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Microcontroller based dual energy Moringa leaf dryer design and development

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ABSTRACT

This paper presents the design and development of an automatic dual energy solar powered Moringa dryer used to remove moisture. Moringa leaves are circulated by hot air evenly in a cylindrical mesh of aluminum mesh which rotates at 20 revolutions per minute through which hot air is passed to extract moisture from the leaves. The Arduino Uno or Atmega32 microcontroller works in conjunction with appropriate sensors to monitor and control humidity, moisture content, motor speed, room temperature, heater, and fan. Based on the moisture content in the Moringa leaves, the sensor sends a control signal to the controller. The results showed a good response in removing the initial moisture content from 18.5% to the final moisture content to 4% of green leaves without changing the nutritional value. Qualitative analysis showed that traditional drying, namely open drying, drying Moringa leaves each for 3 days in 12 hours with a final moisture content of 7%, while double solar drying only takes 3 days in 12 hours with a final moisture content of 4%, and produce better quality Moringa leaves. High efficiency in the drying process of Moringa leaves compared to traditional drying, where this tool can dry Moringa leaves faster by 3%.

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1. INTRODUCTION

Technological advances have to improvise to reduce the workload of farmers and make their work more mechanized and easier [1], [2]. Agriculture is the backbone of the Indonesian economy. Therefore, it is essential to increase the efficiency and productivity of agriculture while at the same time providing safe cultivation for farmers [3], [4]. Drying is the process of removing moisture from the leaves of the Moringa plant after harvesting [5], [6].

After harvesting, Moringa leaves contain a moisture content of about 19% to 18.5% as measured using a digital grain moisture meter and this is not ideal for storage as it can cause discoloration, rot, promote mould development, and increase the likelihood of pest attack. This product to a reduced level of benefit in the case of health products. Therefore, it is important to dry the foliage as soon as possible after harvesting, ideally within 24 hours [7]. Delay in drying, incomplete drying, or ineffective drying will reduce leaf quality, and result in losses [8].

The design and development of this tool are beneficial in reducing dependence on cloudy weather conditions for harvesting and drying processes which in turn allows farmers to spend more time on other post-harvest activities [9]. Several conventional methods for leaf drying include solar bubble drying, layer drying, natural low-temperature airflow drying, and continuous airflow drying [9]. Mechanical drying of agricultural products is an energy-consuming operation in post-harvest technology. Therefore, greater emphasis is being placed on solar energy sources to address the shortage of fossil fuels. A new natural convection dual-energy solar-powered dryer consisting of a solar air heater, heating element, and a drying chamber was developing [10]. The initial moisture content cannot be effectively dried using natural airflow drying because it has a low temperature. It also requires an electrical power supply in each tray for the dryer fan motor. This prototype increases the cost of capital and also requires a skilled and experienced workforce. The most common problem with all these conventional drying methods is that they are ancient and traditional and take up a lot of space and time. Depending on the weather, the initial costs are very high, and medium or small-scale farmers cannot afford it–a new solar-powered automatic dual-energy Moringa leaf dryer designed to solve the problems mentioned above

The purpose of drying is to remove water from Moringa leaves towards equilibrium moisture content with the surrounding air or at a water content level where the quality of Moringa leaves can be prevented from attack by fungi, enzymes, and insect activity. Drying is carried out to reduce the water content to a certain percentage to avoid insects, fungi, rodents, and birds and to prevent moisture from re-entering the leaves [11]. However, if the drying is not done correctly, there will still be any loss in storage.

Meanwhile, according to Zare and Chen [12], the drying process is taking or reducing the water content to a certain extent so that it can slow down the rate of damage to agricultural materials due to biological and chemical activities before the materials are processed or utilized. The greater the temperature difference between the heating medium and the food, the faster the heat transfers to the food, and the faster the evaporation of water from the food. In the drying process, the water removed from the food can be in the form of water vapour [13]. The moisture must be immediately removed from the atmosphere around the dried food. If it doesn't come out immediately, the air around the food will become saturated with water vapour, which slows down the evaporation of water from the food, slowing down the drying process, and especially when measuring water content with a moisture meter. However, depending on the area where the Moringa leaves are dried, the hotter the temperature used for drying the Moringa leaves will make the Moringa leaves shrink quickly, and which affects the quality of the taste of the Moringa leaves obtained.

Advances in technology have brought many changes in our daily lives, and we are very grateful for that. Likewise, the agricultural sector is growing every day both in terms of production and technology. To reduce farmers' post-harvest time, the proposed idea is implemented in the form of a dual-energy solar-powered dryer controlled by a 20-rpm direct current (DC) motor with a cylindrical screen made of aluminum and rotates horizontally.

