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A Review of Dehydration Techniques of Greenhouse

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Abstract

This paper review on the latest development of greenhouses related to the dehydration process of dried food products. In general, greenhouses are categorized into two types of greenhouses: 1) Conventional greenhouses for dehydration, and 2) the Drying technology of greenhouses for dehydration. The greenhouses are compared based on the methodology, concept, objective, advantages, disadvantages, and limitations. The recommendation for the next development of technology that can be implemented in the smart greenhouse for dehydration is included in this paper.

Keywords: Smart Greenhouse, Dehydration, Conventional Greenhouse, Drying Technology, Greenhouse for Dehydration

Introduction

In recent years, the usage of greenhouse has increased dramatically with the main goal is to increase the productivity in the rate at which plants produce fruits, and able to increase the rate of dried fruits and dried fish by using the process of dehydration. The greenhouse is usually defined as a building or structure consisting of pillars, walls and roof made of transparent material, in most cases plastic, which then providing all the climatic conditions needed to allow plants to grow. This structure's main purpose is to act as a protective shield for plants to grow safely disregarding the potential harm and unwanted climate changes or change of seasons (Azaizia et al., 2020). The main purpose of the drying process inside the greenhouse is to control the hygiene of the products. Besides, this invention also allows for more room of improvements and changes can be applied to other systems.

This is where conventional and modern greenhouse for dehydration of seafood products comes in. While using the same concept of a greenhouse, the insides of the structure will instead be replaced with a modernized fish-drying system, which makes it more effective and consistent. Traditionally, the sun drying technique is typically used as the method is theoretically very straightforward, which is by leaving the seafood products in an unenclosed space. Naturally, there are advantages and disadvantages of this method, which mainly concerns the climate and weather (Delfiya, 2019). Thus, this is what lead to the invention of drying technology for the greenhouse, which overall can overcome most of the disadvantages through a protected and controlled ecosystem.

Drying technology for the greenhouse is a newly invented system that utilized multiple functionalities that can provide various types of features for greenhouse solar drying. The built-in features of the system are giving advantages such as increased operational productivity with a reduced drying period, improved product quality with better taste, and appearance, healthier and more hygienic, and reduced reliance on labour to keep and store products in case of sudden rain or strong wind which can also spoil the fish due to infestation of microorganisms and fungi (Azaizia et al., 2020).

This work is focused on three objectives which are as followed.

- Review of methodology, concept and objective based on the conventional greenhouse and drying technology of the greenhouse for dehydration.
- Compare and evaluate the benefits of conventional and modern technology greenhouses.
- Examine and contrast the drawbacks of conventional and modern technology greenhouses.

In this review paper, the techniques of dehydration in the greenhouse that are being used or purposed by past papers are being studied based on the conventional technique and the drying technology that has been used in the greenhouse.

Dehydration Techniques of Greenhouse

In general, greenhouse for fish and fruit dehydration by implementing two types of methods namely conventional greenhouse and solar drying technology of greenhouse. An insight and comparison of the greenhouse have been focused on its purposes, technique, advantages, and limitation.

Conventional Greenhouse for Dehydration

The method to dry the fish using conventional passive and active solar dryers has been reviewed in an article named Advanced Drying Technique for Fish (Delfiya, 2019). The drying process of fish uses solar radiation without using any electrical component is called a passive solar dryer while an active solar dryer uses electricity to run the axial fan inside the greenhouse which gives ventilation, and circulation which also distributes heat equally inside the greenhouse. These solar dryers are dried in a hygienic environment. Figure 1 and Figure 2 show the drawing of passive and active solar dryers respectively. Observation of the drying time in minutes and moisture content in percentage as shown in Figure 3 and Figure 4 respectively (EL-Mesery et al., 2022). This observation is conducted to find the best drying method in order to get the maximum dehydration rate based on the open sun, passive, active mixed flow and active crosses flow.

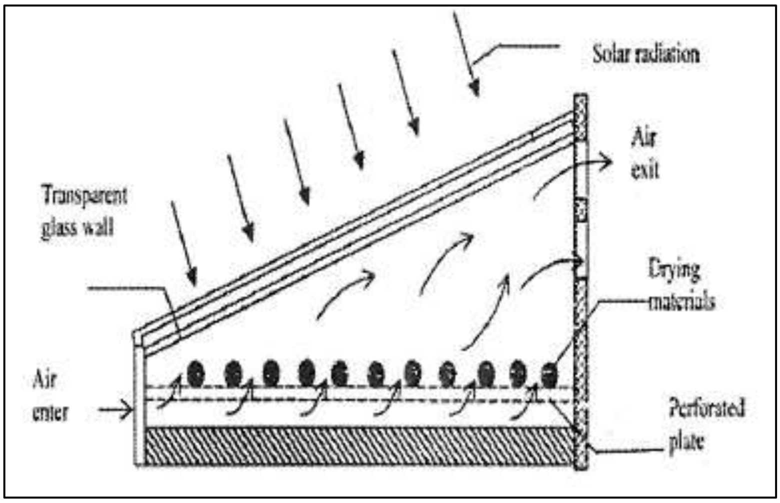

Figure 1: Passive Solar Dryer (Delfiya, 2019)

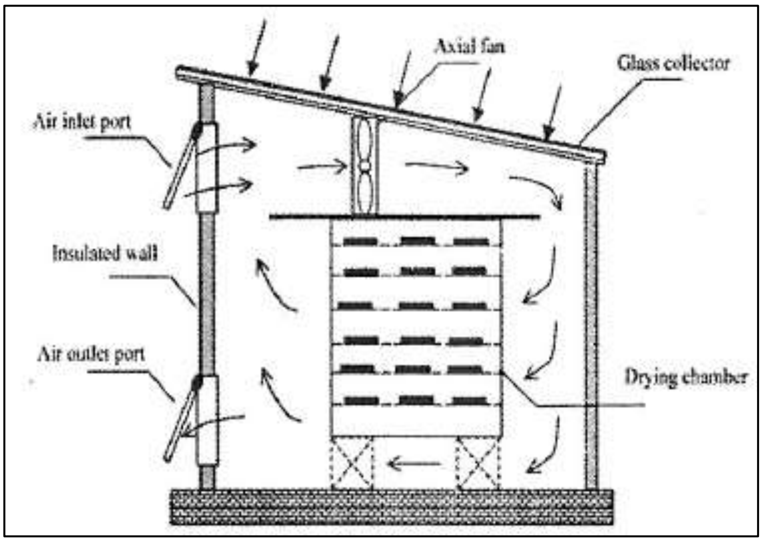

Figure 2: Active Solar Dryer (Delfiya, 2019)

