

The effect of fluidized bed roaster temperature on the roasted coffee beans antioxidant activity and its sensory evaluation

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Abstract. A fluidized Coffee roaster has been developed. Application of the roaster on coffee beans roasting gave a roasted coffee beans with characteristics of clean and well roasted. It also could preserve the coffee beans aroma and maintained the antioxidants activity. In this report, the effect of the roasting temperature on the antioxidant activity as well as the aroma and the taste of the roasted coffee beans was examined. The coffee beans used in this experiment were Arabica coffee originated from Tlahap, Temanggung, Indonesia. The roasting conditions were at temperature of 205 to 240 °C and it was performed to achieve three degree of roasted coffee which was light roasts (205 °C), medium roasts (220 °C) and dark roasts (240 °C). The antioxidants were extracted using methanol as solvent and the antioxidants activity were examined using scavenging effect method. It was observed that light roasted coffee, medium roasted coffee and dark roasted coffee has antioxidant activity $\mu\text{g/g}$ BHA equivalent of 58793.333, 39468.000 and 24721.500 respectively. The sensory evaluation of the roasted coffee beans resulted that the light roasted one has been categorized as specialty grade of coffee with final score of 82.25.

Keywords: *Antioxidant; Coffee bean; Fluidized; Roaster; Sensory evaluation*

1. Introduction

Coffee roaster with fluidization method utilizes hot air as a heat transfer media and a stirrer for the coffee beans. The heat transfer takes place predominantly by convection. This differ with drum type coffee roaster which heat transfer occurs with conduction. The fluidized bed coffee roaster type is also able to shorten the roasting time to become about 5-10 minutes. Moreover, the qualities of roasted coffee beans have excellent uniformity and cleanness.

Coffee has benefit not only as delicious beverage but also has great benefits for our bodies as a source of antioxidants. It is reported that antioxidant content of coffee higher than that of fruit and vegetable. More than 300 substances that have antioxidant activity contain in coffee. The main antioxidant is chlorogenic acid [1]. Coffee flavor is the most important aspect of a good coffee. Coffee flavor is extremely complex and arises from numerous chemical, biological and physical influences of cultivar, coffee cherry maturity, geographical growing location, production, processing, and roasting and cup preparation [2].

A Fluidized Coffee Bean Roaster has been developed in the Research Center for Agroindustry, National Research and Innovation Agency (BRIN). The objectives of this work were to examine the effect of temperature of the developed fluidized bed roaster to the roasted coffee beans antioxidant activity as well

as to characteristic of the roasted coffee beans. Moreover, the performance of the developed fluidized bed coffee roaster were examined.

2 Materials and Methods

2.1 Materials

Sample of coffee beans were Arabia coffee collected from a coffee plantation in Tlahap, Temanggung, Indonesia. At the post-harvest handling, the beans were processed using dry process. The drying process of the beans were performed using sun drying. The samples moisture content were determined before it were used for the experiments, it was 11.4 %. The chemical for the antioxidant analysis were methanol, 1.1-diphenyl-2-picrilhidrazy (DPPH) and Butylated Hydroxy Anesole (BHA).

2.2 Roasting

Roasting processes were performed using a BPPT-Fluidized Bed Coffee Roaster with a capacity of 500 g (Figure 1). The roasting machine was connected with a data acquisition unit (2635A Hydra Data Bucket) and a computer unit to obtain the temperature data in the real time. Sample coffee beans with moisture content of about 11.4% were used as roasting process. First, 300 kg of coffee beans were loaded to the roaster. Roaster operation time and temperature then be set to an operating condition. The roasting time was 10 minutes and cooling time was 5 minutes. Then the air valve of the roaster was opened to one-third position, and the roasting process ready to be started. Roasting process will be ended according to the adjusted roasting time. Temperature data was acquired on-line in real time. After completion of the roasting process, the roasted coffee beans were packed into an airtight jar and stored in a cold chamber for antioxidant analysis and sensory evaluation.

