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Effect of Gelatin and Sugar Concentration on the Characteristic of Panna Cotta

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Abstract

Panna cotta is an Italian dessert made from heavy whipping cream, milk, gelatin and sugar. The formula of Italian panna cotta is less suitable to be applied in Indonesia because heavy whipping cream is unavailable in Indonesia and people don't like thick cream. Replacement of heavy whipping cream with light whipping cream and change in light whipping cream-milk ratio into 1:9 were done to adjust panna cotta with the preference of panelist. This affected on the concentration of gelatin and sugar should be added. The purpose of this study was to determine the effect of gelatin and sugar concentration and their interaction on the characteristic of panna cotta and to determine gelatin and sugar concentration that could produce the most prefer of panna cotta. The research design was a factorial randomized block design that consisted of two factors: the concentration of gelatin (1%, 1,25%, and 1,5%) and the concentration of sugar (2,5%; 5%; and 7,5%) to obtain nine combination treatment and replicated three times. Data were analyzed using ANOVA test at $\alpha = 5\%$, if the results showed a significant effect, data were analyzed by Duncan's Multiple Range Test at $\alpha = 5\%$ to determine the combination treatment that gave a significant difference. The results indicated interactions between gelatin and sugar concentration provided significant effect on texture (hardness) of panna cotta. Increasing gelatin concentration caused an increased in hardness, but when sugar concentration was increased, the increasing of hardness were declined. Increasing concentration of gelatin and sugar caused a decreased in syneresis. Hedonic score of gel firmness was increased as increasing of gelatin and sugar concentration up to 1,25% gelatin and 5% sugar. Hedonic score of ease to melt and ease to swallow were increased as decreasing in gelatin concentration and increasing in sugar concentration. The recommended treatment was 1% of gelatin and 7,5% of sugar.

Keywords: Panna Cotta; Gelatin; Sugar

Introduction

Milk is one source of animal protein that is very important for health because it contains complete nutrition. According to USDA Foreign Agricultural Service (2014), the average milk consumption in Indonesia is still low. Badan Pusat Statistik (2013) showed that the low of milk consumption was caused by people that don't like the taste of milk and prefer soft drinks and other beverage. This indicate that milk consumption has to be improved by processing milk into a product, such as dessert.

Panna cotta is an Italian dessert made from heavy whipping cream, milk, gelatin and sugar then served cold. Panna cotta has the character resembles pudding with more soft gel, but it can maintain its shape when it was cut. One thing that make panna cotta different from the other dessert is it will melt in the mouth.

Panna cotta in Italia is made by heavy whipping cream and milk with the same ratio (1:1). This type of cream and the formula is less suitable to be applied in Indonesia because heavy whipping cream is

unavailable in Indonesia and people don't like thick cream. Replacement of heavy whipping cream with light whipping cream and change in light whipping cream-milk ratio into 1:9 were done to adjust panna cotta with the preference of panelist. This affected to the concentration of gelatin and sugar should be added. This change caused a decreased in fat content of 69,10% of the original formula thereby affected to the texture of panna cotta and give impact on the concentration of gelatin should be added.

Gelatin is protein extracted and processed by partial hydrolizing from collagen tissue in bone, cartilage and skin of animals (Karim, 2009). Gelatin in panna cotta play a role as gelling agent. Gelatin form thermoreversible gel at temperature below 35°C (Mariod dan Adam, 2013). Gelatin gel will melt when heated above the melting temperature, 27-34°C, thus gelatin gels tend to melt in the mouth (deMan, 1999).

According to deMan (1999), gel formation occurs in two stages process. ⁵ The first stage is denaturation of the native protein into unfolded polypeptides. ¹ The second stage is association of polypeptides to form gel matrix. ⁸ Gel formation is the phenomenon involving the association or cross-linking of the polymer chains to form a three dimensional network that traps or immobilises the water within it to form a rigid structure that is resistant to flow. ⁴ The associated regions known as junction zone, may be formed by two or more polymer chains. Junction zones are bound by weak hydrogen bonds (Saha and Bhattacharya, 2010).

The characteristic of gelatin gel is affected by concentration of gelatin. ⁴ As the concentration of gelatin increases, the rate of gelation also increases, thereby increasing the firmness (Mariod and Adam, 2013). If the concentration of the gelatin is too low, it will form a soft gel. This research used three levels of gelatin concentration, that are 1%; 1,25%; and 1,5%.

