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ABSTRACT

K y o :

INTRODUCTION

Fish drying is presumably the oldest method of fish preservation using heat from the sun and atmospheric air, although it has been limited to certain climatic areas and seasons (Ogali and Eyo 1996). However, sun drying may be exposed to problems like contamination by dust and insect infestation because the fishes are dried on mats spread on bare ground. To arrest these problems, many designs of solar dryers have been developed for the preservation of fish (Olokor and Omojowo 2009). Solar drying refers to methods of using solar energy for drying. A solar dryer is an enclosed unit, to keep the food safe from damages, birds, insects and unexpected rainfall (Balasuadhakar 2016). Improved solar tent drying has been suggested for an alternative to the traditional open-air sun drying method. The solar tent works by concentrating solar radiation resulting in increased temperature in the tent and turn, lower humidity. With a solar tent, the drying rate can be increased and lower moisture content can be attained and the product quality is higher (Assefa Tessema 2008).

In Ethiopia, solar tent fish drying has been done in different inland water bodies mainly practiced at pre-scaling and demonstration activities. Among these, more activities are performed around Lake Tana which was northern and north-western part of Lake Tana (Dembia, Alefa and Gondar Zuria district) (Erkie Asmare 2015). According to their findings, the solar tent fish dryer was prepared from readily available simple materials such as wood, white and black plastic, rope, nail and mesh wire. The activity was practiced on fish species that enabled to produce good hygiene and good taste by sense organ. It also increased the shelf life of the fish, which significantly contributes to reduce post-harvest losses by low-cost materials. By drying quickly, it is possible to reduce post-harvest losses, thereby (in that case) ensuring continuous availability of cheap animal protein.

In the same manner, another study from the Lake Tana area was practiced on species, and fish species. The practice was held easily, using low cost and improved drying materials that gained high quality dried fish product with long shelf life (Assefa Tessema 2008). However, the fishing practice in Ethiopia depends on some selected species and others discarded (as a leftover) such as the cyprinidae family. In addition, poor quality and unsafe handling practices are common which exposes fish and fish products for high post-harvest losses. Currently, this problem is pronounced at Tekeze Reservoir fisheries. In view of this, the investigation aims to evaluate and select the best technology from the drying methods and assess fishers' preference towards the drying methods.

MATERIALS AND METHODS

Description of the study area

The study was conducted in the eastern and southern parts of the Tekeze Hydropower Reservoir. The reservoir has a maximum length and width of 75 km and 6 km respectively, about 160.4 km^2

areas (Tsegay Teame   2016) and an average depth of 58 m (Goraw Goshu   2009). It is located at an altitude of 1,145 m above sea level and an annual average rainfall of 150-700 mm and temperature of 15-40   (Hussein Abegaz   ., 2016). It is bordered by five districts, namely Abergele, Ziquala, Sahila and Telemt in the Amhara region and Tanqua-Abergele in the Tigray region. The main purpose of constructing the reservoir was to produce electricity, but fisheries were later recognized as significant socio-economic importance (Tsegay Teame   2016).

For effective management of the training program, two landing sites were selected. Based on proximity the fishers from different Kebeles were clustered into these landing sites. Therefore, 5 Kebeles (4 from Abergele and 1 from Ziquala district) from Kirchifen landing site, and 6 Kebeles (4 from Sehala and 2 from Ziqaula district) from Anteneh-Giba landing site were used for this study. Fishers in the Ziquala district do not have their own landing site; they are supplying the fish product to the nearest landing sites. The preliminary studies were held from the Kirchifen landing site only while the training programs were conducted from the two landings.

