INTELLIGENT COCOA DRYER TECHNOLOGY BASED ON AN EMBEDDED SYSTEM

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Abstract

Technology has become a basic need for humans, which is used by all groups from children to adults, experts and non-experts, in various aspects of their lives. Every innovation is created with the aim of having a positive impact on human life. Cocoa (Theobroma cacao L.) is a plant originating from South America. And cocoa is one of the mainstay commodities of the plantation sub-sector with high economic value and plays an important role in the development of plantations in Indonesia. However, the drying process still uses heat from sunlight, so whether the drying process takes a long time or not really depends on the intensity of the sunlight shining on it. With the Embedded System concept implemented using a microcontroller, embedded systems can provide real time responses. To be a solution for drying cocoa without sunlight and being able to see the temperature and moisture content of the cocoa, the tool "Intelligent Cocoa Drying Technology Based on an Embedded System" was created. In this research, Arduino Uno is used as a microcontroller, a DHT22 sensor to detect the heat temperature in the box, an RTC DS3231 to carry out scheduling and a SoilMoisture sensor to measure water content after drying and a motorbike battery as an electricity backup in the event of a power outage.

1. Introduction

Nowadays, technologyhas become a basic need for humans, which is used by all groups from children to adults, experts and non-experts, in various aspects of their lives. Every innovation is created with the aim of having a positive impact on human life. Apart from that, technology also provides many conveniences and becomes a new way of carrying out human activities. Over the last decade, humans have enjoyed many benefits resulting from technological innovations (Balya, 2023).

Cocoa (Theobroma cacao L.) is a plant originating from South America. In Indonesia there are two types of cocoa plants cultivated, namely noble cocoa (edel) and bulk cocoa. In terms of quality, cocoa is superior compared to bulk cocoa. Cocoa in Indonesia, especially that produced by the people, is still valued at the lowest price on the international market because of its unfavorable image, namely being dominated by unfermented beans, beans with high levels of dirt and contamination by insects, fungi and mitotoxins (Sigalingging et al., 2020)(Ariningsih et al., 2020). Cocoa is one of the mainstay commodities in the plantation sub-sector with high economic value and plays an important role for development plantation in Indonesia, specifically in Province Lampung. Based on plantation statistics data from the Lampung Provincial Plantation Service in 2020, cocoa plantations are fully cultivated by smallholders with a total area of 78,711 ha, production of 57,507 tonnes and cultivated by 140,873 families of planters. Pesawaran Regency and Tanggamus Regency are one of the cocoa producing centers in Lampung Province. Pesawaran Regency contributed the highest production, namely 28,544 tons/ha/year with an area of 27,357 ha. The second position is occupied by Tanggamus Regency with an area of 13,677 ha with a production capacity of 6,711 tons per year (Admin Newsletter, 2021).

QualityThe cocoa beans produced by farmers in Lampung are not yet optimal, resulting in low prices received by farmers. The low quality and quantity of cocoa beans produced by farmers is due to the lack of technology they have (Alim et al., 2020) and they still use a drying process using the heat of the sun so that the length of the drying process depends greatly on the intensity of the sunlight shining on it. Drying using sunlight has positive and negative sides. The positive side is that dried cocoa beans will have a reddish brown bean color. Such color and appearance are the expectations of the cocoa bean drying process, so using sunlight as a drying method is more recommended. However, sun drying has challenges related to weather conditions, especially when it rains. This drying method takes between 5 and 7 days to reach a moisture content below 7.5%. If the moisture content of dry cocoa beans exceeds 7.5%, it will not meet SNI requirements (Bloom & Reenen, 2019). A good temperature for drying cocoa beans is 55-66˚C because if it is below 55˚C cocoa beans are susceptible to fungal attacks caused by the slow drying process (Amin, 2021).

With the Embedded System concept implemented using a microcontroller, embedded systems can provide real time responses. Therefore, embedded systems are classified according to the system embedded in them. The embedded system is designed in such a way as to run a special system to carry out a certain task, so for this system to work it must be equipped with several systems such as electronic circuit systems (Zhang & Li, 2023).

