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Solar Drying in Africa

Proceedings of a Workshop held in Dakar, Senegal, 21-24 July 1986

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ABSTRACT / RÉSUMÉ / RESUMEN

Abstract -- This book presents the proceedings of a workshop on solar drying in Africa attended by 24 participants involved with solar drying research relevant to the continent. Of the papers, 17 describe research activities on socioeconomic aspects, design and testing of solar dryers, and future research needs. In addition, a summary of the discussions held during the workshop to assess the state of the art of solar drying research in Africa are outlined, focusing on progress made and on possible research and collaborative activities that are needed to overcome the technical and socioeconomic problems that limit the development and introduction of improved solar dryers.

Résumé -- Voici le compte rendu d'un colloque sur le séchage solaire en Afrique auquel participaient 24 personnes effectuant des travaux de recherche propres à ce continent. Au nombre des communications, 17 décrivent les activités de recherche sur les aspects socio-économiques, la conception et l'essai des séchoirs solaires, ainsi que les besoins futurs de recherche. En outre,le lecteur trouvera un résumé des discussions sur l'état de la recherche sur le séchage solaire en Afrique, notamment les progrès réalisés et les activités de recherche coopératives nécessaires pour surmonter les problèmes techniques et socio-économiques qui entravent la mise au point et la diffusion de séchoirs solaires améliorés.

Resumen -- Este libro contiene los trabajos presentados en un seminario sobre secamiento solar en Africa, al cual asistieron 24 participantes del área de investigación en secamiento solar referida a este continente. Diez y siete de los trabajos versan sobre actividades de investigación en aspectos socioeconómicos, diseño y prueba de secadores solares y necesidades futuras de investigación. Se describe además la discusión sostenida durante el seminario para sopesar el estado de la investigación en secamiento solar en Africa, discusión que se centró en los progresos realizados y en las posibilidades de investigación y acciones colaborativas necesarias para superar los problemas técnicos y socioeconómicos que obstaculizan el desarrollo y la introducción de secadores solares mejorados.

CONTENTS

OUTLOOK FOR SOLAR DRYING OF FISH IN THE GAMBIA

A.E. N'Jai[1]

Abstract *-- Three types of solar dryer -- tent, house, and dome shaped -- were tested for drying fermented fish in The Gambia. Although the dryers did not reduce drying time significantly, quality of the product in terms of reduced contamination by dirt and infestation by blowflies was improved. Other areas in the preparation of dried fish by the artisanal sectors that should be investigated are suggested.*

Introduction

To reduce postharvest losses in fish and fishery products, traditional processing technology is being improved in The Gambia. This includes improvements in fish smoking and drying and, for the latter, solar drying has been adopted using locally available, low-cost materials to build the solar dryers.

In 1983, the Fisheries Department of The Gambia (unpublished data) estimated the possible quantity of fish to be dried from artisanal landings in connection with a solar-drying project. Total artisanal landings were recorded as 8456 t, of which 1952 t were demersal fish. Of the 1952 t, all the cassava fish (Otolithus brachygnathus), sharks, and rays were presumably sun dried because these species are only used in this way. Of the balance of the demersal catch (1656 t), mainly groupers, croakers, grunts, and threadfins, it was estimated that at least 45-50% was sun dried. Landings of catfishes were recorded as 765.5 t and, because only small quantities of this species are smoked for local consumption, it is reasonable to estimate that about 70% was sun dried. Sea-snails are sun dried almost all year round but data on the amount are difficult to obtain.

Because substantial quantities of the total artisanal landings are sun dried, a technique that has several limitations and problems that lead to losses, the use of solar dryers was considered as an important step toward reducing losses during fish drying, especially during the rainy season. Although systematic quantification of losses has never been attempted, estimates from numerous observations suggest that losses are quite high and insect infestation prevalent. The problems of infestation are even more hazardous during the wet months. Thus, assuming that no matter how little the difference might be from traditional sun-drying, the use of solar dryers could play a vital role in fish-processing technology in the country (N'Jai 1985a).

