Formosa Journal of Science and Technology (FJST)
Vol.3, No.8, 2024: 1771-1782

Design of Moringa Leaf Dryer Based on Programmable Logic Control Laboratory Scale

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ARTICLEINFORE

Keywords: Moringa, PLC, Dryer, Heater

Received: 5, July
Revised: 25, July
Accepted: 20, August

ABSTRACT

Moringa plants can be found in most tropical and subtropical climates. In some parts of Indonesia, the plant is called kelor or marungga. People need the tree as a source of protein, vitamins, minerals, and carbohydrates. The plant contains more than 90 nutrients, antioxidants, and 8 essential amino acids, called the 'elixir tree'. The problem with this plant is that its leaves are easily damaged when picked. One way to avoid this is to perform a drying process. This Moringa dryer consists of an inner cabinet made of aluminum and an outer side made of zinc. The cabinet measures 40 cm long, 35 cm wide, and 35 cm high, has three shelves arranged horizontally, and each shelf can dry between 100 grams to 200 grams of moringa leaves simultaneously. In addition, it has a heater consisting of two 125-watt heaters and two upper and lower fans. In the first experiment, Moringa leaves were dried for 9 hours at 40°C, yielding 30g of dried leaves from 100g of fresh leaves. The second experiment lasted 6 hours at 50 °C, yielding 30 g of dried leaves from 100 g of fresh leaves. Finally, the leaves were dried for 3 hours at 60°C, yielding 30g of dried leaves from the initial 100g. These results also show a large weight loss at various temperatures and durations. After calculating the percentage of weight loss, it was found that the leaves lost 70% of their weight. Outseal PLC can automatically control the drying process according to the pre-programmed program. Temperature and humidity sensors maintain the nutritional quality and texture of the moringa leaves produced by controlling the dryer environment appropriately. This tool can be used easily by users without requiring high technical skills.

ISSN-E: 2964-6804
DOI: https://doi.org/10.55927/fjst.v3i8.10780
https://journal.formosapublisher.org/index.php/fjst

INTRODUCTION

The moringa plant (Moringa oleifera) is native to South Asia in tropical and subtropical regions, but has spread to many places around the world. Since thousands of years ago, this plant has been known and used traditionally by people in various countries. Various communities have used moringa plants for food, medicine, and agricultural needs. Moringa plants have various benefits from leaves, fruits, flowers, bark, and seeds [1]. In many places, moringa leaves have long been part of the diet program. Its leaves are rich in nutrients, such as vitamins, minerals, and protein, making them invaluable as a food source, especially in areas experiencing food shortages. In traditional medicine, the moringa plant has been used to treat a variety of health problems, such as inflammation, infections, digestive problems, diabetes, and others [2]. The parts of the moringa plant, including the bark of the stem, seeds, and leaves, are used for treatment [3].

Moringa plants are used in agriculture in addition to being used for food and medicine. This plant thrives in tropical and subtropical environments. They grow quickly and are resistant to adverse soil conditions. This makes it a great crop for greening, soil restoration, and animal feed. In addition to having the ability to improve human health and welfare in the future, moringa leaves show an important role in meeting human food, medicine, and agricultural needs throughout history [4]. Moringa leaves are often added to various traditional Indonesia dishes, such as clear vegetables, lalapan, stir-fry, and chili sauce. It can be used as the main ingredient to make healthy and fresh salads or lalap. Because moringa leaves have great health potential, many people don't know how to process them. This can be due to several things, such as a lack of awareness of the health benefits of moringa leaves, a lack of information, and a lack of knowledge about the use of this plant in the daily diet. Innovation is needed in the processing and serving of moringa leaves. One way to make it into a conventional food product, which is dried, is one of them.

