EFFECTS OF DIFFERENT ROASTING PARAMETERS ON SELECTED PHYSICOCHEMICAL PROPERTIES AND SENSORY EVALUATION OF COFFEE BEANS

Nur Fatin Najihah Md Sobri[1], Nur Fazliana Mohd Nazri[1], Nurpatin Syuhada Sumani[1], Nurul Adlin Azaman Shah[1], Naemaa Mohamad[1,2], Nadya Hajar[1,2]

[1]*Department of Food Technology, Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Negeri Sembilan, Kampus Kuala Pilah, 72000 Kuala Pilah, Negeri Sembilan, Malaysia*

[2]*Alliance of Research and Innovation for Food (ARiF), Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Kuala Pilah, 72000 Kuala Pilah, Negeri Sembilan, Malaysia*

Email: naemaa953@uitm.edu.my

Abstract

Arabica coffee beans from the same origin were roasted at three different roasting parameters namely minimum roasting (180°C), medium roasting (220°C) and maximum roasting (260°C) each for 20 minutes in order to investigate the changes in the physical, chemical and sensorial evaluation. During the roasting process, the coffee beans becomes more brittle due to the chemical, physical and structural modifications. There are limited studies reported for coffee beans that have been roasted with different roasting parameters in term of selected physicochemical properties and sensory evaluation. The roasted coffee beans oil was extracted by using Soxhlet Extraction method for 8 hours. The objective of this study was to determine the effects of different roasting parameters on selected physicochemical properties and sensory evaluation of coffee beans in the term of: moisture content (%), oil extraction (%), peroxide value (mEq/kg), acid value (mg KOH/g), furan (absorbance) and sensory evaluation. The furan (abs) content was recorded as 0.24 ± 0.04 (minimum roasting), 0.69 ± 0.03 (medium roasting) and 0.91 ± 0.01 (maximum roasting). In terms of sensory evaluation, most participants preferred coffee drink made from medium roasted coffee beans for aroma, colour, sweetness, flavour and overall criteria. Meanwhile, for the acidity and bitterness criteria, the participants preferred coffee drink made from maximum roasted coffee beans. As a conclusion, roasting temperature is the main factor that influences the physicochemical properties and sensory evaluation of coffee beans.

Keywords: Coffee beans, roasting, physicochemical, sensory evaluation, furan

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Introduction

Coffee is one of the most consumed beverages in the world and is the second largest traded commodity after petroleum. There are two variants of coffee namely Robusta coffee (*Coffea canephora*) and Arabica coffee (*Coffea Arabica*). Arabica coffee (*Coffea arabica*) developed in the highlands in the south-east of Ethiopia. Coffee beans were abundantly present in Malaysia because Malaysians love and addicted to it. Malaysia only contributes 0.16% of the worlds' coffee production which ranked 60th worldwide (Nor Amna A'liah Mohammad Nor & Mohd Amirul Mukimin Abd Wahab, 2016). In Malaysia, there are several types of coffees that suitable to develop because of certain factors that influence the production of coffee beans. For example, the type of soil used, the low cost of expenses of labour and high demand. In this region, there are a number of variants, some of which have been considered to be subspecies. Before roasting, coffee is traded as dried seed, known as green coffee. Metabolites accumulating in green coffee beans, act as precursors for the compounds responsible for flavour and aroma after roasting. The chemical composition of green coffee beans is not only dependent upon cultivar, but is also affected by the terroir, harvesting methods (e.g. handpicked or mechanical), seed processing (e.g. wet, dry, or semi-dry) and storage (Casas et al., 2017). The research was done because there are limited studies reported for coffee beans that have been roasted with different roasting parameters in term of selected physicochemical properties and sensory evaluation.

Roasting is an important processing step to develop the unique chemical, physical and sensorial characteristics of roasted coffees (Wang & Lim, 2015). During the roasting process, the coffee bean is subjected to high temperatures, resulting in physical-chemical changes in its structure. The controll sample of this research was roasted coffee beans with different roasting parameters. Initially, when the coffee bean reaches temperatures above 180°C the coffee bean begins to form the compounds responsible for the colour, flavour, and aroma of roasted coffee beans (Ebrahimi-Najafabadi et al., 2012). Different roasting parameters give a different result based on physical-chemical and sensory evaluation properties of sample roasted. In general, the colour of roasted coffee beans ranges from light-dark brown to black depending on the roasting temperature. Increasing in roasting parameters will affect moisture content, fat, peroxide value, acid value, furan and sensory.

