SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin
ISSN: 2088-9038, e-ISSN: 2549-9645
Homepage: http://jurnal.umj.ac.id/index.php/sintek

ANALYSIS OF THE PERFORMANCE OF MOISTURE REDUCTION RATE IN A HORIZONTAL MILL TYPE COFFEE DRYER USING A SUCTION BLOWER

Karnova Yanel[1,*], Surya Hendra[2], Rozi Saferi[3], Sulaiman[1]

[1]D3 Mechanical Engineering Study Programme, Institut Teknologi Padang, Kota Padang, Sumatera Barat, 25173, Indonesia
[2]Undergraduate Mechanical Engineering Students, Institut Teknologi Padang, Kota Padang, Sumatera Barat, 25173, Indonesia
[3]Mechanical Engineering Undergraduate Study Programme, Institut Teknologi Padang, Kota Padang, Sumatera Barat, 25173, Indonesia

[*]E-mail: karnova.yanel@itp.ac.id

Accepted: 15-02-2024 Revised: 28-04-2024 Approved: 01-06-2024

ABSTRACT

Coffee, originating in the 9th century Ethiopia and later expanding across North Africa and tropical regions globally, remains a crucial commodity. Indonesia, recognized for its robust coffee industry, ranks third worldwide in production, contributing 8% of the global supply. However, the drying process poses challenges to Indonesian farmers due to traditional methods and variable weather conditions. This research aims to evaluate a coffee dryer utilizing forced convection with a suction blower to optimize drying parameters for coffee beans. The study employs a horizontal mill dryer with a heated drum for drying experiments. Results demonstrate that the dryer effectively reduces the moisture content of post-harvest coffee cherries to 2%. In the initial test, 20 kg of coffee dried over 7.5 hours at 75°C decreased from 61.66% to 5.3% moisture, while a subsequent test with 17 kg dried over 4 hours reduced from 36% to 2% moisture content. The findings conclude that the suction blower-equipped dryer meets Indonesian National Standards (SNI), achieving the requisite 12% moisture content for post-harvest coffee.

Keywords: Coffee Dryer; Suction Blower; Coffee Bean Drying; Moisture Content; Post-Harvest.

ABSTRAK

Kopi, yang berasal dari abad ke-9 di Ethiopia dan kemudian berkembang ke seluruh Afrika Utara dan wilayah tropis di seluruh dunia, tetap menjadi komoditas yang penting. Indonesia, yang dikenal dengan industri kopinya yang kuat, berada di peringkat ketiga di dunia dalam hal produksi, menyumbang 8% dari pasokan global. Namun, proses pengeringan menjadi tantangan bagi petani Indonesia karena metode tradisional dan kondisi cuaca yang berubah-ubah. Penelitian ini bertujuan untuk mengevaluasi pengering kopi yang menggunakan konveksi paksa dengan blower hisap untuk mengoptimalkan parameter pengeringan biji kopi. Penelitian ini menggunakan pengering gilingan horizontal dengan drum berpemanas untuk percobaan pengeringan. Hasilnya menunjukkan bahwa pengering tersebut secara efektif mengurangi kadar air buah kopi pascapanen hingga 2%. Pada pengujian awal, 20 kg kopi yang dikeringkan selama 7,5 jam pada suhu 75°C berkurang dari 61,66% menjadi 5,3% kelembaban, sementara pengujian berikutnya dengan 17 kg yang dikeringkan selama 4 jam berkurang dari 36% menjadi 2% kadar air. Temuan ini menyimpulkan bahwa pengering yang dilengkapi dengan blower hisap ini memenuhi Standar Nasional Indonesia (SNI), mencapai kadar air 12% yang disyaratkan untuk kopi pascapanen.

Kata Kunci: *Pengering Kopi; Suction Blower; Pengeringan Biji Kopi; Kadar Air; Pascapanen.*

1. Introduction

The history of coffee dates back to the 9th century, originating in Ethiopia where native beans were first cultivated by Ethiopian highlanders [1,2]. With the expansion of trade by the Arabs, coffee beans spread to North Africa and became widely cultivated there [3,4]. Coffee, encompassing around 40 varieties primarily from tropical Africa and a smaller portion from tropical Asia, has now proliferated to tropical regions worldwide. In Indonesia, coffee thrives predominantly at altitudes above 700 meters [5-7], contributing significantly to the country's agricultural sector as the third-largest global producer, supplying 8% of the world's coffee [8-10].

