RAB 81/002/INT/15

DEVELOPMENT OF FISHERIES IN AREAS OF THE RED SEA AND GULF OF ADEN

DRYING SHARKS USING A SOLAR DOME DRYER

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DRYING SHARKS USING A SOLAR DOME DRYER

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Project for the Development of Fisheries in Areas of the Red Sea and Gulf of Aden

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A b s t r a c t

Improved methods of preparation, dressing, salting and drying of sharks are presented in this paper. Demonstration trials of the improved methodology were conducted in Aden; a solar dome dryer was used for drying. Results of the trials are analysed and discussed; a set of recommendations are included.

Contents

1. INTRODUCTION

Sharks are usually caught by smallscale fishermen in the Red Sea and Gulf of Aden region. Almost all the sharks are intended for utilization in the Gulf of Aden area; this is an under-utilized species in the Red Sea area.

This report presents the methods, observations , results and their analysis in respect of drying sharks in the solar dome dryer, which is basically a horticultural green house adapted to suit the requirements of fish drying, it also discusses the relevance of this work to the utilization of sharks in the Red Sea and Gulf of Aden region.

Counterpart Fish Technologist, Dr. Zakaria Ez El Din from Egypt and Counterpart Fish Drying Technologist, Mr. A.K.A. Mansoor from PDR Yemen participated in the drying trials during March 1983 at the Caltex Fish Drying Yard, Aden.

2. GENERAL :

Low consumer preference for sharks in most countries bordering the Red Sea, has resulted in many artisanal fishermen operating in these waters discarding their catches of sharks at sea. However, fishermen in Yemen Arab Republic (YAR) and People's Democratic Republic of Yemen (PDRY) land all their catches of sharks for consumption by Yemenis and for export to Asian markets.

The Project for the Development of Fisheries in Areas of the Red Sea and Gulf of Aden (RAB/81/002) has embarked on activities aimed at :

a) increasing the catch of sharks by smallscale fishermen,

b) promoting consumption of sharks,

c) utilization of the various portions of sharks,

d) facilitating the marketing of sharks and shark products and,

e) preparing techno-economic feasibility studies of shark utilization in the region.

Artisanal fishermen in PDRY land about 3000 to 3500 tons of sharks annually. The landings are mostly in the eastern region of the country. PDRY exported 81 tons of shark fins valued at US $ 835,752 in 1980, 153 tons valued at US $ 724,758 in 1981 and 105 tons valued US $ 1.178,773 in 1982, to markets in Asia. (Source-Ministry of Fish Wealth, PDRY).

Most of the varieties of sharks occurring in the Indian Ocean are landed by PDRY fishermen. (Appendix 1). The length of the sharks landed ranges from 0.5m to 3.5m and the weights vary from 1 kg to 150 kg.

2.1 Dressing sharks

Sharks belonging to the species, Carcharhinus sorrah were used in these experimental trials. measuring 1.92m in length and 63 kg in weight and the other measuring 1.75m in length and 57 kg in weight were dressed. Two methods of dressing were applied. The first was according to the traditional method of dressing in the region as demonstrated by the Yemeni counterpart, and the second was according to an improved method demonstrated by the Egyptian counterpart.

2.2 Traditional method

The shark was cleaned with water; the pair of pectoral fins, the dorsal fin and the caudal fin were cut off. Parts of flesh were funds attached to the fins. The head was cut off at the gill region. The body was washed with water.

The split body musculature was cut transversely into seven pieces, of unequal length. The musculature of each piece was scarified longitudinally at several points. The skin and the dorsal cartilage chord remained with the musculature; head, intestine, liver and other parts of the viscera were discarded.

The body musculature thus prepared forming 68.5% of initial weight was ready for further processing. Percentage weights of the various portions of sharks after dressing are given in Table I.

2.3 Improved method

The shark was washed in clean water, the pair of pectoral fins, the dorsal fin and the caudal fin were removed from the carcass by a concave (half moon) cut, eliminating flesh but preserving as much fin as possible. (Fig.1). With a sharp-edged knife the skin was neatly shaved off the musculature, beginning from the tail end of the mid-ventral line. The skin was stretched tight during skinning, and care was taken to remove the skin without much flesh. The head was removed in the region of the gills. The body was split open along the median longitudinal line on the ventral side. The intestines, liver and other parts of the body were removed. The body musculature was washed with water.

From the ventral side, a central split of the musculature was made longitudinally so as to expose the dorsal cartilaginous chord. The musculature was further separated into two long longitudinal fillets, taking away the dorsal cartilaginous chord without removing too much flesh. The dorsal cartilaginous chord was cleaned and any muscle pieces attached to it were removed.

Ligaments of the long fillets were trimmed off. Rectangular fillets 150mm long, 100mm broad, and 15-20 mm thick were carefully prepared, taking care to leave out minimum amount of flesh. Thirty such pieces of fillet were prepared. The remaining flesh portions were cut into longitudinal pieces 250 mm long and 15-20 mm thick.

Trimmed off ligaments and small pieces of flesh left over were discarded. Head, intestine, liver, and other parts of the viscera were also discarded.

At the end of the dressing, the fillet pieces, the dorsal cartilaginous chord , the fins and the skin remained for further processing. Percentage weights of the various portions of sharks after dressing are given in Table I.

Of the initial weight of the shark, 30.4% was recovered as fillets. Proper filletting would enable the recovery of up to 45% of the initial weight as fillets.

3. SALTING

Salting is an important step in preparing sharks for drying. Shark meat dressed by the traditional method was subject to traditional salting. Fillets prepared by the improved method were brine salted. The skin and fins were salted as well.

3.1 Pickle salting - traditional

Powdered salt was sprinkled over the surface and stuffed between the scarified muscles of the seven pieces of shark meat dressed in the traditional manner. Thereafter, the pieces were arranged with skin down inside an aluminium basin in two layers. When the basin was full it was covered by a lid. After 20 hours the lid was removed and the shark meat was found soaked in brine formed by water diffusing out of the meat. The pieces were taken out, washed

in fresh water and made ready for drying. 43 kg of meat required 9.5 kg of salt. Weight after salting was 30.75kg., 7.6% of the initial weight of meat was lost during salting. The muscular portion had a moisture content of 76% before salting and 62% after the salting process was completed.

