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# Design, Fabrication, and Performance Evaluation of a Batch-Type Fluidized Bed Coffee Roaster for Small-Scale Coffee Growers

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## Abstract

A batch-type fluidized bed coffee roaster was designed, fabricated, and evaluated at the College of Engineering and Applied Technology, Benguet State University to help small-scale farmers roast quantities of coffee beans. The machine is inexpensive with lower capacity, uncomplicated design, and simple to operate. The machine comprised a roasting assembly that included a blower, heating element, roasting chamber, chaff collector and frame. Performance evaluation results showed that the optimal airflow rate was at 9.2m/s with highest capacity and efficiency of 94.06% and 96.46% for medium and dark roast, respectively. Airflow rate of 9.7m/s attained the highest uniformity of 99.80% for medium roast while 10.2m/s attained the highest uniformity of 99.97% for dark roast. The fastest duration of roasting for medium roast took 13.68 min at 234.33°C while 17.98 min at 261.67°C was recorded for dark roast. The cost of the machine was computed at Php21,636. The payback period for medium roast is 1.2 months with return of investment of 212.27% while 1.92 months for dark roast with return investment of 131.37%. The break-even point of 155.18kg of coffee beans per year for medium roast and 185.24kg of coffee beans per year for dark roast.

KEYWORDS

batch-type roaster
fluidized bed
coffee roaster
airflow rate
performance evaluation

## Introduction

Coffee is one of the most widely consumed beverages around the world. The most common degrees of roast sold at the market are medium roast and dark roast. Medium roasted coffees are medium brown in color and has more balanced flavor, aroma, and acidity. Dark roasted coffees, on the other hand, are dark brown in color with a sheen of oil on the surface, has a bitter and smoky taste and the amount of caffeine is substantially decreased (Lokker, 2017).

Due to the increasing demand of roasted coffee beans, it has led to the development of roasting equipment from manual roasting on iron pans to drum roasters and fluidized bed roasters. In drum roasters, beans are heated with hot gas in a horizontal drum or vertical drums equipped with paddles while fluidized bed roasters keep the beans in the air by a blower and roast them inside the roasting chamber (Wang, 2012). In roasting coffee beans, convection by far is the most important mode of heat transfer that determines the rate and uniformity of roasting (Baggenstoss et al., 2008). Eggers and Pietsch (2001) added that coffee roasted in fluidized-bed roaster that is almost exclusive based on convective heating can result in low density and high yield coffee. On the other hand, coffees roasted in drum roaster that involves mainly conductive heat transfer have less soluble solids, more degradation of chlorogenic acids, more burnt flavour, and higher loss of volatiles than the fluidized bed roasters (Nagaraju et al., 1997).

There are already existing roasting machines being used in Benguet State University-Institute of Highland Farming Systems and Agroforestry (BSU-IHFSA) at Bektey, Puguis, La Trinidad, Benguet. The machine has two drum roasters with a capacity of 5kg and 12kg and uses Liquified Petroleum Gas (LPG) as the heat source. These existing machines are excellent for medium-scale farmers but is expensive and impractical for small-scale farmers. Most of local coffee farmers in the locality are into backyard farming (Alimondo, 2019) and one farmer's produce is not enough to meet the required volume of the existing machines. Thus, they either rely on the production of other farmers or wait for the next harvest in order to fulfill the capacity of the machine.

This predicament showed the need to develop a roasting technology that has lower capacity enabling farmers to roast small quantities of coffee beans, uncomplicated in design, inexpensive to manufacture, and simple to operate. A simplified machine that requires less maintenance and cleaning could potentially save costs and increase productivity of small-scale farmers. The study specifically aimed to design, fabricate and evaluate the performance of a batch-type fluidized bed coffee roaster in terms of its roasting uniformity, roasting capacity, roasting efficiency and power consumption in achieving the desired roasting degrees, the medium and dark roast. The study also determined the optimal airflow rate, temperature and time it takes to roast the desired roasting degrees. Lastly, the study performed simple cost analysis of the machine.