The transformation of coffee from harvested cherries to ready-to-consume powder involves several key processes, including peeling, drying, roasting, and grinding, largely adhering to traditional methods [11,12]. Various types of dryers such as rack dryers, conveyor dryers, and rotary dryers offer advantages like weather independence, scalable drying capacities, space efficiency, and controlled drying conditions [13,14]. Drying coffee beans can be achieved through sun drying or mechanical methods [6], with drying representing a critical phase in coffee processing to prevent microbial growth and chemical degradation [15,16].

In Indonesia, many farmers still rely on natural drying methods, which necessitate extensive drying areas and prolonged drying times, ranging from 5-7 days during the dry season to significantly longer periods in the rainy season [17, 18]. To meet Indonesian National Standards, coffee beans must be dried to a moisture content of 12% [19,20]. The development of mechanical dryers presents a viable solution to enhance drying efficiency and ensure quality consistency [21,22], catering not only to coffee but also to other crops like rice and cocoa beans [23].

Effective drying plays a pivotal role in preserving the quality of coffee beans during storage, mitigating the risk of spoilage [24]. This study introduces a novel approach utilizing a horizontal mill type dryer with a rotating heated drum and integrated blower system aimed at expediting moisture removal from coffee beans. Higher drying air temperatures and airflow velocities are known to accelerate the drying process by enhancing liquid evaporation from the surface of the beans [25]. This innovative dryer offers a promising alternative to traditional drying methods, potentially improving efficiency and maintaining coffee quality.

2. Methods

The method used in this research involves forced testing using a furnace with gas fuel, as shown in the schematic in Figure 1.

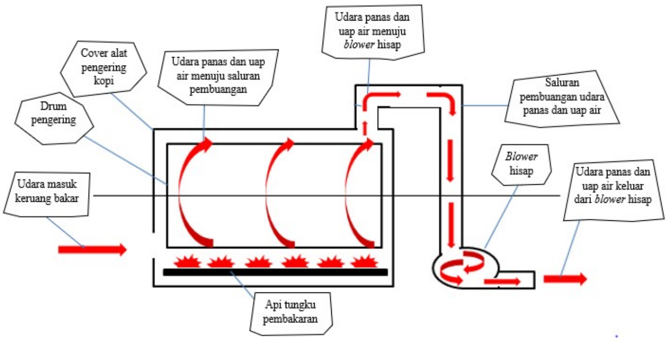

Figure 1. Schematic of The Coffee Dryer Device

2.1. Testing Equipment

The coffee drying device shown in Figure 2 is used for drying coffee cherries post-harvest. The device is a horizontal mill type dryer. It consists of a perforated drum for drying coffee beans, an outer cover, a firebox (along the length of the drum) at the bottom, a blower channel, and a suction blower. A temperature gauge connected to the inside of the cover is used to monitor the temperature. Temperature control is managed by adjusting the gas nozzle that supplies gas to the firebox, with the temperature increase monitored via the temperature gauge. Airflow is drawn out from the cover, with air entering through the bottom vents at the front of the cover and directed out through the top of the cover. This setup ensures that air is drawn through the perforated drum, carrying moisture away from the coffee beans and out of the dryer.

Figure 2. Horizontal Mill Type Coffee Dryer Using Suction Blower

In this study, coffee is placed into the drum by opening the top cover and through a door located on the perforated drum. Periodically (every 30 minutes), the dried coffee is removed through a check door at the bottom of the cover, which connects to the bottom door of the drum, to check the remaining moisture content in the dried coffee beans. Temperature is maintained by monitoring the temperature gauge (Figure 3), while the air exhaust channel is connected to a flow meter to measure the speed of the outgoing airflow.

Figure 3. Front View of the Horizontal Mill Type Coffee Dryer, Including Temperature Gauge, Firebox, and Air Ventilation.

2.2. Testing Materials

Post-harvest coffee refers to freshly picked coffee cherries from the coffee tree, specifically the red cherries. An effective coffee drying process can be conducted at temperatures ranging from 25°C to 80°C [16], following the drying process illustrated in Figure 4.