Based on the research above, the author created a tool "Embedded-based intelligent cocoa drying technology System". This intelligent cocoa technology is capable of drying more quickly, when compared to drying using sunlight because this intelligent cocoa drying technology, according to Muhammad Amin's journal, uses temperatures between 55°C-65°C(Amin, 2021) Using 8 25 watt incandescent lamps and The drying room is equipped with a zinc plate which functions so that it can be used the heat in the drying room is even, the temperature of the drying room in the cocoa dryer has a condition starting with a temperature of 30 ºC and 8 lights are still on if it passes 55 ºC, 1 top light and 1 bottom light will turn off and 6 lights are used to keep the temperature stable at 55 ºC up to 65 ºC, if the temperature exceeds 65 ºC, 1 light at the top and 1 at the bottom, leaving 4 lights to lower the temperature if the box heats up too quickly, and there is a motorbike battery as backup electricity in case of a power outage. Then equipped with dht22 to measure the heat temperature in the box and soil moisture to measure the water content after drying is complete.

2. Research Methods

2.1. Prototype Method

The prototype method is a technique that can be used in the development of a device to produce re-development. The prototype method begins with collecting user needs, in this case the user of the device being developed, namely smart cocoa drying technology based on an Embedded System. Then create a design which will then be re-evaluated before it is produced correctly (Nugraha & Syarif, 2018). A prototype is not something complete, but something that must be evaluated and modified again. Any changes can occur when a prototype is created to meet user needs and at the same time allow developers to better understand user needs (Sentono, Ahmad, Ranu, 2020).

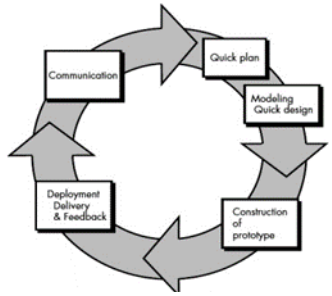

Fig 1. Prototype Method

2.2. Microcontrollers and Sensors

Below are the microcontrollers and sensors that will be used by the author.

2.2.1. Arduino Uno R3

The Arduino board consists of ready-to-use microcontroller hardware/modules and IDE software which is used to program so that we can learn easily. The advantage of Arduino is that we don't have to bother with the minimum system and programmer circuit because it is built in on one board (Arrahman, 2022).

Fig 2. Arduino Uno R3

2.2.2. DHT22 sensor

DHT22 or also known as AM2032 is a sensor that can measure the temperature and humidity of the air around this sensor more accurately and precisely (Puspasari et al., 2020). This sensor can measure temperature in the range of -40 to 80 degrees Celsius with an accuracy of 0.5 degrees Celsius, as well as humidity in the range of 0 to 100% with an accuracy of 2-5%. DHT22 uses a single-wire communication protocol and transmits data in digital form (Roihan et al., 2021).

Fig 3. DHT22 sensors

2.2.3. Soilmoisture Sensor

Soilmoisture Sensor (Sensor YL) is a type of sensor whose function is to measure soil moisture, the operating principle is to detect moisture around the soil (Riska Jupita, Arjun Nuradin Tio, Arinda Rifaini, Chindy Saputri, 2021) and the Soil Moisture Sensor is divided into two parts, namely one electronic board and the other a probe which is equipped with a two potentiometers, their function is to detect water content (Zhao et al., 2022).

Fig 4. Soilmoisture Sensors

2.3. Block Diagrams

Block diagrams are a form of process diagram for systems specialized in engineering activities. The diagram is arranged from a high level point of view or does not highlight too detailed parts of the system. The purpose of making it is to show the main parts when creating a new system or improving an existing system. In this chapter we will discuss a brief overview of the working system of the tool that will be made and used. The block diagram in this research can be seen in Figure 2.5 as follows:

