Innovative Use of Strawberry Jam in Compound Praline Chocolate: A Study of Its Physical Properties

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Abstract. As chocolate demand rises, product innovation continues to grow. The use of compound chocolate for praline with water-based fillings remains underexplored, as most studies use couverture chocolate in high-consumption regions like Europe and America. Since compound chocolate often contains low cocoa solids, resulting in a sweeter, milkier taste, this study adds cocoa powder to enhance cocoa flavour intensity. The impact of cocoa powder addition on key physical attributes - melting point, hardness, particle size, and colour - is the focus of this research. This study aimed to develop compound chocolate praline with a strong cocoa flavour intensity by adding cocoa powder. Three proportions of cocoa powder (10%, 20%, 30%) and strawberry jam were used. Chocolate characteristics were tested on the day of 0, 4, 8, and 12. The result showed that the cocoa powder proportions influenced the chocolate colour, moisture content, melting point and hardness. Chocolate lightness with a higher percentage of cocoa powder was darker than that of the ones with lower percentages. Whereas, regardless of the types of chocolate, moisture content, chocolate hardness and melting point tended to increase as the proportion of cocoa powder increased.

1 Introduction

Chocolate is a confectionary food product made from cocoa beans (Theobroma cacao L.). According to Fernandes et al [1], based on the basic ingredients, chocolate is divided into 3 types, namely dark chocolate, white chocolate, and milk chocolate. Dark chocolate is chocolate with a dark color and bitter taste made from cocoa butter, cocoa paste, and sugar. White chocolate is made from cocoa butter, milk and sugar and contains at least 20% cocoa butter, 14% milk and no more than 55% sugar. Meanwhile, milk chocolate is made from powdered milk, sugar, cocoa butter, and cocoa paste.

Dark, white, and milk chocolate are basic types of chocolate. One of the most popular chocolate derivatives is praline chocolate. Praline chocolate is a type of chocolate that is added with fillings, such as fresh fruit jam which is included in the water-based category, or peanut butter categorized as oil-based [2]. Praline chocolate is one of the variations of processed chocolate, from the lower to the upper class because it has various and attractive shapes, types, flavours, and packaging. However, in tropical countries, praline chocolate has low stability due to relatively high temperatures, causing it to melt easily, lose shape, and change texture.

Praline chocolate shell can be made from couverture chocolate and compound chocolate. The difference between couverture and compound chocolate lies in the type of fat used. The fat in couverture chocolate is 100% cocoa butter. Its triglyceride structure results in a relatively low melting point. The type of fat used in compound chocolate is vegetable fat or cocoa butter alternatives (CBA) which includes cocoa butter substitute (CBS), cocoa butter equivalent (CBE) and cocoa butter replacer (CBR). The use of vegetable fat as a substitute for cocoa butter can increase the melting point of chocolate products [3]. Compound chocolate as an ingredient for making praline chocolate has its own advantages, in addition to have a high melting point, compound chocolate also does not require a tempering process during processing. This makes compound chocolate easier to produce and market in tropical countries. In fact, the use of cocoa butter substitute has been shown to increase the melting point of chocolate to 38–39 °C and its hardness to 19–24 N/mm², supporting its application in warmer climates.

The use of compound chocolate as the basic ingredient for praline chocolate with water-based filling is still not widely explored. Research on praline chocolate with water-based fillings is mostly conducted using couverture chocolate in high-consumption countries like those in Europe and America. Therefore, studying praline chocolate using compound chocolate is necessary, especially for application in tropical countries. Most compound chocolates on the market contain relatively low cocoa solids, mainly due to the high cost of cocoa powder. This results in a sweeter, milkier taste, which some chocolate enthusiasts see as a drawback. Therefore, this study adds cocoa powder to dark, milk, and white compound chocolates to enhance chocolate flavor intensity. Recent studies on single-origin chocolate in Indonesia have shown that consumer emotional responses such as feeling happy, satisfied, and calm are strongly influenced by the quality of raw materials rather than processing methods like roasting. However, adding cocoa powder may alter key praline attributes such as melting point, hardness, particle size, and color. This forms the basis of the present study.

