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Influence of Geographic Region on Fatty Acid and Physical Properties of Indonesian Cocoa Butter from Smallholder Estate

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Abstract

Cocoa butter is the most essensial component in chocolate formulation and represent the biggest characteristic of this product. Indonesia is the third cocoa producers with cocoa producing area spread out in different geographic region and may affect in cocoa butter profiles. The aim of this experiment was to evaluate the fatty acid characteristic and physical properties of cocoa butter from smallholder estate relate to geographic region and climate. This experiment was conducted using unfermented cocoa bean from smallholder estate in eight provinces of Indonesian most growing areas. Fatty acid composition evaluated through the different region and physical properties evaluated in melting profiles and solid fat content. The result explain the fatty acid characteristic of Indonesian cocoa butter consist of palmitic acid (C16:0) 26.28–29.20%, stearic acid (C18:0) 32,14–37.29% and oleic acid (C18:1) 32,14–37,29%. Growing temperature significantly affects the increase of palmitic acid composition contribute to cocoa butter hardness. Cocoa butter completely melt in temperature of 36.65–39.20^{O}C and solid fat content ranged 7.288–16.82% in 33^{O}C and ranged 0.02–0.29% in 38^{O}C. This Indonesian cocoa butter comply to the classification of hard cocoa butter.

Keywords: Cocoa butter, chemical composition, geographic region, physical properties

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is grown comercially between 20^{O} north and south of the Equator with three main-growing areas are West Africa, South East Asia and South America (Beckett, 2009). Indonesia has become the fifth cocoa producer in 2018 after Côte d'Ivoire, Ghana, Ecuador, and Nigria (ICCO, 2018). Cocoa production areas in Indonesia are occupied by smallholder estate over 60%, widely spread in different geographic region and cilmate condition (McMahon *et al*., 2015). Butter content of Indonesian cocoa bean reach 49.85–53.67% higher than bean of both Hainan and Papua New Guinea (Gu *et al*., 2013). The chemical quality of cocoa butter largely influence the physical quality characteristic of chocolate such such as hardness at room temperature, brightness, fast and melting behaviour (Saldaña *et al*., 2002; Afoakwa *et al*., 2014).

The distinctive properties of cocoa butter as the result of specific AGs structure are non comparable with any other natural edible fat (Zyzelewicz, 2014). Triacylglycerols (TAGs) are the major component present in cocoa butter, making up 92 to 96 % of the lipid composition followed by monoacylglycerols (MAGs) and diacylglycerols (DAGs) (Jahurul *et al*., 2013). TAGs composition of CB consist of 1,3-dipalmitoyl-2-oleoyl-glycerol (POP), 1(3)-palmitoyl-3(1)-stearoyl-2monoolein (POS), and 1,3-distearoyl-2-oleoylglycerol (SOS) with oleic acid in the sn-2 position (Liu *at al*., 2007). The main fatty acids (FA) of CB are stearic acid (C18:0) 33.7–40.2%, oleic acid (C18:1) 26.3–35% , palmitic acid (C16) 25–33.7%, and linoleic acid (C18:2) 1.7–3% (Asep *et al*., 2008). Cocoa butter from Indonesia contains high oleic acid (33.06% wt) resemble to Ghana (32.99% wt) and Ivory Coast (32.84% wt) (Spangenberg & Dionisi, 2001).

The basis characteristic of cocoa butter and its fatty acid composition may affected by farming region's climate which relate to changes of its saturated and unsaturated chains following temperature and drought factor (Lehrian & Keeney, 1980; Vieira *et al*., 2015). Demonstrably, ambient temperature and stress caused by drought affect fatty acid biosynthesis through specific enzymes inside the plant cells (Ohlrogge, 1994). High-temperature tolerant plant has strongly shown on decreasing its polyunsaturated fatty acid and high tolerant plant in drought express the ability to maintain or adjust fatty acid unsaturation (Upchurch, 2008). Fatty acid saturation is necessary to evaluate according to certain cocoa butter blend formulation and significantly altering the physical properties as crystallization or melting point profiles. These formulation could be essential for the production of high temperature resistant hard butter products for countries with a hot climate (Jahurul *et al*., 2014).

