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REMOVAL OF ACRYLAMIDA AND CAFFEIN IN GAYO ARABICA COFFE BEANS BY VACUM ROASTING

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KEYWORDS
Acrylamide; caffeine; cancer; vacuum roasting

ABSTRACT
The conventional process of coffee roasting at high temperatures above 120ºC, in addition to having high caffeine levels and reducing nutrients from coffee, will also cause the formation of acrylamide compounds causing cancer in humans. The coffee used was gayo arabica coffee (Green Bean). This study aims to produce healthy, acrylamide-free and low-caffeine coffee using a vacuum roaster. The coffee was roasted using a vacuum oven at a pressure of 0.1 bar (0.102 kgf/cm2) and at a temperature of 120, 140, and 160ºC with time variations ranging from 30, 60 and 90 minutes to obtain acrylamide-free and lower caffeine coffee. Gayo arabica coffee had acrylamide content of 0.48 mg/kg and Ijen robusta coffee of 0.659 mg/kgwhile the caffeine was 1406.87 ppm for Gayo arabica coffee and 3184.80ppm for Ijen robusta coffee. The acrylamide test was carried out using the high-performance liquid chromatography (HPLC) method at a wavelength of 202 nm, while the caffeine test was carried out using the UV-Vis Spectrophotometry method at a wavelength of 275 nm. The resulted coffee is considered safe for consumption because does not contain acrylamide and has lower caffeine content.

INTRODUCTION
Coffee is a popular drink and is favored by most of the population in the world because it not only provides a distinctive aroma and taste but also provides many health benefits. However, the coffee roasting process at high temperatures above 150ºC, in addition to reducing nutrients, will also cause the formation of acrylamide compounds. Currently, acrylamide-free and low caffeine coffee is very difficult to find, so drinking coffee is strictly limited to 2 glasses per day (Naous et al., 2018). Acrylamide compound has genotoxic and carcinogenic properties which are harmful to health (Fadri et al., 2019).

Acrylamide compound in coffee is one of the toxic compounds in fried or baked foods such as potatoes, corn and coffee (Muchtaridi, 2018). This compound is harmful to the body because it is thought to be carcinogenic and mutagenic. The formation of acrylamide can occur at a temperature of 120ºC-170ºC (Rina, 2016).

Caffeine is a type of alkaloid found in coffee beans, tea leaves, and cocoa beans (Fajriana & Fajriati, 2018). Caffeine has clinically beneficial pharmacological effects, such as stimulating the central nervous system, relaxing smooth muscles, especially bronchial smooth muscles and stimulating heart muscles (Rina, 2016).

Caffeine in coffee can be as a free compound or in combination with chlorogenic as potassium caffeine chlorogenate (Fadri et al., 2019). According to SNI 01-7152-2006 on requirements for taste and use in food products, the maximum limit for caffeine in food and beverages is 150 mg/day or 50 mg/serving because too high caffeine content can negatively affect health (Swandi et al., 2020). Therefore, the caffeine content in coffee or caffeinated drinks is not allowed to exceed 50 mg (Nadia, 2010). Based on the importance of precise caffeine content in coffee, this study aimed to analyze the caffeine content of coffee beans roasted in a vacuum oven.

Coffee roasting is the process of forming taste and aroma, but roasting at temperatures above 120ºC can cause changes in the chemical composition of coffee beans such as carbohydrates and amino acids playing an important role in the Maillard reaction and the formation of coffee taste (Peterson, 2013). Carbohydrates and amino acids are the main chemical compounds in coffee as precursors of the Maillard reaction, namely the reaction between amino acids and carbonyl compounds to produce harmful substances such as acrylamide. Acrylamide is a dangerous compound with the potential to cause cancer in about 2% of cases each year in the world, even in a high court, a judge in the State of California decided that coffee companies or coffee shops must include a warning about the dangers of cancer in coffee (Amanu, 2015).

Coffee roasting at a temperature of 240oC (dark roasting) will form acrylamide as much as 7.04 g where the Food and Drug Administration (FDA) limits it should not be taken more than 16 g/day (Klaochanpong et al., 2015). Therefore, to get healthy coffee without acrylamide compound, coffee roasting is carried out using a vacuum roaster to lower the temperature and low pressure below atmospheric pressure. Roasting at low temperatures with vacuum pressure will produce the same nutrients from raw coffee beans so that the nutrients from coffee beans are not lost due to roasting at temperatures above 100ºC (Borbi, 2016). By lowering the pressure in the roasting tube, the temperature inside will also decrease (Umami, 2016). With the pressure created by the vacuum, the temperature will drop further so that roasting can be performed at low temperatures. This vacuum roasting machine works by sucking all the water content in fruits and vegetables using high speed so that the pores of the coffee beans do not close immediately. This high suction speed will make the water content in the coffee can be absorbed perfectly.

