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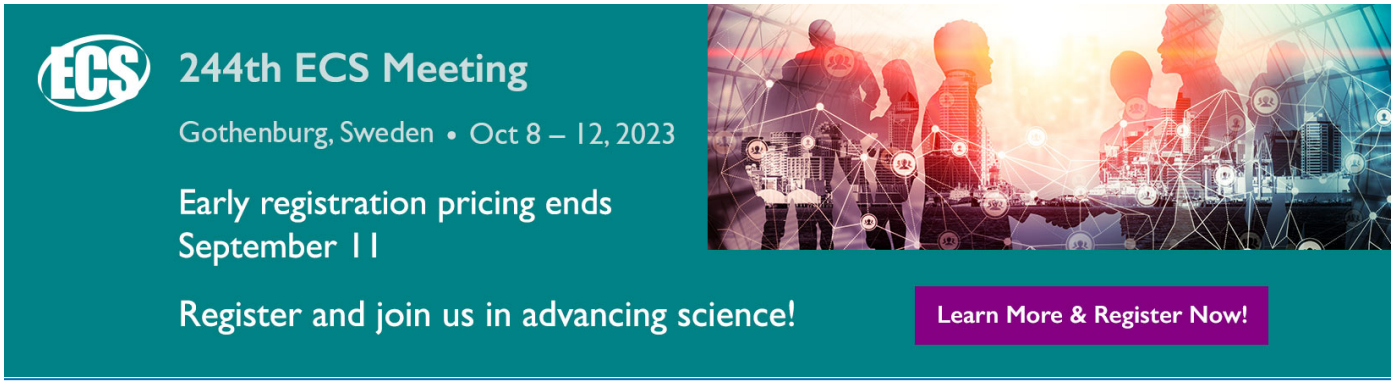

Fruit Characteristics of Cocoa in Various Altitude Place

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Abstract. The cocoa beans of small holders were usually still low quality, it was caused by planting locations on various altitudes. The focus of this study was fruit characteristics and beans quality on several altitudes. The research was carried out from May 2014 to July 2014 at Deliserdang, Simalungun, Karo, and North Tapanuli District, North of Sumatra. The research method was a survey and descriptive method. The observed parameters were pod size, pod diameter, pod weight, wet weight of beans, dry weight of beans, beans count per pod, and beans count per 100 g at 19 different altitudes between 100 m to 1210 m from sea levels, with 10 pods (replications) at each altitudes. The results of research showed that: pod size and dry weight of beans decreased and bean count per 100 g increased with the increasing of altitude. The characteristics of pod and beans were still normally categories. The better characteristic of angoleta cocoa pod type were found on 600 m from sea levels and beans count per pod on 300 m from sea levels.

***Key words** : characteristic, pod, bean, cocoa, and altitude*

1. Introduction

The economic value of cocoa is determined by the quality of the beans which include; flavor, fat content, average seed weight, skin content, moisture content, and defective seeds [1]. The size of cocoa beans for export purposes is between 1.0 - 1.2 g per seed, equivalent to 85-100 seeds per 100 g, the smaller the size of the seeds, the lower the quality. The physical characteristics of cocoa beans are known to vary in various planting locations, according to Prawoto and Karneni (1994) the higher the place for growing cocoa, the larger the seed size, the lower skin content and the relatively higher fat content. Cocoa fruit ripe is strongly influenced by the height of the place, in the lowlands the fruit ripens for about 5 months, at an altitude of 500 m above sea level (**asl**) fruit ripens for about 6 months [2].

The ideal height is 0-600 m above sea level, the higher the altitude, the lower the air temperature. The ideal temperature for cocoa plants is 30^{o}C-32^{o}C (maximum) and 18^{o}C-21^{o}C (minimum). Low temperatures below 10^{o}C cause leaf fall and dry flowers, and the rate of growth decreases, high temperatures will spur flowering but then fall. Flowering is very good at a temperature of 23^{o}C, and temperature of 26^{o}C at night has a better effect on flowering. High temperatures over a long period of time will increase seed weight [3]. High air temperature can inhibit shoot growth and encourage branch growth and result in less developed leaves [4].