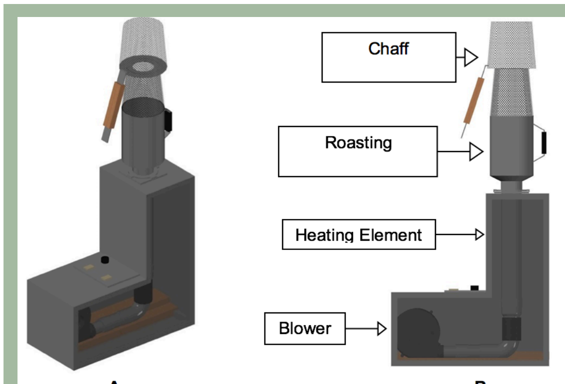

*Figure 1*. Isometric (A) and front view (B) of roaster

## Materials and Methods

### Design of the Machine

A roasting assembly was provided for passing heated air around individual coffee beans at a certain temperature. The roasting assembly included a 600W blower, a 3600W heating element, a 1kg capacity roasting chamber with chaff collector and a frame (Figure 1) .

During the machine design conceptualization, certain criteria were considered. First, the design should be simple for easy fabrication with ease of maintenance and operation. The cost of the roaster must be affordable and made of locally available materials. Lastly, the capacity of the roasting chamber must be one kg.

**Principle of Operation.** The blower force air through the heating element (Figure 2). The heated air is then passed towards the roasting chamber

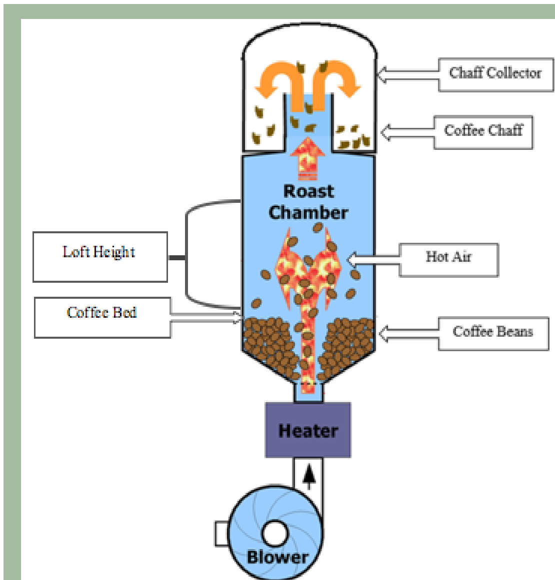

*Figure 2*. Schematic diagram of the roasting principle in the machine

which receives the green coffee beans. The heated air that enters the roasting chamber heat the bean through convection and at the same time, the evacuated air pressure let the beans circulate around the chamber causing a uniform mixing and roasting of the beans. The bean temperature is monitored using a thermocouple connected to a digital thermometer. At the upper portion of the chamber, a chaff collector is provided for gathering the chaff that are forced out of the roasting chamber during the roasting process. Chaff of the beans are light enough to go up into the collector compared to the beans. It has a separator member that serves to separate the chaff from the evacuating air and a cover member to direct the chaff into the collection volume and to allow further evacuation of air from the coffee roaster. If the roasting process is done, the heating element turns off to cool off the beans and avoid further heating.

**Performance Evaluation of the Machine**

The machine was pre-tested to determine the power of the heating element. The different airflow rates were also pre-tested and measured using a digital airflow meter basing on the loft of height of coffee beans. Airflow rate of 9.1m/s, 9.3m/s, 10m/s, and 10.3m/s with a corresponding loft height of 2", 3", 4", and 5", respectively were recorded. The measured airflow rates were then averaged arriving to three final treatments of 9.2m/s, 9.7m/s and 10.2m/s airflow rates. Its performance was further evaluated based on roasting efficiency, capacity, uniformity and power consumption.

**Roasting Uniformity.** The roasting uniformity was computed by weighing the roasted beans and subtracting the weight of the non-uniformly roasted beans. Non-uniformly roasted beans are coffee beans, which show a lighter or darker color compared to the whole batch. (Philippine Agricultural Engineering Standards [PAES], 2017). The formula was

$$\text{Roasting Uniformity} = \frac{(C_f\ W_{nub})}{C_f} \times 100\%$$

where $C_f$ is the final weight of coffee beans in grams, $W_{nub}$ is the weight of non-uniformly roasted beans in grams.

