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Effect of inulin on physiochemical and sensory products cocoa liquor and milk chocolate from cocoa beans local south sulawesi: Indonesia

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Abstract
Changes in the composition of cocoa nibs fermentation and without fermentation that is fortified with inulin to study the physicochemical properties of milk chocolate products produced. This research aims to produce milk chocolate products that can be received by consumers and determine the physicochemical properties of cocoa liquor products and milk chocolate. Milk chocolate products with the composition of cocoa beans fermentation and without fermentation in a comparison of 100:0 without the addition of inulin, 80:20 and 60:40 with the addition of Inulin 2, 4, and 6 %, analyzed with ANOVA *(Analysis of Variance).* Milk chocolate products derived from cocoa nibs fermentation and without fermentation on various compositions with the addition of inulin 2-6% acceptable to consumers, with a safe iron mineral content to consume. Low viscosity cocoa liquor value due to a reduced amount of cocoa fermentation nibs is 50,15 ± 0.05 poise (C1) and the addition of inulin to milk chocolate products significant effect on increasing the value of viscosity so that it affects Hardness value of milk chocolate products are 3970.685 Force (kg) (B 1.3). Milk chocolate products with the addition of prebiotic inulin 2-6% do not show a significant difference to the melting point increase of 32.97 °C (C1.3) but has a significant influence on the change in the value of L* 37,69 ± 0,410 (B 1.3) and increasing value a* and b* 17,29 ± 0,537 (B 1.3).

Keywords: cocoa liquor, fermentation, inulin, milk chocolate, physicochemical properties

1. Introduction

Cocoa *(Theobroma Cacao)* is a top commodity in South Sulawesi. The area of cocoa development in Sulawesi in 2009 reached 953,691 ha with a production of 427,200 tons. Sulawesi can donate the national cocoa needs by 60% of the total national demand of 712,000 tons. The island of Sulawesi, Indonesia, has contributed significantly to the production of cocoa beans for more than a decade. The intensive and extensive development of this plant has been carried out progressively from harvesting to post-harvest stages (Suwastika *et al*., 2015) [28]. Currently, cocoa processing in Indonesia becomes a deficient food product with a variety of quality. It was reflected in the price of Indonesian chocolate products are relatively low when compared with the price of the same chocolate product from another manufacturer's country. One of the reasons is the quality of Indonesian cocoa beans, especially Sulawesi, which is below the quality of the Ivory Coast and Ghana. The fermentation process is not perfect or not fermented. The unfermented cocoa beans contain various compounds of polyphenols in the form of monomers-monomer flavanol (Epikatekin and Catechine) and pro-Cyanidin oligomers (dimer and Dekamer) with varying concentrations (Arteel & Sies, 1999 [5]; Sanbongi *et al.,* 1998) [26].

Chocolate products are experiencing development with variations in the form of functional additives such as inulin, premixed vitamin B6, B12, folic acid and (L-Carnitine when needed) on chocolate. The chocolate industry manufactures products that raw materials derived from cocoa beans of various regions. South Sulawesi as the center of Cocoa production, has an undeveloped processing industry. It was reflected from the commercial chocolate products that are mostly manufactured from outside the area of South Sulawesi, even imported from some countries such as Singapore, Malaysia, and Europe. Inulin functional additives are carbohydrates that cannot be digested by digestive enzymes so that it reaches the colon without experiencing structural changes and can selectively stimulate the growth and activity of the bacteria Beneficial in the digestive tract (Gibson, Probert, Loo, Rastall, & Roberfroid, 2004 [25]; Gibson & Roberfroid, 1995) [11]. Chocolate is one of the best food in the market because it tastes sweet, and texture melted when in the mouth. Generally, chocolate products have a high content of sugar and fat but minimal fiber.