3.2 Salting the fillets

A solution of brine was prepared for salting the fillets prepared by the improved method. Locally produced vinegar was added to the brine solution.

Shark fillets were kept immersed inside the brine-vinegar solution for 20 hours. 4.3 kg of salt was dissolved in 21.6 litres of water to make a 20% brine solution. 2 litres of vinegar (percentage of acetic acid not known) was added to this brine. 17.3 kg of shark fillets were immersed in this brine-vinegar mix for 20 hours. At the end of this period the fillets were removed and, after hand-pressing the brine from the meat, weighted 18.1 kg. The fillets had a moisture content of 76% before the treatment, and a moisture content of 68% after 20 hours in the brine-vinegar mix solution.

These fillets were divided into two batches. The first batch of 9.40 kg was kept ready for drying. The second batch of 8.70 kg was further salted (by sprinkling powdered salt over the surface area of each piece and then arranging them inside a pan in close layers for pickle salting). At the end of 24 hours, the fillets were washed, pressed by hand to remove the brine; fillets weighed 8.30 kg. The first batch was ready for drying after 20 hours of brining while the second batch was ready for drying after 44 hours of salting.

3.3 Salting the skin

The skin of the shark was spread on the floor with the outer surface on the bottom and the fleshy part exposed. The skin was kept stretched with weights and salt sprinkled over the flesh. The skin with the flesh weighed 5.7 kg, (however it would have been much less had the flesh been removed well); 11.6 kg of salt was used for salting. The skin was kept in such state of curing for 6 days.

3.4 Salting the fins

The fins, cut from both sharks, were smeared with salt on the cut-off surface (4.83 kg of fins were recovered from the two sharks and 10 g of salt was used). The fins were ready for drying.

4. SOLAR DOME DRYER

Traditionally, the fish after preparation, is spread on the sand for drying. Occasionally, mats are used for this purpose. Raised platforms are used in the fish drying yard of the Ministry. The end product resulting from this method is of poor quality having a limited storage life. During drying a good percentage (say 40 to 50%) of the fish is lost to insects, birds, cats and other animals.

The use of a polythene tent drier for fish drying proved successful in the experimental trials (Doe et al 1976). The larger version of this tent dryer was considered necessary for drying on a commercial scale by the artisanal fishermen . (Fig. 2). A greenhouse used for horticultural purposes was modified to suit the requirements of fish drying by providing (a) a concrete base with a black-painted metal sheet overlaying it, (b) two lateral vents along the longitudinal sides, (c) a top vent, (d) wooden racks for supporting fish hangers, and (e) hangers for fish. This was made possible by importing

materials for the green house and the modifications from Clovis and Lande Associates, Hildenbrough, Kent, England, U.K.

A concrete base (7.6m x 4.3m) with sloping sides was prepared. Galvanised sheets of 22 guage thickness were overlaid. The top layer was painted black. The frame was erected. UVI stabilized polythene cladding covered the frame except in the regions of the two lateral vents and the top vent. A door (1.8m x 1.2m) was made on one side. The breadth of the two lateral vents was 280mm and that of the top vent was 360mm. The vents were covered with nicofene mesh. The lateral vents were provided with roll-over flaps to control the entry of air into the dome (Fig.3). The dome was divided into 10 bays (1.5m x 1.7m each) with a centre corridor 915mm wide. Bays, 1, 2, 5, 6, 9 and 10 were set aside for drying fish. Bays 3, 4, 7 and 8 were set aside as heat collectors. (Fig. 4). Racks were erected in wood to hold drying trays. Each bay had two wooden racks. Each rack and horizontal support bars at 230mm intervals. These bars were reduced in length as the height increased to fit the curvature of the dome.

5. DRYING

5.1 Shark meat with skin

Seven pieces of meat weighing 39.75 kg at the end of 20 hours of pickle salting were spread on trays in Bay No.1 of the solar dome. (Fig. 4).Weights were recorded every 24 hours for the first ten days and then on the 13th day and the 17th day (Table II).

5.2 Fillets after brining 20 hrs.

Pieces of fillets weighing 9.4 kg at the end of 20 hours of dip in the brine and vinegar mix were spread on a tray in Bay No. 2. Weights were recorded at 0800 hours

each day for 10 days and on the 13th day at the time (1200 hours) of packaging. (Table III).

5.3 Fillets after salting (44 hours)

Pieces of fillets weighing 8.3 kg at the end of 44 hours of salting were spread on a tray in Bay No.9. Weighings were made at 0800 hours each day for 9 days and on the 12th day at the time (1200 hours) of packaging. (Table III).

5.4 Shark fins

4.83 kg of shark fins were dried inside the solar dome in Bay No. 10. Weights were recorded at 0800 hours each day for 10 days and on the 14th day at noon. (Table IV).

5.5 Temperature and relative humidity of the atmosphere, as well as inside the solar dome were continuously recorded using thermohydrographs. The instrument was hung near the top vent at the centre of the dome. (Tables VI and VII). The flaps controlling the entry of air into the dome through the lateral vents were kept open during the first four days and all except one flap (2.5m long x 280 mm wide) were closed for the rest of the period of drying. The top vent (7.6m long x 360mm wide) was fully open during the period of drying. The skin of the shark was removed to take off the remaining flesh after 6 days

6. PACKAGING

The 7 pieces of shark meat with skin, after drying, were packed in polythene bags inside the cartons, each carton holding 5 to 6 kg. The fins and the skin were not packed.

7. DISCUSSION

7.1 The products from the traditional method of dressing are easily marketable. Consumers are familiar with dried shark meat with skin and cartilage. Removing the skin and the cartilage results in a reduction of weight. If the fillets are thinner, more moisture evaporates and the weight reduces. The flesh attached to the fins increases the weight of the fins. It was claimed that the weight reductions due to separating the skin and cartilage and the half moon cut removing flesh from the fins, would not be matched by increased prices in the market.

The improved method provides for (a) a well dried product, (b) less ammoniacal odour because of treatment with the brine and vinegar mix, (c) four different products, viz, fillets, fins, hide and dorsal cartilage. The improved method is more acceptable for future shark utilization projects, provided that these projects take into account consumer attitudes and habits.

