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Increasing the Melting Temperature of Chocolate by Adding Xanthan Gum-Based Hydrogel: A Preliminary Study

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ABSTRACT
Melting temperature of chocolate needs to be increased since it easily melts at temperatures below 34ºC. An elevated melting temperature gives benefits for chocolate producers in tropical countries. In this study, heat-resistant chocolate was developed using indirect incorporation of water. Xanthan Gum-based hydrogel was added into chocolate in the end of conching process with the proportion of 2%. This work aimed to investigate the impact of Xanthan Gum-based hydrogel on the properties of chocolate. The influence of three different Xanthan Gum-based hydrogels concentration, namely 3%, 5%, and 7% was investigated. The results showed that, due to a high moisture content and melting values of chocolates increased.

Keywords: *heat resistant chocolate, xanthan gum, hydrogel*

1. INTRODUCTION

Cocoa is one of the leading commodities in Indonesia that has wide market opportunities. In 2019, cocoa production in Indonesia reached 768,769 tons [1]. Chocolate, indeed is a popular and favored product by the society. The average consumption of chocolate in Indonesia per year is 0.4 kg and has increased by 10%. Meanwhile in the world, chocolate consumption increases by 3% annually based on the number of cocoa bean grinding [2]

Dark chocolate contains 35% total dry cocoa solids with a minimum of 18% cocoa butter and 14% nonfat cocoa solids [3]. Dark chocolate generally melts slowly and produces a thick and creamy mouthfeel with a melting point below the average human body temperature around 33.8ºC [4, 5] The characteristics of chocolate that melts easily becomes a drawback for the chocolate production process in areas with high average temperature like Indonesia [6]. Efforts that can be made to overcome this problem can be done by producing heatresistant chocolate. Heat-resistant chocolate is a chocolate that has relatively high melting temperature [7,8] which is able to maintain the chocolate structure and properties [9].

There are several ways to produce heat resistant chocolate such as increasing the microstructure network, fat-binding polymers additions, increasing melting point of fat [4] adding thermal constituents [10]. Various studies have been conducted regarding the formulation of heat-resistant chocolate. The addition of water indirectly has the potential to increase the melting point of chocolate. Bari et al, 2017 [11] added water in cocoa butter emulsion. The addition of a low-fat dispersed hybrid hydrogel to the chocolate formulation was developed by Francis and Chidambaram, 2019 [12].

The aim of this study was to investigate the impact of Xanthan Gum-based hydrogel on the heat stability of chocolate. In this study, the hydrogel was made in a very simple way, so that the method can be followed by smallscale chocolate makers. Several chocolate characteristics were studied namely melting point, water content, particle size and color attributes. The present study manifested that Xanthan Gum-based hydrogel has potential to produce heat resistant chocolate.

2. MATERIALS AND METHODS

The study was conducted from October 2020 to June 2021 at the Laboratory of Food and Postharvest Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada.

2.1. Materials

The material used in the study were cocoa paste, cocoa powder, cocoa butter purchased from Indonesian Coffee and Cocoa Research Institute (Jember, East Java). Sugar was bought at PT Sugar Group Companies and Xanthan Gum was bought at Subur Kimia Jaya. The characteristics of the ingredients can be seen in **Table 1.**

Table 1. Characterization of Ingredients

Ingredients	Moisture content (%)	Fat content (%)	Fineness Modulus
Sucrose	0,07		2,83
Cocoa powder	3,84	30,18	0,33
Cocoa butter	0,02	100	
Cocoa mass	2,70	51,44	
Xanthan Gum	8,56		1,99

2.2. Sample preparations

Dark chocolate was made from 32% cocoa powder, cocoa mass, cocoa butter, sugar and Xanthan Gum-based hydrogel. Xanthan Gum proportions in hydrogel varies in the percentage of 0%, 3%, 5% and 7%. There were 4 type of chocolates (**Table 2**).

Table 2. Name of Chocolate

Xanthan Gum (%)	Chocolate
0	CXG 0
3	CXG 3
5	CXG 5
7	CXG 7

2.3. Hydrogel preparations

Hydrogel was prepared from Xanthan Gum and distilled water by mixing it with spiral stirrer at 6500 rpm for 5 minutes. Xanthan Gum proportions used in hydrogel formulation were 3%, 5% and 7%. The Xanthan Gum based hydrogel was then stored in a thermostatic cabinet at a temperature of 10ºC before it was further used in chocolate.