According to Weaver and Daniel (2003), gelatin gel is also affected by presence of another compound, such as sugar (sucrose). Sucrose is hygroscopic because thier polyhydroxyl group capable to form hydrogen bonds with water. This can interfere gelatin to trap water and affect to the characteristic of gelatin gel, so it should be determined the most appropriate concentration of sucrose for the best characteristic of panna cotta. This research used three levels of sucrose concentration, that are 2,5%; 5%; and 7,5%.

Various level in concentration of gelatin and sugar affect to characteristic of panna cotta. This become an underlying suspicion that there is interaction effect between concentration of gelatin and sugar to the characteristic of gelatin gel, therefore reasearch about effect of gelatin and sugar concentration on the characteristic of panna cotta should be done.

Materials and Methods

Materials

Light whipping cream, pasteurized milk and sugar are comercial products obtained from supermarket in Surabaya. Gelatin used for making panna cotta is bovine gelatin. Filter paper was used for syneresis analysis and mineral water for sensory analysis.

Instrument

Gas stove (*Rinnai*), refrigerator (*Electrolux*), weigher (*Acculab*), cylinder cup (volume 22 mL), spoon, stirrer, pan, thermometer 0-100°C, measuring cup 200 mL (*Iwaki Pyrex*) and beaker glass 250 mL (*Iwaki Pyrex*) were used for producing panna cotta. Cylinder cup (height: 4 cm, radius: 2 cm), analytical weigher (*Mettler Toledo*), spoon, weighing bottle, exicator, silica gel, Texture Analyzer (*TA-XT Plus*), thermometer infrared (IRtek IR 60), plastic container (10x15 cm), oven (*Binder*), refrigerator (*Electrolux*) and questionnaire were used for physic and sensory analysis.

Experimental Design

The research design was a factorial randomized block design that consisted of two factors: the concentration of gelatin (1%; 1,25%; and 1,5%) and the concentration of sugar (2,5%; 5%; and 7,5%) to obtain nine combination treatment and replicated three times. Data were analyzed using ANOVA test at $\alpha = 5\%$, if the results showed a significant effect, data were analyzed by Duncan's Multiple Range Test at $\alpha = 5\%$ to determine the combination treatment that gave a significant difference. Concentration of gelatin and sugar for the best panna cotta were determined by the highest score in sensory analysis.

Panna Cotta Making

Some of pasteurized milk were set aside to soak with gelatin in ratio 1:15 (gelatin:milk) for 15 minutes (mixture 1). The rest of pasteurized milk were cooked with light whipping cream and sugar until 70°C (mixture 2). Mixture 1 were blended to mixture 2 and were cooked until 70°C then stand for 1 minute. This mixture were pour into several cup size adjusted to the requirement for analysis. This mixture was cooling down until reached the room temperature to prevent condensation at the lid of the cup, then was setting in refrigerator at $\pm 5^\circ\text{C}$ for overnight.

Texture Analysis

Textural parameter (hardness) was measured by Texture Analyzer (Pang *et al.*, 2014) at $15 \pm 1^\circ\text{C}$. A 0,5" (12,7mm) radius cylindrical probe was used to penetrate the sample. Sample in the cylinder cup was put on the container filled by ice cube in order to maintain the temperature. This container were put under the probe, then probe will penetrate the sample and back to the initial position. Hardness was defined by the maximum peak force during the first compression cycle.

Syneresis with modification

Syneresis was measured by measuring the water expelled from the sample panna cotta which has been stored overnight in refrigerator at 5°C (Anggraini, 2008). Water expelled was measured by tilting the cylinder cup filled by sample, then the water was absorbed by the filter paper, then the weight of the water was measured. Syneresis was measured every day until seven days storage in refrigerator.

Sensory Characteristic

Sensory analysis were done using 9-point hedonic scale which score 1 for dislike extremely and score 9 for like extremely. This research was done by 80 untrained panelists to record their opinion about gel

firmness, ease to melt and ease to swallow. The test consisted of two steps, the first step for gel firmness and ease to melt, then the second step for ease to swallow. A new sample come from refrigerator was prepared for every steps.