Kirchifen landing site is found in the eastern part of the reservoir and the major/potential landing site in Abergele district, at 13º03'59" N and 38º50'33" E (Figure 1), the average temperature was 31.25   with an elevation of 1152 m above sea level. This landing site is located at about 92 km from Sekota town and it is one of the drylands from Wag Himra Zone. About 1994 fishers were deployed around this landing site. Anteneh-Giba landing site is a temporal landing site in the Sehala district from the southern part of the reservoir. The landing site is located at 12º56'15'' N and 38º34'45" E with the distances about 130 km from Sekota town (Fig. 1). The average temperature was 35   with an elevation of 1175 m above sea levels. It is also one of the drylands of Wag Himra Zone. About 409 fishers were deployed around this landing site.
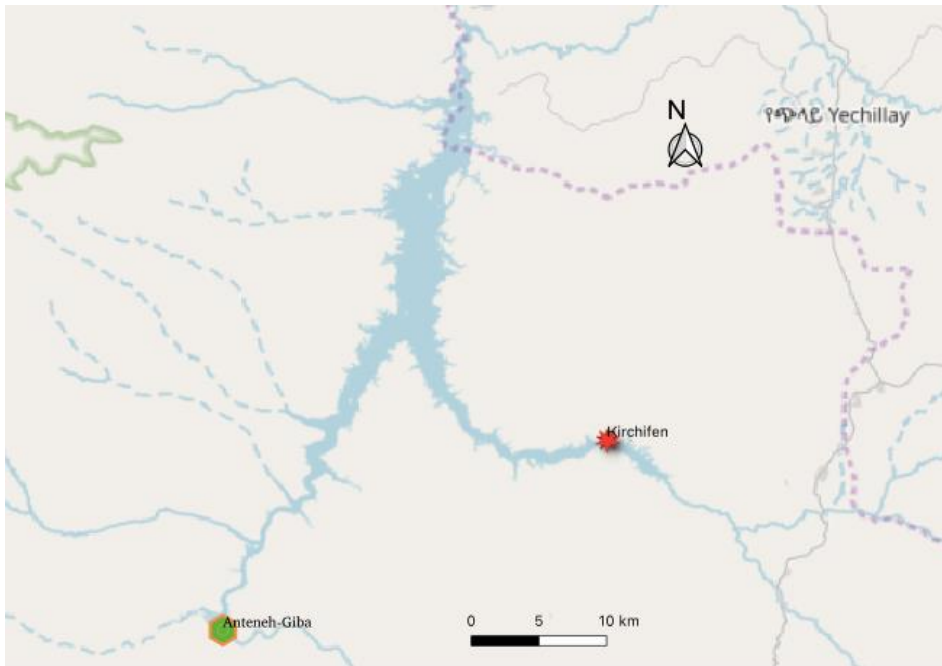
Figure 1: Map of Tekeze Reservoir with the two targeted landing sites (13º03'59"N and 38º50'33"E; 12º56'15''N and 38º34'45"E)

c c **D ＿oll┣ ˌion＿**

The study was conducted from April 2018 to March 2019. It was held by personal observation (preliminary study) and training schedules. Out of 14 cooperatives of the three districts; 11 cooperatives participated in the training program; 2-3 fishers represented their cooperatives. Totally 28 fishers (27 Males and 1 Female) participated and arranged in 7 groups (3-6 fishers in one group) on the training program. Theoretical and practical training was provided to all groups for 3 days in each landing site to make them aware of preparing the tent from readily available materials.

In addition to this, a lot of volunteer fishers participated side by side with their fishing activities. A structured and semi-structured questionnaire was prepared, including oral interviews and discussions. Group discussion and personal observations were also taken in the surroundings of the study area and marketing places that had been evaluated and noted on fish drying practices. Temperature data recorded on prepared datasheet by using SH-117 Digital Thermo-Hygrometer (Yuyao Shuanghe Electron Instrument Co., Ltd., China) and also pictures and GPS data were collected from the training sites. Secondary data were collected in collaboration with the three districts' Livestock and Fish Resource Development Office.

Samples of the fish species targeted at cichlidae family (like   ) and cyprinidae family (like   ). From each species, xx specimen were gutted and filleted using a knife, weighed, and soaked in salt solution 50–60-gram salt dissolved in one liter of water

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for 2 kg gutted and filleted fish (Assefa Tessema   2008 and preliminary study). Weight was taken using manual balance (before drying) and sensitive balance (after drying) to obtain the calculated weight losses.

Three treatments of fish drying methods were performed during preliminary study and training programs as follows:

T_1 = Solar tent drying + Salting
T_2 = Open-air drying + Salting
T_3 = Open-air drying (control)

