Modification and performance test of fish and *keumamah* dryer with solar energy sources

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**Abstract.** This present study aimed to modify and test the performance of fish dryer tunnel type. The size of the dryer will be reduced from its original size to 3 m x 2 m, which is adjusted to the volume of salted fish production in the local industry. Some modifications are also made according to the availability of materials on the market and also consider the drying time more effectively. To achieve the purpose, several procedures were performed: structural and functional design, drawings, assembly, and performance tests. Moreover, data analysis was carried out to measure optimum working capacity of the dryer. Obtained data from artificial dryer were compared with conventional drying. The results showed that natural convective drying required at least five and seven days for *keumamah* salted fish drying respectively. In contrast, forced convective drying by means of modified tunnel dryer shortened the drying period to three and five days for *keumamah* and salted fish respectively. Furthermore, the optimum loading capacity of the modified tunnel dryer is 30 kg of fish and required days of drying period.

1. Introduction

Fish is one of the most consumed foodstuffs and popular for the people due to high nutritional value and source of protein from animal [1,2]. In addition, fish also contains fats and minerals needed by humans for their development. In contrast, fish is tended to rapidly decay and perishable after captured. Abundant fish production in coastal areas required extensive post-handling in order to maintain fish quality [3].

Several techniques and methods are widely employed in preserving fish, among others are: salting, blenching, smoking, drying, and refrigerating as well as transforming it onto derivative products such as processed fish [4]. Salting is one the most common fish preservation in many coastal communities since this method is simple, cheap and easy to perform. Salted fish is a food made of fish meat preserved with co-added of salt accordingly. By preserving fish as salted one, fish can be stored at room temperature for a longer period compared to un-salted ones. In addition, salted fish can also avoid physical damage due to infestations of insects, grubs, flies and some other vandal remains miniscule [5]. Making salted fish is the easiest technique to save fishmen’s catch. After salting, fish must be dried and usually in an open area using direct sunlight. However, in serving salted fish requires a relatively long drying period and relies on climate condition.

Another way in preserving fish made by fisherman and coastal communities especially in Aceh province, is transforming fish onto *Keumamah* (similar to boiled fish). It is one of the typical food sources of Aceh made from raw and fresh fish in which usually tunaf fish. *Keumamah* is made by first boiling, then dried using conventional heat transfer method. After half dry, the boiled fish is sliced...
thinly using a knife, then dried until reach homogeneous states. In order to consume, fish are soaked in warm water for about 15 minutes until its textures tend to soft [6].

Drying salted fish and *keumamah* practiced by the community so far is still conducted by natural heat transfer, by means of drying which utilizes solar energy directly. This method is usually dried by placing the product on fishing nets, mats, a stretch of cement floor, hanging trays, woven bamboo and placed in the open in dryer the sun. This method is not very hygienic and can cause high yield loss rates because the fish being dried in the sun is eaten by birds, insects, cats and other animals. In addition, the product will be easily exposed to dust and easily contaminated which can interfere with consumer health. These problems cause the number and quality of production not as expected [7]. Therefore, it is necessary to design a fish dryer that can help the community by producing high quality products with a shorter drying period. Dryer was designed using the greenhouse effect principle which still utilizes heat from sunlight. Solar dryers for fish can be formed from transparent rooms that utilize the greenhouse effect and can also add solar collectors connected to the drying chamber [8].

2. Material and Methods

This research started with preliminary study from which we investigated the weaknesses of the available dryer. Then, modification was performed in accordance with the results of the preliminary evaluations. Based on evaluation results, tunnel type dryer for the salted fish drying were redesigned properly. The design procedure consists of determining the structural and functional criteria in such a way meets the expectations. Dryer was then assembled and proceed with the performance test. Data analyses were then carried out to calculate working and loading capacity.

2.1 Materials

Materials used for designing and manufacturing fish dryer are plywood, iron (40x40 mm), zinc, wood planks, hollow iron (30x30 mm), iron plate (1 mm), aluminum plate (1 mm), wheels, black paint, fans, plastic, zinc clamps and glue. Materials and general equipment used are carpentry materials consisting of electrical equipment, nails, bolts, hammers, brackets, hacksaw, pliers, screwdrivers, gauges, scales, rollers and pencils. While the materials and equipment used for the functional testing of the modified dryer are pompana fish for making salted fish as much as 60 kg and tuna for the making of common fish as much as 60 kg.

2.2 Design

The design includes functional designs to determine the function of main components and structural designs to determine the shape, material, and layout of the designed dryer. Solar tunnel fish dryer consists of several main parts, namely the bottom and roof frame, drying chamber, absorber plate, blower and cover.