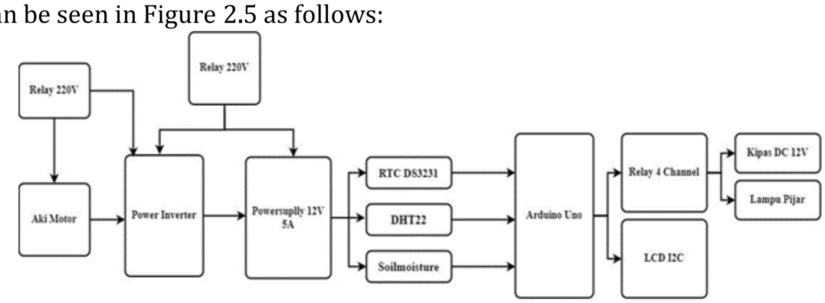

Fig 5. Block Diagrams

The image above is an example of a block circuit diagram that explains in general the design in this research. The way this tool works is that 8 incandescent lamps replace the sun which function to dry the cocoa and the DHT 22 sensor will read the temperature in the drying box as well as a soil moisture sensor to measure the moisture content of the cocoa beans after drying. The condition of the cocoa dryer is that it starts with a temperature of 30 ºC and 8 lights are still on if it passes 55 ºC, 1 top light and 1 bottom light will turn off and 6 lights are used to keep the temperature stable at 55 ºC to 65 ºC, if the temperature exceeds 65 ºC 1 top light and 1 bottom light, leaving 4 lights to reduce the temperature if the box heats up too quickly, and there are 3 motorbike batteries as electricity backup in case of a power outage.

2.4. Design Tools

The design of this tool was made using SketchUp software in the form of 3D modeling to describe the shape of the cocoa dryer that will be used in this research. Cocoa drying system design

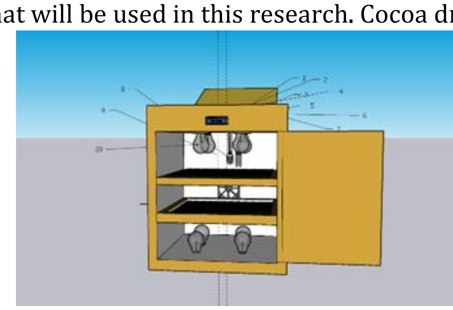

Fig 6. Tool Designs

2.5. Tool Schematic Circuit

A schematic series of tools or a series of components that will be used in this research and formed using Fritzing software in the form of an overall component picture where all the components that have been assembled will be implemented in real form in the system.

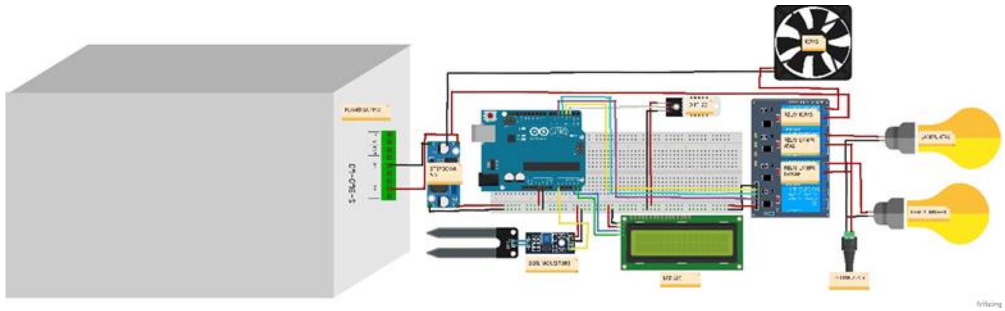

Fig 7. Schematic circuit of tools

2.6. Tool Implementation

After the tools and materials are collected, the next step is to implement the tool design that has been made. At this stage, the design results that have been implemented will be implemented in software and hardware implementation. The following is the tool implementation carried out by the author.

Fig 8. Tool Implementation

3. Result and Discussion

3.1. DHT22 Sensor Testing

Testing of the DHT22 sensor was carried out by placing it in a drying box and testing it during the drying process within 7 hours. The following are the test results of the DHT22 sensor

Table 1. DHT22 Sensor Testing

No	Waktu	Termometer	Sensor DHT 22	Lampu		Kipas
		Suhu Box Alat	Suhu Box Alat	Jumlah	Kondisi	
1	07:00	31°C	30°C	8 Buah	Hidup	Mati
2	07:30	35°C	34°C	8 Buah	Hidup	Mati
3	08:00	40°C	38°C	8 Buah	Hidup	Mati
4	08:30	41 °C	40°C	8 Buah	Hidup	Mati
5	09:00	44 °C	43°C	8 Buah	Hidup	Mati
6	09:30	45 °C	46°C	6 Buah	Hidup	Mati
7	10:00	49 °C	49°C	6 Buah	Hidup	Mati
8	10:30	52 °C	51°C	6 Buah	Hidup	Mati
9	11:00	54 °C	53°C	6 Buah	Hidup	Mati
10	11:30	56 °C	55°C	6 Buah	Hidup	Mati
11	12.00	60 °C	59°C	6 Buah	Hidup	Mati
12	12:30	63 °C	62°C	6 Buah	Hidup	Mati
14	13:00	67 °C	66°C	4 Buah	Hidup	Hidup