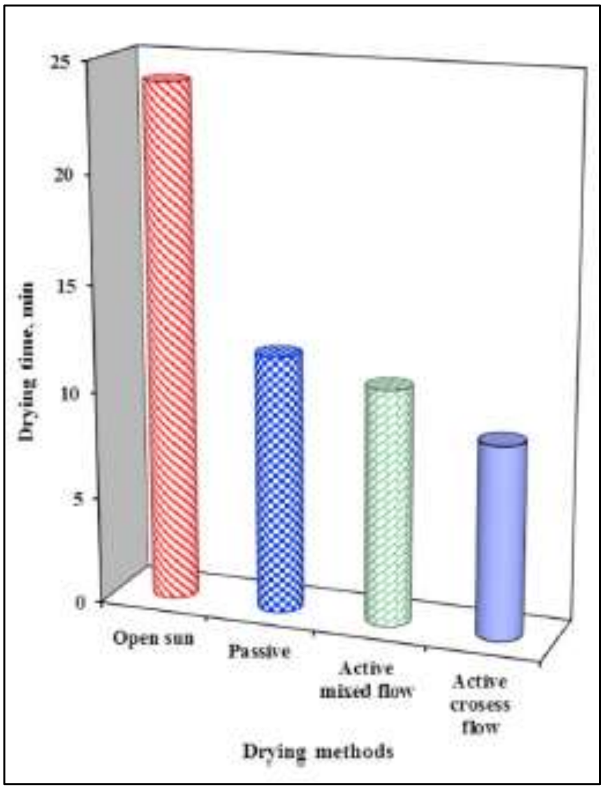

Figure 3: Drying Method vs Drying Time (EL-Mesery et al., 2022)

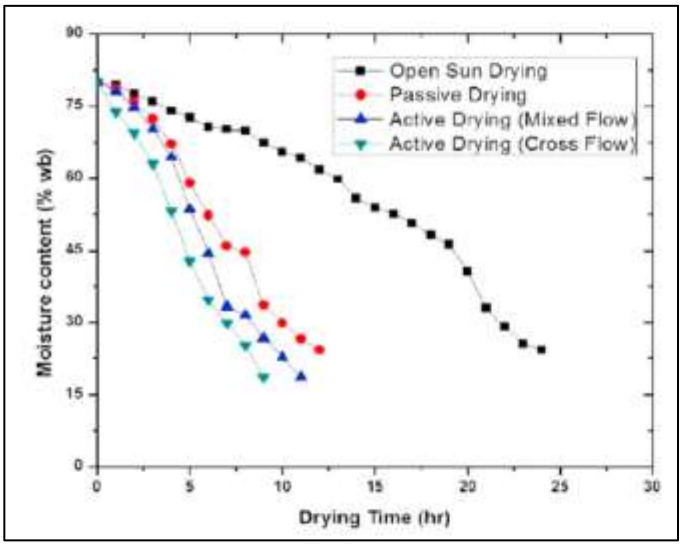

Figure 4: Drying Time vs Moisture Content (EL-Mesery et al., 2022)

Hybrid solar-biomass dryer is introduced to counter the problem related to bad weather which can affect the end products of the drying products (Yuwana et al., 2020). The dryer is in chamber shape to achieve tier rack that can distribute heat efficiently inside the dryer. Biomass is being used as fuel for the heating process. Figure 5 shows the schematic structure of a hybrid solar-biomass dryer. If the temperature is achieved as desired, the fire needs to be extinguished manually to maintain the quality of the dried fish and prevent scorching the fish during the dehydration process.

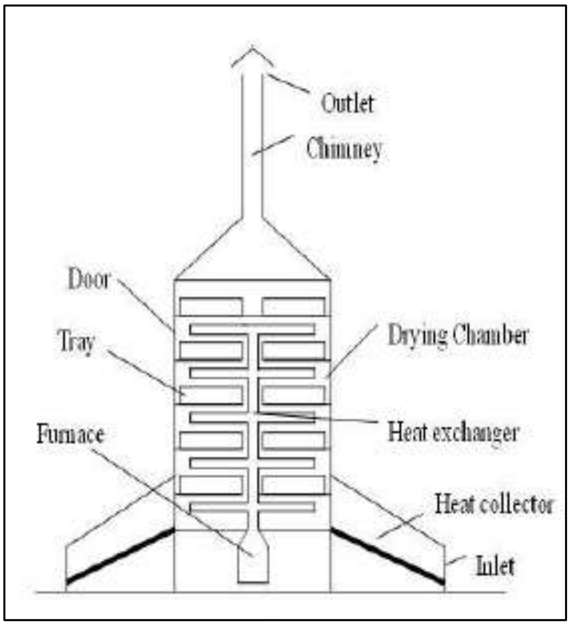

Figure 5: Hybrid Solar-Biomass Dryer (Yuwana et al., 2020)

Simulation of different shapes of the greenhouse is conducted to find the airflow of thermal distribution inside the greenhouse for dehydration purposes (Villagran et al., 2021). Figure 6 illustrate the different types of roof used in this observation while Figure 7 presented the airflow of thermal distribution inside the greenhouse with a different type of roof.

