The assessment of good manufacturing practices (GMP) implementation and critical control point (CCP) determination on the cocoa powder processing in Agricultural Techno Park Nglanggeran, Yogyakarta

T F Djaafar¹*, T Utami²*, T Marwati¹*, P C Pramesi², R Wikandari² and E S Rahayu²*
¹ Department of Postharvest, Yogyakarta Assessment Institute for Agricultural Technology, Indonesia
² Department of Food Science, Faculty of Agricultural Technology, UGM Yogyakarta, Indonesia

Email: titiekfd1212@gmail.com

Abstract. Cocoa powder is a cocoa-based food product. Indonesian cocoa powder has a big potential in the ASEAN (Association of Southeast Asian Nations) market. Agricultural Agro Techno Park is a company that produces cocoa powder in Gunungkidul, Yogyakarta. This company realizes the importance of improving their product safety. Therefore, the research aimed to determine the safety quality of cocoa powder produced by Agricultural Agro Techno Park by assessing its Good Manufacturing Practice (GMP) implementation and determining the critical control points. The results of assessment of GMP implementation showed that it was categorized in Level IV (the lowest level). Thus, it is strongly recommended to do some corrective actions that identified some incompatibilities before planning the Hazard Analysis and Critical Control Point (HACCP). The flow chart assessment showed that there were two stages that might affect the cocoa powder quality. The stages were receiving raw material and the storage at a low temperature. From the determination of the critical control points which was conducted to improve the cocoa powder quality, the same two stages were also found as the critical control points that might affect the final product quality.

1. Introduction
Cocoa is one of the plantation commodities which has a big role in the Indonesian economy. Cocoa powder is one of the food products made of cocoa beans. Production of sweet cocoa powder in Indonesia in 2017 reached 26,011,959 kg while unsweetened cocoa powder reached 11,039,647 kg [1]. Indonesian cocoa powder has a high potential, especially in ASEAN (Association of Southeast Asian Nations) countries.

As one of the ASEAN countries, Indonesia needs to improve national and even international competitiveness for the quality of chocolate production. The Ministry of Industry has issued a lot of new policies including the obligation to apply the Indonesian National Standard for 134 industrial products, one of which is cocoa powder [2]. The fulfilment of Indonesian National Standard requires the implementation of a quality assurance system.
One of the quality assurance that can be applied is the implementation of Good Manufacturing Practices (GMP) in cocoa powder processing. The Good Food Production Method is an important factor in fulfilling the food quality and safety standards [3]. This guideline is implemented to meet the specified requirements to produce quality food products that consumers demand. Implementing a good food production method can be an essential requirement in implementing a Hazard Analysis and Critical Control Point (HACCP) for the product safety guarantee system. In this guarantee system, the hazard analysis and the determination of critical control points or control of a stage that can affect the product safety.

Gunungkidul Regency is one of the cocoa-producing district in Yogyakarta. Cocoa beans produced by farmers are a mixture of unfermented, under fermented (not fully fermented) and fermented (perfect fermented) cocoa beans so that the quality varies [4,5]. In Nglanggeran Village, Patuk Sub-district, Gunungkidul, the Agricultural Techno Park (ATP) processeed the fermented cocoa beans from local farmers into cocoa powder and candies. The factory's production capacity of 5 kg fermented cocoa beans was relatively small, but this factory realized the importance of a food quality assurance and a food safety system. The industry has implemented the good processing food production method and plans to apply HACCP as a food safety assurance system. However, they did not yet have two critical components which should be included in the requirements of good processing food production method namely, flow chart and process control. Based on this case, four research objectives were formulated in this current study, namely (1) to study the implementation of GMP, (2) to study each processing stage based on the flow chart as a first step in determining the standard procedure, (3) to review the intermediate products and the final product through analysis of the water content and water activity (AW) as an effort to control the process, and (4) to determine the critical control point (CCP) as the initial stage of making the HACCP plan for the cocoa powder production.

2. Material and methods

2.1. Material

The material used for this research was cocoa powder obtained from ATP Nglanggeran, Gunungkidul.

2.2. Methods

The assessment was conducted in 2017-2018, starting from the field observation, interview, and sampling at the production stages of cocoa powder including steaming, roasting, deshelling, compressing, and final cooling. The samples from each production stages were analyzed for their water content and water activity (Aw).

2.2.1. The assessment of general description and building layout. Observation and interview methods were used to review the general description of ATP [6]. The observation was carried out by directly observing the processing of cocoa powder at the research location and the factory environment. The interview was conducted to the employees to get a complete explanation related to the raw material, process, and administrative activities. The general descriptions included location, building, factory employees and cocoa powder processing. Meanwhile, the building layout included processing area layout, processing lines, and processing area based on risk.

2.2.2. The assessment of GMP. The GMP assessment was conducted based on the Regulation of the General Director of Agro Industry Number 30/IA/Per/12/2011 concerning The Technical Guidelines for Evaluating Good Processed Food Production Method Application.

2.2.3. The assessment of the processing and the flow chart. The flow chart was made based on the data from the observation and the interview. After that, the assessment to the processing was conducted in order to improve the process control.
2.2.4. Water content and water activity analyses for intermediate and final products. The sampling was carried out three times by taking several 500 g samples. The water content analysis was conducted based on [7] while the water activity analysis was done based on the method presented by [8].

