Preliminary Design of Shallot (*Allium Ascalonicum L.*) Dryer Instore Hybrid Model with Control of Temperature and RH

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Abstract: Shallots (*Allium ascalonicum L.*) is one of the leading commodities of horticultural crops in Bali with a total land area of around 1315 ha, and production reaching 246,679 quintals. The post-harvest process of shallots that must be considered is withering and drying. If drying process were not optimal, it can cause the onion to rot and sprout. The purpose of this research was to make a shallot dryer by controlling temperature and relative air humidity (RH). The design of rack arranged in staggered arrangement, where the heat source combined from the sun power and with the heat of lamp. The hot air produce from a heater and the air flow will circulate using a fan. The temperature and RH sensors were installed in the drying chamber and connected to a control system that will cut off the flow of hot air from the radiator if the desired temperature and RH were reached. The results showed that the design of the drying machine that has been made can work properly.

1 INTRODUCTION

Shallots (*Allium ascalonicum L.*) is one of the leading commodities of horticultural crops in Bali with a total land area of around 1315 ha, and production reaching 246,679 quintals. (BPS Provinsi Bali, 2021). Shallots are widely used as a spice, either in its whole form as a traditional chopped spice (*base genep*) in Bali. The post-harvest process of shallots that must be considered is withering and drying. The drying process by farmers in general is still traditional by drying or hanging, so it requires a long processing time ranging from 7-9 days. If drying is not optimal, this can cause the onion to rot and sprout. (Tahiru, 2019). Instore drying, which is a dryer made by The Ministry of Agriculture by displaying the room temperature, is a drying solution for shallots. (Balitbang Kementerian Pertanian, 2015).

Research about instore drying application on shallot post-process have done by D Histifarina et al, 2019. The research used an experimental method with T-test, consist of 2 treatments, conventional drying method (sun drying) and in-store drying method. The observed parameters include physical properties, tuber hardness, sensory properties, chemical properties, tuber damage, equipment performances and financial feasibilities. The results showed that the application of in-store drying technology has a good efficiency (58.26%), financially feasible (R/C 1.27, BEP 200.92, PBP 4.8 months and net B/C 1.85) and significantly better than conventional way.

Another study on shallot drying process have done by C L Hii, 2021. Microwave drying was chosen to be used due to its numerous advantages such as improved drying time, high drying efficiency and better product quality. Results showed that drying kinetics (moisture content and drying rates) decreased the fastest at higher microwave power and the slowest using convective drying. Microwave drying is therefore able to improve drying kinetics compared to convective drying. Post-harvest handling in shallot such as drying of bulbs can influence bulb seeds quality during and after storage. A study to determine the quality of shallot bulbs during 12 weeks of storage as the impact of drying and storage treatments have done by Lestari, 2018. The research was arranged in factorial randomized complete block design (RCBD) and consisted of two factors. The first was the drying treatments. The results showed that all treatments indicated fluctuating changes of water content and Total Soluble Solids in the bulb to the end of storage while bulb firmness tended to decrease. Another shallot drying and post processing also made by (Indah Widanarti,2018) which was made a shallot dryer using fumigation. (Nugraha S, 2019) made another study showed that In-store drying system could take 2 days faster than sun drying and has a

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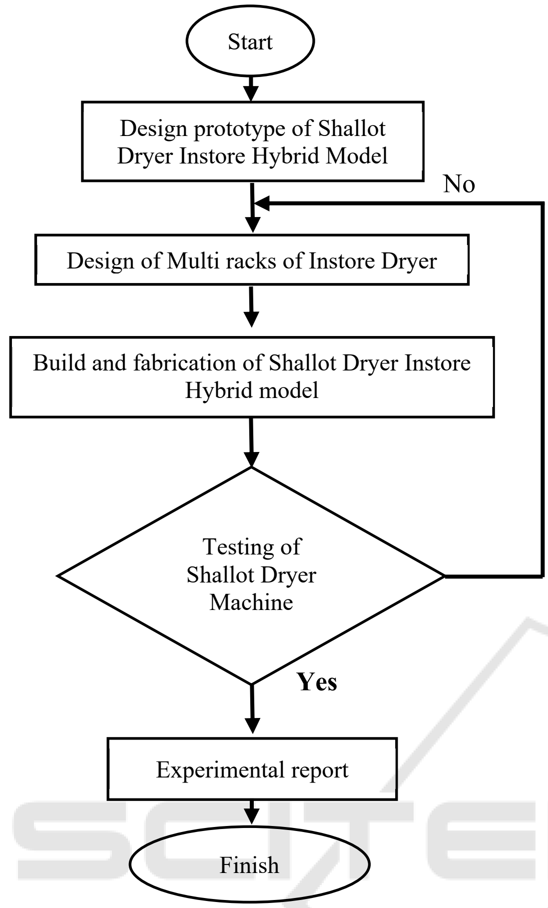

Figure 1.

lower damage rate (0.83% for in-store drying and 3.82% for conventional way). (Setyadjit, 2015) made an experiment to made a powder of shallot during post processing of shallot.