On the other hand, roasting capacity (input and output capacity), roasting efficiency and power consumption were computed using the following equations:

$$\text{Input Capacity} = \frac{(\text{Input Weight (kg)})}{(\text{Roasted time (hr)}}$$

$$\text{Output Capacity} = \frac{(\text{Final Weight (kg)})}{(\text{Roasted time (hr)}}$$

$$\text{Roasting Efficiency} = \frac{C_f}{(C_i - C_i\ (^{W}L))} \times 100\%\ ,$$

where $C_f$ is final weight of coffee beans in grams, $C_i$ is the initial weight of coffee beans in grams, and $(^{W}L)$ is the ideal weight loss of different degree of roast

$$P = V \times I \times t$$

where P is power in kilowatt, V is voltage in volts, I is current in Ampere, and t is time in hours.

**Data Gathered**

Data gathered in the study included initial ($C_i$) and final ($C_f$) weight of the coffee beans, temperature (°C), duration of roasting (min), weight of non-uniformly roasted beans ($W_{nub}$) and current (I). $C_i$ and $C_f$ was measured in terms of grams (g) and recorded using a portable weighing balance before and after roasting. The temperature at the desired degree of roasting was monitored using a thermocouple connected to a digital thermometer. The duration of roasting was determined using a timer in different degree of roasting. Color and audible cracks were the basis for stopping the roasting where medium roast was stopped just after the first crack and just after the second crack for dark roast (Lokker, 2017). $W_{nub}$ was determined by weighing the non-uniformly roasted beans in grams (g). The current in amperes (A) at different airflow rates was measured using clamp meter. It was measured during the operation of the machine and was used to compute the power consumption of the machine.

**Statistical Analysis**

The data gathered were analyzed using Complete Randomized Design (CRD) with three replications. One replication was one kg of green coffee beans to be roasted. The treatments were the different airflow rates of the blower, namely 9.2m/s, 9.7m/s and 10.2m/s as T1, T2, and

T3, respectively. It was tested with two degrees of roasting, Medium and Dark Roast. Analysis of Variance (ANOVA) was used to determine if there was a significant difference on the treatment means. The difference among the means was tested at 5% level of significance by Tukey's Honest Significant Difference (HSD).

## Results and Discussion

### Machine Description

The batch - type fluidized bed coffee roaster was designed to be utilized by small-scale farmers being inexpensive, uncomplicated in design, simple to operate and has lower capacity that will let them roast small quantities. The machine comprises a roasting housing assembly, which consists of a 600W blower with speed controller (Figure 3). The heating element is a 3600W NiChrome (NiCr) coil wire wrapped around a mica frame enclosed with a stainless steel tube, 352mm height and 64mm diameter (Ø). The roasting chamber was made out of a stainless steel with a capacity of one kilogram mainly to contain the green coffee beans. A chaff collector was provided for collecting chaff that were forced out of the roasting chamber during the roasting process. The chaff collector includes a separator member made of stainless steel strainer 130mm x 35mm Ø and a cover member made of stainless steel strainer 154mm in height, 65mm top Ø and 77mm bottom Ø. The frame is made up of stainless steel square tube ¾ with 0.4mm thickness and covered with stainless steel sheet mounted by rivets. The front part of the roasting assembly housing is made up of removable fiberglass for ease of maintenance or replacement of machine components.

### Performance Evaluation of the Coffee Roaster

**Duration of Roasting (min).** Roasting was stopped when the desired color and audible cracks were achieved, just after the first crack for medium roast (Lokker, 2017). Table 1 shows the duration of roasting in minutes for medium roast. It can be readily gleaned from the table that the duration of roasting was highly affected by airflow rate. The duration of roasting was observed at the range of 13 min to 31.83 min depending on the temperature. It was observed that as the airflow rate increases, the duration of roasting also increases. This agrees with the study of Nagaraju et al. (1997) that the roasting time was reduced as the temperature of the spouting air was increased. Since higher airflow rate has lower temperature, it takes longer for coffee beans to attain medium roast. In general, low-temperature-long time roast process results in sour, grassy, woody, and underdeveloped flavor properties while high-temperature-short-time produces higher coffee quality in terms of producing more aromatic volatiles and higher brew yield (Lyman et al., 2003; Schenker et al., 2002; Wang, 2012).