This study was aimed to identify the roasting parameters that can be controlled in order to produce high quality of coffee beans. Since roasting process greatly affects other samples such as rambutan seeds (Chai et al., 2019), cocoa seeds (Frauendorfer & Schieberle, 2008), peanut (Idrus et al., 2017), it is expected a similar result on coffee beans. It is also very crucial to determine the acceptability of coffee beans after roasting process. Therefore, the objective of this study was to determine the effects of different roasting parameters on selected physicochemical properties and sensory evaluation of coffee beans.

Methods

Coffee seed samples

Green Arabica Coffee was purchased from the farmers from the AAA Entrepreneur, Kuala Terengganu green coffee supplier and stored in dark at room temperature before processed. The defective beans were sorted out and separated due to its damage (discolouration, insect damage and defect texture of the shells).

Chemicals

Sodium hydroxide, 1% phenolphthalein, 1% starch, the solvent mixture (glacial acetic acid and chloroform (2:1)), 5% potassium iodide solution, sodium thiosulfate and potassium iodide powder), methanol, and petroleum ether.

Selection of roasting parameters

Three roasting parameters were selected as 180℃ (minimum), 220℃ (medium) and 260℃ (maximum) for 20 minutes for each roasting temperature (Dong et al., 2017). The roasting parameters were selected due to the studies done by (Dong et al., 2017; Cho et al., 2017) to obtain the desirable physicochemical properties and acceptable sensory evaluation of coffee beans and at the same time parallel with roasting parameters used in industry for coffee beans. Once the roasted coffee beans have reached the room temperature, they were stored at -5℃ in the airtight container for further analysis. The weight of the coffee beans before and after roasting was recorded to measure the weight loss.

Sample preparation

Green coffee beans (100g) were roasted by using the baking oven for 20 minutes for each roasting parameters (Zanin et al., 2016). The oven was preheated for an hour to ensure the temperature in the oven is uniform. Before roasting, the green coffee beans were placed on the tray (width 57cm × height 35cm) and the trays were wrapped with aluminium foil to ensure the heat will uniformly roast the coffee beans.

The weight loss was then expressed as the percentage of coffee bean weight. After the roasting process, the roasted coffee beans were rapidly cooled at room temperature before grinding. All the roasted coffee beans were ground using the waring commercial blender (U.S.A) until the samples were completely turned into a ground powdered form. The samples were stored in the airtight container (Yang et al., 2016) and stored at - 5℃ before further analysis. All the analyses used the ground coffee beans except for the texture.

Physicochemical properties

Moisture content

The samples of roasted coffee beans were finely ground and then analyzed using a moisture analyzer (PMB 53; ADAM). Approximately 1g of the roasted coffee powder was weighed accurately onto a loading tray and the instrument calculated the moisture content of the ground coffee automatically. The moisture was determined in triplicate and the moisture contents were expressed as percentages (%) (Cho et al., 2017).

Fat

The oil from the coffee beans was extracted using Soxhlet extraction method (Romano et al., 2014). The roasted coffee powder was weighed accurately (20g) into an extraction thimble. The opening of the thimble was loosely plugged with cotton and the thimble was placed into the Soxhlet extractor. The dried round bottom flask was weighed accurately and 150ml of petroleum ether was measured into round bottom flask. The apparatus was connected to the condenser. The tap water was connected and the extraction was carried out for 8 hours on the electrothermal extraction unit. The heating mantle was set at 50°C. The flask containing the petroleum ether extract was removed after the extraction period was completed. Then, the petroleum ether extract was evaporated on the boiling water bath. The flask was transferred into an oven at 105°C for one hour to dry the extract. The flask was then transferred immediately into a desiccator to cool and weighed. Three replicate extractions were performed for the three roasting parameters sample.