The aluminium gauze is perfect for laying Moringa leaves comfortably and also for proper hot air penetration [10]. This research architecture has never been used on Moringa leaf objects based on article reviews [9], [14]. It uses Arduino/Atmega microcontroller for intelligent control actions that need to be implemented for the drying process [15]–[17]. The natural sun drying technique will use the heat from the sun to dry the leaves for 2–5 days, which can be very tedious and monotonous. Utilizing the same principle, in this paper, we use the heat generated from the heating coil along with the exhaust fan, and thereby generating the heat needed to dry the leaves to the desired specifications and standards.

The main objective of this paper is to make the work of farmers more accessible, faster, and highly efficient in drying Moringa leaves post-harvest for storage and health products. The designed mechanism requires less time to dry Moringa leaves using solar photovoltaic-based drying than traditional drying processes. It also aims to reduce the labour-intensive experienced by the farmers. The dual energy method was chosen for drying Moringa leaves, with this method the calories and various nutrients of dried Moringa leaves were not damaged compared to open sun drying [18]–[21].

2. RESEARCH METHOD

The components used to overcome these problems include solar panels, buck-boost converter, load control circuit, Johnson DC gear motor (20 rpm), Arduino, temperature and humidity sensor (DHT11), humidity sensor, dual-channel 5 V relay, L298N circuit H-bridge motor driver, heating element, DC fan, conveyor belt, circuit board, and jumper cable. The simple dual-energy solar-powered automatic Moringa leaf dryer is designed to dry Moringa leaves effectively and quickly [22]–[26]. The dryer has a simple architecture that makes it easy to assemble and disassemble components. The functional block diagram of the dryer is shown in Figure 1. The operation of each block is described in this section.

The power circuit system consists of solar panels, maximum power points tracker, controller, battery charging circuit, and battery. Solar panels will provide electricity to charge the battery during the day, which is then used to power the system. Battery charging is controlled by the solar charge controller. The hardware structure is design as shown in Figure 1; the cylindrical net is made using aluminium mesh material to provide flexibility and holes to penetrate the air through the Moringa leaf and aluminium mesh. Arduino Uno/Atmega coded according to requirements and connections to various components. Figure 2 shows the tool design and development of a solar-powered dual energy dryer for drying Moringa leaves.

