Effects of Kaempferia galanga L. essential oil incorporation on sensory and physical properties of dark chocolate bar

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Abstract. Chocolate is the world’s most popular confectionery product of processed cocoa. The antioxidant content of cocoa flavanols in dark chocolate is higher than other types of chocolate. Widely cultivated in Indonesia, kencur (Kaempferia galanga L.) rhizome has many health benefits, including antitussive, expectorant, antioxidant, and hypcholesterolemic. The aims of this research were to evaluate the effects of variation concentration of kencur (Kaempferia galanga L.) rhizomes essential oil incorporation on sensory and physical properties of dark chocolate bar. Three formulas of dark chocolate bar with an addition of Kaempferia galanga L. rhizomes essential oil (0.1%, 0.2%, and 0.3%) were studied. The results showed that the addition of variation of the essential oil concentration (0.1%, 0.2%, and 0.3%) had no significant effect on the overall sensory properties. However, dark chocolate bar with the addition of 0.3% Kaempferia galanga L. essential oil (F3) showed the highest panelist acceptance on aroma attributes. It had very small color difference and the lowest hardness based on the result of physical characterization, suggesting that dark chocolate bar with the addition of 0.3% Kaempferia galanga L. essential oil (F3) is expected to be developed as one of chocolate-based functional food products.

1. Introduction

Indonesia is the third world biggest producer of cocoa after Ivory Coast and Ghana in 2016/2017 [1]. Cocoa has contributed Indonesia’s fourth crop in area planted and Indonesia’s third foreign exchange in the national plantation sub-sector. Indonesia’s cocoa area in 2015 was recorded 1,709,284 hectares with 593,331 tons of cocoa production. Total cocoa exports in that year reached 355,321 tons or valued at US$ 1,307,771 [2]. Based on the average data of Indonesian cocoa production over the past five years (2012-2016), there are six cocoa production centers in Indonesia (Central Sulawesi, South Sulawesi, Southeast Sulawesi, West Sulawesi, West Sumatra, Lampung, and North Sumatra). The six provinces contributed 80.19% cumulative contribution [3].

Chocolate is the world’s most popular confectionery product of processed cocoa [4]. Chocolate is widely accepted by the public because of its taste, aroma, color [5], and health benefits [6]. There are three types of chocolate based on the composition of the constituent: dark chocolate, milk chocolate, and white chocolate [7,8]. The antioxidant content in dark chocolate is higher than in other types of chocolate [9,10]. Some research have been conducted to enrich the chocolate by using functional material from plant substrate which contains bioactive compound. The addition of dried fruits have been reported in dark and milk chocolates [11].
Spices are potential sources of antioxidants. This ingredient is effective in a number of food products, including confectionery. The main antioxidant compounds in spices are phenolic groups [12]. In some previous researches, spices have been used as additives in chocolate bars, such as cinnamon [8,13,14,15,16], aniseed, and ginger [17]. Kencur (Kaempferia galanga L.) as spice is widely known and intensively cultivated in Indonesia [18]. Kencur is fifth rank (6.33%) on the total production of biopharma plants in Indonesia [19]. Health benefit of kencur rhizome is antitussive [20], expectorant, antioxidant, and hypocholesterolemic [21]. Dark chocolate bar with the addition of essential oil of kencur rhizomes (Kaempferia galanga L.) is expected to be chocolate product that can provide health benefits (functional food product).

