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Effect of Lecithin Addition and Conching Time on the Physicochemical Quality of Milk Chocolate Couverture

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A B S T R A C T

Couverture chocolate is a type of chocolate that uses a high percentage of cocoa butter to produce a better flavor. The method used was a completely randomized design (CRD) factorial pattern with two factors and two replicates. Factor I was lecithin concentration (0.5%; 0.7%; and 0.9%), and factor II was conching time (20 hours, 24 hours, and 28 hours). Data were analyzed using ANOVA and DMRT further test at the 5% level. The results of the study with the best treatment were obtained in the treatment combination of 0.9% lecithin concentration with a conching time of 28 hours which produced Milk Chocolate Couverture with a moisture content of 1.24%, fat content of 39.46%, melting point of 38oC, hardness 2.3 N, cohesiveness 0, 28, springiness 1.22 mm, gumminess 37.50 g, chewiness 0.22 mJ, color test (L* value 38.60, a* value 15.51 and b* value 47.66) and organoleptic test which includes color quality attributes 3.88 (neutral-like), aroma 3.76 (neutral-like), taste 4.04 (like) and texture 4.20 (like).

Contribution to Sustainable Development Goals (SDGs):
SDG 3: Good Health and Well-being
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

Cocoa is one of the plantation commodities that has an important role in economic activities in Indonesia. The amount of cocoa produced in Indonesia in 2022 reached 650,612 tons [1]. Cocoa is processed into various kinds of processed products, one of which is the chocolate bar. Chocolate is a solid suspension of small particles derived from cocoa paste and sugar (dark chocolate), from cocoa paste, sugar and milk powder (milk chocolate), or from cocoa butter, sugar and milk powder (white chocolate), in a continuous fat phase [2].

The problem in the chocolate industry is that the final product has an unstable quality. The unstable quality is found in the flavor and texture of the chocolate bar, making it less desirable to consumers.This is thought to be because in the manufacturing process the company has not added lecithin as an emulsifier. The hydrophilic and lipophilic nature of lecithin makes it widely used as an emulsifier in the food industry. Soy lecithin is one of the emulsifiers that can be used in food products. Soy lecithin is composed of a mixture of natural phospholipids of fat molecules formed during the processing of soybeans [3].

The second factor that causes unstable quality is the improper duration of the conching process. The quality of a chocolate bar is greatly influenced by the processing performed at each stage of its production. One of the critical stages in chocolate manufacturing is the conching process, which involves stirring, heating, and aerating the chocolate mass to produce a smooth texture, balanced flavor, and complex aroma. This process not only aims to homogenize the chocolate ingredients but also to remove volatile compounds. This process not only aims to homogenize the chocolate ingredients but also to remove unwanted volatile compounds and develop the flavor and aroma profile of the chocolate [4].

Lecithin is one of the natural emulsifiers whose use is widely applied in various industries. The composition of lecithin consists of three types of phospholipids such as phosphatidylcholine (PC), phosphotidylinositol (PI), and phosphatidylethanolamine (PE) [5]. Lecithin is known as an amphiphilic compound with a unique structure because it has polar and non-polar group parts. The polar part is called hydrophilic which is composed of phosphate esters, while the nonpolar part is lipophilic and composed of two fatty acid chains [6].

Emulsifiers such as lecithin are used to lower the interfacial tension between the two phases so that they can be emulsified and improve mixing so prevent fat bloom from occur. Emulsifiers are added in chocolate making to decrease the viscosity of the mixture so as to maintain the stability of the oil and water emulsion. In addition, emulsifiers can bind fat to the chocolate so that white spots will not occur. Emulsifiers can prevent the texture from melting. This is due to the dispersion of the ingredient fat with the air cell structure, which results in a hard and dry texture character. The structural properties of chocolate can be influenced by the addition of emulsifiers so that it will affect the level of consumer preference for the texture and taste of chocolate [7].

