

Physical Characteristics of Analog Coffee from Kepok Banana Skin (*Musa paradisiaca*) Fermented with *Lactobacillus plantarum*

Anggun Desiana Sofa, Fafa Nurdyansyah, Umar Hafidz Asy'ari Hasbullah

Food Technology Department, Universitas PGRI Semarang, JL. Sidodadi Timur No. 24 Semarang, Jawa Tengah, Indonesia 50232

umarhafidzah@gmail.com

Abstract. Kepok banana peel can be used as analog coffee. The use of *Lactobacillus plantarum* is expected to be able to increase flavor during roasting. This study aims to study the effect of fermentation with *L. plantarum* and roasting time on physical characteristics and analog coffee preferences. This research uses factorial design with the first factor, fermentation, and non-fermentation, while the second factor is the roasting time of 10, 20, and 30 minutes. Kepok banana skin-fermented with *L. plantarum* for 4 days at 37°C. Drying banana peels done at a temperature of $\pm 50^{\circ}\text{C}$ for 24 hours. The roasting is done in 10, 20, and 30 minutes. Then milling and sifting are carried out. The results showed that the longer the roasting would decrease the L^* value. Fermentation treatment will reduce the value of L^* . The fermentation treatment will increase the panelists' liking for color and appearance.

Keywords: analog coffee, kepok banana peel, *L. plantarum*, fermentation

1. Introduction

Kepok banana peel is proven to be processed into analog coffee [1]. But the analog coffee produced still has a less strong flavor. So those efforts are needed to improve the flavor and aroma during roasting. One effort that can be done by increasing the flavor precursor through fermentation. The use of *L. plantarum* for fermentation has been proven to produce various precursors or flavors [2,3].

The flavor precursor will be used in the flavor formation reaction during roasting [4]. The taste and aroma produced will determine the acceptance of analog coffee by consumers [5]. During roasting there will also be changes in physical characteristics of the product [6,7]. The roasting time can determine the reaction that results in flavor [8].

Research on analog coffee made from fermentation with *L. plantarum* has never been found. So this study aims to investigate the physical characteristics and consumer preferences for analog coffee produced from fermentation with *L. plantarum* and roasted at different times.

2. Methods

2.1. Materials and Tools

Kepok banana peel was selected from ripe banana with full yellow skin color, *Lactobacillus plantarum* FNCC 0127 was obtained from FNCC Gadjah Mada University. Equipment used includes electric stoves, roasters, analytical scales (Shimadzu ATX224), incubators (Mettler IN 55), cabinet dryers, chromameters (Konika Minolta).

2.2. Experimental design

This research uses factorial design with the first factor is fermentation and the second factor is roasting time. The first factor consists of fermentation and non-fermentation. The second factor consists of a roasting time of 10 minutes, 20 minutes and 30 minutes. Each treatment was repeated three times.

2.3. Research stage

a) Fermented banana peel with *L. plantarum*

A total of 100 grams of banana peel were inoculated with 10 ml of *L. plantarum* starter culture. Fermentation was carried out for 96 hours under anaerobic conditions at 37 °C.

b) Drying fermented banana peels

Fermented and non-fermented samples are dried in a cabinet dryer at 50°C for 24 hours.

c) Roasting

The samples were roasted according to the roasting time treatment (10, 20, and 30 minutes). Furthermore, the size is reduced and sieved 40 mesh. Then it is stored in the aluminum foil bag until it is analyzed.

d) Physical analysis

The color analysis uses Chromameter to determine the value of L*. Analysis of yield and density of cages with gravimetry.

e) Analysis of preferences

The hedonic test was carried out by 20 panelists. The parameters tested consisted of color, aroma, and appearance of coffee grounds.

f) Data analysis

Data were analyzed with ANOVA on roasting time treatment and t-test on fermentation and non-fermentation treatment. Data analysis using SPSS 21.0 software.

3. Results and discussion

3.1. Physical characteristics

a) Color

Color is an attribute that determines consumer acceptance. The color in coffee is formed due to several chemical reactions that occur during roasting. These reactions include caramelization, Maillard reactions, and pyrolysis. This reaction occurs in precursors present in materials and high-temperature conditions above 100°C. During the roasting of the banana peel, the color changes as indicated by the L* value which can be seen in Table 1.

Table 1. Analog Coffee Color (L*)

	Roasting Time		
	10 minutes	20 minutes	30 minutes
Non-Fermentation	45.89±0.60 ^{eA}	29.99±0.86 ^{cA}	28.61±0.99 ^{cA}
Fermentation	32.01±1.52 ^{dB}	25.03±0.37 ^{bB}	18.36±0.97 ^{aB}

The same lowercase superscript in the same line shows no significant difference (P <0.05) which was tested using One Way Anova. The same superscript capital letters in the same column show no significant difference (P <0.05) which was tested using the Independent-Samples T-Test.

The fermentation treatment causes the powder color to darken, which is indicated by a significantly different L* value. During fermentation with *L. plantarum* there will be degradation of various macromolecular compounds into micromolecules including the production of flavor precursors [9]. During roasting various flavor precursor compounds will turn into compounds that cause the aroma, flavor, and color to change [10]. The longer roasting causes the analog color of the coffee to be darker and significantly different. The temperature of the roasting will increase along with the longer roasting process.