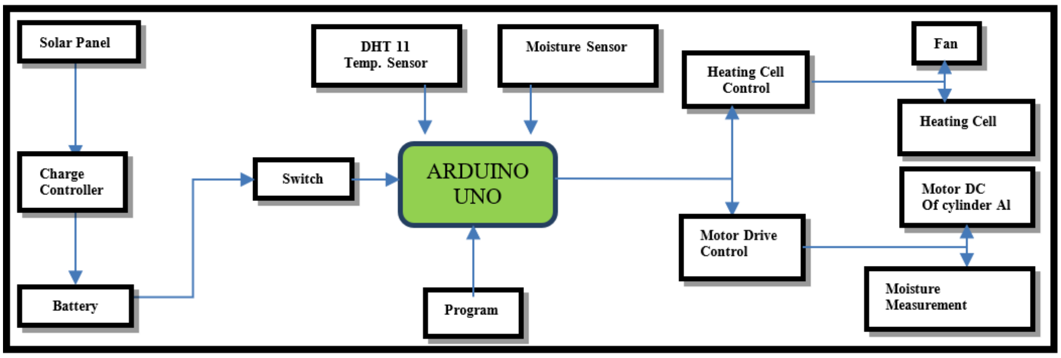

Figure 1. Function block diagram

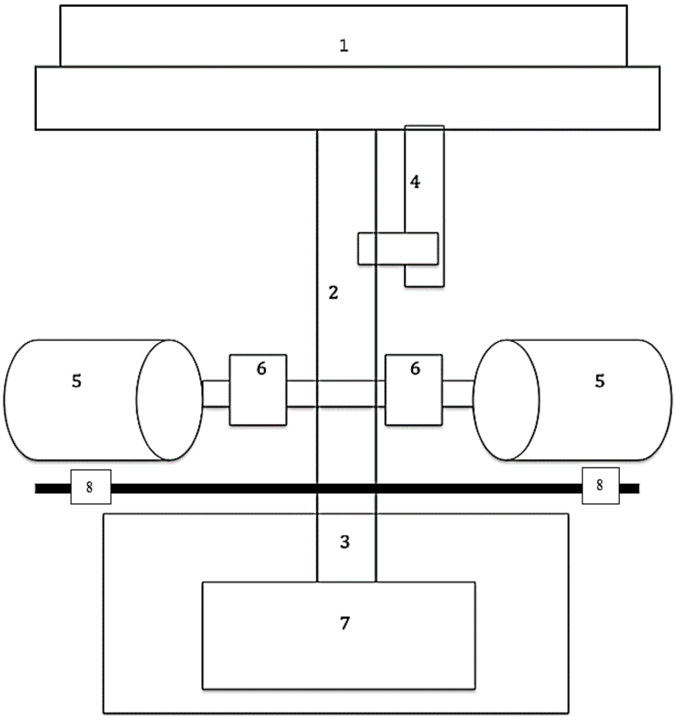

Figure 2. Tool design and development

Caption
1. 200 Wp. Solar Panel
2. Prototype Main Support Rod
3. Microcontroller and System MotherBoard
4. Hydraulic Motor/Servo Motor
5. Aluminum Gauze Cylinder
6. Aluminum Mesh Cylinder Drive AC/DC Motor
7. Battery VRLA AGM 12V 150 Ah
8. Heating Element

3. RESULTS AND DISCUSSION
3.1. Traditional Moringa oleifera drying
Table 1 and Figure 3 show that traditional drying of Moringa leaves with an average drying temperature of 41.6 ºC takes three days to achieve a 7% reduction in moisture content from the initial water content of 18.5%. Every day an average of 4 hours is required for the traditional drying process. It can reduce water content by 5% to 2% per day. The total time need for drying from 18.5% to 7% is for 12 hours if the average drying temperature is 41.6 ºC. The reason for the start of drying was taken at 11:15:00 am because at that time, the maximum light and heat were obtained because at that time, and nthe angle of the sun to the earth reached 90º [16], [27].

Table 1. Traditional Moringa oleifera drying data

Day	Experiment	Time	Decrease in Water Content		Drying Temperature
			Initial Moisture Content	Final Moisture Content	
First day	1	11:15:00–15:20:00	18.5%	13.5%	41 °C
The second day	2	10:45:00–15:39:00	14.5%	9.0%	43 °C
The third day	3	11:07:00–14:20:00	9.0%	7.0%	41 °C

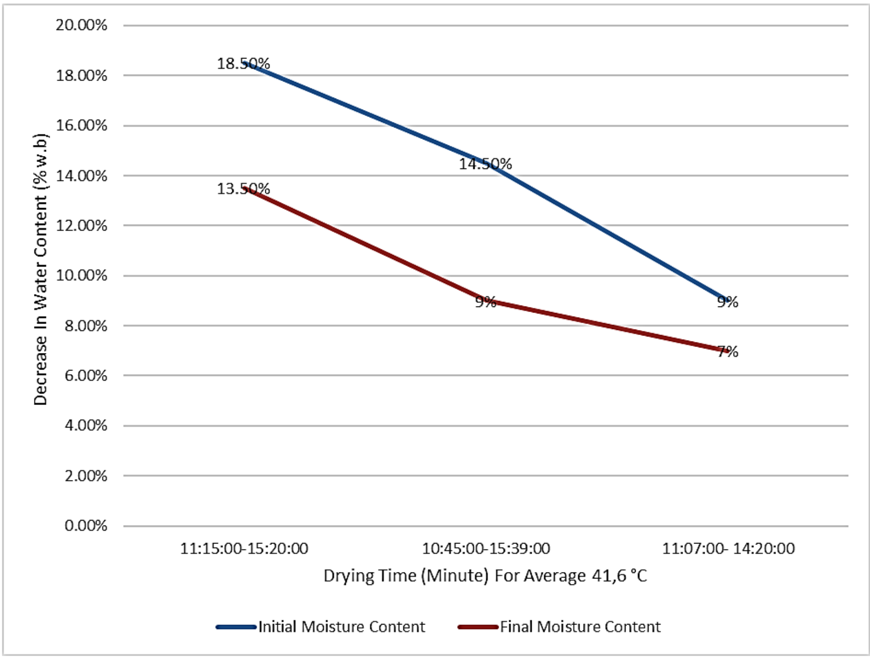

Figure 3. Graph of traditional Moringa oleifera leaves drying

3.2. Drying Moringa oleifera using a dual energy dryer
Table 2 and Figure 4 show that Moringa oleifera drying using a dual-energy dryer has been carried out for three days with an average drying time of 4 hours per day starting from 11:15:00 noon to 14:45:00. The reason for collecting data is from 11:15:00 to 14:45:00 in the afternoon, because at that time, the direction of the sun is perpendicular to the earth and emits maximum light and heat with the sun's angle to the earth reaching 90º, and so it is very beneficial for solar panels to absorb maximum photovoltaic energy. The drying of Moringa leaves with a solar powered dryer produces an average temperature of 63 ºC resulting from the combination of the dual energy of sunlight and battery energy.