The addition of 1-3 g/kg soy lecithin led to a viscosity reduction equivalent to the addition of 10 times cocoa butter, so the addition of lecithin was effective in reducing production costs by saving the use of cocoa butter [8].

Conching is a unit operation based on the agitation of the chocolate mass at high temperatures (above 50°C) and is an essential step for the development of the right viscosity and the achievement of the final texture and flavor [10] & [11]. It is an important process that contributes to the development of viscosity, final texture, and flavor. During conching, a process achieved by long-term exposure to heat, oxygen, and agitation, volatile acids and most of the residual water are evaporated, and the viscosity of the chocolate decreases [9].

Conching is recommended for chocolate making at temperatures below 50°C to avoid maillard reaction. Conching plays an important role in chocolate flavor formation due to the removal of unwanted volatile compounds, the moisture content of the chocolate, and most importantly, it reduces the particles in the chocolate batter [30].

The conching process is divided into three stages: dry phase, pasty phase, and liquid phase. During the dry and pasty stages, the water content of the material is evaporated along with unwanted volatile compounds from the cocoa beans. The relatively high temperature of the conching process also causes many chemical reactions to take place that lead to changes in the flavor pattern of the chocolate. In the liquid phase, the remaining fat and other additives are added to make the chocolate fully liquid [4].

The combination of appropriate soy lecithin addition and optimal conching time can result in smooth chocolate texture, appropriate viscosity and balanced flavor. Another study by [12] highlighted that the addition of soy lecithin not only affects the rheology of the chocolate mass, but also influences the aeration process during conching, which in turn contributes to the formation of complex aromas and flavors.

Therefore, this study aims to explore how the combination of these two factors can affect the moisture content, fat content, melting point, and texture of milk chocolate couverture. This research aims to determine the effect of different combinations of lecithin addition and conching duration without compromising product quality. By studying the relationship between the amount of soy lecithin, conching duration and the final quality of the chocolate bar, it is hoped that this research can make a significant contribution to the development of more efficient and high quality chocolate production technology.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in the manufacture of products in this study are cocoa paste, cocoa butter, milk powder, sugar, and soy lecithin The material used for analysis is petroleum ether.

2.2. Research Procedures

This research was conducted in a completely randomized design (CRD) with two treatment factors. The first factor used was different concentrations of lecithin (0.5%; 0.7%; and 0.9%). The second factor was the length of time in the conching process (20 hours, 24 hours, and 28 hours). The data obtained were then analyzed using Analysis of Variance (ANOVA) at the 5% confidence level to determine any significant differences. If there is a significant difference between treatments, further tests are carried out using the DMRT (Duncan't Multiple Range Test) method at the 5% level.

2.3. Preparation of Chocolate Paste

Nibs that have gone through the peeling and breaking process are then roasted using a roaster machine at 100°C for 1 hour. After roasting, the nibs were ground to a coarse paste. Then, the coarse paste is pulverized using a ballmill machine at 40°C for 2 hours until it becomes a smooth paste.

2.4. Making Chocolate Bars

Smooth cocoa paste was mixed with sugar, cocoa butter, and milk powder until homogeneous. Soy lecithin was added according to the research variables 0.5%; 0.7%; 0.9% and mixed until homogeneous. The chocolate paste was candled at 45°C for 20 hours, 24 hours, 28 hours. Then, the temperature was adjusted on the chocolate paste. Finally, the chocolate paste was poured into molds and frozen into chocolate bars

3. RESULT AND DISCUSSION

3.1. Moisture content

Moisture content in chocolate products affects the quality of appearance, flavor, and texture. Chocolate ideally has a low moisture content, the decrease in moisture content occurs during the process of chocolate refining, heating, and conching [31].

ANOVA showed that there was no significant interaction ($P > 0.05$) between lecithin concentration and conching time on the moisture content of Milk Chocolate Couverture.

