Study of Good Handling Practices and Critical Control Point Determination of Dried Fermented Cocoa Bean in Gunung Kidul Regency, Yogyakarta

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Abstract. The Hazard Analysis Critical Control Point is needed to improve the quality and competitiveness of cocoa beans. The objectives of this research were to study of Good Handling Practices at cocoa beans fermentation and determination of critical control point as the first step in making Hazard Analysis Critical Control Point plan. The research was conducted at Processing Product Unit Ngudi Raharjo II, Gunung Kidul Regency, Yogyakarta. The method used in this research were interview, observation, recording of cocoa quality, temperature and pH during fermentation, drying temperature and water content reduction in cocoa beans during drying, while determination of critical control point by answering the question from decision tree associated with the risk assessment matrix. The results shown that Good Handling Practices there were 26 of 76 elements that have not been applied, so it needs to be improved. The average temperature of cocoa beans fermentation on the surface for five days is 38.5 °C, in the middle section is 42.3 °C and in the bottom was 34.8 °C. The average pH of cocoa beans fermentation for 5 days was 3.2. Temperature and pH of fermentation are lower than they should be, this is due to too much cocoa bean pulp. The average temperature in sun drying for four days was 30.3 °C. The average drying temperature with drying machine for three days was 39.2 °C. The drying process should be carried out at 55-60 °C for 40-50 hours. Of the nine stages of the process, drying was a critical control point.

1. Introduction
Cocoa (Theobroma cacao L) is one of the potential plantation commodities. Indonesia is the third largest cocoa producer in the world after Ivory Coast and Ghana with cocoa bean production of 760,429 tons in 2016 [1]. But in international trade the selling value of Indonesian cocoa beans is still low because the quality of cocoa beans is considered low and cocoa beans are diverse. This is due to the fact that the processing or fermentation process of cocoa beans is mostly carried out by farmers with equipment that is not guaranteed to be clean as found in Gunung Kidul, Yogyakarta. In Indonesian cocoa beans there are still unfermented seeds, contaminated with mold and insects [2, 3, 4].

Gunung Kidul is one of the districts in Yogyakarta Special Region which has a lot of potential natural resources including cocoa plantations. Cocoa from Gunung Kidul Regency is one of the commodities that can potentially contribute to the dynamics of the people's economy in 5 sub-districts, namely Patuk, Karangmojo, Gedangsari, Ponjong and Nglipar. Cocoa beans from Gunung Kidul have still a lot of problems, especially in the quality, so it needs attention for increase the quality of cocoa beans [5].
Many studies have shown that fermented cocoa beans have low quality due to mold contamination. The postharvest process of cocoa beans started from breaking fruit, fermentation, drying before storage, increasing the risk of contamination by bacteria (Salmonella) and fungi (Aspergillus and Penicillium) [6, 7]. Aspergillus sp are known to produce mycotoxins in cocoa beans, namely ochratoxin A [8, 9, 10].

The efforts to improve the quality and safety of fermented cocoa beans can be done from harvest to fermentation process. Quality and security guarantees of processing can be carried out with the Hazard Analysis Critical Control Point (HACCP) system. The application of Good Handling Practices is important and as a guarantee to consumers that the products marketed come from a series of processes that are efficient, productive and environmentally friendly [11]. Therefore, this study aimed to examine the application of GHP and determination of critical control point as the first step in making Hazard Analysis Critical Control Point plan at the Processing Unit in the Ngudi Raharjo II farmer group, Gunung Kidul, Yogyakarta.

2. Methodology

2.1. Material
The material used in this study was cocoa beans from Processing Unit (PU) Ngudi Raharjo II, Gunung Kidul Regency, Yogyakarta.

2.2. Equipment
The thermometer, Sanfix digital thermometer, portable ATC pH meter, Grain Moisture Tester Kett PM-410, Memmert drying oven, dextrometer, weighing bottle, METTLER PM4600 analyte scales, Philips blender, spatula were used for analysis. The tools used for interviews, observation, and assessment of Good Handling Practices (GHP) were guidelines that contain various questions and a check list sheet on the application of cocoa beans quality. The question guide were used as a reference for conducting observations and interviews with Ngudi Raharjo II cocoa farmers. Check list for the application of quality cocoa beans was used as a GHP study.