[1] Fisheries Department, Banjul, The Gambia.

In 1983, with the assistance of the African Energy Programme of the Commonwealth Science Council (CSC), a solar drying project was launched by the Fisheries Department on a pilot scale. At the project's inception, a "solar-tent" design (Fig. 1) was adopted. This had been originally tested by Doe et al. (1977) but later modified and tested again by Trim and Curran (1983). Because both these studies generally postulated favourable results and because fish drying is a widely practiced traditional activity in The Gambia, the present project was initiated.

However, later in 1984, with the assistance of the Food and Agriculture Organization of the United Nations (FAO), a commercially manufactured dryer capable of holding 1 t of fish was tested. This dryer is dome shaped (Fig. 2) with frames made of metal hoops and has hooks for hanging fish while they dry (Fig. 3). Most recently, the design of the solar tent has been modified into a house shape (Fig. 4) and the dryer tested against the tent shape to determine any differences in efficiency and loading capacity.

This report summarizes the experiments conducted using the three designs and considers the effects of socioeconomic factors in technology transfer of this kind in developing countries such as The Gambia.

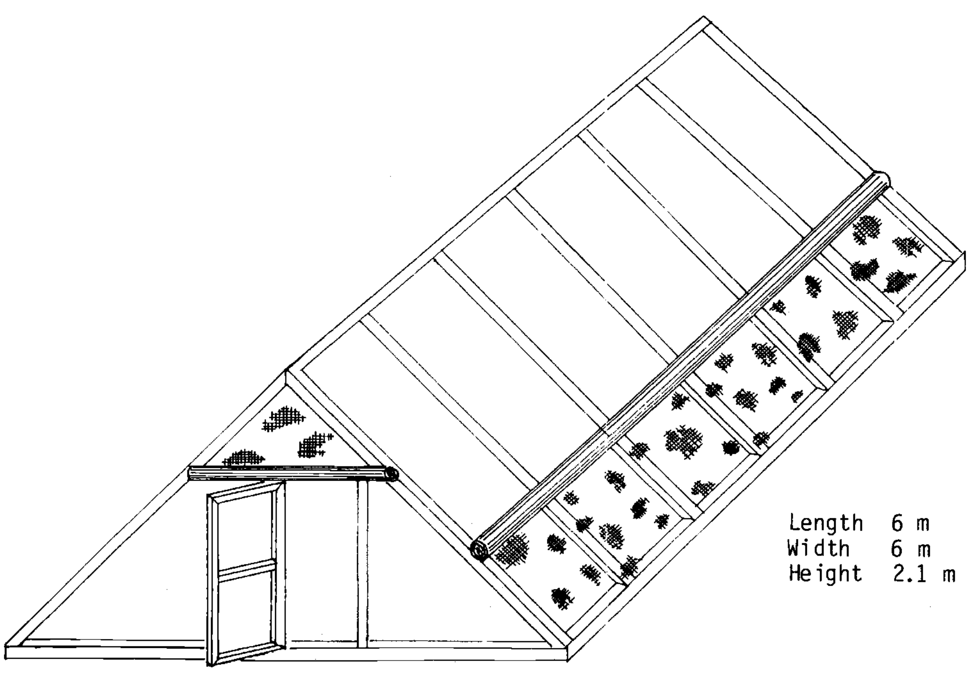

Fig. 1. Solar tent dryer.