$$\%\ \text{Fat in sample} = \frac{\text{weight of fat in sample (g)}}{\text{weight of sample taken (g)}} \times 100$$

The weight of fat in sample = (weight of flask + fat) – weight of flask

Peroxide value

Extract oil (1g) from the roasted coffee powder was placed in the test tube. Then, 1 g of potassium iodide powder and also 20 mL of solvent mixture (glacial acetic acid: chloroform in 2:1, (v/v)) were added in the test tube. After that, the test tube was placed in the boiling water (H_2O) and the mixture was boiled for 30 seconds. Then, the content in the test tube was immediately poured into a conical flask that contained 20 mL of 5% potassium iodide solution to avoid evaporation occur and the test tube was rinsed with 25 mL of distilled water. The solution was titrated (Cesa et al., 2012) with 0.002M sodium thiosulphate solution (in the burette) using 1% starch solution as indicator until the clear solution is achieved. Thus, the volume of the sodium thiosulphate used for titration was recorded and the blank was determined (Cesa et al., 2012).

The calculation was as follows:

$$\text{Peroxide value (mEq/kg)} = \frac{V_s - V_b}{\text{weight of sample}} \times T \times 10^3$$

Where;

T = Molarity of sodium thiosulphate
V_s = Volume in ml titration for sample
V_b = Volume of ml titration for blank.

Acid value

The acid value (AV) was defined as the weight (mg) of potassium hydroxide that required to neutralize the fatty acid in oil (Al-Hamamre et al., 2012). The AV was observed by mixing the same volume of 25ml of diethyl ether and 25ml of alcohol with 2 or 3 drops of phenolphthalein indicator solution in a conical flask. Then, the solution was neutralized with 0.1M NaOH. The oil sample (1g) was dissolved in the mixture of neutral solvent and titrated with 0.1M NaOH with constant shaking until a pink colour persists for 15 seconds is obtained (Afolayan et al., 2014). The calculation was followed as:

$$\text{Acid value (mg KOH/ g)} = \frac{\text{titre (ml)} \times 5.61}{\text{weight of sample}}$$

Furan

A mixture of methanol and water was used to extract furan compounds from oil samples. Up into 70% MeOH was used as the extraction solvent. A 0.5g portion of oil sample was transferred to a test tube for analysis. It was extracted with 1 ml of 70%, MeOH in a vortex mixer for 1 min. The mixture was centrifuged at 1000g for 5 min using benchtop centrifuge (Kubota corporation 29-9 Hongo 3-Chome, Bunkyo-ku, Tokyo 113-0033). After centrifuged, the upper phase was separated from the oil and the extraction was repeated three times under the same conditions. The combined upper phases were diluted to 5ml by 70% methanol and filtered through 0.45µm nylon acrodisc syringe filters (Waters Corporation, Mil-ford, MA, USA). Coffee roasted under different conditions were determined and the analysis was performed for three times with different roasting temperature. UV-Vis spectra of 70% methanol extracts of oils were recorded in a wavelength range of 250–500 nm using a double-beam spectrophotometer. UV-Vis spectra of roasted ground coffee oil extracts were recorded in order to monitor the formation of furan compounds as a result of roasting (Durmaz & Gökmen, 2010).

Sensory evaluation

Brewing

Hot water (100℃) was poured over the ground coffee powder (200g) and sugar (200g) was added into the jug to make the coffee drink. Each jug was labelled with sample number and (5 ml) of coffee drink was poured into the plastic cup and cooled to 60℃ (Giacalone et al., 2019).

Consumer test

Thirty participants (n=30) were selected from UiTM Cawangan Negeri Sembilan students (Kuala Pilah Campus). The basic requirement needed to participate in the test was the participant must be a coffee drinker. There was no specific training for participants was conducted since the objective of the sensory evaluation was to determine participants preferences in term of sensory attributes of coffee prepared from minimum, medium and maximum roasted coffee beans. The sensory evaluation tool used was a 9-point Hedonic scale. The participants were served with three cups of coffee drinks from three different roasting parameters and one cup of plain water. Test were conducted in a sensory analysis laboratory, in individual booths, under white light. Sensory evaluation was carried out based on the sensory evaluation by participants using a hedonic questionnaire and its contain 9 scale which is extremely hate referred as scale number 1, fairly like referred as scale number 5 and extremely likes referred as scale number 9. Before they answered the hedonic survey, they need to read and understand the instruction given to them. The participants need to drink the coffee and evaluate the coffee drinks, accordingly to each of the attribute. Seven tested criteria namely as aroma, colour, sweetness, acidity, bitterness, flavour and overall were written on the hedonic scoreboard. At the end of the test, participates were asked to fill and complete the questionnaire given based on their preference to each of the attributes on the sample (Giacalone et al., 2019).