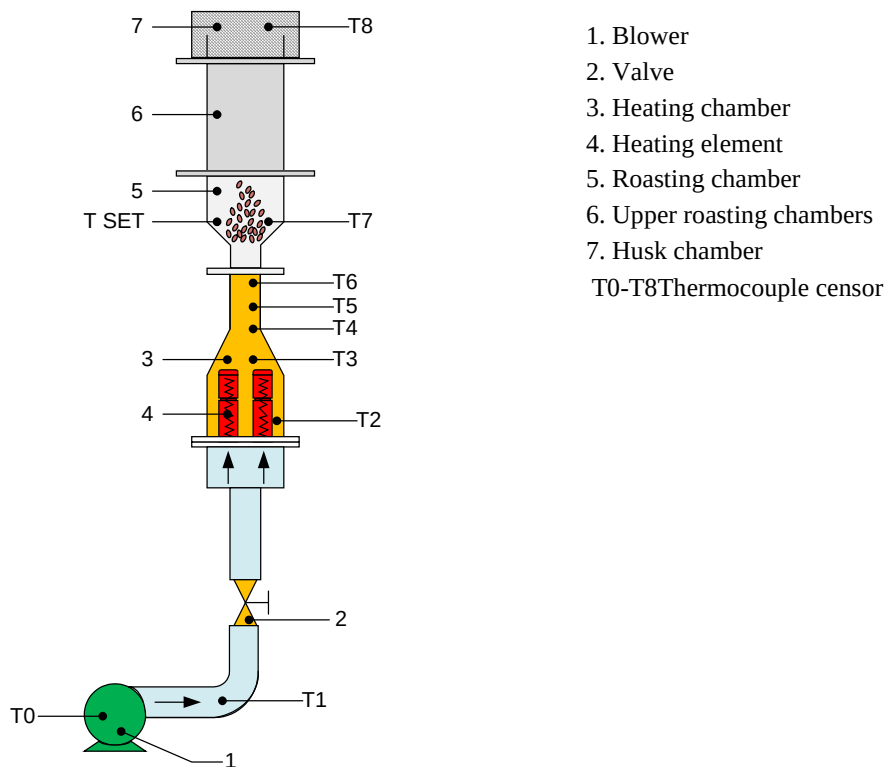


Figure 1 The schematic system of the fluidized bed coffee roaster.

2.3 Analysis

2.3.1 Antioxidant activity

The antioxidant activity was examined using method of scavenging activity [3]. The activity was calculated as BHA equivalent from the standard correlation obtained from BHA standards. The activity was also presented according to absorbance of a solution resulted from the reaction of the BHA and the antioxidant of sample.

2.3.1 Sensory evaluation

Sensory evaluation was performed by expert panelist from Indonesia Coffee and Cocoa Research Institute. The evaluation was performed using cup testing method. The characteristic of aroma, flavor, aftertaste, acidity, body, uniformity, balance, clean cup, sweetness, taint and overall as well as final score were evaluated [4], [5].

3 Results and Discussion

The coffee beans were roasted in the three degrees of roasting. It was light roasted beans, medium roasted beans, and dark roasted beans. Roasting of coffee bean can be considered as two consecutive phases. The first corresponding to the drying (beans temperature of below 160) and the second phase is the roasting (beans temperature of 160-260). In the second phase pyrolytic reaction start at 190 causing oxidation, reduction, hydrolysis, polymerization, decarboxylation, and others chemical changing leading of the formation of substances essentials to give among other the sensory quality of coffee [6]. For this reason, cooling after the roasting phase is important to avoid over roasted that lead to the further reaction. The reaction may alter the quality of the coffee beans. The roasting machine that has been developed is equipped with an air-cooling system, online temperature monitor and timer. The typical temperature behavior of the roasting process can be observed in the Figure 2.

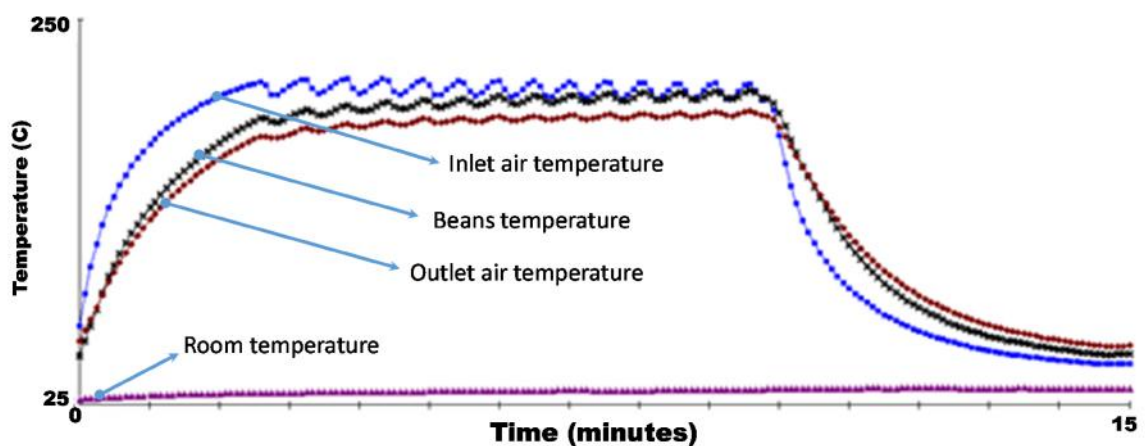


Figure 2 The typical temperature behavior during roasting process.