Result and discussion

Hardness

Hardness is defined as the force that should be given to deform an object. Hardness is measured as the maximum peak force during the first compression cycle (Boume, 2002). The higher hardness, the more force needed to deform panna cotta, so it indicated the gel more firm. Hardness of panna cotta ranged from 8,684 g to 26,732 g as shown in Figure 1. The result indicated that interactions between gelatin and sugar concentration provided significant effect on hardness of panna cotta.

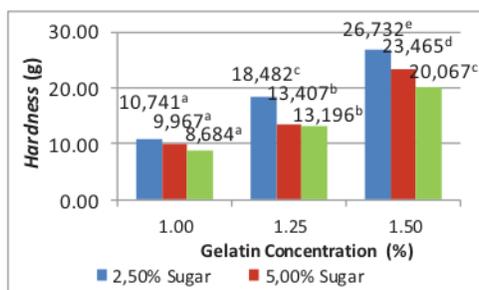


Figure. 1. Hardness of panna cotta as the function of gelatin and sugar concentration. Different superscripts letter indicate significant differences between samples ($\alpha = 5\%$).

The difference effect of gelatin concentration on hardness in every concentration of sugar indicated interaction between gelatin and sugar. Increasing concentration of sugar interfered gelatin gel formation because of competition of water available between gelatin and sugar. Increasing gelatin concentration caused increased in hardness, but when sugar concentration was increased, the increasing of hardness were declined. The higher concentration of sugar, the more water were bound therefore the less water available for gelatin. This caused gelatin gel weaken due to a lack of water available to maintain gel integrity. According to Choi (2004), sugar retarded gelatin gelation. The presence of sugar reduce gelation rate and prevent of gelatin chains from approaching each other kinetically during gelation because of increased viscosity. The movement of the protein aggregates were slow down in sugar system because increasing the viscosity. This may resulting in increasing distance between entangled points of the chain thereby decreasing the gel firmness.

Syneresis

The result showed that concentration of gelatin and sugar provided significant effects on syneresis of panna cotta respectively. Increasing concentration of gelatin caused decreased in syneresis because of the ability of gel to trap water in matrix system. The higher concentration of gelatin, the more matrix that can trap water therefore the less water expelled from gel during storage and impact on decreasing syneresis.

Increasing concentration of sugar caused more water will be bound by hydrogen bond. The higher concentration of sugar, the more water bound. This resulting decreased in water that has to be trapped by gelatin therefore the ability of gel matrix to retain water in it became higher therefore reduced the level of syneresis. Decreasing syneresis were also evidenced in the research done by Sugiarto (2011) which showed that the higher concentration of sugar in reeds jelly drink with the addition of carrageenan caused the amount of water expelled was reduced so that the syneresis.

Percentage syneresis of panna cotta also increased during storage. Syneresis occur due to the instability of gel matrix in trapping water. According to Glicksman (1983), the instability were caused by the formation of cross-linking between gelatin chains continuously during storage. This process caused gel shrank and loss of elasticity. As the result, the gel becomes brittle and loss the ability of trapping water. The percentage of syneresis was also increased due to the weakening ability of sugar in binding water in gel system during storage. Percentage syneresis of panna cotta can be seen in Table 1.

Table 1. Syneresis of Panna Cotta for 7 Days

Percentage of Syneresis on Day -	Gelatin (%)			Sugar (%)		
	1,00	1,25	1,50	2,50	5,00	7,50
1	0,077 ^c	0,070 ^b	0,059 ^a	0,076 ^c	0,069 ^b	0,062 ^a
2	0,097 ^c	0,080 ^b	0,058 ^a	0,087 ^c	0,079 ^b	0,069 ^a
3	0,324 ^c	0,240 ^b	0,215 ^a	0,291 ^c	0,264 ^b	0,232 ^a
4	0,673 ^c	0,609 ^b	0,357 ^a	0,592 ^c	0,544 ^b	0,503 ^a
5	1,411 ^c	0,994 ^b	0,634 ^a	1,109 ^c	1,006 ^b	0,875 ^a
6	1,952 ^c	1,336 ^b	0,769 ^a	1,467 ^c	1,332 ^b	1,259 ^a
7	2,542 ^c	1,729 ^b	1,209 ^a	1,968 ^c	1,812 ^b	1,700 ^a