2.2.1 Functional and Structural Criteria

Functions of solar power tunnel-type fish dryer component designed are:

- **Bottom frame**: primarily serves as a backdrop for the support and attach to other parts of the solar tunnel type fish dryer.
- **Roof frame**: major part of the solar tunnel type fish dryer, which is the base for the solar tunnel dryer.
- **Dryer chamber**: serves as a place for the material to be dried. The absorber: defined as a solar collector that acts as a part of the solar heat absorber which then transmits heat to the dryer supported with a blower.
- **Cover**: used to keep the air conditioning of the dryer warm and so that the heat energy inside the dryer is not affected by the outside air.

2.2.2 Engineering design

Fish dryer designed based on established structural and functional criteria. Engineering design contain information about the location of the components of the fish dryer as it reflects the actual prototypes as presented in Figure 1.
2.2.3 Assembly and performance test

Each component was assembled into a tunnel dryer with proper positions as presented on the engineering design. The performance test of the tool is carried out to find out which dryer has been designed to function properly. Functional testing needs to be done to investigate drying yield of fish produced and the main instruments can work well such as absorber plates, fans and ventilation.

Analysis was carried out on the working capacity of the dryer and yield of salted and common fish, both in drying using a solar tunnel type fish dryer and traditional drying that is commonly carried out by the community. The test was carried out using 30 kg of pompana fish each using traditional tools and methods, and 30 kg of tuna for traditional tools and methods.

Working and loading capacity is expressed as:

\[ B = \frac{W}{T} \]

where
- \( B \): Dryer capacity (kg / hour)
- \( W \): Total weight of dried material (kg)
- \( T \): Drying time (hours)

yield is calculated as:

\[ R = \frac{S}{P} \times 100\% \]

where
- \( R \): yield (%)
- \( S \): fish mass after drying (kg)
- \( P \): fish mass before drying (kg)

3. Result and discussion

3.1 Modification results

The modification of this solar tunnel type fish dryer aims to improve the efficiency of the dryer. Where the weakness of the pre-designed dryer is found before modification, including the rectangle of the one
sided dryer is too wide (8 meters) causing uneven air circulation in the drying chamber so that the dry level of the material becomes uneven and tends to occur in the drying chamber. After modification, the drying results look more even shorter and the drying time is shorter.

The solar tunnel type fish dryer is designed with the aim of increasing the quantity and quality of the dried product. The design is focused on the ability of the tool to dry the product in a shorter time, produce more hygienic products and create working comfort for producers of salted fish and *keumamah*. As an alternative to shorten the drying time is by raising the temperature in the drying chamber with the help of an absorber plate as a heat absorber obtained from sunlight and with the presence of a transparent cover, heat is trapped in the drying chamber. In other words, this dryer uses the principle of the greenhouse effect. The working mechanism of this modified dryer is, first place the dryer in an open place that gets sunlight. Next put the material into the drying chamber, then turn on the fan that functions as a blower. After half a day, the fish is turned over to dry evenly. Figure 2 shows an image of the traditional drying process and uses a designed dryer.

![Figure 2. Comparisons between conventional and artificial drying](image)

3.2 Working capacity of designed dryer

The results working and loading capacity of the solar tunnel fish dryer and conventional direct sunlight drying is presented in Table 1.

| No | Drying method         | Working capacity |
|----|-----------------------|------------------|
| 1  | conventional          | 30 kg/5 days     |
| 2  | solar tunnel fish dryer | 30 kg/day       |

Drying time greatly affects the working capacity of the dryer. Based on Table 1, it can be seen that drying using a solar tunnel type fish, capable of drying fish within 2 days, very short when compared to conventional direct sunlight drying, requires 5 days to complete.

3.3 Yield

The results of the calculation of salted fish yield and *keumamah* obtained from the fish dryer type solar tunnel can be seen in Table 2. From 30 kg of fish samples dried by means of tunnel dryer, salted fish obtained as much as 7.5 kg. While from 30 kg of tuna, resulted 13.5 kg of *keumamah*. The premium yield is higher because the product has a higher final moisture content. While salted fish have a low final moisture content.
Tabel 2. Yield of salted fish and *keumamah*

| No | Type of product | yield |
|----|----------------|-------|
| 1  | Salted fish    | 25    |
| 2  | *Keumamah*     | 45    |

4. Conclusion
Based on obtained result, it may conclude that modified and reconstructed of solar tunnel fish dryer has been completed through design and assembly stages. The artificial solar tunnel dryer generated working capacity reach 30 kg / 2 days while conventional drying reaches 30 kg / 5 days respectively. Moreover, the yield of solar tunnel dryer produced 25% of salted fish and 45% of *keumamah*.

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