Table 1 shows the effect of lecithin addition and conching time. The lower concentration of lecithin and the longer conching caused the moisture content of Milk Chocolate Couverture to decrease. The water content decreased due to the length of the conching process causing the water content to decrease because in the conching process, heating occurs which causes the water content to evaporate. This is also related to the function of the conching process in chocolate processing, where the purpose of the conching process is to remove water contained in chocolate [13].

Table 1. Analysis Results of Moisture Content, Fat, and Melting Point of Milk Chocolate Couverture

Samples (Lecithin : Conching)	Moisture Content (%)	Fat (%)	Melting Point (°C)
0.5% : 20 h	1.29 ± 0.01	32.23 ± 0.16	35.5 ± 0.70
0.5% : 24 h	1.18 ± 0.06	33.25 ± 0.13	35.5 ± 0.70
0.5% : 28 h	1.07 ±0.05	33.49 ± 0.16	36 ± 0.70
0.7% : 20 h	1.21 ±0.004	35.20 ± 0.10	36 ± 0.70
0.7% : 24 h	1.19 ± 0.13	35.22 ± 0.37	37 ± 0.70
0.7% : 28 h	1.18 ±0.02	35.72 ± 0.04	37.5 ± 0.70
0.9% : 20 h	1.32 0.06	38.40 ± 0.01	37.5 ± 0.70
0.9% : 24 h	1.27 ± 0.20	38.88 ± 0.16	38 ± 0.70
0.9% : 28 h	1.24 ± 0.04	39.46 ± 0.15	38 ± 0.70

However, the higher concentration of lecithin added caused the moisture content of Milk Chocolate Couverture to increase. Lecithin has more hydrophilic groups than hydrophobic groups. Hydrophilic groups have the property of binding water. The higher the concentration of lecithin added, the higher the availability of hydrophilic groups from lecithin that play a role in binding water. This condition causes water to be bound and difficult to evaporate so that the water content increases as the concentration of lecithin increases [14].

3.2. Fat Content

In the chocolate-making process, other ingredients such as cocoa powder particles, sugar, temperature will be bound by a layer of fat. This condition will affect the quality of the fat quality produced. The fat content contained in chocolate ranges from 31.3-52.6% [32]. ANOVA showed that there was a significant interaction ($p \leq 0.05$) between lecithin concentration and conching time, where each treatment had a significant effect on the fat content of Milk Chocolate Couverture**.**

The higher the addition of lecithin concentration and the longer the conching time causes the fat content of Milk Chocolate Couverture to increase, which can be seen in **Table 1**. This is due to the presence of hydrophobic groups in lecithin which function as fat binders to increase the fat content of chocolate. Lecithin has two types of groups and one of them is a hydrophobic group which is two fatty acid chains with non-polar properties. The two fatty acid groups in lecithin form a lipophilic part that has a high affinity for fat [15].

The conching process also affects the increase in fat content in the product, this is because in the conching process there is stirring and heating which causes the solid particles contained in the product to be covered by fat. This is in line with the statement of [16] and [17] that in the conching process cocoa powder, sugar and milk powder particles will be bound and well covered by a layer of fat.

3.3. Melting Point

Melting point is one of the important physical properties to determine the quality of chocolate and to determine the right storage technique. This will affect consumer preference when consuming chocolate [33]. ANOVA showed that there was no real interaction and no significant effect ($p > 0.05$) on the conching time, but the lecithin concentration treatment gave a significant effect ($p \leq 0.05$) on the melting point of Milk Chocolate Couverture.

Table 1 shows that the higher the addition of lecithin concentration and the longer the conching time causes the melting point of Milk Chocolate Couverture to increase. The higher melting point of the chocolate is due to the stability of the chocolate crystals that form with the addition of lecithin. Melting point is an important parameter in determining the quality of chocolate products, chocolate with good quality is chocolate that does not melt quickly at room temperature [18].

The longer the conching time, the smaller the particle size of the chocolate. When the particle size is smaller, the crystals formed will become denser. This condition results in the stabilization of the chocolate crystals resulting in an increase in the melting point of the chocolate [19].