7.2 The advantages of solar dome drying techniques compared with sun drying are (a) the drying rate is increased, (b) windborne dust is excluded, (c) sand particles in the product are excluded, (d) insect pests are eliminated because of the higher temperatures inside the dome, (e) higher temperatures and faster drying rates reduce microbiological activity, (f) loss due to birds, cats and other animals is excluded, and (g) lower moisture content not attainable during sun drying is attainable with solar dome drying.

7.3 Solar dome drying works on a principle of heating the air inside the dome and the air that comes in through the lateral vents. The hot air is let out through the top vents. The hot air heats the fish, evaporating the moisture from the surface and taking it away through the top vent.

During the initial period of fish drying the current of air flow required to remove the moisture vapour from the fish should be adequate. Inadequate flow of air may result in condensation of the vapour on the inner sides of the polythene.

During the final stages of drying an adequate amount of heat is required to remove as much of the moisture as possible. The solar dome dryer facilitates an adequate flow of air during the initial stages of drying as the flaps can be fully rolled up to allow maximum inlet of air. Much depends on the windspeed outside, as faster wind could push in more air. The temperature inside the dome will fall owing to this large influx of air; however, it is the airflow which is important rather than the temperature during the initial stages of drying. More airflow could be effected by having a door with a nicofene mesh during the first two days, this door being replaced with a door with polythene for the rest of the pericd.

Gradually the flaps are rolled down to restrict air flow and increase the temperature inside the dome. Temperatures above 40°C were maintained for at least 8 hours on normal sunny days. The solar dome temperature maxima ranged between 47°C, and 50°c, while the atmospheric temperature maxima were between 36°C. (Table VI). Of the total 408 hours of drying of shark meat with skin, 121 hours (29.6 %) were above 40°C; of the 316 hours of drying of brined fillets, 87 hours (27.5%) were above 40°C; of 292 hours of drying pickle salted fillets, 82 hours (28 %) were above 40°C.

7.4 With the increase in temperature, inside the solar dome dryer, relative humidity decreases. This low level of saturated water vapour in the air, (less than 50% RH for a continuous period of 6 to 8 hours Table VII) facilitates faster transfer of water vapour from the fish to the air.

Atmospheric relative humidity minima ranged between 65% and 75%. During the night the RH rose to higher saturation points inside the solar dome, and this resulted in slower drying rates. Reabsorption of moisture was evident during the final stages of drying when the shark meat and fillets were hard dry by the evening time, (Fig. 6), whereas they appeared moist wet during the early hours of the morning. Of the 400 hours of drying shark meat with skin, 100 hours (24 %) were below 50% RH; of the 316 hours of drying brined fillets 67 hours (21 %) were below 50% RH; of the 292 hours of drying pickle salted fillets, 62 hours (21 %) were below 50% RH.

7.5 Shark meat with skin took 96 hours, shark fins took 66 hours and the fillets took 45-48 hours to lose 45 % by weight. Shark meat skin took 408 hours, shark fins took 234 hours and the fillets took 144 hours to lose 55% by weight. The thickness of the material is an important factor inducing faster drying rates (Fig.5).

7.6 The maximum temperature recorded during the first 3 days, when the level of moisture content was high in the flesh, was 50°C. There was neither evidence of cooking-effect during this initial period nor evidence of case hardening during the final periods when the temperature maximum was 53°C. The products at the end of the drying process were hard dry and appeared as any other sun dried shark meat or fin.

7.7 The only insect that infested the portions of shark during the first four days was the beetle Dermestes frischii. The beetles crept and hid inside crevices or congregated at the mesh where cooler air was available and then migrated and sat on the fillets, meat and fins during the night. Many beetles and their larvae were seen dead on the floor and at the sides of the dome. When the surface of the muscles had dried well, these beetles were not seen on them anymore even though some of them were still seen around the dome. It was difficult to ascerlain whether these insects caused any damage to the fish.

7.8 It is usual for seagulls and crows as well as cats and dogs to prey on sun drying fish. According to rough estimates losses of dried fish due to birds, cats etc are about 40 - 50%. The solar dome dryer provided an enclosure to prevent such losses.

8. RECOMMENDATIONS

8.1 The initial quality of sharks ear-marked for drying should be good. The present practice of using sharks of poor quality should be discontinued.

8.2 Introduction of a proper dressing method for separating skin, hide, cartilage and teeth is essential for maximum utilization.

8.3 Shark fins should be cut in a concave (half moon) fashion to obtain as much fin as possible and the minimum amount of flesh.

8.4 Shark meat should be prepared into fillets of 15 to 20 mm thickness, to facilitate effective salt penetration and moisture removal.

8.5 Treating shark fillets in a vinegar and brine mix for 24 hours facilitates removal of ammoniacal odour, and makes the product consumer-attractive.

8.6 Solar dome dryers are more effective than sun drying methods. The use of solar dome dryers should be encouraged. To achieve faster drying rates, rapid air flow during initial stages and higher air temperatures during final stages of drying inside the solar dome dryer, is recommended.

8.7 A well dried product should always be removed from the solar dome during the afternoon for packaging, to eliminate insects adhering to the product during storage.

8.8 Dried fillets should be packaged in polythene and sealed. These polythene packs should be packed in cartons. Sharks fins should be packed in cartons.

