Semesta Teknika
Vol. 26, No. 2, 203 - 213, November 2023
DOI: https://doi.org/10.18196/st.v26i2.17077

Study the Applicability of a Shelf-Type Fish Drying Machine with a Heat Source from Coconut Shell Biomass

Agus Sulistyo Budi, Mohammad Samsul Bakhri*, Yuli Nurasri, Aghna Ilma Nurdin Suripto, Sultan Krisna Amir, Rojikin
Mechanical Engineering, Politeknik Purbaya

Jalan Pancakarya Nomor 1, Talang District, Tegal Regency, Central Java, Indonesia

*Corresponding author email: moh.samsulbakhri@gmail.com

Keywords:
dryer; coconut shell; shelf type; temperature

Abstract
The sun's heat is usually utilized to dry traditional processed salted fish. However, its quality suffers as a result of the lengthy drying process. This issue can only be resolved with the help of efficient drying equipment. Advantages of artificial drying include selecting the drying capacity according to requirements, without requiring a considerable space, and managing the drying conditions. This research aims to discover an effective way to utilize biomass waste from coconut shells to speed up the drying process for salted fish. The study method involved several steps: acquiring data, analyzing the tools and machine, observing the machine, and designing a new machine. The three airspeed parameters tested in this study were 7 m/s, 10 m/s, and 12 m/s. The drying shelf reached a maximum temperature of 81.4 °C at 7 m/s, 100.3 °C at 10 m/s, and 99.4 °C at 12 m/s.

INTRODUCTION

Fish is a source of animal protein that is widely consumed by the public, is easy to obtain, and is cheap (Margono et al., 2000). Energy needs in the world are increasing with the increasing number of human populations and the use of technology. This increase is not balanced by an increase in energy sources, especially fossil fuels. So many studies use biomass fuel as an energy source (Tung et al., 2009; Sylvia, et al., 2015).

Salted fish is a common byproduct of the fish-processing industry. Conventional drying methods for salted fish products include exposure to heat from the sun. The drying process takes quite a long time, and the quality of the product is partly poor (Ruus, 2009).

Processed salted fish in coastal locations is frequently dried traditionally, meaning directly in the sun, where the drying process takes a long time, and the quality of the product is not excellent. To address this issue, it is required to utilize more appropriate drying equipment (Samsul, 2001; Suharto, 2014; Swamee, et al., 2009).

Compared to natural drying methods, which are limited by the weather and the available space, mechanical drying (artificial drying) employing extra heat has several advantages. Heating the drying tool, compensating for the radiation heat lost from the tool, heating the material, evaporating the water from the material, and moving the air are all energy-intensive processes necessary for this artificial dryer to function.

Biomass waste, such as coconut shells, which includes active carbon as an alternative fuel or new and sustainable energy, is not yet optimized. Coconut shell husks are a common form of disposable energy. As a result, this coconut shell waste can be converted into green energy (Soekarto, 1991; Winarno, 1980).

A shelf-type drying machine is an alternative for drying salted fish with a heat source from coconut shells. This study primarily aims to (1) design a salted fish shelf-type drying machine with a coconut shell heat source, (2) test the performance of the salted fish shelf-type drying machine, and (3) observe changes in water content in salted fish.

Previous research findings discussing the use of LPG gas fuel for drying have been reported by Juwita and Rusli (2018). This research emphasizes the development of a technological system with fuel using coconut shell biomass waste. Therefore, this research focuses on new renewable energy and environmentally friendly technology.

Characteristics of the temperature that occurs in the air entering the dryer in the drying bath. The temperature in the drying tank is divided into 3, namely the temperature of the left, middle and right side of the drying tank to determine the temperature distribution in the dryer (Soeseno, 1985). The maximum temperature entering the dryer in treatment 1 was up to 55,56^{o}C but the average temperature that occurred from the beginning to the end of the process was 40,08^{o}C. Meanwhile, the maximum temperature in the drying tank reaches 43,11^{o}C. This phenomenon is different from the simulation carried out for shelf type drying with temperature distribution on shelves 2, 3 and 4 where the average temperature reaches 80^{o}C (Al-Kindi et al., 2015).

