Development of Liberica Coffee Roasting Machine Using Quality Function Deployment (QFD) Method as the Leading Product of Farmers of Meranti Islands Riau

Razali and Imran
Department of Mechanical Engineering Politeknik Negeri Bengkalis, Jl. Bathin Alam, Bengkalis, Indonesia

Keywords: Coffee Roasting Machine, Voice of the Consumer, House of Quality.

Abstract: Meranti Islands Regency is one of the regencies in Riau province which is famous for its Liberica coffee production. According to the management of the Liberica Meranti Coffee Community Association (LMPK) Al-Amin, Liberica coffee farm in Kedabu Rapat Village is currently 775 hectares and 100,000 hectares in Rangsang Coastal area. The original Liberica coffee of Meranti is in huge demand by foreigners, especially Malaysian. Malaysian Market demand holds up to 90% of the commodity. In order to improve the competency, innovation will always be needed and carried out. This study conducted was to develop a coffee roasting machine to enhance the coffee flavor by using Quality Function Deployment (QFD) method to resolve the problems. The data obtained is in quantitative form by spreading 23 questionnaires to coffee merchant. There were several phases conducted, which are collecting data by interviewing consumers, compiling the house of quality matrix, and developing the concept of the tool. The data collected showed that House of Quality requested large coffe roasting machine, while regular consumers wished to learn coffee developement proccess. The final result of the study revealed that the design of the roasting coffee machine proposed suits the request and needs of the users, called C concept (14 points) compared to other concepts.

1 INTRODUCTION

Meranti Islands is one of the regencies in Riau province which is famous for its Liberica coffee production. Liberica is a type of coffee cultivated on lowlands around one meter above sea level. Liberica Coffee is currently registered as a geographical indication at the Directorate of Intellectual Property with application number G002014000014 by Rangsang Meranti Liberica Coffee community (MPKLRM). (Tiaraputri, Law, & Riau 2021).

Based on the information from the management of the Meranti Liberica Coffee Community Association (LMPK) Al-Amin, Liberica coffee farm in Kedabu Rapat Village is currently 775 hectares and 100,000 hectares in Rangsang Coastal area, The original Liberica coffee of Meranti is in huge demand by foreigners, especially.

Malaysian. Malaysian Market demand holds up to 90% of the commodity, while only 10% penetrates the local market. In 2016, the export volume of Meranti Liberica coffee beans to Malaysia was 71 tons or equivalent to 800 tons of fresh beans. Each coffee bean has different flavor, the factors that affect the flavor of coffee are the variety of coffee beans, the coffee growing area, the harvesting process, fermentation and roasting. Roasting is an important thing in processing coffee. (Novison and Sapta 2021).

Since the post-harvest coffee beans is still less in value, those beans need to be further proccessed to add the value to the farmers. However, during the process of roasting, the merchant found it difficult to determine that the beans are roasted evenly. To get the flavor of the coffee, filling is still applied so that the production cost and the final product can be balanced since the price of the machine is extremely expensive, for instance, a machine from otten coffee with a capacity under 700 grams costs Rp. 1.8 million while large capacity machine costs up to hundreds of millions. (Zakaria Purnama et al. 2020).

Liberica coffee beans which grows in the lowland of Rangsang coastal area, Meranti Islands, is one of the leading products of Meranti, which has

Razali, . and Imran, .
Development of Liberica Coffee Roasting Machine Using Quality Function Deployment (QFD) Method as the Leading Product of Farmers of Meranti Islands Riau.
DOI: 10.5220/0011899300003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 857-862
ISBN: 978-989-758-619-4; ISSN: 2975-8246

certain characteristic that cannot be found in other coffee. Therefore, to maintain the distinct flavor, the coffee beans should be well-roasted using proper machine. Although the farmers need a proper machine for roasting process, it is not affordable for all coffee farmers and the merchants due to the expensive price. Additionally, the farmers do not have the required knowledge to operate the machine or to roast the coffee beans perfectly, which affect the flavor of the beans.

