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# Effect of wind speed and time on performance of cleaned Jerusalem artichoke dryer

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**Abstract**

This project aimed to find out proper operating factors of cleaned Jerusalem artichoke dryer. Performance was evaluated from capacity, percentage of dry Jerusalem artichoke and electric power. Three levels of wind speed (6, 11 and 16 m/s) and fifteen levels of time (2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28 and 30 min). The result showed that wind speed and time significantly impact all indicators. The wind speed was 16 m/s and time about 10 min are suitable operating factors of the cleaned Jerusalem artichoke dryer, providing capacity, percentage of dry Jerusalem artichoke and electric power about 16.40 kg/h, 95.56% and 0.10 kwh, respectively.

**Keywords:** Jerusalem artichoke, Dryer, Washing

## 1. Introduction

Jerusalem artichoke is a plant with an underground tuber that looks like ginger or galangal, as shown in Figure 1. It contains inulin, a substance that is beneficial to the body, helping to increase appetite, build immunity, reduce blood fat, and reduce the risk of heart disease and high blood pressure. The tuber can be eaten fresh and processed into a variety of foods, and mixed with animal feed [1]. In addition, Jerusalem artichoke can also be used as a raw material for the production of alcohol fuel or known as ethanol [2]. Harvesting can be done by shovel, hoe or spade and pulling out by hand [3] and harvesting with a Jerusalem artichoke digger installed on a walking tractor [4]. After digging, the Jerusalem artichoke cores must be separated from the soil. Ansuree et al. [5] studied the effects of transportation speed and vibration on the separation of soil from Jerusalem artichoke cores. Later, Srison et al. [6] studied the effects of sieve speed and sieve tilt angle on the soil separation set from Jerusalem artichoke cores, which helps save effort and reduce the time for digging up the Jerusalem artichoke core. After the aforementioned Jerusalem artichoke core digging process, the Jerusalem artichoke cores must be washed with clean water. Drain the water and put the fresh bulbs in a plastic bag and store in a cold room at 5-10 $^{O}$C. Jerusalem artichokes can be harvested for 120 days after planting [3].

**Figure 1** Jerusalem artichoke

Cleaning is an important process for adding value to agricultural products. Most products are grown in soil, causing soil or mud to stick to the surface of the product, especially plants with underground bulbs that must be washed before storage or before sale [7]. Washing Jerusalem artichoke bulbs still requires manual labor, which is time-consuming and labor-intensive. Currently, there is still a shortage of labor in the agricultural sector due to the expansion of the industrial sector, resulting in labor migration to the industrial and service sectors. In addition, the remaining labor in the agricultural sector is quite old [8]. Srison et al. [9] designed a water pressure core washer to replace the use of human labor. It consists of a water basin, a rotating grate, and a water pressure pump. However, there is no system for managing Jerusalem artichoke bulbs after washing. Currently, farmers still have to prepare an area to dry Jerusalem artichoke heartwood after washing, as shown in Figure 2, to drain water before packing in bags for storage or sale. The drying area must be open, well-ventilated, and free from sunlight, because sunlight will cause the surface of the Jerusalem artichoke heartwood to wither and become unappetizing.

**Figure 2** Jerusalem artichoke drying

From the above, it can be seen that farmers' process of handling Jerusalem artichoke heartwood after washing requires a lot of space, time, and labor. Currently, there are no machines that can replace the labor shortage. Therefore, this research aims to design and evaluate the performance of a Jerusalem artichoke heartwood dryer after washing, which may be a guideline to help farmers increase their yield and income from Jerusalem artichoke heartwood production.

## 2. Methodology

### *2.1 Design of the Jerusalem artichoke dryer*

The designed Jerusalem artichoke dryer is a small-sized machine that can be moved as shown in Figure 3. The structure of the machine is 40 cm wide, 240 cm long and 165 cm high. It consists of 5 main parts:

1) Conveyor belt
2) Conveyor belt control unit
3) Blowing chamber
4) Jerusalem artichoke storage tank
5) Power transmission unit


**Figure 3** The cleaned Jerusalem artichoke dryer

The working principle of the Jerusalem artichoke dryer is as follows: Place the washed Jerusalem artichoke on the conveyor belt and spread it to cover the width of the belt and not more than 110 cm long. Then start the Jerusalem artichoke dryer. The conveyor belt and the blower will work together. When the Jerusalem artichoke conveyor belt enters the blowing chamber at the specified position, the limit switch will stop the conveyor belt and the blower will blow dry Jerusalem artichoke according to the time specified by the timer. When the specified time is up, the limit switch will work again to transport the Jerusalem artichoke from the blowing chamber to the Jerusalem artichoke storage tank.