Some chocolate producers add inulin to increase the fiber content in cocoa products and fats as raw material to better quality chocolate (Cardarelli, Aragon-Alegro, Alegro, De Castro, & Saad, 2008) [7]. According to (Shoaib *et al*., 2016) [27], Inulin is a natural food ingredient that can be found in many plants such as wheat, shallots, bananas, garlic, and chicory plants *(Chicorium intybus)*. According to (Niness, 1999b) [19], it was found the fact that the average American community consumed inulin and oligofructose as much as 1-4 grams per day and the average European Community consuming inulin and oligofructose as much as 3-10 grams per day. In general, Inulin and Oligofructose are widely used in the food industry lately derived from chicory plant root extracts. The roots of the chicory plant contain 15-20% inulin and 5-10% oligofructose. The powder-shaped inulin has a sugar content of 6-10%, which includes glucose, fructose, and sucrose. Inulin can stabilize water into a creamy structure, but with the same flavor as fat. Using Inulin in small quantities also allows manufacturers to enhance the flavor and texture of low-fat products that refer to increased taste in the mouth (M. Roberfroid, 2002) [24].

Inulin is prebiotic that the prebiotic is a non-digestible (indigestible) foodstuff that has beneficial effects by stimulating healthy bacterial growth that naturally lives in the intestines. So inulin beneficial to the body (Niness, 1999a) [18].

Inulin is the most widely used prebiotic as a functional foodstuff because it provides the most excellent prebiotic effect compared to other prebiotics (Rastall & Gibson, 2015) [22]. Legally inulin has become a daily prebiotic diet that is mostly used by residents and as a prebiotic component that can be supplemented in foodstuffs without any minimum permissible concentration limits (Loo, Coussement, De Leenheer, Hoebreg, & Smits, 1995 [17]; Marcel Roberfroid, 2004) [25]. Based on the potential of cocoa and excess inulin, it is necessary to do applied research by producing and evaluating the quality of milk chocolate made from the composition of cocoa fermentation and without fermentation that is fortified with inulin prebiotic. The cocoa beans used are from Soppeng, South Sulawesi province. The composition of fermented cocoa and without fermentation as raw material as well as the addition of food, fiber inulin in the manufacture of milk chocolate is expected to add the functional properties of milk chocolate so it not only has a strong flavor but can Beneficial to health *(healthy food).* The objective of our study was to determine physicochemical properties (viscosity, melting point, the mineral content of iron, color, and texture) and sensory acceptability properties of products cocoa liquor and milk chocolate. Organoleptic properties of the cocoa liquor and milk chocolate were also evaluated during the storage, use different from the control test method.

2. Material and Methods

2.1 Material

The chocolate samples evaluated in this study were made and kindly supplied by Cocoa varieties Forastero from Soppeng Regency, South Sulawesi, Indonesia. All samples were made of white chocolate with skim milk, lecithin, cocoa fats from Mars Symbioscience Company (Makassar, South Sulawesi, Indonesia), inulin from Cosucra Company (Warcoing, Belgium), and sugar in this order. All samples were made of inulin, fermented cocoa beans, and cocoa beans without fermentation in this order. Enrichment ingredients and their addition to plain milk chocolate are listed in Table 1.

Table 1: Basic composition of products milk chocolates

	Code Samples	Inulin (%)	Fermented Cocoa Beans (%)	Cocoa Beans Without Fermentation (%)
1	A1.1	0	100	0
2	B1.1	2	80	20
3	B1.2	4	80	20
4	B1.3	6	80	20
5	C1.1	2	60	40
6	C1.2	4	60	40
7	C1.3	6	60	40

Legend: Sample A1.1 (0% of inulin, 100% of fermented cocoa beans, and 0% of without fermentation), sample B1.1 (2% of inulin, 80% of fermented cocoa beans, and 20% of without fermentation), sample B1.2 (4% of inulin, 80% of fermented cocoa beans, and 20% of without fermentation), sample B1.3 (6% of inulin, 80% of fermented cocoa beans, and 20% of without fermentation), sample C1.1 (2% of inulin, 60% of fermented cocoa beans, and 40% of without fermentation), sample C1.2 (4% of inulin, 60% of fermented cocoa beans, and 40% of without fermentation), sample C1.3 (6% of inulin, 60% of fermented cocoa beans, and 40% of without fermentation).

