croaker, mullet and herring

Species	Rehydration Ratio	Rehydration Coefficient Ratio
A. Croaker		
traditionally dried	1.008	0.332
solar-dried	1.146	0.365
B. Mullet		
traditionally dried	1.030	0.337
solar-dried	1.110	0.353
C. Herring		
traditionally dried	1.065	0.587
solar-dried	0.962	0.562

Proximate Composition

Table III shows the proximate composition of solar and traditionally dried croaker, mullet and herring. The solar-dried samples of croaker, had a higher protein content and a lower fat and moisture content than the traditionally dried samples. However, the solar-dried samples had a higher salt and ash content. The high fat content of the traditionally dried croaker, i.e., 6.14 per cent, might contribute to the faster onset of rancidity during storage.

Similarly, a higher protein value was obtained in solar-dried herring, i.e., 48.72 per cent, while lower values of fat, ash, moisture and salt were obtained in the same product.

On the other hand, the protein values of the traditionally dried mullet were higher than those of the solar-dried samples. It is also noteworthy that both products had the same amount of moisture, i.e., 30.2 per cent. There was also a slight difference between the solar and traditionally dried samples as regards fat and salt content.

Table III. Proximate composition of solar and traditionally dried croaker, mullet and herring

Species	Percentages				
	Protein	Moisture	Fat	Ash	Salt
A. Croaker					
traditionally dried	45.90	36.14	6.14	11.82	6.45
solar-dried	50.40	34.2	2.59	12.81	6.56
B. Mullet					
traditionally dried	55.36	30.20	4.18	10.26	7.40
solar-dried	54.84	30.20	4.45	10.51	7.42
C. Herring					
traditionally dried	47.80	38.20	3.82	10.18	6.95
solar-dried	48.72	37.70	3.75	9.83	6.85

Storage Stability

(a) Sorption Isotherm

The sorption isotherm is important in determining the storage stability of dried products. It is the plot of the amount of water absorbed as a function of the relative humidity (RH) or activity of the vapour pressure surrounding the material (Labuza, 1968). The relationship between RH and moisture of food substances exhibits several characteristics curves which are generally sigmoid (Caurie, 1971).

Figure 10 shows the moisture sorption of solar and traditionally dried croaker, mullet and herring. The curves, as can be observed, are not sigmoid. Furthermore, an increase in the relative humidity showed an increase in the moisture content of the samples. This can be ascribed to the increase in the amount of water absorbed by the samples as the saturation of the surrounding atmosphere with water molecules increased.