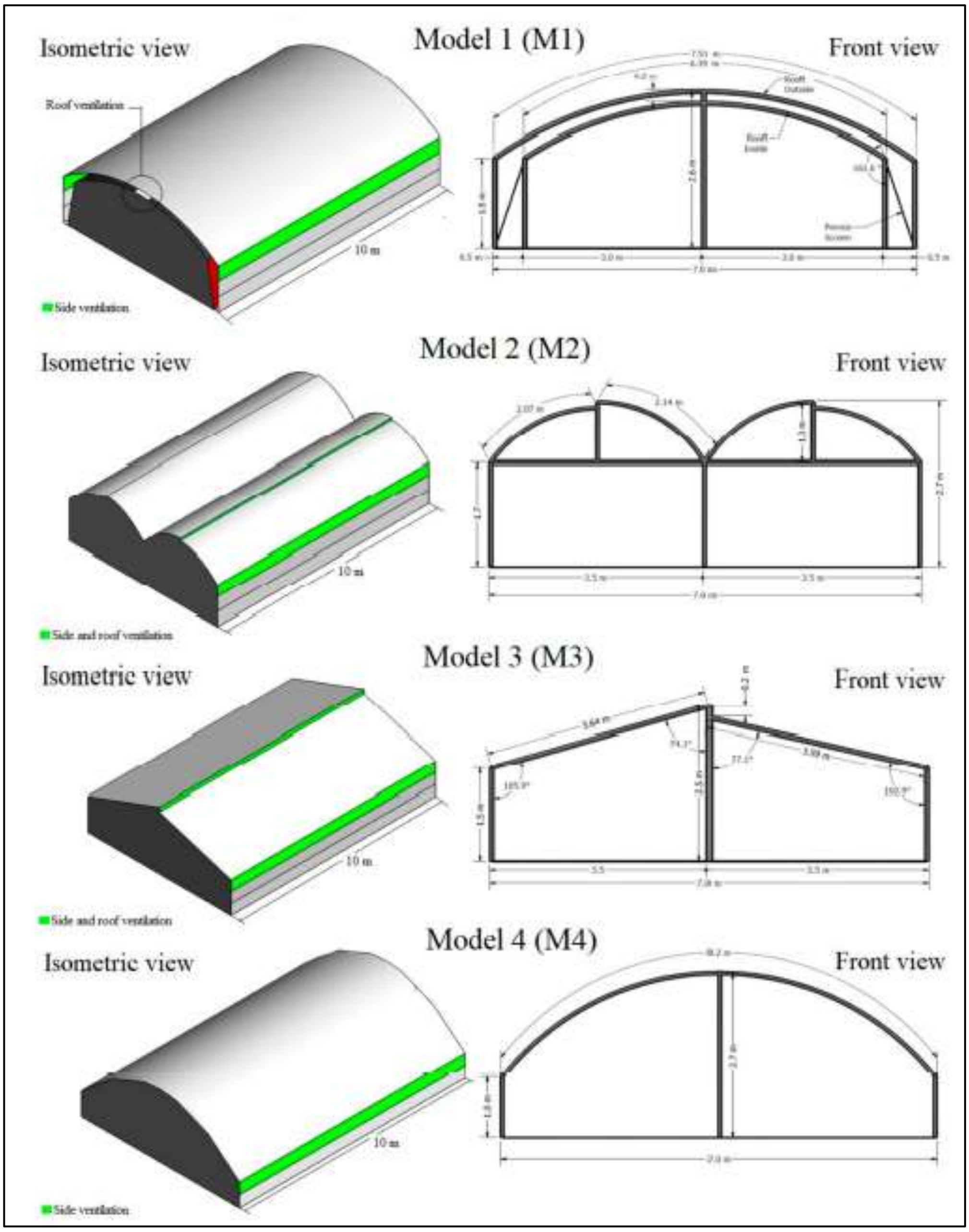

Figure 6: Different Types of Roof Shape for Greenhouse (Villagran et al., 2021)

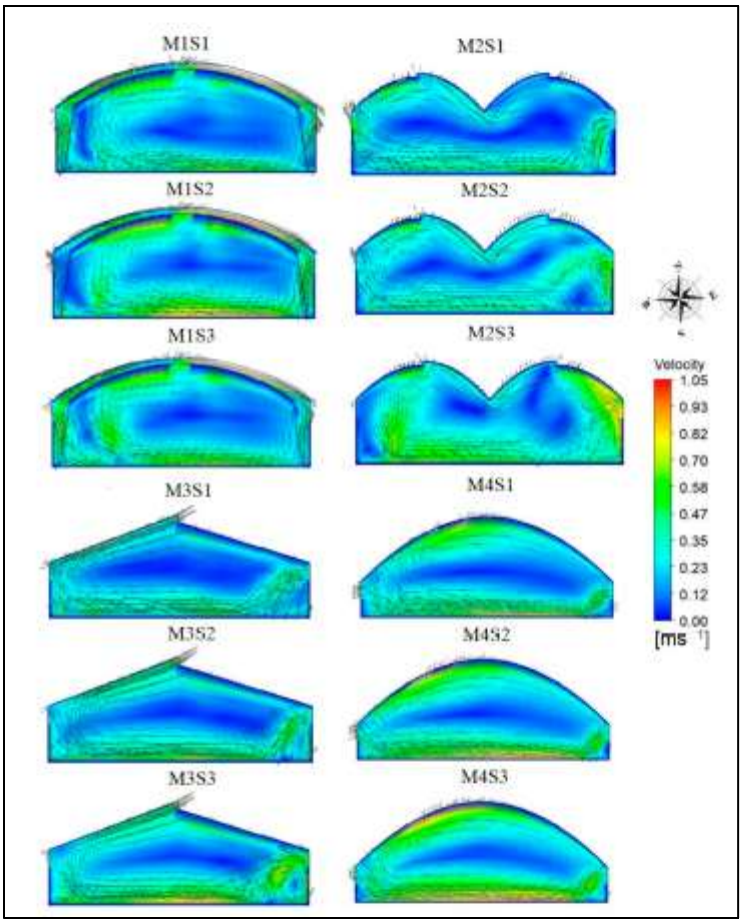

Figure 7: Air Flow of Thermal Distribution Inside Different Shape of Greenhouse Roof (Villagran et al., 2021)

Tent-type solar collector of the greenhouse has been constructed to determine the condition of the dried products (Mehta et al., 2018). This project's objective is to find an adequate temperature for the dehydration of the product. The colour of the end product which is tomatoes shows the quality of the colour as no direct sunlight on the product. Thus, this system needs low start-up costs as no implementation of electrical components. Figure 8 shows the prototype of tent-type solar collector of the greenhouse.