Dried moringa leaves can be used to produce tea and processed flour such as puddings, cereals, and cakes. Moringa leaves have a lot of potential to produce innovative and creative products. Not only do these products have significant health benefits, but they can also help with local economic development and environmental conservation. Traditionally, the process of drying moringa leaves can be done by drying them directly in the sun, but there are some problems. This includes the risk of exposure to dust, insects, air pollution, or even animal waste. This can have an impact on the safety and cleanliness of dried moringa leaf products. To get the best results from drying in direct sunlight, the weather should be sunny and cloudy. Unsunny weather, such as rain or high humidity, can slow down the drying process or even damage the already dried Moringa leaves [5].

Direct sunlight can change the quality and color of moringa leaves. Too much sunlight can dry leaves quickly, but too little can also cause them to become brittle and lose their color [6]. Drying in direct sunlight can reduce the nutritional quality of moringa leaves because some vitamins and nutrients are sensitive to light and heat [7]. There may be reasons to consider alternative drying methods,

such as supervised drying, drying using a drying device such as an oven or air dryer, or controlled solar energy-assisted drying. Therefore, the quality and safety of dried moringa leaves can be better maintained. The PLC based automatic moringa leaf dryer Outseal can be built to solve the problems that arise when drying moringa leaves. One of the main goals is to reduce the time it takes to dry moringa leaves traditionally. The automatic dryer can complete the drying process faster and more efficiently. With process automation, users don't need to supervise drying directly. This reduces the workload and gives users more time to do other tasks. The use of automatic controls ensures that temperature, humidity, and drying time are set consistently, resulting in a uniform and high-quality final product [8].

A proper drying process can help maintain the nutrients and health properties of moringa leaves [9]. The tool is designed to be easy to use by many people, from individuals to small businesses. Outseal PLCs that use Outseal Studio for ladder diagram programming are inexpensive and accessible platforms, allowing users to create or purchase inexpensive devices.

THEORETICAL OVERVIEW

In recent research, various methods and technologies can be used to provide information on the design of a moringa leaf dryer that uses programmable logic control (PLC) on a laboratory scale. To optimise the drying process and ensure efficiency and consistency in the final product, key design components include the integration of sensors and control systems. One way is to use an Arduino Uno microcontroller equipped with a DHT11 sensor to regulate temperature and humidity. By activating a fan in response to temperature changes, the system automates the drying process and results in a significant reduction in moisture content from 73% to 7.2% within 7 hours [16]. This demonstrates the ability of microcontroller-based systems to control drying conditions well. One other creative design uses a solar photovoltaic thermal dryer (PV/T), which uses solar energy to generate heat and electricity. The system reduced moringa leaf mass by 72% over nine hours, demonstrating that solar energy can be used for drying applications [17].

To improve sustainability and energy efficiency, integration of solar technology can be incorporated into PLC-based systems. Designs that utilise air conditioning condenser heat also show that other heat sources can be used. These systems, both with and without suction fans, showed different results in reducing moisture; the setup with the improved fan resulted in a 40.8% reduction in moisture content [18]. This shows that combining fans and alternative heat sources can increase the drying rate, which can be controlled with a PLC to achieve the best performance. In addition, a drying oven system using fuzzy logic demonstrated an advanced control method; this system used sensors and fuzzy logic to ensure precise temperature control, which resulted in a 50% reduction in leaf weight [19]. To improve the adaptability and precision of the drying process, these control systems can be integrated into a PLC framework. In summary, integrating microcontrollers, solar energy, alternative heat sources, and advanced control methods such as fuzzy logic can aid in the design of a PLC

moringa leaf dryer at laboratory scale. Overall, these technologies provide a solid foundation for building effective and sustainable drying systems [16] [17] [18] [19].

METHODOLOGY

The moringa leaf drying machine dries the moringa leaves and removes the remaining water. Moringa leaf dryers typically have a more compact and structured design, which allows for space conservation and can be placed in a variety of places, both indoors and outdoors. This makes it easy to use and can be used by people who don't have any special skills [10].

The dryer machine can be measured according to production needs, ranging from industrial size to small size. This increases user productivity and business scalability. Moringa leaf dryer machines provide safety and certainty in the drying process with the right automatic settings and controls.