Thermal efficiency reaches a maximum of 70% at maximum air speed, but the temperature change under this condition is smaller because there is a thermal deficit (Setyaningsih et al., 2010). The optimum thermal conditions in this drying process occurred in experiment 2 which resulted in an average temperature difference during the process in the drying tank reaching 4,6^{o}C with an air speed of 3,89 m/s and was able to reduce the water content by up to 35,9%, resulting in a thermal efficiency of 29,6%. This result is lower when compared to drying water hyacinth using a vacuum drying oven where the efficiency can reach 35% at a temperature of 50^{o}C (Prasetyaningrum, 2010). However, when compared with rack type drying. Test results using wood charcoal fuel with a capacity of 50 kg and using a blower which produces an efficiency of 23,54%, research on the use of waste heat for the water hyacinth drying process is better (Purbono et al., 2010).

RESEARCH METHOD

This research put several methods into practice: (1) field observation to determine the average temperature in conventional drying of salted fish; (2) making a design concept; (3) designing the drying equipment; (4) assembling the drying equipment; and (5) testing dryer performance.

Dryer design concept

The design concept for a salted fish dryer included a heat exchanger, drying shelf, combustion furnace, chimney, drying chamber exhaust, and environmental air intake.

Testing method and experimental setup

This drying machine test was carried out three times for each measurement, with airspeed parameters of 7 m/s, 10 m/s, and 12 m/s. Figure 1 displays the experimental setup. Data were collected based on the machine parts—the points of air fluid flow in the salted fish drying machine.

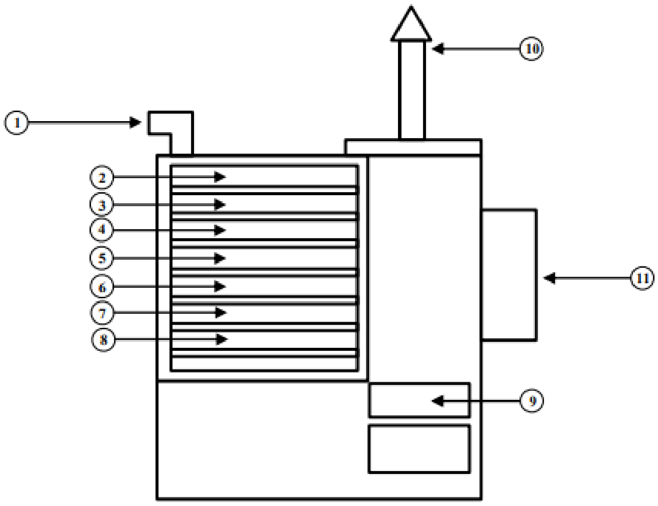

Figure 1. Experimental setup method

The experimental setup, as displayed in Figure 1, demonstrates the data collection points performed on the salted fish drying machine with the following information: (1) Temperature data collection on the blower exhaust or air flow utilized a 4-channel digital thermocouple with a bead probe thermocouple cable. (2) Temperature data collection on the first drying shelf employed a digital thermocouple with a built-in thermocouple. (3) Temperature data collection on the second drying shelf deployed a 4-channel digital thermocouple with a bead probe thermocouple cable. (4) Temperature data collection on the third drying shelf applied a digital thermocouple with a built-in thermocouple. (5) Temperature data collection on the fourth drying shelf implemented a digital thermocouple with a built-in thermocouple.

Tools and material

This study employed equipment encompassing a shelf-type salted fish dryer with heat source energy from coconut shells, a stopwatch, a blower, a thermometer, a thermocouple, and an anemometer. The material was fish from Tegalsari Village, West Tegal District, Tegal City.