Different manuscript letter in a row indicate significant differences between samples ($\alpha = 5\%$)

Sensory Characteristic

Hedonic score of panna cotta can be seen in Table 2. The results showed that increasing concentration of gelatin and sugar caused increasing in preference of panelists to gel firmness up to gelatin concentration levels of 1,25% and 5% sugar. Increasing concentration of gelatin above 1,25% with various concentration of sugar caused decrease in preference of gel firmness. The most preferred treatment was concentration of gelatin 1,25% and 5% sugar. This produce gel that were firm enough. Gelatin concentration above 1,25% in various concentration of sugar has a lower score. This treatment produced a rigid gel because the higher concentration of gelatin gave more intense intermolecular contacts and stronger protein-protein interaction. The use of gelatin concentration below 1,25% at various concentration of sugar also gave a lower score because it produced a very soft gel.

Score of ease to melt and ease to swallow were increased due to decrease in concentration of gelatin and increase in concentration of sugar. The highest score was obtained in 1% gelatin and 7,5% sugar. This treatment produced panna cotta that was melt easily inside the mouth. Cross-link formation of gelatin chains were not intense in low concentration of gelatin. It only formed a little entangled points of polypeptide chains, so the hydrogen bonds binding it were more easy to be break and gelatin gel were melt easily by heat in the mouth. High concentration of sugar also caused gel more easy to melt because sugar increased viscosity of the system. Cross-link formation in viscous system occurred slowly as

described before, therefore the entangled points were not intense and it caused gel more easy to melt.

Table 2. Hedonic Score of Panna Cotta

Attributes	Sample								
	A ₁ B ₁	A ₂ B ₁	A ₃ B ₁	A ₁ B ₂	A ₂ B ₂	A ₃ B ₂	A ₁ B ₃	A ₂ B ₃	A ₃ B ₃
Gel Firmness	4,34 ^a	6,23 ^{cd}	5,69 ^b	5,65 ^b	6,69 ^c	5,63 ^b	5,81 ^{bc}	6,55 ^{de}	6,08 ^{bc}
Ease to Melt	6,29 ^d	4,89 ^b	4,40 ^a	6,86 ^c	6,14 ^{cd}	5,08 ^b	7,43 ^f	6,49 ^{de}	5,78 ^c
Ease to Swallow	6,65 ^d	5,50 ^c	4,55 ^a	7,13 ^c	5,75 ^c	4,99 ^b	7,59 ^f	6,69 ^d	5,76 ^c
Total Score	17,28	16,62	14,64	19,64	18,58	15,70	20,83	19,73	17,62

A₁B₁ = 1% gelatin, 2,5% sugar; A₂B₁ = 1,25% gelatin, 2,5% sugar; A₃B₁ = 1,5% gelatin, 2,5% sugar; A₁B₂ = 1% gelatin, 5% sugar; A₂B₂ = 1,25% gelatin, 5% sugar; A₃B₂ = 1,5% gelatin, 5% sugar; A₁B₃ = 1% gelatin, 7,5% sugar; A₂B₃ = 1,25% gelatin, 7,5% sugar; A₃B₃ = 1,5% gelatin, 7,5% sugar. Different manuscript letter in a row indicate significant differences between samples ($\alpha = 5\%$)

Ease to swallow was related to gel firmness and ease to melt. Treatment of 1% gelatin and 7,5% sugar produced the softest gel therefore it was the most easy to swallow. Panna cotta with properties of the most easy to melt would undergo rapid change from solid to liquid so that it would have a tendency to flow and swallow easily in esophagus. Based on the highest score, the recommended treatment was 1% of gelatin and 7,5% of sugar.

Conclusion

Interactions between gelatin and sugar concentration provided significant effect on hardness of panna cotta. Increasing gelatin concentration caused an increased in hardness, but when sugar concentration was increased, the increasing of hardness were declined. Increasing concentration of gelatin and sugar caused a decreased in syneresis. Hedonic score of gel firmness was increased as increasing of gelatin and sugar concentration up to 1,25% gelatin and 5% sugar. Hedonic score of ease to melt and ease to swallow were increased as decreasing in gelatin concentration and increasing in sugar concentration. The treatment recommended was 1% gelatin and 7,5% sugar.

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