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Good Handling Practice Study to Reduce The Level of Contamination in Cocoa Beans in East Luwu

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Abstract. Research on the content of heavy metals in cocoa beans from mining and non-mining areas in South Sulawesi has been done. The purpose of this study was to determine the effectiveness of handling cocoa according to SNI 2323-2008 in reducing heavy metal contamination of cocoa beans at mining and non-mining locations. The research method used was a completely randomized factorial design pattern with three replications. The first factor was two-region (mining and non-mining areas), the second factor was various quality handling (GHP and non-GHP). The results showed that the heavy metal analysis of cocoa beans that met the SNI requirements was found in the non-mining areas of Luwu district, both GHP (Pb 0.13 ppm, Cd 0.37 ppm, Cu 1.26 ppm, and Zn 41.72 ppm) and non-mining. GHP (Pb 0.13 ppm, Cd 0.31 ppm, Cu 0.51 ppm, and Zn 37.02 ppm). Meanwhile, cocoa beans in mining areas in East Luwu Regency have not met the SNI requirements because Pb, Cd, and Zn levels exceed the safe limits for the quality requirements of cocoa beans. The best cocoa beans from non-mining with GHP treatment (11.98% fat, total acid 313.25, pH 5.05, crude fiber 13.49%, polyphenols 0.37, and moisture content 7.84%)

1. Introduction

In 2016, cocoa production in South Sulawesi exceeded 145,674 tons, with a production value of IDR 4.6 trillion. Meanwhile, South Sulawesi exported 16,990.36 tons of cocoa beans from the export side with an income of US. $ 48.44 million [1]. Cocoa production centers in South Sulawesi are located in Luwu Raya, with a total production of 63,259.21 tons of a total area of 133,469.70 hectares consisting of 3 districts (Luwu Regency, North Luwu Regency, East Luwu Regency) and one town (Palopo), this means that Luwu Raya supplies about 54% of the total cocoa production in South Sulawesi of 117,118.52 tonnes [2]

Cocoa beans in Indonesia have increased significantly, but the quality produced is deficient and varied. Many factors significantly influence the quality of cocoa products, such as the raw material for cocoa beans and the production process to produce cocoa products, including not fermented, not dry enough, non-uniform bean size, high skin content, high acidity, very diverse and inconsistent flavors [3-5]. Therefore, it is necessary to carry out efforts to control the quality of cocoa beans, increase added value, competitiveness, create healthy business competition, and guarantee food safety quality.

Food safety is a problem that has become an essential topic in the world. Heavy metal contamination in agricultural products is one factor that affects food safety [6]. The cocoa plant can grow anywhere, both lowland and highland, dry land, or wetland. This plant can also grow in mining areas where soil contamination can occur where cocoa is grown.

Heavy metal is the term used for transition elements that have an atomic density greater than six gcm-3. Mercury (Hg), lead (Pb), copper (Cu), cadmium (Cd), and strontium (Sr) are examples of heavy metals in the form of contaminants that come from outside the soil and are of great concern because they impact human health, agriculture and their ecotoxicology [7]. Therefore, determining the maximum limit for heavy metal content in cocoa beans is very important to avoid the risk of heavy metals entering the food chain.

The expansion of the cocoa planting area will undoubtedly result in the widespread use of fertilizers, plus the geographical conditions that have mining potential, causing the possibility of heavy metal contamination of the soil and water used for cocoa cultivation, so that this allows the high content of heavy metals in cocoa beans that come from Sulawesi [6].

The high content of heavy metals in cocoa beans and low-quality control of cocoa beans where nearly 90% of farmers sell low-quality cocoa beans for export, of course, will have an impact on several export destination countries. The effect is that Indonesian cocoa is imposed with automatic detention and automatic discount so that its competitiveness is lower than that of cocoa produced in other countries. Therefore it is necessary to have Good Handling Practices (GHP) or proper and correct post-harvest handling of cocoa, starting from harvest to post-harvest, where this activity plays a vital role in securing the results from the loss in both quantity and quality so that the results obtained are following SNI or Requirements. Minimal Technical (PTM) suppresses the level of contamination in cocoa beans, both in mining and non-mining areas.

