Performance of a Forced-Convection Greenhouse Dryer for Fish Drying

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Abstract

This research present experimental performance of a forced convection greenhouse dryer for drying of fish.The greenhouse dryer was installed at Aceh province, Indonesia. It has a concrete floor with the area of 6×4 m^2. The roof of dryer is built in semi-cylindrical shape and covered with transparent polycarbonate sheets. Two axial flow fans powered by a 50-watt solar cell module was used to generate forced convection for ventilating the dryer.To investigate its performance, the dryer was used to dry two batches of fish.The Results showed that to dry 50 kg fish with initial moisture 68 % required 11 hours. Incontrast, to dry the same amount of fish using sun drying take a time about 2 days. The air temperature inside greenhouse dryer at noon in the clear day was 45-55°C.

Keywords: Performance**,** Solar Drying, Forced-Convection, Greenhouse Dryer, Fish Drying

Kinerja Pengering Rumah Kaca Dengan Metode Konveksi Paksa Untuk Pengeringan Ikan

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Abstrak

Penelitian ini memperlihatkan hasil percobaan terhadap kinerja pengering rumah kaca dengan metode konveksi udara secara paksa pada pengeringan ikan. Penelitian pengering rumah kaca ini dilakukan di Propinsi Aceh, Indonesia. Pengering ini berlantaikan beton dengan luas sebesar 6x4 m^2. Atapnya dibuat berbentuk semi-selinder dan ditutup dengan lembaran plastik transparan berbahan polikarbonat. Dua buah kipas dengan aliran udara secara aksial dipasang dengan sumber daya berasal dari panel surya sebesar 50 Watt dan dipakai untuk menghasilkan konveksi udara paksa pada ventilasi pengering. Untuk menginvestigasi kinerja rumah kaca ini, pengering ini digunakan untuk mengeringkan dua tumpukan ikan. Hasilnya menunjukkan bahwa untuk mengeringkan sebanyak 50 kg ikan dengan kadar air awalnya sebesar 68% membutuhkan waktu selama 11 jam. Sebaliknya, dengan menggunakan sinar matahari secara langsung, untuk mengeringkan ikan dengan jumlah yang sama, maka waktu yang dibutuhkan lebih lama yaitu sekitar 2 hari. Suhu udara di dalam rumah pengering tepat pada siang hari yang cerah berkisar antara 45-55^oC.

Kata kunci: Kinerja, Pengeringan Sinar Matahari, Konveksi paksa, Pengering Rumah Kaca, Pengeringan Ikan

I. INTRODUCTION

Fish drying like other traditional fish processing, is an important economic activity in coastal village communities. It has multiplier effects on economic activities in the Aceh, specifically providing employment opportunities, adding value to products and improving fishermen's income.

Conventionally, most fishermen preserve fish by drying it in solar radiation. Unluckily, this proces contains a large number of dissuperiority. It could not work at rainy and windy condition, disable to protect product from dust and easy to catch by fly and other animal. On the otherside, handmade dryer also has some limitation such as less and expensive energy consumption that lifting up production cost.

Recent technology for food drying tends to use solar radiation as main source of energy. Food drying based on solar energy has widely applied due to it can maintain hygienies and clean of product. The important thing is less energy cost and environmentally.

Brenndorfer [1], stated that passive solar dryer is suitable applied for drying small amount of agriculture products. Meanwhile, an active solar dryer is preferred to work at large amount of agriculture product and operated countinuesly. In addition, it can be hybrid with other energy resources when solar energy is not appropriate enough to generate energy.

Nowadays, a lot of active solar dryer types have been developed. Among of the active solar dryer types that shown good visibility is greenhouse solar dryer. It is not complicated construction and less expensive [2-4].

This paper presents complete description of research report of greenhouse solar dryer.

Construction of drying chamber

This research was conduct at an integrated small fish processing unit in Lancang village, Pidie Jaya district. This region lay on latitute 5.28 ^{o}N and 96.13 ^{o}E. The drying chamber was built in from hollow steel frame with dimension length 6 m, width 3.5 m and height 2.75 m. The roof dryer chamber is construct folowing hemisphere shape. The chamber is covered by a thin layer of transparant *polyethylene* with 0.007 m thicness, as shown in Fig 1.

The greenhouse solar dryer consist of three trays to locate the products. The trays are covered by black thin net polymer. Two axial flow fans powered by a 50 –watt solar cell module attached on top of dryer about 2 m form floor surface.