*2.2 Factors studied and experimental plan*

The factors used in the study were 3 levels of wind speed: 6, 11 and 16 m/s. The range of wind speed used was derived from the preliminary air blowing test of Jerusalem artichoke cores. When blowing Jerusalem artichoke cores at a distance of 25 cm, air speeds lower than 5 m/s could not dry Jerusalem artichoke cores within 30 min, and speeds higher than 17 m/s caused Jerusalem artichoke cores to bounce off the specified area. The air blowing time was 15 levels: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28 and 30 min. The test was designed as Factorial analysis in CRD, Two-way ANOVA.

*2.3 Method of testing*

1) Prepare Jerusalem artichoke cores by weighing 3 kg of Jerusalem artichoke cores each and adjusting the Jerusalem artichoke core dryer according to the studied factors.

2) Wash the prepared Jerusalem artichoke cores with water and arrange them on a conveyor belt according to the specified area size. Start timing the operation from placing the Jerusalem artichoke core on the conveyor belt.

3) Start testing the Jerusalem artichoke core dryer using a wind speed of 6 m/s. Measure the wind speed using an anemometer and press the switch to start the blower and conveyor belt. When the Jerusalem artichoke core is transported into the drying room, the belt will stop working and the blower will blow air for the specified time (2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, and 30 min). When the specified time is up, the belt will start to transport the Jerusalem artichoke core from the drying room to the Jerusalem artichoke core storage tank.

4) Measure the electrical power using a wattmeter, which is a measuring device used to measure the electrical power (Power) of the Jerusalem artichoke core dryer test.

5) Sort the dried Jerusalem artichoke cores. (No water on the surface of the Jerusalem artichoke core) and not dry (with water on the surface of the Jerusalem artichoke core) as shown in Figure 4, separate them and weigh them.

6) Test the Jerusalem artichoke core dryer by changing the wind speed to 11 and 16 m/s respectively, by testing the same as in items 3), 4) and 5).

7) Analyze the obtained data to find the working capacity, percentage of dryness by weight and electrical power according to equations 1, 2 and 3 respectively.

- Working capacity (kg/h) = $W_D/t$ (1)

- Percentage of dryness by weight (%) = $(W_D/W_T)$ x100 (2)

- Electrical power (kWh) = (P x t)/1000 (3)

Where $W_D$ = the weight of dry Jerusalem artichoke core (kg)
$W_T$ = the total weight of Jerusalem artichoke core (kg)
t = the working time (h)
P = the electrical power (W)

a) b)

**Figure 4** a) Dry Jerusalem artichoke b) Wet Jerusalem artichoke

## 3. Results and discussion

The results of statistical analysis of wind speed and time on the working capacity, percentage dry by weight, and electrical energy were analyzed using the Factorial analysis in CRD test plan. Two-way ANOVA was used. The details of the study are as follows:

### *3.1 Working capacity (kg/h)*

The effect of wind speed and time on the working capacity of the Jerusalem artichoke dryer is shown in Table 1

Table 1 the capacity (kg/h) at three different wind speeds and fifteen different time

| Time (min) | Wind speed (m/s) | | |
|---|---|---|---|
| | 6 | 11 | 16 |
| 2 | 0.00 | 0.00 | 4.75 |
| 4 | 0.00 | 0.00 | 10.69 |
| 6 | 8.69 | 9.24 | 15.33 |
| 8 | 9.17 | 11.99 | 17.20 |
| 10 | 10.87a | 13.17 | 16.40 |
| 12 | 10.38b | 12.11 | 14.40 |
| 14 | 10.47b | 11.72 | 12.40 |
| 16 | 10.05 | 10.88 | 10.89 |
| 18 | 9.51 | 9.73 | 9.72 |
| 20 | 8.78 | 8.78 | 8.78 |
| 22 | 8.01 | 8.01 | 8.01 |
| 24 | 7.34 | 7.34 | 7.34 |
| 26 | 6.79 | 6.79 | 6.79 |
| 28 | 6.31 | 6.31 | 6.31 |
| 30 | 5.90 | 5.90 | 5.90 |

From Table 1, the effect of wind speed and time on the working capacity was analyzed as shown in Table 2. It was found that wind speed, time, and the interaction between wind speed and time had a significant effect on the working capacity statically. The wind speed of 16 m/s gave the highest working capacity. The ideal drying time was 6-10 min because it had the highest working capacity of 15.33-17.20 kg/h. When the wind speed increased in the range of 2-10 min, the working capacity tended to increase. When the wind speed increased in the range of 12-30 min, the working capacity tended to decrease as shown in Figure 5.