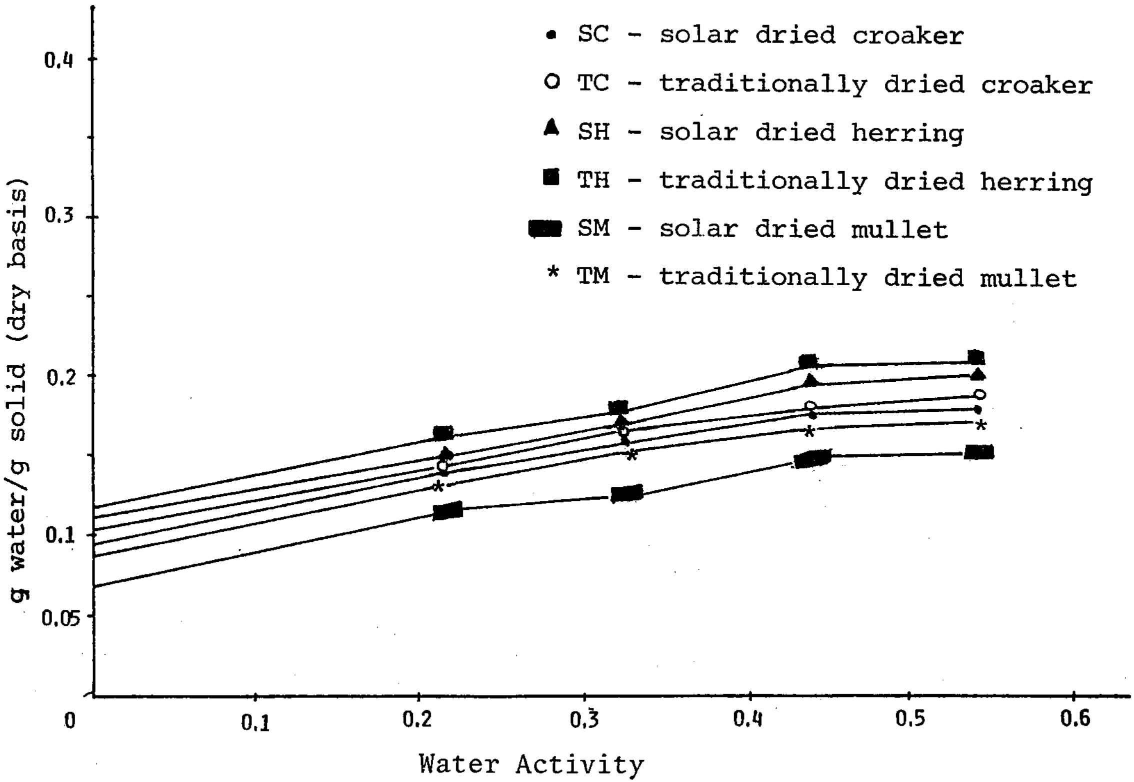


Fig. 10. Sorption isotherms of traditionally and solar dried croaker, mullet and herring.

(b) BET (Brunauer, Emmet and Teller, 1938)

The moisture sorption curves of the different samples were transformed into the corresponding BET curves as shown in Figures 11 and 12. The monolayer values were calculated and were used in defining the safe, minimum moisture content of the samples.

The calculated BET values varied in each dried product. In traditionally dried products the values obtained were as follows: croaker, 0.126 g water/g solid; mullet, 0.129 g water/g solid; and herring, 0.046 g water/g solid. On the other hand, the BET monolayer values for solar dried products were: 0.019 g water/g solid in croaker; 0.078 g water/g solid in mullet; and 0.104 g water/g solid in herring. These values represent the level at which the products are safe from any type of spoilage, whether oxidative, enzymatic or microbial in nature.