RESULTS AND DISCUSSION

The designed salted fish drying machine comprised several components: heat exchanger, drying shelf, combustion furnace, chimney, drying chamber exhaust, and environmental air intake. This salted fish drying machine, measuring 80 x 30 x 90 cm, had a capacity of 4 kg and utilized a shelf-type drying system with coconut shell biomass as an energy source.

The machine had several components: the blower fan frame and cover, heat exchanger, combustion furnace, and drying shelf. The frame functioned to support the machine components. Apart from that, it also had to withstand the loading forces. Apart from its solid design, the frame was designed to move quickly.

Figure 2. Dryer frame

Figure 3 exhibits the intake blower cover functioned to protect the intake blower. This intake blower cover could limit the heat exchanger to the intake blower, producing maximum air. It had 36 x 36 cm dimensions, with a 3 x 3 cm angle iron.

Figure 3. Blower intake cover

As illustrated in Figure 4, the heat exchanger functioned as a heat conductor for the engine. It was produced from burned coconut shell biomass and released hot air, sending smoke from the combustion out through the chimney. The heat exchanger was 30 x 30 x 60 cm, with 12 tubes and a six baffle design.

Figure 4. Heat exchanger

Figure 5 portrays the combustion chamber, or biomass fuel burning furnace, as a room for burning coconut shell biomass—a heat source in the drying process. This combustion chamber measured 30 x 30 x 10 cm.

Figure 5. Fuel-burning furnace

Figure 6 illustrates the drying shelf, serving as a container for materials placed in the drying room. This shelf measured 40 x 30 cm and was made from woven bamboo. There were seven shelves with a distance of 6 cm between units.

Figure 6. Drying shelf

Figure 7 displays the overall design results of the shelf-type salted fish drying machine.