Also in dark roasting, the duration was also highly affected by airflow rates. Roasting was stopped just after the second crack for dark roast (Lokker, 2017). The duration of roasting was observed at the range of 17.5 min to 52.26 min depending on the temperature. As observed, the airflow rate increases with duration of roasting. This agrees with the study conducted by Nagaraju et al. (1997) that the roasting time was reduced as the temperature of the spouting air was increased. Since higher airflow rate has lower temperature, it takes longer for coffee beans to attain dark roast.

**Bean Temperature (°C).** The final bean temperature for medium and dark roast is also shown in Table 1. The Analysis of Variance (ANOVA) shows that airflow rate has a significant effect on roasting temperature. For medium roast, airflow rate of 9.7m/s and 10.2m/s are not

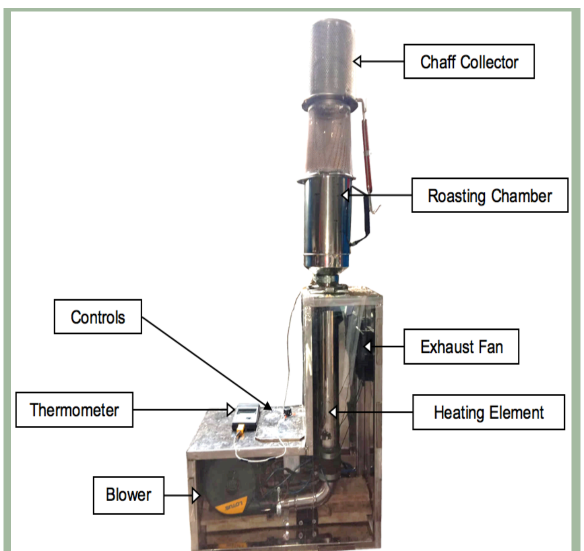


*Figure 3.* Overview of the batch - type fluidized bed coffee roaster designed in the study.

significantly different with each other but are both significantly different with airflow rate of 9.2m/s. The machine was able to reach a temperature of 203°C to 238°C for medium roast and 224°C to 263°C for dark roast. As the airflow rate increases, the temperature decreases in both medium and dark roast which agree with the findings of Chun (2018). Furthermore, Chun explained that the faster the air flow rate, the more readily the surface cools as air forming a boundary layer is replaced and the temperature measured in the area is maintained low. That is why the temperature is getting lower as the fan frequency goes higher. This can be seen from the table that the lowest airflow rate of 9.2m/s has an average temperature of 234.33°C while the highest airflow rate of 10.2m/s has an average temperature of 208.67°C for medium roast. For dark roast, lowest airflow rate of 9.2m/s has a mean temperature of 261.67°C while the highest airflow rate of 10.2 m/s has a lower temperature of 228°C.

**Roasting Uniformity (%)**. ANOVA shows that there is no significant difference among the treatments for roasting uniformity, which implies that airflow rate has no effect on the uniformity of roasting. It was observed during the evaluation that regardless of the different airflow rates, there were few coffee beans that were non-uniformly roasted for medium roast. Airflow rate of 9.7m/s attained a highest uniformity of 99.80%. It was observed that at airflow rate of 9.2m/s, tipping occurred where the tip of the bean burns black due to high temperature. On the other hand, airflow rate of 10.2m/s, which has the lowest temperature, resulted to few coffee beans that were lighter in color.

For dark roast, it was observed that airflow rate of 9.2 m/s has the highest temperature that resulted to few coffee beans with darker color while 10.2m/s has longer duration of roasting. Airflow rate of 10.2m/s has higher roasting uniformity. This agrees with the study of Mahlmann et al. (1985) that a minimal thermal gradient is desirable in furthering uniformity among the roasting coffee beans as well as minimizing structural stresses in the bean, permitting optimal bean expansion. Hence, roasting at low temperatures results in less moisture loss and improved color uniformity of roasted coffee beans.