Cocoa cultivation is still carried out in the highlands, at an altitude between 700-1.350 m asl cocoa plants are still growing and developing with good results. In North Sumatra, cocoa cultivation is often found in the lowlands, besides that cocoa cultivation is also found in the highlands such as in Deliserdang Regency at an altitude of 760 m asl [5], in Simalungun Regency at an altitude of 870 m asl [6], in the Karo Regency altitude of 860 m asl [7], and in North Tapanuli Regency at an altitude of 1.000 m asl [8]. Studies and research on cocoa cultivation in the highlands, especially at altitudes>600 m asl have never been done before. The characteristics of harvested cocoa fruit will determine the quality of cocoa beans.It is necessary to describe the characteristics of cacao fruit at various heights in North Sumatra, in some places in the lowlands and highlands. The study aimed to describe the characteristics of cocoa

fruit as the picture quality of cocoa at various altitudes based on survey method research. The results of the study can be used to control the quality of cocoa yields after harvest. Characteristics of cocoa fruit in various altitudes become guidelines for farmers to cultivate cocoa plants.

2. Materials and methods

The study was conducted in May 2014 to July 2014. The location (area) of the study (sampling) was determined purposively in several locations in the districts of Deliserdang, Simalungun, Karo, and North Tapanuli, North Sumatra Province. The materials used were picking ripe cocoa fruit from the farmer, the type angoleta of Forastero as many as 10 pieces per site **(Table 1.).** The tools used include: altimeter, oven, calipers, standard scales, and analytical scales. The research method is a survey and descriptive method, according to the nature of the problem under study, research technique, time of study and research area [9]. The cocoa fruit used as a sample is ripe fruit harvested and then sorted. Normal fruit was separated by 40 pieces in a composite and then taken 10 samples randomly.Technical implementation of the research: the sample of fruit harvested is measured and weighed. Cocoa beans are separated, cleaned and dried in an oven for 6 hours at 70^{o}C, then their characteristics are observed.

Table 1. Research location and sample source of cocoa fruit

No.	Location	Altitude (m asl)	No.	Location	Altitude (m asl)
1	Deliserdang Regency		3	Karo Regency	
	- Biru-Biru	100		- Mardinding	150
	- Sibolangit	300		- Laubaleng	280
	- Sibolangit	550		- Tigabinanga	600
	- Sibolangit	760		- Juhar	710
				- Munte	810
2	Simalungun Regency		4	North Tapanuli Regency	
	- PanombeianPanei	430		- Garoga	725
	- PanombeianPanei	560		- Garoga	827
	- Raya	670		- Garoga	998
	- Raya	740		- Pangaribuan	1.170
	- Raya	860		- Pangaribuan	1.213