First of all, these treatments were conducted in a preliminary study, and then, training programs were undertaken through a participatory approach of fish cooperatives from different Kebeles and clustered into two nearby landing sites. Six fish drier tents were prepared, five from Kirchifen and one from Anteneh-Giba landing sites (Figure 2). The two fish families (cichlidae and cyprinidae) were applied on three treatments in duplicates for each family.
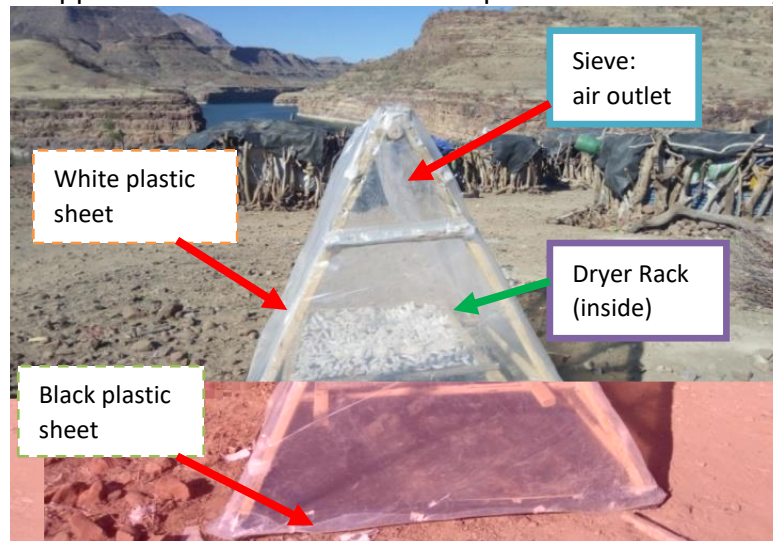

Figure 2: Solar tent drier constructed at Anteneh-Giba landing site.

c T m   ⊔ o

The temperatures were recorded in June and December during the preliminary study and the training programs. During the first observation in June, maximum and minimum temperatures inside the solar tent were 50   and 22.6   , respectively from the Kirchifen landing site. During the training program in December, the temperature raised to 52.9   from the Kirchifen landing site. The maximum and minimum temperatures were 47.4   and 32   , respectively from the Anteneh-Giba landing site at the beginning of January (Table 1). The highest and lowest humidity recorded in all sites was 69 (comfort) and 20 (dry), respectively, whereas the average humidity was under 40% that was 'Dry' (Table 1).

Table 1: Temperature record inside the tent drier

Months	Landing sites	Record time	Temperature at				Humidity in %		
			N	Max	Min	Mean	Max	Min	Mean

June	Kirchifen	6:00 am - 6:00 pm	7	50	22.6		69	20	
December	Kirchifen	07:20 am - 05:50 pm	20	52.9	22.9		49	21	
January	Anteneh-Giba	10:35 am - 05:00 pm	5	47.4	32	**0**	30	20	**7**

During the first observation in June, maximum and minimum temperatures of the environment were 42.9   and 25.5   , respectively from the Kirchifen landing site. Besides this, during the training program in December, the temperature reduced to 41.1   from the Kirchifen landing site. The maximum and minimum temperatures were 47.4   and 32   , respectively from the Anteneh-Giba landing site at the beginning of January (Table 2). The number of temperature records varied depending upon the time of the day and season; and also, it was not constant record time.

Table 2: Environmental temperature record (outside the tent)

Months	Landing Sites	Record time	Temperature at				Humidity in %		
			N	Max	Min	Mean	Max	Min	Mean
June	Kirchifen	6:00 am - 6:00 pm	7	42.9	25.5	**1**	69	20	
December	Kirchifen	07:20 am - 05:50 pm	20	41.1	25.6	**0**	49	22	
January	Anteneh-Giba	10:35 am - 05:00 pm	5	37.1	31.4		30	20	

D ⎯ n⎯ly i

The moisture content of fish samples dried with three treatment samples was computed after oven drying as follows (Reeb and Milota, 1999; Demeke Teklu and Alemu Lemma, 2015).

Perception and attitude of fishers were analyzed by a Likert scale scoring calculated as (Likert 1932).

To know fishers level of agreement on different aspects of the technology scores were given as follows: Strongly agree = 5; agree = 4; neutral = 3; disagree = 2; strongly disagree = 1 (Erkie Asmare 2015). A sum score was calculated by using a formula = F. Strongly agree*5 + F. agree*4 + F. neutral*3 + F. Disagree*2 + F. Strongly disagree*1; where, F is the frequency. Additionally, primary social data like perception and attitude of fishers towards the technologies were summarized and analyzed by descriptive statistics such as frequency, percentage, and minimum, maximum and mean value by using SPSS (V-20) software and SAS (V-9.1). Additionally, tables and graphs of the data were done by using Microsoft Excel 2007.

