Journal of Engineering, Electrical and Informatics
Vol.4, No.2 June 2024
e-ISSN: 2809-8706; p-ISSN : 2810-0557, page 18-27
DOI: https://doi.org/10.55606/jeei.v4i2.3049

Automatic Compact Coffee Maker Using Temperature and Weight Sensors With Arduino Microcontroller

Soraya Norma Mustika *[1]
Electronic Systems Engineering Technology Study Program, Faculty of Vocational Studies, Malang, Universitas Negeri Malang, Indonesia

Narendra Handaryan Yudhistira [2]
Electronic Systems Engineering Technology Study Program, Faculty of Vocational Studies, Malang, Universitas Negeri Malang, Indonesia

Eko Noerhayati [3]
Civil Engineering Study Program, Faculty of Engineering, Malang, Universitas Islam Malang, Indonesia

Achmad Hamdan [4]
Electronic Systems Engineering Technology Study Program, Faculty of Vocational Studies, Malang, Universitas Negeri Malang, Indonesia

Jl. Semarang 5 Malang, Indonesia
Correspondent: soraya.norma.ft@um.ac.id

Abstract. *In carrying out the process of grounding coffee manually, some people still rely on manual tools and based solely on the help of human hands, ineffectiveness often occurs. If the coffee beans are processed manually, the process will take quite a long time or if the coffee beans are processed manually themselves, it will produce less than perfect coffee bean powder. It is difficult to regulate the level of maturity or detect the right temperature of the coffee beans to produce the right coffee taste. It also requires a roasting process to a grinding process to turn the coffee beans into coffee powder with the right taste. Based on the problems above, the aim of this research is to simplify the process of converting coffee beans into coffee powder automatically and easily. In carrying out the roasting process to the process of refining the coffee beans, you need to pay attention to three aspects, namely the hot temperature during the roasting process, and determining the weight of the coffee beans when the coffee beans are finished going through the roasting process with a capacity of 100 g. In this research, to control and monitor the temperature and weight of coffee beans using an arduino microcontroller.*

Keywords: *Coffee Beans, Arduino, Temperature and Weight.*

INTRODUCTION

Understanding the intricacies of the roasting process is essential for anyone involved in the world of coffee, from passionate enthusiasts to café owners striving to deliver exceptional quality to their customers. While many may enjoy the end product of a finely brewed cup of coffee, the journey from bean to cup involves a series of carefully orchestrated steps, with roasting standing out as a pivotal stage.In this exploration, we delve into the nuanced realm of coffee roasting, shedding light on its multifaceted nature and its profound impact on the sensory experience of coffee aficionados worldwide. While the allure of a perfect cup often steals the spotlight, it is the roasting process that

Received Mei 30, 2023; Accepted June 10, 2024; Published June 30, 2024
* Soraya Norma Mustika, soraya.norma.ft@um.ac.id

lays the foundation for the rich flavors and aromas cherished by discerning palates (Fadri et al., 2020; Bettaieb et al., 2023; Liu et al., 2022).

At the heart of the roasting process lies the concept of roasting levels, each contributing distinct characteristics to the final product. From light to dark roasts, the spectrum of flavors elicited during roasting reflects the intricate dance between heat, time, and the inherent qualities of the coffee beans themselves. While some may favor the bright acidity of a light roast, others may be drawn to the deep, caramelized notes of a dark roast, illustrating the subjective nature of coffee appreciation.Moreover, research indicates that the roasting process exerts a profound influence on the quality of coffee beans, shaping both their aroma and flavor profile. Studies have revealed that up to 30% of the aroma and flavor of coffee can be attributed to the roasting process, underscoring its significance in the pursuit of coffee excellence (J. Li., 2022; Moccand et al., 2023; Freitas et al., 2024).

Central to the quest for high-quality coffee beans is the meticulous selection of ripe coffee cherries. The journey begins with the careful harvesting of fully ripe cherries, signaling their readiness for processing. Subsequent stages, including sorting, drying, peeling, and the crucial act of grinding, each play a pivotal role in preserving the integrity of the beans and unlocking their full potential.In this study, we focus on the Robusta variety of coffee beans, renowned for its robust flavor profile and distinct characteristics (Zhang et al., 2022; Manfrin Artêncio et al., 2023; Aswathi et al., 2023). While previous research has often centered around the Arabica variety, our exploration seeks to shine a spotlight on the unique attributes of Robusta beans and their role in shaping the coffee landscape (Macheiner et al., 2021; Al Attiya et al., 2021; Hidayat et al., 2020).