Description: Number of samples 10 each location

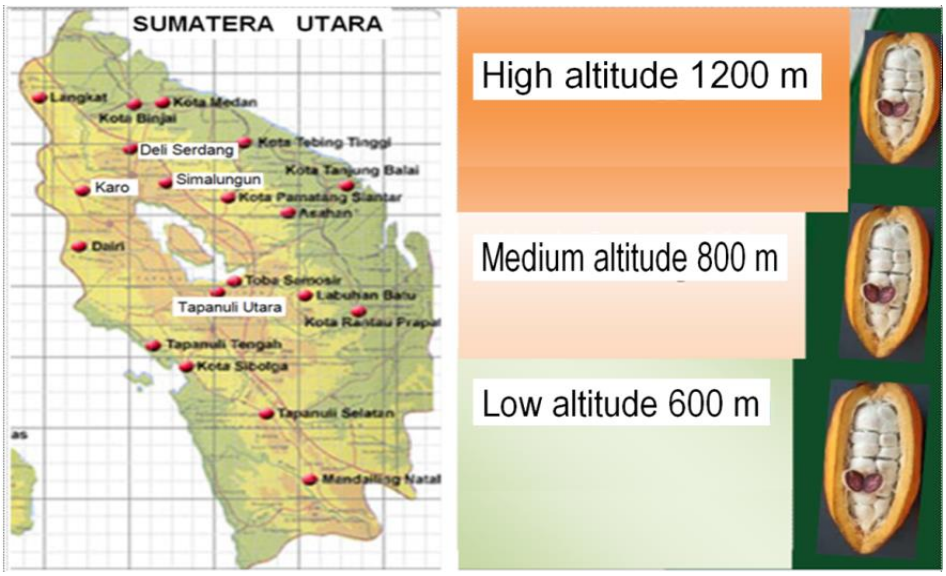

Figure 1. Research location with various altitudes

Observation variables include altitude (m asl), characteristics of fruit and cocoa beans. Altitude was determined by an altimeter at each sampling location. Characteristics of cocoa fruit include: length of cocoa fruit (cm), diameter of cocoa fruit (cm), and weight of cocoa fruit (g). Characteristics of cocoa beans include: wet seed weight (g), dry seed weight (g), average number of seeds per pod, number of dried seeds per 100 g. **Analysis of** research **data** with SPSS/PC program to determine appropriate regression and correlation [10]. The data obtained were also analyzed descriptively according to their needs [11]. The analysis is based on a simple function: **Y = f(X)** where *Y* is the dependent variable, namely: fruit length, fruit diameter, fruit weight, wet seed weight, dry seed weight, average number of seeds per pod, and number of seeds per 100 g. Whereas *X* is the independent variable which is altitude.

3. Results and discussion

The average fruit length, fruit diameter, fruit weight, wet seed weight, dry seed weight, number of seeds per pod and number of seeds per 100 g at various heights can be seen in **Table 2.** Fruit length between 14.08 cm (1.000 m asl) up to 18.20 cm (600 m asl), fruit diameter of 7.23 cm (730 m asl) to 8.31 cm (580 m asl), fruit weight 395.65 g (580 m asl) up to 574.75 g (730 m asl), wet seed weight 94.75 g (1.000 m asl) up to 151.25 g (760 m asl), dry seed weight 25.27 g (1.170 m asl) up to 43, 18 g (600 m asl), the number of seeds per pod is 29.69 (430 m asl) up to 39.71 (300 m asl), and the number of seeds per 100 g is 79.7 (810 m asl) up to 127, 9 (600 m asl).

Table 2. Average fruit length, fruit diameter, fruit weight, wet seed weight, dry seed weight, number of seeds per pod, and number of seeds per 100 g in various altitudes

Altitude (m asl)	Fruit Length (cm)	Diameter Fruit (cm)	Weight Fruit (g)	Wet Seed Weight (g)	Dry Seed Weight (g)	Number of Seeds per Pod (seed)	Number of Seeds per 100 g (seed)
100	15.98	7.86	431.00	115.00	36.26	39.07	104.5
150	17.53	8.00	492.00	131.00	40.82	38.40	92.9
280	18.11	7.86	489.50	139.75	39.66	36.08	89.8
300	17.42	7.94	542.00	128.25	30.13	29.69	105.5
430	17.11	8.02	548.25	142.50	37.65	39.71	101.2
550	15,57	7.98	482.50	128.00	33.34	32.83	94.2
580	16.75	8.31	574.75	145.00	34.57	34.67	95.8
600	18.20	7.96	534.00	133.00	43.18	31.51	79.7
670	17.04	8,28	515.47	139.99	33.48	39.52	106.1
710	18.09	7.95	503.75	120.25	31.68	34.78	108.2
730	15.17	7.23	395.65	133.75	30.28	33.44	110.9
740	16.14	8.12	509.45	146.11	32.37	36.04	106.1
760	14.54	7.36	402.25	94.75	26.34	33.58	127.2
810	17.06	7.44	428.50	99.50	27.14	35.77	127.9
830	16.10	7.46	467.32	118,17	31.54	32.71	113.4
860	15.26	8.13	483.25	141.75	36.83	37.85	102.1
1000	14.08	7.63	500.00	151.25	29.49	34.12	105.7
1170	15.77	7.67	463.00	108.75	25.27	32.26	117.6
1210	17.63	7.49	507.75	144.52	33.27	34.33	118.7
Average	*16.50*	*7.83*	*487.92*	*129,54*	*33.33*	*35.07*	*105.7*
Highest	*18.20*	*8,31*	*515.47*	*151.25*	*43.18*	*39.71*	*127.9*
Lowest	*14.08*	*7.23*	*395.65*	*94.75*	*25.27*	*29.69*	*79.7*
BNJ .01	2.98	0.81	166.69	42.80	10.56	6.90	18.17

