

Participatory Evaluation of Some Fish Drying Methods in Tekeze Reservoir Fishery Wag-Himra Zone, Ethiopia

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ABSTRACT

Received: February 14, 2023

Revised: May 28, 2023

Accepted: June 21, 2023

Available online: June 28, 2023

Keywords: Solar tent, fishers, dry salting, moisture, perception, post-harvest loss, shelf-life

This study aimed to evaluate and select the best technology among the drying methods through fishers' participation. Data were collected from the observation and training program for 14 cooperatives in 3 districts from April 2018 to March 2019. A total of 28 fishers participated in the participatory approach. Three treatments (solar tent drying with salting, open-air drying with salting, and open-air drying) were conducted and the primary data were summarized and analyzed using descriptive statistics. The recorded temperature inside the solar tent was in the range of 22.6 °C to 52.9 °C and the environmental air temperature was in the range of 25.5 °C to 42.9 °C, whereas the average humidity was under 40% that was 'Dry.' The moisture content of the cyprinidae family in a solar tent drier significantly differed from the other treatments, but it was not significant for the cichlidae family. The fishers' perception of solar tent drier (T1) was acceptable on most statements like short duration for drying, low moisture content, good quality (taste, color, and odor), long shelf life, and easily reduce post-harvest loss. However, fishers had less confidence to use open-air drying with salting (T2) and open-air drying (T3) due to the vulnerability of these methods for animals, insects, birds, dust and rainfall and short shelf life with low quality. Therefore, solar tent drier in the form large scale like a greenhouse on multi-rack dome may be the best option to reduce post-harvest loss and avoid the discarding and dumping of the fishers' harvest at in some remote areas Tekeze Reservoir fishery.

1. 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 (Olokori 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 (Balasubhadhakar *et al* 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 *et al* 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 *et al* 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 *Labeobarbus intermedius* 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 *Labeobarbus* species, *Clarias gariepinus* and *Oreochromis niloticus* 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 *et al* 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.

2. MATERIALS AND METHODS

2.1. 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 km² areas (Tsegay Teame *et al* 2016) and an average depth of 58 m (Goraw Goshu *et al* 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 °C (Hussein Abegaz *et al.*, 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 *et al* 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 Ziquala 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 13°03'59" N and 38°50'33" E

(Figure 1), the average temperature was 31.25 °C 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 12°56'15" N and 38°34'45" E with the distances about 130 km from Sekota town (Fig. 1). The average temperature was 35 °C 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.

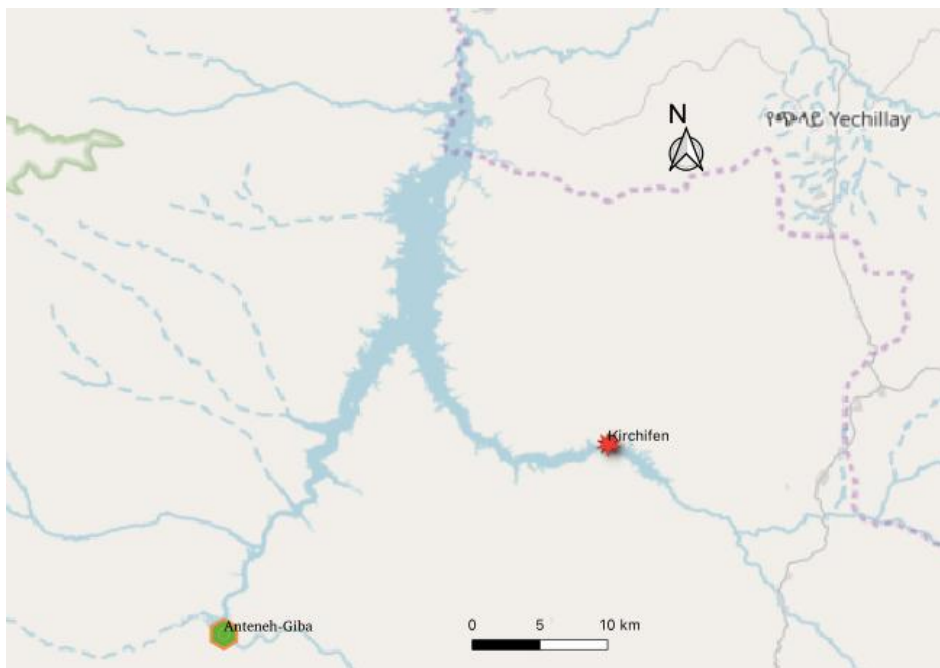


Figure 1: Map of Tekeze Reservoir with the two targeted landing sites (13°03'59"N and 38°50'33"E; 12°56'15"N and 38°34'45"E)

2.2. Data collection

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 *Oreochromis niloticus*) and cyprinidae family (like *Labeobarbus intermedius*). 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 for 2 kg gutted and filleted fish (Assefa Tessema *et al* 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:

T₁ = Solar tent drying + Salting

T₂ = Open-air drying + Salting

T₃ = 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.