Based on the test results of the DHT22 sensor in table 3.1 above, it shows that the DHT22 sensor can detect the temperature inside the dryer box accurately. According to [6] explains that the ideal temperature for drying cocoa beans ranges from 55ºC - 65 ºC, so that the test results show that the cocoa dryer carries out a drying experiment for 7 hours, in the experiment when the temperature has passed 56 ºC the top light is 1 and the bottom 1 fruit will turn off and use 6 lights to keep the temperature stable at 55ºC to 65ºC, if the temperature exceeds 65 ºC 1 light at the top and 1 at the bottom and leave 4 lights to lower the temperature if the inside of the box heats up too quickly because it can affect the cocoa beans .

3.2. DHT22 Sensor Calibration

Calibrating a sensor is testing the suitability of the sensor to achieve results that match the expected indicators. You can see in table 4.1 the comparison between DHT22 and Thermometer Hygrometer gets an error of 1.0 with a temperature difference of 1ºC so it is very necessary to calibrate the sensor. The following is a table of calibrated DHT22 temperatures and a comparison with a hygrometer thermometer.

Table 2. Sensor Calibration

No	Thermometer Hygrometer	DHT22 Sensor Calibration
1	31ºC	31ºC
2	35ºC	35ºC
3	39ºC	39ºC
4	41ºC	41ºC
5	44ºC	44ºC
6	45ºC	45ºC
7	49ºC	49ºC
8	52ºC	52ºC
9	54ºC	54ºC
10	56ºC	56ºC

3.3. Soilmoisture Sensor Testing

Soilmoisture sensor testing is carried out after the cocoa beans have finished the 7 hour drying process to measure the moisture content of the cocoa beans. The following are the results of testing the soil moisture sensor.

Fig 3. SoilMoisture Sensor Testing

Based on the picture above, the moisture content of the cocoa beans is 6.8% after drying for 7 hours, so according to [12] the moisture content obtained shows that the quality of the cocoa beans is classified as good.

3.4. Electrical Power and Cost Calculations

The following is a calculation of the electrical power and usage time of the cocoa dryer, so the researchers obtained the data, namely

$$W = p\ x\ t \mid p = 25\ wat \mid t = 24 \text{ hours} \mid 1\ Kwh = 1{,}500$$

Calculation of power and costs for 24 hours of use: 8 $lampu\ x\ 25wat\ x\ 24\ jam$ = 4,800Wh � 1,352 = 3.2 kWh so during 24 hours = 1 x 3.2 $kWh\ x\ Rp$. 1,500 = Rp. 4,800. and next is the calculation for 7 hours of use: 8 $lampu$ x 25$wat\ x$ 7jam = 1,400Wh � 1,352 = 2.7 kWh so for 7 hours = 1 x 2.7 $kWh\ x\ Rp$. 1,500 = Rp. 4,050

4. Conclusions

After carrying out various tests on each component of the Embedded System Based Smart Cocoa Dryer Technology tool, the following conclusions can be drawn:

1. This tool can dry cocoa beans for 7 hours properly and is not dependent on sunlight because this tool is equipped with a DHT22 sensor to measure the temperature in the drying box and the tool is able to control the temperature based on the measurement results from the DHT22 sensor and this tool is equipped with 8 25W incandescent lamps. which is used to dry cocoa beans.
2. Based on the test results obtained, it is able to maintain the quality of cocoa beans so as to avoid fungal attacks because this tool is able to maintain temperature stability in the drying box with a temperature of 55 ºC – 65 ºC.
3. This tool is equipped with sensorssoil moisture to measure the moisture content of cocoa beans after the drying process so that it can determine the quality of the cocoa beans after drying.

4.1. Suggestion

Making a prototype of intelligent cocoa drying technology based on an embedded system in this research still has shortcomings and needs further development. The following are several suggestions given so that this research can be developed further.