2. Materials and methods

2.1. Materials and tools

The cocoa bean samples' research material was taken from cocoa plants in mining and non-mining areas (cocoa belonging to farmers). The chemicals used include HNO_3, HCl, 30% H_2O, and standard Cd, Pb, Cu, and Zn. The equipment used includes analytical balance, measuring flask, silica plate, furnace, oven with ventilation, heater, Kjeldahl flask, and Perkin Elmer type AA700 atomic absorption spectrophotometer.

2.2. Research Implementation

2.2.1. Sampling Method. Soil and cocoa beans were sampled purposively by determining specific criteria for cocoa-producing areas in South Sulawesi. These criteria are in cocoa-producing centers with cooperative farmers and cocoa plantations in mining areas in South Sulawesi.

*2.2.2. Experimental design.*The research method used was a completely randomized factorial design pattern with three replications. The first factor was two-region (mining and non-mining areas), the second factor was various quality handling, two levels (GHP and non-GHP).

Grouping of farmers in the application of GHP as cooperator farmers and non-cooperators (Farmer's way), both in mining and non-mining areas. As for post-harvest handling of cocoa, SNI starts from harvesting, sorting, ripening, breaking the fruit, fermentation, washing, drying, sorting dry beans, packaging and storage called a cooperator or GHP. Meanwhile, farmers who do not apply according to SNI are non-cooperators or non-GHP.

2.2.3. Observation and Data Analysis. The parameters observed were the physical and chemical quality of cocoa beans in the sample using GHP and non-GHP (Farmer's method), both in mining and non-mining areas. Physical aspects include the number of dry seeds/100 grams, weight per dry seed (g), mold content (%), dirt content (%), and germination content. Chemical aspects include fat, moisture, total acid, pH, and heavy metal content (Cd, Pb, Cu, and Zn). Analysis of the physical and chemical quality of cocoa bean samples refers to SNI 2323: 2008. Observation data were analyzed using variance [8], Duncan's Multiple Range Test of 5%.

3. Results and Discussion

3.1. Soil analysis results

The results of soil analysis showed in Table 1. The soil analysis showed that the location had soil acidity (pH) ranging from 6.54 to 6.78 and neutral soil. The C-organic content in this soil is from 1.21 to 2.74% and is classified in the low to moderate category. Soil organic matter has a vital role and function in forming and maintaining the stability of the soil structure and increasing the holding capacity of groundwater. In addition, organic matter gives color to the soil, reduces soil cohesion, increases CEC and soil buffering capacity, binds or neutralizes toxic compounds or elements, and dissolves nutrients from soil minerals to be available for plants [9].

Table 1. Results of analysis of mining and non-mining areas with GHP and non-GHP treatments

Description	GHP		Non-GHP	
	Mining Area (East Luwu)	Non mining area (Luwu)	Mining Area (East Luwu)	Non mining area (Luwu)
Texture:				
Sand	18	13	22	17
Dust	55	17	62	25
Clay	27	70	16	58
pH:				
H_2O	6.55	6.70	6.54	6.78
KCl	5.74	5.62	5.94	6.02
Organic material:				
C	1.95 L	1.21 L	2.74 M	1.81 L
N	0.11 L	0.11 L	0.11 L	0.12 L
C/N	18 H	11 M	25 H	15 M
25% HCl Extract:				
P_2O_5	54 H	32 M	29 M	27 M
K_2O	49 VH	75 VH	54 VH	59 VH
Olsen:				
P_2O_5	2 VL	8 VL	8 VL	7 VL
K_2O	21 M	24 M	24 M	32 M
Acidity				
Al-exchange	0	0	0	0
H-swap	0	0	0	0
Cation Exchange Rate				
Ca	7.90 M	10.06 M	9.70 M	16.30 H
Mg	1.02 L	2.03 L	1.20 L	3.30 L
K	0.05 VL	0.05 VL	0.05 VL	0.07 VL
Na	0.13 L	0.15 L	0.14 L	0.22 L
Amount	9.10	12.29	11.09	19.89
KTK	8.17	13.68	11.23	20.92
KB	100*	90	99	95

Remaks: VL = Very Low; L = Low; M = Medium; H = Heigh; VH = Very High

The N-Total content in this soil is 0.11 - 0.12% and is in a low category. Nutrient N is a nutrient that functions as a constituent of many components of plant cells, including amino acids and nucleic acids. Therefore, nitrogen deficiency can inhibit plant growth and cause chlorosis symptoms [10].