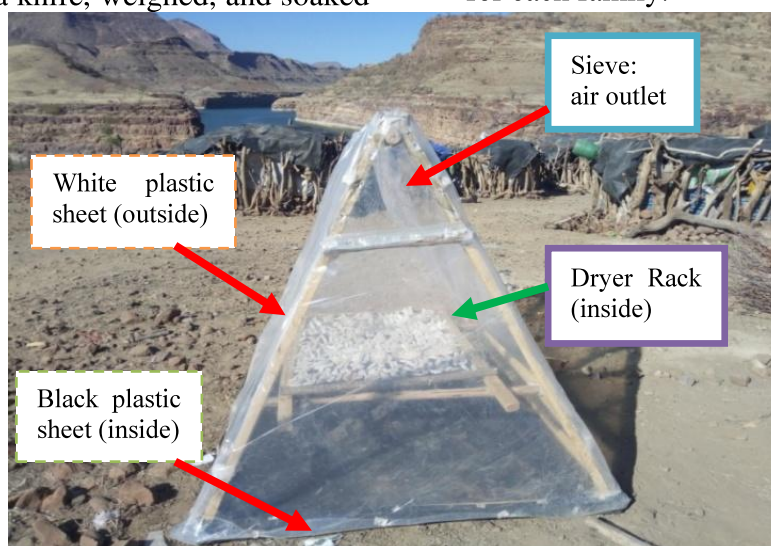


Figure 2: Solar tent drier constructed at Anteneh-Giba landing site.

Temperature records

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 °C and 22.6 °C, respectively from the Kirchifen landing site. During the training program in December, the temperature raised to 52.9 °C from the Kirchifen landing site. The maximum and minimum temperatures were 47.4 °C and

32 °C, 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 °C				Humidity in %		
			N	Max	Min	Mean	Max	Min	Mean
June	Kirchifen	6:00 am - 6:00 pm	7	50	22.6	33.3	69	20	38.4
December	Kirchifen	07:20 am - 05:50 pm	20	52.9	22.9	38.2	49	21	36.4
January	Anteneh-Giba	10:35 am - 05:00 pm	5	47.4	32	40.5	30	20	27.5

During the first observation in June, maximum and minimum temperatures of the environment were 42.9 °C and 25.5 °C, respectively from the Kirchifen landing site. Besides this, during the training program in December, the temperature reduced to 41.1 °C from the Kirchifen landing site. The maximum and minimum temperatures were 47.4 °C and 32 °C, 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 °C				Humidity in %		
			N	Max	Min	Mean	Max	Min	Mean
June	Kirchifen	6:00 am - 6:00 pm	7	42.9	25.5	31	69	20	38.36
December	Kirchifen	07:20 am - 05:50 pm	20	41.1	25.6	30.8	49	22	36.6
January	Anteneh-Giba	10:35 am - 05:00 pm	5	37.1	31.4	34.6	30	20	22.4

Data analysis

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).

$$\text{Moisture content} = \frac{(\text{Weight of wet sample} - \text{Weight of dried sample})}{\text{Weight of wet sample}} \times 100$$

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

$$\text{Average score} = \frac{\text{The sum score}}{\text{Sample size}}$$

$$\text{The sum score} = \sum_{i=1}^5 \text{Strongly agree, Agree, neutral, Disagree, Strongly disagree}$$

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 *et al* 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.

3. RESULTS AND DISCUSSION**3.1. Duration of fish drying**

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 *et al* 2008).