2.2 Methods

Determination of viscosity

The viscosity of the melted chocolate samples was obtained by fitting shear stress and shear rate values using the Casson fitting model (Glicerina, Balestra, Dalla Rosa, & Romani, 2016) [12].

Determination of melting point

Tempering method DSC-60 Plus Series Shimadzu**.** Approximately 70 g of a samp milk chocolate bar, was melted in the empty cup at 50°C, and the inner bob was gradually lowered. Once the chocolate had fully melted, and the inner bob was correctly positioned, the motor was switched on, and the motor speed adjusted to the prescribed rotational speed.

Determination of iron mineral content

The primary elements, like iron, were determined by AAS *(Atomic Absorption Spectrophotometry)* method. This test is a measurement of iron in milk chocolate in the method of AAS in the range of Fe 0.3-6.0 mg/L and wavelengths 248.3 (Rehman & Husnain, 2012) [23].

Product evaluation Colour analysis of food products

Colour lightness of the chocolate samples was measured Hunter method (as L, a, and b value) in triplicate with a Minolta Chroma CR-400 (Minolta Co, Osaka, Japan) (Zhu *et al*., 2009) [30].

Texture measurement of developed food products

The TA evaluated the texture of the developed products.XT Plus Texture Analyzer (Stable Micro Systems, Surrey, UK), according to the standard method AACC (74-09), expressed as the hardness of the *milk chocolate*. Hardness of the chocolates was measured (as a maximum peak force in newtons) using a TA-XT2 texture analyzer (Texture Technologies Corp, Scarsdale, NY) equipped with a steel cylinder (5mm in diameter, 47mm in length), set at a speed of 1mm s^{-1} and to a penetration depth of 5mm (two replications per sample).

Sensory evaluation of food products

We are using Sensory analysis methods, Difference from Control Test. The panelist is presented with 1 (one) Control sample (R) and 7 (seven) samples as a test, and 1 Control sample is treated as a blind control test sample. A panel of skilled evaluators assessed the samples with a 9-point scale (1- Very, very good taste of R, 2-Very better taste of R, 3- Flavors better than R, 4- Taste somewhat better than R, 5- Taste as good as R, 6- Taste somewhat worse than R, 7- Taste worse than R, 8- Taste very worse than R, and 9- Very bad taste of R). For the sensory evaluation of the samples *milk chocolate*, we used a point test that examines each designated descriptor in general or as partial properties (hardness, softness, etc.) — a number of the panelists used as many as 37 people. The results of the sensory analysis were processed using the sensometric methods used - calculating the standard deviation and the mean values.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) followed by *Duncan's Multiple Range*, with a significance level of 0.05. All analysis was performed using the statistical program Statistical Package for the Social Sciences (SPSS) version 17.0 (International Business Machines Corporation, New York, NY, USA).

3. Results and Discussion

Viscosity

The rheological properties of molten chocolate are important for confectionery quality assurance andaccurate weight measurements. The manufacture of chocolate products begins with grinding nibs into cocoa liquor as a semi-productive in the liquid phase (Afoakwa *et al*., 2009) [3]. One parameter that determines the characteristics of chocolate products is the viscosity of cocoa liquor. Table 2 shows the viscosity value of cocoa liquor resulting from a comparison of the fermented cocoa nibs composition and without fermentation (Fig.1). Data Table 2 showed that the value of cocoa liquor viscosity decreased with a decrease in the number of fermented cocoa nibs. The phospholipid content in cocoa butter affects viscosity. Decreasing the amount of cocoa beans fermentation in cocoa liquor causes a decrease in the amount of fat thereby increasing the viscosity value. The viscosity is reduced by the rise of phospholipids in cocoa butter. Gross fat content (crude fat) fermented cocoa beans amounting 22 ± 0.10% and cocoa beans without fermentation of 6 ± 0.07%