Indonesian most cocoa growing estate located in Sulawesi island alongside to the equator with average rainfall is 100-1.300 mm per year (McMahon *et al*., 2015). Brazilian cocoa estates located in between 5^{O}N and 24^{O}S with the highest rainfall 2.250 mm per year while Ghana rainfall value ranged 1000 mm to 1900 mm in the forest zone (Amissah *et al*., 2014; Vieira *et al*., 2015). Therefore, Indonesia as potentially the hottest cocoa growing area is necessary to characterize its cocoa butter altogether in different geographic region to determine both physical and chemical composition and to obtain brief comparison with cocoa butter from another countries. The aim of this work was to make a comparative study of the physicochemical properties of raw cocoa butter from different geographical areas in Indonesia as well as assess whether the climate condition produces differences in the physicochemical properties of cocoa butter among the growing areas.

MATERIALS AND METHOD

Cocoa Sample and Preparation

Cocoa bean cultivated from eight provinces include West Sumatera, Lampung, East Java, West Sulawesi, Central Sulawesi, South Sulawesi, Southeast Sulawesi, and West Papua. Every provinces require fiveteen estates as composite sample of provinces and involve intensive, semi-intensive and non intensive smallholder estates. The non-fermented cocoa bean were processed (harvesting, pod opening, drying until moisture content 20-25% and packaging) at the estate, continuing drying before the fitfth days using oven (Ehret, Germany) in temperature 35^{O}C until 7–7.5% held in Indonesian Coffee and Cocoa Research Institute (ICCRI) on Jember, East Java. Table 1 provides information about the cocoa origin taken by Digital Logger Tiny Tag 2.0 and BMKG. The sampling of cocoa beans aimed to cover all the main Brazilian producer states and elaborate actual geographical variations.

Raw cocoa bean (dry and unfermented) determined for weight per bean, bean count and shell content then broke to separated between cotyledon and shell using deshelling machine uquipped with cyclone winnower as describe in Firmanto *et al*., (2015) and grinded into coarse cocoa mass using mechanical

Table 1. Indonesian geographic region of cocoa cultivation and climate condition of the samples

Samples	Harvesting	District/estates	Rainfall (mm/year)	T (^{O}C)	Humidity (%)
West Sumatera	Oct/2016	West Pasaman, Padang Pariaman	4,249	26.33	88.50
Lampung	Oct/2016	Pringsewu, East Lampung, Pasewaran	1,891	26.71	70.31
East Java	Oct/2016	Pacitan, Madiun, Blitar	1,619	25.66	88.92
West Sulawesi	Oct/2016	Majene, Polewali Mandar, Mamuju	2,103	28.57	82.07
Central Sulawesi	Oct/2016	Sigi, Donggala, Parigi Mountong	2,084	27.03	82.62
South Sulawesi	Oct/2016	Soppeng, Pinrang, Luwu	1,831	29.02	-
Southeast Sulawesi	Jan/2017	Konawe, Kolaka, North Kolaka	1,679	27.48	84.78
West Papua	Nov/2016	Manokwari, South Manokwari	2,200	28.13	83.88

grinder as describe in Mulato *et al*., (2004) to gain particle size of 300-400 µm. Cocoa oil extracted from cocoa mass using laboratory hydraulic press unit as describe in Venter *et al*, (2007). Raw cocoa oil take in isolated water bath (Memmert, Germany) for precipitation for 12 hours on temperature 35^{O}C. Cocoa oil taken from the upper layer for 75 mL and molded into block to storage in cooling temperature of 15^{O}C into cocoa butter.

Fatty Acid Analysis

FA profiles were analyzed using a CGC Agilent 6850 capillary gas chromatograph (Santa Clara, CA, USA) after esterification according to the methodology described by Hartman & Lago (1973). FA methyl esters were separated according to the AOCS Ce1f-96 method (2009). Chromatograph operation conditions: a DB23 Agilent capillary column (50% cyanopropyl methylpolysiloxane), dimensions 60 m, øint: 0.25 mm, 0.25 µm film thickness. Analysis conditions: oven temperature program: 110^{O}C/5 min, 110–215^{O}C (5^{O}C/min), 215^{O}C/24 min; detector temperature: 280^{O}C; injector temperature: 250^{O}C; carrier gas: helium; split ratio 1:50; injected volume: 1.0 µL. The qualitative composition was determined by comparison of the peak retention times with those of respective FA standards. Quantitative analysis was carried out by normalization of peak areas, expressed as mass percentage.