Overall, it can be concluded that this soil has relatively low fertility for the content of C-organic and N-total, while for K_2O and P_2O_5, it is very high, and the pH is acidic. It is necessary to make efforts to overcome soil fertility. It is required to handle the provision of input in fertilizers to increase soil fertility.

3.2. Results of analysis of heavy metals in soil

In the soil, in general, the content of heavy metals is naturally shallow unless the land is in a mining area or the land has been polluted. The results of the analysis of heavy metals in soil showed in Table 2.

Table 2. Results of analysis of heavy metals in mining and non-mining areas with GHP and non-GHP treatments

Description	GHP		Non-GHP	
	Mining Area (East Luwu)	Non mining area (Luwu)	Mining Area (East Luwu)	Non mining area (Luwu)
Pb (ppm)	12	36	18	31
Cd (ppm)	ND	ND	ND	ND
Cu (ppm)	27	20	16	11
Hg (ppm)	ND	ND	ND	ND

Note: ND = Not Detected

From Table 2, it can be seen that the heavy metals Cd and Hg are not detected in the soil, which means that the heavy metal comes from outside. Heavy metal contamination can be caused by anthropogenic factors such as pesticide and fertilizer residues, contamination from mining activities, and heavy industry [11]. Metals are first extracted from underground mining (the earth's crust), liquefied and refined in factories to become pure metals. In the metal refining process, part is wasted in the environment.

Heavy metals are naturally present in the soil and cannot be degraded, they can remain in the soil and water bodies for a long time, so they will continue to increase over time [12]. The accumulation of metals in the soil can decrease soil microbial activity, soil fertility, overall soil quality, and a decrease in yields and the entry of toxic materials into the food chain [13]. Soil and water are two components that are the target of pollution; if the soil and water are contaminated with heavy metals, the heavy metals will enter the food chain and form food webs and eventually go to humans as consumers of the universe, causing various kinds of diseases in humans, especially disorders, on the nervous system [14].

Heavy metal pollution has emerged due to anthropogenic activity, which is the prime cause of pollution, primarily due to mining the metal, smelting, foundries, and other industries that are metal-based, leaching of metals from different sources such as landfills, waste dumps, excretion, livestock and chicken manure, runoffs, automobiles, and roadworks. Heavy metal use in the agricultural field has been the secondary source of heavy metal pollution, such as pesticides, insecticides, fertilizers, and more. Natural causes can also increase heavy metal pollution such as volcanic activity, metal corrosion, metal evaporation from soil and water [15,16].

3.3. Result of physical analysis of cocoa beans

The physical analysis of dry cocoa beans from two regions (mining and non-mining), both GHP and non-GHP, is presented in Table 3. Based on the physical analysis of cocoa beans originating from mining and non-mining areas, both GHP and non-GHP (Table 3) show that farmers' moisture content is produced by farmers 2.07 - 9.67% on average; this value is according to the standard. Cocoa beans from mining areas are both GHP and non-GHP treatment. Meanwhile, cocoa beans from non-mining regions, both GHP and non-GHP, are still above the SNI 2323-2008 standard, namely a maximum of 7.5%. It is assumed that the drying time for cocoa beans is too short, so the moisture content of the beans is still high.

Table 3. Physical characteristics of dry cocoa beans from mining and non-mining areas treated with GHP and non-GHP

Description	Mining		Non Mining		Quality Requirements Cocoa Beans SNI 2323-2008
	GHP	Non GHP	GHP	Non GHP	
Water content (%)	5.22	2.07	7.84	9.67	Max 7,5
Life insects	Nothing	Nothing	Nothing	Nothing	Nothing
Smoked / hammy / foreign-smelling seeds	Nothing	Nothing	Nothing	Nothing	Nothing
Foreign object content	Nothing	Nothing	Nothing	Nothing	Nothing
Number of seeds per 100 g sample	110.00 B	100.00 A	97.00 A	90.00 A	-
Content of moldy seeds (seeds/seeds)	2.80	2.70	2.70	1.80	Max. 2
Slaty seed content (seed/seed)	0	0	0	0	Max. 3
Insect seed content (seeds/seeds)	0	0	0	0	Max. 1
Dirt content (seeds/seeds)	0	0	0	0	Max. 1,5