2.3. Location
The study was conducted in Processing Unit of NgudiRaharjo II farmer group, Plosokerep, Bunder, Patuk, GunungKidul, Yogyakarta.

2.4. Method
The study was conducted in 4 stage, namely (1) observation and interview, (2) evaluation of GHP application, (3) study of cocoa beans fermentation stage (4) critical control point analysis.

2.4.1. Observation and Interview
The observations was conducted by direct observation of the cocoa beans fermentation process, to get a true picture of the cocoa beans fermentation activities at the PU Ngudi Raharjo II. Interviews were conducted directly with cocoa farmers, to find out the stages of the process carried out by cocoa farmers and the reason cocoa farmers did not conducting unsafe work practices. Observations and interviews included eight things on the check list on the application of cocoa beans quality, namely institutional, harvest, postharvest handling, quality standards, postharvest facilities and infrastructure, environmental preservation, supervision, and labor.

2.4.2. Evaluation of GHP Application
Evaluation of GHP application was conducted based on the regulation of the Minister of Agriculture of the Republic of Indonesia number 67/permentan/OT.140/5/2014. The analysis was conducted by comparing existing conditions with the conditions that should be.
2.4.3. Study of Cocoa Beans Fermentation Stage
At this stage, a study was carried out observation on all stages of the processing in PU NgudiRaharjo II for producing fermented dried cocoa beans and compared with the stages of the production process of the dried cocoa beans that should be.

2.4.4. Critical Control Point Analysis
Determination of critical control point was conducted by answering questions from the decision tree that was linked to the risk assessment matrix and hazard assessment.

3. Results and Discussion

3.1 Identification and Evaluation of Good Handling Practices (GHP) Application
The Ngudi Raharjo II Processing Unit (PU) measures 4 X 6 meters, located far from the garbage disposal area and farm area. The PU building was closed to the house of members of the Ngudi Raharjo II farmer group and close to the road. The PU inside, there were 5 fermentation boxes, 1 drying machine and bamboo makers as a base for drying the cocoa beans by the sunshine method (Figure 1). Inside the PU was often used to store dried fermented cocoa beans that have been packed in plastic sacks.

Figure 1. Processing Unit of cocoa at Ngudi Raharjo II farmers group; a. front look, b. inside.

Drying and fermentation areas in the same place. This areas have a high risk of cross contamination. During the fermentation process, producing heat and water causes the humidity increase while the drying and storage processes require low air humidity. Therefore, it is recommended that the process of fermentation, drying, and storage of cocoa beans be carried out in a different place or by giving a barrier between areas to produce fermented cocoa beans of good quality [12, 13]. The PU layout recommendations is presented in Figure 2. Drying of cocoa beans in PU building a transparent roofed is better than drying the cocoa beans outside the building.
Information:
- **Blue** = sorting area of cocoa beans
- **Yellow** = drying area by sun drying method
- **Brown** = fermentation area
- **Light Gray** = drying area by machine
- **Purple** = washing area after fermentation
- **Green** = storing area of fermented dried cocoa beans

**Figure 2.** Recommendation of PU layout for fermentation of cocoa beans.

The data shows that 26 elements from 76 elements of GHP has not been applied, namely 2 institutional elements, 8 postharvest elements, 2 elements of quality standards, 12 elements of infrastructure facilities and 2 elements of supervision. This was due to the lack of knowledge of group members about GHP, where as to produce dry fermented cocoa beans of good quality according to SNI 01-2323-2002 and SNI 01-2323-2018 it is necessary to GHP application [13, 14].