2.2.5. Critical control point determination. Critical control point was determined on the basis of the CODEX Alimentarius, namely determination of product description, making and verification of flow chart, hazard analysis, and critical control point determination [9, 10]. The results of this water activity analysis were to determine the presence of potential hazards of microorganisms [11].

3. Results and discussion

3.1. General description and building layout assessment

Agricultural Techno Park (ATP) is a chocolate processing factory, located in Nglanggeran Village, Patuk District, Gunungkidul Regency. This factory is located in the tourism area of Embung and Purba Mount, Nglanggeran, so that it becomes a destination for tourists from various countries. It produces cocoa powder and Etawa goat milk powder, 3 in 1 cocoa powder, chocolate candies, chocolate dodol, and Etawa goat milk ice cream.

During the study, there were 13 employees who worked in the factory consisting of 10 process employees, two janitors and night guards, and an administrative staff. The process employees were divided into three groups: five people for processing chocolate candies and cocoa powder, two persons for processing of goat milk powder, and two persons for processing chocolate dodol. One employee helped the processing of all products and as a shopkeeper.

The processing of cocoa powder at ATP was not done every day. The processing was carried out either when the product was sold out or if there were orders from consumers. The employees worked from 8:00 a.m. to 04.00 p.m. for five working days. The lunch break was from 12.00 a.m. to 01.00. p.m. During the break time, all the equipment was turned off for the sake of the maintenance.

The ATP building consisted of two floors. The processing rooms and outlets were on the first floor, while the meeting room was on the second floor (figure 1). There were three rooms on the first floor, and the processing room doors were restricted to employee access. The first processing room was for the raw material storage, steaming, roasting and deshelling. The second processing room was for pasting, compression, crushing, grinding and sifting. In this room, there was a cooler for storing cake and cocoa powder. The third room was for product-packaging activities. The separation of the processing rooms was carried out based on a risk analysis where the first room as a low risk area while the second and the third rooms as a high-risk area. There was an additional process after deshelling, which was separating nibs from cocoa skin manually. On the second floor, there were two meeting rooms and facilities for visitors, such as a prayer room (mushola) and two toilets.

The cocoa powder processing line had been effective, putting the machines in order according to the processing stages. However, it would be better if the refrigerator was placed close to the crushing machine to shorten the material transfer. The refrigerator was also used for tempering chocolate candies so that it required a large space because the chocolate molds cannot be stacked. Therefore, it is necessary to add shelves to the refrigerator so that the chocolate molds, cocoa cake and cocoa powder can be stored in the refrigerator.

3.2. The assessment of GMP

The assessment results showed that the Good Manufacturing Practices (GMP) implementation in the cocoa powder processing at ATP was in the level IV category with one major incompatibility, five serious incompatibilities and three critical incompatibilities. The detailed assessment results of the GMP implementation are explained as follows.
3.2.1. *Aspect 1: Location and factory environment.* The location and environment around ATP production had fulfilled the requirements in the reference regulation. It was well-maintained and clean due to the regular cleaning (figure 2). The factory building was higher than the surroundings that made the wind did not bring much dust into the building, so that it made the building easier to clean up.

![Figure 1](image1.png)

**Figure 1.** The ATP building layout in Nglanggeran, Gunungkidul, Yogyakarta.

![Figure 2](image2.png)

**Figure 2.** The ATP building in Nglanggeran, Gunungkidul, Yogyakarta.

3.2.2. *Aspect II: Building and facilities.* The ATP building was made of 60x60 cm ceramic tiles that had bright colors, gypsum plafond, and brick walls painted with bright colors, too. The building components had met the requirements for good food processing, easy to clean and to maintain.

Regarding the building facilities, here is the description. The building had five windows in the first room that could be opened (facing outside of the building) and one was closed (facing the second room). Besides, there were two doors in the first room (figure 3). One door faced outside of the building which was always opened because the additional processing stage after deshelling was done in that room. Another door connected to the second room but was always closed. Meanwhile, the two and the three processing rooms had the same number of windows, vents and doors (figure 3). There were two windows between the rooms that could not be opened, eight ventilations facing outside of the building and could be opened, and two doors to connect the processing rooms with the outlet which were always closed. The second and the third rooms were equipped with air conditioners.
Figure 3. The first (left) and the second (right) processing rooms at ATP Nglanggeran, Gunungkidul, Yogyakarta.

However, from this aspect there were two serious incompatibilities with SPP-IRT regulation. The first incompatibility found in the factory building structure was the meeting point between the wall and the floor that formed a dead angle. This caused a lot of dirt and puddle in that space that was difficult to clean. A corrective action that can be done is by using a hospital plint (figure 4), a patch that can be put on a dead angle to form a basin so the space is easier to clean.

The second incompatibility was the dirty windows. The corrective action suggested is by cleaning the windows regularly. It can be done using a bristle brush covered with a patchwork so that the sharp part of the brush does not damage the surface of the wall.

Figure 4. Hospital plint.

3.2.3. Aspect III: Equipment. The ATP equipment had fulfilled the requirements. All the equipment was clean and made of stainless steel. Besides, there was also a maintenance for the equipment, and the cleaning devices were available. All equipment was cleaned by the employees every day using hot water, detergent and alcohol. This cleaning activity was done before the working time ended.