Note: *Primer data, 2018*

Water content is a critical physical property and is very important to the buyer. In addition to significantly affecting yield, moisture content also affects the resistance of cocoa beans to damage, especially during warehousing and transportation. Cocoa beans, which have a high moisture content, are very susceptible to fungi and insects. Consumers highly dislike both because they cause irreparable damage to the base flavor and aroma in subsequent processes. The moisture content standard for export quality cocoa beans is 6-7%. If it is higher than this value, cocoa beans are not safe for long storage, while if the moisture content is too low, the beans tend to become brittle. The moisture content of cocoa beans, which is more than 8%, causes the beans to be easily attacked by fungi and insects, increasing the beans' risk. Still, if the moisture content of the beans is less than 5%, it will cause the beans to break easily [17].

According to Munarso [18], the quality of cocoa beans is strongly influenced by plant genetic characteristics, physical environment, cultivation practices, and post-harvest handling such as harvesting, fermentation, washing, drying, and transportation. In trade, it is known that there is a classification of cocoa beans based on the number of beans [18]. Cocoa beans are classified as AA class if the maximum number of beans per 100 g sample is 85 beans, class A ranges from 86 to 100 beans, class B is 101-110 beans, class C is 111-120 beans, and class S is more than 120 beans [19]. Cocoa beans have various quality classes. The bean count value obtained from mining areas with GHP treatment has 110 seeds per 100 g or equivalent to class B quality and non-GHP treatment 100 seeds per 100 g or equivalent to quality class A. In non-mining areas, the bean count values range between 90-97 seeds per 100 g or equivalent to class A quality, whether produced from GHP or non-GHP treatments.

The size of the seeds determines the yield of fat yield. The larger the cocoa bean size, the higher the fat gain from the bean. The size of cocoa beans is expressed in terms of the number of beans (beans account) per 100 g of the sample taken randomly. The average seed size that enters export quality is between 1.0 - 1.2 grams or the equivalent of 85 - 100 seeds per 100 g of sample.

The size of dry cocoa beans is strongly influenced by the type of plant material, garden conditions (rainfall) during fruit development, agronomic treatment, and processing methods. Supported by Wahyudi *et al.* [20] that the size of the beans is determined by the type of plant material (clones); large beans are obtained from superior planting material that is well cared for and produced from ripe cocoa pods [20].

Good Handling Practices (GHP) are general guidelines for carrying out post-harvest handling of agricultural products correctly and precisely, obtain high productivity, good product quality, optimum profit, environmentally friendly, and pay attention to aspects of safety, safety, and welfare of farmers as well as sustainable production efforts. In the plantation world, especially cocoa, GHP has also been introduced in its production activities, both in cultivation, maintenance, and harvesting, to produce good cocoa beans [21]. Quality control of cocoa beans will ensure the quality of cocoa beans. The treatment largely determines cacao seed quality criteria, including physical aspects, taste, cleanliness, uniformity, and consistency aspects at each stage of the production process. The rejection of cocoa bean products from Indonesia by importers almost always occurs, mainly because the shipped cocoa does not meet international quality standards (Codex) [22].

3.4. Results of analysis of cocoa beans nutrition
The results of the analysis of cocoa bean nutrition showed in Table 4.

Table 4. Results of analysis of nutrients for cocoa beans from mining and non-mining areas with GHP and non-GHP treatments

