IMPROVED FISH DRYING USING A POLYTHENE SOLAR DRYER

[AMÉLIORATION DU POISSON SÉCHÉ EN UTILISANT UN SÉCHOIR SOLAIRE EN POLYÉTHYLÈNE]

by/par

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Abstract

Post-harvest fish losses along Lake Turkana beaches were estimated to be about 60%. One of the main causes of loss was the low technology used in sun drying, resulting in high contamination of fish with sand. Further, the drying process is slow, resulting in a product that is of low quality with a short shelf life, consequently loss of income to fishers. It was therefore essential to identify, test and adapt appropriate technology to shorten drying time, improve product quality and increase shelf life of fishery products.

This study assessed the effectiveness and efficiency of drying fish using solar dryer made of polythene (PE) sheets compared to the traditional open drying. Five drying systems consisting of a bamboo solar dryer on the ground, a raised solar dryer, a plywood solar dryer with black and another with white polythene sheet, were tested. Fish was harvested, split, washed and dried using the different systems.

The temperature inside the drying chamber increased from 33 ºC to 56 ºC, representing an increase by factor of 69.6%. The temperature inside the fish increased from ambient temperature to a maximum of 62.9 ºC, indicating an increase factor of 90.6%. Comparatively, the maximum temperature attained under open drying was 42.5 ºC, which indicates an increase factor of 28.8%. The enhanced temperature during solar drying reduced drying time from 48 hours to 30 hours. The drying ratio in solar dryer was about 0.28–0.30 compared to 0.29 under open drying. The water activity attained within 30 hours under solar dryer was 0.39–0.41 compared to 0.39–0.55 under open drying.

The results demonstrate that solar drying is more effective and efficient than open drying. In addition, solar dried fish products are of higher quality, with significantly less sand, have a firm texture, fresh fish odour and an extended shelf life of over six months. Solar dryers also have lower operating costs than mechanized dryers. In conclusion, solar dryers shorten drying time, improve product quality, extend the shelf life of the products, reduce costs and thus improve income to fishers.

Key words: Polyethylene, Solar dryer, Drying time, Drying ratio, Product quality, Insect infestation

Résumé

Les pertes post capture du poisson le long des plages du lac Turkana ont été estimées à environ 60%. Une des principales causes de perte était la faible technologie utilisée pour le séchage au soleil, d'où un poisson hautement contaminé en sable. Par ailleurs, le procédé de séchage est lent, engendrant un produit de faible qualité avec une courte durée de conservation, par conséquent une perte en revenus pour les pêcheurs. Il était donc essentiel d'identifier, tester et adapter une technologie appropriée pour réduire le temps de séchage, améliorer la qualité du produit et augmenter la durée de conservation des produits de la pêche.

Cette étude a évalué l'efficacité de sécher le poisson en utilisant des séchoirs solaires construits avec des feuilles de polyéthylène (PE) comparés aux séchoirs traditionnels ouverts. Cinq systèmes de séchoirs comprenant un séchoir solaire en bambou sur le sol, un séchoir solaire surélevé, un séchoir en contreplaqué avec une feuille en polyéthylène noire et un autre avec une feuille en polyéthylène blanc, ont aussi été testés. Le poisson a été capturé, séparé, lavé et séché par les différents systèmes.

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La température à l'intérieur de la chambre de séchage augmentait de 33 ºC à 56 ºC, représentant une augmentation d'un facteur de 69,6%. La température à l'intérieur du poisson augmentait d'une température ambiante jusqu'à un maximum de 62,9 ºC indiquant une augmentation d'un facteur de 90,6%. Comparativement, la température maximale atteinte sous un séchoir ouvert était de 42,5 ºC, ce qui indiquait une augmentation par un facteur de 28,8%. La température améliorée pendant le séchage solaire réduisait le temps de 48 heures à 30 heures. Le ratio de séchage avec un séchoir solaire était environ 0,28-0,30 en comparaison à 0,29 sous séchoir ouvert. L'activité de l'eau atteinte en 30 heures sous séchoir solaire était 0,39-0,41 en comparaison à 0,39-0,55 sous séchoir ouvert.

Les résultats démontrent que le séchage solaire est plus efficace que le séchage ouvert. En plus, les produits de pêche séchés sont de qualité supérieure, ont significativement moins de sable, une texture ferme, une odeur de poisson frais et une durée de conservation prolongée de plus de 6 mois. Les séchoirs solaires ont aussi des coûts opérationnels plus bas que les séchoirs mécaniques. En conclusion, les séchoirs solaires raccourcissent la durée de séchage, améliorent la qualité du produit, augmentent la durée de conservation, réduisent les coûts et ainsi améliorent les revenus des pêcheurs.