II. METHODOLOGY

To investigate some parameters effecting to solar dryer performance, various measuring devices were installed. Apyranometer (LI-COR LI200) was used to measure incident solar radiation ontop of the roof of the greenhouse. Thermocouples type Jwere used to measure air temperatures in the dryer and ambient air. The outlet air speed from the dryer was monitored by an anemometer. To measure the relative humidity of the air, a hygrometer was employed. The electrical signal from the thermocouples and the pyranometer was recorded with a 24-channel data logger (34970A *Data Acquisition Agilent)*. The air speed and the weight of fish samples were manually recorded. These fish had an initial moisture content of about 68% (wb). They were dried to the final moisture content of 30 % (wb). Two experiments were conducted. Fifty kilogram of fish was used for each experiment. In the experiments, fish were cleaned and spread on the trays in the dryer. There are three levels of the trays namely, upper trays, middle trays and lower trays. The drying started at about 7:00 a.m. and stopped at about 6:00 p.m. Samples of fish in the dryer were weighted at 1-hour interval for the determination of the moisture.

III. RESULTS AND DISCUSSIONS

This research was started on February 12, 2011 within two days by drying 50 kg of anchovy fish.Based on solar radiation measurement, as shown in Fig 2; the maximum solar radiation is about 923 W/m^2 that happened on Februari 12, 2012 at 1:50 AM. While, on February 15, 2011 at 2:30 AM, and the maximum solar radiation achieved 988 W/m^2.

Fig1. Greenhouse solar dryer chamber

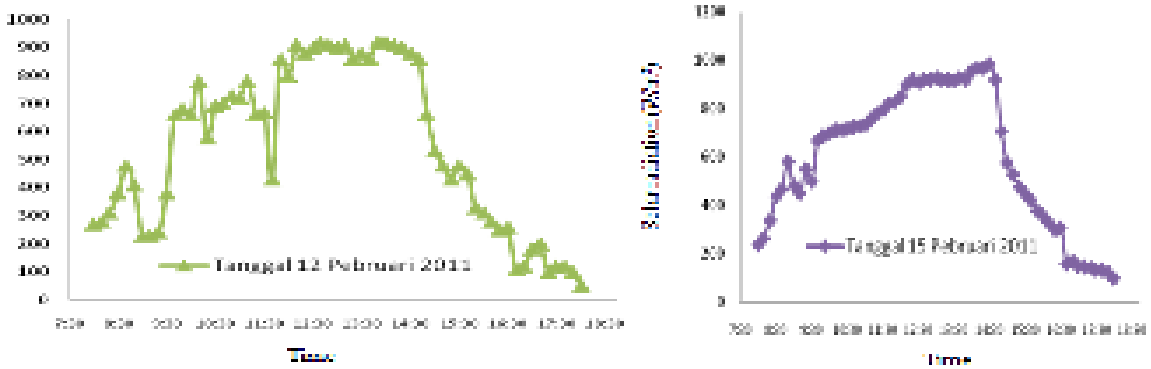

Fig2. Solar radiation measurement results

Measurement results of moisture changeable within anchovy fish presented in Fig.3. Measurement of weight change of fish is taken into every 30 minutes using random methods at three levels of the trays. In the graph clearly shown that the moisture contained in fish change rapidly at initial measurement testing. It can be concluded that moisture content at fish skin is remove drastically as proportional to temperature in drying chamber increase. Refer to all measurement and testing result in this research stated that final fish moisture contained is about 28 % at 11 hours drying time. By initial fish moisture content at about 65% clearly said that drying rate is 3.29 %/hour. Based on visually observation, the drying process occurs at the entire levels of the trays. Whereas, there were no colour changes happened during observation.

Meanwhile, result of measurement relative air moisture into drying chamber as shown in Fig. 5.

Based on graph in Fig 5, shows that air moisture in drying chamber able to achieve at 22 – 25%. It means air circulating process inside of chamber has been done quite good. Then, air has absorbed water inside of fish, the moisture raise gradually as shown in Fig 5. Total amount of water going out from drying chamber is below total amount of air inside of chamber. The air inside of chamber has ability to absorb a kind of dry material. Since, recirculating process inside of drying chamber is still possible to do.