Praline chocolate processing has its own challenges because the stability of chocolate is influenced by the composition and interactions between the constituent ingredients (shell and filling). This study was conducted to investigate the impact of cocoa powder addition into compound chocolate on the characteristics of water-based filling praline.

2 Material and Method

2.1 Materials

The ingredient used in this study consisted of compound dark, milk, and white chocolate, cocoa powder and strawberry jam. The compound chocolate used was Tulip brand produced by Freyabadi Indotama, while the cocoa powder was purchased from Indonesian Coffee and Cocoa Research Institute (Jember, East Java) and the strawberry jam was purchased from PT Astaguna Wisesa.

2.2 Chocolate processing

Three types of compound praline chocolate namely dark, white and milk chocolate with strawberry jam filling were produced. Cocoa powder at three different levels (10%, 20%, and 30%) were added into the formulation. **Table 1** showed the chocolate samples. The reference chocolate was a chocolate without strawberry jam filling made with 15 minutes of shell formation.

Table 1. Name of Compound Praline Chocolate with Added Cocoa Powder

Cocoa powder proportion	Type of chocolate	Cocoa powder proportion	Type of chocolate
	Dark	White	Milk
0%	DC	WC	MC
10%	DC+10%	WC+10%	MC+10%
20%	DC+20%	WC+20%	MC+20%
30%	DC+30%	WC+30%	MC+30%

Compound praline chocolate was processed in melanger for 3 hours to mix and produce fine chocolate. Afterwards, praline chocolate filled with strawberry jam was moulded and placed into thermostat cabinet at 15-19^{o}C [4]. Next, the measurement of the physical properties of compound chocolate praline was conducted on days 0, 4, 8, and 12. This process demonstrates how crystal maturation affects the physical properties of the chocolate.

2.3 Analytical Methods

2.3.1 Melting point

Chocolate melting point was determined using water bath, beaker glass, spoon and thermocouple. A beaker glass was put into water bath that was already filled with water. The temperature of water bath was set at 28^{o}C and the actual temperature inside the water bath and beaker glass was measured using thermocouple.

Afterwards, chocolate sample was placed into a spoon and submerged into the water. The temperature of water bath was increased periodically in one minute interval. The melting point of chocolate was indicated by the change of chocolate form to be softer.

2.3.2 Hardness

Chocolate hardness was measured using Brookfield texture analyzer. A compression test was chosen using TA39 probe with 2 mm diameter, 0.5 mm/s compression speed and 3 mm target value. The data obtained from the measurement was hardness in gram converted into tension (N/mm^2). The formulation can be seen in equation 1.

$$\sigma = \frac{load\ x\ a}{\pi r^2} \quad \textbf{(1)}$$

Description:σ = tension
a = gravity acceleration
r = radius of probe

2.3.3 Particle size

The chocolate particle size was measured using optical microscope Olympus CX23 connected into Optilab software as image viewer and Image Raster 3.0 as a measuring tool. Chocolate sample of approximately 0.5 g was melted at 55^{o}C for 1 hour and dissolved into vegetable oil in a vacuum tube. To obtained a well-mixed solution, the sample was shaken vigorously for 1 minute. Afterwards, the solution was heated at 55^{o}C for an hour. After heating, the solution was put in preparation glass and the particle image obtained from the microscope was captured.

2.3.4 Color measurement

Color measurement was done using chromameter Konica Minolta Model CR 400. Praline chocolate sample was placed in a black-colored squared-board and the colour was measured by clicking the chromameter button. Chromameter displayed the lightness (L*), redness (a*) and yellowness (b*) value. Subsequently, hue angle (H^{o}) and chroma (C) were obtained by converting the redness (a*) and yellowness value (b*) using equation 2 and 3.

$$\text{hue}^{o} = tan^{-1}\left(\frac{b^*}{a^*}\right) x\ \frac{360^{o}}{(2\ x\ \pi)} \quad [5] \quad (2)$$

$$\text{Chroma} = \sqrt{\left(a^{*2}\right) + \left(b^{*2}\right)}\ [6] \quad (3)$$

2.4 Data analysis

Data was analyzed using IBM SPSS version 25.0 software consist of Analysis of Variance. Prior to the one-way ANOVA test, the homo-geneity of the sample was tested using the Levene's test with <0.05 level of significance. Tukey test was chosen to determine the differences in sample variations [7].