3.2.4. Aspect IV: Water supply or clean water supply facilities. Agricultural Technology Park had an adequate supply of clean water coming from wells and stored in some water tanks. The use of this facility had been good and followed the reference regulation. The factory used clean water to clean the equipment and for toilet facilities. Meanwhile, the employees and the visitors used mineral water as the drinking water.

3.2.5. Aspect V: Hygiene and sanitation facilities. In this aspect, a serious incompatibility was found based on SPP-IRT regulation. There was an unavailability of several sanitation facilities, such as hand dryers and soaps for washing hands. Although hand-washing sinks were available in each processing room, soaps and hand dryers were not provided. In this case, one corrective action suggested is providing soaps and hand dryers. The dryers should be wiped dryers as they are easy to absorb water and to wash so that the regular cleaning can be done more easily.

3.2.6. Aspect VI: Health and hygiene of employees. The incompatibility found in this aspect was the absence of a person in charge of employee hygiene. Even though the employees had taken good care of their personal hygiene, such as wearing special work clothes when processing, washing their hands when
starting to work in the food processing and after handling the raw material, there should be one person in charge of employee hygiene. This person’s tasks are related to supervising personal hygiene, reminding employees when they do not apply personal hygiene and documenting a report if there is any employee is absent due to illness. These responsibilities can be given to an employee based on his or her work performance and working experiences in the production. It is recommended that there should be one person from each processing group to be responsible for the employee hygiene.

3.2.7. Aspect VII: The Maintenance and hygienic sanitation program. The incompatibility found in this aspect was quite critical. There was a pet—a cat, that freely came inside the building. The cat was in an open area that was used to separate hulls and nibs. Thus, the recommended corrective action is that the door that leads to the production area should always be closed.

3.2.8. Aspect VIII: Storage. For this aspect, the factory had implemented it well and met the good food processing requirements. The packaging materials, the food additives, and the final products were stored separately in clean and closed containers. The equipment was stored closely. The containers used for food storage, packaging and final products were not placed against the wall and did not touch the floor directly, so that contamination from dust on the floor or wall did not occur.

3.2.9. Aspect IX: Process control. One incompatibility with SPP-IRT regulation was also found in this aspect. The factory did not make any process flow chart yet. This flow chart functions as the main guideline and operating standard in processing cocoa powder. Therefore, this flow chart is basically important in the industry. The recommended corrective action is to make a flow chart. The design of a recommended flow chart is explained further in the flow chart assessment section.

3.2.10. Aspect X: Product label and description. In this aspect a critical incompatibility with SPP-IRT regulation was the product label did not list the ingredients and the production code. Production code is crucial because it can improve traceability in a claim from consumers and form a systematic record. Regarding this case, the corrective action that can be done is adding information about the list of ingredients and the production code.

3.2.11. Aspect XI: Supervision by the person in charge. In the cocoa powder processing, there was no regular internal control carried out, including monitoring and correction. So far a supervision had been conducted through documentation in notebooks about the raw material and the products. Internal control such as whether the process specifications had reached had not been implemented. Consequently, corrective actions could not be established if product specifications did not meet. The recommended corrective action for the factory is to fill in the forms that contain the required data to facilitate the recording and supervision by the person in charge. By utilizing such forms, the person in charge can record the results of the process supervision in an organized manner.

3.2.12. Aspect XII: Product withdrawal. One incompatibility with SPP-IRT regulation found in this aspect was that the product withdrawal procedure had not been established. The product sales of ATP was limited to sales at the outlet only, so this had not become a serious problem. Although there were only a few cases found regarding the product withdrawal from the market, it is still better if the withdrawal plan preparation is carried out as a corrective measure. Moreover, the product withdrawal procedure can be applied in case the company will expands its market.

3.2.13. Aspect XIII: Recording and documentation. The ATP had conducted good documentation dealing with the production and had good records (recorded in a notebook). The notebook had been stored for one year or similar to two times of the food production. However, the requirements for selecting the raw material were not yet documented. Last, it is recommended to record the results of processing in a structured form.
3.2.14. Aspect XIV: Employee training. Employees who worked at ATP had attended a food safety training in ATP. The topic of training was The Planning of Hazard Analysis and Critical Control Point in Chocolate Powder Processing. By attending the training, the employees were expected to be able to understand the importance of food quality and safety and be able to implement the system in the processing of cocoa powder.

Based on the assessment of each aspect as explained above, it is necessary to improve the aspects that did not follow the regulation and to maintain those that met the regulation to improve the implementation of GMP. The main corrective action that must be taken is to make a flow chart as the main guideline for the processing as an effort to improve the supervision process. The aspects to be in the flow chart should not only include the specification of the process, but also the monitoring method and the corrective action when there is any incompatibility that serve as an internal control. In addition, by making a complete flow chart, the GMP assessment will be better as the incompatibility was reduced in two aspects, so that a significant change in the results was seen.

3.3. The assessment of flow chart
The twelve stages of cocoa powder processing were carried out at the ATP Nglanggeran. They were receiving raw material, steaming, roasting, deshell ing, pasting, pressing, breaking, grinding, sifting, cooking, cooling and packaging. This cocoa powder processing generally took 2-5 days depending on the cooling time of the powder. The flow chart of the cocoa powder processing is presented in figure 5.