Figure 7. Shelf-type salted fish drying machine

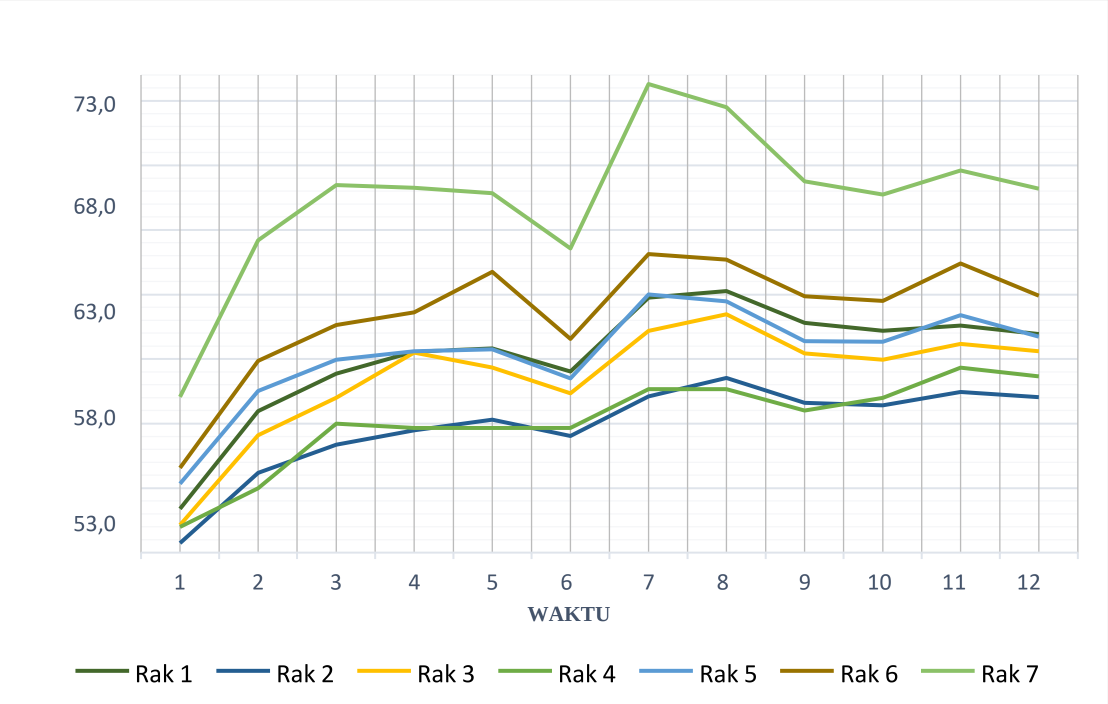

Figure 8. Average drying shelf temperature with a parameter of 7 m/s

Figure 9. Average drying shelf temperature with a parameter of 10 m/s

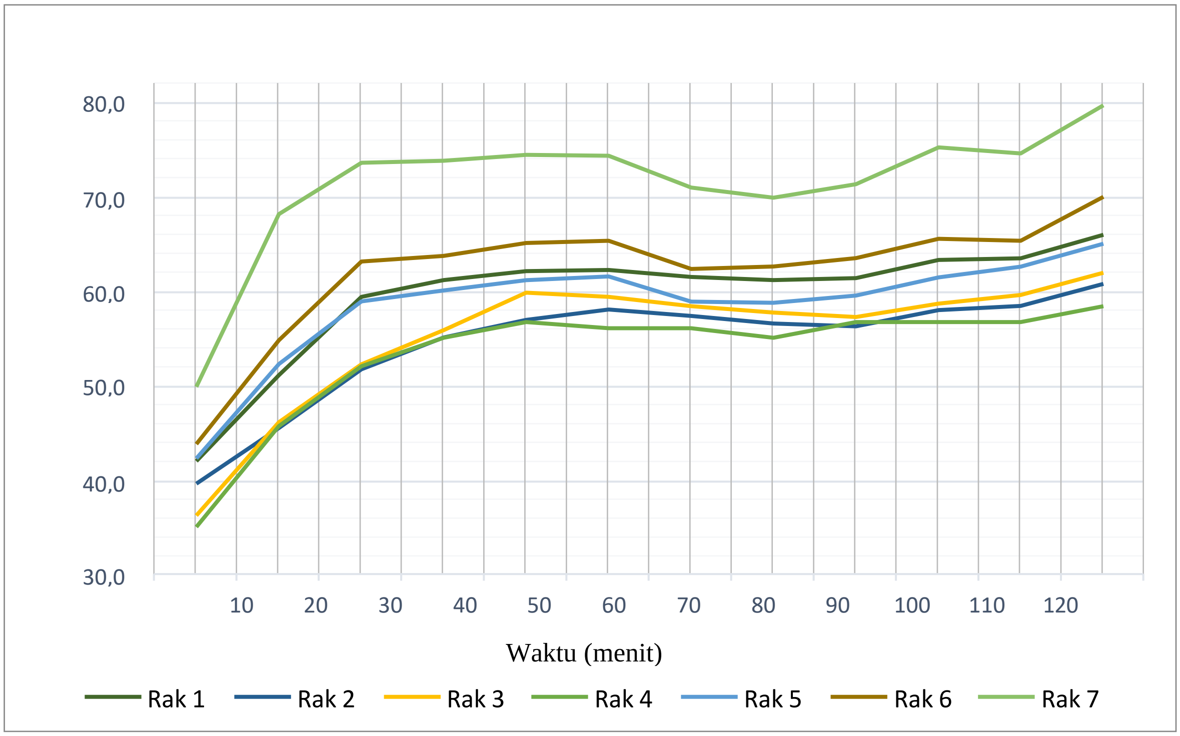

Figure 10. Average drying shelf temperature with a parameter of 12 m/s

The different input volumes of coconut shells as biomass fuel every 10 minutes caused the combustion furnace to produce unstable or highly fluctuating temperatures. The more the volume of biomass fuel put in the combustion furnace, the higher the temperature. Environmental factors also caused the temperature graphs to fluctuate significantly—the environmental temperature outside the salted fish drying machine, which later entered the blower intake.