This study aims to determine the effect of time and temperature of vacuum roasting on acrylamide formation and caffeine reduction in coffee beans. Apart from comparing vacuum and conventional roasting on the acrylamide formation and caffeine reduction.

RESEARCH METHOD

The tool used in this research is a removal of acrylamida and caffein in gayo arabica coffe beans by vacum roasting

Coffee roasting

Green coffee beans were weighed in an aluminum plate of 440 grams each for roasting. The coffee beans were then placed in the oven for 30, 60, and 90 minutes at 120, 140, and 160ºC. The sample was then cooled and mashed. Then, the sample was extracted for acrylamide and caffeine testing, organoleptic testing, and moisture content observation using a moisture analyzer

Analysis method

Sample Preparation for Acrylamide Analysis with HPLC

20 grams of ground coffee beans were put in a 50.0 ml volumetric flask. Then, it was dissolved in 25 ml of dichloromethane and then homogenized for 30 minutes on a hot plate using a magnetic stirrer. The solution was filtered with Whatman 40 paper and the filtrate was added with 10 ml 1% H^3PO^4. Dichloromethane was evaporated on a hot plate at 70ºC. The remaining liquid was poured into a 10 ml flask then added 1% H3PO4 to the mark and filtered. 1.0 ml of the filtrate was taken and put in a 25.0 ml flask then added with 1% H3PO4 to the mark. Then, the sample was filtered with Whatman 40 paper. 20 µl of the sample was injected into the column and then the peak area was recorded and the concentration was calculated using the calibration curve equation. The above steps are repeated for each sample tested.

Preparation of Standard Solutions and Acrylamide Curves

100 mg of standard acrylamide was weighed and put into a 500 ml volumetric flask, the stock solution of acrylamide was dissolved with the mobile phase to the mark, standard solution of acrylamide with concentrations of 2,4,6,8 and 10 ppm was made by diluting the stock solution using mobile phase

20 µl of standard solution with concentrations of 2,4,6,8 and 10 ppm was injected into the HPLC system under selected conditions. After that, the peak area obtained was recorded and a curve for the ratio of the peak area to the concentration of the solution was made. The area of the selected curve was calculated to determine the equation of the linear regression line.

Preparation of Mobile Phase

The mobile phase was made using a mixture of phosphoric acid, acetonitrile, and double distilled water in a ratio (1:5:94) with a flow rate of 1.2 ml/minute.

Isolation of caffeine content in coffee

The coffee sample was weighed up to 20 grams. The sample was dissolved in 250 ml of hot distilled water. Hot coffee was filtered using a glass funnel into the Erlenmeyer, the filtrate was put into a separating funnel. After that, 2 grams of calcium carbonate ($CaCO_3$) was added and then extracted with the addition of 25 ml of chloroform, the bottom layer was taken, the extract (chloroform phase) was evaporated with a hot plate until the chloroform evaporated completely.

Preparation of 100 PPm Caffeine Raw Solution

0.01 gram of caffeine was weighed and put into a beaker glass and dissolved with sufficient distilled water. Then, it was put into a 100 ml volumetric flask and diluted with distilled water to the marking line, and then homogenized. 1 ml of the caffeine solution was put into a 10 ml volumetric flask then diluted with distilled water to the marking line then homogenized

Preparation of Caffeine Standard Solution

0.1; 0.3; 0.6; 0.9; 1.2 ml of standard solution of 100 ppm caffeine was diluted to 10 ml so that the concentration of standard solution obtained was: 1; 3; 6; 9; 12; mg/L. The standard caffeine solution was measured using a UV-Vis Spectrophotometer to obtain λ max

Caffeine Content Test

The caffeine extract from the solvent-free coffee sample was put into a 100 ml volumetric flask. Then 100 times dilution was carried out on a 10 ml volumetric flask using distilled water to the marking line, then homogenized. Then, the caffeine content was determined by UV-Vis spectrophotometry at a wavelength of 275 nm.

Taste, Aroma, and Color Test

Testing on the aroma, taste and color of the coffee produced was carried out by 20 panelists, by assessing the level of preference for the aroma, color, and taste of the coffee produced. The following is a numerical scale table that must be filled in by each panelist.

RESULTS AND DISCUSSION

Acrylamide in coffee using vacuum and conventional roasting methods

Acrylamide in coffee processed conventionally and sold in the market or coffee shops shows positive results as shown in Table 1.