2. Experimental
The main materials used in this research were dark chocolate couverture 65% (PT. Tulip, Indonesia) and essential oil of Kaempferia galanga L. rhizomes (CV. Orizho Indonesia, Bantul, Indonesia). The process of producing dark chocolate bars included several stages, including material preparation, melting, refining, mixing, dark chocolate block printing, cooling, tempering, moulding, demoulding, and packaging. Dark chocolate was melted using chocolate melter with a temperature of 46°C ± 0.1 for ± 30 minutes. Refining was done by using ball mill with a rotary speed of 90 rpm at 45-46°C. After mixing chocolate and essential oil finished, chocolate paste was printed into chocolate blocks and cooled in a cooling room at 4°C. Tempering process was done by melt down dark chocolate block with a temperature 46°C. ¾ part of the melted chocolate then stirred and slid on marble table for 10-15 minutes until the temperature stabilized at 28°C. ¾ part of the chocolate paste that had been conditioned on the marble table was mixed with ¼ parts. The whole chocolate paste was heated to a temperature of 32°C and printed (moulding). After that, chocolate was put into cold storage 4°C for ± 30 minutes. The demoulding was done by slowly turning the mold on the marble table. Dark chocolate bar which was released from the mold and packed using aluminum foil.

Dark chocolate with addition Kaempferia galanga L. rhizomes essential oil were evaluated with Hedonic methods [22]. 30 panelists with varying in age 21-24 years were used in this sensory evaluation. The sensory properties were presented on five point scoring scale (dislike, dislike moderately, neither like nor dislike, like moderately, and like very much) and seven attributes (color, glossiness, aroma, taste, texture, melting, and overall). The physical properties of dark chocolate bar were evaluated with color and hardness measurements. Color measurements were conducted with Chroma Meter CR-400, Konica Minolta Optic, Inc. Before the test was carried out, the test samples were removed from the cold box and conditioned at room temperature (27°C). The results were expressed in the L* (lightness), a*(redness), and b*(yellowness). Hue value calculated based on the value of a* and b* [23,24]. This color test aimed to determine the effect of variations in the essential oil of kencur rhizomes on the color quality of the sample. Hardness measurements were conducted with Zwick Universal Testing Machine (UTM) series SA/0.5. This measurement was based on the compression method with the ASTM standard. Dark chocolate bar was placed between the two anvils and was given a compressive force with a pressure in the form of a cylindrical acrylic plate until it broke.

Completely Randomized Design with one factor of variation of 0.1% (F1), 0.2% (F2), and 0.3% (F3) concentration of Kaempferia galanga L. rhizomes essential oil was used in this study. The data were statistically analyzed using One-Way ANOVA. If there was a significant difference, Duncan's Multiple Range Test (DMRT) was conducted (α=5%).

3. Results and Discussion
3.1 Sensory Properties
Sensory evaluation was used for market needs survey, quality improvement, and product development [5]. Hedonic was defined as the act of choosing based on preference. This scale included a series of statements or panelist statement points that state the level of preference or dislike of the sample [22]. The results of this sensory analysis used 1-5 hedonic scale. The results were statistically processed to
obtain conclusions about the preference of dark chocolate bar with the addition of *Kaempferia galanga* L. rhizomes essential oil. Sensory properties results are shown in Table 1.

### Table 1. Sensory properties of *Kaempferia galanga* L. dark chocolate bar

| Formula  | Color | Glossiness | Aroma | Taste | Texture | Melting | Overall  |
|----------|-------|------------|-------|-------|---------|---------|----------|
| F1 (0.1%)| 4.70±0.535 | 4.40±0.724 | 4.00±0.871 | 4.20±0.925 | 4.23±0.858 | 4.47±0.819 | 4.30±0.794 |
| F2 (0.2%)| 4.77±0.450 | 4.37±0.718 | 4.17±0.699 | 4.20±0.664 | 4.33±0.758 | 4.33±0.758 | 4.33±0.547 |
| F3 (0.3%)| 4.80±0.407 | 4.33±0.758 | 4.43±0.568 | 4.50±0.682 | 4.33±0.844 | 4.27±0.828 | 4.50±0.682 |

*Within a row, means the same superscript letters are not significantly different from one another at 5% level of significance based on One-Way ANOVA (α=0.05).*

#### 3.1.1 Color Attributes

Color is the first attribute that is valued from product. Color affects the threshold of gustative, sweet perception, preference, and acceptance of panelists [25]. The difference in the composition of dark chocolate bar is only found in variations in the concentration of essential oils of *Kaempferia galanga* L. rhizomes so that the sample did not have significant differences between each other. Table 1 shows that panelist acceptance rates increased insignificantly with the increasing concentration of essential oils added. It is suspected because the essential oil of *Kaempferia galanga* L. had clear or colorless so it did not affect the color of dark chocolate bars. The results of the color attribute of the panelist acceptance of this research (4.80 ± 0.407) were relatively better than Dwijatmoko research [8].