Figure 5. The flow chart of cocoa powder processing at ATP Nglanggeran, Gunungkidul.
3.3.1. Receiving raw material. The cocoa powder processing began with receiving the fermented cocoa beans produced by the local cocoa farmers. The purchasing of cocoa beans was done when the supply had run out. The cocoa beans were placed in an open plastic container in the first processing room, and the maximum length of storage was three weeks. The requirements for the raw material had been conducted, such as the cocoa beans had been fermented for five days, had been washed and dried to a maximum 7.5% water content.

The study at this stage focused on the method of storing cocoa beans after being received. The cocoa beans were stored in an open container in processing room 1, resulting in moisture and Aw of cocoa beans due to the absorption of water vapor from the environment. Although the received raw materials had been dried to 7.5% water content based on the regulation, when the storage was not good, an increase in water content could occur that allowed microorganism contamination.

The next investigation was the specifications of cocoa beans that were accepted by the industry. According to [12], in the ATP’s cocoa powder, there was still found E. coli which commonly grew during storage. [5] also suggested that drying fermented cocoa beans used for the raw materials for making cocoa powder in Gunungkidul can be done through two methods: using machine drying or manual drying (without machine). When using machines, the drying time to reach water content of 7.5% is faster than that of the manual drying, so molds cannot grow. Therefore, it is recommended for ATP to add another specification for the received fermented cocoa beans, namely the beans should be dried with a drying machine. The method of storing raw materials also needs to be improved. The use of open containers could increase the potential for physical hazards (dust and hull) and biological hazards (insects) because in processing room 1 there was a door facing outside of the building which was always opened. To avoid the increase in water content and the emergence of these hazards, the seed storage can be done with a plastic vacuum then put it in a plastic box and closed.

3.3.2. Steaming. Steaming is an optional step in the cocoa powder processing. This step was done to clean the surface of the cocoa bean shell and to deactivate enzymes. The steaming machine capacity in ATP was 10 kg. The steaming process was carried out at a temperature of 80-100 °C for 30 minutes.

The steaming is an important stage in cocoa powder processing in the industry. In US patent 6025002 published on February 15, 2000, it is explained that steaming cocoa beans at 100-140 °C for 10 to 120 minutes is an economical process in the cocoa beans processing that maximizes chocolate flavor and suppresses off-flavor [13]. Steaming serves to clean the surface of cocoa beans and can improve the quality of the cocoa powder. Thus, the industry has chosen the right decision to carry out the processing stage of steaming and producing high quality cocoa powder.

3.3.3. Roasting. The roasting of cocoa beans was done at 120°C for 30 minutes with the capacity of roasting machine of 5 kg. The purpose of this stage was to develop the distinctive taste and aroma of chocolate, reduce water content, kill microbes, reduce acidity, and make nibs crispier.

This stage is a fundamental process for developing chocolate flavor during fermentation and drying [14], [15] suggested that the roasting temperature of 120 °C for 30 minutes can produce roasted cocoa beans with color characteristics (Browning Index and L * value) that can be accepted by consumers. [16] also suggested that roasting at 120 °C for 50 minutes produces a higher chocolate flavor and lower acidity. However, the cocoa beans from each of those studies had several differences such as the types of cocoa fruit, fermentation treatment, and the drying method. Therefore, further research was needed to obtain specification of cocoa bean roasting that was used in ATP.

3.3.4. Deshelling. The machine used for separating the cocoa beans shell was a desheller machine (capacity of 40-50 kg) which was capable of carrying out two processes, namely separation of the cocoa bean shell and breaking. When the roasted cocoa beans entered the machine, the seeds were crushed and then the shell would be exhaled by air so that the mild shell was blown into the drainage area while the heavy nibs fell into the nibs container. To produce cleaner nibs, manual removal of the cocoa beans shell was carried out.
3.3.5. Pasting. At this stage, the nibs were ground to produce cocoa paste (cocoa liquor). There was no definite process specification because the process took place depending on the nibs resulted from deshelling. The machine was equipped with a temperature regulator to produce the heat which was capable of melting cocoa butter and resulting in a semi-liquid cocoa paste.

3.3.6. Pressing. At this stage, the cocoa paste was pressed to separate the cocoa butter and the cocoa cake (cocoa mass). The resulting cocoa fat was used in the chocolate candy processing, while the cocoa cake was used as the raw material of cocoa powder. There were two machines used for the pressing stage, namely: manual and automatic machines. Similar to the pasting process, there was no exact process specification because it took place depending on the number of intermediate products produced from the previous process.

3.3.7. Breaking. The breaking stage was done using a breaker machine to crush the cocoa cake into coarse cocoa powder. Before being put into the machine, the cocoa cake was crushed manually to ease the machine’s work.

3.3.8. Cooling 1. At ATP, there were two refrigerators and the temperatures were at 9-12 °C. The first refrigerator was used to store the finished products while the second one was for storing the intermediate products. The cooling stage was conducted for two hours. The cooling time was dependent on the processing schedule for the other products. This was due to the limited number of employees who processed and be responsible for processing the other products, so that sometimes the cooling stage was done overnight.