Through a combination of scientific inquiry and sensory evaluation, we aim to deepen our understanding of the roasting process and its implications for coffee quality. By unraveling the mysteries concealed within the humble coffee bean, we hope to empower coffee enthusiasts and industry professionals alike to embark on a journey of discovery, one cup at a time.In the pages that follow, we invite you to embark on a sensory odyssey through the world of coffee roasting, where science meets artistry in a harmonious union. Together, let us unravel the complexities of the roasting process and celebrate the rich tapestry of flavors that define the world's most beloved beverage.

RESEARCH METHODS

This research aims to design and develop an automatic coffee powder maker using temperature and weight sensors with an Arduino Uno microcontroller (Castillo et al., 2023; Waluyo et al., 2021; Agustian et al., 2022).

Diagram Block System

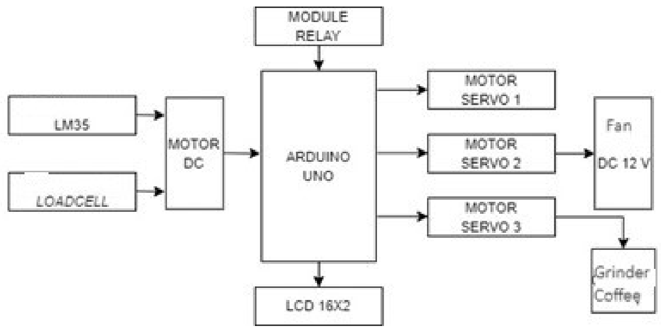

Figure 1. Diagram Block

Figure 1 shows the components used in the automatic coffee powder maker system, which include Arduino Uno, LM35 (Ohoiwutun et al., 2023; Susanto et al., 2020), load cell (Martello et al., 2022; Anwari et al., 2023), servo motor, DC motor, 16x2 LCD, 12V DC fan, relay, and coffee grinder machine. The Arduino Uno used is the Atmega 328P microcontroller IC (Wibawa & Putra, 2022; Sipos & Simonak, 2020). This device functions to process inputs into the desired system outputs. The load cell acts as a weight sensor to weigh the coffee beans to be ground into coffee powder. The relay functions as a controller or regulator for the heating element in the coffee bean roasting chamber. The DC motor functions as a rotator and stirrer for the coffee beans during the roasting process. Servo motor 1 is used to pour the coffee beans into the cooling container. Servo motor 2 is used to pour the coffee beans into the coffee grinder machine. Servo motor 3 is used to pour the ground coffee into the coffee powder container or cup.

Flowchart System

In Figure 2, the carefully designed automation system illustrates a well-coordinated series of steps for processing coffee beans with high efficiency. Each step in this process is executed automatically by well-programmed hardware.