Table 2: Viscosity of cocoa liquor in the composition of cocoa nibs at 50ºC

No	Sample	Average viscosity value (Poise)
1	A1	40,631±0,03
2	B1	46,46±0,042
3	C1	50,15±0,05

The difference in the viscosity of cocoa liquor is significantly less influential in milk chocolate products produced. Inulin food Additives added as a functional ingredient food is a component that significantly affects the viscosity of the product. It is indicated by a very high viscosity milk chocolate so that the viscosity value of the viscometer Brookfield tool is not measured (non-determinated). Table 3 shows the viscosity value of milk chocolate products on various cocoa nibs compositions and the addition of inulin. According to (Homayouni Rad, Delshadian, Arefhosseini, Alipour, & Asghari Jafarabadi, 2012) [13], the addition of the amount of inulin in milk chocolate can significantly increase the viscosity. The addition of Inulin from 0 to 8%, significantly increases the total solids, total soluble, viscosity and sensory scores. In addition to the effect of viscosity, food products (dark chocolate) containing the concentration inulin 25 to 100% can increase the moisture content of dark chocolate. Conversely, the presence of inulin compounds in dark chocolate can decrease the value of water activity (a_w) through the binding of the water molecules so that the moisture content is freely reduced. The viscosity of a fluid is a trait that indicates large and small prisoners in the fluid against friction. Friction between the spindle surfaces of the appliance with fluid determines the viscosity fluid level.

A B

Fig. 1: Appearance of cocoa beans with and without fermentation. (A - fermented cocoa beans; B - Cocoa beans without fermentation)

Table 3: Viscosity milks chocolate products on various cocoa nibs compositions and the addition of inulin

No	Sample	Average viscosity value (Poise)
1	A1.1	65,37±0,028
2	B1.1	Cannot be determined
3	B1.2	Cannot be determined
4	B1.3	Cannot be determined
5	C1.1	Cannot be determined
6	C1.2	Cannot be determined
7	C1.3	Cannot be determined

Melting point

A melting point of chocolate is a specific temperature range when the chocolate melts entirely. The initial melting point is the temperature when the first drip occurs fat. While the final melting point is the temperature when the whole fat has melted perfectly (Beckett, 2008) [6]. Afoakwa *et al*., (2008) [2], concluded that largest particlesize and solid-specific surface area are the two keyparameters for chocolate manufacture. The former determines chocolate coarseness and textural character,while the latter evaluates chocolate desirable flow properties. rheological properties are important in chocolate manufactur-ing for quality-control purposes and can be related tocomposition, processing strategy and solid particle sizedistribution (Afoakwa, 2016) [1].

Table 4: Melting point milks chocolate products

No	Sample	Melting point (°C)
1	A1.1	31,56
2	B1.1	28,50
3	B1.2	30,24
4	B1.3	31,27
5	C1.1	31,51
6	C1.2	31,65
7	C1.3	32,97

Table 5: Chocolate crystal type (Lipp & Anklam, 1998) [16].

Crystal	Melting point	Description
I	13,1°C	Soft, Crumbly, melts too easily
II	17,1 °C	Soft, Crumbly, melts too easily
III	22,4°C	The firm, poor snap, melts too easily
IV	26,4°C	The firm, good snap, melts too easily
V	30,7°C	The glossy, firm, best snap, melts near body temperature
VI	33,8°C	Hard, takes weeks to form

The results showed that the lowest melting point is 28,85°C, which is below room temperature is there in milk chocolate samples B1.1 milk chocolate products from comparison nibs fermentation and without fermentation 80:20 with the addition of 2% Inulin. While the highest melting point is 32,97° C on sample C1.3 milk chocolate products from comparison nibs fermentation and without fermentation 60:40 with the addition of 6% inulin, these results can be seen in Fig. 2 and 3 curve DSC *(Differential Scanning Calorimetry).*