Figure 4. Post-Harvest Coffee

3. Results and Discussion

Table 1. Test Results-1 Robusta Coffee Beans from Pasaman Region (Initial Weight: 20 Kg, Initial Moisture Content: 61.66%)

No.	Time (Min)	Air Temp. (on mill) (C°)	Water Content / Moisture Content (%)	Decrease of Coffee Weigth (kg)	Decrease in Water Content per 30 minutes (%)	Gas Fuel / LPG (kg)	Air Speed Coming out of The Blower (m/s)	Air Temperature Coming Out of the Blower (C°)
0	0	-	61,66		0	0	-	-
1	30	75	59,33	18,83	2,33	0,3	7,29	54,2
2	60	75	57,33	17,95	2	0,5	6,68	49,49
3	90	75	56,33	17,54	1	0,8	7,19	45,42
4	120	75	49,33	15,11	7	1	8,32	51,2
5	150	75	46,66	14,36	2,67	1,3	8,12	53,3
6	180	75	41	12,98	5,66	1,5	8,06	44,1
7	210	75	34,6	11,71	6,4	1,8	8,17	45,3
8	240	75	32,33	11,31	2,27	2	8,01	48,3
9	270	75	27	10,49	5,33	2,3	7,96	42,6
10	300	75	24,33	10,12	2,67	2,5	7,6	39
11	330	75	22,66	9,90	1,67	2,8	7,71	38.9
12	360	75	20,66	9,65	2	3	7,71	41,1
13	390	75	11	8,60	9,66	3,3	8,53	38,8
14	420	75	7	8,23	4	3,5	9,25	41,3
15	450	75	5,3	8,08	1,7	3,8	8,42	45,1
Rata-rata		75			3,75	2,02	7,93	45,28

Sample 1 consists of robusta coffee beans from the Pasaman region, West Sumatra. Post-harvest coffee refers to coffee that is still red in color with a moisture content of approximately 60%-65%. Coffee is considered dry when it reaches a moisture content of 11%-12%. After conducting drying tests using a horizontal mill type coffee dryer with suction blower, fueled by gas, as seen in the table above, it is observed that to achieve coffee with a moisture content of 11-12%, a drying time of 390 minutes is required (highlighted in yellow in the table). In this drying process, 20 kg of post-harvest coffee was used. From the 20 kg of dried coffee, samples of 200 grams each were taken for testing, with 15 samples taken at 30-minute intervals. This was done to observe the rate of moisture reduction in the coffee beans using the horizontal mill dryer. From the 20 kg of wet coffee, the drying process yielded 8 kg of dried coffee. One testing session consumed approximately 3.8 kg of LPG and utilized 2796.27 Watts of electricity during the testing period.

Table 2. Test Result-2 Robusta Coffee Beans from Solok Region (Initial Weight: 17kg, Initial Moisture Content: 36%)

No	Time (Min)	Air Temp. (on mill) (C°)	Water Content / Moisture Content (%)	Decrease of Coffee Weigth (kg)	Decrease in Water Content per 30 minutes (%)	Gas Fuel / LPG (kg)	Air Speed Coming out of The Blower (m/s)	Air Temperature Coming Out of the Blower (C°)
0	0	-	36		0	0	0	0
1	30	75	33	16,23	3	0,3	8,22	38,4
2	60	75	28	15,11	5	0,5	7,96	39,2
3	90	75	25,66	14,63	2,34	0,8	8,32	43,5
4	120	75	20	13,6	5,66	1	8,32	43,4
5	150	75	16,66	13,05	3,34	1,3	8,66	40,8
6	180	75	12	12,36	4,66	1,5	7,4	38,9
7	210	75	5,66	11,53	6,34	1,8	8,53	43,2
8	240	75	2	11,10	3,66	2	8,58	36,8
Rata-rata		75			4,26	0,61	4,39	21,61

Sample 2 consists of robusta coffee beans from the Solok region, West Sumatra. From Table 2, it can be observed that in the drying process of post-harvest coffee with an initial moisture content of 36%, the coffee was dried using a horizontal mill type coffee dryer to achieve a moisture content of 11-12%. In this drying process, 17 kg of post-harvest coffee was used. From the 17 kg of dried coffee, samples of 200 grams each were taken for testing, with 15 samples taken at 30-minute intervals. From the 17 kg of wet coffee, the drying process yielded 11 kg of dried coffee. In Test 2, fuel consumption amounted to 2 kg of LPG, and 1491.4 Watts of electricity were used during the testing.

From the two tests conducted with different locations of coffee bean collection, it can be concluded that the horizontal mill type dryer can effectively dry coffee beans, with a moisture content reduction of 2%-9% every 30 minutes, with constant temperature and suction airflow speed. The moisture content reduction graph of the coffee beans can be observed in Figure 4.