The assessment was carried out to check the purpose of processing and the length of processing time. The purpose of cooling was to prevent cake formation during the grinding stage. This was in accordance with the literature because cocoa beans relatively change to be smooth because of the effect of fat content. If the refining temperature is below 34 ° C, the glyceride fraction in cocoa butter becomes unstable and causes the powder to coagulate again to form lumps and cause an optimum sifting stage [17]. During the breaking process, there can be an increase in the temperature of the coarse cocoa powder due to friction among the powders. This is why a cooling step is needed to reduce the temperature. However, there had not been a control to the cooling process to prevent excessive processing time and to stop the cooling stage when the coarse cocoa powder reached the temperature below 34 °C.

Cocoa powder is hygroscopic which is able to absorb water from the surrounding air. If this process is intended to reduce the temperature until the clots do not form, then the time needed should be shorter that there is no increase in water content. Therefore, further research is required to determine the appropriate cooling time.

3.3.9. Grinding. In this grinding stage, the coarse cocoa powder was refined so that it was able to shape the sifting process. After grinding, the cocoa powder was put in the refrigerator to prevent clotting. The grinding process was conducted four times until the powder did not pass the sifter.

3.3.10. Cooling 2. This second cooling stage was done between the grinding and the sifting stages. Cocoa powder that did not pass the sifter was put in the refrigerator for one night. The result of the study in this part was the same with the result in cooling 1 stage, namely the control to the processing time had not been done efficiently at this cooling stage.

3.3.11. Sifting. At this stage, the cocoa powder was sifted to produce 200 mesh cocoa powder based on the Indonesian National Standard (SNI 3747:2013). After the cooling stage, the sifting was repeated especially to the cocoa powder that did not pass the sifter in order to get the better yield of cocoa powder. The process was carried out four times. Further, the cocoa powder that could not be refined was used as the raw material for chocolate dodol or chocolate dumplings by home industries around ATP.
3.3.12. *Alkalization.* In this part, the cocoa powder was added to baking soda as an alkalizing agent and then heated. The alkalization process aimed to reduce the acidity level and to increase the color darkness. The addition of some amount of alkalizing agent needs to be considered. According to [18], baking soda in the manufacture of cocoa powder can increase the pH and make the powder color darker but there is a decrease in flavone compounds and antioxidant activity. Stahl said that the final pH of chocolate powder \( \geq 7.25 \) indicates the loss of flavone compounds. Therefore, it is recommended to readjust the dosage of baking soda in the processing to prevent the decrease in flavone compounds and the antioxidant activity of the cocoa powder.

3.3.13. *Packaging.* The final stage of cocoa powder processing was the packaging. The cocoa powder was packaged manually with the capacities of 100 grams and 200 grams. The manual packaging took longer time so this stage was considered less efficient. In addition, human error could also occur. Last, the packaging used was aluminum foil and was labelled.

3.4. *Water content and water activity (Aw) analyses*

The results of water content and water activity analyses during cocoa powder processing are presented in figure 6 and figure 7. In figure 6, it can be seen that the water content of cocoa beans increased during steaming and decreased after roasting, deshelling and pressing compared to the water content of fermented dried beans (7.5%). The roasting process at high temperatures caused the cocoa bean water to evaporate that made the water content decrease. However, an increase in the water content occurred again in the cocoa powder product. This was due to the absorption of water vapor from the environment during the treatment process which took a long cooling time as previously explained.

Based on the results of this study, three stages showed different water contents which were contrast with some previous literature, namely steaming, roasting, and alkalization. In terms of steaming stage, the water content obtained was 11.69%. Meanwhile, according to [19], the steaming treatment temperature of 95 °C for 15 minutes increased the water content of cocoa beans up to 10%. The difference in these water content results was due to the use of different process specifications. In ATP, the process applied higher temperature and the longer time than that of the previous study. It made the exposure to water vapor in cocoa beans was also higher.

In terms of roasting stage, ATP did the roasting of cocoa beans at 120 °C for 30 minutes and then produced the roasted cocoa beans with a water content of 2.78%. Meanwhile, the previous literature applied a roasting temperature of 130 °C for 30 minutes and obtained the water content of 2.36% [20]. The use of high temperature will reduce the water content of products. Therefore, a strict supervision is necessary at this stage. Changes in processing specification cause a decrease in product quality and safety. If the temperature and/or
the time is used excessively, charred beans result in a decrease in volatile components. Conversely, lower temperature and shorter time will increase the potential hazard of microorganisms because this stage is a process that involves heat to reduce water content and $A_w$.

In this study, the water content of cocoa powder produced was 8.69%, while the water content of cocoa powder according to SNI 3747: 2013 should be 5% [21]. This discrepancy occurred due to the repeated grinding and sifting stages, and the cocoa powder was stored in the refrigerator for two hours to overnight. Storage in humid condition (refrigerator) can increase the water content of chocolate powder which has hygroscopic characteristic.

In figure 7, it can be seen that the levels of $A_w$ in the roasting, deshelling and compression stages decreased. This was because of the high heat exposure to cocoa beans which could evaporate water and finally could reduce $A_w$. In the deshelling stage, $A_w$ slightly increased due to the nib separation from the cocoa shell. The nibs had higher water content compared to the roasted cocoa beans. Decreased $A_w$ levels occurred again during the compression stage because of the separation of cocoa cake from cocoa butter.