SFC was determined using nuclear magnetic resonance (NMR) spectrometry (Bruker MINISPEC PC-120, Rheinstetten, Germany) and Duratech TCON 2000 high-precision dry bath (Carmel, IN, USA) according to the AOCS Cd16b-93 direct method (2009). Sample tempering followed the temperature/time program: 100^{O}C/15 min, 60^{O}C/5 min, 0^{O}C/90 min, 26^{O}C/40 h and finally 0^{O}C/90 min, after which the samples were kept at each reading temperature (10, 15, 20, 25, 30, 35, and 40^{O}C) for a period of 1 h prior to registering the measurement. Analyses were performed in triplicate for each sample.

The thermal behavior of CB was analyzed using TA Instruments Q1000 DSC (New Castle, DE, USA) according to the AOCS Cj1-94 method (2009) with some modifications. The equipment was calibrated with TA Instruments indium (New Castle, DE, USA), Sigma-Aldrich azobenzene and Acros Organics undecane before analysis, and nitrogen was used to purge the system. Then 5–11 mg of melting CB was filled and hermetically sealed in aluminum pans, and an empty pan was used as a reference. The following temperature-time procedure for non-isothermal crystallization was used: equilibration at 80^{O}C/10 min and the ramp cooled at 10^{O}C/min to -40^{O}C and maintained for 10 min to be heated again until 80^{O}C at a rate of 5^{O}C/min. Each assay was performed in triplicate. Initial temperature (Tonset), peak melting temperature (Tpeak), all in degrees Celsius, and melting enthalpy (ÄH) in J/g were determined.

IBM SPSS Statistics 22 software (Statistical Analysis System) for the statistical treatment of the collected data was used. The differences between means were determined at a 5% level of significance ($p < 0.05$) using Duncan's test

RESULTS AND DISCUSSION

Bean Count and Weight

The characteristic of Indonesian dry bean from smallholder estate in most growing area as shown in Table 2 have range bean count 91–107 beans per 100 g weight, net weight 1.09–1.43 g per bean and shell content 12.89–15.78%. Bean count and shell content have similar value among the provinces resemble to the result of McMahon (2015) held in top production area of Sulawesi, stated the bean count of 60–100 beans per 100 grams weight, net weight 0.78–1.69 grams per bean and shell content 11.94–20.25%. This result indicate no significant difference or geographic region factor influence the bean count and shell content. Southeast Sulawesi have low weight and East Java determined as the highest with net weight 1.43 g/beans, but in other provinces show uniformity, therefore the bean characteristic from smallholder estate among the provinces in Indonesia not differentiate by geographic region or different climate condition in Table 1.

Saturated Fatty Acid Profiles

Table 3 show saturated fatty acid of cocoa butter from 8 provinces involving 22 district. Saturated fatty acid show significant difference in component of palmitic acid (C16:0), stearic acid (C18:0) and arachidic acid (C20:0). The wet growing area (Table 1) such East Java (temperature 25.66^{O}C; rainfall 226.60 mm/year) and West Sulawesi (temperature 28.57^{O}C; rainfall 214.83 mm/year) produce more palmitic acid (C16:0) but low stearic acid (C18:0) contrast to low rainfall growing area such Lampung (temperature 26.71^{O}C; rainfall 197.64 mm/year) and West Papua (temperature 28.13^{O}C; rainfall 195.03 mm/year). Palmitic acid (C16:0) and stearic acid (C18:0) as the

Table 2. Bean count, net weight and shell content of dry bean (non-fermented)

Samples	Bean count (beans)	Net weight, g	Shell content, %
West Sumatera	99 ± 5 ^{a}	1.30 ± 0.19 ^{ab}	13.67 ± 0.47 ^{a}
Lampung	101 ± 1 ^{a}	1.21 ± 0.08 ^{ab}	13.78 ± 2.69 ^{a}
East Java	91 ± 10 ^{a}	1.43 ± 0.25 ^{a}	13.78 ± 2.04 ^{a}
West Sulawesi	96 ± 3 ^{a}	1.19 ± 0.02 ^{ab}	15.78 ± 2.14 ^{a}
Central Sulawesi	107 ± 5 ^{a}	1.14 ± 0.02 ^{ab}	12.89 ± 1.39 ^{a}
South Sulawesi	91 ± 8 ^{a}	1.23 ± 0.21 ^{ab}	16.00 ± 1.76 ^{a}
Southeast Sulawesi	107 ± 1 ^{a}	1.09 ± 0.13 ^{b}	15.78 ± 1.54 ^{a}
West Papua	91 ± 1 ^{a}	1.20 ± 0.00 ^{ab}	13.67 ± 0.47 ^{a}

Note: Mean values assigned with a common letter within the same column are not significantly different according to Duncan's multiple range test at the 5% level.