Different model and method to drying horticulture product has also made in the past. The model of multi racks with staggered arrangement has been introduce by (Santosa, 2020) to drying clove. The dryer also builds with control of temperature and RH to optimize the drying quality. (Jamil, F., 2018) has made a design, fabrication and evaluation of rotary hot-air dryer for the value addition of fruit waste. This research showed that the optimum drying conditions for citrus fruit waste was at 60˚C temperature, 1m/sec air flow rate and 40 rpm of drum speed.

According to a press release from the Director General of EBTKE, Ministry of Energy and Mineral Resources (2021), the potential for solar energy as a source of electricity is 200,000 MW, while the utilization of solar energy itself is currently only around 150 MW or 0.08% of its potential.

Based on the description above, is it interesting to made an instore hybrid shallot dryer. The dryer will be made with temperature and humidity control and use solar cells as an alternative power source.

2 RESEARCH METHODOLOGY

The methodology in this research were divided into two sections. The first was creates a design of the dryer machine, and the second was fabrication or build the shallot dryer machine.

2.1 Design

The design of the instore hybrid shallot dryer machine shown in figure 2 below:

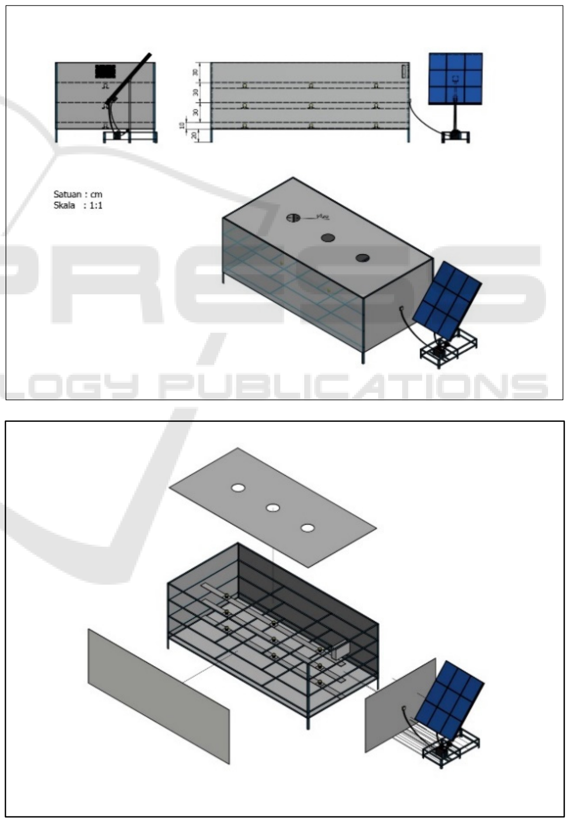

Figure 2: Design of instore hybrid model of shallot dryer.

The heat transfer rate from inside of the drying chamber across the wall can be expressed by equation below:

$$q' = U.A.\Delta T \quad (1)$$

$$U = \frac{1}{R_{tot}A} = \frac{1}{[(1/h_1) + (L_A/k_A) + (L_B/k_B) + (L_C/k_C) + (1/h_4)]} \quad (2)$$

Humidity is a level of state of the wet air environment caused by the presence of moisture or moisture in the air. Dew is a very small H2O particle that fills air volume (Incroepera F P, 2011).

3 RESULT AND DISCUSSION

3.1 Fabrication of Dryer

The shallot instore hybrid dryer was build based on the design above. The drying chamber was made from aluminium with flat plate model. The heat of dryer was made with light bulb that connected with electric battery. The battery source from the solar panel collector. Beside from the heater, the heat source of the dryer also came from the *glasshouse effect* that created by the solar absorption of the dryer's wall which was made from glass panel. To maintain the air circulation, an exhaust fan also attached on the top of drying chamber. To control the temperature and humidity of the air, a control module made with Arduino is used.

Figure 3: The shallot instore hybrid dryer model.

3.2 Experimental Analysis

The experimental investigation was observed from the instore hybrid shallot dryer. The heat source of dryer produces from light bulb, where the air circulated using an exhaust fan with a flow rate of 2.8 m/s. The temperature of the drying chamber, temperature of the tray observed using a K-type thermocouple. The temperatures of the shallot dryer controlled and maintain between 40°C - 50°C.