RESULTS AND DISCUSSION

Du ⎯ion o, i h ying

The duration of fish drying from the Kirchifen landing site was 2-2.5, 2.5 and 3.5 days of (solar tent drying + salting, open-air drying + salting and open-air drying (control), respectively. Besides this, from Anteneh-Giba landing site was 3, 2.5 and 4 days of treatment one, two and three, respectively (Table 3). From the result, drying by solar tent drier was a short duration compared to the other methods from the Kirchifen landing site i.e., it took place only 2 days at the beginning of December, but 2.5 days in June. The difference might have been due to an occasional rainfall occurred in June. However, long-duration for solar tent and short for dry salting was recorded from the Anteneh-Giba landing site due to a variety of weather conditions like occasional rainfall, dusty and frost season since the experiment was conducted at the beginning of January. Similarly, some limitations were observed like easily burst the white plastic during a high blowing of wind and rainfall. This implies that the duration of fish drying varied and affected by different seasons (Assefa Tessema 2008).

Table 3: Duration of fish drying for each treatment

T m n	Du ion ying in y	
	Ki hi n l n ing i	An n b Gi l n ing i
1 Solar tent drying + salting	2-2.5*	3
2 Open air drying + salting	2.5	2.5
3 Open-air drying	3.5	4

c   **Moi u on n**

The moisture content was taken from the sample weight before and after the drying of the two fish families (cichlidae and cyprinidae) that applied on three treatments and six replications. The moisture content of the cichlidae family showed no significant difference between the treatments (Table 4). It might be a limitation between measurements by manual balance during initial raw fish measuring and sensitive balance the final weight measuring. The moisture content of the cyprinidae family showed that a significant difference between the treatments, i.e., treatment one (solar tent drying + salting) was significantly different from the other treatments, but the two were related (Table 4).

Table 4: Moisture content between fish species for each treatment

T m n	c Moi u on n ( )	
	Oreochromis niloticus	*Labeobarbus intermedius*
Solar tent drying + salting	75.91[a]	71.14[b]
Open air drying + salting	77.293[a]	78.57[a]
Open-air drying	76.913[a]	78.64[a]
LSD	NS	3.77
CV (%)	2.86	3.85

P ion o h i h

Perception of fishers on the availability of inputs (Table 5) were most probably agreed that the mean scored was above 3.5, but some participants did not respond on five statements (i.e.,

neutral). However, fishers did not yet start to apply the technology practically.

Table 5: Fisher's level of agreement to making the solar tent

Available constructing inputs	14.3	85.7	-	-	-	29	**1**
Not labor intensive	28.6	42.9	28.6	-	-	28	
Not expensive to construct	-	57.1	42.9	-	-	25	**7**
Easy to implement	28.6	57.1	14.3	-	-	29	**1**
Easy to manage	28.6	42.9	28.6	-	-	28	
Fish holding capacity is good	-	85.7	14.3	-	-	27	
					Average		**9**
				Cronbach's alpha coefficient		**0**	**7**

Note:

The fisher's perception on treatment one (solar tent drying + salting) was acceptable on most of the statements. Pulse to this they were strongly disagrees on vulnerability for animals, insects, birds, dust and rain, i.e., not vulnerable for animals, insects, birds, dust and rain because the treatment had a plastic cover (Table 6). Likewise, the respondent's and stakeholder's attitudes and perceptions towards solar tent drier were good and acceptable in most aspects (Erkie Asmare 2015). Fisher's perception on treatment two (open-air drying with salting) was agreed on post-harvest loss reducing, but vulnerable for animals, insects, birds, dust and rain because the method had not included the protector (cover). They were also disagreeing on hygienic quality and the shelf life of the dried fish because they observed some spoilage. Above the half of participants were given their neutral attitude on quick drying and goodness of (taste, texture, odor and color) from the treatment (Table 7). This perception seems to contradict the duration of fish drying in treatment three, but they respond in the way of their own trends that related to the traditional drying methods. Furthermost, the other level of agreement was not acceptable that the mean score under 2.50 (50%) from treatment three (Table 8).

Table 6: Fisher's level of agreement on the solar tent drying + salting (T1)