Table 3. Saturated fatty acid composition

Samples	Saturated fatty acid (%)						ÓSFA (%)
	C10:0	C12:0	C14:0	C16:0	C18:0	C20:0	
West Sumatera	0.02 ± 0.03 ^{a}	0.18 ± 0.25 ^{a}	0.63 ± 0.73 ^{a}	27.28 ± 0.64 ^{ab}	35.15 ± 0.45 ^{ab}	2.16 ± 0.78 ^{a}	65.42 ± 0.70 ^{a}
Lampung	ND	0.10 ± 0.13 ^{a}	0.45 ± 0.16 ^{a}	26.28 ± 0.11 ^{b}	36.42 ± 0.66 ^{a}	1.52 ± 0.13 ^{ab}	64.78 ± 0.69 ^{a}
East Java	0.02 ± 0.03 ^{a}	0.09 ± 0.11 ^{a}	0.23 ± 0.23 ^{a}	27.03 ± 0.21 ^{ab}	34.59 ± 0.65 ^{ab}	1.63 ± 0.17 ^{ab}	63.58 ± 2.00 ^{a}
West Sulawesi	0.01 ± 0.01 ^{a}	0.10 ± 0.08 ^{a}	0.32 ± 0.26 ^{a}	27.75 ± 0.47 ^{ab}	34.61 ± 0.63 ^{ab}	1.69 ± 0.05 ^{ab}	64.48 ± 0.76 ^{a}
Central Sulawesi	0.04 ± 0.05 ^{a}	0.04 ± 0.04 ^{a}	0.32 ± 0.31 ^{a}	27.44 ± 0.28 ^{ab}	34.44 ± 0.87 ^{a}	1.92 ± 0.96 ^{ab}	64.20 ± 0.98 ^{a}
South Sulawesi	0.03 ± 0.05 ^{a}	0.15 ± 0.17 ^{a}	0.63 ± 0.66 ^{a}	29.20 ± 0.57 ^{a}	32.14 ± 0.46 ^{b}	1.80 ± 0.23 ^{ab}	63.95 ± 0.75 ^{a}
Southeast Sulawesi	0.10 ± 0.16 ^{a}	0.25 ± 0.20 ^{a}	0.40 ± 0.32 ^{a}	26.37 ± 1.86 ^{b}	34.35 ± 1.18 ^{ab}	ND	61.47 ± 2.89 ^{a}
West Papua	ND	0.02 ± 0.01 ^{a}	0.19 ± 0.01 ^{a}	25.88 ± 1.64 ^{b}	37.29 ± 2.58 ^{a}	0.92 ± 1.01 ^{bc}	64.31 ± 0.04 ^{a}

Note: Mean values assigned with a common letter within the same column are not significantly different according to Duncan's multiple range test at the 5% level. ND: *not detected.*

essential fatty acid in cocoa butter acylglycerol shows in range 26.28–29.20% and 32,14–37.29%, with the highest content C18:0 is in West Papua belong to the high temperature and low rainfall. This effect of high growing temperature and drought in C18:0 also had been evaluated in the soybean by Cheesbrough (1989) to prove its concern in reducing the performance of specific enzyme for saturation.

Unsaturated Fatty Aid Profiles

Unsaturated fatty acid profiles in growing areas as shown in Table 4 express significant difference only in linolenic acid (C18:3) otherwise its oleic acid (C18:1) which determine cocoa butter characteristic. Tabel 5 shows the correlation of climate condition including rainfall, temperature and humidity to palmitic acid (C16:0) is more obvious than oleic acid (C18:1) which content 32,14–37,29%. Temperature of growing area have correlation value 0.452 in palmitic acid in p value < 0.05. These result confirm the effect of temperature rises the palmitic acid content inside Indonesian cocoa butter. Palmitic acid content of these cocoa butter is rather high comply to the commercial cocoa butter ranged 24.4–33.7% (Liu *et al*., 2007), but this oleic acid is higher than Malaysian cocoa butter which stated containing oleic acid 26.36–30.49% (Asep *et al*., 2008).