![Figure 7. Water activity of the product during processing.](image)

Compared with the results of the previous literature, this current study found three products had slightly higher $A_w$ content, namely steam seeds, cocoa cake and cocoa powder. According to [22], the $A_w$ level limit for steamed seeds was from 0.4 to 0.85. The $A_w$ levels of roasted cocoa beans and nibs in this study were also lower than the literature. The $A_w$ level of roasted cocoa beans was 0.50, while the research conducted by [23] recorded that the $A_w$ level in the roasted cocoa beans was around 0.54 and the nibs was around 0.52. In figure 7, it can also be seen that the $A_w$ level of cocoa powder was higher (0.79) than the results of [23]’s study who stated that the $A_w$ level of cocoa powder was 0.58. This difference occurred due to the cocoa powder processing at ATP Nglanggeran where the powder was stored at prolonged cold temperature resulting in absorption of water vapor from the surrounding air.

3.5. Potential hazards and hazard analysis

The potential hazards and the hazard analysis are presented in table 1. The hazards that potentially occurred in the cocoa powder processing in ATP Nglanggeran were divided into three on the basis of their causes: physical, chemical and biological hazards. The potential physical hazards in each processing were found because the transfer of products between one to the next stage was still done manually. Moreover, in the first room processing, there were door facing faced outside of the building and windows that were often opened. Such situation could increase some potential physical hazards to enter during the processing such as small twigs, leaves, and insects. These hazards can be prevented by closing the door that faced outside of the building. In addition, the microbiological hazard identification was carried out based on the analysis of $A_w$ levels and water content of the cocoa powder (figure 6 and figure 7). The contamination was found from six types of microorganism in the cocoa powder.
processing, namely *Aspergillus carbonarius, Aspergillus parasiticus, Aspergillus flavus, Aspergillus ochraceus, Aspergillus niger*, and *Penicillium citrinum*.

**Table I.** Hazard analysis on the cocoa powder processing at ATP Nglanggeran.

| Processing Stages | Types of Hazards | Hazard Justification | Hazard Evaluation (Hazard Signification) | Preventive Action |
|-------------------|------------------|----------------------|----------------------------------------|-------------------|
| Receiving Raw material | B: *Aspergillus sp* dan *Penicillium* C: Ochratoxin A & citrinin P: foreign object | - From raw material - Contamination from the processing environment | H H S | - Select raw material - Close raw material containers |
| Steaming | B: *Aspergillus sp* & *Penicillium* C: Ochratoxin A dan citrinin | - From raw material | H H S | - Follow the steaming procedure of cocoa beans |
| Roasting | B: *Aspergillus sp* & *Penicillium* C: Ochratoxin A & citrinin | - From raw material | H H S | - Follow the roasting procedure to fulfill stage specification |
| Deshelling | P: foreign object & epidermis | - From factory employees - From processing environment | L M NS | - Further separation is done in closed room |
| Pasting/grounding | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |
| Compression | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |
| Crushing cake | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |
| Cooling | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |
| Grinding | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |
| Sifting | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |
| Packaging | P: foreign object | - From factory employees | L L NS | - Maintain employees’ personal hygiene and working area sanitation |

**B:** Biological Hazard; **P:** Physical Hazard; **C:** Chemical Hazard; **Se:** Possibility; **Se:** Severity; **HS:** Hazard Signification; **L:** Low; **M:** Medium; **H:** High; **S:** Significant; **NS:** Not Significant

The chemical hazards were identified from the presence of toxin molds that grew on the product. In the microbiological hazard analysis, five types of molds producing Ochratoxin A were found; *Aspergillus carbonarius, Aspergillus parasiticus, Aspergillus flavus, Aspergillus ochraceous* and *Aspergillus niger*, and one type of mold producing citrinin mycotoxin, namely *Penicillium citrinum*. 
However, in some previous literature, the presence of these microbes had not shown the potential for toxin hazards when viewed from the low water activity of the product ($A_w$ of cocoa powder was 0.79). This type of mold will produce toxins at $A_w$ more than 0.8 [24, 25, 26].

Each processing stage had the potential hazards. At the stage of receiving raw material, the physical hazard came from some foreign objects. This potential physical hazard was caused by the use of open containers for storing the raw material (figure 8) and the processing rooms which had doors opened and faced outside of the building. However, this hazard had a low severity so that it was included in the not significant hazard category. Additionally, the stages of receiving raw material, evaporation and roasting had potential biological hazard. It came from the mycotoxin-producing molds and the chemical hazards from mycotoxin contamination. This happened because the dry fermented cocoa beans and the steamed cocoa beans had $A_w$ levels of 0.85 and 0.88. In these $A_w$ levels, the five types of molds identified could grow and produce mycotoxins. This hazard had a high severity because it produced mycotoxins, such as ochratoxin A and citrinin. According to [27], ochratoxin A can an increase in fat vacuoles (more fat in the liver) and mitochondrial swelling in the liver cells. It also has bad effect on kidney, that is necrosis in the tubules. [27] further claimed that the citrinin mycotoxins produced by Penicillium citrinum can affect the kidneys and cause tubular damage similar to glomerulonephrosis kidney disease. Thus, the level of potential hazard from mold contamination was high due to the high $A_w$ levels.