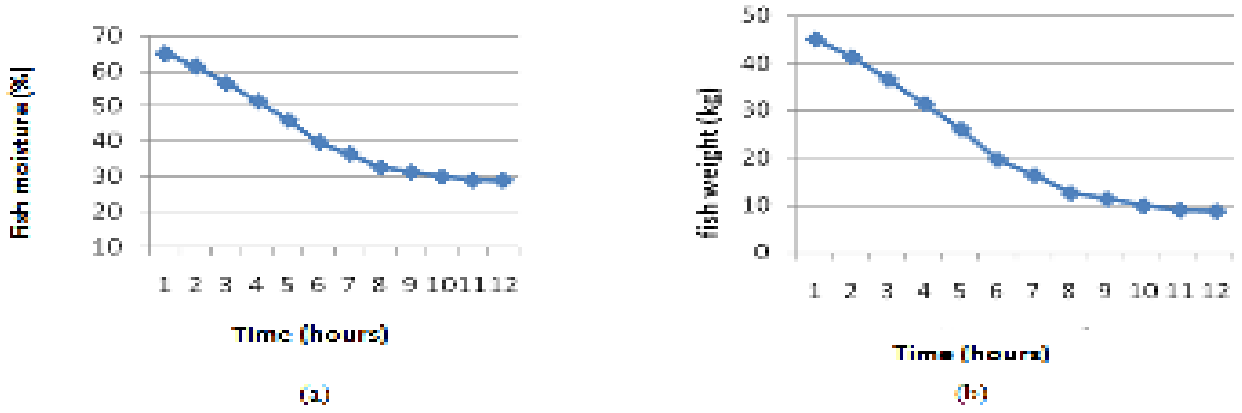

Fig3. a) Measurement result of fish moisture content, b) Measurement of mass change of fish during drying

Based on measurement result, shown that mass of fish decrease due to water diffusion within of material to air in drying chamber. Suppose to initial fish mass is 45 kg, then during 11 hours of drying time, it will decrease amount of mass up to 8.6 kg. Mass change of fish is shown in Fig. 3b.

In this research air temperature in and out within drying chamber are measured. For air temperature out of dryer is measured in front of fan. Fig 4 shows temperature distribution of air out from drying chamber. In the graph, describing that at solar provides maximum radiation, the air out of dryer achieving up to 45 ^{o}C. It means there is a possibility to recirculate air to drying chamber.