The relationship between the characteristics of fruit and cocoa beans with the height of the place is illustrated by the regression in **Figure 2.** The increase in altitude is followed by a decrease in fruit length, fruit diameter, fruit weight, seed weight and number of seeds, as well as an increase in the number of seeds per 100 g (or a decrease in the average weight seed). The best fruit characteristics were found at an altitude of 580 - 670 m asl with fruit lengths of 18.20 cm (600 m asl), fruit diameter of 8.31 cm (580 m asl), and fruit weight of 515.47 (670 m asl). The physical characteristics of the best seeds were

found at an altitude of 600 m asl with a dry seed weight of 43.18 g, and the number of seeds 79.7 per 100 g.

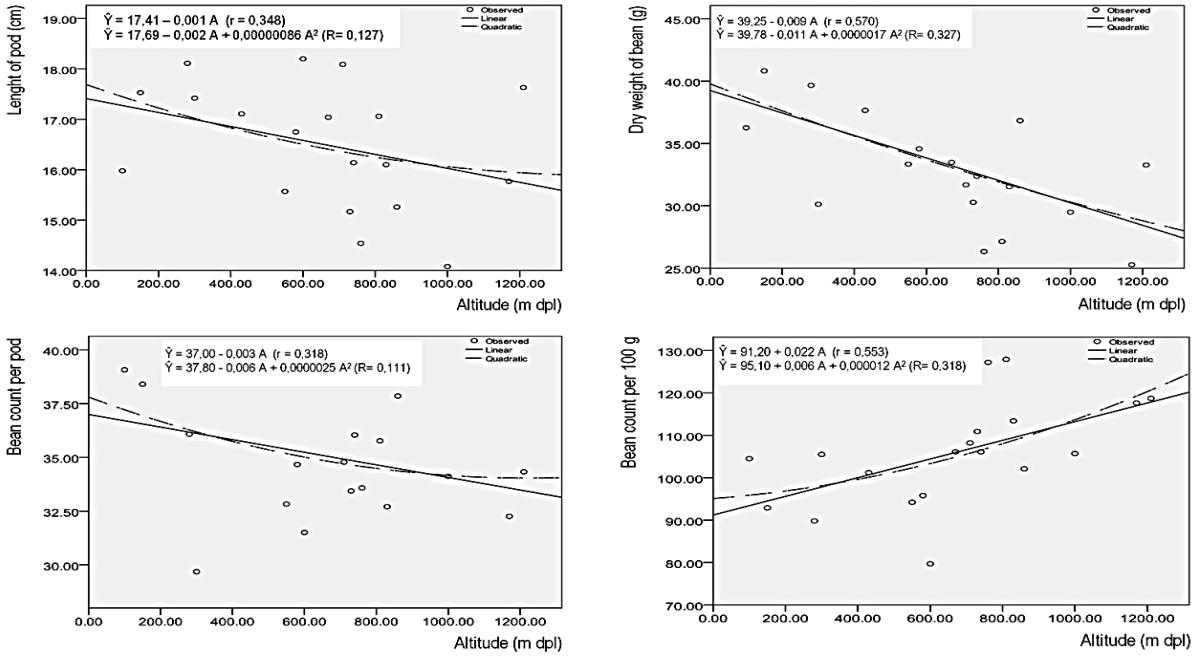

Figure 2. Relation of fruit length, dry seed weight, number of seeds per pod, and number of seeds per 100 g with altitude

The correlation between observable variables can be seen in **Table 3.** Variable length of fruit, fruit diameter, wet seed weight, dry seed weight, and number of seeds per pod positively correlated with each other. Variable number of seeds per 100 g was negatively correlated with fruit length, fruit diameter, fruit weight, wet seed weight, dry seed weight, and number of seeds per pod.