Figure 8: Prototype Tent-Type Solar Collector of Greenhouse (Mehta et al., 2018)

Drying Technology of Greenhouse for Dehydration

Infrared drying method also has been combined with a conveyor system to produce time efficient in producing dried products which can increase the production rate. The infrared act as an artificial sun to dry the wet product (Delfiya, 2019). The quality of products also increases as the system is usually used in the factory that produces mass production. Thus, high initial cost needs in setup this system. Figure 9 presents the drawing of the infrared drying method with a conveyer system.

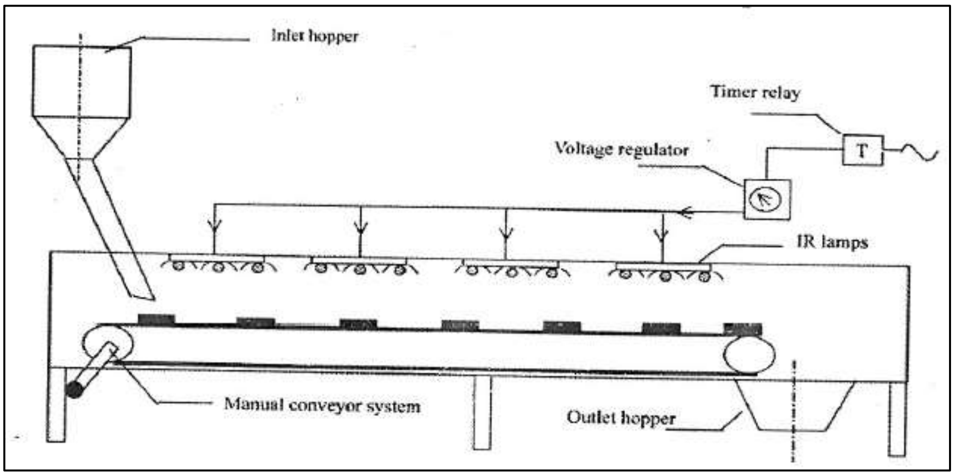

Figure 9: Infrared Dryer with Conveyer (Delfiya, 2019)

Comparisons between weight reduction and time, between relative humidity and time, and also temperature over time are summarised in Figure 10 to Figure 12. This comparison is to analyse the effect of three types of greenhouses which is open, simple, and modified greenhouse of the tomato that can produce the final product as tomato flakes (Dhurve et al., 2017). This greenhouse uses black cloth as a base of the greenhouse which can increase the temperature and maintain the temperature for quite some time. Thus, the temperature inside cannot be controlled and dehydration only happened only in sunny days. Also, the modified greenhouse system uses an exhaust fan for ventilation inside the greenhouse as shown in Figure 13.

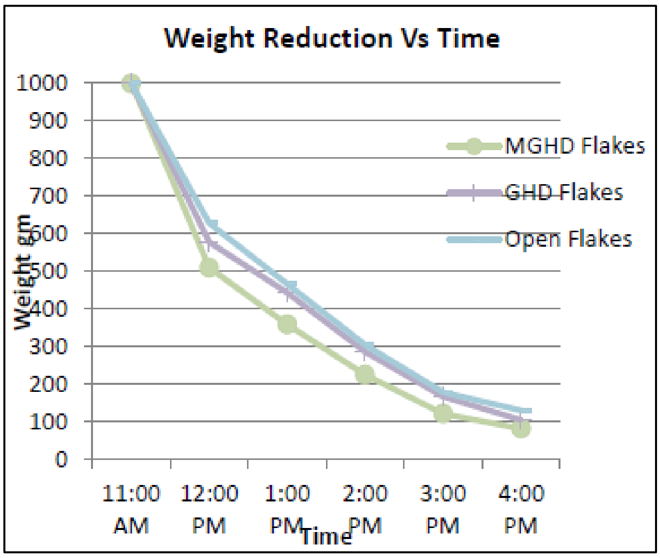

Figure 10: Comparison between Weight Reduction vs Time (Dhurve et al., 2017)

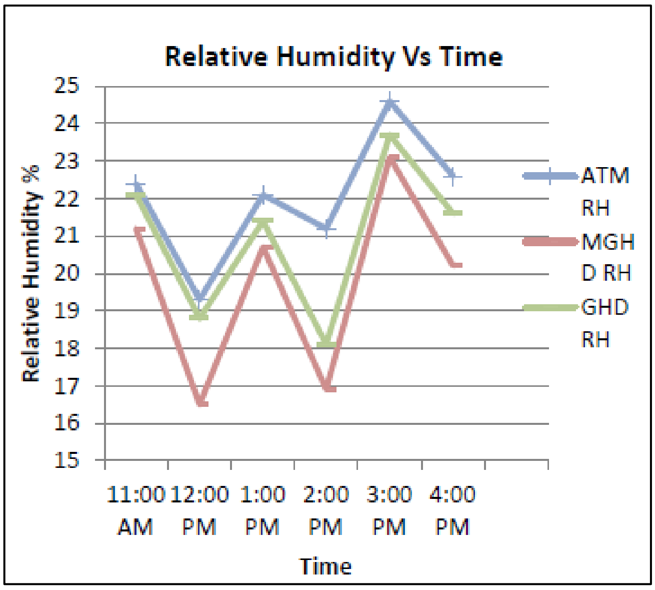

Figure 11: Comparison between Relative Humidity vs Time (Dhurve et al., 2017)