The data for each parameter testing were processed, generating an average of the experimental setup points as well as the lowest and the highest temperatures. Tables 1, 2, and 3 display the average values for each part in the salted fish drying machine for each parameter.

Table 1. Average, Minimum, and Maximum Temperatures at the 7 m/s Parameter

No	Part Name	Average (°C)	Minimum (°C)	Maximum (°C)
1	Exhaust	46.7	40.4	53.6
2	Drying Shelf 1	53.3	40.5	64.6
3	Drying Shelf 2	47.8	38.2	58.8
4	Drying Shelf 3	51.6	38.5	63.1
5	Drying Shelf 4	48.2	35.0	65
6	Drying Shelf 5	53.4	40.6	67.1
7	Drying Shelf 6	56.5	41.8	72.8
8	Drying Shelf 7	65.5	46.3	81.4
9	Furnace	310.7	162.7	425.2
10	Chimney	74.1	47.3	140.3
11	Intake	36.0	31.4	40.8

Table 2. Average, Minimum, and Maximum Temperatures at the 10 m/s Parameter

No	Part Name	Average (°C)	Minimum (°C)	Maximum (°C)
1	Exhaust	56.4	42.9	73.6
2	Drying Shelf 1	59.7	40.9	82.7
3	Drying Shelf 2	54.5	38.8	75.9
4	Drying Shelf 3	55.3	33.6	76.9
5	Drying Shelf 4	53.3	30	70
6	Drying Shelf 5	58.6	41.6	82.3
7	Drying Shelf 6	62.1	42.4	88.
8	Drying Shelf 7	71.4	45.9	100.3
9	Furnace	359.1	217	565.8
10	Chimney	123.3	66.9	211
11	Intake	37.3	32.3	43.7

Table 3. Average, Minimum, and Maximum Temperatures at the 12 m/s Parameter

No	Part Name	Average (°C)	Minimum (°C)	Maximum (°C)
1	Exhaust	53.3	42.7	67.7
2	Drying Shelf 1	55.4	44.5	72.5
3	Drying Shelf 2	50.7	39.3	65.1
4	Drying Shelf 3	52	41.9	67.3
5	Drying Shelf 4	49	35	69
6	Drying Shelf 5	53.4	42.2	71.4
7	Drying Shelf 6	56	43.3	77.7
8	Drying Shelf 7	66.7	47	99.4
9	Furnace	261	136.1	467.9
10	Chimney	88.6	50.5	146
11	Intake	35.7	32	41.3

The simplified data tables unveiled various average temperatures of the combustion furnace following the parameters. At the 7 m/s parameter, the temperature reached 310.7 °C. The parameter of 10 m/s generated the highest temperature of 359.1 °C. In contrast, the parameter of 10 m/s produced the lowest average temperature of 261 °C.

CONCLUSION

Several factors led to differences in temperature for each shelf. The distance of the shelf to the furnace emerged as one factor causing the temperature differences. The closer the shelf was to the furnace, the higher the shelf's temperature. In this case, the bottom shelf had the highest temperature than those above it.

The distance and surface area of the iron wall of the machine to the shelf contributed as the second factor causing temperature differences. The closer the shelf was to the top or bottom wall, with a large surface readily conducive to heat from the furnace and heat exchanger, the higher the temperature.

In sum, the optimal temperature of the drying shelf for salted fish ranged between 50 °C and 60 °C, not exceeding 70 °C. Hence, the most optimal parameter used in drying salted fish was the airspeed parameter of 12 m/s because the average temperature range on the conventional shelf was 49.0 °C to 66.7 °C—the optimal temperature for drying salted fish. The sixth shelf or the shelf above the bottom shelf could dry the salted fish optimally at airspeed parameters of 7 m/s and 10 m/s, while the fifth shelf from the top was at the parameter of 10 m/s. Suppose the highest temperature achieved by this salted fish drying machine system is desired. In that case, the parameter 10 m/s produces high temperatures. Moreover, the highest temperature peak was on the bottom or seventh shelf.