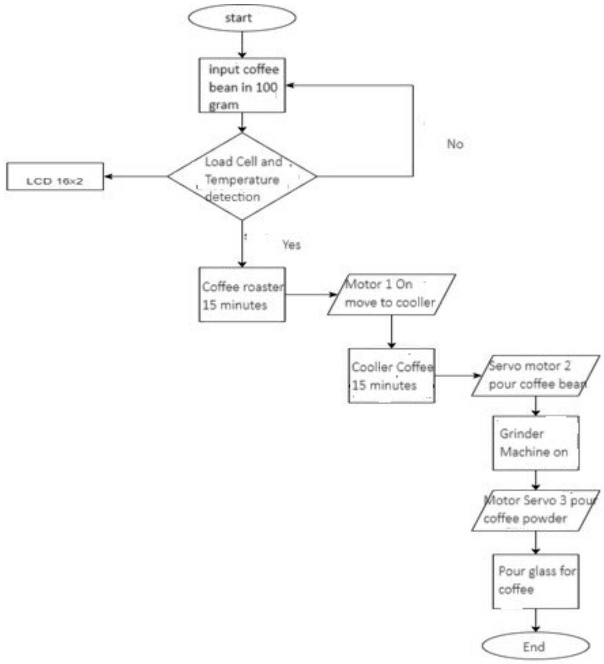

Figure 2. Flowchart System

Device Circuit Schematic

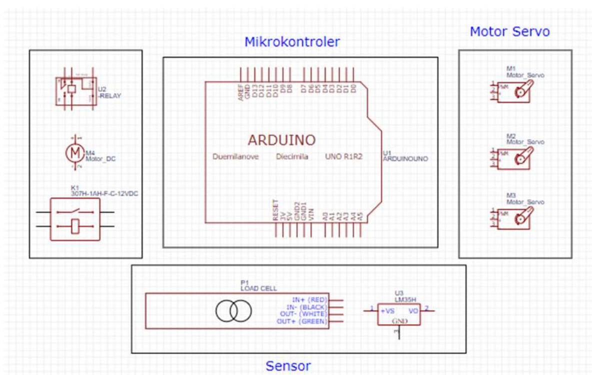

Figure 3. Device Circuit Schematic

In the circuit schematic shown in Figure 2.3, the load cell weight sensor functions as the initial trigger to start the coffee bean processing, while the LM35 temperature sensor is used to maintain the environmental temperature within the desired range during the processing (Wibowo et al., 2022). The DC motor is responsible for rotating the coffee bean roasting chamber. Servo motors 1, 2, and 3 are respectively responsible for regulating the flow of coffee beans through various processing stages according to the specified conditions.

Mechanic Design

The mechanical design of the automatic coffee powder maker includes three main parts: the coffee bean roasting chamber, the coffee bean cooling container, and the coffee bean grinding container until it becomes coffee powder. This design ensures good consistency in grinding coffee beans into powder, accurate measurement of the coffee bean temperature, precise measurement of the weight of the coffee powder, and easy serving of coffee. The LM35 temperature sensor is placed or attached to the coffee bean roasting chamber and covered with a heat-resistant cable to prevent burning. Meanwhile, the load cell weight sensor should be connected to the container holding the coffee beans at the beginning of the roasting process. The placement of the LM35 temperature sensor and its load cell weight sensor is shown at the beginning of the coffee bean roasting process in Figure 2.4.

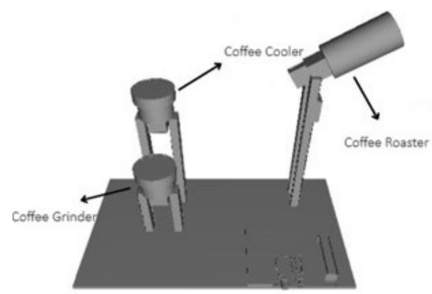

Figure 4. Mechanical Device Design

RESULTS AND DISCUSSION

The test results of this research have been conducted. The testing was carried out to understand the performance processes and characteristics of the device. The testing of this device itself is divided into several parts such as testing the LM35 temperature sensor, testing the load cell weight sensor, testing the servo motor, testing the DC motor, and testing the overall system. It is expected that all system tests can confirm that the device design runs well and optimally.

Measuring the Temperature Sensor LM35

The datasheet for the LM35 temperature sensor states that the output voltage of the sensor is linearly calibrated at 10 mV/°C. This means that at 0 °C, the output voltage will be 0 V, and at 25 °C, it will be 25 × 10 mV = 250 mV.

The LM35 temperature sensor's output voltage value is the voltage value that the Arduino Uno microcontroller reads. The output of the Arduino Uno microcontroller is then transformed into a read temperature value and shown on the 16x2 LCD. Table 1 below shows the results of the LM35 temperature sensor test that the Arduino microcontroller displayed on the 16x2 LCD.

Table 1. LM345 Temperature Sensor Testing

No	Temperature in Thermometer (°C)	Temperature in LCD 16x2 (°C)	Error (%)
1	85	85.2	0.235%
2	86	86.3	0.348%
3	87	87.5	0.574%
4	88	88.1	0.114%
5	89	89.7	0.786%
6	90	90.10	0.111%
7	91	91.6	0.659%
8	92	92.5	0.543%
9	93	93.3	0.323%
10	94	94.4	0.426%

LoadCell Weight Sensor Testing

Table 2 below shows that the measurement with an electric scale outside or before to the roasting of the coffee beans is 100 grams. Coffee bean weight decreases by about 2 grams every 3 minutes, according to load cell readings. In the meantime, 4.4% is the average mistake percentage.

Table 2. LoadCell Weight Sensor Testing

Electric Scales Measurement (grams)	Load cell measurements (grams)	Error (%)
100 gram	100 gram	0%
100 gram	98 gram	2%
100 gram	95 gram	5%
100 gram	93 gram	7%
100 gram	90 gram	10%
100 gram	94 gram	6%
100 gram	91 gram	9%
100 gram	96 gram	4%
100 gram	100 gram	0%
100 gram	99 gram	1%

Servo Motor Testing

Table 3 below shows that the servo motor experiment consisted of 10 tests on 3 motors: motors 1, 2, and 3 were tested for degree, and motors 1, 2, and 3's protractor motors had very minor errors, less than 0.05.