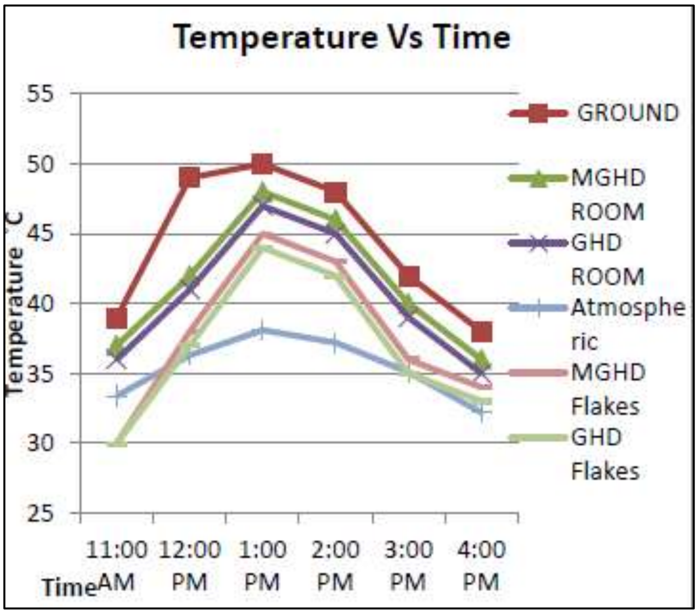

Figure 12: Comparison between Temperature vs Time (Dhurve et al., 2017)

Figure 13: Modified Greenhouse System (Dhurve et al., 2017)

The mechanical drying method consists of using a fan for air flow, an exhaust fan, a sloping roof, a heating coil and a transparent cover. If there is the absence of sunlight, can use a heating coil to increase the temperature inside the greenhouse (Karim et al., 2018). But there must be a monthly electrical bill cost because of the use of electrical components. The system has a sloping roof which can avoid water from being stagnant if there is rain. Table 1 shows the data of different weight of fish that has been put inside the greenhouse and moisture loss in kilogram at the first recorded data by using the same time to record.

Table 1
Recorded Parameters with Different Weight of Fish (Karim et al., 2018)

Time (Hrs)	M_1 (kg)	Moisture loss (M kg)	M content (%) dry basis	M_2 (kg)	Moisture loss (M kg)	M content (%) dry basis
08.00	650	------	83.6	400	------	58.1
09.00	617	33	79.3	376	24	54.6
10.00	583	34	74.9	348	28	50.3
11.00	551	32	70.8	319	29	46.1

Greenhouse dryer by using a PV system and solar collector is performed to analyse the thermal data specification (Azam et al., 2020). Figure 14 shows the construction prototype of the PV system with a solar collector. The PV system is used to turn on the DC fan only while the solar collector is used to collect and trap heat inside the greenhouse. This can lengthen the time of dehydration happened in one day due to a slow decrease in temperature.

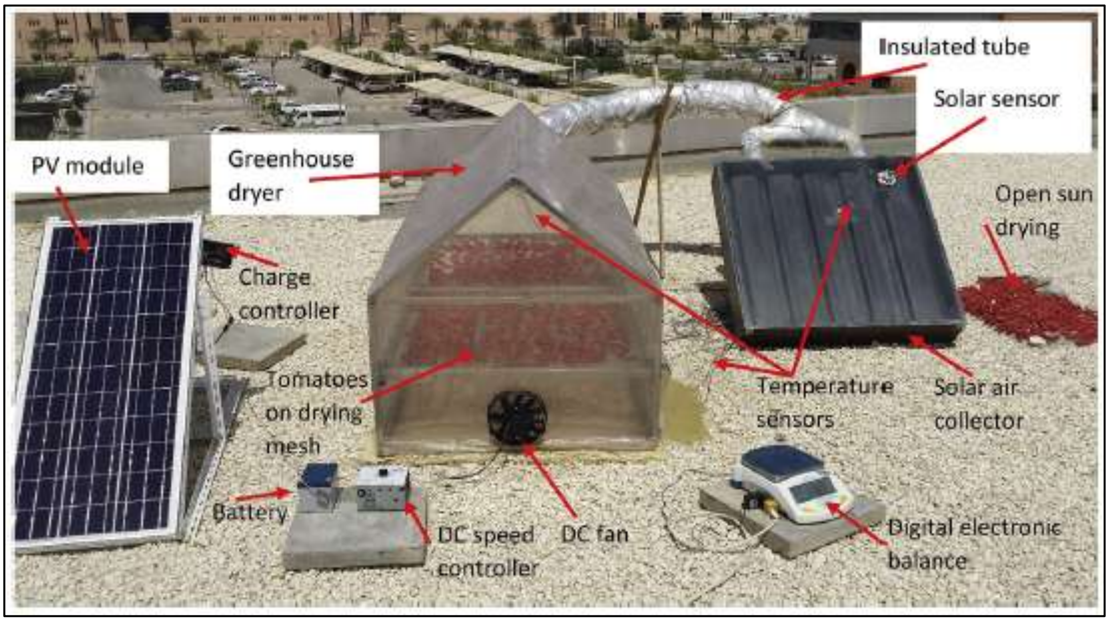

Figure 14: Greenhouse Prototype of the PV system with Solar Collector (Azam et al., 2020)

Phase Change Material (PCM) is used by the project to absorb heat and use the heat during the night-time (Azaizia et al., 2020). The PCM act as a thermal energy storage unit. This project also uses a DC fan for the ventilation of the greenhouse. Thus, an electrical supply is needed to run the DC fan which can affect the monthly electrical bills. This project is conducted to increase the drying process efficiency. Figure 15 shows the principle of heat flow during day and night for this project while Figure 16 illustrates the observation graph on temperature with and without thermal storage unit versus time.

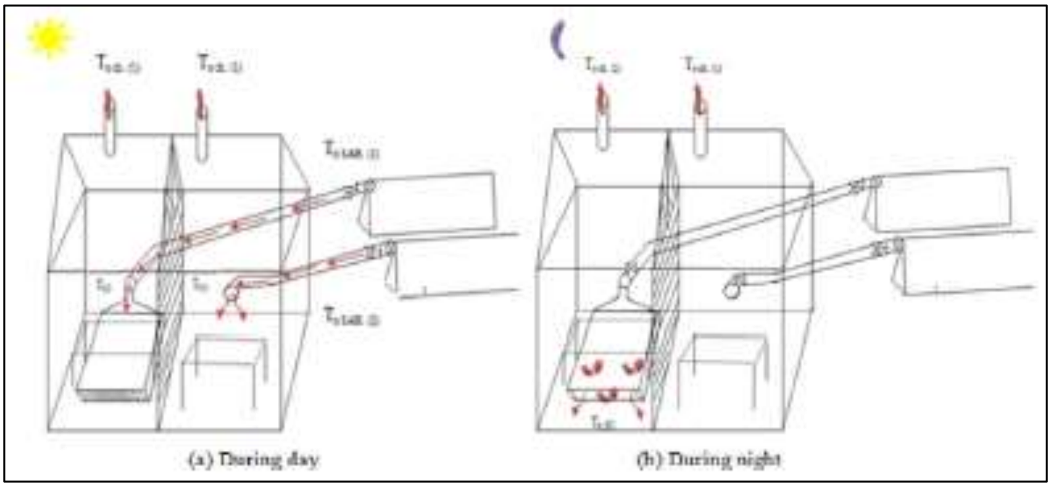

Figure 15: Principle of Heat Flow during Day and Night (Azaizia et al., 2020)