For the drying of moringa leaves, the ideal temperature is 40 to 60 degrees Celsius; This temperature is considered low enough to remove nutrients and quality moringa leaves, but it is still effective for removing excess water. Additionally, proper temperature settings can help maintain the natural color, texture, and aroma of moringa leaves. However, keep in mind that the ideal temperature can vary depending on environmental conditions, the type of moringa leaves, and the user's preferences. If possible, it is advisable to try and change the drying temperature to get the result that best suits the specific needs and conditions.

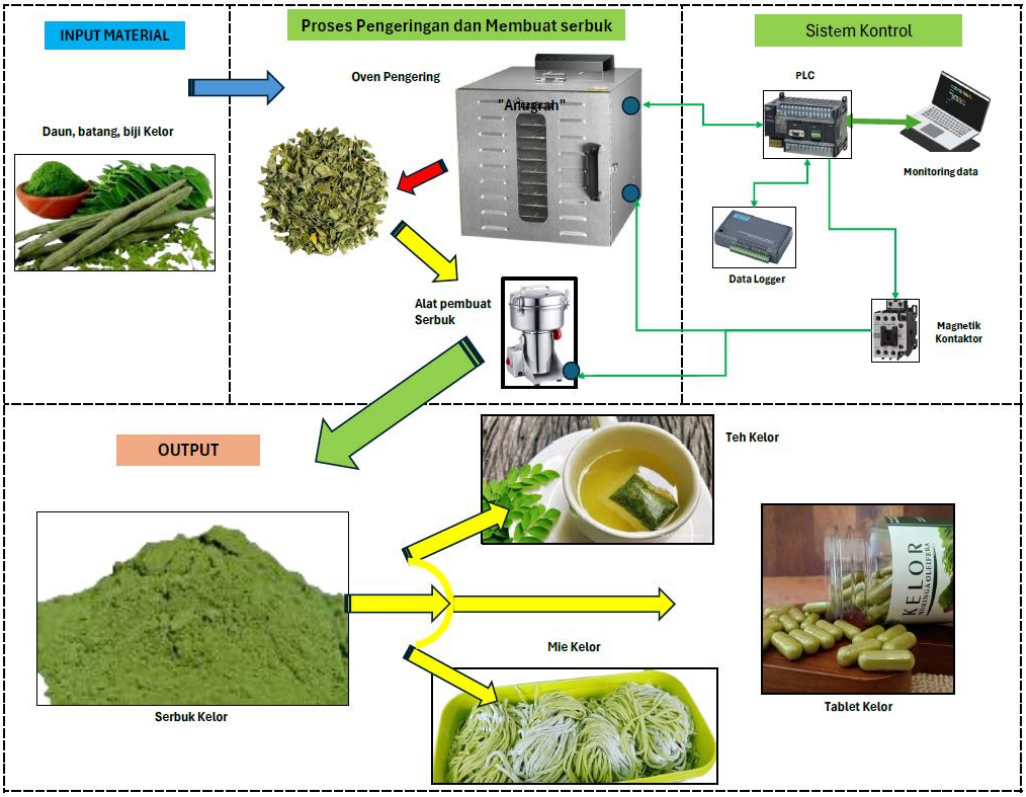

Figure 1. Flow Diagram of Dryer Design

The process of making moringa-based products (Moringa) consists of several main stages. First, the raw materials of moringa, which consists of leaves,

stems, and seeds, are collected and cleaned of impurities or other substances. After that, the cleaned moringa material is put into the drying oven to be dried. The drying process is carried out using a drying oven managed by programmable logic control (PLC). The drying temperature and time can be set to guarantee optimal drying without damaging the nutrient content. This drying process is consistently monitored through data loggers and computers. This is done to ensure that drying conditions remain constant.