**Capacity of the Roaster (kg/hr)**. Table 2 shows that there is a highly significant difference among the treatments and this implies that airflow rate greatly affects the input and output capacity of the machine. As airflow rate increases, the capacity decreases. In medium roast, airflow rate of 9.2m/s, that has the lowest duration of roasting, has the highest input capacity at 4.39kg of green coffee beans per hour and 3.59kg of roasted coffee beans per hour output capacity. On the other hand, dark roast attained highest input capacity of 3.34kg green coffee beans per hour and 2.58kg of roasted coffee beans per hour output capacity at airflow rate of 9.2m/s. With airflow rate of 10.2m/s, the input and output capacity was 1.17kg and 0.91kg/ hr.

**Roasting Efficiency (%).** Roasting efficiency was calculated by taking the initial and final weight of coffee beans based on the ideal weight loss of 13% for medium roast and 20% for dark roast (Newell, 2007). As seen in Table 2, airflow rate has no effect on the roasting efficiency of the machine. The roasting efficiency of the different treatments ranged from 93.68% to 95.40% for medium roast while 96.25% to 96.88% for dark roast.

Table 1

*Duration of roasting, bean temperature and roasting uniformity of the batch - type fluidized bed coffee roaster for medium and dark roast*

| Treatments | Duration of Roasting (min) | | Bean Temperature (°C) | | Roasting Uniformity (%) | |
|---|---|---|---|---|---|---|
| | Medium Roast | Dark Roast | Medium Roast | Dark Roast | Medium Roast | Dark Roast |
| 9.2 m/s | 13.68[c] | 17.98[c] | 234.33[a] | 261.67[a] | 99.68[a] | 99.94[a] |
| 9.7 m/s | 18.96[b] | 29.12[b] | 216.33[b] | 239.67[b] | 99.80[a] | 99.96[a] |
| 10.2 m/s | 30.22[a] | 51.27[a] | 208.67[b] | 228.00[c] | 99.75[a] | 99.97[a] |

*Note: Means with the same letter are not significantly different at 5% level of significance*

**Power Consumption (kW-hr).** Power consumption differ significantly among the treatments indicating that airflow rate greatly affects the machine's power consumption during the operation. As the airflow rate increases, the power consumption also increases. In medium roast, airflow rate of 9.2m/s has also the lowest power consumption of 0.838kW-hr and highest power consumption of 1.884kW-hr at 10.2m/s. Same trend was observed in dark roast, 9.2 m/s has also the lowest power consumption of 1.10kW-hr while highest power consumption of 3.20kW-hr at 10.2m/s. The power consumption is directly related to duration of roasting. Shorter duration was observed at 9.2m/s thus resulting to lower power consumption but vice-versa for 10.2m/s.

**Determination of the Optimal Airflow Rate**

From the results presented for medium roast, the optimal airflow rate for the designed machine is 9.2m/s since it has the lowest duration of roasting with 13.68 min with the highest temperature of 234.33°C for medium roast. In general, low-temperature-long time roast process result in sour, grassy, woody, and underdeveloped flavor properties while high-temperature-short-time produced the higher quality coffee in terms of producing more aroma volatiles and higher brew yield (Lyman et al., 2003 and Schenker et al., 2002 as cited by Wang, 2012). It has also the highest input capacity of 4.39kg of green coffee beans per hour and output capacity of 3.59kg of roasted coffee beans per hour. The roasting uniformity was 99.68% with roasting efficiency of 94.06%. Furthermore, airflow rate of 9.2m/s has the lowest power consumption of 0.838kW-hr.

For dark roast, the results showed that the optimal airflow rate is also at 9.2m/s, which has the lowest duration of roasting at 17.98 min. It has the highest input capacity of 3.34kg green coffee beans per hour and output capacity of 2.58kg roasted coffee beans per hour. It has 99.94% roasting uniformity with 96.46% efficiency. Furthermore, airflow rate of 9.2m/s has the lowest power consumption of 1.10 kW-hr.

**Cost and Return Analysis**

Table 3 presents the cost and return analysis in using the machine for medium roast and dark roast. The cost of fabricating the machine was Php21,636. Some basic assumptions were considered and the depreciation was determined using the straight line method using the following assumptions: the machine has a life span of 10 years; salvage value of 10% of the initial cost; interest on investment of 10%; tax and insurance of 3%; and repair and maintenance of 10%.