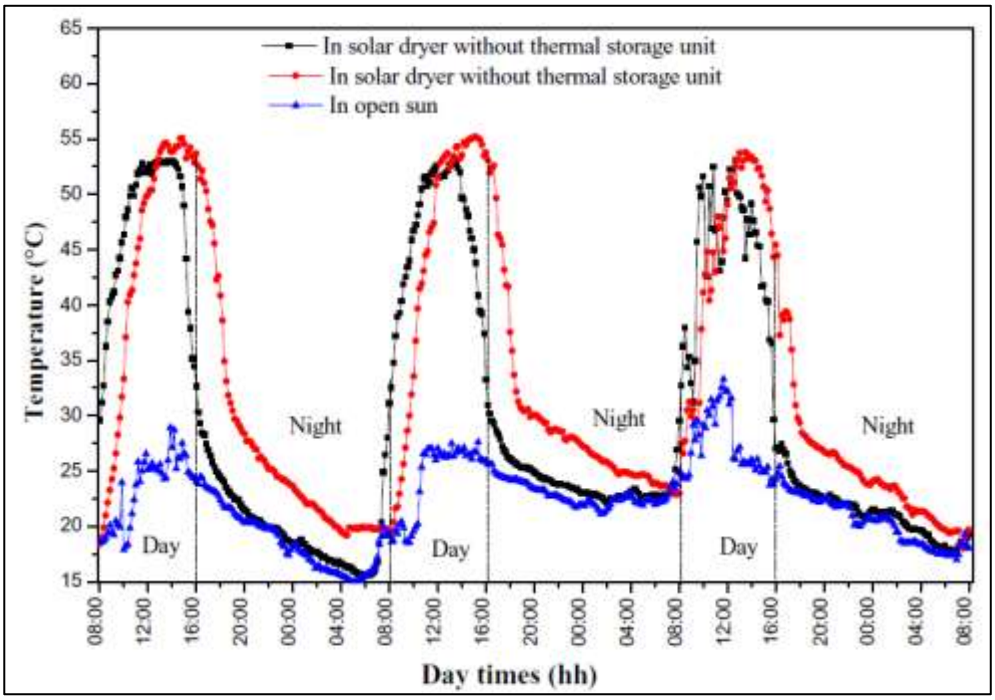

Figure 16: Temperature with and Without Thermal Storage Unit vs Time (Azaizia et al., 2020)

Another study also used the PCM to collect heat but from a different source of heat (Ananno et al., 2020). Usually, greenhouse systems use sunlight as the heat source of energy but this project uses geothermal to get the heat for the greenhouse system as shown in Figure 17. This underground heat is only suitable for a certain area and needs a high start-up due to the digging soil to put the thermal conduction pipe. This system can increase the production rate of dried products as the system can operate during the day and night. But surely the temperature will decrease slowly as during the long night time. Figure 18 presents the comparison between temperature and time with different processes of drying. There are three main processes drying being used in this project which are geothermal dryer, PCM dryer and Hybrid Combined Geothermal with PCM dryer.

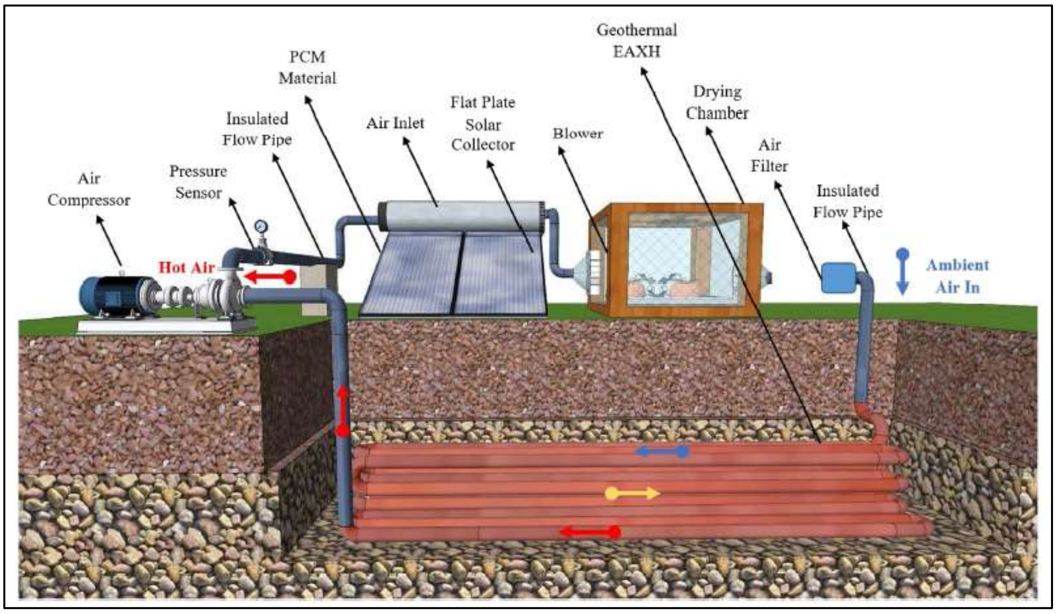

Figure 17: Concept Design of Geothermal PCM Solar Collector Greenhouse (Ananno et al., 2020)