Melting Profiles

Sensory qualification of acceptable cocoa butter for customer preference is already melt in the mouth temperature around 32–34^{O}C (Norton *et al*., 2009). DSC is the most widely used thermal analysis applied to oil and fat studies. Parameters obtained from endothermic thermograms are presented in the Table 6, T.onset ranged from 31.24–33.88^{O}C, T.peak ranged 36.65–39.20^{O}C and T.endset ranged 43.28–45.87^{O}C. T.onset describe the melting behaviour for complete melting while Central Sulawesi obtain the

Tabel 4. Unsaturated fatty acid composition

Samples	Unsaturated fatty acid (%)				ÓUFA, %	ÓMUFA, %	ÓPUFA, %
	C16:1	C18:1	C18:2	C18:3			
West Sumatera	0.42 ± 0.03 a	32.21 ± 0.68 a	1.85 ± 0.08 a	0.09 ± 0.08 b	34.58 ± 0.70 a	32.64 ± 0.70 a	1.94 ± 0.00 a
Lampung	0.70 ± 0.36 a	33.05 ± 0.39 a	1.27 ± 1.04 a	0.20 ± 0.04 ab	35.22 ± 0.69 a	33.76 ± 0.42 a	1.46 ± 1.05 a
East Java	1.87 ± 2.43 a	32.62 ± 1.09 a	1.70 ± 1.13 a	0.24 ± 0.10 a	36.42 ± 2.00 a	34.48 ± 1.41 a	1.94 ± 1.17 a
West Sulawesi	0.42 ± 0.33 a	33.14 ± 0.55 a	1.74 ± 0.09 a	0.22 ± 0.06 a	35.52 ± 0.76 a	33.56 ± 0.83 a	1.97 ± 0.08 a
Central Sulawesi	0.46 ± 0.21 a	32.87 ± 0.60 a	2.26 ± 0.33 a	0.20 ± 0.03 ab	35.80 ± 0.98 a	33.34 ± 0.64 a	2.46 ± 0.35 a
South Sulawesi	0.75 ± 0.38 a	33.25 ± 0.75 a	1.80 ± 0.29 a	0.25 ± 0.02 a	36.05 ± 0.75 a	34.00 ± 0.55 a	2.04 ± 0.27 a
Southeast Sulawesi	0.90 ± 0.76 a	32.98 ± 0.39 a	2.30 ± 0.21 a	0.16 ± 0.06 ab	36.34 ± 0.94 a	33.88 ± 1.09 a	2.46 ± 0.27 a
West Papua	0.39 ± 0.03 a	32.77 ± 0.26 a	2.33 ± 0.24 a	0.20 ± 0.01 ab	35.69 ± 0.04 a	33.16 ± 0.29 a	2.53 ± 0.25 a

Note: Mean values assigned with a common letter within the same column are not significantly different according to Duncan's multiple range test at the 5% level.

Table 5. Pearson correlation of fatty acid and climate condition (rainfall, temperature, and humidity)

Fatty Acid	Rainfall		Temperature		Humidity	
	Pearson correlation	Sig.	Pearson correlation	Sig.	Pearson correlation	Sig.
C10:0	-0.191	0.395	-0.008	0.97	0.06	0.791
C12:0	-0.083	0.712	-0.012	0.956	-0.164	0.465
C14:0	0.010	0.965	0.105	0.643	-0.088	0.696
C16:0	0.105	0.643	0.452 *	0.034	0.017	0.939
C16:1	-0.315	0.153	-0.450 *	0.036	0.104	0.647
C18:0	0.042	0.854	-0.23	0.303	-0.191	0.395
C18:1	-0.093	0.680	0.31	0.161	0.057	0.802
C18:2	0.070	0.756	-0.236	0.29	0.279	0.208
C18:3	-0.070	0.756	0.268	0.228	-0.248	0.266
C20:0	0.321	0.145	0.02	0.929	-0.101	0.654

Note: Correlation is significant at the 0.05 level.

Tabel 6. Cocoa butter melting profile

Samples	T onset, ^{O}C	T peak, ^{O}C	T endset, ^{O}C	ÄH, J/g
West Sumatera	32.81 ± 0.12 ^{ab}	37.95 ± 0.96 ^{a}	44.11 ± 1.82 ^{ab}	88.58± 2.27 ^{ab}
Lampung	32.11 ± 0.78 ^{ab}	38.72 ± 0.08 ^{a}	45.37 ± 0.35 ^{ab}	83.98± 0.23 ^{ab}
East Java	33.17 ± 1.29 ^{ab}	38.08 ± 0.82 ^{ab}	44.29 ± 0.64 ^{ab}	69.19± 4.92 ^{ab}
West Sulawesi	32.81 ± 0.97 ^{ab}	38.65 ± 0.19 ^{ab}	45.87 ± 0.66 ^{a}	86.97± 2.36 ^{a}
Central Sulawesi	33.88 ± 0.27 ^{a}	39.20 ± 0.68 ^{a}	45.34 ± 0.44 ^{ab}	66.47± 8.53 ^{b}
South Sulawesi	32.13 ± 0.77 ^{ab}	38.74 ± 1.38 ^{a}	44.98 ± 1.93 ^{ab}	80.38± 5.36 ^{ab}
Southeast Sulawesi	31.24 ± 1.73 ^{b}	36.65 ± 0,71 ^{b}	43.28 ± 0.97 ^{b}	73.56± 7.01 ^{ab}
West Papua	32.95 ± 0.06 ^{ab}	38.45 ± 1.48 ^{a}	44.54 ± 1.85 ^{ab}	81.54± 9.31 ^{ab}