Condluding the problems mentioned above, the author conduct a study to develop a coffee roasting machine using Quality Function Deployment (QFD) method which is affordable, user-friendly and high in quality.

These are several studies related to this research which has previously conducted.

- A study conducted by (Novison and Sapta 2021) entitled "Application of the Taguchi Method to Determine the Quality of Liberica Roasted Coffee Based on Roasting Parameters". The results of the study showed that the best roasting can be produced with variable value ratio SN 260 °C, in 60 minutes with 60 RPM roasting speed and the best to method is by reducing moisture and acid level (pH).
- Another research conducted by (Sulistyo 2020) entitled "Design of Semi-Automatic Coffee Bean Roasting Machine". The results obtained from the performance of the control system on the semi-automatic roasting machine were able to reduce the water of 11% to 7%-5% with light roast beans at 155 °C with an average time of 12 minutes for heating 170 °C and 150 °C the average roasting time is 20 minutes, medium roast at a temperature of 160 °C with an average time of 14 minutes for heating 170 °C and 150°C, the average roasting time is 25 minutes. Semi-automatic roasting is more gas efficient, 1 can of gas can be used to roast 6-7 times while manual roasting is only 3 times.
- A study conducted by (Arda 2020) entitled "Design of Microcontroller-Based Smart Coffee Roasters". The results of the automatic research obtained the results of the coffee roaster research with a choice of four roasting menu options that work automatically, called light roast, medium roast, dark roast, and set timer. The Set timer is used when to roast the coffee beans for a specific time by by setting the timer
- The results of the study conducted by (Sasongko et al. 2018) entitled "Coffee Bean Roasting Machine With Controlled Temperature Using Arduino Due". The results showed that the roasted level of coffee beans can be determined based on the final temperature of the coffee beans, 235°C for the medium roast level, and 240°C for the dark roast level.

Research Objectives
The purposes of this study are:

1. Collecting House of Quality (HoQ) to get the largest 5 weights from the QFD (Quality Function Deployment) method.
2. Developing a coffee roasting machine design based on concept development on the QFD (Quality Function Deployment) method.

1.1 Product Development

a) Development Concept.
In the concept development phase, the needs of the target market are identified, alternative product concepts are generated and evaluated and a concept is selected for further development.

b) Design System.
The systems design phase includes defining the product architecture and dividing the product into sub-systems and components. The final assembly scheme for a production system is often undefined clearly during this phase.

c) Design Details.
Overall specifications are in two dimensions, materials to be used and tolerances of all unique product components and identification of all standard components to be purchased from suppliers.

d) Testing and Screening.
The testing and screening phase involves establishing and pre-producing evaluation of the many types of products to be developed.

1.2 Quality Function Deployment (QFD)

QFD is a structured product planning and development method that allows the development team to clearly define consumer needs and then evaluate the capacity of each proposal and product and service systematically (Aston□Jones and Cohen, 2005). According to (Djati, 2003), Quality

Function Deployment is a product development system that starts from product design, manufacturing processes, to delivering product to the consumers, which is based on consumer needs.

The QFD process involves the establishment of one or more quality matrix or tables. This matrix, known as the House of Quality (HoQ), consists of several parts or sub-matrix which are merged in several ways, each of which contains related information.

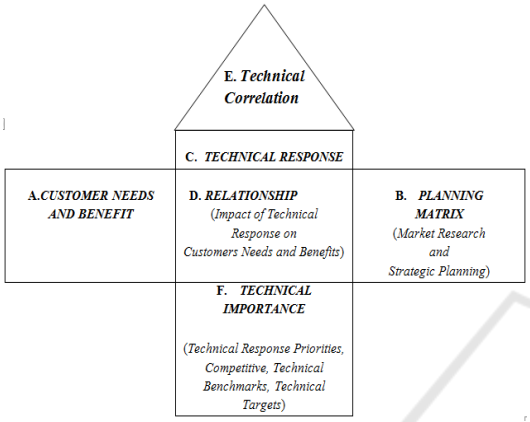


Figure 1: House of Quality.