#### 3.1.2 Glossiness Attributes

Glossiness interprete as the reflection power of the plane's surface to light. Panelists tend to like glossy chocolate [26]. The decrease in the acceptance of panelists on the glossiness attribute is thought to be related to a fairly high temperature difference between the storage room and the organoleptic test room. It is consistent with Haryadi and Supriyanto [27] which states that chocolate experienced condensation due to extreme temperature changes. The glossiness attribute of dark chocolate bars in this research were not significantly different. The panelists still stated that they liked three samples (F1,F2, and F3) of the dark chocolate bar.

#### 3.1.3 Aroma Attributes

Aroma is formed by the chemical components of cocoa bean compilers such as volatile compounds, namely aldehydes, ketones, and carbonyl. Aroma formation is influenced by precursors of fermentation results, temperature, roasting time, and moisture content of the material. The precursors forming component of chocolate aroma are aliphatic acid, α, β, unsaturated aldehyde, sulfur compounds, and alkylpirazine (Strecker degradation secondary products) [27]. Based on Table 1, aroma attributes had a trend that tend to increase along with the addition of the essential oil of *Kaempferia galanga* L. rhizome. Sample F3 or dark chocolate bar with the addition of 0.3% had the highest level of preference and had a significant difference to sample F1, but not significantly different from F2. It shows that more essential oil of *Kaempferia galanga* L. is added, the panelists increasingly liked the aroma formed.

#### 3.1.4 Taste Attributes

The basic taste of chocolate that consumers want is sour and bitter with a balanced state. Chocolate sweetness is caused by aliphatic inorganic compounds that contain OH groups such as alcohol, some amino acids, aldehydes, and glycerol. The source of sweetness was mainly produced by sugar (sucrose, monosaccharides, or disaccharides). Bitter taste was caused by alcoholoids, such as caffeine, theobromine, quinone, glycosides, and phenolic compounds [27]. Chocolate flavor with the addition of 0.3% (F3) essential oil of kencur (*Kaempferia galanga* L.) gave the highest preference which is not significantly different with the addition of 0.1% (F1) and 0.2% (F2) essential oil of kencur rhizome. The essential oil of rhizomes kencur gave after taste like a strong mint flavor.
3.1.5 Texture Attributes
Chocolate’s texture is smooth. It can melt softly in the mouth. Based on the panelists statements that they found dark chocolate with addition of 0.3% essential oil of kencur (Kaempferia galanga L.) rhizomes is easier to break down. Therefore, it is suspected that this made the acceptance increased.

3.1.6 Melting Attributes
Cocoa fat in chocolate is composed of stearic acid (34%), palmitic acid (27%), and oleic acid (34%) which functions at room temperature and melts at body temperature giving a smooth texture in the mouth [9]. From the results of hedonic test of melting ability attributes, the difference in the concentration of essential oils did not provide a real value for the resulting dark chocolate bar. Dark chocolate bar with the addition of 0.3% essential oil of kencur rhizome (F3) had a texture that is not harder than 0.1% concentration. Sample F3 had a mouth feel that can be melted in the mouth and had melting point lower than F1. According to research by Limbardo [28], chocolate with a high melting point gave great hardness.

3.1.7 Overall Attributes
The level of acceptance of the three variations of essential oils concentration did not give a significant difference in overall parameters (except aroma parameters) of dark chocolate bars. The acceptance level of panelists in overall attributes had an increasing trend along with the increasing number of essential oils. Overall parameters indicated that the dark chocolate bar with the addition of 0.3% essential oil of kencur (F3) can still be accepted by the panelists.