3 Result and Discussion

3.1 Relationship between treatment

The proportion of cocoa powder and the time of crystal formation (maturation) in this study affected the final characteristics of the three types of compound praline chocolate (dark chocolate, white chocolate, and milk chocolate). In compound chocolate, the use of cocoa powder had an effect on the formation of the texture, aroma, and taste of chocolate. In addition, the maturation of the praline compound chocolate with water-based filling also affected the characteristics of the chocolate. This was because the use of water-based filling will indirectly add water to the praline so that the particles in praline chocolate will agglomerate and cause sugar blooms if the storage is not done properly [8].

According to the result, the addition of cocoa powder had a significant influence on the hardness of all the chocolate. Praline chocolate consists of several non-fat ingredients such as cocoa powder and sugar, which were dispersed in the liquid state of the fat. The existence of non-fat ingredients influences crystallization, affecting the texture and overall quality of food [9].

Based on **Table 2 (a),** it can be seen that the proportion of cocoa powder addition, time of crystal formation, and interaction between the two had a significant effect ($p<0.05$) on the characteristics of dark praline chocolate. The percentage of cocoa powder had an effect on hardness, melting point, appearance (redness, yellowness, hue, and choma). While the maturation time affected hardness and appearance (redness, hue, chroma). However, the interaction between the two affected the hardness and appearance (redness, yellowness, hue, chrome).

The effect of cocoa powder addition and time of crystal formation (maturation) on praline milk chocolate can be seen in **Table 2 (b)** that the percentage of addition of cocoa powder and maturation time significantly ($p<0.05$) influenced the characteristics of praline chocolate. The percentage of cocoa powder affected the characteristics of chocolate in the form of hardness, melting point, and appearance (lightness, yellowness, hue). Meanwhile, maturation time only affected appearance (redness, yellowness, hue, chroma). In **Table 2 (c),** it can be seen that the percentage of cocoa powder addition, the time of crystal formation (maturation), and the interaction between the two had a significant effect ($p<0.05$) on the characteristics of praline white chocolate which include hardness, melting point, and appearance (lightness, redness, yellowness).

Table 2. Interaction between proportion of cocoa powder and crystal maturation on (a) dark chocolate (b) milk chocolate (c) white chocolate characteristics

Chocolate Type	Factor	Hardness	Melting Point	Particle Size	Light-ness
Dark	Cocoa Powder (CP)	*	*	–	–
	Maturation (M)	*	–	–	–
	CP × M	*	–	–	–
Milk	Cocoa Powder (CP)	*	*	–	*
	Maturation (M)	–	–	–	–
	CP × M	–	–	*	–
White	Cocoa Powder (CP)	*	–	–	*
	Maturation (M)	*	*	–	*
	CP × M	*	–	–	*

3.2 Praline characteristics

3.2.1 Melting Point

The melting point of chocolate is a parameter that is determined by the proportion of fat and the type of crystals formed when the chocolate is produced. Chocolate containing cocoa butter has a melting point ranging from 33-34°C.

As shown in Figure 1, praline chocolate made with dark chocolate and milk chocolate tended to have comparable melting points. However, white praline chocolate compound has a slightly lower melting point than other types of chocolate. Moreover, as the duration of crystal formation (maturation) increases, the melting point of the chocolate tend to rise. This is due to the crystals becoming more stable over a longer maturation period [10].

3.2.2 Hardness

Hardness is one of the quality parameters in praline chocolate, especially on the texture and distinctive sound of the resulting snap. The parameters of chocolate hardness are influenced by several factors including water content, fat, particle size, and tempering level [8]. Cocoa powder is a basic ingredient that contains water and fat. These components could affect the hardness of chocolate due to the disruption of crystal structure or the interference with proper fat crystallization of compound chocolate which depends on a specific fat matrix [11]. In addition, the use of water-based filling also affects the parameters of the hardness of chocolate.