Table 3. Servo Motor Testing

Number	Servo Motor Degrees	Servo Motor Protractor	Error (%)
1	110	108	0.02%
2	100	109	0.01%
3	120	118	0.02%
4	125	122	0.03%
5	130	129	0.01%
6	135	133	0.02%
7	140	138	0.02%
8	145	143	0.02%
9	150	148	0.02%
10	155	152	0.03%

Comprehensive System Examination

The coffee beans are deemed ready for grinding when they have been roasted for 15 minutes and have reached an average temperature of 89.5 degrees Celsius. Aside from that, the servo motor that is part of this tool has been put through testing and is operating by the uploaded program code to Arduino. When compared to protractor measurements, the performance of servo motors 1, 2, and 3 has been confirmed with an average error rate of less than 0.05%. Table 4 below shows the results of testing the complete system.

Table 4. Comprehensive System Evaluation

Number	Temperature°C	Coffee Bean Weight (gram)	Quality of Coffee Grounds	Details
1	85.2	100 gram	Smooth powder	Succeed
2	86.3	98 gram	Smooth powder	Succeed
3	87.5	95 gram	Smooth powder	Succeed
4	88.1	93 gram	rather coarse powder	Succeed
5	89.7	90 gram	rather coarse powder	Succeed
6	90.10	94 gram	rather coarse powder	Succeed

7	91.6	91 gram	Smooth powder	Succeed
8	92.5	96 gram	Smooth powder	Succeed
9	93.3	100 gram	Smooth powder	Succeed
10	94.4	99 gram	Smooth powder	Succeed

CONCLUSION

The accuracy of the temperature the sensor reads at different heating levels during the coffee-making process will be measured as part of the temperature sensor test results. In the meanwhile, testing for weight sensors will involve figuring out how accurate the equipment is at weighing the coffee grinds it produces. The automatic coffee powder maker's quality and dependability will be ascertained by the test's outcomes with error less than 1 %.

REFERENCE

A. I. Daza Castillo, J. A. Miguel Ruiz, J. Ortiz-Hernandez, and Y. Hernández, “Comparison of Integrated and Non-Integrated Sensors in Arduino Boards,” in *2023 12th International Conference On Software Process Improvement (CIMPS)*, Cuernavaca, Morelos, Mexico: IEEE, Oct. 2023, pp. 275–276. doi: 10.1109/CIMPS61323.2023.10528830.

A. Waluyo, A. Tafrikhatin, and S. R. Heri, “Robot Arm Design for Coffee Maker Arduino Based:,” presented at the 2nd Borobudur International Symposium on Science and Technology (BIS-STE 2020), Magelang, Indonesia, 2021. doi: 10.2991/aer.k.210810.076.

C. Moccand, A. D. Manchala, J.-L. Sauvageat, A. Lima, Y. FleuryRey, and A. Glabasnia, “Improvement of Robusta coffee aroma by modulating flavor precursors in the green coffee bean with enzymatically treated spent coffee grounds: A circular approach,” *Food Res. Int.*, vol. 170, p. 112987, Aug. 2023, doi: 10.1016/j.foodres.2023.112987.

D. D. Hidayat, A. Sudaryanto, Y. R. Kurniawan, A. Indriati, and D. Sagita, “Development And Evaluation Of Drum Coffee Roasting Machine For Small-Scale Enterprises,” *INMATEH Agric. Eng.*, vol. 60, no. 1, pp. 79–88, Apr. 2020, doi: 10.35633/inmateh-60-09.

I. Bettaieb *et al.*, “The effect of freeze-drying process and arabica coffee enrichment on bioactive content, aroma volatile, and sensory characteristics of date seed coffee,” *Food Biosci.*, vol. 57, p. 103473, Feb. 2024, doi: 10.1016/j.fbio.2023.103473.

I. M. S. Wibawa and I. K. Putra, “Design of air temperature and humidity measurement based on Arduino ATmega 328P with DHT22 sensor,” *Int. J. Phys. Sci. Eng.*, vol. 6, no. 1, pp. 9–17, Jan. 2022, doi: 10.53730/ijpse.v6n1.3065.

J. Li, “What Determines Coffee Aroma and Flavor?,” *Berkeley Sci. J.*, vol. 26, no. 2, Aug. 2022, doi: 10.5070/BS326258271.

J. W. Wibowo, A. Munandar, O. Mahendra, J. V. Josary, D. I. S. Ningrum, and B. Sejati, “A review of a smart coffee roaster: electronics, design, and artificial intelligence,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1116, no. 1, p. 012011, Dec. 2022, doi: 10.1088/1755-1315/1116/1/012011.