![Figure 8. The raw materials (the fermented cocoa bean storage at the ATP Nglanggeran.)](image)

3.6. Critical control point determination

The determination was done by describing the product. The steps were forming the HACCP team, describing the product, compiling and verifying the flow chart, conducting the hazard analysis and critical control point determination. Detailed descriptions of the cocoa powder product are presented in table 2 and figure 9.

| Product description | Cocoa powder “original taste” |
|---------------------|--------------------------------|
| Composition         | Dry fermented cocoa beans and an alkalinizing agent |
| Primer package      | Aluminium foil |
| Secondary package   | ---- |
| Storage method      | ---- |
| Storage condition   | Stored and closed, dry, dark and relatively in cold condition |
| Distribution method | Sale on line and off line (outlet) |
| Expired time        | Six months after production |
| Consumer target     | All ages |
| How to consume      | Brewed or mixed as coloring and flavor enhancers in bread products |
Figure 9. Cocoa powder produced by ATP.

Table 3. Critical control point determination of the cocoa powder produced by ATP Nglanggeran, Gunungkidul, Yogyakarta.

| Processing Stages | Types of Hazard | Hazard Justification | P1 | P2 | P3 | P4 | CCP | Reason for Decision |
|-------------------|----------------|----------------------|----|----|----|----|-----|---------------------|
| Receiving Raw material | Biological: *Aspergillus* sp and *Penicillium* | From raw material | √ | √ | √ | √ | This step was done for raw material grading with low biological and chemical hazards |
| | Chemical: Ochratoxin A and Citrinin | | | | | | |
| Steaming | Biological: *Aspergillus* sp and *Penicillium* | From surrounding air and raw material condition that supported the growth of fungi and production of mycotoxins | √ | √ | √ | √ | At the roasting stage, hazard could be eliminated or reduced to an acceptable level |
| | Chemical: Ochratoxin A and Citrinin | | | | | | |
| Roasting | Biological: *Aspergillus* sp and *Penicillium* | From surrounding air and raw material condition that support the growth of fungi and production of mycotoxins | √ | √ | √ | √ | Roasting was a stage to reduce the potential hazard to an acceptable level |
| | Chemical: Ochratoxin A and Citrinin | | | | | | |

P1: potential hazard 1; P2: potential hazard 2; P3: potential hazard 3; P4: potential hazard 4; CCP: critical control point.

Based on the hazard analysis, there were three stages which were considered having significant hazards and needed to be reviewed as the critical control points. The critical control point determination for the cocoa powder processing is presented in Table 3. The stage of receiving raw materials was determined as a critical control point. According to [12], the cocoa powder produced by ATP contained Eurotium sp. molds even after the processing. This indicated that the processing was not able to reduce or eliminate molds that had contaminated raw materials. The discovery of the molds strengthened the results of hazard identification and analysis. Therefore, selecting raw materials which are free from mold contamination is needed. Besides, Eurotium fungi could cause biodeterioration, and generally the growth of the fungi are followed by the growth of Aspergillus and Penicillium which were found from the hazard
identification results in this study. This might cause economic losses. Another concern was the possibility of the mycotoxin hazard presence [28].

The determination of a critical control point at the roasting stage was carried out based on the critical control point tree in the second decision, that the roasting stage was specifically designed to eliminate or reduce the hazards that might occur to an acceptable level. Thus, the roasting stage was done to reduce the biological and chemical hazards identified by decreasing $A_w$ levels where the molds (hazardous microorganism) could not grow. Therefore, it is highly necessary to add a microorganism boundary specification to the requirements for receiving dry fermented cocoa beans as the raw material by the ATP Nglanggeran.

4. Conclusion

Based on the findings of this study, the GMP implementation in ATP Nglanggeran was classified as level IV in accordance with the regulation of home industry food product certification (SPP-IRT). Therefore, several corrective actions are required before planning HACCP so that the product safety can be guaranteed. As stated in the flow chart, two processing stages that affected the cocoa powder quality and safety (receiving raw material and cooling 2) also need some improvements. At the stage of receiving raw material, an additional specification is required, such as a method for drying raw material. Additionally, the cooling 2 stage requires a new processing time setting that can increase the water content and $A_w$ of cocoa powder. These two stages are critical control points for the cocoa powder processing. Further research needs to study on the cooling process time that can reduce the temperature of the cocoa powder but does not increase the water content and $A_w$.

Acknowledgments

The Authors would like to deliver their thanks to the Indonesian Agency for Agricultural Research and Development that has supported the funding for this work through a research collaboration project entitled “The Control Technology of Mycotoxin Contaminants Using Lactic Acid Bacteria to Improve Cocoa Beans Quality”.