8.9 Cartilage, teeth and skin of sharks should be prepared according to market requirements.

Acknowledgement

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Table I. Percentages of the various portions of sharks during dressing for drying

	Traditional Method	Improved Method
Number of sharks	1	1
Initial Weight	63 kg	57 kg
Total length	1920 mm	1750 mm
	Percentage of wet weight	
Body Portion :		
Head	15.4	16.5
Viscera (with intestine)	5.2	6.8
Liver	4.8	7.7
Skin (with a very thin layer of flesh)	-	10.0
Dorsal Chord	-	3.5
Fins	3.9	4.2
Blood etc.	2.45	2.8
Meat with skin and bones	68.25	-
Meat	-	48.5
Total	100	100
Fillets from meat	-	30.4

Table II Shark prepared by the traditional method and dried in the solar dome dryer. Weight losses and % Moisture content

Initial weight of meat with skin	43 kg
Initial moisture content	76 %
Weight after pickle salting for 20 hours	39.75 kg
Moisture content after 20 hours of pickle salting	62 %
Weight at the time of packaging after 17 days of drying in solar dome dryer	18.05 kg
Moisture content at the time of packaging	26 %

Weight loss as percentage of initial weight and moisture content level during drying in solar dome dryer

Hours	weight - loss as % of initial weight	% Moisture content
0	100	62
24	89.9	-
48	82.3	57
72	71.6	53
96	67.7	54
120	64.0	47
144	61.4	46
168	58.9	38
192	56.8	-
216	55.1	38.6
240	53.1	34
316	47.6	-
408	45.4	26

Table III Shark prepared by the improved method and dried in the solar dome dryer. Weight losses and % Moisture content

	Brining (20 Hours))	Pickle salting(24 hours) after brining (2 hours)
Initial weight of meat	9.03 kg	8.27 kg
Moisture content	76 %	76 %
Weight after brining (20 hours)	9.40 kg	8.70 kg
Moisture content after brining	68 %	68 %
Weight after brining 20 hours and pickle salting 24 hours	-	8.30 kg
Weight at the time of packaging	3.1 kg	2.9 kg
Percentage Moisture content at the time of packaging	17 %	18 %

Percentage of initial weight and moisture content level during drying in solar dome dryer

Hours	Weight loss as (brined salted) % of initial weight	% Moisture content brine salted	Weight loss as (pickle salted) % of initial weight	% moisture content pickle salted after brining
0	100	68	100	68
24	77.7	-	76.4	52
48	66.5	50	62.7	48
72	56.0	44.5	56.4	46.2
96	52.1	39.1	51.4	36
120	48.3	38.5	48.8	32
144	46.7	36	45.7	28.5
168	43.8	28	44.0	-
192	42.5	-	42.4	25.0
216	41.1	-	40.6	-
240	39.2	22.5	-	-
292	-	-	35.1	18.0
316	33.1	17.0	-	-

Table IV Weight losses in shark fins dried inside the solar dome dryer.

Initial weight of shark fins	4.83 kg
Final weight after 14 days of drying	1.90 kg

Hours	weight loss as % of initial weight
0	100
42	71.4
66	63.6
90	58.6
114	55.6
138	52.9
162	51.6
186	49.7
210	48.7
234	47.5
334	39.3

Table V Yield of Final Product

	Traditional method	Improved method
Shark meat (dried) with skin and bones	29.3%	-
Shark fillets (dried)	-	10.6 %
Shark fins	1.5%	1.6 %
Shark skin	-	4 %

The yield from the traditional method appears high. However, this product, with skin and bones and a moisture content, of 26 %, is inferior to the product obtained through the improved method, without skin and bones and with a moisture content of 17 - 18 %.

Table VI Temperatures inside and outside the solar dome dryer (^{o}C)

DAY	Outside		Inside		Solar dome dryer
	Min	Max	Min	Max	No. of hours above $40^{o}C$
1	26	37	27	43	4
2	26	36	27	50	8.5
3	27.5	37	29	48	8.5
4	27.5	37	29	-	-
5	27.5	36	29	45	9
6	27.5	38	29	46.5	8
7	28	37	29.5	46.5	9
8	28	36	30	47.5	8.5
9	29	36	30	48.5	8
10	29.5	37	30.5	50.5	10
11	29.5	36	30.5	-	-
12	28	37	-	49.5	6
13	26	39	27	47.5	9
14	26	36	28	47.5	9
15	26	37	27.5	50	9
16	26	37	17	51	8.5
17	26	37	28.5	53	8

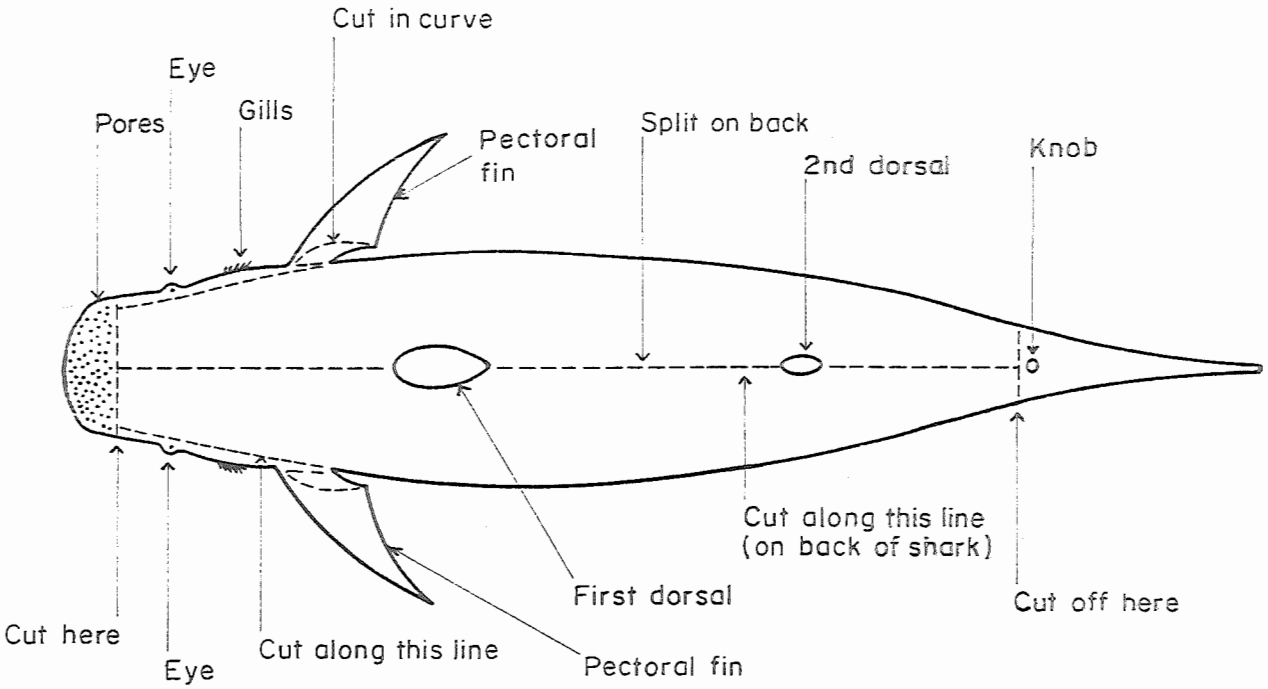
Table VII Relative humidity inside and outside the solar dome dryer (%)