After the drying process is complete, the dried moringa material is transferred to the powder making machine to be ground into fine powder. After that, the moringa powder is collected and ready for use or packaging. The PLC control system guarantees the drying and grinding process runs precisely, and the data logger records all process parameters for tracking and quality control purposes. The use of magnetic contacts and relays in the control system also ensures safe and efficient electrical operation.

Moringa powder can be further processed into various products such as moringa noodles, moringa tablets, moringa tea, and more. Moringa noodles are made by mixing moringa powder with noodle dough, then formed into noodles and dried or cooked as needed. However, moringa powder is formed into tablets by a tablet press machine. The final product is tested through laboratory testing to ensure it meets quality standards, and then packaged well to maintain freshness and extend shelf life. The results that will be achieved from this test are, for this drying process can produce dried moringa leaves with a humidity of 8-10%, drying temperature of around 40°, 50°, 60°, to maintain the nutrient content of moringa leaves.

RESULTS

This automatic moringa leaf dryer is made with PLC Outseal as the brain of the system. This device has a sensor to measure the temperature and humidity inside the drying chamber. During the drying process, there is a fan that regulates the airflow and a heater that generates heat. The appliance automatically regulates the temperature and humidity inside the dryer according to a pre-programmed program. The system will change the heating and fan settings to ensure that the temperature and humidity are in line with the purpose [11]. The tool has a simple user interface that consists of an LCD screen and a few buttons. This interface allows users to view and set the temperature, humidity, and drying time. The system has safety sensors that can detect abnormal conditions, such as high temperature or humidity, and automatically stop drying to prevent harm or damage [12].

The drying process can be controlled automatically with PLC Outseal, which reduces reliance on human supervision and improves the consistency of drying results [13]. This tool can save operational costs in the long run by automatically regulating temperature and humidity. This tool can help maintain the nutritional quality and texture of the moringa leaves produced by precisely controlling the environmental conditions in the drying room.

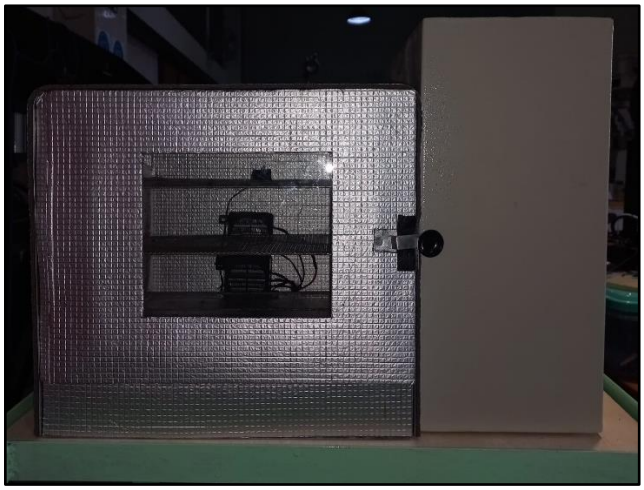

Figure 2. Dryer

This moringa leaf dryer has a capacity of 500-grams and uses 150 watts of electric power. The size (W x H x H) is 400 x 350 x 350 (mm). It has 3 shelves arranged horizontally, and each shelf can dry between 100-grams to 200-grams of moringa leaves at the same time. In addition, it has a heater consisting of two 125-watt heaters and two upper and lower fans, using an Outseal PLC based setup combined with an external timer.

The tool is easy to use by people from different demographics without requiring great technical expertise. The presence of safety sensors protects users from danger and damage to the drying machine. This PLC Outseal-based automatic moringa leaf dryer can help dry moringa leaves safely, efficiently, and consistently [14]. If the production of moringa leaves is very large, the moringa leaf dryer may not be able to process many moringa leaves at once. Moringa leaf dryers require electricity to function. In the event of a power outage or unstable access to electricity, it can be a problem, especially in rural areas. Moringa leaf dryers still require a lot of electricity costs, especially if they are used intensively in the long term. This happens even though energy use can be optimized. Regular maintenance is necessary for moringa leaf dryers to keep them functioning properly. Mechanical maintenance, cleaning, and sensor calibration are all parts of this maintenance, which requires additional time and cost.