2.4. Chocolate processing

Dark chocolate was produced in small scale using Wonder Premier Grinder manufactured by Premier Sivanesan Group of Companies which has motor speed of 1440 rpm and equipped with 2 grinding wheel stones. Dark chocolate production lasted for 10 hours. The temperature of chocolate processing was approximately 60ºC. The process was carried out in melanger consist of mixing, refining and conching. Two percent of hydrogel was added into chocolate formulation in the end of conching process. The molten chocolate was then tempered manually using the oven referring to the research conducted by Jati et al (2019) with the modification of the tempering duration to form stable chocolate crystal, molded and stored in thermostatic cabinet at a temperature of 10ºC for 13 days [13].

2.5. Analytical Methods

2.5.1 Melting point

The melting point of chocolate was measured manually using a water bath. A 250 ml beaker was prepared and put into a water bath filled with water. The temperature of the water bath is set to 27 ºC. The temperature in the water bath and beaker was measured using a thermocouple. After the water temperature in the water bath and beaker reached 27ºC, the chocolate samples were prepared and then tested for their melting points. A sample of chocolate with 1x1x1 cm^3 dimension is placed on a plastic spoon and immersed in a beaker. The sample was stirred slowly and the temperature of the water bath was increased by 1ºC every one minute until the chocolate melted. The melting of the chocolate was indicated by the softening of the chocolate sample in a plastic spoon shown in temperature displayed on the thermocouple.

2.5.2Moisture content

Moisture content of the chocolate was determined using thermogravimetric methods. Chocolate samples were heated in the oven at a temperature of 105ºC for 24 hours. The sample was further cooled and put in a desiccator for ± 15 minutes. The sample was weighed as the final mass of the sample. The difference between the initial mass and the final mass of the sample is the moisture content value obtained assuming the final mass of the sample is only chocolate solids.

$$\text{Moisture content (wb)} = \frac{M0 - M1}{M0} \text{x } 100\%$$

Where:

M_1 = Final mass

M_0 = Initial mass

2.5.3 Particle Size

Chocolate particles were measured using an Olympus CX23 optical microscope connected to the Optilab software as an image viewer and capturer, Image raster 3.0 software which was used to measure chocolate particles. A sample of 0.5 g of chocolate was melted and dissolved in 10 ml of palm oil. The sample was then homogenized by shaking until the chocolate was dissolved in the oil for 5 minutes. The dissolved chocolate sample was then heated at 55ºC in the oven for one hour. Afterwards, the sample was dropped on a glass slide and placed on the preparation table for later magnification through an optical microscope. The lens focus can be adjusted by slowly rotating the lens magnification.

2.5.4 Color measurement

The chocolate color was tested using a chromameter with settings L*, a*, b*. The chocolate sample was placed on a black base. Measurements were made by positioning the chromameter just above the sample and then pressing the color meter button. The flash of light produced when the button was pressed indicates the color measurement process was in progress. The values of L*, a*, b* were displayed on the monitor screen immediately after the measurement process took place.

2.6. Data analysis

Data analysis was carried out using IBM SPSS version 25.0 software. One way ANOVA and TOPSIS to characterized the best treatment from the study. Prior to the one-way ANOVA test, the homogeneity of the sample was tested using the Levene's test. Tukey test was chosen to determine the differences in sample variations. Topsis analysis was also used as multi-criteria decision making to obtain the best alternative.

3. RESULT AND DISCUSSION

The incorporation of water into chocolate indirectly by Xanthan Gum-based hydrogel addition affected the physical characteristics of chocolate. The high moisture content and improper storage of chocolate indicates agglomeration and sugar bloom in chocolate [14] Chocolate crystal needs time to form stable crystal. Melting point have correlation with chocolate moisture content. Chocolate color showed the undesired pattern due to the high of water content.