3.2 Physical Properties
Color is an important indicator or attribute. CIELab is one method in measuring color in food [29]. The values of dark chocolate bars’ L*, a*, b*, and *Hue in this study were found in Table 2. Whereas, hardness is the force needed to crush chocolate. Snap is a sound that is heard when the chocolate sample becomes broken. The desired chocolate was chocolate with a hard texture, steady and easily melts in the mouth [9].

3.2.1 Color Measurement

| Formula   | L*       | a*       | b*       | *Hue      |
|-----------|----------|----------|----------|-----------|
| Control (0%) | 28.310±0.185 | 7.700±0.119 | 4.812±0.141 | 31.996±0.522 |
| F1 (0.1%)  | 27.877±0.387 | 7.712±0.231 | 4.677±0.274 | 31.212±0.869 |
| F2 (0.2%)  | 28.087±0.474 | 7.888±0.235 | 4.962±0.419 | 32.118±1.559 |
| F3 (0.3%)  | 27.628±0.446 | 7.617±0.133 | 4.395±0.129 | 29.981±0.336 |

Table 2 shows that the color of three formulas of dark chocolate bar with the addition of essential oils 0.1%, 0.2%, and 0.3% had a positive a* and b* values, the intersection between red and yellow. The addition of the concentration of essential oil of Kaempferia galanga L. rhizomes did not significantly affect the *Hue sample of F1 (0.1%) and F2 (0.2%), but significantly affected the sample F3 (0.3%). The three samples (F1, F2, and F3) of the dark chocolate bar were in the red chromatic color (*Hue). The addition of essential oil of Kaempferia galanga L. rhizomes gave darker red color to the dark chocolate bar. The effect of the color difference between the three samples were very small (TCD*<1.0), thus it did not affect the level of panelist preference.

3.2.2 Hardness Measurement
The results of the hardness measurement showed a significant difference between one sample and the others. The four samples of the dark chocolate bar had their own subset of a, b, c, and d. The highest
hardness of dark chocolate bar was found in the control or sample with no addition of rhizome rhizome essential oil. Meanwhile, the dark chocolate bar that had the lowest hardness is the sample with the addition of the highest concentration of *Kaempferia galanga* L. rhizomes essential oil (0.3%) as shown in Table 3. Based on this research, the higher the concentration of addition of essential oil of *Kaempferia galanga* L. rhizomes reduced the level of hardness of the dark chocolate bar.

**Table 3.** Hardness measurement of *Kaempferia galanga* L. dark chocolate bar

| Formula      | Hardness (N)         |
|--------------|----------------------|
| Control (0%) | 89.724 ± 2.363       |
| F1 (0.1%)    | 75.291 ± 5.245       |
| F2 (0.2%)    | 51.346 ± 4.273       |
| F3 (0.3%)    | 22.771 ± 2.366       |

*Within a row, means the same superscript letters are not significantly different from one another at 5% level of significance based on One-Way ANOVA (α=0.05).*

4. Conclusion
This research evaluated the effects of variation concentration (0.1%, 0.2%, and 0.3%) of kencur (*Kaempferia galanga* L.) rhizome essential oil incorporation on sensory and physical properties of dark chocolate bar. The addition of variation of the essential oil concentration had significant effect on the aroma attribute but had no significant effect on six attributes (color, glossiness, taste, texture, melting, and overall). Three formulas of dark chocolate bar were represented in red of color range. The addition of variation of the essential oil concentration had significant effect on dark chocolate bar’ hardness. The higher concentration of kencur rhizome essential oil reduced the hardness of dark chocolate bar. Dark chocolate bar with the addition of 0.3% *Kaempferia galanga* L. essential oil (F3) showed the highest panelist acceptance on sensory properties with insignificant effect and the lowest hardness with very small color difference.

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