Part A:
Contains a structured list of consumers' needs, the arrangement is usually determined by conducting market research.
Part B:
Contains three main types of information, quantitative market data, setting strategic goals for services and calculations for ranking consumers' needs.
Part C:
Contains a high-level description of a product or service that is planned to be improved, usually this technical explanation is generated from the consumers' needs in part A.
Part D:
Contains the development group's consideration of the strength of the relationship between each element of the engineering response and each consumer's wishes.
Part E:
Technical correlation, is the half of a square matrix, which is separated along its diagonal and rotated 45 degrees. Since this part resembles the roof of a house, the term 'Quality House' is used for the entire matrix and has become the standard term for the matrix structure. Part E contains the development team activities to implement the correlation between engineering response elements.
Part F:
Contains three kinds of information, ranking order, comparative information on competitors' technical performance and technical performance targets.

1.3 Definition of Coffee Roasting

Coffee roasting machine is a tool used to roast coffee to seperate the coffee beans from the skin. This machine will also grind the coffee beans into coffee powder to be distributed to the consumers. (Tiaraputri, Hukum, and Riau 2021) The function of the roasting process is to bring out the original flavor of the coffee beans and make it more delicious. The higher the temperature and the longer the roasting time, the more charred the beans will be. If it gets burnt, the original character and roasting aroma will be stronger

There are interesting percentages about the flavor of coffee that we enjoy. Coffee farmers have a role of 60%, 30% during roasting process, and the rest depends on the baristas. Brewing it by yourself means we play the remaining percentage.

2 RESEARCH METHODS

2.1 Research Design

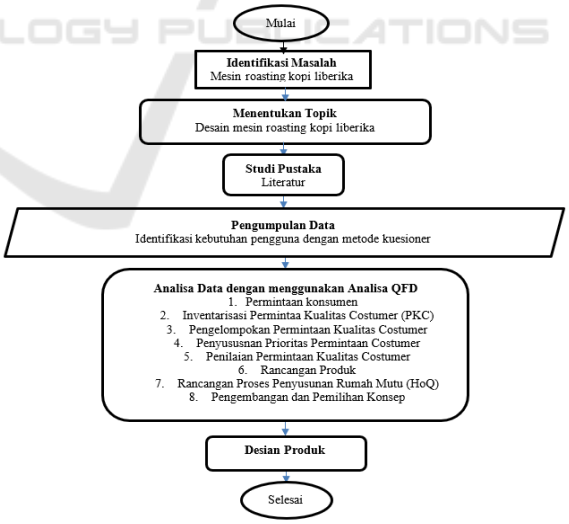


Figure 2: Research Chat Flow.

2.2 Population and Sample

The objects of this research are Brem entrepreneurs in Kaliabu village, Mejayan sub-district, Madiun Regency. based on research on picnic coolers by

Griffin and Houser (Eppinger & Ulrich, 1995). The sample used was 23 respondents, to be able to describe consumer needs up to 90%. To collect data, questionnaires were spread to respondents to find out their rewuirements and needs for the development of Liberika coffee roasting machine design.

2.3 Data Collection Technique

To involve consumers in the process of product design and development, a data search process is needed about the market demands. The market demands can be found through the responds of the consumers (merchant/coffee beans farmers). To be able to catch consumers' needs, a method is needed. The methods commonly used are interviews and/or questionnaires. Taking into account the cost and time required, the questionnaire method was chosen to collect data from consumers.