3.1. Melting point

Chocolate melting point influenced by fat, particle size and heat transfer rate in the sample with different size [15]. Chocolate properties are highly affected by the water addition. The melting behavior of the chocolate product influenced by the amount of fat content and fat crystalline state [16]. Chocolate with Xanthan Gumbased hydrogel showed higher melting point. The higher the proportion of the Xanthan Gum-based hydrogel, the higher the melting point of chocolate.

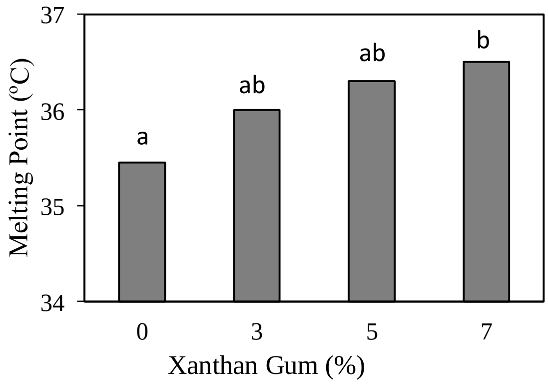

Figure 1. Melting point of chocolate formulated with several proportion of Xanthan Gum-based Hydrogel

The data obtained from the table showed that the chocolate with the addition of Xanthan Gum-based hydrogel in higher concentration exhibited higher melting point. Chocolate melting temperature above 34ºC has possibility to be developed in tropical countries [17], however it should be in accordance to the other chocolate properties to produce good quality of chocolate.

3.2. Moisture content

Chocolate moisture content affects physical characteristics such as hardness, melting point and chocolate appearance. The initial moisture content of the ingredients highly affects the final product of the chocolate [6,8]. The addition of Xanthan Gum based hydrogel has important role in the increase of chocolate water content since Xanthan Gum has high ability to absorb water. Chocolate with Xanthan Gum-based hydrogel has higher moisture content (**Figure 1**). Chocolate moisture content higher than 2% results in a less optimal chocolate product[7],

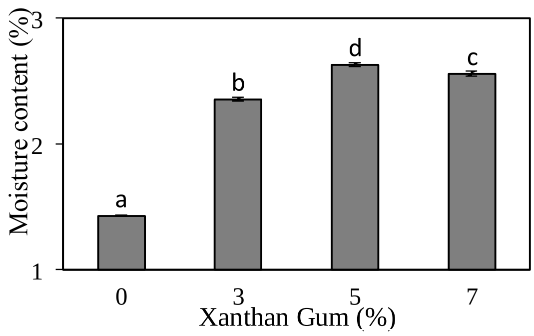

Figure 2 Chocolate moisture formulated with several proportion of Xanthan Gum-based Hydrogel

The high chocolate water content can be overcome [22]. Moreover, particle size influences several chocolate by increasing the fat content to produce chocolate with characteristics such as hardness, flow behavior, etc. good rheological properties [18]. However, it should be Generally, the smaller the particle size, the harder the

Table 3. Color of the chocolate formulated with several proportion of Xanthan Gum-based Hydrogel

Sample	L	a	B	hue	Chroma
CXG0	24,99±0,35^{c}	7,53±0,02^{ab}	7,03±0,13^{a}	43,03±0,47^{a}	10,30±0,11^{a}
CXG3	24,47±0,72^{bc}	8,88±0,67^{b}	7,32±0,76^{a}	39,44±1,05^{a}	11,51±0,99^{a}
CXG5	21,64±0,17^{a}	8,26±0,45^{ab}	6,97±0,41^{a}	40,19±3,10^{a}	10,82±0,15^{a}
CXG7	24,03±0,23^{b}	8,37±0,25^{a}	6,82±0,09^{a}	39,16±0,97^{a}	10,80±0,19^{a}

noted that high water content can also result in agglomeration that occurs caused by non-optimal evaporation [4,24]. This is related to research conducted by Francis & Chidambaram, 2019 [12] which states that hydrogel particles are trapped in cocoa butter. A suitable processing to evaporate the moisture content of chocolate by increasing the conching time at a temperature of 60°C or above is expected to help the evaporation process of the water content.