### 3.2. Production Process of Cocoa Beans Fermentation Stage

The stages of fermented cocoa beans was carried out by the Ngudi Raharjo II farmer group include harvesting, fruit sorting, fruit splitting and seed taking, sorting of wet cocoa beans, weighing of wet cocoa beans, fermentation, drying, weighing of fermented cocoa beans, packaging and storage, is presented in Figure 3.
Cocoa Plant

Harvesting
Picking the optimum ripe fruit using scissors

Sorting
Selection of good fruit

The breakdown of cocoa fruit and beans collection using wooden bat

Wet beans sortation
Separation of healthy beans from diseased beans and dirt

weighing of wet cocoa beans

Fermentation
Capacity of box is 40 kg, 5 days

Drying
Drying machine and sun drying

Dried fermented cocoa beans

Weighing of dried cocoa beans

Packing and storage
Using plastic sack and storage in PU

Figure 3. The production stage of fermented cocoa beans in Ngudi Raharjo II farmer group

3.3. Determination of Critical Control Point
3.3.1. Identification of Hazards Potential at Cocoa Beans Fermentation Stage

Dry fermented cocoa beans produced by the Ngudi Raharjo II farmer group in GunungKidul. Fermentation was conducted for 5 days and dried in sun drying or drying machine to 7.5% moisture content and packed in plastic sacks.

Harvesting of cooked cocoa fruit has the potential for biological hazards in the form of pests and diseases that originate from pests and infectious diseases. The hazards has an opportunity value of 3 because it is almost always encountered and the severity value was 2 because the danger is only outside the skin of the cocoa fruit. Cocoa fruit sorting has the potential for biological hazards in the form of pests and diseases derived from pests and diseases. The hazards has an opportunity value of 2 because it is rarely found and the severity value 4 because it can contaminate all the good cocoa fruits. Potential physical hazards in the form of twigs, gravel, leaves, and soil carried from the cocoa farm. The hazards has an opportunity value of 2 because it was rarely found and has a severity value 1 because it does not give any effect.

The breakdown of cocoa fruit has the potential biological hazards, such as insects and fungi come from the surrounding air, hands of farmers and equipment that was not clean. The danger has an opportunity value of 2 because it rarely occurs and the severity value 4 because it can have a direct impact on the quality of the cocoa beans. The potential physical hazards such as cocoa beans are injured due to exposure to cocoa fruit breakers. The hazards has an opportunity value of 2 because it was rare and has a severity value of 2 because it only affects the appearance of cocoa beans. The
potential of chemical hazard such as metal contamination from rusty breakers. The hazards has an opportunity value of 2 because it rarely occurs and the severity value is 3 because it can have a direct impact on the quality of cocoa beans.

Sortation of wet cocoa beans has the potential for biological hazards such as insects, mold contamination, *E. coli* and *Salmonella* Sp. which comes from the surrounding air and hands of farmers who are not clean. These hazards have an opportunity value of 2 because they rarely occur and the severity value was 4 because if they occur they can have a direct impact on the quality of the cocoa beans. The potential for physical hazards in the form of gravel, twigs, leaves, and soil originating from the work environment with an opportunity value of 2 because it rarely occurs and the severity value 2 because it does not have a direct impact on the quality of cocoa beans.

Weighing of wet cocoa beans has the potential for biological hazards such as insects, mold contamination, *E. coli* and *Salmonella* Sp. which comes from the surrounding air and hands of farmers who were not clean. These hazards have an opportunity value of 2 because they rarely occur and the severity value was 4 because if they occur they can have a direct impact on the quality of the cocoa beans. Potential physical hazards such as gravel, twigs, leaves, and soil originating from the work environment. The hazards has an opportunity value of 2 because it rarely occurs and the severity value 2 because it does not have a direct impact on the quality of cocoa beans.

Fermentation of cocoa beans have the potential for biological hazards such as insects, mold contamination, *E. coli* and *Salmonella* Sp. which comes from hands of farmers who were not clean and the fermentation temperature was not optimal. The hazards has an opportunity value of 2 because it rarely occurs and the severity value was 3 because if it happens it can have a direct impact on the quality of the cocoa beans. Potential physical hazards such as foreign objects from fermentation boxes, wooden cows and farmers' hands. The hazards has an opportunity value of 2 because it rarely occurs and the severity value 2 because it does not have a direct impact on the quality of cocoa beans.