Outseal's PLC-based moringa leaf dryer can suffer from technical failures, such as component malfunctions or system errors, such as all electronic devices [15]. This can interfere with drying and take time to repair. This appliance can control temperature and humidity, but it cannot control environmental factors such as weather or high air humidity. This can impact the efficiency and consistency of drying. Reliance on certain electronic components, such as temperature and humidity sensors, can be a problem, especially in places where accessibility is limited. Although it can be automated, this tool has limited functionality if the user needs additional features or special modifications. These drawbacks must be considered, users must create appropriate risk mitigation and management strategies to minimize their impact on the operation of moringa leaf dryers. The drying process using a PLC Outseal-based dryer is shown in figure 3.

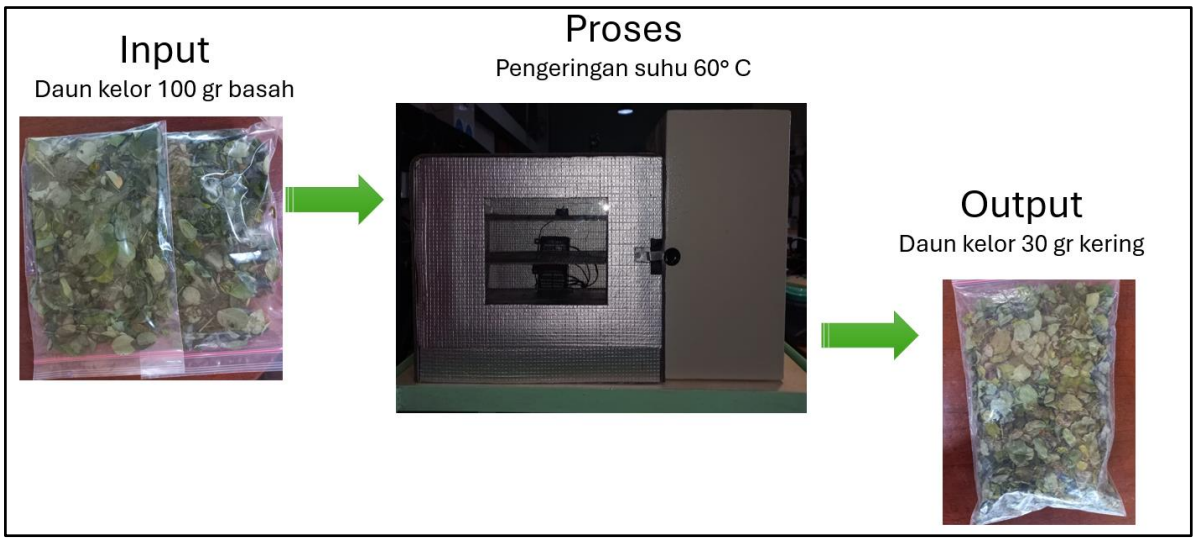

Figure 3. Moringa Leaf Dryer Process

In order to produce high-quality and long-lasting moringa leaf products, the drying process of moringa leaves is very important, as shown in the picture. At first, 100-grams of wet moringa leaves are put in the dryer. This drying process is carried out at a temperature of 60^0C, which is the ideal temperature to evaporate water without damaging the essential nutrients in moringa leaves. The drying equipment used has an automatic temperature controller that keeps the temperature constant during the drying process.

The water in the moringa leaves is gradually evaporated during the drying process, reducing the weight of the moringa leaves significantly. After the drying process is complete, 30-grams of dried moringa leaves are produced, which indicates that about 70% of the initial weight of the moringa leaves is water. This drying reduces the volume and weight of moringa leaves and extends their shelf life, so they can be stored for longer without being damaged or losing their quality.