Statistical analysis

In order to investigate the effect of different roasting parameters on selected physicochemical properties and sensory evaluation of coffee beans, all the measurements were performed in triplicates. Data were presented as means ± standard deviation. Analysis of variance was evaluated using one-way ANOVA and Welch, SPSS version 15.0. The differences were considered statistically significant at $p < 0.05$.

Result and discussion

Table 1, 2 and 3 are the result summary of roasting characteristics of green Arabica Coffee. In this study, the green Arabica Coffee beans were roasted for three different roasting parameters namely 180℃ (minimum), 220℃ (medium) and 260℃ (maximum) for 20minutes.

Table 1: Selected physicochemical properties of roasted coffee powder

Treatment	Moisture content (%)	Fat (%)	Peroxide value (mEq/kg)	Acid value (mg KOH/g)	Furan (abs)
Minimum	6.86 ± 0.09^{a}	9.47 ± 1.23^{b}	25.01 ± 0.24^{c}	32.10 ± 0.51^{c}	0.24 ± 0.04^{c}
Medium	7.10 ± 0.38^{a}	13.75 ± 0.83^{a}	29.21 ± 0.68^{b}	40.28 ± 0.15^{b}	0.69 ± 0.03^{b}
Maximum	10.31 ± 3.57^{a}	15.23 ± 1.11^{a}	42.34 ± 0.29^{a}	52.41 ± 0.48^{a}	0.91 ± 0.01^{a}

Data are mean±SD, n=3

Means with different letter are significantly different at a $p<0.05$ level

Table 2: Sensory attributes of coffee drinks made from roasted coffee powder

Treatment	Aroma	Colour	Sweetness	Acidity	Bitterness	Flavour	Overall
Minimum	3.07 ± 1.68^{c}	2.53 ± 1.33^{c}	4.03 ± 2.34^{b}	3.83 ± 1.80^{b}	3.33 ± 1.81^{b}	3.40 ± 2.14^{c}	3.70 ± 2.00^{c}
Medium	7.10 ± 1.54^{a}	6.40 ± 1.45^{b}	5.43 ± 1.50^{a}	5.20 ± 1.69^{a}	5.87 ± 1.70^{a}	6.30 ± 1.74^{a}	6.77 ± 1.52^{a}
Maximum	4.93 ± 1.44^{b}	7.47 ± 1.33^{a}	3.53 ± 1.96^{b}	5.00 ± 1.72^{a}	6.00 ± 2.45^{a}	4.70 ± 1.97^{b}	5.17 ± 1.90^{b}

Data are mean±SD, n=3

Means with different letter are significantly different at a $p<0.05$ level

Moisture content

During the roasting process, the moisture in the green coffee beans was evaporated with the increased of roasting temperatures (Santos et al., 2016). Based on the result in Table 1, increase in the roasting temperature, moisture content of the roasted coffee beans was increased. During roasting, the free water at the surface of the bean must be evaporated away by the heat. According to Santos et al., (2016), the higher the temperature of roasting, the removal of moisture content would be increased.

Fat

Roasting could affect the oil yield by increasing the roasting temperature. The higher the roasting parameters, the higher the oil yield would be obtained. During roasting, more oil cells in coffee beans will break down and reduce oil viscosity as the temperature increase makes the oil flow more easily. The trend of the result showed that medium roasting temperature was significantly ($p < 0.05$) increased the oil yield than the minimum roasting temperature. It means more oil yield was produced if medium roasting temperature is used. It indicated the increased in the breakdown of oil cells and reduction of oil viscosity in coffee beans compared to minimum and medium roasting temperature.