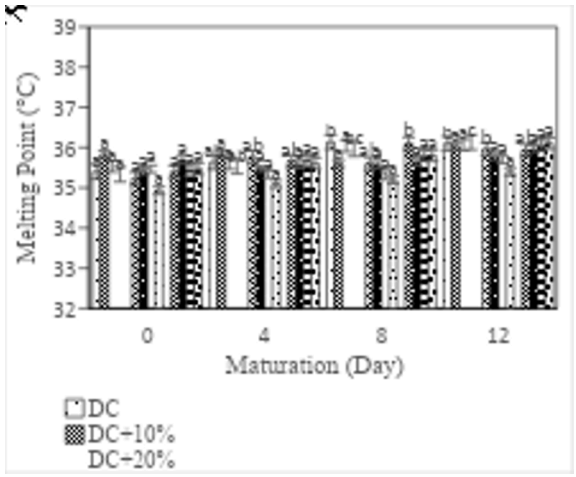

Fig. 1. The effect of crystal maturation on chocolate melting point

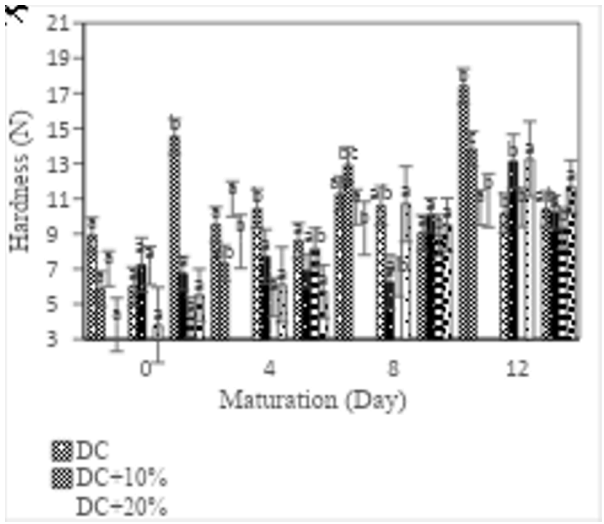

Fig. 2. Interaction between crystal formation (maturation) and chocolate hardness