The result of performance test of the instore hybrid dryer machine shown in table 1 below:

Table 1: Experimental test result.

Time (Minutes)	Temperatures (˚C)			RH
	Test 1	Test 2	Test 3	
0	28.8	29.5	32.3	80.9
30	34.1	35.5	38.1	69.7
60	47.3	44.1	45.8	53.2
90	47.3	47.1	48.6	66.7
120	47.3	47.3	48.3	66.1
150	47.4	47.5	48.5	64.4
180	47.5	48.2	48.6	64.2
210	47.7	48.5	48.9	63.2
240	47.3	49.1	48.9	63.2
270	47.5	49.2	48.8	62.6
300	47.3	49.3	49	61.5
330	47.7	49.4	48.4	60
360	45.8	49.5	48.3	58.4

The result of shallot's mass and water content are shown in table 2 and 3 below:

Table 2: Mass content of shallot.

Mass (kg)					
Test 1		Test 2		Test 3	
before drying (m0)	after drying (m1)	before drying (m0)	after drying (m1)	before drying (m0)	after drying (m1)
1.5	0.8	1.5	1	1.5	0.9

Table 3: Water content of shallot.

Water Content (%)					
Test 1		Test 2		Test 3	
before drying (Wc0)	after drying (Wc1)	before drying (Wc0)	after drying (Wc1)	before drying (Wc0)	after drying (Wc1)
50	28.1	50	28.8	50	28.5

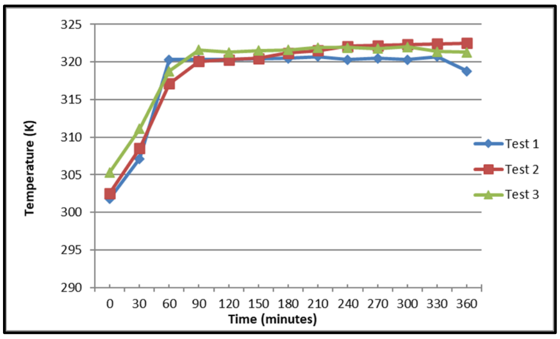

Figure 4: Temperature Distribution.

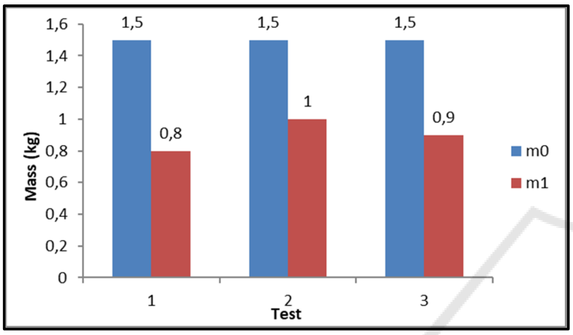

Figure 5: Mass content of shallot.

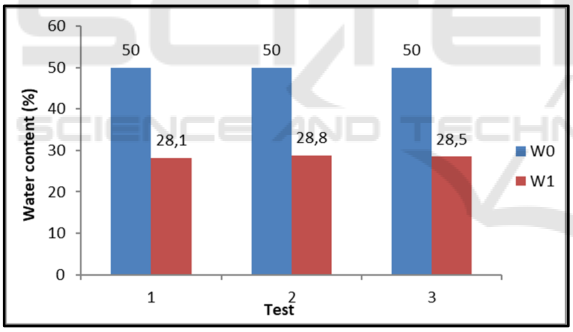

Figure 6: Water content of shallot.

Figure 4 above shows that at the temperature of drying chamber evenly distributed. Temperatures control in drying chamber work very well, where the highest temperatures were on the second test which was about 322.5 K. Figure 5 and figure 6 show the test result for drying shallot during the process. The mass and water content of shallot measured 3 times, and the result showed that both the mass and water content decreasing after the drying process. This can explain that the shallot instore dryer hybrid glasshouse effect can work properly. The temperature and RH that maintained with control module Arduino can help the shallot in their optimum condition during the drying process. The mass content of shallot after drying process decreasing about 40% and the water content were decreasing about 44 %.

4 CONCLUSIONS

From the foregoing analysis, it can be concluded that the shallot dryer instore hybrid model that has been design and with controlling the temperature and relative air humidity in the drying chamber can work properly. The result showed that the drying of the shallots uniform for different test, that described the heat in the drying chamber distributed properly. The decreasing of shallot mass contents about 40% after drying and the decreasing of shallots water content about 44%.

From the results of experimental it can be suggested several things to improve the dryer performances. The first is an improvement on the system design, including the material of dryer, tray and insulation.

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