DAY	Outside		Inside		Solar dome dryer
	Min.	Max.	Min.	Max.	No. of hours below 50%
1	60	95	43	95	5
2	75	95	34	95	8
3	60	90	38	92	8
4	62	91	-	-	-
5	55	90	42	-	-
6	55	88	42	95	7
7	60	88	42	95	6
8	70	90	38	95	7
9	72	91	37	95	8.5
10	65	88	34	92	9
11	70	88	-	92	-
12	70	85	36	-	-
13	65	85	39	92	9
14	70	88	40	90	7
15	65	88	35	90	8
16	70	85	35	90	9
17	70	85	32	88	9

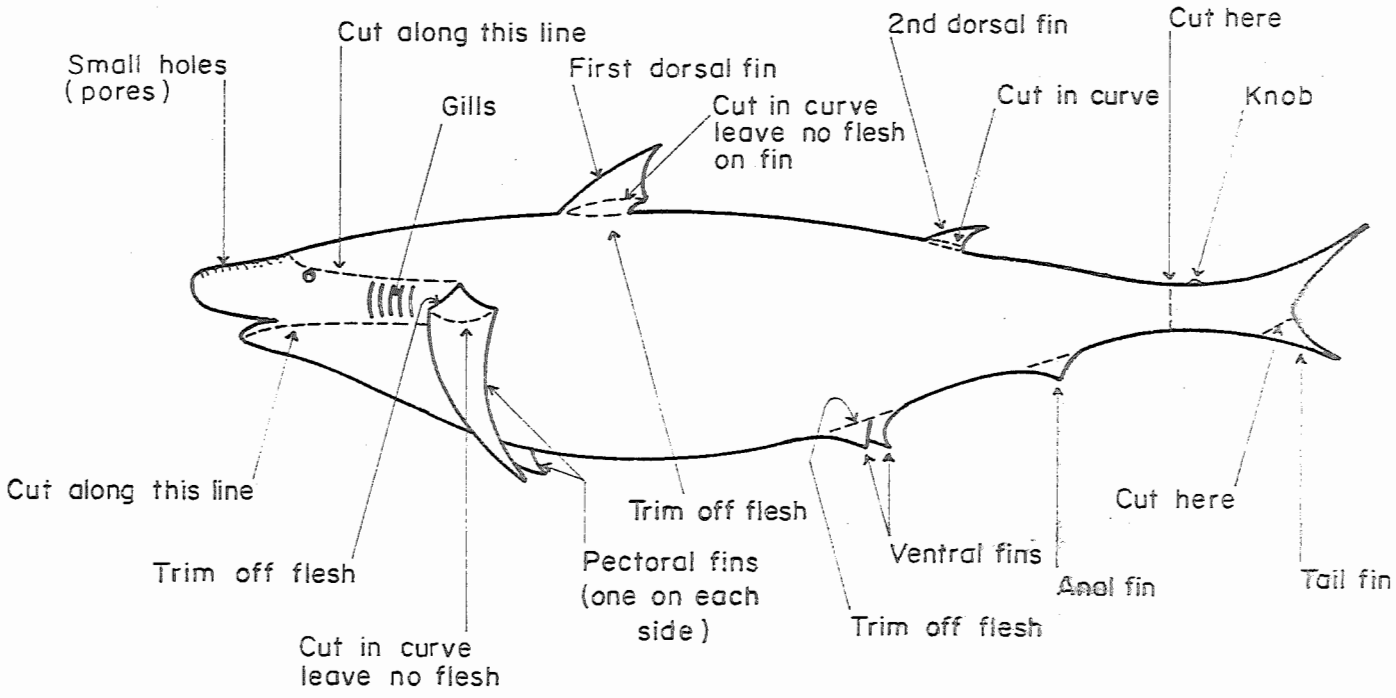
APPENDIX I

Short list of the species of sharks landed in People's Democratic Republic of Yemen (adapted from various sources)

Species	Size of adult
Carchorhinus albimarginatus	2.5 to 3.5 m
C.. maou	3 to 3.5 m
C. altimus	2 to 3 m
C. amboinensis	1 to 2 m
C. plumbeus	1 to 2 m
C. limbatus	2 to 3 m
C. sealei	less than 1 m
C. melanopterus	1 to 2 m
C. brevipinna	2 to 3 m
C. sorrah	less than 2 m
C. wheeleri	less than 2 m
Galeocerdo cuvieri	4 to 6 m
Negaprion acutidens	2 to 2.5 m
Triaenodon obesus	1 to 1.5 m
Hemipristis elongatus	2 to 2.5 m
Lovadon macrorhinus	less than 1m
Rhizopronodon acutus	less than 1m
Isurus oxyrinchus	3 to 4 m
Alcopus pelagicus	
Nebrius concolar	3 to 4 m
Stegostoma varioum	2 to 3 m
Sphyrna blochii	less than 1m
Sphyrna mokkaran	3 to 4 m
Sphyrna lewini	2 to 3 m



a) Top view



b) Side view

Fig. 1. Skinning of large shark (from Kreuzer and Ahmed - 1978)