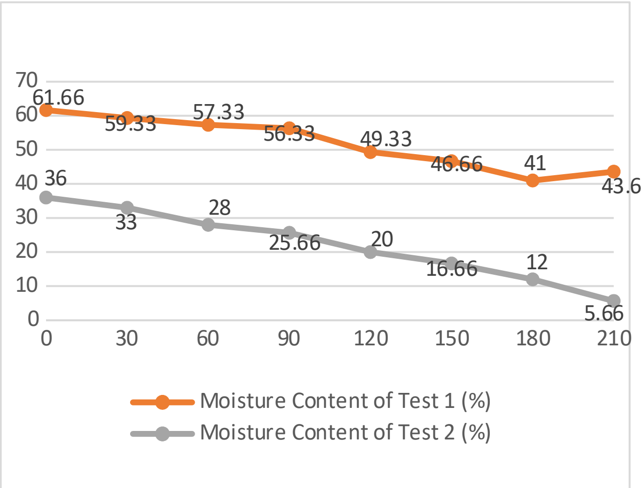

Figure 5. Graph of Moisture Content Reduction

From both tests, Test 1 with a weight of 20 kg and an initial moisture content of 61.66%, and Test 2 with a weight of 17 kg and an initial moisture content of 36%, the reduction in moisture content every 30 minutes of sample collection during the testing can be observed in the graph in Figure 5.

The graphical representation in Figure 6 illustrates the process of weight reduction over time. At the onset of Test 1, the initial weight of 20 kg gradually decreased to 8.08 kg by the conclusion of the experiment. Similarly, in Test 2, starting with an initial weight of 17 kg, the weight reduced to 11 kg by the end of the testing period.

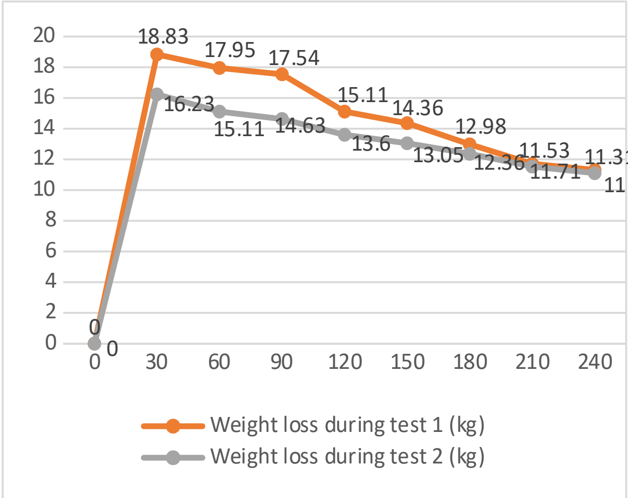

Figure 6. Weight Reduction Graph

The graphical representation in Figure 7 provides insight into the rate of fuel consumption, specifically LPG gas. During Test 1, the apparatus consumed a total of 3.8 kg of LPG gas, while processing a test specimen weighing 20 kg, over a duration of 7.5 hours. Conversely, during Test 2, with a test specimen weighing 17 kg, the consumption of LPG gas amounted to 2 kg over a testing duration of 4 hours, maintaining a constant temperature of 75°C.

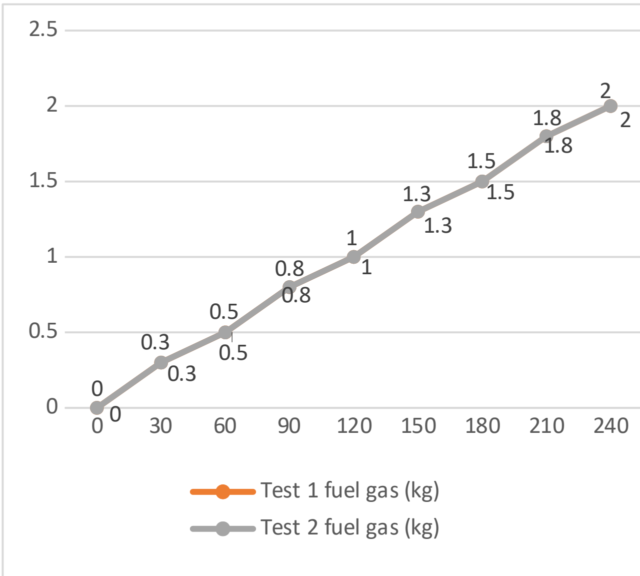

Figure 7. Graph of Fuel Consumption

In Test 1, the airflow emanating from the blower exhibited a range of speeds, with the highest velocity recorded at 9.25 m/s and the lowest at 7.6 m/s. Similarly, during Test 2, the airflow displayed varying speeds, reaching a maximum of 8.66 m/s and a minimum of 7.7 m/s. These distinct airflow rates are clearly depicted in the graphical representation provided in Figure 8.