Mots clés: Polyéthylène, Séchoirs solaires, Temps de séchage, Ratio de séchage, Qualité du produit, Infestation par les insectes

1. INTRODUCTION

Studies conducted by KMFRI in Lake Turkana in early 2007 indicated that fish post-harvest losses were about 60% (LTRP, 2007).One of the main causes of this loss was the low technology used in sun drying .The fish is simply split and spread on the ground to dry. This leads to long drying time, low product quality and hence short life of the product. The market value of the product is significantly reduced with subsequent low income to fishers. It is therefore vital to identify, test and adapt appropriate technology to shorten drying time, improve product quality and increase shelf life of fishery products. One option is the use of solar dryer technology. 'Solar drying' is the method of using sun's energy for drying but excludes open air drying. The justification for solar dryers is that they may be more effective than direct sun drying, but have lower operating costs than mechanized dryers. Solar dryers can be more effective than direct sun drying and have lower operating costs than mechanized dryers. This will shorten drying time; improve product quality, long shelf life, reduce post-harvest losses and thus improve income to fishers.

This study was one of the components of the Lake Turkana Research Project whose broad objective was to generate information for sustainable development and management of Lake Turkana fisheries for enhanced food security through reduction of post-harvest fish losses, provision of high quality fish and fishery products, increased income and improved socio-economic status of the fisher community. The specific objective of the study was to identify, test and adapt an appropriate solar dryer for fish along Lake Turkana, so as to produce high quality sun-dried fish products. One of the activities was to evaluate the quality of sun-dried fish products from solar dryer compared to the traditional drying methods.

2. METHODOLOGY

Experimental design

The experimental design included five sets of drying regimes, namely:

- Bamboo trays with white polythene on the ground;
- Plywood trays with white polythene on the ground;
- Plywood trays with black polythene on the ground;
- Raised trays with white polythene; and
- Artisanal drying method on the ground.

Tray construction

The bamboo trays were constructed from bamboo as shown in Plate 1. Bamboo slats comprising the arcs are attached to the horizontal frame by cutting a slit just large enough to insert the slats. UV-protected polyethylene

(PE) sheets are used for the cover. PE sheets accumulate less dust and can remain serviceable even after 31 months of use (Rouweler, 1995).

The plywood tray is constructed using plywood, mosquito mesh and PE sheets, Plate 2. The raised tray was built with timber and cedar poles fixed on the ground with ballast Plate 3. The PE sheets are fixed on open doors on the sides to allow for turning of the fish during drying. Plate 4 shows the artisanal raised drying rack that will still not prevent contamination of fish from sand. Materials and cost estimates for construction of bamboo and raised rack dryers are given in Annexes I and II.

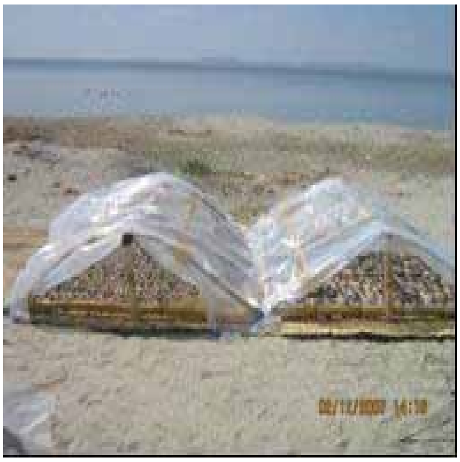

Plate 1. Improved bamboo solar dryer

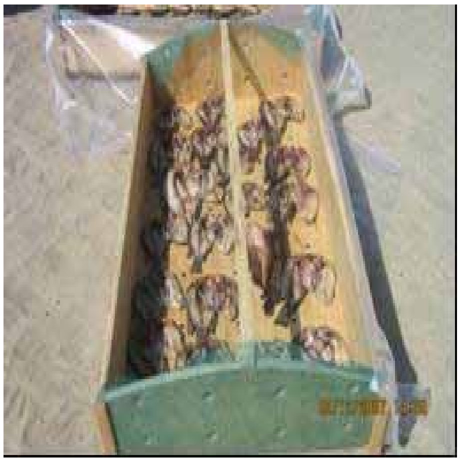

Plate 2. Plywood solar dryer

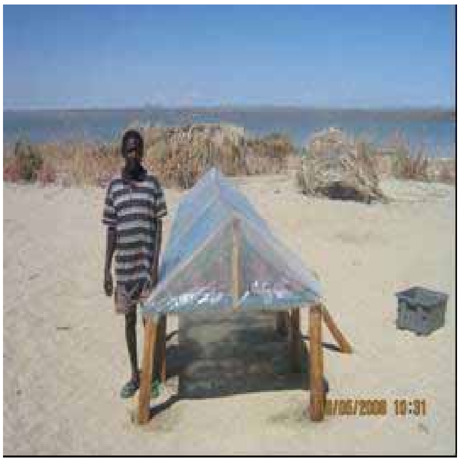

Plate 3. Improved raised fish solar dryer

Plate 4. Traditional raised fish dryer

3. FISH SAMPLE PREPARATION

All the trial fish samples were fished using gillnets. Immediately after landing, the fish were scaled, split and washed using lake water. The samples were allowed to drain and were placed in the individual trays to dry. The unit operations are shown in Figure 1.