The formation of dark colors during roasting occurs because of the caramelization reaction. The sugar content in banana peels will experience caramelization at high temperatures. This reaction is

accelerated in the presence of acid produced during fermentation [11]. Besides, Maillard's reaction also occurred during the roasting. This reaction occurs in reducing sugars and amino acids at high temperatures resulting in a dark color in the product [12]. Pyrolysis occurs at very high temperatures during roasting. During the pyrolysis reaction, carbon dioxide is produced and the formation of dark colors [5].

b) Yield

Analog coffee yield is closely related to the number of solids in a banana peel. The effect of fermentation and roasting time on analog coffee yield can be seen in Table 2. The fermentation treatment did not cause a statistically significant difference in the yield. Nevertheless, fermentation treatment on banana peels tends to reduce the yield value. This is possible because during fermentation macromolecular degradation becomes micromolecules that are easily lost during roasting. The roasting time does not have a statistically significant effect on the yield. During the roasting a component of water will be evaporated, volatile compounds, released by gases such as carbon dioxide which cause weight loss [5]. This will affect the yield of the product. Reduced yield after roasting also occurs in raw and ripe banana peel coffee [1].

Table 2. Analog Coffee Yield

	Roasting Time		
	10 minutes	20 minutes	30 minutes
Non-Fermentation	7,63%±0,52 ^{aA}	8,78%±2,65 ^{aA}	10,37%±2,71 ^{aA}
Fermentation	4,37%±3,47 ^{aA}	3,85%±1,90 ^{aA}	5,87%±2,77 ^{aA}

The same lowercase superscript in the same line shows no significant difference ($P < 0.05$) which was tested using One Way Anova. The same superscript capital letters in the same column show no significant difference ($P < 0.05$) which was tested using the Independent-Samples T-Test.

c) Bulk Density

Bulk density is closely related to the packaging process of the product. The bulk density value of analog fermented coffee can be seen in Table 3. The fermentation treatment tends to increase bulk density significantly different. The longer roasting tends to reduce bulk density. Bulk density results of this study are still lower than ripe and raw banana peel coffee research results [1].

Table 3. Analog Coffee Bulk Density

	Roasting Time		
	10 minutes	20 minutes	30 minutes
Non-Fermentation	0,37±0,025 ^{cdA}	0,33±0,022 ^{ba}	0,30±0,022 ^{aa}
Fermentation	0,36±0,022 ^{bcA}	0,39±0,023 ^{db}	0,36±0,020 ^{cb}

The same lowercase superscript in the same line shows no significant difference ($P < 0.05$) which was tested using One Way Anova. The same superscript capital letters in the same column show no significant difference ($P < 0.05$) which was tested using the Independent-Samples T-Test.

3.2. Hedonic characteristics

The panelists' liking score on the color, aroma, and appearance of coffee powder can be seen in Table 4. The fermentation treatment on banana peels caused an increase in the liking score on the color of analog coffee powder significantly different. The longer roasting process causes an increase in the panelists' liking score for the color of analog coffee grounds. This is closely related to the darker color of coffee causing the panelists' liking for coffee powder color which is increasing. Panelists have the perception that coffee is identical to a dark color.

Table 4. Analog Coffee Powder Liking Score

Treatment	Color	Aroma	Appearance
Non-Fermentation 10 minutes	2,55 ± 1,32 ^a	4,1 ± 1,48 ^a	3,1 ± 1,62 ^a
Non-Fermentation 20 minutes	4,75 ± 1,45 ^b	4,45 ± 1,61 ^a	4,7 ± 1,38 ^b
Non-Fermentation 30 minutes	5,05 ± 1,32 ^b	4,75 ± 1,21 ^a	5,3 ± 1,03 ^{bc}
Fermentation 10 minutes	5 ± 1,17 ^b	3,9 ± 1,71 ^a	4,75 ± 1,21 ^b
Fermentation 20 minutes	5,5 ± 0,95 ^{bc}	4,55 ± 1,79 ^a	5,35 ± 1,23 ^{bc}
Fermentation 30 minutes	6,1 ± 0,72 ^c	4,75 ± 1,62 ^a	5,95 ± 0,60 ^c

The same superscript in the same column shows no significant difference ($P < 0.05$) which was tested using One Way Anova.

The fermentation treatment tends not to cause a change in the panelists' liking score for the aroma of coffee grounds. However, roasting time tends to increase the panelists' liking score for the aroma of imitation coffee powder, although it is not significantly different. The longer roasting the chemical reactions that cause the formation of the aroma of analog coffee is increasing. The Maillard reaction, caramelization, and pyrolysis are intensified when the roasting takes longer and the temperature increases [5].

The fermentation treatment caused an increase in the panelist liking score for the appearance of coffee powder that was significantly different. The longer roasting causes an increase in liking scores for the appearance of analog coffee grounds. Panelists tend to like the appearance of analog coffee which is increasingly brewed. This is in line with the bulk density that always decreases with increasing roasting.

4. Conclusion

Fermentation of banana peels with *L. plantarum* causes the color of coffee to darken as indicated by the L^* value which decreases and the panelists' liking for color and appearance is increasing. Prolonged roasting causes the powder to darken, panelists' liking for color, aroma, and appearance are increasing.

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