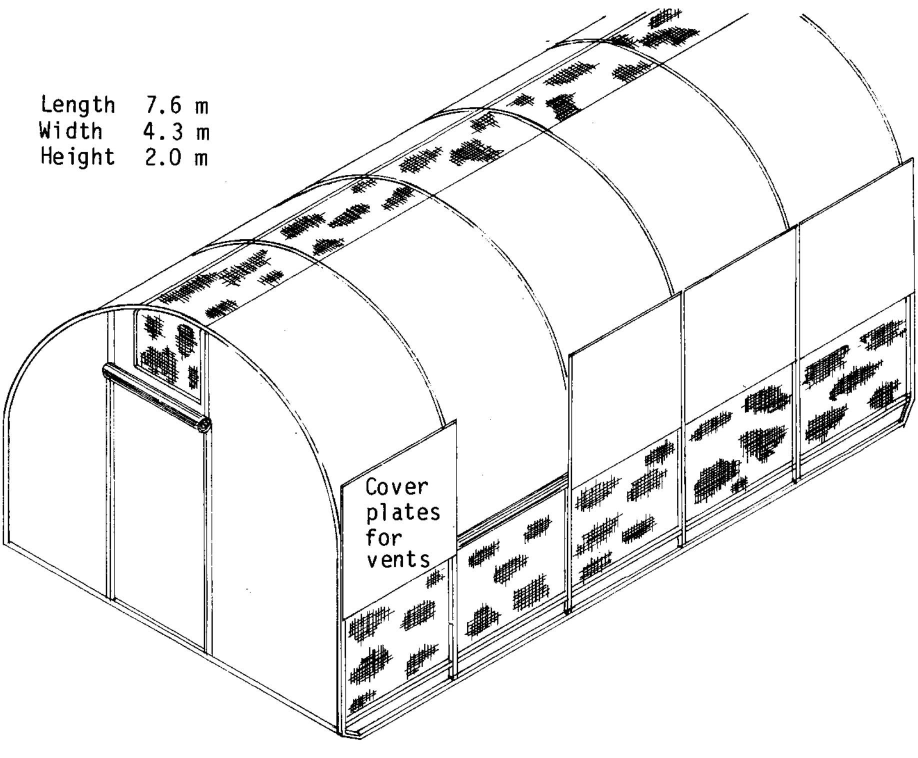

Fig. 2. Solar dome dryer.

Materials and Methods

Because of constraints related to artisanal landings and purchase of the catches, it was difficult to have the same species in all the batches. However, the following species were used: bonga (shads), croakers, threadfin, mackerel, and catfish.

Unfermented fish is unacceptable to the consumer in The Gambia, thus all trials of dried fish products were conducted with fermented fish. This was prepared by placing the fish samples in plastic buckets or concrete tanks covered with polyethylene and leaving them overnight. After fermentation, all fish samples were weighed (about 340 kg) and divided into two equal batches, one for solar drying and one for sun drying. Samples were then gutted, washed, and salted. Because the fish loses its rigidity after fermentation, they were at times difficult to handle during gutting and washing, and the fish flesh often disintegrated.

Batches were subsequently placed in the dryer under test or on wooden racks in the open. Temperature and humidity of the dryers and ambient were recorded before drying started and at intervals during drying. At the end of the drying period, the samples were reweighed and final moisture content determined using an Ohans 5100 HE Balance Moisture Meter.

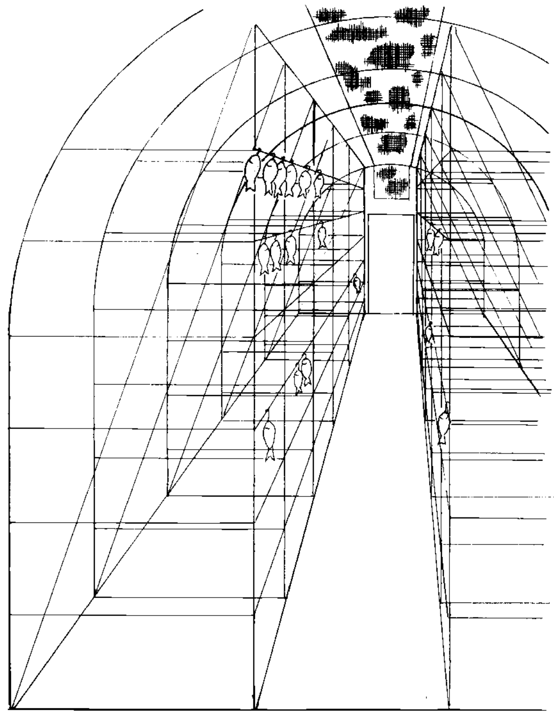

Fig. 3. Drying beams with hooks inside solar dome.