3.4. Hardness

Hardness is one of the main textural quality parameters of chocolate. The right hardness determines the resistance to physical damage and temperature changes [34]. ANOVA showed that there was a significant interaction ($p \leq 0.05$) between lecithin concentration and conching time, where each treatment had a significant effect on the hardness of Milk Chocolate Couverture.

Table 2 shows that the higher the addition of lecithin concentration and the longer the conching time caused an increase in the hardness value of Milk Chocolate Couverture. This indicates that lecithin acts as a good emulsifier because it produces a compact chocolate. The addition of lecithin to chocolate formulations is useful to control flow properties and alter the rate of fat crystallization. The lecithin formulation must be optimal to produce the flow properties

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and crystallization rate that will determine most of the chocolate hardness [8].

Conching increases the hardness of the chocolate due to a decrease in particle size. The particle size is inversely proportional to the hardness of the chocolate, where chocolate with a smaller particle size has a higher hardness. The smaller particles that result in increased hardness occur as a result of interactions between the chocolate particles [20].

3.5. Cohesiveness

Cohesiveness is an empirical property that is often determined using Texture Profile Analysis (TPA) through compression tests [21]. ANOVA showed that there was no significant interaction (p>0.05) but the treatment of lecithin concentration and conching time each had a significant effect (p≤0.05) on the cohesiveness of Milk Chocolate Couverture.

Table 2. Analysis Result of Hardness, Cohesiveness, Springiness, Gumminess, and Chewiness of of Milk Chocolate Couverture

Samples (Lecithin : Conching)	**Texture**				
	Hardness (N)	**Cohesiveness**	**Springiness (mm)**	**Gumminess (g)**	**Chewiness (mJ)**
0.5% : 20 h	1.759 ± 0.05	0.11 ± 0.01	0.87 ± 0.02	24.3 ± 0.14	0.44 ± 0.05
0.5% : 24 h	1.93065 ± 0.02	0.13 ± 0.02	1 ± 0.01	25.7 ± 0.98	0.4 ± 0.07
0.5% : 28 h	1.99775 ± 0.02	0.16 ± 0.01	1 ± 0.07	28.5 ± 0.28	0.36 ± 0.01
0.7% : 20 h	2.13155 ± 0.01	0.16 ± 0.02	1.01 ± 0.01	29.6 ± 0.28	0.33 ± 0.01
0.7% : 24 h	2.14115 ± 0.02	0.195 ± 0.02	1.09 ± 0.01	30.9 ± 0.56	0.32 ± 0.01
0.7% : 28 h	2.2135 ± 0.01	0.21 ± 0.01	1.09 ± 0.01	32 ± 0.42	0.32 ± 0.02
0.9% : 20 h	2.2391 ± 0.01	0.24 ± 0.01	1.15 ± 0.01	32.2 ± 0.14	0.28 ± 0.01
0.9% : 24 h	2.2467 ± 0.08	0.25 ± 0.01	1.21 ± 0.01	33.2 ± 0.28	0.24 ± 0.02
0.9% : 28 h	2.37985 ± 0.04	0.28 ± 0.02	1.22 ± 0.02	37.5 ± 0.56	0.22 ± 0.01

Table 2 shows that a higher the addition of lecithin concentration and the longer the conching time causes an increase in the cohesiveness value of milk chocolate couverture. The increase in cohesiveness value is because the addition of lecithin helps emulsify the fat and liquid in the chocolate, resulting in a more even distribution of fat, with an increase in cohesiveness value making the chocolate denser, less brittle, and easier to cut without breaking. This is because lecithin emulsifiers can act to form fat networks that are more cohesive, denser and with more homogeneous polymorphs [8].

The longer the conching process, the smaller the particle size. The increased cohesiveness of chocolate is due to the reduction in particle size during conching. A shorter conching process results in a larger particle size, which can reduce the cohesiveness because the particle size is evenly distributed and the smaller particles fill the space between the larger particles, reducing the cohesiveness of the chocolate.