Antioxidant activity in the coffee beans was reported comes from the coffee constituent like caffeine, the phenolic compounds, chlorogenic acid, hydroxycinnamic acid and the compound resulted from Maillard reaction [7]. In this experiment, it was observed that the antioxidant activity was reduced with increasing temperature of roasting. It was resulted that light roasted coffee, medium roasted coffee and dark roasted coffee has antioxidant activity $\mu\text{g/g}$ BHA equivalent of 58793.333, 39468.000 and 24721.500 respectively (49.6; 44.0 and 37.1% respectively (Table 1). It is reported that roasting has remarkable affects the composition of coffee. The antioxidative capacity of coffee can be altered during roasting. This is associated with the degradation of chlorogenic acid [8], [9]. The roasting process causes changes the chemical composition of the coffee as well as its biological activity. Though some antioxidants can be formed during roasting process, but the natural antioxidant compound may be lost [10]. The degradation of antioxidant activity that was occurred in this worked could be caused by the degradation of the main natural antioxidant of the coffee.

Table 1 Antioxidant Activity of the Roasted Coffee Beans.

No.	Degree of Roasting	Antioxidant activity (%)	Equivalent of $\mu\text{g/g}$ BHA
1	Light roasting (205 °C),	49.6	58793.333
2	Medium roasting (220 °C)	44.0	39468.000
3	Dark roasting (240 °C).	37.1	24721.500

One of the advantages of this roaster is the heat transfer is occurred by convection that make the heating of the coffee beans can be performed evenly. This can be observed from the results of sensory evaluation that all the degree of roasting resulted roasted coffee beans with uniformity score of the beans was 10. The adjustment of the air flow is also an important facility of the roaster. By using the fluidized bed model, the air could be an agent for the cleanness of the beans. The unnecessary impurities were exhausted to the husk chamber. Using this system, this can also be observed that the three-degree process of roasting performed resulted roasted coffee beans with clean up score of 10 (Table 2).

Table 2 Cup Testing Results.

No.	Characteristic	Cup Testing Score		
		Light coffee (190-200 °C),	Medium coffee (200-210 °C)	Dark coffee (210-220 °C).
1	Fragrance/aroma	7.63	7.38	7.25
2	Flavor	7.5	7.38	7.00
3	Aftertaste	7.38	7.13	6.50
4	Acidity	7.38	6.00	6.00
5	Body	7.63	7.63	7.50
6	Uniformity	10.00	10.00	10.00
7	Balance	7.38	6.88	6.25
8	Clean up	10.00	10.00	10.00
9	Sweetness	10.00	0.00	0.00
10	Overall	7.38	6.88	6.25
11	Taint/defect	None	None	None
12	Final score	82.25	69.25	66.75
13	Comments	Lemony, Caramelly	Chocolaty, No Sweetness	Chocolaty, Rather burnt, No Sweetness

In the roasting process, controlling the roasting condition according to the formation of particular chemical can prepare a roasted coffee with preferable flavor [1]. In this report the sweetness of the roasted coffee beans, however, showed an extreme difference between light roasted coffee and the two others degree of

roasting. The light roasted beans had 10 score of sweetness, while the medium and dark roasted coffee beans had no sweetness at all (zero score). The post-harvest of the coffee beans was designed to developed sweetness and fruity flavor. However, in the high temperature roasting the sense of sweetness and fruity could be altered due to the heating process. Coffee aromatic compound are formed during the roasting process through some reaction such as Maillard reaction, degradation of sugar and breakdown of amino acid [11]. The certain temperature of roasting might degrade the sugar excessively make the sense of sweetness of the coffee beans was eliminated. However, the light roasting process produced roasted coffee beans with high sweetness sensory, lemony and caramels significantly. It is remarkable, the sensory evaluation of the light roasted coffee beans has obtained the excellent final score of 82.25 and it was categorized as specialty grade of coffee.

4 Conclusions

The fluidized bed coffee roaster has been developed and it was well performed during the examination. The antioxidant activity of the light roasted coffee bean was better than that of the two others. The roasting has resulted coffee beans with the best sensory evaluation score when it was performed at the light roasting condition.

Author contribution

All the authors have equal contribution as the main authors.

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