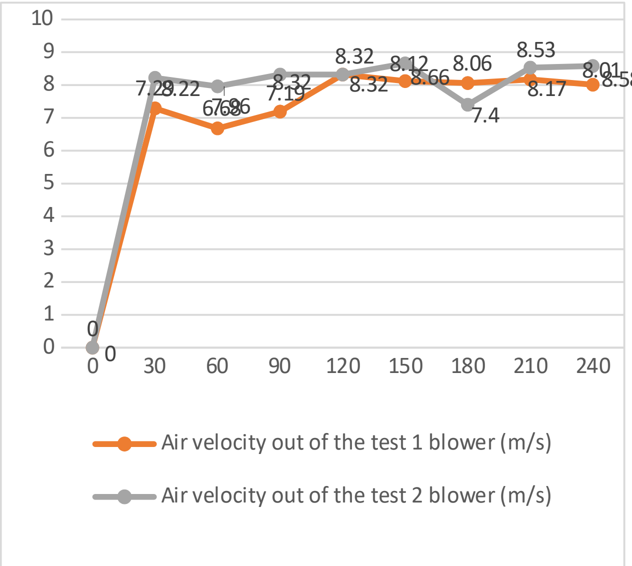

Figure 8. Graph of Airflow Speed from the Blower

The air temperature readings taken from the blower every 30 minutes reveal notable fluctuations: in Test 1, the highest temperature peaked at 54.2 °C, while the lowest dropped to 38.9 °C. Conversely, during Test 2, the highest recorded temperature reached 43.5 °C, with the lowest being 38.4 °C. These variations in temperature are distinctly presented in the graphical representation provided in Figure 9.

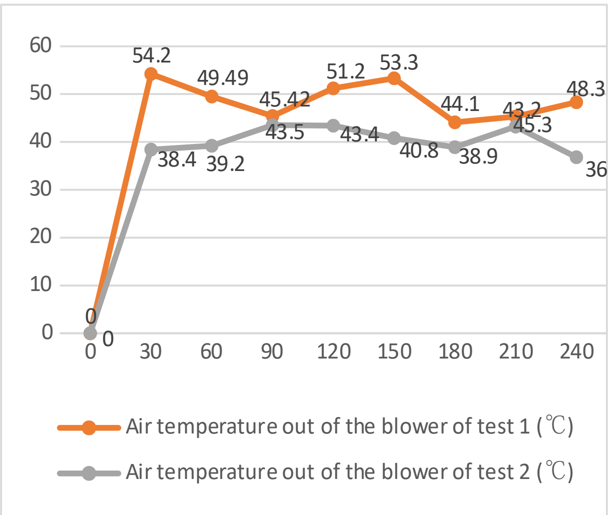

Figure 9. Graph of Air Temperature from the Blower

4. Conclusion

Based on the conducted research, it can be concluded that the horizontal mill type coffee dryer, which was modified by adding a suction blower, successfully dried post-harvest coffee cherries with a moisture content reduction rate ranging from 2% to 9% every 30 minutes, utilizing a rotating drum and maintaining a constant temperature of 75°C. From the two rounds of testing, in the first drying session, employing post-harvest coffee with an initial weight of 20 kg, the drying process lasted for 7.5 hours at a temperature of 75°C, resulting in a decrease in the initial moisture content from 61.66% to 5.3%, yielding 8 kg of dried coffee. Throughout the testing period, 13 kg of coffee weight was lost through evaporation. Meanwhile, in the second test, drying post-harvest coffee with an initial weight of 17 kg took 4 hours at a temperature of 75°C, reducing the initial moisture content from 36% to 2%. During this test, 12 kg of coffee weight was lost through evaporation.

References

[1] Dessie, A. K. (2017). The Role of Coffee-based Agriculture in the Socio-economic Development of Borecha District, Ethiopia (Doctoral dissertation).