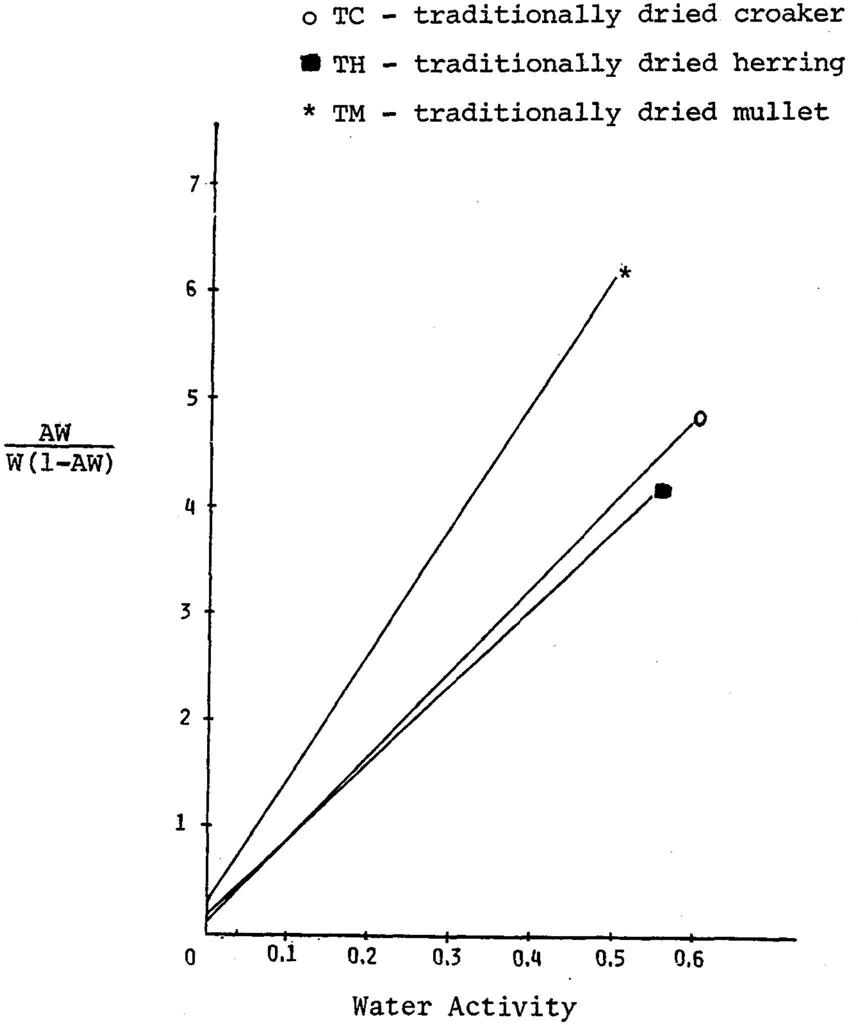


Fig. 11. BET plots of traditionally dried croaker, herring and mullet

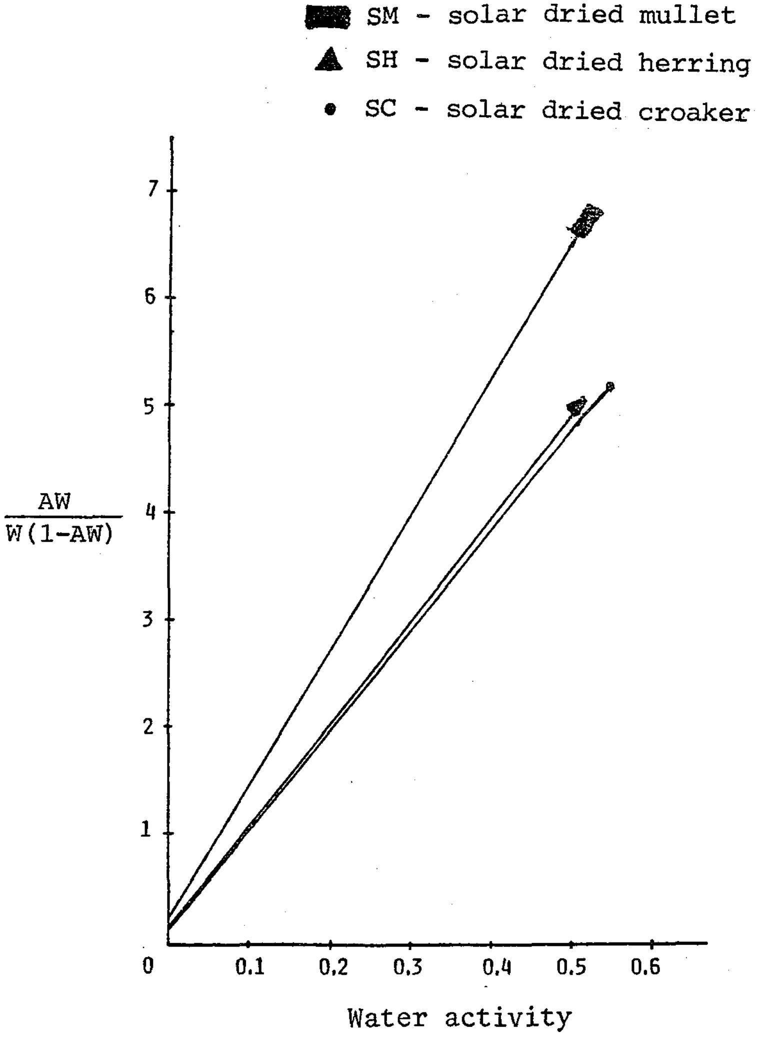


Fig. 12. BET plots of solar dried croaker herring and mullet.

(c) Henderson Isotherm plot

The Henderson plot is used to determine the limits of Region II of the sorption isotherm. The lower and upper limits in Region II of the Henderson plot of the different dried products are shown in Table IV. The moisture content of each specific product must be kept within the given limits in order to attain stability. As can be seen from the table, traditionally dried mullet and herring had a wider moisture range than the other products. The latter will, therefore, have a wider range of stability. It is said that the BET values mentioned earlier must coincide with the values in the lower limit of Region II of the Henderson plot. However, the computed BET values of all the samples were lower than the values of the lower limit of Region II of the Henderson plot.