The Ngudi Raharjo II farmer group has carried out the stages of fermentation of cocoa beans correctly but the temperature and pH of the fermentation have not reached optimal. On day 5, the fermentation temperature at the surface reached 38.5 °C, the middle part was 42.3 °C and the bottom part was 34.8 °C. According to [16], on the third day the fermentation temperature had reached 47.6 °C and at the end of the fermentation temperature reached 48.7 °C. Fermentation is considered successful if it has reached a temperature of 44 °C for at least 6 hours. So that it can be said that the fermentation carried out by the Ngudi Raharjo II farmer group has not been optimum. Non-optimum fermentation temperatures can cause cocoa beans to not be fermented properly and allow some cocoa beans to not die [17].

The fermentation temperature was not optimum can be caused by too much pulp so that it blocks the aeration process, consequently the oxidation reaction was less optimal. Criollo varieties generally have less pulp while Forastero varieties have more pulp. Therefore, it is necessary to sort cocoa based on varieties. Pulp reduction before fermentation can be carried out using depulper thus accelerating the increase in fermentation temperature [18, 19]. The acidity of the seeds at the end fermentation reached 3.4. According to [16] and [20], the pH of cocoa beans at the end fermentation increased to 5 - 5.8.

The drying of cocoa beans has the potential for biological hazards such as fungi caused by high water content due to the drying temperature is not optimal and contamination from the environment. The Hazards has an opportunity value of 3 because it almost always occurs and the severity value 4 because fungal mycotoxins have an impact on the quality and safety of cocoa beans. The Physical hazards in drying process such as dust from the environment. The hazards has an opportunity value of 2 because it rarely occurs and the severity value 2 because it does not have a direct impact on the quality of cocoa beans. The drying of fermented cocoa beans was carried out until the water content reaches 7.5% [21] to prevent contamination of mycotoxin-producing fungi. Fungi contamination on dry fermented cocoa beans will be identified in chocolate products such as candy and chocolate powder [22, 23].

The weighing of dry fermented cocoa beans has the potential for biological hazards such as farmers and scales that are not clean. The hazards has an opportunity value of 2 because it rarely occurs and the severity value was 3 because if it happens it can affect the quality of the cocoa beans. Potential physical hazards in weighing
such as foreign objects originating from the environment. The hazards has an opportunity value of 2 because it rarely occurs and the severity of value is because it does not have a direct impact on the safety of cocoa beans. Packaging and storage have the potential biological hazards such as fungi, insects and rats, have a probability value of 2 because they rarely occur and the severity value 3 because it effects on the quality of cocoa beans. Physical hazards in this stage such as foreign objects from packaging bags were reused. The hazards has an opportunity value of 2 because it rarely occurs and the severity value 2 because it does not have a direct impact on the quality of cocoa beans.

3.3.2. Identification of Critical Control Point

To determine the critical control point refers to the decision tree and hazard control [24]. From the 9 stages of the process at PU Ngudi Raharjo II, there was identified 1 critical control point, namely drying of fermented cocoa beans. This based on the question of the decision tree at the stage of the drying process, question 1: Are there any control measures at this stage? Yes. Control measures in the drying process are not delaying the drying process of the cocoa beans, setting the thick stack of dried cocoa beans, and increasing the temperature of the drying machine. Question 2: Are the stages specifically designed to eliminate or reduce possible hazards to acceptable limits? Yes. The drying process aims to reduce the water content of fermented cocoa beans to a maximum of 7.5% so as to minimize the growth of fungi on the cocoa beans.

In addition, the drying process was classified into high risk (IR = 12), therefore it must be controlled by HACCP. While the other eight stages of the process, such as harvesting cocoa fruits, sorting cocoa fruits, breaking cocoa fruit, sorting wet cocoa beans, weighing wet cocoa beans, fermented cocoa beans, weighing dry cocoa beans, packaging and storage were not critical control points so they are controlled by prerequisite programs (PREP) which based on Good Handling Practices (GHP). Determination of critical control points was presented in Table 1.