3.6. Springiness

Springiness is the ability of a material or product to return to its original shape when given a force, then the force is released again [22]. ANOVA showed that there was no significant interaction (p>0.05) but the treatment of lecithin concentration and conching time each had a significant effect (p≤0.05) on the springiness of Milk Chocolate Couverture.

Table 2 shows that the higher lecithin concentration and the longer conching time cause an increase in the springiness value of milk chocolate couverture. The increase in springiness value is because the addition of lecithin can reduce friction between particles and increase the bond between chocolate particles, which contributes to elastic properties, so that the higher addition of lecithin causes the springiness value of chocolate to increase.

The increase in springiness value is because during the conching process the cocoa butter is evenly distributed around the solid particles, reducing the particle size. Smaller particles and an even distribution of fat help to create elastic properties in chocolate. Longer conching times can affect the particle size of chocolate. The particle size of the chocolate gets smaller the longer the conching time, resulting in the chocolate having a wider particle surface and thus continuous contact and interaction between particles. This condition will then increase the springiness value of the chocolate [20].

3.7. Gumminess

Gumminess is the energy required to chew a semi-solid food to the swallowed state and is numerically expressed as the result of hardness and compactness values [21]. ANOVA showed that there was a significant interaction (p≤0.05) between leisitin concentration and conching time, where each treatment had a significant effect on the gumminess of Milk Chocolate Couverture.

Table 2 shows that the higher lecithin concentration and the longer the conching time caused an increase in the gumminess value of Milk Chocolate Couverture. The addition of lecithin is thought to increase the gumminess value [23]. This is related to the fat contained in the ingredients, where fat shows a very significant effect on gumminess [24]. In line with the nature of lecithin, which has two types of groups, one of these groups is a hydrophobic group with non-polar properties. Hydrophobic groups in lecithin can form lipophilic parts that have a high affinity for fats [15].

The gumminess value increased significantly at a conching time of 28 hours, this is because the conching time that lasts longer affects the particle size. The longer the conching time, the smaller the particles produced. This condition causes an increase in the gumminess value. In addition, the gumminess of chocolate is also influenced by its hardness so that the harder the chocolate, the chewier the chocolate. The increase in gumminess is also in line with hardness, where the higher the hardness value of the chocolate, the higher the chewiness level of the chocolate.

3.8. Chewiness

Chewiness is the energy required to chew food finer. The greater the chewiness value, the tighter the food matrix and the more difficult it is to crush, requiring greater chewing power [25]. ANOVA showed that there was no significant interaction ($p>0.05$) but the treatment of lecithin concentration and conching time each had a significant effect ($p\leq0.05$) on the chewiness of Milk Chocolate Couverture.

Table 2 shows that the higher lecithin concentration and the longer conching time cause a decrease in the cohesiveness value of milk chocolate couverture. The decrease in chewiness value is because the addition of lecithin can reduce the viscosity of chocolate, resulting in a smoother and easier-to-chew texture. Lecithin has more hydrophilic groups than hydrophobic groups. The lower the concentration of lecithin, the lower the hydrophilic groups so that less water is bound and can cause an increase in chewiness value [14].

The longer the conching of Milk Chocolate Couverture, the lower the chewiness. This is related to the fat contained in food ingredients. Chewiness characteristics can be influenced by fat content. Fat can be oxidized especially in processing using high temperatures [26]. High temperatures will increase the reaction rate of chemical compounds contained in the product. Temperatures above 40°C can trigger oxidation reactions. Conching that lasts for a long time followed by high temperatures can affect the fat of the ingredients, the longer conching can cause fat oxidation and then reduce the chewiness value [27].