References

[1] Badan Pusat Statistik 2017 Statistik Indonesia 2017 https://www.bps.go.id/publication/2017/07/26/b598fa587f512432533a656/statistik-indo Download 6 Januari 2020
[2] Herjanto E 2011 Mandatory application of SNI in industrial sector: effectivity and aspects in its implementation J. Ris. Industri 2 121-30
[3] Balai Besar Pengawasan Obat dan Makanan 2012 Peraturan Kepala Badan Pengawas Obat Dan Makanan Republik Indonesia Nomor Hk.03.1.23.04.12.2206 Tahun 2012 Tentang Cara Produksi Pangan Yang Baik Untuk Industri Rumah Tangga
[4] Marwati T et al 2018 Fermentasi biji kakao pada akhir panen: Studi kasus di Gunung Kidul Yogyakarta Pros. Seminar Nasional Hasil Penelitian Pangan dan Hasil Pertanian 2018 “Inovasi Teknologi Pengolahan Pangan dan Hasil Pertanian untuk Meningkatkan Daya Saing Global” Yogyakarta, 30-31 Agustus 2018
[5] Djiafar TF, Elghina L, Widodo S, Marwati T, Utami T, and Rahayu E S 2019 Study of good handling practices and critical control point determination of dried fermented cocoa bean in Gunung Kidul Regency, Yogyakarta 2nd International Conference on Agriculture Postharvest Handling and Processing. IOP Conf. Series: Earth and Environmental Science 309(2019) 012015 doi:10.1088/1755-1315/309/1/012015
[6] Creswell J W 2012 Educational Research: Planning, Conducting, and Evaluating Quantitative And Qualitative Research (4th ed.) (Boston: MA Pearson)
[7] Association of Official Analytical Chemists (AOAC) 2006 Official Methods of Analysis, the Association of Official Analytical Chemists 14th ed. (Arlington: AOAC, Inc.)
[8] Susanto A 2009 Pros. Seminar Nasional Teknologi Peternak dan Veteriner Halaman 826-836.
[9] Mortimore, Sarah and Wallace C 2001 HACCP (Oxford: Blackwell Science Ltd.)
[10] Surak, John G and Wilson S 2014 *The Certified HACCP Auditor Handbook, Third Edition* (Wisconsin: American Society for Quality, Quality Press)

[11] ICMSF (International Commission on Microbiological Specifications for Foods) 1998 *Microorganisms in foods 4: Application of the Hazard Analysis Critical Control Point (HACCP) System to Ensure Microbiological Safety and Quality* (London: Chapman and Hall)

[12] Djiaafar T F, Monika D C, Marwati T, Triwitono P and Rahayu ES 2020 Proc. of 10th Asian Conference of Lactic Acid Bacteria (UGM Digital Press 2

[13] Holsche, W J, Konopka U, Vitzhun O G, Bolenz S, Grosso M C, and Koch K D 2000 *Method of Removing Off-Notes from Cocoa Product* (US Patent 6025002)

[14] Toker O S, Palabiyik I, Pirouzian H R, Aktar T and Konar N 2020 Chocolate aroma : Factor, importance and analysis *Trends in Food Science & Technology* 99 580-92

[15] Afoakwa E O, Budu A S, Brown H M, Takrama J F and Ansah E O 2014 Effect of roasting conditions on the browning index and appearance properties of pulp pre-conditioned and fermented cocoa (*Theobroma Cocoa*) beans *J. Nutr. Health Food Sci.* 2(1) 1-5

[16] Rocha I S, de Santana L R R, Soares S E and Bispo E S 2017 Effect of the roasting temperature and time of cocoa beans on the sensory characteristics and acceptability of chocolate *J. Food Sci. Technol. 37*(4) 522-30

[17] Mulato S, Widyotomo S and Handaka 2004 Desain teknologi pengolahan pasta, lemak, dan bubuk cokelat untuk kelompok tani Warta Penelitian dan Pengembangan Pertanian Badan Litbang Pertanian Departemen Pertanian. http://pustaka.bogor.net. (Diunduh tanggal 19 Juni 2020)

[18] Stahl L, Miller K B, Apgar J, Sweigart D S, Stuart D A, McHale N, Oub B, Kondo M and Hurst W J 2009 Preservation of cocoa antioxidant activity, total polyphenols, flavan-3-ols, and procyanidin content in food prepared with cocoa powder *J. Food Sci. 74*(6) C456-C61

[19] Kopp G M 2014 Process for Producing High Flavor Cocoa European Patent Application (EP 2241190A1)

[20] Azizah S 2005 Uji kinerja mesin sangrai tipe silinder horizontal berputar untuk penyangaan biji kakao “Under Grade” (Skrripsi Universitas Jember)

[21] SNI 3747 2013 *Kakao Bubuk* (Badan Standar Nasional Indonesia)

[22] Copetti M V, Lamanaka B T, Frisvad J C, Pereira J L and Taniwaki M H 2011 Mycobiot of cocoa: from farm to chocolate *Food Microbiol. 28*(8) 1499-504

[23] Nascimento M S, Reolon E M, Santos A R B, Moreira V E, da Silva I F and da Silva N 2011 *Enterobacteriae* in processed cocoa products *Dev. Do Inst. Adolfo Lutz J.* 70(1) 81-5

[24] Ardhana M M and Fleet G H 2003 The microbial ecology of cocoa bean fermentations in Indonesia *Inter. J. of Food Micro. 86* 87-99

[25] Taylor S L 2005 *Advances in Food and Nutrition Research* (Houston: Gulf Publishing Company)

[26] Passamani F R F, Hernandez T, Lopez N A, Bastos S C, Santiago W D, Cardoso M G and Batista L R 2014 Effect of temperature, water activity, and pH on growth and production of ochratoxin A by *Aspergillus niger* and *Aspergillus carbonarius* from Brazilian Grapes *J. of Food Protect 77* 1947-52

[27] Rahayu E S, Sarjono S and Samson R A 2014 Jamur Benang (Mold) Pada Bahan Pangan (Yogyakarta: Kanisius) p 284

[28] Arvanitoyannis I S 2012 *Modified Atmosphere and Active Packaging Technologies* (Boca Raton: CRC Press)