Because drying had to continue for several days, the air vents of dryers were shut and the fish on sun-drying wooden racks were covered with clear polyethylene each day before sunset.

Dryers

All the dryers operated by natural convection and were situated near the beach at artisanal fish-landing sites.

Solar Tent Dryer

As its name denotes, the tent dryer has a tent-shaped structure with frames made of rhun palm sticks, which are low-cost and available locally. Inside the dryer are two rectangular racks (Fig. 5) stretching along the sides of the dryer. On top of the racks, finely woven bamboo sticks (kirinting) are fitted firmly to carry the fish during drying.

The whole dryer is covered with clear polyethylene except at the base and the top of the end walls where air vents are provided. The vents at the base run the length of the dryer and, like those on the top, are fitted with fine-mesh plastic netting to prevent flies from entering the dryer. There is a door at one end of the dryer.

Inside the dryer beneath the racks are black metal plates that

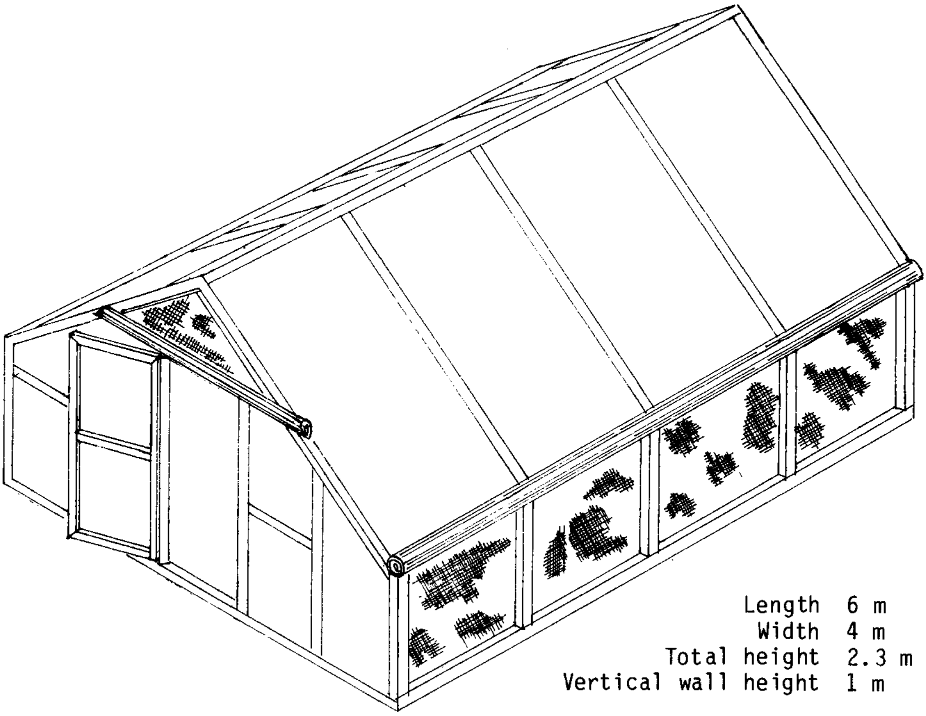

Fig. 4. Solar house dryer.

act as collectors of solar radiation. Dimensions of the dryer and racks are given in Figs 1 and 5. The side vents are 0.5 m high and 6.0 m long. The top vents are triangular in shape. The front one has an area of 0.7 m^2 and the back vent is somewhat smaller (the difference in the sizes was a construction problem and not a deliberate plan).