The annual use was assumed to be 250 days based from coffee production as of December 2018 at La Trinidad, Benguet. Alimondo (2019) noted that the number of coffee plants grown in the valley has reached 70,722. Arabica production has a range of 400g to 1kg per plant per harvest per year. An average of 750g of coffee cherries can be harvested per tree. A ratio of 6kg of coffee cherries produce 1 kg of coffee beans. Custom rate of Php35.00/kg was based from the roasting price at BSU-IHFSA Cupping Laboratory.

Figure 4 presents the break-even point (kg/yr) in using the fluidized bed coffee roaster for medium roast. It indicates a break-even point of 155.18 kg/yr of coffee beans. Additional weight beyond this break-even point indicates the start of profit, which increases as annual weight of

Table 2

*Input and output capacity, roasting efficiency and power consumption of the batch - type fluidized bed coffee roaster for medium and dark roast*

| Treatments | Input Capacity (kg/hr) | | Output Capacity (kg/hr) | | Roasting Efficiency (%) | | Power Consumption (kW-h) | |
|---|---|---|---|---|---|---|---|---|
| | Medium Roast | Dark Roast | Medium Roast | Dark Roast | Medium Roast | Dark Roast | Medium Roast | Dark Roast |
| 9.2 m/s | 4.39a | 3.34a | 3.59[a] | 2.58[a] | 94.06[a] | 96.46[a] | 0.838[c] | 1.10[c] |
| 9.7 m/s | 3.17[b] | 2.06[b] | 2.61[b] | 1.59[b] | 94.37[a] | 96.58[a] | 1.168[b] | 1.79[b] |
| 10.2 m/s | 1.99[c] | 1.17[c] | 1.64[c] | 0.91[c] | 94.83[a] | 96.88[a] | 1.884[a] | 3.20[a] |

*Note: Means with the same letter are not significantly different at 5% level of significance*

Table 3

*Cost and Return Analysis for the Use of the batch - type fluidized bed coffee roaster*

| Basic Assumptions | Medium Roast | Dark Roast |
|---|---|---|
| Initial Cost | Php21,636.00 | Php 21,636.00 |
| Salvage value, 10% of initial cost | Php2,163.60 | Php2,163.60 |
| Estimated life, n | 10 | 10 |
| Interest | 10% | 10% |
| Tax and Insurance | 3% | 3% |
| Repair and Maintenance | 10% | 10% |
| Power Consumption | 0.838 kW-hr | 1.1 kW-hr |
| Electricity Cost | Php8/ kW-hr | Php8/ kW-hr |
| Input Capacity | 4.39 kg/hr | 3.34 kg/hr |
| Annual Use | 250 days | 250 days |
| Operation per day | 8 hrs | 8 hrs |
| Number of Operators | 1 | 1 |
| Salary per day (DOLE, 2018) | Php310.00 | Php310.00 |
| Custom rate | Php35.00/ kg | Php35.00/ kg |
| 1. Fixed Cost | | |
| Depreciation Cost | Php1,947.24 /yr | Php1,947.24 /yr |
| Interest on Investment | Php1,189.98 /yr | Php1,189.98 /yr |
| Tax and Insurance | Php649.08 /yr | Php649.08 /yr |
| Total Fixed Cost | Php3786.3 /yr | Php3786.3 /yr |
| 2. Variable Cost | | |
| Labor Cost | Php38.75 /hr | Php38.75/hr |
| Repair and Maintenance | Php1.08 /hr | Php1.08/hr |
| Power Cost | Php6.704 /hr | Php8.8 /hr |
| Total Variable Cost | Php46.54 /hr | Php48.63 /hr |
| 3. Annual Operating Cost | Php96,857.90 | Php101,049.90 |
| 4. Total Revenue | Php307,300.00 | Php233,800.00 |
| 5. Net Income | Php210,442.10 | Php132,750.10 |
| 6. Payback Period | 1.2 months | 1.92 months |
| 7. Return on Investment | 212.27 % | 131.37% |
| 8. Break-even Point (kg/yr) | 155.18 | 185.24 |

coffee beans increases. On the other hand, Figure 5 presents the break-even point (kg/yr) in using the fluidized bed coffee roaster for dark roast. It indicates a break-even point of 185.24kg/yr of coffee beans. Additional weight beyond this break-even point indicates the start of profit, which increases as annual weight of coffee beans increases.