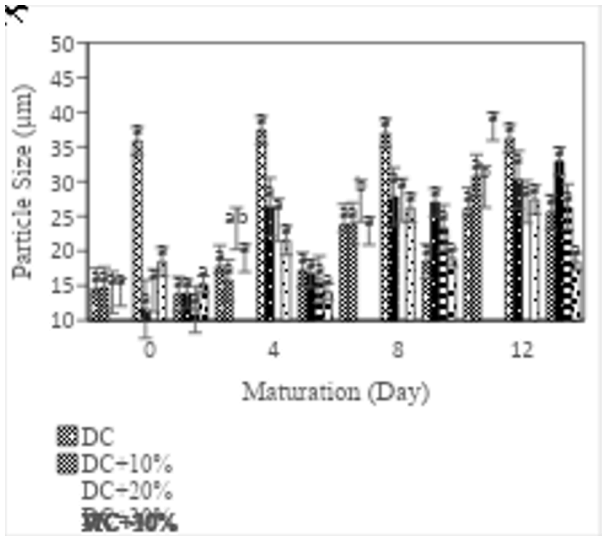

Fig. 3. The effect of crystal maturation on chocolate particle size

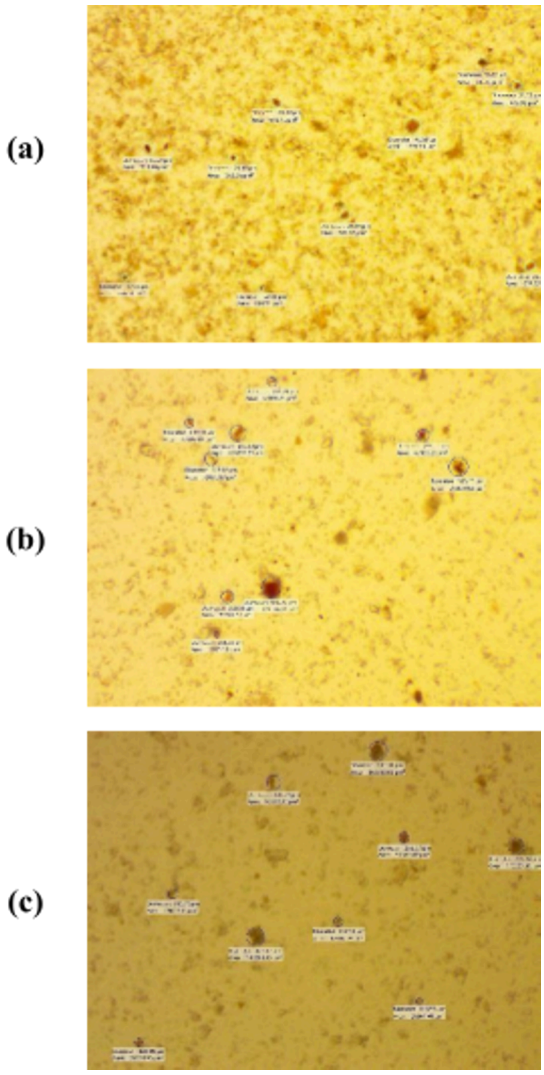

Fig. 4. Particle size of compound (a) dark chocolate (b) milk chocolate (c) white chocolate

In Figure 2 it can be seen that regardless of the time of crystal formation (maturation) the hardness of chocolate tends to decrease with the increase in the percentage of cocoa powder. Fat thereby reducing the interaction between particles. In addition, with increasing time of crystal formation (maturation), the hardness of chocolate also increased. This happens because the crystals formed will be more stable with increasing maturation time [10], In this study, the compound praline chocolate that had the highest hardness was praline dark chocolate without the addition of cocoa powder on the 12th day of maturation.

3.2.3 Particle size

Particle size in chocolate has a direct effect on the human sense of taste when consuming chocolate. This is because the particle size distribution is related to the smoothness of chocolate which affects consumer perceptions when chocolate is in the mouth [2]. Chocolate containing particle with size more than 30 µm has a gritty texture [10], [12]. Based on Figure 4, it can be seen that the praline compound chocolate had a small

particle size ranging from 21-24 µm, so this type of praline chocolate had a fine texture.

In Figure 3 it can be seen that the maturation time of chocolate had no significant effect ($p<0.05$) on particle size. However, from Figure 3 it can be seen that the smallest chocolate particle size was milk praline chocolate. This phenomenon can be caused by the fat content in the chocolate and the duration of the conching process. The longer the conching process, the smoother the final chocolate product and the smaller the particle size [13]. Fat is needed to cover the chocolate particles so that they can flow optimally to reduce the interaction between particles [8].

3.2.4 Appearance

The appearance of chocolate can be determined by the colour, and glossiness attributes [14]. The colour of chocolate is influenced by particle size and fat content, while for glossiness it is influenced by fat bloom and sugar bloom. In this study, the appearance of praline chocolate with strawberry filling was assessed only based on colour attributes (Figure 4). The value of the chocolate colour was indicated by the parameters L*, a*, b*, hue (H^o), and chroma (C). It can be seen in Figure 5.a that the time of crystals formation (maturation) had no significant effect ($p<0.05$) on the lightness value (L*). Furthermore, in Figure 5a it can be seen that the highest lightness value was in white praline chocolate, this was because white praline chocolate has a light colour compared to dark chocolate and dark milk chocolate (Figure 6).