Peroxide value

Chemical compositions are the factor that depends on oil quality, such as the percentage of unsaturated fatty acid in the oil, high in fatty acids and longer contact time with oxygen can cause the coffee to deteriorate and produce rancid flavours' once brewed. The peroxide value (PV) depends on temperature, time and light. It is used to measure the extent of primary oxidation of oil. The rancidity of the oil would increase as the PV increase. Oils with a higher degree of unsaturation are highly susceptible to oxidation as compared to saturated oil. This may lead to the production of unwanted odours and flavours (Kaleem et al., 2015). Maximum roasting temperature significantly ($p < 0.05$) increased the PV in coffee. The highest PV in coffee that have been roasted with maximum parameter could be explained by the fact that peroxide is unstable compounds towards high temperature. Oxidation of lipids is another common and often undesirable chemical change that may influence flavour, aroma, nutritional quality and in some cases even the fineness of the product. Darkening of the oil colour, formation of foam on the oil surface and increases the viscosity of the oil are among the effects of oxidation. Oxidation can be inhibited methods such as vacuum packaging, modified atmosphere packaging and refrigeration/freezing were implemented (Kaleem et al., 2015).

Acid value

To indicate the quality, age, eligibility and suitability of oil for use in industries, the acid value is one of the important index of the physicochemical properties of oil. Acid value also is used to measure the extent to which glycerides in the oil has been decomposed by lipase and other physical factors such as light and heat. To indicates the previous lipase activity, other hydrolytic action or oxidation, it can be detected by the presence of the free fatty acids (FFA) in an oil or fats (Afolayan et al., 2014). By increasing the roasting temperature, the acid value increased significantly $(p < 0.05)$. The acid value of the coffee from maximum roasting temperature was higher compared to the coffee from minimum and medium roasting temperature. The higher the FFA content in the oils would increase their susceptibility to oxidation, reduce the oil stability and accelerate ageing and degradation (Al-Hamamre et al., 2012).

Furan

Furan is present in a coffee as a part of volatile aroma compounds generated during roasting of green coffee beans. The analysis was conducted to differentiate furan presence between different roasting temperature. The darker roasted coffees with long roasting temperature were tended to have higher furan levels than lighter roasted coffees (European Food Safety Authority [EFSA], 2011). From the result, the trend showed that coffee from maximum roasting temperature produced more furan compound compared to coffee from minimum and medium roasting temperature. This is because the higher roasting temperature would speed up Maillard reaction and sugar dehydration during heating which formed of sulphur-containing volatile compounds and involve with the main amino acids, cysteine and methionine (Liu et al., 2019).

Sensory evaluation

The aim of the sensory evaluation was to determine which coffee drink from different roasting parameters would be chosen by participants. The hedonic test with seven attributes namely aroma, colour, sweetness, acidity, bitterness, flavour and overall acceptance were used to evaluate the preferences among the participants. The maximum roasting temperature produced the strongest aroma of roasted coffee drinks. Most participants highly preferred the coffee drink from medium roasted temperature for the aroma, sweetness, acidity and flavour while for the colour and bitterness they preferred coffee drink from maximum roasting temperature. When the coffee beans undergo a roasting process (high temperature), it will produce strong aroma because the volatile compound will be released and the colour becoming darker. The peroxide value is correlated with the acidity. The higher the roasting temperature, the bitterness and flavour of the coffee drinks would be increased. As the overall acceptance, most of the participants preferred coffee drink made from medium roasting parameters. As previously reported by Cristovam et al., (2000) participants choose selection might be contributed by several factors including gender and more recently, physiological differences in terms of taste sensitivity (Hayes et al., 2011).

Conclusion

This study showed that the roasting process is the main factors that influence the physicochemical properties and sensory evaluation of coffee beans. The higher the roasting temperature, fat, peroxide value, acid value and furan would increase. Overall for physicochemical properties, the minimum roasted coffee beans are the highest quality of coffee beans in terms of low in moisture, peroxide value, acid value and furan. Meanwhile, for sensory evaluation the medium roasted coffee beans was the most preferred coffee drink by participants. The objective of this study was achieved.

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