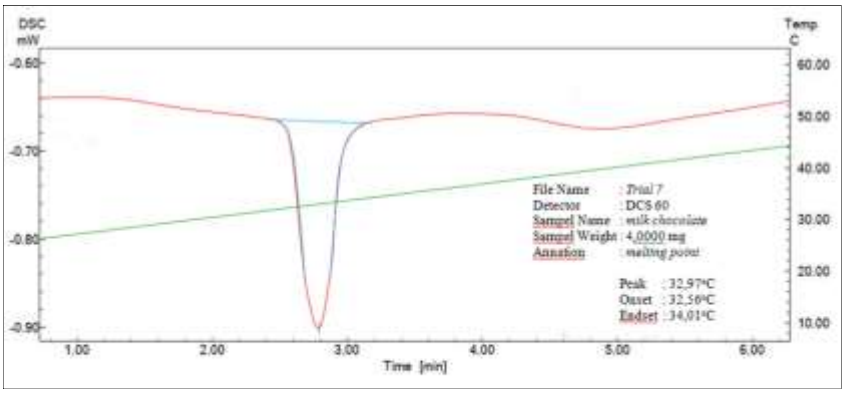


Fig 2: Curve DSC *(Differencial Scanning Calorimetry)* milk chocolate sample C1.3

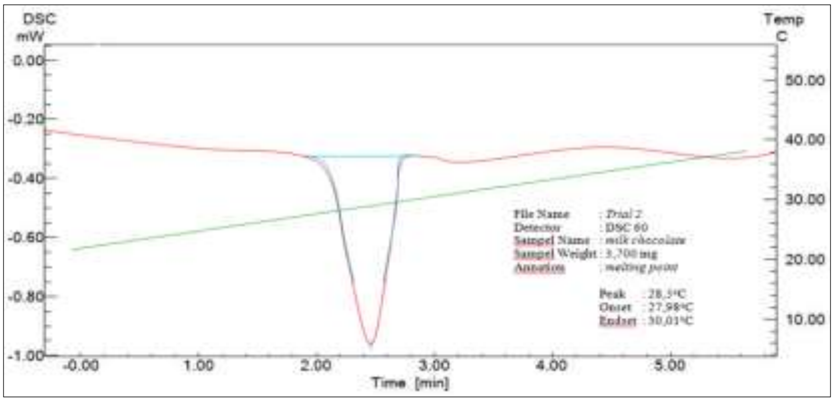


Fig 3: Curve DSC *(Differential Scanning Calorimetry)* milk chocolate sample B1.1

Iron mineral content

Iron mineral content for each milk chocolate product shown in table 6; in general, the mineral content of iron in the product is below 1mg/100g. Milk chocolate Products By comparison of the composition nibs fermentation and without fermentation (60:40) added Inulin 6% have the highest iron mineral content of 1,0542 ± 0, 021mg/100g. Also, research conducted by (Aikpokpodion & Dongo,

2010) [4], reported that the mineral content of iron in fermented cocoa powder ranged from 0.008% (80 mg/kg of cocoa powder-free). The daily sufficiency rate of iron minerals recommended by health experts is 15 mg/day. Based on the permissible iron mineral standard, the products produced are in the category of safe for consumption. The iron content of milk chocolate products can be seen on table 6.