**Table 2** Analysis of variance wind speed and time affecting the capacity (kg/h)

| SOV | df | SS | MS | F |
|---|---|---|---|---|
| Wind speed | 2 | 199.96 | 99.98 | 264.65* |
| Time | 14 | 1506.55 | 107.61 | 254.86* |
| Wind speed x Time | 28 | 332.44 | 11.83 | 31.43* |
| Error | 90 | 33.99 | 0.38 | |
| Total | 135 | 12167.28 | | |

Note: * Significant (p<0.05).

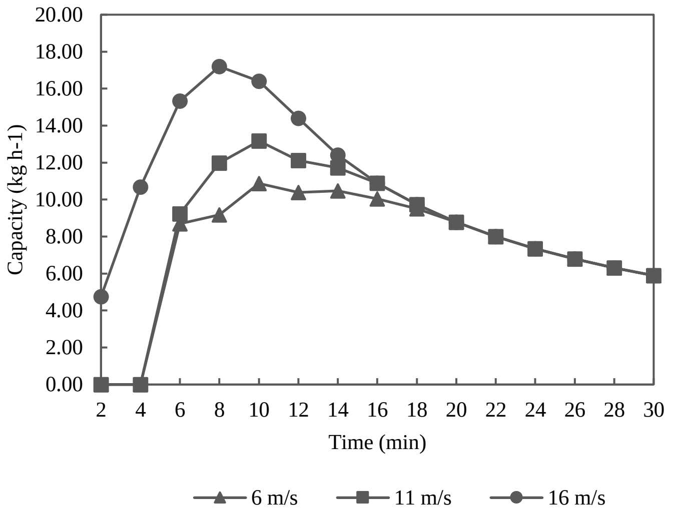


**Figure 5** Relationships between wind speed and time affecting capacity

*3.2 Percentage of dry weight*

The effect of wind speed and time on percentage of dry weight of Jerusalem artichoke dryer is shown in Table 3.

**Table 3** The percentage of dry Jerusalem artichoke at three different wind speeds and fifteen different time

| Time (min) | Wind speed (m/s) | | |
|---|---|---|---|
| | 6 | 11 | 16 |
| 2 | 0.00 | 0.00 | 6.67 |
| 4 | 0.00 | 0.00 | 26.67 |
| 6 | 31.11 | 33.33 | 55.56 |
| 8 | 43.33 | 56.67 | 81.11 |
| 10 | 63.33 | 76.67 | 95.56 |
| 12 | 72.22 | 84.44 | 100.00 |
| 14 | 84.44 | 94.44 | 100.00 |
| 16 | 92.22 | 100.00 | 100.00 |
| 18 | 97.78 | 100.00 | 100.00 |
| 20 | 100.00 | 100.00 | 100.00 |
| 22 | 100.00 | 100.00 | 100.00 |
| 24 | 100.00 | 100.00 | 100.00 |
| 26 | 100.00 | 100.00 | 100.00 |
| 28 | 100.00 | 100.00 | 100.00 |
| 30 | 100.00 | 100.00 | 100.00 |

From Table 3, the variation of wind speed and time on the percentage of dry weight is analyzed as shown in Table 4. It is found that wind speed, time and the interaction between wind speed and time have significant effects on the percentage of dry weight, where wind speed of 16 m/s gives the highest percentage of dry weight. The ideal drying time is 10-30 min because the percentage of dry weight is more than 95%. When wind speed and time increase, the percentage of dry weight tends to increase as shown in Figure 6.

**Table 4** Analysis of variance wind speed and time affecting the percentage of dry Jerusalem artichoke

| SOV | df | SS | MS | F |
|---|---|---|---|---|
| Wind speed | 2 | 3395.68 | 1697.84 | 307.68* |
| Time | 14 | 146571.02 | 10469.36 | 1897.24* |
| Wind speed x Time | 28 | 4653.70 | 166.20 | 30.12* |
| Error | 90 | 496.64 | 5.52 | |
| Total | 135 | 969713.02 | | |

Note: * Significant ($p<0.05$).