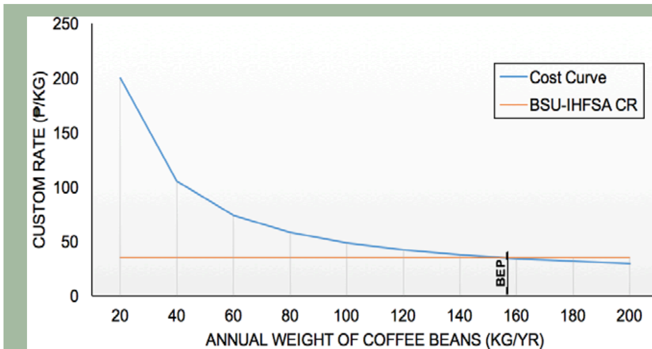


*Figure 4.* Break-even point (kg/yr) in using the fluidized bed coffee roaster for medium roast

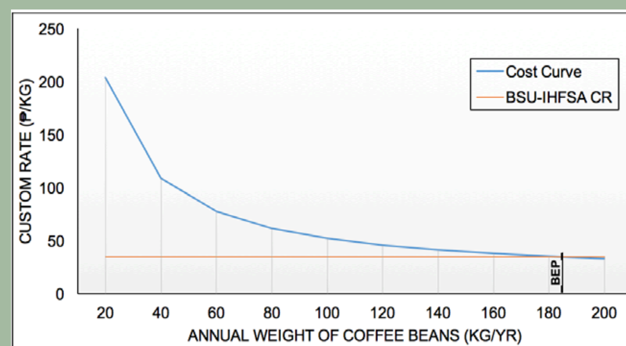


*Figure 5.* Break-even point (kg/yr) in using the fluidized bed coffee roaster for medium roast

## Conclusions

A batch-type fluidized bed coffee roaster was designed and fabricated to be utilized by small-scale farmers as an inexpensive machine, uncomplicated, simple to operate and has lower capacity to roast small quantities of coffee beans. At an optimal airflow rate of 9.2m/s, the machine was able to roast coffee beans in medium roast for 13.68 min at 234.33°C and duration of 17.98 min at 261.67°C for dark roast. Thus, small-scale farmers can roast small quantities of coffee beans that is uniform, efficient with an input capacity of 4.39kg of green coffee beans per hour for medium roast and 3.34kg of green coffee beans per hour for dark roast. The machine has a return investment of 212.27% and 131.37% for medium and dark roast, respectively. The break-even point is 155.18kg/yr for medium roast and 185.24kg/yr for dark roast.

## References

Alimondo, L. (2019). Coffee production thriving in La Trinidad. Retrieved from https://www.sunstar.com.ph/article/1786601. Accessed on January 27, 2019.

Chun, F. (2018). Effects of airflow and heating on temperature: Experiment. Retrieved from https://www.ukessays.com/essays/physics/effects-air-flow-heating-temperature-5612.php?vref=1. Accessed on August 20, 2018.

Lokker, B. (2017). Coffee Roasts from Light to Dark. Retrieved from https://www.coffeecrossroads.com/coffee-101/coffee-roasts-from-light-to-dark. Accessed on July 2, 2018.

Mahlmann, J.P., Scher, L., Schecter, S.M. (1984). Controlled coffee roasting. Retrieved from https://patents.google.com/patent/EP0183878B1. Accessed on July 30, 2018.

Nagaraju, V. D., Murthy, C. T., Ramalakshmi, K., & Srinivasa Rao, P. N. (1997). Studies on roasting of coffee beans in a spouted bed. *Journal of Food Engineering* 31: 263-270. doi: 10.1016/S0260-8774(96)00026-X.

Newell, C. (2007). Home coffee roasting chapter 2 - the bean basics. Retrieved from https://www.coffeecrew.com/gear-equipment-coffee/390-homeroasting-chapter-2.html. Accessed on October 5, 2018.

Wang, N. (2012). Physicochemical changes of coffee beans during roasting. Retrieved from https://pdfs.semanticscholar.org/7b63/bc2fcdc2b126416e638ea98820c98529bb24.pdf. Accessed on December 15, 2018.