Table 3. Correlations between observed parameters

Parameter	ALT	LCF	DCF	WCF	WSW	DSW	NSP	NS_{100}
ALT	1	-	-	-	-	-	-	-
LCF	-0,348 ^{ns}	1	-	-	-	-	-	-
DCF	-0.408 ^{ns}	0.351 ^{ns}	1	-	-	-	-	-
WCF	-0.136 ^{ns}	0,508 *	0.743 **	1	-	-	-	-
WSW	-0,010 ^{ns}	0.145 ^{ns}	0,565 *	0.612 **	1	-	-	-
DSW	-0.389 ^{ns}	0.395 ^{ns}	0.419 ^{ns}	0.405 ^{ns}	0.453 ^{ns}	1	-	-
NSP	-0.312 ^{ns}	0.081 ^{ns}	0.385 ^{ns}	0.020 ^{ns}	0.348 ^{ns}	0,293 ^{ns}	1	-
NS_{100}	0,553 *	-0,376^{ns}	-0,645 **	-0,566 *	-0,480 *	-0,846 **	-0,085 ^{ns}	1

$r_{0.05}$ = 0.456 and $r_{0.01}$ = 0.575

Information : ALT = altitude; LCF = length of cocoa fruit; DCF = diameter of cocoa fruit; WCF = weight of cocoa fruit; WSW = wet seed weight; DSW = dry seed weight; NSP = number of seeds per pod; NS_{100} = number of seeds per 100 g

Variations in altitude cause variations such as temperature, radiation, humidity and air pressure. Cold temperature has the effect in reducing the rate of plant growth, because it slows down metabolism, which is related to compaction of lipid membranes and decreased enzyme activity in

membrane lipids [12]. At low temperatures the availability of phosphate in chloroplast decreases, because triose phosphate accumulates in the cytosol in the form of starch, so the photosynthesis of the plant becomes constrained, so that the synthesis of starch and sucrose will decrease rapidly due to a decrease in temperature [13]. Fruit growth requires nutrients and photosynthetic results. During fruit development, accumulation of assimilates and translocation from other organs is needed. Fruit size increases mainly due to post-fertilization cell enlargement. The main hormones of fruit growth are auxin and giberellin, which naturally come from pollen and seed formation [14]. Sucrose from photosynthesis can be a barrier to pollination and seed formation at higher altitudes, because photosynthesis is reduced [15]. Best temperature for respiration and accumulation of carbohydrates sink is 25°C [16].

Low temperatures reduce the intensity of cocoa flowers, fruit formation, fruit development and composition of cocoa flour, while high winds can damage cocoa leaves and affect production [17]. The development of cocoa fruit follows the sigmoid curve. Growth is slow until the age of 40 days, the increase in length and diameter of the fruit quickly until the age of about 70 days, then growth slows in line with the development of seeds and accumulation of fat in the seeds. If the pollination process is good, at the age of 5-6 months the ripe fruit is between 10-30 cm in size [18]. The maturation of the cocoa fruit takes 4.5-7 months after flowering depends on temperature [19]. The maturity level of the cocoa fruit determines the content of the pulp layer and the weight of fresh cocoa beans (wet). Cocoa beans are the desired end product, each fruit pod contains 30-50 seeds, with an average dry seed weight of 0.8 - 1.3 g. The smaller the seed size, the lower the quality [18]. According to Prawoto and Karneni (1994), an increase in altitude to a height of about 500 m above sea level results in increased seed size, but different circumstances actually occur at even higher altitudes [2]. In addition to altitude, other factors that influence the characteristics of cocoa fruit are: plant material, plant age, soil fertility, pest, fertilization, pruning and postharvest.

4. Conclusions

At various altitudes in North Sumatra, the size of the fruit and cocoa beans tend to decreased lower at higher altitudes. Fruit length ranged from 14.08 to 18.20 cm, fruit diameter from 7.23 to 8.31 cm, the weight of the fruit from 395.65 to 574.75 g, the weight of wet beans from 94.75 to 151.25 g, the weight dry seeds 25.27 - 43.18 g, the number of seeds per pod 29.69 - 39.71, and the number of seeds 79.7 - 127.9 per 100 g. The best dry seed production is obtained at an altitude of 600 m above sea level and the highest number of seeds at an altitude of 300 m above sea level.

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