House-Shaped Solar Dryer

Like the tent dryer, the house-shaped dryer also has frames made of rhun palm sticks and is fitted with two drying racks beneath which are black metal plates. The structure is somewhat an adaptation of the tent-shaped design, but it is mounted on poles and beams 1 m off the ground to give it the shape of a house. Dimensions of the dryer and the drying racks are given in Figs 4 and 5. The side vents are 1 m wide and 6.0 m long and the top vents have an area of 0.5 m^2 each (front and back).

The dryer is clad with clear polyethylene (UV-resistant) and the vents are covered with plastic mesh to prevent entry of flies.

The loading capacity of both this dryer and the tent dryer is estimated at 400-500 kg, although during the trials enough fish was not available to load at full capacity.

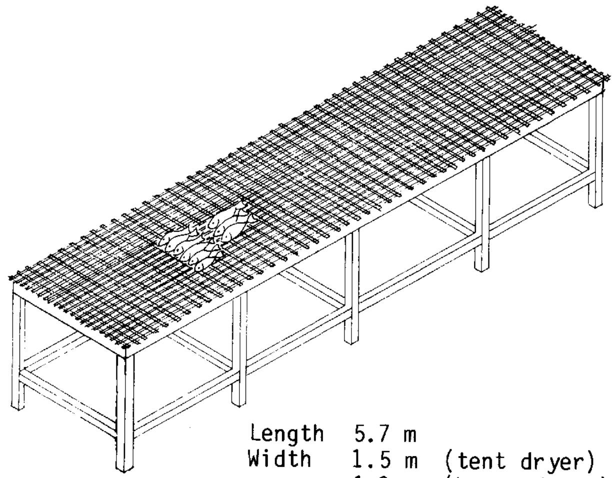

Fig. 5. Drying rack inside solar tents.

Solar Dome Dryer

The solar dome dryer was manufactured in the U.K. by Clovis Lande and provided to the Department of Fisheries as an FAO grant-in-aid. It is basically for large-scale commercial use with a capacity of 1 t. Its dimensions are given in Fig. 2. Six metal hoops shaped as arches form the frame, which is covered with clear UV-resistant polyethylene. Inside the dome are vertical and horizontal beams: the latter allow for the fish to be hung on hooks while drying.

There are two doors, back and front, covered with a plastic material. There are vents along the bottom of the side walls and along the top at the centre of the arch. As in the other dryers, the vents are covered with plastic netting. The vents can be closed with metal plates that slot easily into special openings. This dryer does not use metal plate collectors; instead, the dryer is fixed to a black-painted concrete base.

Results

Differences in temperature and humidity between the tent and house dryer designs under loaded conditions were slight but both raised the temperature and lowered the relative humidity over the ambient values in January (Table 1) and May (Table 2). It is assumed that the differences in temperature and humidity between the dryers and the ambient would have been greater if the dryers had been located inland and not near the beach. In areas around the beaches, these parameters could be affected by weather conditions not necessarily the same as those inland. It is generally windy in these places and relative humidity is high.

Table 1. Comparison of temperature and humidity conditions under load in the solar tent and house dryers compared with ambient conditions for two trials, January 1986.

Date	Time of day (hour)	Tent dryer		House dryer		Ambient	
		Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
1st trial							
10.1.86	1345	33	17	38	21	31	29
	1545	38	30	37	22	34	22
11.1.86	1350	31	29	35	20	32	22
12.1.86	1100	27	24	25	27	23	24
	1400	34	24	37	9[a]	30	20
	1615	32	19	30	20	29	19
13.1.86	0950	23	29	21	26	19	36
	1330	32	23	29	27	26	28
	1445	31	24	29	18	26	23
14.1.86	0930	23	29	21	32	21	32
	1300	31	18	30	28	28	26
2nd trial							
17.1.86	1430	40	20	35	14	30	24
18.1.86	1330	30	24	29	26	26	28
19.1.86	0930	29	26	28	26	22	22
	1230	31	12	39	9[a]	26	-
	1600	35	12	32	14	31	12
20.1.86	1400	31	18	28	22	23	34
	1600	34	18	31	18	26	28
21.1.86	0915	20	31	19	22	19	28
	1230	30	24	28	22	26	32

[a] Questionable values.