[2] A. K. Dessie, "The Role of Coffee-based Agriculture in the Socio-economic Development of Borecha District, Ethiopia," PhD dissertation, 2017.

[3] W. G. Clarence-Smith and S. Topik, Eds., The Global Coffee Economy in Africa, Asia, and Latin America, 1500–1989. Cambridge University Press, 2003.

[4] J. Morris, Coffee: A Global History. Reaktion Books, 2018.

[5] D. Grigg, "The worlds of tea and coffee: Patterns of consumption," GeoJournal, vol. 57, pp. 283-294, 2002.

[6] O. Jonasson, "The Potential Areas of Coffee-Growing: And Their Relation to the Settlement of the White Man," Geografiska Annaler, vol. 40, no. 2, pp. 89-100, 1958.

[7] T. Hills et al., "Starbucks Coffee, Conservation and Carbon in Sumatra, Indonesia," 2010.

[8] N. Definiati, A. Sahputra, and N. Setyowati, "Weed Availability as A Ruminant Forage Source on Coffee Farmers' Land in Kandang Village, Indonesia," Int. J. Life Sci. Agric. Res., vol. 2, no. 7, pp. 166-173, 2023.

[9] B. Arifin, "On the competitiveness and sustainability of the Indonesian agricultural export commodities," in On the Competitiveness and Sustainability of the Indonesian Agricultural Export Commodities, 2013, pp. 81-100.

[10] J. Neilson, "The value chain for Indonesian coffee in a green economy," Buletin Ristri, vol. 4, no. 3, pp. 183-198, 2013.

[11] A. Wahyudi et al., "Sustainability certification as a pillar to promote Indonesian coffee competitiveness," in IOP Conf. Ser.: Earth Environ. Sci., vol. 418, no. 1, p. 012009, 2020.

[12] V. V. Freitas, "Chemical and sensory composition of arabica and robusta coffee in response to modifications in the roasting process," 2023.

[13] A. Ramakrishna, P. Giridhar, and M. Jeszka-Skowron, Eds., Coffee Science: Biotechnological Advances, Economics, and Health Benefits. CRC Press, 2022.

[14] C. Acar, I. Dincer, and A. Mujumdar, "A comprehensive review of recent advances in renewable-based drying technologies for a sustainable future," Drying Technol., vol. 40, no. 6, pp. 1029-1050, 2022.

[15] C. Bonazzi, B. Broyart, and F. Courtois, "Dryer modeling," in Advances in Food Dehydration, CRC Press, 2008, pp. 373-418.
[16] P. Ghosh and N. Venkatachalapathy, "Processing and drying of coffee–a review," Int. J. Eng. Res. Technol., vol. 3, no. 12, pp. 784-794, 2014.
[17] F. Kulapichitr et al., "Impact of drying process on chemical composition and key aroma components of Arabica coffee," Food Chem., vol. 291, pp. 49-58, 2019.
[18] B. Kusumasari, "Climate change and agricultural adaptation in Indonesia," MIMBAR: J. Sos. dan Pemb., vol. 32, no. 2, pp. 243-253, 2016.
[19] A. B. Sekaranom, E. Nurjani, and F. Nucifera, "Agricultural climate change adaptation in Kebumen, central Java, Indonesia," Sustainability, vol. 13, no. 13, p. 7069, 2021.
[20] D. D. Hidayat et al., "Changes of some engineering properties of coffee beans due to roasting process," Asian J. Appl. Sci., vol. 8, no. 01, 2020.
[21] A. Yani and E. Novitasari, "Quality Evaluation of Robusta Coffee Bean from Four Superior Clones with Semi-Wet Processing in Lampung Province," in IOP Conf. Ser.: Earth Environ. Sci., vol. 1024, no. 1, p. 012028, May 2022.
[22] R. O. Lamidi et al., "Recent advances in sustainable drying of agricultural produce: A review," Appl. Energy, vol. 233, pp. 367-385, 2019.
[23] R. W. Thurston, J. Morris, and S. Steiman, Eds., Coffee: A Comprehensive Guide to the Bean, the Beverage, and the Industry. Rowman & Littlefield Publishers, 2013.
[24] J. Hughes, "Coffee and chocolate–can we help developing country farmers through geographical indications?," 2010. Available: SSRN 1684370.
[25] E. O. Afoakwa, Cocoa Production and Processing Technology. CRC Press, 2014.