In addition, this drying process helps in the packaging and distribution of goods. Compared to fresh moringa leaves, dried moringa leaves are easier to carry and store because they are lighter. In addition, properly dried moringa leaves retain most of their nutrients, including vitamins, minerals, and antioxidants, so they remain beneficial as a health supplement. Therefore, the drying process increases the shelf life and ease of use of moringa leaves. This process also ensures that the final product remains highly nutritious and ready to be eaten or processed.

The results of drying moringa leaves under various conditions are shown in table 1. To assess the effect on the final weight of the dried leaves, three different temperature settings and drying times were tried. In the first experiment, Moringa leaves were dried for 9 hours at 40^0C, resulting in a reduction of 100-grams of fresh leaves to 30-grams of dried leaves. The second experiment lasted for 6 hours at 50 ^{0}C, resulting in a final weight of 30-grams of fresh leaves. Finally, the leaves are dried for 3 hours at 60 ^{0}C, resulting in also 30-gram dried leaves from the initial 100-gram. The results are shown in table 1, the

dried moringa leaves, with a consistent drying time and temperature. This table shows that the final dry weight for each experiment remains the same at 30 grams, although the drying conditions differ. Initially, 100-gram fresh moringa leaves undergo various drying processes, with the final weight being 30-grams in each of those processes. These same results show significant weight reductions over a wide range of temperatures and durations. It was found that the leaves lost 70% of their weight after calculating the percentage of weight loss.

To calculate the percentage decrease in weight of moringa leaves after drying

$$\text{Pengurangan } \% = \left(\frac{(berat\ awal - berat\ akhir)}{berat\ awal}\right) \text{ x } 100\%$$

$$\text{Pengurangan } \% = \left(\frac{(100 - 30)}{100}\right) \text{ x } 100\% = 70\%$$

This high percentage of weight loss indicates that there is a large water removal during the drying process, which indicates that the drying techniques used are efficient.

Table 1. Dried moringa leaves

No	Dryer Temperature (C)	Time (hours)	Weight of wet moringa leaves (grams)	Weight of dried moringa leaves (grams)	Dried moringa leaves
1	40	9	100	30	

No	Dryer Temperature (C)	Time (hours)	Weight of wet moringa leaves (grams)	Weight of dried moringa leaves (grams)	Dried moringa leaves
2	50	6	100	30	
3	60	3	100	30	

CONCLUSIONS

Outseal PLC-based automatic moringa leaf dryer is a great way to dry moringa leaves safely, quickly, and regularly. Using Outseal PLC, this tool can control the drying process automatically according to the program that has been programmed. Temperature and humidity sensors maintain the nutritional quality and texture of the Moringa leaves produced by controlling the dryer environment appropriately. In the first experiment, Moringa leaves were dried for 9 hours at 40°C, producing 30g of dried leaves from 100g of fresh leaves. The second experiment lasted 6 hours at 50 °C, producing 30 g of dried leaves from 100 g of fresh leaves. Finally, the leaves were dried for 3 hours at 60°C, yielding 30g of dried leaves from the initial 100g. These results also show a large weight loss at various temperatures and durations. After calculating the percentage of weight loss, it was found that the leaves lost 70% of weight. The device can be used easily by users without requiring high technical skills.

RECOMMENDATION

The design of a PLC-based moringa leaf dryer for laboratory scale includes a PLC system to automatically control temperature, humidity, and airflow. The system has sensors to monitor conditions during the drying process and ensure energy efficiency. Additionally, the system has safety features to prevent malfunctions. In addition, the design considers scalability for larger production needs, ease of operation, and process monitoring by the user.

FURTHER STUDY

This study focuses on designing and using a PLC-based logic control laboratory-scale moringa leaf dryer. This research aims to create an effective automatic drying system that can maintain the quality and nutritional value of moringa leaves by precisely controlling temperature and humidity. Through testing and performance analysis, the results of this study are expected to provide a better solution than traditional drying methods and offer suggestions for further development in small industries or laboratories.

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