3.3. Particle size

Particle size is closely related to consumer preferences in choosing chocolate products. The smaller the particle size, the finer the chocolate when it's consumed [20]. The particle size correlates with the raw materials and the processing. The longer the refining time, the finer the chocolate particle size [20, 21, 22, 24]. Generally, particle size is inversely proportional to the hardness of chocolate. This is in accordance with the statement of Afoakwa et al., (2008) [15].

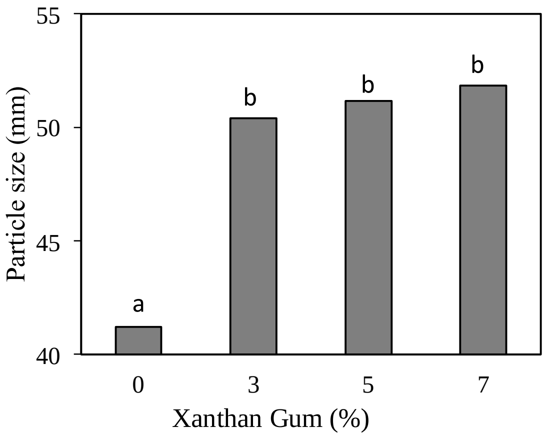

Figure 3. Particle size of chocolate formulated with several proportion of Xanthan Gum-based Hydrogel

Chocolate with particle size greater than 30 µm will result in rough and gritty texture when it's consumed chocolate and the higher the viscosity [15, 19]. According to the study, the chocolate shows the higher particle size along with the increase of Xanthan Gum percentage. The presence of moisture content in chocolate matrix will stick the sugar particle and cause agglomeration, affecting the chocolate particle size and its flow behavior to be greater [7, 19]

3.4. Color

Color is a parameter that indicates the physical quality of chocolate. Factors affecting the color of chocolate are the materials used, production methods, tempering processes [20]. The conching process in chocolate production requires a temperature of around 60-80°C which can cause a Maillard reaction due to high temperature [14]. Aside from this, color of chocolate is also influenced by particle size. The value of chocolate color (**Table 3)** was expressed by the attributes L*, a*, b*, hue (h°), chroma (C*).

The lightness value of the chocolate was in the ranged 21.63-24.99, however chocolate with 5% Xanthan Gumbased hydrogel shows a darker lightness value. Uneven chocolate surface roughness and different storage time caused the different color pattern of chocolate [25]. The redness value (a*) and yellowness (b*) which were converted to hue (h°) and chroma (C*) showed tendency for the resulting chocolate color to be red (18°-54°) with different color intensities. In general, the color of chocolate produced with different proportion of Xanthan Gum-based hydrogel tended to be similar.

3.5. Preference Value using TOPSIS Analysis

Topsis analysis was used as multi-criteria decision making to obtain the best alternative in this study. The parameter characteristics of the chocolate sample used as the criteria. The weighing of the criteria of each parameters described as follows: melting point (42%), moisture content (12%), particle size (12%), lightness (10%), redness (6%), yellowness (6%), hue (6%), chroma (6%). Melting point had the highest preference value since the addition of Xanthan Gum-based hydrogel in this study aimed to increase the melting point of chocolate. Whereas, moisture content and particle size also contributed important effect on it. The color parameter had the least preference value since the appearance of the chocolate were mostly affected by the main material used.

Table 4. Chocolate preference value

Chocolate	Preference Value	Rank
CXG 7	0,97	1
CXG 5	0,94	2
CXG 3	0,91	3
CXG 0	0,04	4

The best alternative from this technique considered to be the sample with the highest positive ideal solution according to the value of the weighing criteria. According to the study shown in the **Table 4,** chocolate CXG 7 had the highest preference value of 0.97. Consequently, CXG 7 was chosen as the best treatment as this treatment showed the highest melting point compared to the other samples.

4. CONCLUSION

Chocolate formulated with the addition of Xanthan Gum-based hydrogel with the different concentration of (0, 3, 5 and 7%) were characterized in four parameters namely melting point, moisture content, particle size, and color attributes consist of lightness, redness, yellowness, hue and chroma). It is concluded that the chocolates added with Xanthan Gum-based hydrogel exhibited higher melting point and moisture content. The best sample in this study was CXG 7. Rheological behavior and organoleptic test can be further applied to optimize the preference of the consumers.

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