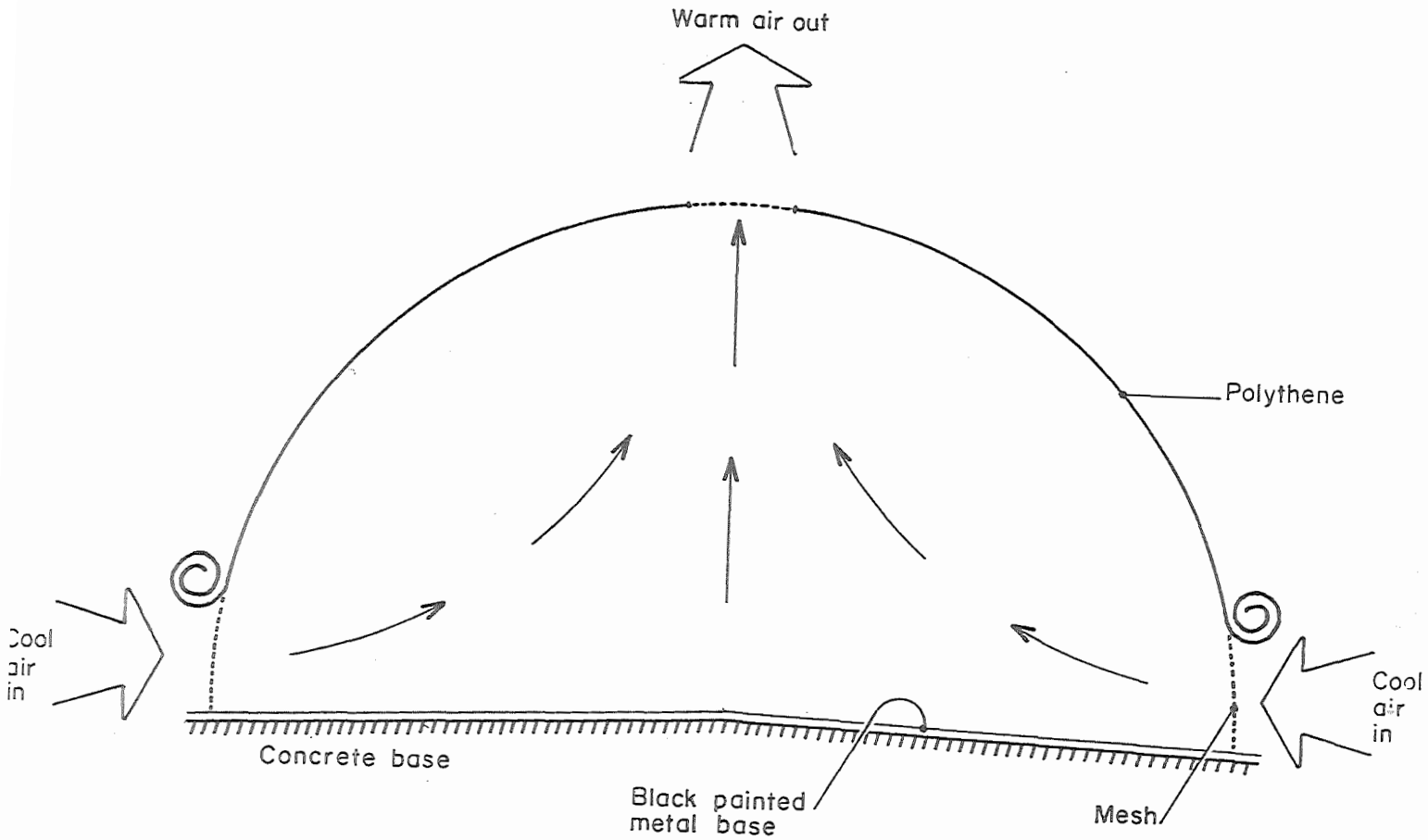


Fig. 2. The adaption of a green house to suit its requirements of fish drying.