Table 6: Iron mineral concentrations of milk chocolate products

No	Sample	Average iron content (mg/100g)
1	A1.1	0,7379±0,229
2	B1.1	0,6865±0,056
3	B1.2	0,5781±0,223
4	B1.3	0,4076±0,105
5	C1.1	0,5353±0,161
6	C1.2	0,9030±0,053
7	C1.3	1,0542±0,021

Product evaluation

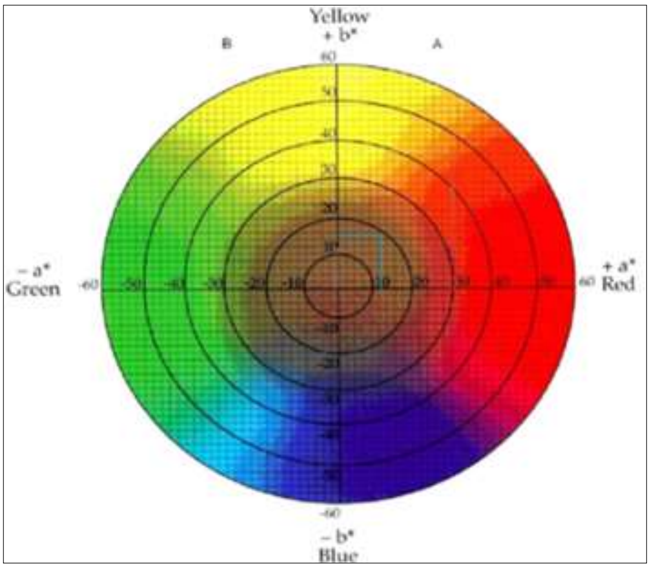
Colour analysis of food products

Color cocoa liquor and milk chocolate products are defined with the color system Hunter (L, a, b). The value L*, a*, b*, is calculated using the Chromameter instrument Minolta CR-400. The basic principle of this tool is the interaction between the diffuse light energy and the atom or molecule of the object being analyzed. In the Hunter Color System, the L * (lightness) value states the brightness parameter that has a value of 0 (black) to 100 (white). A value of a * represents a blend of chromatic red to green with a value of +a* (positive) from 0 to + 100 for the red color, and -a* (negative) from 0 to -80 for the green color. The value b* represents the blue to the yellow mixture, mix with a value of +b* (positive) from 0 to +70 for the yellow color, and the -B* (negative) value from 0 to 70 for the blue color. Color analysis results with the Hunter method can be seen in Table 7 and Fig. 4.

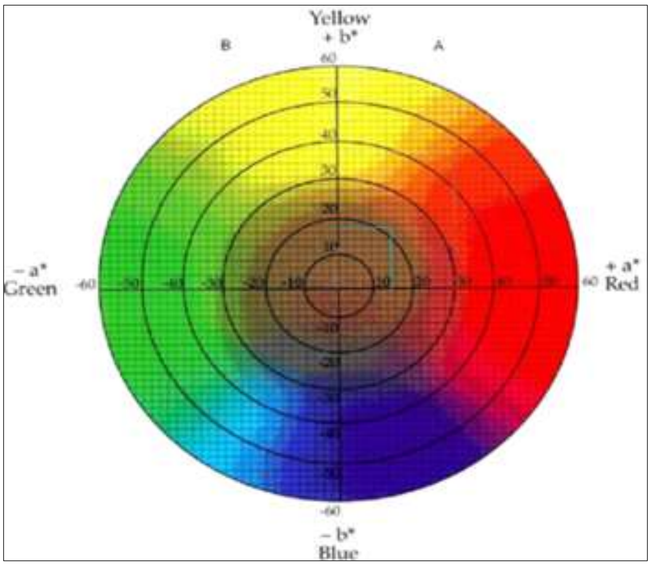
Table 7: Color measurement of cocoa liquor and milk chocolate with Chromameter Minolta CR-400

No	Sample	Value		
		L*	a*	b*
1	A1	27,96±0,396	3,93±0,078	4,67±0,057
2	B1	27,12±0,3041	4,81±0,226	5,36±0,354
3	C1	17,97±0,023	5,06±0,9919	6,52±0,3323
4	A1.1	41,28±0,304	9,64±0,021	14,35±0,025
5	B1.1	41,18±0,665	10,69±0,474	14,84±0,503
6	B1.2	38,57±0,481	11,77±0,651	15,82±0,410
7	B1.3	37,69±0,410	12,77±0,459	17,29±0,537
8	C1.1	41,05±0,332	10,50±0,537	14,66±0,382
9	C1.2	38,47±0,573	11,57±0,622	15,84±0,523
10	C1.3	38,29±0,926	12,74±0,567	16,93±0,636