| Process stage | Hazards | Hazards source | Decision tree | IR | CCP | PREP |
|---------------|---------|----------------|---------------|----|-----|------|
| Harvesting fruit | Biological: pest & diseases | Pest and infectious diseases | yes | no | no | 6 PREP |
| Sortation fruit | Biological: pest & diseases | Pest and infectious diseases Get carried away from the cocoa garden | yes | no | no | 8 PREP |
| Physical: twigs, leaves, gravel, soil | yes | no | no | 4 PREP |
| Breaking fruit | Biological: insect, fungi, E. coli, Salmonella sp. | Air contamination is around, farmers’ hands are not clean, tools are not clean | yes | no | no | 8 PREP |
| Physical: cocoa seed is damage | The method of breaking cocoa fruit is not right | yes | no | no | 4 PREP |
| Chemical: metal contamination | Rusty of fruit breaker | yes | no | no | 6 PREP |
| Sortation of wet cocoa beans | Biological: insect, fungi, E. coli, Salmonella sp. | Air contamination is around, farmers’ hands are not clean | yes | no | no | 8 PREP |
| Physical: twigs, leaves, gravel, soil | Contamination of the work environment | yes | no | no | 4 PREP |
| Weighing of wet cocoa beans | Biological: insect, fungi, E. coli, Salmonella sp. | Air contamination is around, farmers’ hands are not clean | yes | no | no | 8 PREP |
| Physical: air contamination, farmers’ hands are not clean | Contamination of the work environment | yes | no | no | 4 PREP |
| Process stage                          | Hazards                                           | Hazards source                                                                 | Decision tree | IR | CCP | PREP |
|---------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------|---------------|----|-----|------|
| Fermentation of cocoa beans           | Biological: insect, fungi, *E. coli*, *Salmonella* sp. | Contamination from farmers’ hands are not clean and temperature fermentation is not optimum | yes           | no | no  | 6    | PREP |
|                                       | Physical: foreign object                          | Contamination from fermentation box, wood stirrer, farmers                      | yes           | no | no  | 4    | PREP |
| Drying of fermented cocoa beans       | Biological: fungi                                  | The water content of cocoa beans is high because the drying temperature is not optimal and contamination from the environment | yes           | yes|     | 12   | CCP  |
|                                       | Physical: dust                                     | Contamination from environment                                                  | yes           | no | no  | 4    | PREP |
| Weighing of fermented cocoa beans     | Biological: fungi, insect                          | Contamination from farmers’ hands are not clean                                 | yes           | no | no  | 6    | PREP |
|                                       | Physical: foreign object                           | Contamination from environment                                                  | yes           | no | no  | 4    | PREP |
| Packing and storage of fermented cocoa beans | Biological: fungi, insect, rat                     | Temperature and humidity of room storage is not optimum, pest, diseases and rat attack | yes           | no | no  | 6    | PREP |
|                                       | Physical: foreign object                           | Contamination from packaging                                                     | yes           | no | no  | 4    | PREP |

Description: Q1 = Are there any control measures at this stage?, Q2 = Are the stages specifically designed to eliminate or reduce possible hazards to acceptable limits? Q3 = Can contamination with identified hazards exceed acceptable levels or can the hazard level this increases to an unacceptable limit?, Q4 = Will the next step eliminate or reduce the danger identified to the level received?, IR = Risk Index, CCP = Critical Control Point, PREP = Prerequisite program

4. Conclusion

Based on the results of this study, it was concluded that PU Ngudi Raharjo II had implemented 50 elements out of 76 elements of the application of cocoa bean quality. There were 26 elements that had not been implemented. Therefore it needed improvement to Good Handling Practices (GHP) could run well. In addition, the temperature and pH at the fermentation stage were not optimal, the highest fermentation temperature achieved was only 42.3 °C and pH at the end of fermentation was 3.35. The critical control point at the process stage at the PU Ngudi Raharjo II was the drying of fermented cocoa beans. The Ngudi Raharjo II farmer group should use a drying machine to dry the cocoa beans. Monitoring the drying process of cocoa beans such as observing the temperature of the drying machine and controlling the temperature by adjusting the drying temperature as big as 55-60 °C for 40-50 hours to reach a maximum moisture content of 7.5%.

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