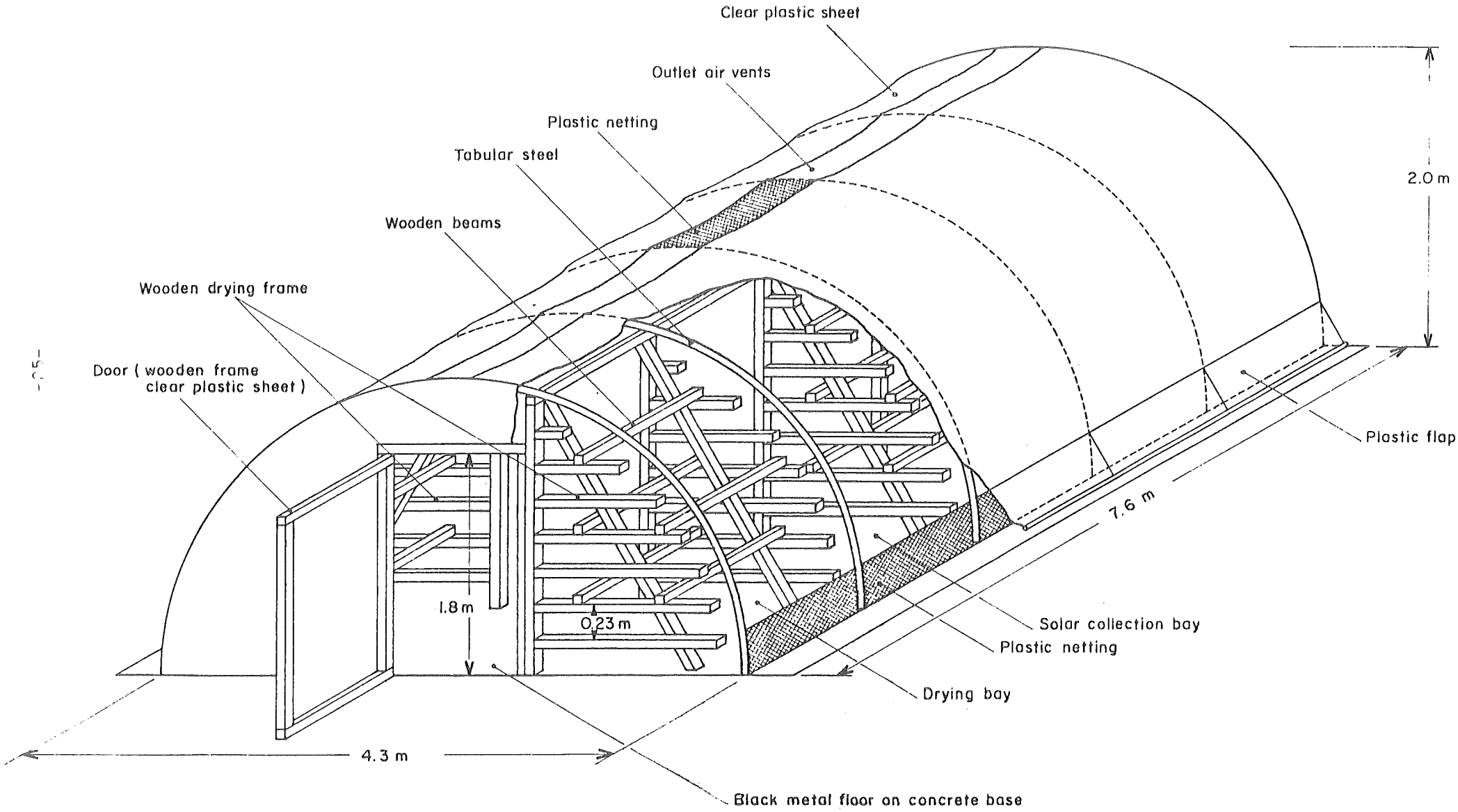
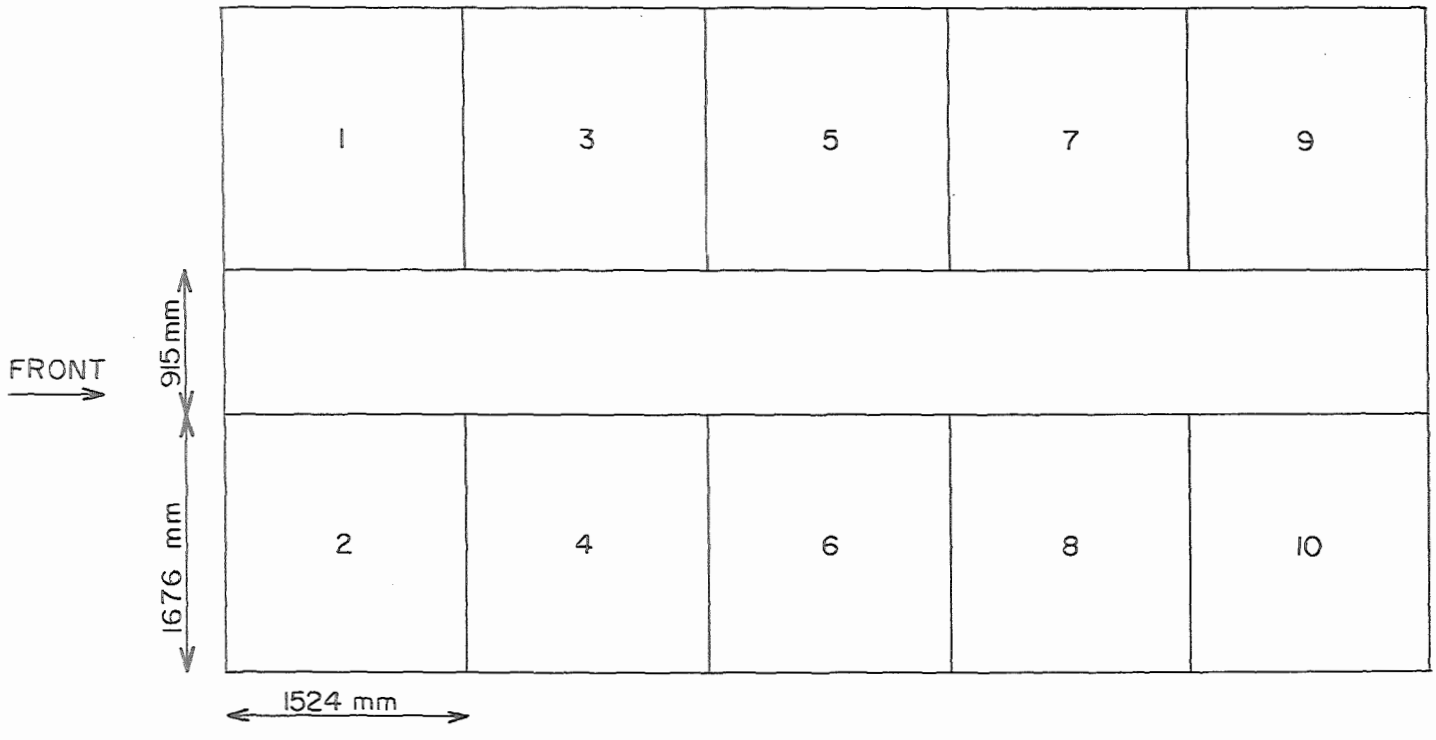


Fig. 3. Solar dome dryer.



Bays 1,2,3,4,9,10 for drying fish

Bays 3,4,7,8 for heat collection

Fig. 4. Fish drying and heat collecting areas inside solar dome dryer.