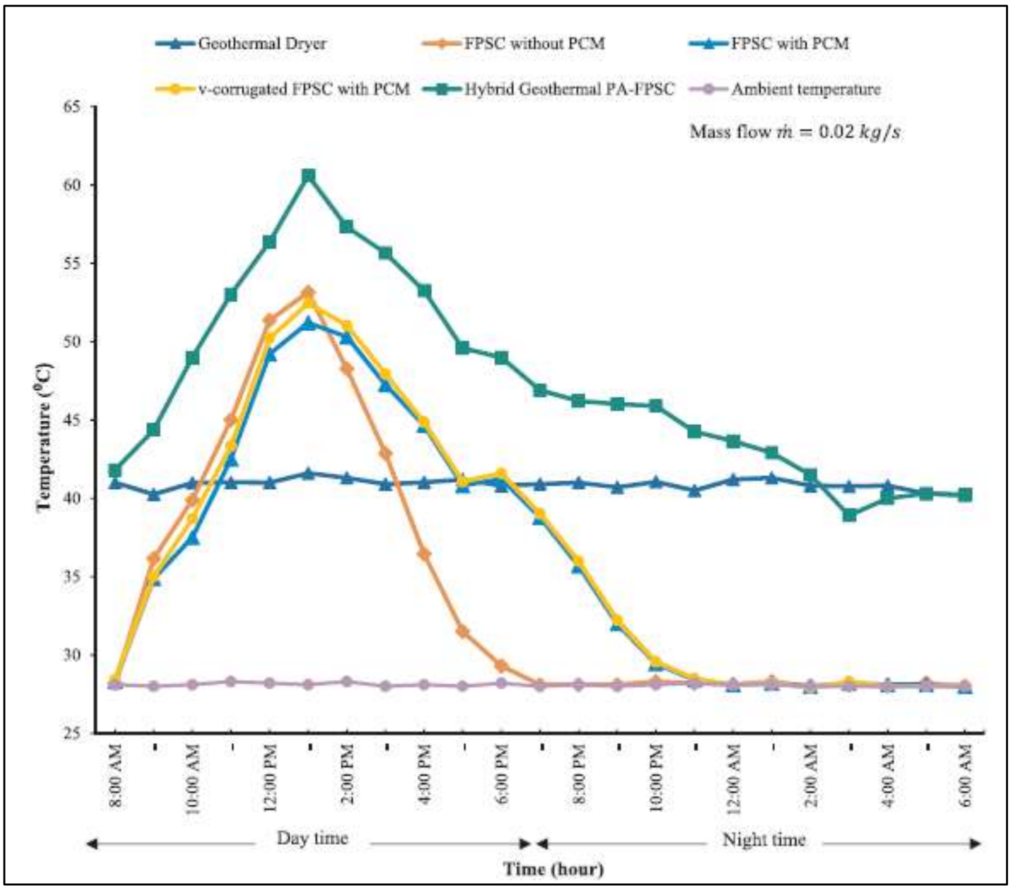

Figure 18: Comparison between Temperature and Time with Different Process of Drying (Ananno et al., 2020)

The overview and comparison of the greenhouse are presented in this paper. The solar dehydration greenhouse with smart technologies has the advantage of decreasing the time needed to produce high quality products as the greenhouse itself can provide protection to the product that will be produced from dust and rain during the drying process. Other than that, the production rate can also be increased as a result of smart technologies such as a heater that are being used to operate not only in the daytime but also at night time. Hence, the previous researcher's work is summarized in Table 2.

Table 2
Summary of Greenhouse for Dehydration

Author	Methodology / Concept / Objective	Advantages	Disadvantages / Limitation
Delfiya (2019)	• Consist of a combination of drying method which is the initial conventional drying process followed by infrared. • Advanced drying methods decrease time, increase production rate and better quality of the product.	• Drying under a hygienic environment. • Free solar energy. • Using conveyor type of infrared drying increases production rate.	• High startup cost.
EL-Mesery et al (2022)	• Review of several types of solar dryers. • Consist of direct, indirect, mixed-mode, natural convection, forced convection and hybrid solar dryers. • To observe the best dryer that gives maximum quality parameters and high dehydration rate.	• Short dehydrating periods. • Enhance the quality of the product.	• High primary cost. • Low capacity of the product.
Yuwana et al (2020)	• Consist of drying chamber, chimney, furnace, structure made of light steel frame, covered with UV plastic, heat collector and heat exchanger. • Hybrid solar-biomass dryer. • To faster the process of drying fish.	• Tiered shelf that can increase production in one time.	• Manually extinguish the fire when the temperature is achieved. • Check temperature manually.
Villagran et al (2021)	• Simulation of greenhouse dryers by using 3D Computational Fluid Dynamics (CFD) model.	• No cost because does not have to make the prototype.	• Based on software simulation only.

	• Simulation of solar drying using greenhouse simulation. • To study the performance of air flow patterns, temperature, and humidity inside four different types of greenhouses.		
Mehta et al (2018)	• Consist of air vent, air duct, solar collector, drying chamber, and racks. • Tent-type solar dryer that used solar collector. • To produce adequate temperature for drying the product.	• Control the quality colour of product because not directly exposed to sunlight. • Low startup cost of the prototype.	• Happened during day light only. • Cannot control the heat temperature inside the greenhouse dryer.
Dhurve et al (2017)	• The drying of the product was performed in three types of drying methods which are open sun drying, simple greenhouse dryer and modified greenhouse dryer. • Proposed a greenhouse dryer under natural convection that used exhaust fan, black sheet as base and incline roof even type. • To design and develop a modified greenhouse dryer and reduce drying time for the product. • Observation based on temperature, relative humidity, wind velocity, weight reduction and time.	• Using an exhaust fan to remove the air inside. • Increase the rate of absorption of solar radiation by using a black sheet.	• Cannot control the temperature inside the greenhouse. • Dehydration happened only when the sun is available.
Karim et al (2018)	• Using fan for air flow, exhaust fan, sloping roof, heating coil and transparent cover.	• Hygiene because covered with transparent cover. • Stagnation of rainwater cannot	• Extra cost for the electrical bills.