2.4 Data Analysis Using QFD (Quality Function Deployment) Analysis

The data collected from the questionnaires that have been filled out and returned, are then processed and summarized to be used as the basis for making a "Consumer Quality Request (CCP)" or Voice of Consumer (VoC)". Based on the CCP that has been obtained, it can then be used to build a House of Quality (HoQ). The data processing steps are:

- Step 1 Collecting data based on the questionnaire responds, called Data 1 and Data 2
- Step 2 Grouping the questionnaire data according to the responds.
- Step 3 Grouping Consumer Quality Demand (CCP)"
- Step 4 General Grouping Consumer Quality Demand (CCP)"
- Step 5 Prioritizing Consumer Quality Demand (CCP)"
- Step 6 Assessment of Consumer Quality Demand (CCP)"
- Step 7 Preparation of Construction Quality Performance (PKK)"
- Step 8 Structuring Construction Quality Performance (PKK)"
- Step 9 How to Optimize and Roof Matrix
- Step 10 Comparison between CCP and PKK
- Step 11 Ranking (Weighting) of Quality Demand
- Step 12 Compilation of the House of Quality (HoQ)

3 RESULTS AND DISCUSSION

3.1 Questionnaire Data Collection

Collecting 23 questionnaire data that were returned to the researcher and then grouped into table.

Table 1: Data.

No.	Question	A	B	C	D	Results
1-	What is your favorite "Roasting Machine" frame color?	9	1	13		C
2-	What is your favorite "Roasting Machine" ingredient?	0	9	0	14	D
3-	How ergonomic "Roasting Machine" do you like?	21	2			A
4-	What is the price of your favorite "Roasting Machine"?	12	6	5		A
5-	What is your favorite "Roasting Machine" computer control system?	0	23			B
6-	How is the tube movement system "Roasting Machine" that you like?	4	9	10		C
7-	What is your favorite "Roasting Machine" Tube Material?	5	15	3		B
8-	How is the locking system of the "Roasting Machine" that you like?	0	19	4		B
9-	Motion Tool "Roasting Machine" with what you lie?	23	0			A
10-	Do you like the "Roasting Machine" which is equipped with a timer control?	0	0	23		23
11-	What is your favorite "Roasting Machine" Air Flow System?	5	8	4	6	B
12-	What capacity of "Roasting Machine" do you want?	9	1	13		C

(Source: Research Results)

3.2 Priority Setting "Consumer Quality Demand (CCD)"

The stages after the general grouping of the data are carried out, then at this stage is to determine the priority of consumer quality requests by looking at the results of the most selected questionnaires based on the consumer's desire to determine priority on primary requests, while for secondary requests are data that have a moderate value. And the least demand is tertiary.

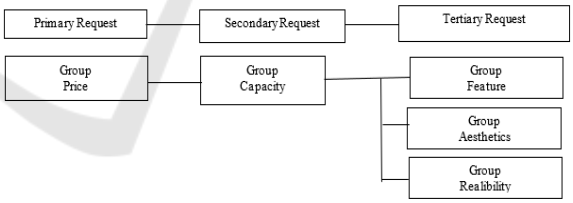


Figure 3: Priority Setting Chart Flow.

3.3 Consumer Quality Demand Assessment

In the following stages, a comparison will be made between the data on consumer quality requests that have been obtained. The assessment is done by giving a value of 3 if the comparison result which is deemed more important, a value of 2 if the comparison result which is equally important and a value of 1 if the comparison result which is less important.

Table 2: Evaluation PKC.