Meanwhile, for redness (a*) and yellowness (b*), Figure 5(b) and Figure 5(c) showed that the samples were not significantly different ($p<0.05$). Different results were observed for hue and chroma values, some chocolates showed significantly different hue and chroma values ($p<0.05$). This could be due to differences in the surface roughness of the chocolate. However, for the hue value there was no clear trend, while the chroma value showed a decrease with the increase in the percentage of cocoa powder addition. This showed that the addition of cocoa powder in the raw material for making praline chocolate affected the colour parameters. According to Saputro et al [15] the factors that influence colour parameters include raw materials, production methods, tempering methods, and chocolate surface hardness.

4 Conclusion

Proportion of cocoa powder, time of crystal formation (maturation) and their interaction had a significant effect on the characteristics of dark praline chocolate. Praline compound chocolate made with dark and milk chocolate tended to have comparable melting points. However, white praline chocolate compound has a slightly lower melting point. The hardness of chocolate tended to decrease with the increase in the proportion of cocoa powder. The time of crystals formation (maturation) had no significant effect on the lightness value (L*)

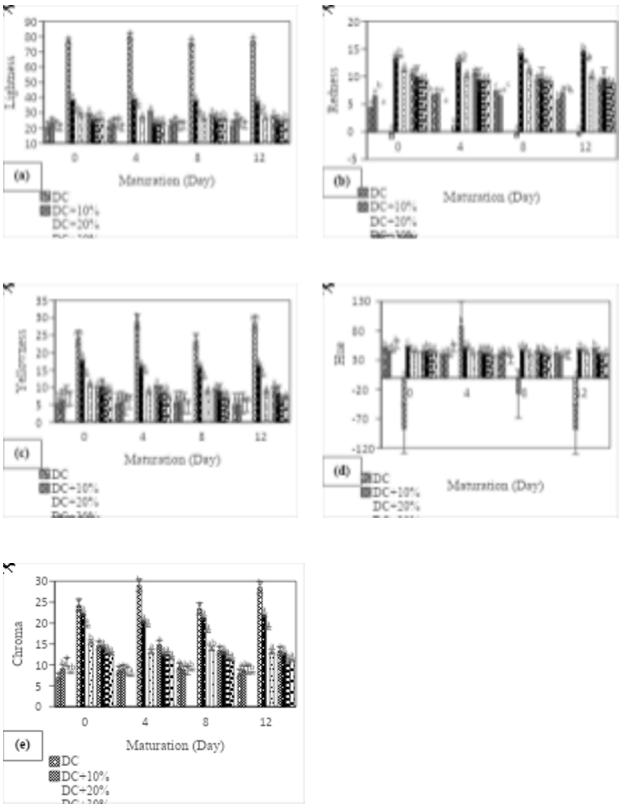

Fig. 5. The effect of crystal maturation on chocolate lightness, redness, yellowness, hue, angle, chroma

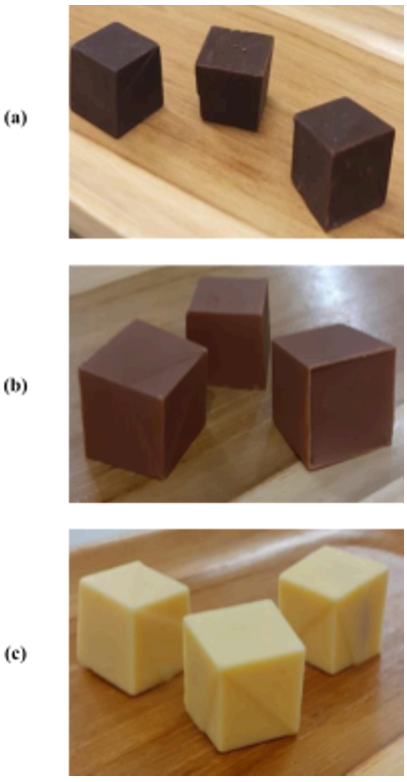

Fig. 6. Praline chocolate appearance (a) dark chocolate (b) milk chocolate (c) white chocolate

Acknowledgement
This work was financed by RTA Program Universitas Gadjah Mada with the Grant Number 3550/UN1.P.III/Dit-Lit/PT.01.05/2022 and supported by the Department of Agricultural and Biosystems Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada.

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