Oxidation of the epicatechin compounds in the seeds during the fermentation and drying process determines the characteristic of brown color in the fermented cocoa beans as the raw material of chocolate. Polyphenols content contributes to bitterness, astringency, color (a* and b*), flavor, smell and oxidative stability (Kirchhoff, Biehl, & Crone, 1989 [14]; Pandey & Rizvi, 2009) [20].



A



B

Fig 4: Chromaticity Diagram shows all visible colors. A - Sample B1.1 (2% of inulin, 80% of fermented cocoa beans, and 20% of without fermentation). B - Sample C1.3 (6% of inulin, 60% of fermented cocoa beans, and 40% of without fermentation).

The composition of cocoa nibs on cocoa liquor samples and milk chocolate fortified with inulin affects the value of L *, a* and b*. Tasneem *et al.*, (2014) [29], showed a similar state with the addition of 1 to 5% prebiotic inulin in milk chocolate significantly affect the changes in the L* value and the increased value a* and b* are increasing.

Texture measurement of developed food products

The measuring texture of milk chocolate products is done using a puncture test (prick method), using the tools XT Texture Analyser. In the puncture test, the probe is pressed by a constant style of magnitude to be able to stab the sample at a given depth and time as well as in a predetermined state. Hardness Chart of milk chocolate products can be seen in Fig. 5 and 6.

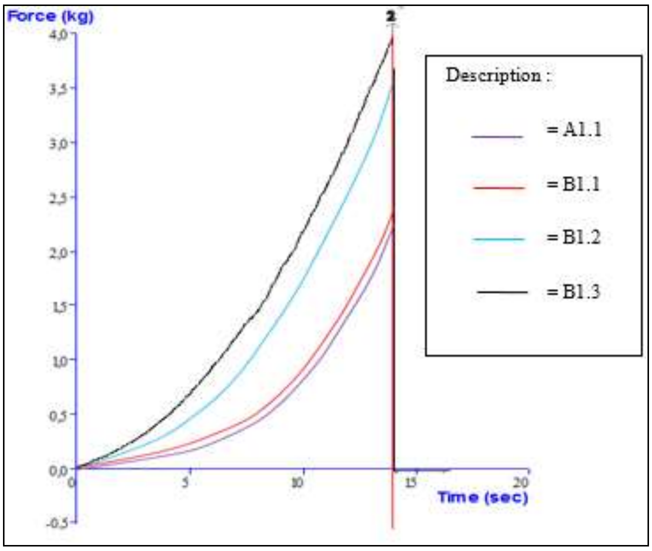


Fig 5: Hardness graphs samples milk chocolate B1.1, B1.2 and B1.3 against samples A 1.1

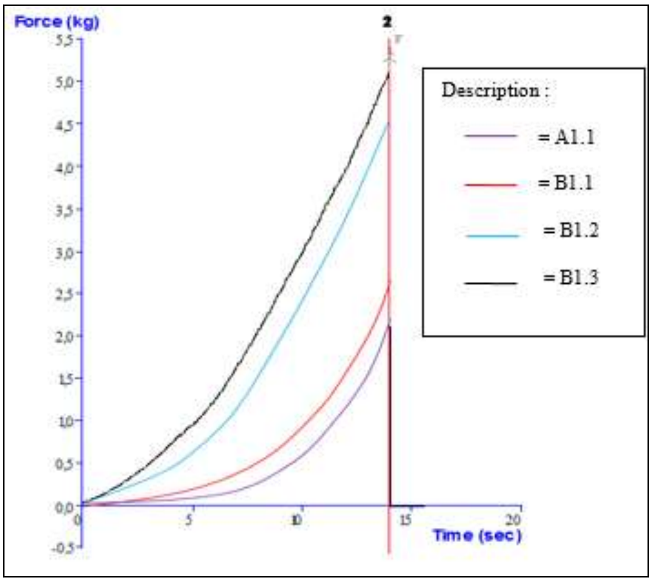


Fig 6: Hardness graphs samples milk Chocolate C1.1, C1.2 and C1.3 against samples A 1.1