Table 1. Acrylamide content in coffee using conventional methods

Sample	Area	Acrylamide concentration in sample solution (ppm)	Acrylamide concentration in coffee sample solution (mg/ kg)
Ijen Robusta	120577	0.527	0.659
Arabica Gayo	90793	0.383	0.48

Based on Table 1, the acrylamide content in the coffee samples processed conventionally showed positive acrylamide, where the acrylamide content in it was higher than the coffee samples processed in a vacuum. With such a large content, conventionally processed coffee should be wary of, because according to FAO and WHO, the tolerance limit for acrylamide is 0.3-0.8 g/kg BW/day. A study of experimental mice showed that this compound triggers cancer, damages DNA, and causes miscarriage (Anese et al., 2014). Meanwhile, the acrylamide content in coffee processed using the vacuum method can be seen in Table 2.

Table 2. Acrylamide content in coffee using vacuum methods

Sample Code	Area	Acrylamide concentration in sample solution (ppm)	Acrylamide concentration in coffee sample solution (mg/ kg)
T120, W30	0.000	0.000	0.000
T120, W60	0.000	0.000	0.000
T120, W90	0.000	0.000	0.000
T140, W30	0.000	0.000	0.000
T140, W60	0.000	0.000	0.000
T140, W90	0.000	0.000	0.000
T160, W30	0.000	0.000	0.000
T160, W60	0.000	0.000	0.000
T160, W90	0.000	0.000	0.000

Based on Table 2, the acrylamide content in vacuum-processed coffee has absolutely no acrylamide content, because vacuum roasting at low pressure can reduce or eliminate acrylamide content and produce the same nutrients as raw coffee beans so it does not remove nutrients from coffee beans. This is in line with a study by Joko, Lumbanbatu and Sri (2018) that coffee roasting with low pressure at a temperature of 200ºC resulted a coffee with 50% lower acrylamide content.

Caffeine content

Based on the results, there was an influence of roasting time and temperature on caffeine content in coffee beans where the longer the roasting time, the higher the caffeine content formed, and the higher the roasting temperature, the higher the caffeine content formed, and vice versa as in Figure 1.

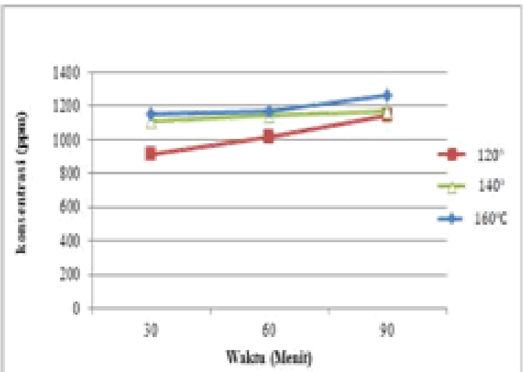

Figure 1. The influence of roasting time on caffeine content at a temperature variation of 120-160 ^{O}C

Moisture content

Based on moisture content analysis, the interaction between temperature and roasting time on the moisture content of coffee beans was significant. The average moisture content at 120ºC for 30 minutes was 8.72%, for 60 minutes was 7.32%, for 90 minutes was 6.11%. Furthermore, moisture content at a temperature of 1400 C for 30 minutes was 4.18%, for 60 minutes was 3.91%, for 90 minutes was 3.48%. Meanwhile, at 1600 C for 30 minutes it was 4.03%, for 60 minutes it was 3.54%, and for 90 minutes it was 3.16%.

The moisture content of coffee beans after roasting tends to decrease with increasing temperature and roasting time. This is in line with a study by (Dermawati, Rizka Aji, 2020) that the greater the temperature difference between the heating medium and the food, the faster the heat transfers to the food and the faster the evaporation of water from the food. From the data above, it can also be seen that only a few samples met SNI 01-2907-2008 for moisture content.

One of them is the sample at a temperature of 140 and 1600 C with a time of 60 and 90 minutes. While the other samples did not meet the applicable SNI standards. This is because the vacuum oven used only produces a pressure of 0.1bar and is also influenced by the age factor.