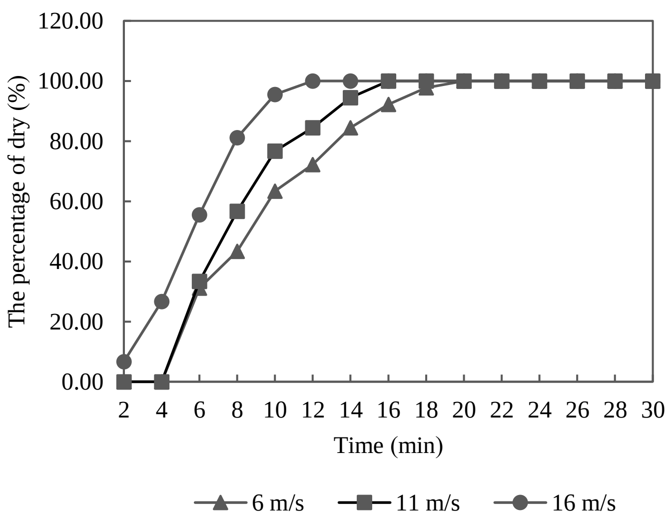


**Figure 6** Relationships between wind speed and time affecting percentage of dry Jerusalem artichoke

*3.3 Electric power*

The effect of wind speed and time on the electric power consumption of the Jerusalem artichoke dryer is shown in Table 5.

**Table 5** The electric power at three different wind speeds and fifteen different time

| Time (min) | Wind speed (m/s) | | |
|---|---|---|---|
| | 6 | 11 | 16 |
| 2 | 0.00 | 0.01 | 0.02 |
| 4 | 0.01 | 0.02 | 0.04 |
| 6 | 0.01 | 0.03 | 0.06 |
| 8 | 0.01 | 0.04 | 0.07 |
| 10 | 0.01 | 0.05 | 0.09 |
| 12 | 0.02 | 0.06 | 0.10 |
| 14 | 0.02 | 0.07 | 0.12 |
| 16 | 0.02 | 0.08 | 0.14 |
| 18 | 0.02 | 0.09 | 0.16 |
| 20 | 0.03 | 0.10 | 0.17 |
| 22 | 0.03 | 0.11 | 0.19 |
| 24 | 0.03 | 0.12 | 0.21 |
| 26 | 0.04 | 0.13 | 0.22 |
| 28 | 0.05 | 0.14 | 0.24 |
| 30 | 0.06 | 0.15 | 0.26 |

From Table 5, the effect of the variation of wind speed and time on electrical energy is analyzed as shown in Table 6. It is found that wind speed, time, and the interaction between wind speed and time have significant static effects on electrical energy, with wind speed of 16 m/s producing the highest electrical energy value. Each period of time used for drying has an electrical energy value of less than 1 kW-h. As wind speed and time increase, the electrical energy tends to increase as shown in Figure 7.

**Table 6** Analysis of variance wind speed and time affecting the electric power

| SOV | df | SS | MS | F |
|---|---|---|---|---|
| Wind speed | 2 | 0.30 | 0.15 | 18055.36* |
| Time | 14 | 0.26 | 0.20 | 2237.20* |
| Wind speed x Time | 28 | 0.80 | 0.003 | 340.77* |
| Error | 90 | 0.001 | $8.27x10^{-6}$ | |
| Total | 135 | 1.54 | | |

Note: * Significant (p<0.05).

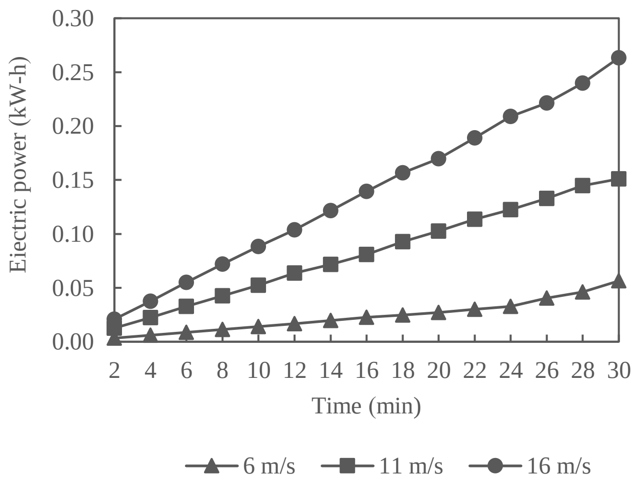


**Figure 7** Relationships between wind speed and time affecting electric power

**4. Conclusions**

Study on the effect of wind speed and time on Jerusalem artichoke dryer after cleaning. The performance of the Jerusalem artichoke dryer after cleaning was evaluated from the working capacity, percentage of dry by weight and electrical energy. The results showed that wind speed, time and the interaction between wind speed and time had statistically significant effects on the working capacity, percentage of dry by weight and electrical energy. The wind speed of 16 m/s and the air blowing time of 10 min were the most suitable for the performance of the Jerusalem artichoke dryer after cleaning, which had the working capacity of 16.40 kg/h, the percentage dry by weight was more than 95% and the electrical energy was 0.10 kw-h.

## 5. Acknowledgements

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