Note: Mean values assigned with a common letter within the same column are not significantly different according to Duncan's multiple range test at the 5% level.

highest melting point 39.20^{O}C and Southeast Sulawesi in the lowest poin. In accordance to Table 1, Central Sulawesi and Southeast Sulawesi have similarities in growing temperature but Central Sulawesi have more intensity in rainfall that would be the reason in the total amount of saturated fatty acid (SFA) and the lowest Southeast Sulawesi as shown in Table 3. Indonesian cocoa butter melt in 36.65–39.20^{O}C is much higher compare to melting point of Brazilian cocoa butter in 21.07^{O}C (Vieira *et al*, 2015). This result prove the classification of Indonesian butter as one of hard cocoa butter (Beckett, 2009).

Solid Fat Content Profiles

The SFC of cocoa butter and its blends is an important quality parameter in the technological process of chocolate manufacture. Cocoa butter SFC values calculated at temperatures in the range of 27–33^{O}C (T_1) indicate intensive melting of cocoa butter occurs, and value at temperatures above 35^{O}C (T_2) signals the presence of a fat fraction which causes a waxy taste (Torbica *et al*., 2005). Table 7 shows SFC value in T_1 ranged 7.288–16.82% and T_2 ranged 0.02–0.29%. T_1 for SSL is 7.28% as the lowest and West Papua as the highest SFC in value 18.82%, although SSL and West Papua have no difference in enthalpy and melting point as shown in Table 6, but South Sulawesi and West Papua declare gap value for stearic acid content and total unsaturated fatty acid at Table 3. Average SFC value of Indonesian cocoa butter is 12.46% for T_1 and approximately higher than Brazilian cocoa butter but lower than Ghanaian cocoa butter. Bazilian cocoa butter have SFC 6.6% in 32.5^{O}C lower than Ghanaian 13.3%, but in setting temperature T_2, both Brazilian and Ghanaian cocoa butter are completely melted (Beckett, 2009; Vieira *et al*., 2015).

Tabel 7. Solid fat content value

Samples	T_1 = 33^{O}C (%)	T_2 = 38^{O}C (%)
West Sumatera	13.59 ± 3.35 ^{ab}	0.11 ± 0.02 ^{a}
Lampung	13.44 ± 0.62 ^{ab}	0.02 ± 0.07 ^{a}
East Java	9.05 ± 0.41 ^{ab}	0.29 ± 0.09 ^{a}
West Sulawesi	13.50 ± 0.79 ^{ab}	0.07 ± 0.01 ^{a}
Central Sulawesi	11.96 ± 0.52 ^{ab}	0.10 ± 0.27 ^{a}
South Sulawesi	7.28 ± 1.98 ^{b}	0.09 ± 0.04 ^{a}
Southeast Sulawesi	14.04 ± 2.21 ^{ab}	0.28 ± 0.06 ^{a}
West Papua	16.82 ± 3.38 ^{a}	0.14 ± 0.37 ^{a}

Note: Mean values assigned with a common letter within the same column are not significantly different according to Duncan's multiple range test at the 5% level.

CONCLUSIONS

Characteristic of Indonesian cocoa butter described in fatty acid composition consist of palmitic acid 26.28–29.20%, stearic acid 32.14–37.29% and oleic acid 32.14–37.29%. Geographic region of growing area shows similar climate condition but temperature of growing specifically influence the palmitic acid composition changes compare to rainfall and humidity. Physical properties of cocoa butter describe in melting point of 36.65–39.20^{O}C also solid fat content ranged

7.288–16.82% in 33°C and ranged 0.02–0.29% in 38°C. Indonesian cocoa butter confirmed to be classified as hard cocoa butter source where in temperature 38°C still have solid component but Ghanaian and Brazilian cocoa butter completely melted.

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