		Life		Capacity				Beauty (Aesthetics)			Features				Reliability (Reality)			
	With PKC	Economical/more affordable price	Easy to get on the market	Tube Size	Tube movement system	Tube capacity	Construction size	Frame color	Ergonomic	Cover with Stainless Steel plate	With electric motor	With Timer Control	System control by	Easy to operate/use	Corrosion resistant tube material	Holo iron construction material	Able to operate continuously	Easy to maintain and repair
Harga	Economical/more affordable price	0	3	3	2	2	2	1	2	3	3	3	1	3	3	3	1	3
	Easy to get on the market	3	0	1	1	3	2	2	1	2	3	3	3	2	2	3	1	1
Capacity	Tube Size	3	3	0	3	3	2	1	2	3	2	2	2	2	3	1	1	3
	Tube movement system	1	1		0	3	1	1	2	2	3	3	3	3	2	1	3	1
	Tube capacity	2	1	3	2	0	1	1	1	2	2	2	1	1	3	1	3	2
	Construction size	2	1	1	1	1	0	2	3	1	1	1	1	2	1	3	1	1
Beauty (Aesthetics)	Frame color	2	2	1	1	1	2	0	1	1	1	1	1	1	2	2	1	3
	Ergonomic	2	2	2	2	2	3	1	0	1	1	1	1	3	1	1	3	3
	Cover with Stainless Steel plate	3	3	2	1	2	1	2	3	0	1	1	1	2	3	1	2	3
Features	With electric motor	3	3	2	2	2	1	1	1	1	0	3	2	2	1	1	3	3
	With Timer Control	2	2	1	3	1	1	1	2	1	3	0	3	3	1	1	3	3
	System control by computer	1	1	1	2	1	1	1	1	1	3	3	0	1	1	1	2	1
	Easy to operate/use	2	1	1	2	1	1	1	3	1	1	2	1	0	1	3	1	2
Reliability (Reality)	Corrosion resistant tube material	2	2	2	2	3	1	2	2	2	1	1	1	1	0	3	1	2
	Holo iron construction material	3	3	1	1	1	3	3	3	1	1	1	1	1	1	0	1	2
	Able to operate continuously	2	1	3	2	1	1	1	1	1	1	1	1	2	3	1	0	2
	Easy to maintain and repair	1	1	2	2	2	1	2	2	1	2	2	2	2	2	2	2	0
	Σ	34	30	26	29	29	24	23	30	24	30	30	25	31	30	28	29	35

(Source: Research Results)

3.4 Comparison of PKC and PKK

The next step is to assess the comparison between PKC and PKK by giving a score of 9 for a strong correlation, a value of 3 for a moderate correlation (medium) and a value of 1 for a weak correlation.

Table 3: Comparison of PKC and PKK.

	Desain / PKC / Request / Customer	Score PKC	Just turn on the button (on - off)	There will be a sound after the process is complete	There is a temperature monitor layer	Using electrical energy	Can be set long time	Process Few components, easy to install, and components available on the market	Tube capacity= 5 kg	Tube Length: 400 mm, diameter: 250 mm	Height: 640 mm, width: 760 mm, Length: 310 mm	Tube Stainless Steel Plate Steel	Steel Frame	Electric Motor Power 350/220 V	Price <=5 million	Air Flow System
Harga	Economical/more affordable price	34	Δ	Δ	Δ	Δ	Δ	Δ	Θ	Θ	O	Δ	Δ	Δ	Θ	Θ
	Easy to get on the market	30				Δ		O	Θ				Θ	Δ	Θ	
Capacity	Tube Size	26		Δ		O			Θ	Θ			Δ	O	Δ	Θ
	Tube movement system	29		Δ		Θ	O		Δ	Δ	O		Θ	O	Δ	
	Tube capacity	29					O		Θ	Θ	Δ	O	Δ	Θ	O	
	Construction size	24						Θ			Θ		Θ	Θ		
Beauty (Aesthetics)	Frame color	23											Θ	Θ	Θ	
	Ergonomic	30						Θ			Θ		Θ			
	Cover with Stainless Steel plate	24							Θ	Θ						
Features	With electric motor	29	Δ			Δ			Δ					Θ	Θ	Θ
	With Timer Control	30	Δ	Θ				Δ	Δ						Θ	
	System control by computer	25			Θ	Θ										
	Easy to operate/use	31	Θ		Θ	Θ					Θ			Θ		
Reliability (Reality)	Corrosion resistant tube material	30						Δ	Δ			Θ			Θ	Θ
	Holo iron construction material	28						Θ					Θ		Θ	Δ
	Able to operate continuously	29	Θ					Θ						Θ	Θ	Θ
	Easy to maintain and repair	35						Θ				Δ	Δ		Θ	Θ