Description	Fat (%)	Total acid (%)	pH	Crude fiber (%)	Polyphenol (%)	Water content (%)
Region						
Mining	7.38 b	68.03 b	6.4 a	13.78 a	0.22 b	3.65 b
Non Mining	13.75 a	257.70 a	5.2 b	12.62 b	0.63 a	8.76 a
Farmer						
GHP	8.56 b	190.54 a	5.73 b	14.99 a	0.36 b	6.53 a
Non-GHP	12.57 a	135.19 b	5.88 a	11.42 b	0.49 a	5.87 b
Interaction both location and Farmer						
Mining GHP						
Mining non GHP	5.14 d	67.84 c	6.40 a	16.48 a	0.34 b	5.22 c
Non-Mining GHP	9.61 c	68.22 c	6.40 a	11.07 d	0.09 c	2.07 d
Non Mining non GHP	11.98 b	313.25 a	5.05 c	13.49 b	0.37 b	7.84 b
	15.53 a	202.16 b	5.35 b	11.77 c	0.89 a	9.67 a

The numbers followed by the same letters in the same column are not significantly different in Duncan's multiple range test α = 0.05

Fat
Table 4 showed that the highest fat content of cocoa beans was obtained from non-mining areas without GHP treatment (15.53%) and fat content lowest from mining areas treated with GHP (5.14%). The low-fat content in the mining area also allows the presence of heavy metals in cocoa beans. Cocoa beans, cocoa butter, cocoa powder, and chocolate products may contain heavy metal by-products that affect consumer health. Pb metal usually accumulates on the seed coat, which can be removed during the winnowing process. Meanwhile, Cd is usually present in more oversized cocoa products, which can also be obtained during the manufacturing process [23].

The constituent components of the fat determine the characteristics of fat. The fat constituent components are relatively unaffected by the cocoa bean processing process. Still, they are influenced by 1) the maturity level of the beans when harvested, 2) clones, 3) where the plants are grown, and 4) the harvest season. Cocoa beans originating from rainy season fertilization generally have a higher fat content [24].

Total Acid
The total titrated acid measurement results in cocoa beans in mining and non-mining areas, both GHP and non-GHP, significantly affect. The relationship between mining areas and GHP to total acid is presented in Table 4.

The acid in cocoa beans is included in organic acids divided into volatile organic acids (mainly acetic acid) and non-volatile organic acids (lactic, succinic, malic, oxalic, and tartaric acids). Acetic acid is an acid component with the greatest concentration reaching 788 μg / g [20]. Organic acids are formed, such as lactic acid and acetic acid. These acids will affect the acidity (pH) of the beans after fermentation [25-27].

Among the attributes of chocolate taste, sour taste is an important attribute that contributes to the overall taste of chocolate products [28]. A slightly acidic taste contributes to the flavor balance of the chocolate, but the sour taste is accepted as a taste defect to a greater extent.

pH

The influence of mining areas and their interactions with GHP has a significant effect on the pH of cocoa beans. The average pH of the seeds is shown in Table 4. The high pH value of cocoa beans for treating both GHP and non-GHP mining areas is because the mass of cocoa beans has better acetic acid bacterial activity. The process of forming acetic acid is easier to occur in the mining area. The pH value of a good cocoa bean is close to neutral (pH> 6) so that distinct chocolate compounds can be formed intensively [29].

Cocoa beans with acidity values expressed in pH units with a value of 5.20-5.50 or an acid titration value of 0.12-0.15 meq/g are accepted as cocoa beans with optimal acidity by chocolate manufacturers. Seeds classified as acid have a pH <5.0. According to Lopez and Passos (1984), manufacturers in Europe and America want dry cocoa beans with a pH of 5.1– 5.8, and pH 5.2 is preferred. The pH of the cocoa cannot be less than 3.5 [30].

The cocoa processing industry requires a bean pH between 5.2-5.8 to produce quality cocoa butter [31]. So, those that meet the requirements for manufacturers in Europe and America are cocoa beans from non-mining areas with a pH of 5.05 for GHP treatment and a pH of 5.35 for non-GHP treatment.

3.5. Results of heavy metal analysis of cocoa beans

Sources of heavy metals in the environment can come from: natural factors, agriculture, industrial activities, household waste, the atmosphere, and other sources. Activities such as mining and smelting, and agriculture have resulted in widespread pollution by heavy metals such as Cd, Cu, and Zn in several countries in the world, including Japan, Indonesia, and China [16].