Fresh tilapia (caught by gill nets)

↓

Sorting according to size

↓

Scaling, gutting

↓

Washing and draining

↓

Drying
(Bamboo trays - white Polythene: Wooden trays - white Polythene: Wooden trays -black Polythene)

Conventional (open air)

↓

Packaging in baskets

Figure 1. Process flow of improved drying of tilapia along Lake Turkana

During the drying process the parameters monitored were, weight changes, ambient temperature, temperature inside the drying chamber and in fish flesh. Temperature changes were monitored by a hand held thermometer. To compare the efficiency and effectiveness of the different drying systems, the drying ratio and product output were computed. The drying ratio is important in identifying a drying phase which does not correspond to the dryer's performance for a given product, and can assist in improving the drying system to improve the drying process. It is also useful for the end-user to check how advanced the drying process is, and the extent to which the dryer's characteristics change with time.

4. RESULTS

The white polythene solar dryer (Plates 1 and 2) gave better drying regimes than black polythene which generated a lot of humidity inside the chamber and thus affected the drying of the product.

The drying process took a minimum period of 24 hours and maximum of 30 hours in the solar dryers compared to the traditional drying method which takes up to 48 hours. The temperature inside the solar drying chamber increased from ambient temperature of 33 ºC to 39 ºC to reach a maximum of 62.6 ºC. Temperature inside fish during drying increased to a maximum of 62.9 ºC in the solar dryer, representing 90.6% increase from ambient temperature. Comparatively, the increase of temperature in fish under open drying rose to a maximum of 42.5 ºC i.e. 28.8% from ambient temperature. Product temperature profiles during the drying process indicate the relationship between temperatures at ambient, inside drying chamber and inside fish muscle. Drying rhythms indicate that the system is efficient and effective using raised rack as exemplified by the gradient of the weight loss versus time of drying. The time required to reach constant drying for both systems is approximately 24 hours.

The measured drying ratio in raised solar dryer was 3.01, bamboo 2.63 and artisanal (open) 2.93. The reciprocal of drying ratio in solar dryer was about 0.28–0.30 compared to 0.26 under artisanal drying, conforming to the values in the product datasheet of 0.25–0.33 (Rozis, 1997). Product output showed that raised solar dryer was more effective and efficient than the bamboo dryer and open drying. The water activity attained within 30 hours under solar dryer was 0.39–0.41 compared to 0.39–0.55 under open drying. This indicates that solar drying is actually more effective and efficient than open drying, as demonstrated by the narrow range of water activity. The solar dried fish product is of higher quality, since it has significantly less sand, has a firm texture, brown colour and fresh fish odour. Table 1 shows the drying parameters and organoleptic characteristics of the solar and artisanal dried products. The colour of the products was dark brown. After storage trials of up to six months there was no evidence of insect infestation.

Table 1. Drying parameters in different drying systems

	Drying Systems			
Drying Parameter	**Raised Solar Dryer**	**Bamboo solar dryer on ground**	**Tray solar dryer on ground**	**Conventional drying(Open Control)**
Ambient Temp (ºC)	32.0–37.0	32.1–39.3	32.1–39.3	32.1–39.3
Maximum T(ºC) in dryer	47.3	50	nd	38.1
Maximum T(ºC) in Fish	39.6*	50.0	48.4	42.5
Reciprocal of drying ratio	0.28–0.72	0.30–0.76	nd	0.26–0.72
Product output	1.6–31.5	1.5–28.3	nd	1.4–28.5
Water activity(aw)	0.39–0.41	0.39	0.39	0.39–0.55
Texture of product	Firm	Firm	Firm	Soft
Odour	Neutral	Neutral	Neutral	Fishy
Drying time	30 maximum	30	30	48
Insect infestation	absent	absent	absent	Evident within first week of drying

5. DISCUSSION

Foods are usually very well preserved if their water activity (a_w) has a value 0.2–0.4. At that a_w level bacterial growth and toxin production is zero, browning and enzyme activity are rather low, and food oxidation reactions have a minimum rate (Rouweler, 1995). Drying sometimes considerably changes the texture, colour, flavour, aroma and nutritive value of foods (Fellows, 1988).