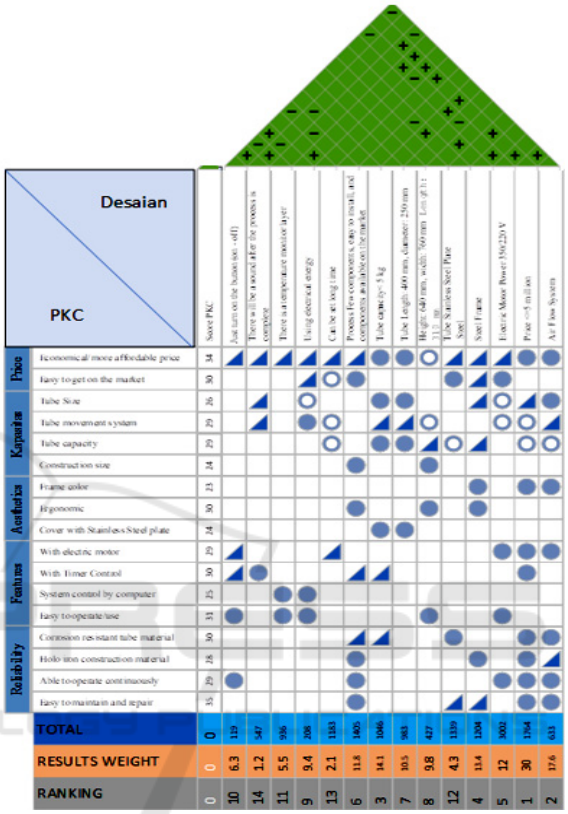
(Source: Research Results)

description:

Strong	Θ : 9
Middle	O : 3
Weak	Δ : 1
There isn't any	emptied

3.5 Preparation of House of Quality (HOQ)

The last step is to create a House of Quality (HOQ) which is built based on the optimization matrix and others which have been created previously.



(Source: Research Results)

Figure 4.

3.6 Concept Development

Table 4.

No.	Kriteria	Draft A (Referensi)	Draft B	Draft C
1.	Price <=5 million	-	+	+
2.	Air Flow System	0	-	+
3.	Tube capacity< =5 kg	-	+	+
4.	Iron frame	+	+	+
5.	Electric Motor Power 350/220 V	+	+	+
6.	Few components, easy to install, and components available in the market	-	+	+
7.	Tube Length: 400 mm, diameter: 250 mm	-	+	+
8.	Height: 640 mm, Width: 760 mm, Length: 310 mm	-	+	+
9	Using electrical energy	+	+	+
10	Just turn on the on - off button	+	+	+
11	There is a temperature monitor layer	-	-	+
12	Stainless Steel Plate Tube	+	+	+
13	Can be set the processing time	-	-	+
14	There will be a sound after the process is complete	0	-	+
	Quantity (+)	5	10	14
	Quantity (-)	)9	4	0
	Quantity (0)	2	0	0
	Net Score	5	10	14
	Ranking	3	2	1
	Next?	Not	Not	Yes

(Source: Research Results)

3.7 Developed Product Concept

After filtering the matrix, it is concluded that concept C will be developed. The selection of concept C to be developed is based on the highest score obtained by concept C (14 points) compared to concept B (10 points). Among 14 requested component criteria, concept C matched the requirements. The following is a detailed image of the concept C machine to be developed and manufactured.