The texture of chocolate products is a significant factor in determining the feasibility of the product for consumers. Sample C1.1, C1.2 and C1.3 derived from the composition of fermentation nibs and without fermentation (60:40) with the addition of Inulin 2, 4 and 6% against samples A1.1 showed Figure 5 and 6. Based on the image, the sample C1.1, C1.2, and C1.3 had the same pattern as the sample B1.1, B1.2, and B1.3 against the A1.1 sample, wherein the hardness value increased with the increased addition of inulin. The hardness value of sample C1.1 to C1.3 higher by 2697.537 to 4635.817 compared to sample B1.1 to B1.3 of 2468.73 to 3970.685. Many factors affect the hardness of brown products, such as the dispersion of fundamental particles and the fatty crystal system (Franke & Heinzelmann, 2008 [9]; Liang & Hartel, 2004) [15]. According to (Coussement, 1999 [8]; Niness, 1999b) [19], adding 8% inulin long-chain in skim milk products will have a soft texture. Hardness chocolate milk products are increased with increasing inulin additions. According to (Homayouni Rad *et al.*, 2012 [13]; Ramírez-Sucre & Vélez-Ruiz, 2011) [21], an increase in the number of additions to inulin significantly affects the quality and nature of the texture of chocolate products.

Sensory evaluation of food products

Sensory testing systems are developed based on assessment objectives. Test the difference of control applied in the testing of milk chocolate products produced. Product Comparator (control) used is a commercial milk chocolate product that already has a market. Product of milk chocolate research results compared with the control product to determine the intensity of difference in various aspects of the assessment. Milk Chocolate has a variety of distinctive flavors that can be scanned through sensory assessment.

Table 8: Variance analysis of flavor milk chocolate

Sources of diversity	df	JK	JKT	F count	F table	
					5%	1%
Sample	7	72,29392	10,3277	2,396305	2,015	2,655
Panelist	36	557,6486	15,49024	3,594152	1	1
error	252	1086,081	4,309845			
Total	295	1716,024				

Legend: df (Degree of freedom), JK (Sum Squares), JKT (Mean Squares), F_{count} (F Calculate), F_{table} (F Table) ased on the test results using the print system (ANOVA) indicates that there is a noticeable difference between product control and sample (A1.1, B1.1, B1.2, B1.3, C1.1, C1.2, and C1.3) at the 5 % level indicated by the difference in the value F count more Larger than the F-value of the table so further testing is carried out using the *Duncan test* or the *Duncan's Multiple Range Test*. Advanced testing is conducted to determine the composition of the nibs and the extent of the addition of inulin, which can cause Difference. At a 5% level, A1.1 product differs from other products (R, B1.1, B1.2, B1.3, C1.1, C1.2, and C1.3). Panelist chose A1.1 product derived from 100% fermented cocoa beans with the highest LSR value as a product with a better flavor compared to other samples.

4. Conclusion

Milk chocolate is made using local cocoa beans forastero varieties from the South Sulawesi region of Indonesia. Addition of food, fiber inulin on the manufacture of milk chocolate can add the functional properties of milk chocolate so it not only has a high taste but can benefit health *(healthy food),* it can be seen from the viscosity value, melting point, iron content, hardness, flavor and color of milk chocolate products that resemble commercial chocolate. This research can be useful in developing milk chocolate products that have an equivalent nutritional value with the value of taste, so that can be a reference for chocolate products that are worth the functional food.

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