Drying of Moringa leaves with this dryer with an average drying temperature of 63 ºC takes three days to achieve a 4% reduction in moisture content from the initial water content of 18.5%. Each day an average of 4 hours is required for the drying process. It can reduce the final water content by 6% to 4% per day with an average of 5.3%. The total time required for drying from the initial moisture content of 18.5% to the final moisture content of 4% is for 12 hours if the average drying temperature is 63 ºC.

Table 2. Drying Moringa oleifera using a dual energy dryer

Day	Experiment	Time	Decrease in Water Content		Drying Temperature
			Initial Moisture Content	Final Moisture Content	
First day	1	11:15:00–12:15:00	18.5%	17%	63 °C
First day	2	12:15:00–13:15:00	17%	16%	63 °C
First day	3	13:15:00–14:15:00	16%	15%	63 °C
First day	4	14:15:00–15:20:00	15%	14.5%	63 °C
The second day	6	10:45:00–11:45:00	15%	14%	63 °C
The second day	7	11:45:00–12:45:00	14%	13%	63 °C
The second day	8	12:45:00–13:45:00	13%	12%	63 °C
The second day	9	13:45:00–14:00:00	12%	11%	63 °C
The second day	10	14:00:00–14:45:00	11%	10%	63 °C
The second day	11	14:45:00–15:39:00	10%	9%	63 °C
The third day	12	11:07:00–11:50:00	9%	8.5%	63 °C
The third day	13	11:50:00–12:50:00	8.5%	7.5%	63 °C
The third day	14	12:50:00–13:40:00	7.5%	6.5%	63 °C
The third day	15	13:40:00–14:20:00	6.5%	4%	63 °C

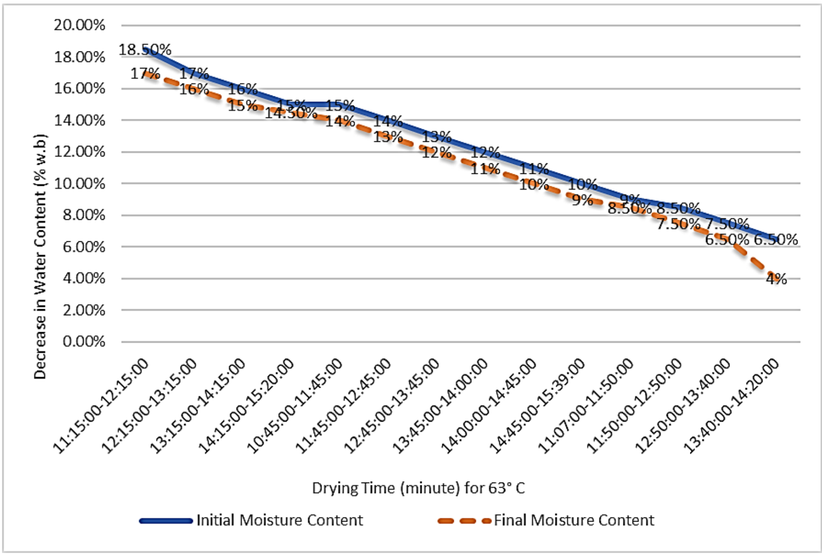

Figure 4. Graph of Moringa oleifera drying using a dual energy dryer

The solar-powered automatic Moringa leaf dryer prototype shows that the drying process was completed in three days with a final moisture content difference of 3% from conventional drying, which takes three days with a final moisture content of 7%. The system is designed using a rotating aluminium cylinder system in which the Moringa leaves are evenly coated and dried thoroughly with the help of heating coils and fans mounted under the aluminium cylinder net. The hot air will draw the moisture out of the Moringa leaves and allow them to dry to the desired level, which is ideally required for storage. The value displayed on the Arduino Uno/Atmega32 serial monitor is validated by a grain moisture meter to ensure there is no difference with the displayed value.

4. CONCLUSION

The model provides a reasonably good picture of how the system can be scaled up with the same ideas and the same prospectus. The proposed system is portable and convenient to use and does not require any operating expertise because everything works automatically. This system is best suited for small and medium farmers who do not have the possibility of using expensive and technologically advanced dryers. The drying process can be completed in a few hours in this system. This system takes into account the current temperature of the aluminium cylinder net and the output of the solar panel is healthy.

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