Based on the Decree of the Director-General of Drug and Food Control No. 03725/B/ SK/VII/1989 regarding the maximum limit of metal contamination in food stipulates that the maximum permissible metal contamination limit in food products is: lead (Pb) 0.1 - 10 mg/kg and copper (Cu) 0.1 - 150 mg/kg, Zn 100 mg/kg and Cadmium (Cd) 0.2-0.5 mg/kg. The maximum limit of heavy metal content in food for the metal category As, Cd, Hg, Sn, and Pb has also been stipulated through SNI No. 7387: 2009, including for candy, chocolate, and cocoa powder. The limit of Cd content for chocolate and cocoa products according to SNI No. 7387: 2009 is 0.5 mg/kg. The limit of Hg content in cocoa powder is 0.03 mg/kg, while arsenic levels are limited to 1.0 mg kg [32].

From the results of the heavy metal analysis in cocoa beans, it is known that the beans that meet the requirements of SNI 2323-2008 are non-mining plantations, namely Luwu district, both GHP (with Pb content of 0.13 ppm, Cd 0.37 ppm, Cu 1.26 ppm, and Zn 41.72 ppm) and non-GHP (with a Pb content of 0.13 ppm, Cd 0.31 ppm, Cu 0.51 ppm, and Zn 37.02 ppm). Meanwhile, cocoa beans in the mining area, namely the East Luwu District, do not meet the SNI 2323-2008 requirements because Pb, Cd, and Zn content levels exceed the safe limits of the SNI 2323-2008 cocoa bean quality requirements. So that for food security, mining areas such as the East Luwu district are designated for mining, not for agriculture, especially for cocoa. According to Munarso (2016), heavy metal contamination in cocoa beans needs to be watched out for, especially cocoa produced by plantations in mining areas. Cocoa beans are susceptible to heavy metal contamination in this area, accumulating in the soil, air, and water [18].

Table 5. Results of analysis of heavy metals for cocoa beans from mining and non-mining areas with GHP and non-GHP treatments

Description	GHP		Non-GHP		Max.limit of heavy metal contamination (mg/kg)
	Mining Area (East Luwu)	Non mining area (Luwu)	Mining Area (East Luwu)	Non mining area (Luwu)	
Pb (ppm)	11.00 a	0.13 b	0.00 c	0.13 b	0,1 – 10
Cd (ppm)	2.03 a	0.37 c	0.94 b	0.31 c	0,2 – 0,5
Cu (ppm)	28.03 a	1.26 c	25.00 b	0.51 c	0,1 - 150
Zn (ppm)	108.00 b	41.72 c	122.00 a	37.02 d	100

The numbers followed by the same letters in the same row are not significantly different in Duncan's multiple range test α = 0.05

The results of Cd analysis on cocoa beans from Luwu and East Luwu in both GHP and non-GHP treatments showed a high value of about 0.31 - 2.03 ppm. This value is still quite high when compared to the Cd content in West Sulawesi, where North Mamuju and Mamuju Districts have cadmium levels of only 0.2326 ppm and 0.241 ppm, respectively. Regarding the regulation on the flexibility of cocoa beans with cadmium content> 0.8 ppm, the cocoa beans originating from Luwu Regency can still meet these requirements. In contrast, cocoa beans from East Luwu Regency in the mining area must first be checked for their cocoa bean content strictly. Cadmium content is a parameter that is of great concern in the international trade in cocoa beans because Cd is toxic, even in small amounts.

The heavy metal content in cocoa will not change during processing. The high cadmium accumulation in cocoa is determined by soil texture, soil pH, and plant type. To anticipate this, the researchers suggest using more than one variety or clone of cocoa. Gardens with a variety of plant materials will reduce the lower cadmium content. For example, in the case of Peru, farms that plant CCN-51, ICS95, and ICS39 cacao have a lower cadmium content than plantations that only use one type of cocoa. The addition of zinc also has an impact on increasing cadmium in plants [33].

The high copper (Cu) content of cocoa beans in mining areas is probably due to the application of fungicides to cocoa pods. According to Ristanti et al. [6], the accumulation of copper (Cu) in cocoa beans is associated with using a Cu-based fungicide. Cu enters the cocoa beans through uptake and translocation of Cu from the soil, as well as Cu permeation in the cuticles of the pods after the use of fungicides [6]

3.6. Results of heavy metal analysis of cocoa leaves

The highest concentration of lead is found in the leaves and roots, absorbed through the soil, then spread to other parts of the plant [34]. The results of heavy metal analysis of cocoa leaves showed in Table 6.