Table 2. Comparison of temperatures and relative humidities in the solar dome dryer and under ambient conditions in two trials, May 1985.

Date	Time of day (hour)	Solar dome		Ambient	
		Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
1st trial					
17.5.85	1017	30.5	56	21.5	86
	1150	27.5	67	22.5	86
18.5.85	1219	24.0	70	23.0	77
19.5.85	1030	27.0	70	23.0	83
	1430	33.0	51	27.0	63
20.5.85	1121	31.0	54	24.0	76
2nd trial					
22.5.85	0910	29.5	62	25.0	76
	1450	27.5	72	25.0	76
23.5.85	1030	28.0	71	24.0	84
	1400	29.0	72	25.0	82
24.5.85	-	-	-	-	-
25.5.85	1145	29.5	51.5	26.5	68
	1410	31.5	66	27.5	74.5

Table 3. Final moisture content (%) of samples under three drying methods.

Species	Solar tent	Solar house	Traditional sun-drying racks
Bonga	62	61	65
Ladyfish	55	48	-[a]
Cassava fish	41	-	-
Threadfins	-	40	-
Mackerel	40	-	-

[a] Because of logistical constraints, moisture content of all the samples could not be determined after the drying period.

Overall efficiency of the dryers, in terms of reduced drying time, was not much greater than sun drying (Tables 3-5) but the difference, coupled with the importance of the dryers during the rains, was observed to be very essential in improving existing traditional technology.

Table 4. Weight of samples before and after drying in the solar tent and house compared with open-air drying (representative results from only one trial).

	Solar tent	Solar house	Sun-drying racks
Weight of samples (kg)			
At start	168.7	168.6	168.0
After 4 days of drying	93.8	94.6	118.9
% weight reduction	44.4	43.9	29.3

Table 5. Moisture content (%) of fish species after drying in two trials, May 1985.

Species	Solar dried	Sun dried
1st trial		
Ladyfish (Croaker)	39	39
Mackerel	38	42
Catfish	39	29
Threadfins (Cheken)	40	38
Ribbonfish (Pike congers)	40	52
2nd trial		
Cassava fish (Croaker)	36	15[a]
Mackerel	45	44
Catfish	40	40

[a] Small sliced pieces.

Discussion

The use of solar dryers for drying fish and other crops has wide applications in improving traditional food technology: especially in reducing postharvest losses, improving product quality and, in some cases, reducing drying time. The results presented here represent a series of trials and focus on the utility aspect of solar dryers to prevent losses and improve quality rather than on the physics of dryer operations and drying processes.

Although temperature and humidity were measured periodically during the experiments, the intent was not necessarily to compute "pick-up" efficiency, solar radiation, and other mechanical parameters, but to determine if there are vast differences in utilization between the dryers and ambient conditions and between the various dryer types.

Solar Dome

Trials during the study of the solar dome indicated a not too significant difference between solar and sun drying in terms of final moisture content (Table 5), weight reduction, and drying rates (N'Jai 1985). In fact, in previous experiments (Curran 1984) "very similar drying rates were obtained for sun and solar drying of several different products and blowfly infestation could be a problem." During the rainy season, however, many factors contribute to the abundance of blowflies; these cause hazards for fish drying and make infestation difficult to prevent. Walker and Wood (1985) have noted that "little is known about the actual mechanisms of blowfly infestation and the problem is widespread during sun drying under adverse conditions and is one of the greatest causes of losses in cured fish in Africa."

Temperatures that were recorded inside the dome, although of varying degrees at different times of the day and from one day to another, were not high enough to be lethal to flies entering the dryer. Doe (1979) reported that temperatures of over 60°C are lethal to blowflies but such temperatures may also have adverse effects on the nutritional quality of the fish (FAO 1981).