The white polythene solar dryer gives better drying regimes than black polythene which generates a lot of humidity inside the chamber and thus affects the drying of the product. The drying process take a minimum period of 24 hours and maximum of 30 hours in the solar dryers compared to the artisanal drying method which takes up to 48 hours, and thus shortens the drying time by 37.5%. The enhanced temperature in the drying chamber and inside fish muscle hastens the evaporation of water from the fish, causing faster drying. In general, rapid drying and high temperatures cause greater changes to the texture than do moderate rates of drying and lower temperatures. High air temperatures, particularly with fish, cause formation of a hard impermeable skin. Flavours are lost at high drying temperatures. Longer drying times and higher drying temperatures cause greater pigment losses. The tested solar dryer attained maximum temperature of 62.9 ºC and drying time of 30 hours. From the drying rhythms observed the system is efficient and effective .The observed drying ratios are in agreement with data from the product data sheet described by (Rozis, 1997). The water activity attained within 30 hours under solar dryer was 0.39–0.41 compared to 0.39–0.55 under open drying. The narrow range of water activity indicated that solar drying is actually more effective and efficient than open drying. The solar dried fish product is of higher quality, since it has significantly less sand, has firm texture, brown colour and fresh fish odour.

Drying parameters and organoleptic characteristics of the solar and artisanal dried products indicated that drying process occurred within the recommended conditions as described by Rouweler (1995). The colour of the products was dark brown indicating that the drying process was slow. After storage trials of up to six months there was no evidence of insect infestation.

The improved quality and extended shelf life of the fishery products dried in solar dryer may be attributed to two factors:

- Drying under solar, hence higher internal temperatures, ensures that the adult *Demestes maculatus is* kept off from the wet, drying fish and hence no deposition of eggs in the fish occurs; and
- Attainment of lower water activity of 0.39–0.41 after 30 hours. The lower water activity inhibits the hatching of insect eggs that could have been laid.

Cost benefit analysis

To evaluate the benefits of the live polyethylene solar dryer a simple cost benefit analysis was conducted based on the cost inputs of the dryer, the increase in selling price of the dried fish product and period of replacing the polyethylene paper and, therefore, savings in terms of revenue. The results presented in Table 3 show that the payback period is about 6 days for dryer whose capacity is 50 kg of fish. The durability of the polyethylene paper may be up to 2 months.

Table 3. Investment analysis for polyethylene solar dryer

Without solar dryer		**With solar dryer**	
Total fish (kg) processed	50	Total fish (kg) processed	50
Expected Price/kg (K Sh)	80	Expected Price/kg (K Sh)	120
Daily value loss/kg	40	Daily savings (kg)	40
Daily value loss/50 kg	2,000	Daily savings/50 kg	2,000
		Investments cost (K Sh)	12,000
		Payback period (days)	6

6. CONCLUSIONS AND RECOMMENDATIONS

Solar dryers are therefore more efficient and effective than direct sun drying and have lower operating costs than mechanized dryers. Solar dryers shorten drying time; improve product quality, long shelf life for products, reduce post-harvest losses and thus improved income to fishers.

Due to the limited time dedicated to the studies on insect infestation, further investigation is required to ascertain the exact stage of the supply chain when the infestation occurs and thus mitigate preventative measures.

It is recommended that this technology should be available to the end users through selected pilot sites along the Lake Turkana shores to assess acceptability and effectiveness. There are at least five ideal sites for pilot study, namely: Longech, Namkuse, Nachukui (Northern Island), Todonyang, Ile Springs, Loiyangalani, Moite and Illeret.

7. REFERENCES

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ANNEX I

Materials and cost estimates for the construction of a bamboo solar dryer

S/No.	Item description	Quantity	Estimated cost
1	Bamboo pole – 10’ long, 3" diam.	8 pcs @ 50	400
2	Bamboo pole - 6' long, 2" diam.	4 @ 50	200
3	0.125 mm X 240 cm UV-protected PE sheet	10m @ 350	3,500
4	1" common wood nails	1 kg @ 100	100
5	2" common wood nails	2 kg @ 100	200
6	Matt-1 pc	1 pc @ 120	120
7	Indirect costs		2,480
		Total	**7,000**

ANNEX II

Materials and cost estimates for the construction of a raised solar dryer

S/No.	Item description	Quantity	Estimated cost
1	Timber 2 x 2	100 ft @ 15	1,500
2	Cedar posts-9 ft	5 pcs @ 200	1,000
3	Timber 11/2 x 1 ft	60 ft @ 12	720
4	2" common wood nails	2 kg @ 100	200
5	1" common wood nails	1 kg @ 100	100
6	0.125 mm x 240 cm UV- protected PE sheet)	10 m @ 30	300
7	Wire gauze	10 m @ 350	3,500
8	Indirect costs		4,700
		Total	**12,000**