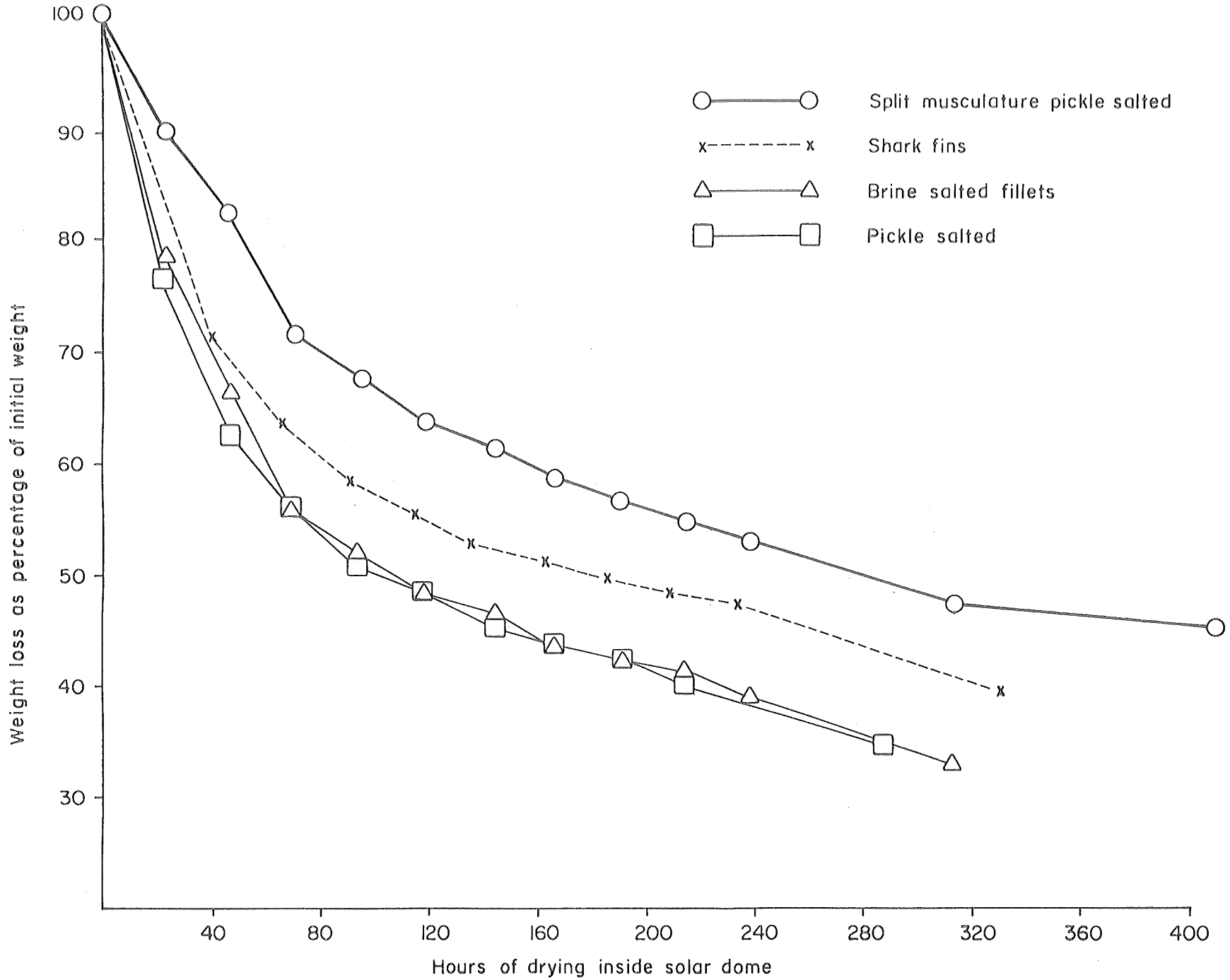


Fig. 5. Drying rate of shark meat, fillets and fins in solar dome.

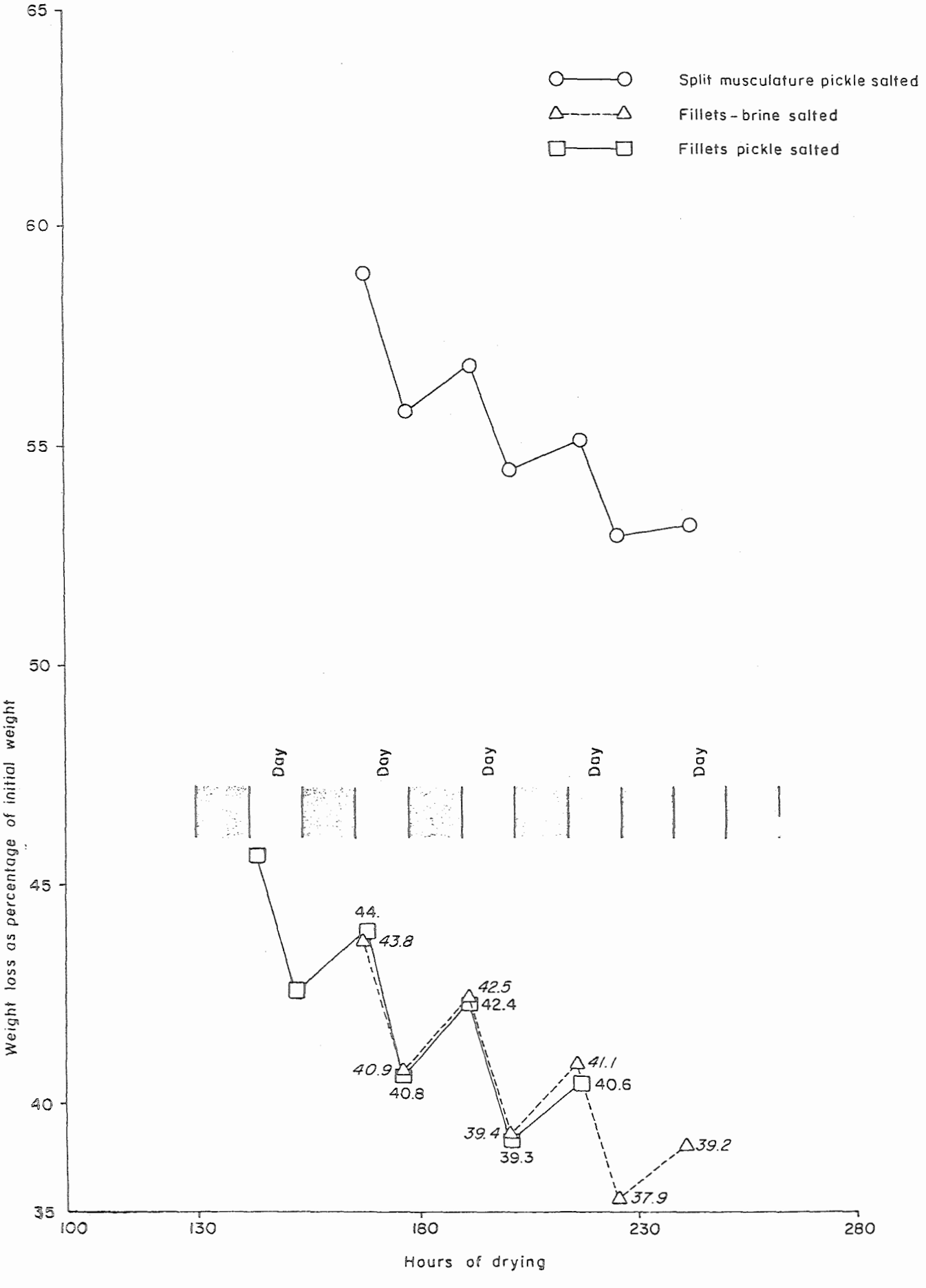


Fig. 6. Moisture reabsorption during drying of shark meat in solar dome dryer.