Table 3. Milk Chocolate Couverture Color Test Results

Treatment (Lecithin : Conching)	Color		
	L	a*	b*
0.5% : 20 h	37.745 ± 0.04	13.905 ± 0.04	45.205 ± 0.21
0.5% : 24 h	37.9 ± 0.09	14.575 ± 0.09	45.795 ± 0.14
0.5% : 28 h	38.035 ± 0.10	14.665 ± 0.07	45.905 ± 0.27
0.7% : 20 h	38.145 ± 0.06	15.155 ± 0.06	46.12 ± 0.28
0.7% : 24 h	38.25 ± 0.04	15.29 ± 0.07	46.57 ± 0.45
0.7% : 28 h	38.41 ± 0.05	15.485 ± 0.07	46.82 ± 0.41
0.9% : 20 h	38.48 ± 0.02	15.475 ± 0.04	46.92 ± 0.60
0.9% : 24 h	38.545 ± 0.02	15.495 ± 0.07	47.46 ± 0.62
0.9% : 28 h	38.6 ± 0.08	15.515 ± 0.09	47.66 ± 0.43

3.9. Milk Chocolate Couverture Color

Color is an important parameter in determining food quality, this is because color is the first impression for the sense of sight for consumers. Attractive colors will attract consumer tastes to try the product. Table 3 color parameters L* values range from (37.74 - 38.6), a* ranges from (13.90 - 15.51), and b* ranges from (45.20 - 47.66).

Lightness is a color parameter for brightness with a scale of 0-100. A value of 0 is an indicator of black color, while a color of 100 is white color. ANOVA showed that there was no significant interaction ($p>0.05$) but the treatment of lecithin concentration and conching time each had a significant effect ($p\leq0.05$) on the lightness of Milk Chocolate Couverture.

Table 3 shows that the higher the addition of lecithin concentration and the longer the conching time causes an increase in the lightness value of milk chocolate couverture. This happens because lecithin helps distribute the cocoa butter evenly throughout the mixture. Homogeneous cocoa butter gives a brighter surface appearance.

The a* value with a range of values from 0 to 80 for red chromatic colors and the *a value with a range of values from -80 to 0 for green chromatic colors [28]. ANOVA showed that there was a significant interaction ($p\leq0.05$) between lecithin concentration and conching time, where each treatment had a significant effect on the redness of Milk Chocolate Couverture.

According to the a* results in the study, it shows that Milk Chocolate Couverture is still in the reddish brown color range. The reddish color produced is due to a combination of lecithin concentration and conching time. Lecithin contains amine groups and will react with sugar and then cause the Maillard reaction when exposed to heat [29]. It is known that the conching process involves heating (>50ºC) [20]. This causes the reddish brown color of Milk Chocolate Couverture to appear.

The b* value indicates the chromatic color of the blue to yellow mixture with a range of 0 to 70 for yellow and a value of -70 to 0 for blue. The higher the value obtained means the higher the level of yellowish color in the product [28]. ANOVA showed that there was no significant interaction ($p>0.05$) but the treatment of lecithin concentration and conching time each had a significant effect ($p\leq0.05$) on the yellowness of Milk Chocolate Couverture.According to [29] in their research, lecithin emulsifiers gave the highest value to the yellowness of the product. Lecithin has a yellow-brown color so the higher the addition, it can affect the yellowness of the ingredients.

4. CONCLUSION

Lecithin addition and conching time in milk chocolate couverture showed a significant interaction ($p\leq0.05$) on the treatment of fat content, color (a*), hardness, gumminess, organoleptic parameters of taste and texture. However, it did not interact

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significantly with the parameters of moisture content, melting point, cohesiveness, springiness, chewiness, and organoleptic parameters of aroma and color of Milk Chocolate Couverture.

Milk chocolate couverture with 0.9% lecithin addition and 28 hours conching time is the best treatment with 1.24% moisture content, 39.46% fat content, melting point 38ºC, hardness 2.3 N, cohesiveness 0.28, springiness 1.22 mm, gumminess 37.50 g, chewiness 0.22 mJ, color test (L* value 38.60, a* value 15.51 and b* value 47.66).

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