Likewise, from the results of heavy metal analysis on the leaves of cocoa plants, it is known that plants that meet the requirements of SNI 2323-2008 are non-mining plantations, namely Luwu district with good GHP (with Pb content of 0.58 ppm, Cd 0.39 ppm, Cu 0.00 ppm, and Zn 46.86 ppm) and non-GHP (containing Pb 0.44 ppm, Cd 0.45 ppm, Cu 0.00 ppm, and Zn 47.61 ppm). Meanwhile, cocoa plants in mining areas, namely the East Luwu District, did not meet the SNI 2323-2008 requirements because Pb and Cd content levels exceeded the safe limits of the SNI 2323-2008 cocoa bean quality requirements. According to Gunawan et al. (2015), the mining environment can be the main distribution of heavy metals, and this can cause the degradation of soil, water, and grass quality [35]. Cocoa leaves contain heavy metals (Cd, Mn, Pb, and Zn) from the soil [36-38]. Plant to absorb these metals from the soil through the roots and then translocate them to the leaves [39-41].

Table 6. Results of study of heavy metals in cocoa leaves from mining and non-mining areas with GHP and non-GHP treatments

Description	GHP		Non-GHP		Max.limit of heavy metal contamination (mg/kg)
	Mining Area (East Luwu)	Non mining area (Luwu)	Mining Area (East Luwu)	Non mining area (Luwu)	
Pb (ppm)	16.70 a	0.58 b	18.80 a	0.44 b	0,1 – 10
Cd (ppm)	1.99 a	0.39 b	2.00 a	0.45 b	0,2 – 0,5
Cu (ppm)	10.57 a	0.00 b	10.60 a	0.00 b	0,1 - 150
Zn (ppm)	74.30 a	46.86 c	74.67 a	47.61 b	100

The numbers followed by the same letters in the same column are not significantly different in Duncan's multiple range test $\alpha = 0.05$

The distribution of Cd in cacao plant generally decreased in the order of beans >> shell>> leaves [42,43]. Arevalo-Gardini et al. [44] reported that the concentration of Cr, Ni, and Pb in cocoa beans and leaves was influenced by sampling location and cocoa bean genotype [44,45]. It is supported by Jung [14] that increased levels of heavy metals can be found in and around mining areas due to the disposal and distribution of mining waste to agricultural land, food crops, and river flow systems. It can cause health potential for residents around the mining area [14, 46]. These heavy metals are in the soil and then enter the plant to risk people who consume these plants. These metals can also change soil pH, color, porosity, and natural chemistry to impact soil quality and pollute water [47,48]. Heavy metals in soil pose a serious ecological risk as these metals cannot be degraded or permanently removed from the land. Developing methods for the in situ remediations of heavy metal contaminated soils is needed to make such soils acceptable for agriculture [49]. Heavy metals have toxic effects when biochemical reactions occur in living organisms, inhibiting growth, lack of oxygen needed, reproductive disorders, and tissue repair [50,51].

4. Conclusions

This research results of the heavy metal analysis in cocoa beans, it is known that the beans that meet the requirements of SNI 2323-2008 are plantations in non-mining areas, namely Luwu district, both GHP (0.13 ppm Pb, 0.37 ppm Cd, 1.26 ppm Cu, and 41.72 ppm Zn) and non-GHP (0.13 ppm Pb, 0.31 ppm Cd, 0.51 ppm Cu and 37.02 ppm Zn). Meanwhile, cocoa beans in the mining area, namely East Luwu Regency, do not meet the SNI 2323-2008 requirements because Pb, Cd and Zn content levels exceed the safe limits of the quality requirements for cocoa beans. So that for food security, mining areas such as the East Luwu district should not be designated for agriculture, especially for cocoa. The best cocoa beans are produced from non-mining areas with Good Handling Practice (GHP) treatment containing 11.98% fat, 313.25 total acids, 5.05 pH, 13.49% crude fiber, 0.37 polyphenols, and 7.84% moisture content.

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