1. For developmentNext, you can add the capacity of the cocoa beans to be dried.
2. The number of Amperes has been increased in the electricity backup source so that it can keep the system running longer if a power outage occurs
3. Added elements of the Internet of Things so you can monitor the temperature and moisture content of cocoa in real time on your smartphone or laptop

5. References

Admin Newsletter. (2021). *Kakao Lampung*. May 15. https://sdgcenter.unila.ac.id/kakao-lampung/

Alim, S., Lestari, P. P., & Rusliyawati, R. (2020). Sistem Pakar Diagnosa Penyakit Tanaman Kakao Menggunakan Metode Certainty Factor Pada Kelompok Tani Pt Olam Indonesia (Cocoa) Cabang Lampung. *Jurnal Data Mining Dan Sistem Informasi*, *1*(1), 26. https://doi.org/10.33365/jdmsi.v1i1.798

Amin, M. (2021). *Rancang bangun alat pengering biji kakao berbasis iot dengan kendali suhu otomatis*.

Ariningsih, E., Purba, H. J., Sinuraya, J. F., Suharyono, S., & Septanti, K. S. (2020). Kinerja Industri Kakao di Indonesia. *Forum Penelitian Agro Ekonomi*, *37*(1), 1. https://doi.org/10.21082/fae.v37n1.2019.1-23

Arrahman, R. (2022). Rancang Bangun Pintu Gerbang Otomatis Menggunakan Arduino Uno R3. *Jurnal Portal Data*, *2*(2), 1–14. http://portaldata.org/index.php/portaldata/article/view/78

Balya, D. (2023). KEMAJUAN TEKNOLOGI DAN POLA HIDUP MANUSIA DALAM PERSPEKTIF SOSIAL BUDAYA. *Jurnal Ilmu Komunikasi, Sosial Dan Humaniora*, *1*(3), 274–301.

Bloom, N., & Reenen, J. Van. (2019). ANALISIS MUTU BIJI KAKAO (Theobroma cacao L) DARI DESA TOMBOLO DAN DESA KALOLING DI KABUPATEN BANTAENG DENGAN VARIASI SUHU PENGERINGAN. *NBER Working Papers*, 89. http://www.nber.org/papers/w16019

Nugraha, W., & Syarif, M. (2018). Penerapan Metode Prototype Dalam Perancangan Sistem Informasi Penghitungan Volume Dan Cost Penjualan Minuman Berbasis Website. *JUSIM (Jurnal Sistem Informasi*

Musirawas), *3*(2), 94–101. https://doi.org/10.32767/jusim.v3i2.331

Puspasari, F., Satya, T. P., Oktiawati, U. Y., Fahrurrozi, I., & Prisyanti, H. (2020). Analisis Akurasi Sistem sensor DHT22 berbasis Arduino terhadap Thermohygrometer Standar. *Jurnal Fisika Dan Aplikasinya*, *16*(1), 40. https://doi.org/10.12962/j24604682.v16i1.5776

Riska Jupita, Arjun Nuradin Tio, Arinda Rifaini, Chindy Saputri, M. F. (2021). Otomatisasi Penyiraman Tanaman Dengan Sensor Soil Moisture. *Jurnal Portal Data*, *7*(2), 1–12. http://portaldata.org/index.php/portaldata/article/view/29

Roihan, A., Mardiansyah, A., Pratama, A., & Pangestu, A. A. (2021). Simulasi Pendeteksi Kelembaban Pada Tanah Menggunakan Sensor Dht22 Dengan Proteus. *METHODIKA: Jurnal Teknik Informatika Dan Sistem Informasi*, *7*(1), 25–30. https://doi.org/10.46880/mtk.v7i1.260

Sentono, Ahmad, Ranu, A. (2020). *Rancang Bangun Inkubator Penetas Telur Berbasis Internet Of Things*. 1–29.

Sigalingging, H. A., Putri, S. H., & Iflah, T. (2020). Perubahan Fisik Dan Kimia Biji Kakao Selama Fermentasi. *Jurnal Industri Pertanian(JUSTIN)*, *2*(2), 158–165. http://

Zhang, Z., & Li, J. (2023). A Review of Artificial Intelligence in Embedded Systems. *Micromachines*, *14*(5). https://doi.org/10.3390/mi14050897

Zhao, J., Zhang, C., Min, L., Guo, Z., & Li, N. (2022). Retrieval of Farmland Surface Soil Moisture Based on Feature Optimization and Machine Learning. *Remote Sensing*, *14*(20). https://doi.org/10.3390/rs14205102