	• Using sun rays and electric heating system if absence of sunlight with the black painted floor. • To make better insulation and fully utilize the heat energy for drying the fish.	happen because of sloping roof.	
Azam et al (2020)	• Consists of speed controller, DC fan, a solar collector with tube, PV module and battery. • Using PV system and solar collector with the greenhouse dryer. • To observe the best pretreatment and quality of the prototype greenhouse dryer with open sun drying.	• No cost for electrical supply. • Hygiene because the product is placed inside the greenhouse dryer.	• Not an accurate result because of the small size of the prototype. • Cannot control the heat temperature inside the greenhouse. • Happened during day light only.
Azaizia et al (2020)	• Consist of Phase Change Material (PCM), solar collector and DC fan. • Mixed mode solar greenhouse drying system with and without thermal energy storage unit. • To increase the drying process efficiency.	• Can work during day and night. • Trapped heat can be used during the night.	• Heat temperature used during the night decrease as time increase. • Need 24-hours electrical supply from utility for DC fan.
Ananno et al (2020)	• Consist of Phase Change Material (PCM) flat plate, solar collector, blower, air compressor, Earth-to-Air Heat Exchanger (EAHX) and pressure sensor. • Hybrid geothermal PCM Flat Solar Collector. • To increase efficiency and productivity of the product.	• Dehydration happened during day and night. • Use electrical supply only for air compressor and blower. Thus, low energy supply needed.	• Cannot control the heat temperature inside the greenhouse dryer. • Low temperature during night. • High startup cost. • Not all area suitable for underground heat.

Conclusion

This review has covered a few types of greenhouses for dehydration mainly conventional and technology of greenhouses which are related to their advantages and disadvantages, also the limitation of each design of the greenhouse. Nowadays, the drying process in the greenhouse has widely been used as this can control the hygiene of the products that are being produced and increase the production rate. Thus, this greenhouse is focused on the business owner that related business with drying products such as dried tomatoes, dried chillies and dried croaker fish. Based on the review given, the drying technology for the greenhouse that implements the heating coil in the greenhouse with a blower has the best concept that can maximize the production rate of the dried fish. In this review paper, the limitation or disadvantages of past projects are discussed. Thus, this information can initiate new ideas for the next project that relates to the dehydration of the greenhouse or the design smart greenhouse. The recommendation that has been given in this paper also can be used to design the greenhouse of dehydration for the next project.

Some of the ideas that can be implemented in the drying technology of a greenhouse are designing a greenhouse system that generates power from renewable energy sources that include battery storage by using a PV system, controlling the temperature of the heater and the humidity inside the greenhouse that suitable for drying fish by using temperature and humidity sensor and optimizing the usage of the greenhouse with a battery storage system that can be used during night time and hygienic which decrease dehydration time for each production and produce a premium quality product. Thus, the quantity of the product can be increased. Contextually, it addresses the challenges of food preservation and storage in developing and developed countries and demonstrates that the combination of conventional greenhouse technology and modern drying technology is a viable alternative for drying and dehydrating food products, which can help to improve product quality, shelf-life, and food security. Additionally, it has the potential to support local food systems and promote sustainable food production. Overall, this research has made a valuable contribution to the field of food preservation and storage, providing valuable insights into how the combination of conventional greenhouse technology and modern drying technology can be used for food preservation and storage.

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References

Ananno, A. A., Masud, M. H., Dabnichki, P., & Ahmed, A. (2020). Design and numerical analysis of a hybrid geothermal PCM flat plate solar collector dryer for developing countries. *Solar Energy (Phoenix, Ariz.)*, *196*, 270–286. https://doi.org/10.1016/j.solener.2019.11.069

Delfiya, A. D. S. (2019). Advanced drying techniques for fish. *Model Training Course on Advanced Fish Drying and Chilling Technology*, 36–43. http://krishi.icar.gov.in/jspui/handle/123456789/32293

Azaizia, Z., Kooli, S., Hamdi, I., Elkhal, W., & Guizani, A. A. (2020). Experimental study of a new mixed mode solar greenhouse drying system with and without thermal energy storage for pepper. *Renewable Energy*, *145*, 1972–1984. https://doi.org/10.1016/j.renene.2019.07.055

Azam, M. M., Eltawil, M. A., & Amer, B. M. A. (2020). Thermal analysis of PV system and solar collector integrated with greenhouse dryer for drying tomatoes. *Energy (Oxford, England)*, *212*, 118764. https://doi.org/10.1016/j.energy.2020.118764

Dhurve, B., Gupta, V., & Singh, A. K. (2017). Experiment analysis of open, simple and modified greenhouse dryers for drying tomato flakes. In *International Journal of Research and Scientific Innovation (IJRSI), 4, 128-131*. https://www.rsisinternational.org/IJRSI/Issue42/128-131.pdf

EL-Mesery, H. S., EL-Seesy, A. I., Hu, Z., & Li, Y. (2022). Recent developments in solar drying technology of food and agricultural products: A review. In *Renewable and Sustainable Energy Reviews*, 157(112070), 112070. https://doi.org/10.1016/j.rser.2021.112070

Karim, E., & Hoq, E. (2018). Improvement of dried fish products through using a Mechanical Fish Dryer. Bangladesh Journal of Fisheries Research, 17(1–2), 91–99. https://www.researchgate.net/publication/336603160

Mehta, P., Samaddar, S., Patel, P., Markam, B., & Maiti, S. (2018). Design and performance analysis of a mixed mode tent-type solar dryer for fish-drying in coastal areas. *Solar Energy (Phoenix*, Ariz.), *170*, 671–681. https://doi.org/10.1016/j.solener.2018.05.095

Villagran, E., Henao-Rojas, J. C., & Franco, G. (2021). Thermo-environmental performance of four different shapes of solar greenhouse dryer with free convection operating principle and no load on product. *Fluids*, *6*(5), 183. https://doi.org/10.3390/fluids6050183

Yuwana, Y., Silvia, E., & Sidebang, B. (2020). Observed performances of the hybrid solar-biomass dryer for fish drying. *IOP Conference Series: Earth and Environmental Science*, *583*(1), 12-32. https://doi.org/10.1088/1755-1315/583/1/012032