Perception	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	**Sum o**	**M o**	**n**
Hygienically high	57.1	42.9	-	-	-	32		**7**
Drying fish quickly	28.6	71.4	-	-	-	30		**9**
Good taste, texture, odor and color	42.9	57.1	-	-	-	31		
The shelf life of the dried fish is longer	71.4	28.6	-	-	-	33		**71**
Post-harvest loss reduced	57.1	42.9	-	-	-	32		**7**
Demand of marketability	-	-	-	85.7	14.3	13	**1**	
High price	14.3	28.6	14.3	42.0	-	22	**1**	
Easy to adopt technology for the future	14.3	57.1	28.6			27		
Vulnerable for animal, insect, bird, dust	-	-	-	14.3	85.7	8		**1 1**

and rain

			Average				
			Cronbach's alpha coefficient				**0 7**

Note:

c   **E in o ion i h ying o i h in h y**

According to personal observation, group discussions and individual interviews, fishers practiced on the open-air drying from the reservoir especially using the cyprinidae family in traditional methods (Figure 3). However, different challenges observed like unexpected rainfall, extreme dusty wind blow, earthworms, clearwings (a type of insect), and market and transport problems. Besides these problems, some fishers sold their dried fish products from Kirchifen and Anteneh-Giba landing sites. The price of dried fish from the Anteneh-Giba landing site was better than the Kirchifen landing site. The wholesalers collected the dried fish from the fishers and then, resells to ultimate customers i.e., to East Belesa district (Central Gondar Zone) and Wolkait district (North Gondar Zone).

Table 7: Fisher's level of agreement on the open-air drying + salting (T2)

Perception	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	**Sum o**	**M o**	**n**
Hygienically high	-	14.3	14.3	71.4	-	17		
Dried fish quickly	-	42.9	57.1	-	-	31		
Good taste, texture, odor and color	-	28.6	71.4	-	-	18	**7**	
The shelf life of the dried fish is longer	-	42.9	-	42.9	14.3	19	**71**	
Post-harvest loss reduced	-	57.1	-	42.9	-	22	**1**	
Demand of marketability	-	-	-	42.9	57.1	10	**1**	
Vulnerable for animal, insects, birds, dust and rain	57.1	42.9	-	-	-	32	**7**	
				Average			**0**	
				Cronbach's alpha coefficient			**0**	

Note:

Table 8: Fisher's level of agreement on the open-air drying (T3)

Perception	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Sumo	Mo	n
Hygienically high	-	-	14.3	28.1	57.1	11	1	7
Dried fish quickly	-	85.7	-	14.3	-	26	71	
Good taste, texture, odor and color	-	-	-	28.6	71.4	9	1	9
The shelf life of the dried fish is longer	-	-	-	57.1	42.9	11	1	7
Post-harvest loss reduced	-	-	-	42.9	57.1	10	1	
Demand of marketability	-	-	-	42.9	57.1	10	1	
Vulnerable for animal, insects, birds, dust and rain	57.1	42.9	-	-	-	32		7
				Average				
				Cronbach's alpha coefficient			0 71	

Fisher's perception on all levels of agreement in (Table 5, 6, 7 and 8) was reliable and consistent. Each statistical table showed that the coefficient of alpha, $\alpha > 0.7$ which illustrates the perception test from all categories (items) were consistent and reliable. The statistics table gives coefficient of alpha; in this case, a = 0.78, which illustrates that the information generated were consistent and reliable.

Figure 3: Plate showing traditional methods of fish drying [cyprinidae family (left and middle) and cichlidae family (right)]

CONCLUSIONS AND RECOMMENDATIONS

In general, the two landing sites had a high ambient temperature, lowest humidity, the hottest

and driest land in most months of the year. In the total (averagely), drying by solar tent drier was a short duration compared to the other methods. The moisture content of the cyprinidae family showed that a significant difference between the treatments i.e., solar tent drying with salting (T1) was significantly different from the other treatments. Also, solar tent drier (T1) had more acceptable by fishers due to different reasons. It takes a short duration to dry, low moisture content, good quality, and good handling, long shelf life, and easily reduce post-harvest loss that compared to the other methods. However, some limitations are observed like easily burst (rupture) the white plastic during a high blowing of wind and rainfall. Besides this, open-air drying with salting (T2) and open-air drying (T3) had also agreed on quick drying. However, many limitations were observed like vulnerable to the extreme dusty wind blow, rainfall, animals, birds, clearwings or insect infestation; and low quality, most probably long duration to dry, bad tastes and odor. Likewise, traditional fish drying methods of the fishers were also exposed to product loss. Therefore, to reduce the loss of the cyprinidae family in the surrounding of the reservoir; solar tent drier should be demonstrated in the form of a large scale like greenhouses (multi-rack dome) to deploy a lot of fishers in together. It is easily controlled and manageable. In addition to this, hard plastic is required to construct the tent drier from each landing site, in the way it can protect the rupture or burst. If the input materials are expensive and not available in the nearest market for fishers to make solar tent drier, they will be used open-air drying with salting as a second option in the way of control the above limitations.

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