Table IV. **Lower and upper limits in Region II of the Henderson Isotherm plot in solar and traditionally dried croaker, mullet and herring**

Species/Treatments	Lower Limits (g water/g solid)	AW*	Upper Limits (g water/g solid)	AW*
Solar-dried				
Croaker	0.135	0.2	0.152	0.3
Mullet	0.120	0.2	0.130	0.3
Herring	0.145	0.2	0.170	0.3
Traditionally dried				
Croaker	0.141	0.2	0.160	0.3
Mullet	0.129	0.25	0.149	0.4
Herring	0.152	0.2	0.210	0.4

* AW = Water activity

CONCLUSION AND RECOMMENDATION

The solar drier has advantages compared with the traditional drier in terms of drying rate of mullet and herring; rehydration capacity of croaker and mullet; and proximate composition, i.e., protein, fat and moisture content, of mullet and herring. However, the traditional method has advantages which the former lacks when it comes to storage stability of mullet and herring.

A further study on the use of the various types of drier is recommended. It should include a microbiological examination of the dried products and comprise total plate count (TPC), and a moulds and yeasts count.

LIST OF SAFIS EXTENSION MANUALS

SEC/SM/1	Khumua liang pla namcheut (Freshwater Fish Farming: How to Begin)-- in Thai
SEC/SM/2	Oyster Culture
SEC/SM/3	Mussel Culture
SEC/SM/4	Ang pagpuna ug pagtapak sa pukot (Net Mending and Patching)-- in Cebuano-Bisaya
SEC/SM/5	Mussel Farming
SEC/SM/6	Menternak Ikan Airtawar (Freshwater Fish Farming: How to Begin)-- in Bahasa Malaysia
SEC/SM/7	Makanan dan Pemakanan Udang Harimau, *Penaeus monodon* (Nutrition and Feeding of Sugpo, *Penaeus monodon)* -- in Bahasa Malaysia
SEC/SM/8	Macrobrachium Culture
SEC/SM/9	Selection of Marine Shrimp for Culture
SEC/SM/10	Induced Breeding of Thai Silver Carp
SEC/SM/11	Culture of Sea Bass
SEC/SM/12	Smoke-curing of Fish
SEC/SM/13	Cockle Culture

SEC/SM/14	Net Mending and Patching
SEC/SM/15	Kanliang hoy malangphu (Mussel Farming)-- in Thai
SEC/SM/16	Nursery Management of Prawns
SEC/SM/17	Culture of Sultan Fish (*Leptobarbus hoevenii*)
SEC/S/18	The Use of the Traditional Drying Method and Solar Drier for Croaker, Mullet and Herring

SAFIS

O What is SAFIS?

SAFIS is the Southeast Asian Fisheries Information Service. It is a project of the SEAFDEC Secretariat set up to provide extension materials for small-scale fishermen and fish farmers in the region.

O What are its objectives?

The immediate objectives are to collect and compile fisheries extension manuals, brochures, pamphlets and related aids for small-scale fisheries development, and to translate selected literature into local languages for distribution to fisheries extension workers in Southeast Asia.

- o <u>What services will SAFIS provide?</u>

  SAFIS will attempt to provide information and publications such as:

  - lists of available texts in fisheries extension services,
  - translation of suitable manuals,
  - manuals of appropriate technologies,
  - photocopies of appropriate fisheries extension literature,
  - a current awareness service of regional fisheries.

- o <u>How much will these services cost?</u>

  A nominal cost of US $0.15 per page will be charged for photocopying, handling, and surface mail. Airmail costs will be extra. The publication cost per manual will vary according to the book.

SAFIS is grateful for financial
support received from the
International Development
Research Centre (IDRC) of Canada.

SAFIS is the Southeast Asian Fisheries Information Service. It is a project of the SEAFDEC Secretariat set up to provide extension materials for small - scale fishermen and fish farmers in the region. For additional information, contact the Project Leader of SAFIS

SEAFDEC Liaison Office
956 Rama IV Road
Olympia Building, 4th floor
Bangkok 10500, Thailand