At times, the weather was rather hazy with plenty of wind and occasional cloud cover. This prevented high solar insolation and, hence, caused the low temperatures inside the dryer. Also, the covers for the vents and doors were not properly fitted making it difficult to regulate airflow inside the dryer. The dryer may be overventilated and this could partly explain its poor performance. No obvious disparity in drying time was found between solar and sun drying and the sun-dried products were ready at the same time as the solar-dried products. However, quality of solar-dried products was better in appearance and they contained fewer maggots than the sun-dried products.

Another reason for the poor performance of the dryer was its collector. This was the black-painted concrete slab and concrete has a comparatively low absorptivity value compared with metal plates. Thus, the rate at which the concrete floor can absorb solar radiation is so low that the temperature rise inside the dryer was slow. This being so, it was then assumed that the air flowing into the dryer and coming in contact with the floor (collector) would have a correspondingly low pick-up efficiency (N'Jai 1985b). The use of more suitable solar collectors, such as black-painted metal plates or black polyvinyl chloride (PVC), has demonstrated elsewhere more encouraging results in reducing drying time and lowering final moisture content of products (Doe et al. 1977; Doe 1979).

Thus, if the excess ventilation were reduced and the solar-collector surface improved, the solar dome could be an excellent dryer for large-scale commercial fish drying in the artisanal sector. Its loading capacity of 1 t is quite reasonable and, like the other dryers, it is very useful during the rains. One important disadvantage of the dome dryer is that it uses hooks to support the fish. This mainly limits drying to small pelagics or "cuts" of large pieces of fish flesh. Large, whole individual fish cannot be dried because they fall off the hooks easily.

Solar Tent and Solar House

As stated earlier, marked differences in temperature and humidity between the dryers and ambient conditions were not observed. During the course of trials, however, there was not enough sun and it was windy most of the time. This was the cool season (January) with generally low ambient temperatures and considerable cloud cover.

Nonetheless, on the basis of percent weight reduction during the drying periods, the solar-dried products of both dryers had better storage potentials (higher weight loss) and, hence, they would encounter a lesser degree of losses to beetles than products dried in the open.

The solar house is an adaptation of the tent design and was only constructed in an attempt to scale-up the structure for increased loading capacity. Although enough fish was not available to fill up both dryers simultaneously, practical observations during the trials have shown the capacity of the house dryer was not increased significantly; however, working in the house shape is more convenient.

General Discussion

Solar dryers are essential in the improvement of traditional fish drying technology. Blowfly infestation, which normally occurs during the initial stages of drying when the fish is wet, is considerably reduced with the use of solar dryers. Thus, where the purpose is to reduce postharvest losses, especially by preventing growth and proliferation of maggots in fish, the introduction of solar dryers need not necessarily be confined to tests of efficiency in increasing drying rates. Solar dryers can produce well-dried, dust-free products and can be used effectively during the rains when flies are abundant and traditional sun drying difficult. Even though it is virtually impossible under normal weather conditions to completely eliminate contact between fish and flies, this phenomenon could be considerably alleviated if solar dryers are used.

The technoeconomic aspect of solar drying of fish, although it has not been assessed adequately, has been favourable because the dryers are cheap and can be constructed easily. The cost of building the solar tents is about GMD 500 (1 U.S. dollar [USD] = 0.1302 Gambian dalasi [GMD]) and it takes only 2 days, including transport to the sites, to construct a dryer. The solar dome is a manufactured dryer and very expensive, but the other dryers are affordable by local fishing communities either on an individual or collective basis. The only problem that must be solved is the supply of the special type of polyethylene, which is not sold locally. A further problem is that, given the prevailing consumer behaviour, the solar-dried products could not find better market prices than the traditional sun-dried products because appearance is of secondary importance to need among the consumers in the country.