Table 3: Duration of fish drying for each treatment

Treatments		Duration for drying in days	
		Kirchifen landing site	Anteneh-Giba landing site
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

Note: * 2 days in December and 2.5 days in June from Kirchifen landing site

Moisture content

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

Treatments	Moisture content (%)	
	<i>Oreochromis niloticus</i>	<i>Labeobarbus intermedius</i>
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

Note: LSD = least significant difference, CV= coefficient of variation, NS = no significant

Perception of the fishers

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	4.14
Not labor intensive	28.6	42.9	28.6	-	-	28	4
Not expensive to construct	-	57.1	42.9	-	-	25	3.57
Easy to implement	28.6	57.1	14.3	-	-	29	4.14
Easy to manage	28.6	42.9	28.6	-	-	28	4
Fish holding capacity is good	-	85.7	14.3	-	-	27	3.86
Average							3.95
Cronbach's alpha coefficient							0.87

Note: The values of scales are in percentage, and the number is (The system usability scale on a five-point scale of agreement: mean score greater than 70% (>3.51): acceptable; between 50 and 70% (2.51-3.50): marginal (neither of the two) and less than 50% (<2.50): unacceptable (Tullis 2013)).

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 *et al* 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. Furthermore, 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 scores	² Mean scores
Hygienically high	57.1	42.9	-	-	-	32	4.57
Drying fish quickly	28.6	71.4	-	-	-	30	4.29
Good taste, texture, odor and color	42.9	57.1	-	-	-	31	4.43
The shelf life of the dried fish is longer	71.4	28.6	-	-	-	33	4.71
Post-harvest loss reduced	57.1	42.9	-	-	-	32	4.57
Demand of marketability	-	-	-	85.7	14.3	13	1.86
High price	14.3	28.6	14.3	42.0	-	22	3.14
Easy to adopt technology for the future	14.3	57.1	28.6	-	-	27	3.86
Vulnerable for animal, insect, bird, dust and rain	-	-	-	14.3	85.7	8	1.14
Average							3.65
Cronbach's alpha coefficient							0.73

Note: The values of scales are in percentage; and the number is (Cronbach's alpha reliability analysis carried out for internal consistency among Likert scale items. The reliability

coefficient normally ranges between 0 and 1, while a high value for Cronbach's alpha indicates good internal consistency of the items in the scale (Gliem and Gliem 2003).

Experience of traditional fish drying of fishers in the study areas

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 scores	² Mean scores
Hygienically high	-	14.3	14.3	71.4	-	17	2.43
Dried fish quickly	-	42.9	57.1	-	-	31	4.43
Good taste, texture, odor and color	-	28.6	71.4	-	-	18	2.57
The shelf life of the dried fish is longer	-	42.9	-	42.9	14.3	19	2.71
Post-harvest loss reduced	-	57.1	-	42.9	-	22	3.14
Demand of marketability	-	-	-	42.9	57.1	10	1.43
Vulnerable for animal, insects, birds, dust and rain	57.1	42.9	-	-	-	32	4.57
Average							3.04
Cronbach's alpha coefficient							0.83

Note: The values of scales are in percentage; and the number is (Cronbach's alpha reliability analysis carried out for internal consistency among Likert scale items. The reliability coefficient normally ranges between 0 and 1, while a high value for Cronbach's alpha indicates good internal consistency of the items in the scale (Gliem and Gliem 2003).

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

Perception	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Sum scores	² Mean scores
Hygienically high	-	-	14.3	28.1	57.1	11	1.57
Dried fish quickly	-	85.7	-	14.3	-	26	3.71
Good taste, texture, odor and color	-	-	-	28.6	71.4	9	1.29
The shelf life of the dried fish is longer	-	-	-	57.1	42.9	11	1.57
Post-harvest loss reduced	-	-	-	42.9	57.1	10	1.43
Demand of marketability	-	-	-	42.9	57.1	10	1.43
Vulnerable for animal, insects, birds, dust and rain	57.1	42.9	-	-	-	32	4.57
Average							2.22
Cronbach's alpha coefficient							0.71

Note: The values of scales are in percentage; and the number is (Cronbach's alpha reliability analysis carried out for internal consistency among Likert scale items. The reliability coefficient normally ranges between 0 and 1, while a high value for Cronbach's alpha indicates good internal consistency of the items in the scale (Gliem and Gliem 2003). The acceptable values of alpha coefficient are in the range of 0.7 to 0.95, but the maximum alpha value of 0.90 has the best. If alpha coefficient is closer to 1.00, as the result gets greater internal consistency of the items in the scale and alpha coefficients above 0.70 are considered acceptable (Tavakol and Dennick 2011; Taherdoost 2016)). 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, $\alpha = 0.78$, 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)]

4. 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.

ACKNOWLEDGMENT

Thanks to Abergele, Ziquala and Sihala Woreda Agricultural Offices for their good participation in the training.

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