K. N. Aswathi, A. Shirke, A. Praveen, S. R. Chaudhari, and P. S. Murthy, “Pulped natural/honey robusta coffee fermentation metabolites, physico-chemical and sensory profiles,” *Food Chem.*, vol. 429, p. 136897, Dec. 2023, doi: 10.1016/j.foodchem.2023.136897.

K. Zhang *et al.*, “Identification of changes in the volatile compounds of robusta coffee beans during drying based on HS-SPME/GC-MS and E-nose analyses with the aid of chemometrics,” *LWT*, vol. 161, p. 113317, May 2022, doi: 10.1016/j.lwt.2022.113317.

L. Macheiner, A. Schmidt, and H. K. Mayer, “A novel basis for monitoring the coffee roasting process: Isomerization reactions of 3-caffeoylquinic and 4-caffeoylquinic acids,” *LWT*, vol. 152, p. 112343, Dec. 2021, doi: 10.1016/j.lwt.2021.112343.

M. F. Anwari *et al.*, “Automation System in Coffee Beans Dying Process Based on IoT,” in *2023 9th International Conference on Wireless and Telematics (ICWT)*, Solo, Indonesia: IEEE, Jul. 2023, pp. 1–5. doi: 10.1109/ICWT58823.2023.10335337.

M. Manfrin Artêncio *et al.*, “The impact of coffee origin information on sensory and hedonic judgment of fine Amazonian robusta coffee,” *J. Sens. Stud.*, vol. 38, no. 3, p. e12827, Jun. 2023, doi: 10.1111/joss.12827.

M. M. M. Ohoiwutun, A. Latununuwe, E. K. Huliselan, and F. Manuhutu, “Using LM35 sensor based on Arduino Uno R3 for Newton cooling process analysis of coffee solution,” presented at the THE 7TH INTERNATIONAL CONFERENCE ON BASIC SCIENCES 2021 (ICBS 2021), Ambon, Indonesia, 2023, p. 040008. doi: 10.1063/5.0111818.

M. Susanto, R. Saputra, Herlinawati, S. Savetlana, and S. Alam, “Prototype of Sensor Node for Low-Cost Machine Vibration Monitoring System Using Accelerometer Sensor,” in *2020 IEEE International Conference on Communication, Networks and Satellite (Comnetsat)*, Batam, Indonesia: IEEE, Dec. 2020, pp. 222–226. doi: 10.1109/Comnetsat50391.2020.9328973.

M. Martello, J. P. Molin, and H. C. Bazame, "Obtaining and Validating High-Density Coffee Yield Data," *Horticulturae*, vol. 8, no. 5, p. 421, May 2022, doi: 10.3390/horticulturae8050421.

M. Šipoš and S. Šimoňák, "Development of ATmega 328P micro-controller emulator for educational purposes," *Acta Univ. Sapientiae Inform.*, vol. 12, no. 2, pp. 159–182, Dec. 2020, doi: 10.2478/ausi-2020-0010.

R. A. Fadri, K. Sayuti, N. Nazir, and I. Suliansyah, "Analysis of Caffeine Levels in the Beverages of Roasted Arabica Coffee Balango in Bukik Apik with the Method of Spectroscopic," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 515, no. 1, p. 012071, Jun. 2020, doi: 10.1088/1755-1315/515/1/012071.

R. Agustian, A. Bintoro, R. Rosdiana, M. Jannah, S. Salahuddin, and W. K. A. Al-Ani, "Design of Automatic Coffee Bean Roaster Based on Arduino Uno Microcontroller," *Int. J. Adv. Data Inf. Syst.*, vol. 3, no. 2, pp. 49–57, Nov. 2022, doi: 10.25008/ijadis.v3i2.1238.

S. Liu *et al.*, "Insights into flavor and key influencing factors of Maillard reaction products: A recent update," *Front. Nutr.*, vol. 9, p. 973677, Sep. 2022, doi: 10.3389/fnut.2022.973677.

V. V. Freitas *et al.*, "Influence of roasting levels on chemical composition and sensory quality of Arabica and Robusta coffee: A comparative study," *Food Biosci.*, vol. 59, p. 104171, Jun. 2024, doi: 10.1016/j.fbio.2024.104171.

W. Al Attiya, Z. U. Hassan, R. Al-Thani, and S. Jaoua, "Prevalence of toxigenic fungi and mycotoxins in Arabic coffee (Coffea arabica): Protective role of traditional coffee roasting, brewing and bacterial volatiles," *PLOS ONE*, vol. 16, no. 10, p. e0259302, Oct. 2021, doi: 10.1371/journal.pone.0259302.