ACKNOWLEDGMENT

The authors would like to express gratitude to LLDIKTI Region VI for funding this study under the Penelitian Dosen Pemula scheme, as well as to the members of the research team.

REFERENCES

Al-Kindi, H., Purwanto, Y. A., & Wulandani, D. (2015). Analisa CFD aliran udara panas pada pengering tipe rak dengan sumber panas energi gas buang, *Jurnal Keteknikan Pertanian*, *3*(1), 9-16. https://doi.org/10.19028/jtep.03.1.%25p

Juwita, A. I., & Rusli, A. (2018). Inovasi oven pengering ikan hemat energi untuk masyarakat usaha ikan asin Kabupaten Barru. *Jurnal Dinamika Pengabdian*, *3*(2), 202-210. https://doi.org/10.20956/jdp.v3i2.4251

Margono,T., Suryati, D., & Hartinah, S. (2000). Ikan asin cara kombinasi penggaraman dan peragian (Ikan peda). "http://www.warintek.ristek.go.id

Prasetyaningrum., A. (2010). Rancang bangun oven drying vacuum dan aplikasinya sebagai alat pengering pada suhu rendah. *Jurnal Riptek*, *4*(1), 45-53.

Purbono, K., Ainuri, M., & Suryandono., S. (2010). Rancang bangun dan uji kelayakan finansial alat pengering mekanis untuk pemenuhan pasokan enceng gondok (Eichhornia Crassipes) sebagai bahan baku kerajinan. *Agritech, 30*(2), 80-89. https://doi.org/10.22146/agritech.9677

Ruus. O. V. (2009). *Pengaruh konsentrasi larutan garam dan lama pengeringan terhadap mutu ikan layang* (*Decapterus* sp) *asin dengan kadar garam rendah*. Skripsi. Fakultas Perikanan dan Ilmu Kelautan Universitas Sam Ratulangi. Manado.

Samsul, B. (2001). Eceng gondok. Mesinku. Proceeding National Symposium on Thermofluids VIII 2016 Yogyakarta 25, 107-111.

Setyaningsih, D., Anton, A., & Maya, P. S. (2010). *Analisis sensori untuk industri pangan*. IPB Press.

Soeseno, S. (1985). *Teknik penangkapan dan teknologi ikan*.Yasaguna.

Soekarto, S. (1991). *Penilaian organoleptik untuk industri pangan dan hasil pertanian*. IPB Press.

Suharto, D. (2014). Rancang bangun mesin penggilas dengan penggerak bervariasi digunakan pada kelompok usaha enceng gondok. *SNST Ke-5*. Semarang: Teknik Mesin Fakultas Teknik Universitas Wahid Hasyim.

Swamee, P., Aggarwal, N., & Bhobhiya, K. (2009). Optimum design of cyclone separator. *AIChE* , *55*, 2279-2283. https://doi.org/10.1002/aic.11837

Sylvia, N., Maryana, M., Elwina, E., & Bindar, Y. (2015). Analisa pengaruh geometri tinggi konis dan diameter hidraulik ash hopper terhadap kinerja siklon persegi menggunakan metoda CFD (Computational Fluid Dynamic). *Jurnal Integrasi Proses*, *5(2)*, 94-100. http://dx.doi.org/10.36055/jip.v5i2.242

Tung, N. D., Steinbrecht, D., & Vincent, T. (2009). Experimental investigation of extracted rapeseed combustion emissions in a small scale stationary fluidized bed combustor, Energies, 2, 57-70.

Winarno, F. G., Fardiaz, S., & Fardiaz, D. (1980). *Pengantar teknologi pangan*. PT. Gramedia.