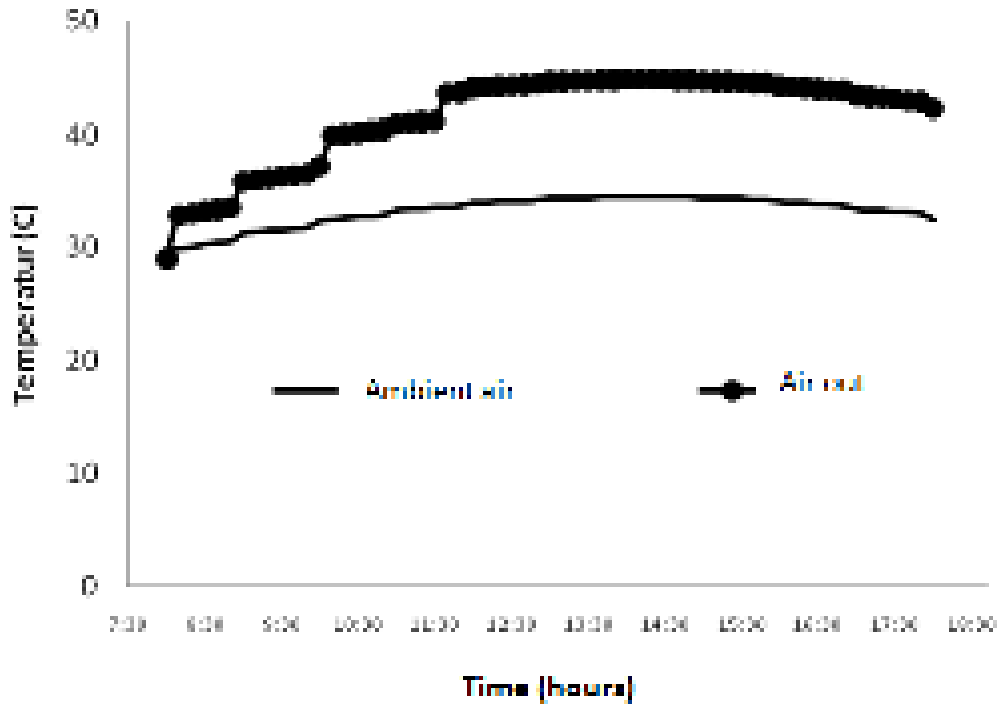

Fig 4.Measurement result of air out temperature of drying chamber

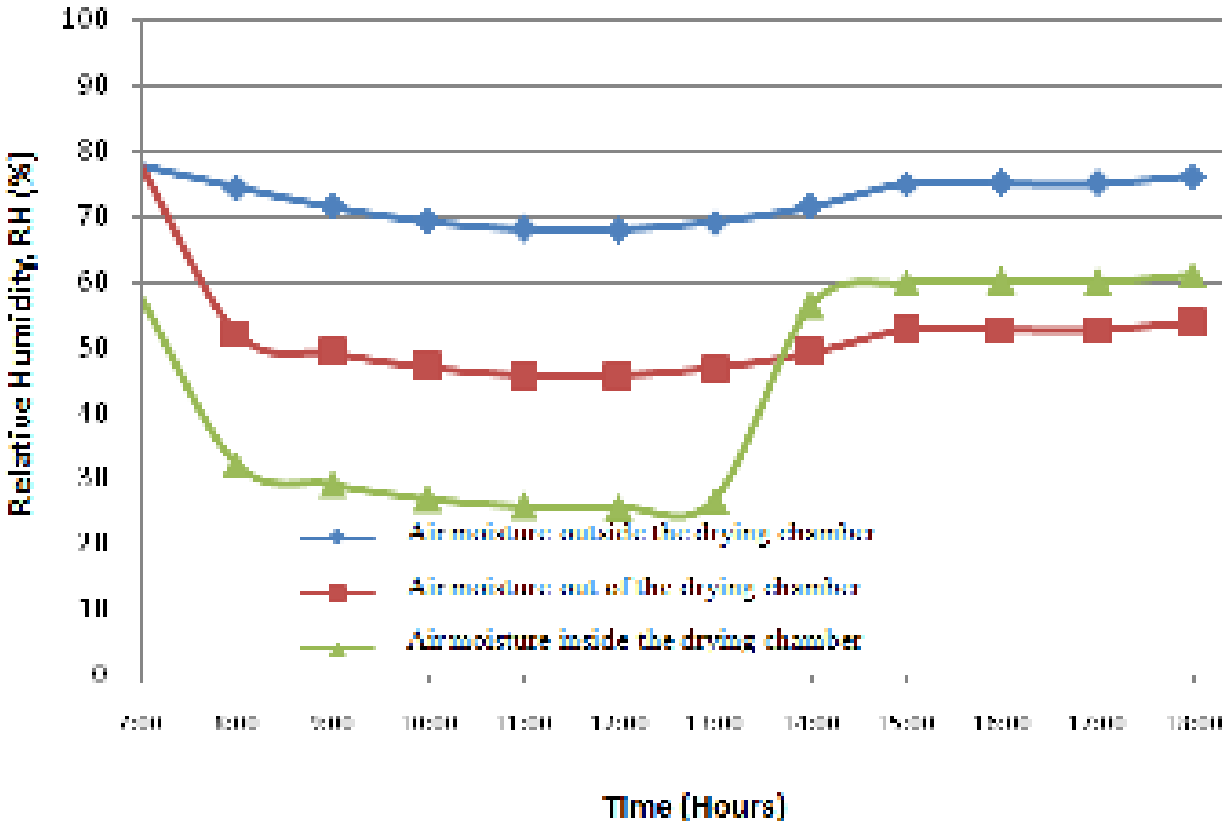

Fig 5.Measurement result of air moisture drying chamber

IV. CONCLUSION

1. It has been developed a unit of greenhouse solar dryer to preserves fish. It dimension is length 6 m, width 3.5 m and height 2.7 m. Since, base on this research can be concluded:
2. Air moisture outside drying chamber shows that at 7.00 water contained quite high due to a greenhouse solar dryer installed 200 m from coast area.
3. Solar radiation maximum is measured during this research 988 W/m^2at 2 AM.
4. Testing result presents that water content in fish is about 28%, during 11 hours of driying time and base on visual observation drying rate 3.29 %/hour.

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