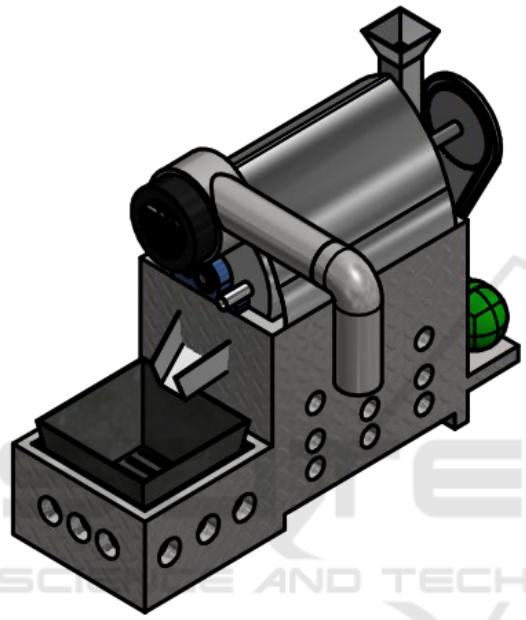


Figure 5: Coffee roasting machine design.

4 CONCLUSION

Based on the results of the development of the coffee roasting machine with the QFD method in this study, the following conclusions can be drawn:

1. The data obtained and compiled through the House of Quality resulted in 5 rankings (weights) of the highest PKK value criteria, which is Price Price <= 5 million with a capacity of 30%, Air flow system with PKK weight value of 17.6%, Tube capacity < = 5 kg with PKK weight 14.1%, iron frame with PKK weight 13.4%, and by using an electric motor with PKK weight 912.0%.
2. From the discussion conducted to develop a coffee roasting machine design using QFD (Quality Function Deployment) analysis, the results of the coffee roasting machine design on concept C are obtained. The selection of the concept C to be developed is based on the highest score obtained by the concept C (14 points) compared to the concept B (10 points). Of the 14 desired component criteria, all of them are in the concept C.

REFERENCES

Arda, Abdul Latif. 2020. “Design smart coffee roasters based on microcontroller 1.” 11(1): 57–64

Hardiyansyah, Muhammad Vikih et al. 2021. “Design of a Temperature Control System on an Arduino-Based Rotary Coffee Oven Machine.” 4(1): 67–76

Jatmoko Awali, Asroni. 2013. "Analysis of Shaft Failure With Finite Element Method Approach." 1(May): 39–44.

Sasongko, Irwan Juniar, Muhammad Rivai, A Kopi Bean, and Coffee Bean. 2018. “Coffee Bean Roasting Machine with Controlled Temperature Using Arduino Due.” 7(2)

Sulistyo, Ahmad. 2020. “Final Project Report of Semi Coffee Bean Roasting Machine.”

Tiaraputri, Adi, Faculty of Law, and the University of Riau. 2021. “Importance Of Registration For Liberica Coffee In Communal Intellectual District The Importance Of Registration For Liberica Coffee In The Regency Of Meranti Archipelago, Riau.” unilak.ac.id/index.php/gh/ 03(02): 172–85.

Zakaria Purnama, Putra et al. 2020. “Rancang Bangun Mesin Oven Kopi Dengan Prinsip Qfd Dan Ergonomi.” *Jurnal Mahasiswa Teknik Industri* 3(2): 25–31.

Novison, R., & Sapta, R. D. (2021). Aplikasi Metode Taguchi untuk mengetahui Kualitas Kopi Sangrai Liberika berdasarkan Parameter Peyangraian: Taguchi. *Jurnal Elektro dan Mesin Terapan*, *7*(2), 89-101.

Aston□Jones, G., & Cohen, J. D. (2005). Adaptive gain and the role of the locus coeruleus–norepinephrine system in optimal performance. *Journal of Comparative Neurology*, *493*(1), 99-110.

Djati, S. P., & Khusaini, M. K. M. (2003). Kajian terhadap kepuasan kompensasi, komitmen organisasi, dan prestasi kerja. *Jurnal manajemen dan Kewirausahaan*, *5*(1), 25-41.

Eppinger, S. D., & Ulrich, K. (1995). Product design and development.