The use of solar dryers has so far stimulated a genuine interest and involvement of nationals, and some entrepreneurs have expressed their desire to adopt the facility for large-scale fish drying. It was for this among other reasons that the tent design was scaled-up in an attempt to increase the loading capacity. The use of large-scale dryers can play a meaningful role in improving fish-drying and loss-reduction technology in The Gambia. During the rainy season when sun drying is difficult and there appears to be seasonal peak in abundance of certain species, the use of solar dryers will be found indispensable.

However, it has been noted that the introduction of any new technology to the traditional sector in developing countries is usually met with problems and constraints that are fundamentally socioeconomic. For instance, traditional fish processors engaged in drying are commonly obsessed with the weight of their products and, thus, prefer dried fish with some moisture, enough to give a greater weight, and therefore more money, when marketed on a wholesale basis.

Furthermore, solar dryers should not be introduced in isolation from other parameters that effectively contribute to losses and also need improving. Because fermenting is a stage in the traditional process that should not be omitted if the products are for local consumption, this aspect needs investigating for improvement. Better salting methods and storage and packaging are all areas that should be studied with a view to improving them so as to complement the improvement made in the drying technology (N'Jai 1985a).

Taking into account the general view of local processors who rely on sun drying, investing in this new technology might seem folly because, even with a well-dried and cleaner product, the price remains the same or almost the same as that prepared traditionally. Therefore, local processors must be shown how solar drying can reduce losses and thus increase the weight of the final product produced from a given input (N'Jai 1985a).

Undoubtedly, such actions would require intensive and effective operations of extension services, especially at the initial phase of introduction when both skepticism and enthusiasm are expressed by the target communities. In this direction also, close interactions between extension and research and development staff of the implementing institution would be imperative to identify and select appropriate strategies and approaches to use when introducing the technology.

Conclusion

In spite of all the technical problems and inadequacies associated with solar drying in terms of increasing drying rates and improving product quality, the use of low-cost, locally made dryers cannot be disputed as having important advantages in reducing postharvest loss in the traditional sector.

Solar dryers produce well-dried products with reasonably long storage life. When used, the degree of losses due to insect infestation and maggots becomes insignificant.

Solar dryers for fish, however, should not be introduced in isolation. Other parameters, which are integral aspects of the drying process and effectively contribute to losses, should be investigated and improved. For instance, better fermenting techniques, improved salting, better packaging and storage methods, and proper sanitary conditions are areas to be looked into and developed.

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References

Curran, C.A. 1984. Report on a visit to The Gambia to investigate the reduction of losses in traditionally dried fisheries products. Tropical Development and Research Institute, London, U.K. Report R1222 (L), 55 pp.

Doe, P.E. 1979. The polythene tent fish drier: a progress report. Paper presented at the International Conference of Agricultural Engineering in National Development, held at the Universiti Pertanian Malaysia, Serdang, Selangor, September 1979. Paper 79-12.

Doe, P.E., et al. 1977. A polythene tent drier for improved sun-drying of fish. Food Technology in Australia, 29(11), 437-441.

FAO (Food and Agriculture Organization of the United Nations). 1981. The prevention of losses in cured fish. FAO, Rome, Italy. Fisheries Technical Paper 219.

N'Jai, A.E. 1985a. Fermenting and drying fish in The Gambia (considerations and possible impact of commercial solar drying in the artisanal fisheries sector). FAO, Rome, Italy. Fisheries Report 329, Supplement FIIU R329.

———— 1985b. Trials of a solar dome for fish drying. Fisheries Department, Banjul, The Gambia. Publication 39.

Trim, D.S., Curran, C.A. 1983. A comparative study of solar and sun drying of fish in Ecuador. Tropical Development and Research Institute, London, U.K. Report L 60, 44 pp.

Walker, D.I., Wood, C.D. 1985. Non-insecticidal methods of reducing losses caused by infestation of blowflies (Diptera) during fish curing procedures. FAO, Rome, Italy. Fisheries Report 329, Supplement FIIU R329.