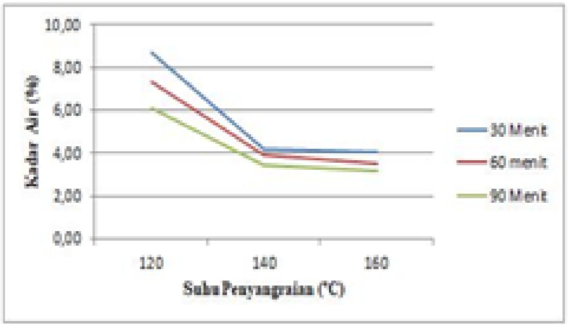

Figure 2. Changes in water content of coffee beans based on temperature

Organoleptic test (taste, aroma and color)

Organoleptic test was carried out on 20 panelists to determine preference of the resulting product and get a comparison of the taste and aroma of coffee from vacuum and conventional roasting. The results of the organoleptic test on 20 panelists are as follows:

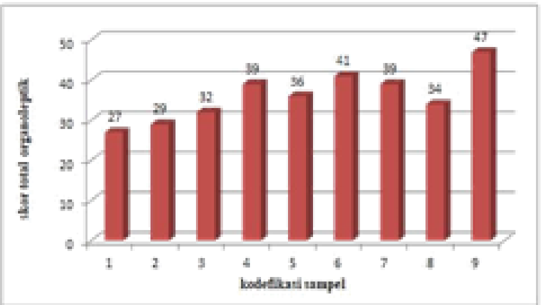

Figure 3. Taste preference diagram of resulted coffee

Figure 3 shows the taste preference of coffee roasted at low pressure with temperatures of 120, 140, and 160ºC varied with times ranging from 30, 60, and 90 minutes. Coffee roasting at a temperature of 160ºC for 90 minutes had the best value of 47 based on preferences carried out on 20 panelists Aroma preference test can be seen in figure 4.

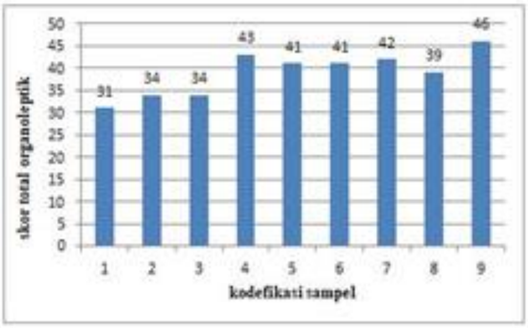

Figure 4. Aroma preference diagram of resulted coffee

Based on Figure 4, coffee roasted at a temperature of 160ºC for 90 minutes had the best value of 47 as the highest value for coffee aroma testing. Color preference test can be seen in figure 5

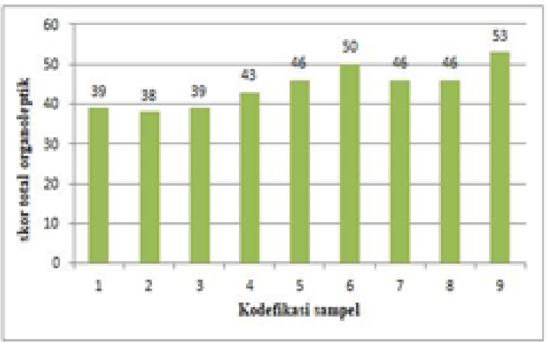

Figure 5. Color preference diagram of resulted coffee

Based on Figure 5, coffee roasted at a temperature of 160ºC for 90 minutes had the best value of 53. Thus, it can be concluded that sample no 9 (160ºC for 90 minutes) was the best. This is because the aroma and coffee taste produced resemble the aroma of beans with a fairly good taste and have an attractive color from other coffee samples. In addition, another factor influencing sample no. 9 to be the best was due to organoleptic testing carried out on semi-expert panelists to determine the quality of coffee processed in a vacuum.

CONCLUSION

From the results of the study it can be concluded as follows: (1) based on the results, it can be concluded that vacuum roasting at temperatures of 120,140 and 160ºC for 30, 60, and 90 minutes did not form acrylamide, reduced water content, and slightly affected the sensory impact on coffee, (2) through conventional roasting, the acrylamide content of gayo arabica coffee was 0.48 mg/kg and ijen robusta was 0.659 mg/kg. While through vacuum roasting at low pressure and temperature 120,140 and 160ºC for 30, 60, and 90 minutes, no acrylamide content was found during the roasting process, (3) the coffee roasting process using the vacuum method can overcome the formation of acrylamide in coffee beans that are harmful to health, and (4) the higher the temperature and the longer the roasting time, the higher the caffeine content in coffee. On the other hand, the lower the temperature, the shorter the roasting time, the lower the caffeine content in coffee. Roasting at a temperature of 120ºC for 30 minutes had a caffeine content of 910.96 ppm, while roasting at a temperature of 160ºC for 30 minutes had a caffeine content of 1155.23 ppm.

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