# Hazard Analysis and Critical Control Points in Cocoa Bean Fermentation

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*(Received: Sep 15, 2015 Reviewed: Feb 23, 2016; Accepted: May 20, 2016)*

**Abstract:** The objective of this research is to develop Hazard Analysis and Critical Control Points (HACCP) in cocoa bean fermentation at farmer level, starting from harvesting of cocoa pods until storage of dried fermented cocoa beans. The case study was conducted at Fajar Mas and Mandar Jaya cocoa farmer groups, located in Bukit Sutera Village, District of Larompong, Luwu Regency of South Sulawesi Province, Indonesia. For quality and food safety assurance, production process follows standard operation procedures, though in general the process is done by manual means. Of 11 steps of the process, sortation of cocoa pods, sortation of wet- cocoa beans, and drying of cocoa beans have been identified as CCPs. Potential hazards are found as biological hazards i.e. molds, especially Aspergillus spp., insects, Salmonella, E. coli and pest, and physical hazards i.e. waste and foreign matters. Verification of the HACCP showed compliance with SNI 2323-2008 for moisture, germinated, moldy, and insect damaged bean, insect, foreign matter, waste, and slaty bean contents. Implementation of the HACCP principles by the cocoa farmer groups in producing dried- fermented cocoa beans consistently will improve quality and food safety of the product, which will increase their bargaining power in the cocoa market.

**Keywords:** HACCP; cocoa beans; fermentation; farmer level

## 1. Introduction

Global Study Analysts (GIA) in "The 2012 Annual Report" announced that over the last decade, world consumption of cocoa sturdy increased; at times even exceeding production. The nutritive and cancer fighting capabilities of cocoa rich chocolates seem to be the main cause of the increase of market demand of cocoa. By the year 2017, the world cocoa grindings are forecasted to reach 5.2 million metric tons (GIA, 2012).

As the third biggest producing country of cocoa after Ivory Coast and Ghana (contributing for 13 % of the world production) (Wahyudi and Misnawi, 2008), Indonesia should anticipate this world demand trend. The issue that should be put in account, however, is the sustainable cocoa production. That is because Indonesia is still facing problems in low cocoa plant productivity (mostly planted in 1980's), CPB and VSD attacks, and classical problems of low cocoa bean quality, non-fermented cocoa beans, lack in hazard risk handling, and weak bargaining position of the farmers on marketing (WCF, 2007; Yunus *et al., 2012)*. Currently there has been the issue of farmers converting their cocoa plants to less disease risk plants (Sikumbang, 2013).

The low in quality and lack in hazard risk handling are shown by relatively high moisture, moldy, insect- damaged, slaty,

waste and foreign matter contents of the cocoa beans produced (Achmad and Sumarna, 2013).

Efforts to improve quality and food safety of cocoa beans, as a main raw material for various chocolate products can be done by a consistent integrated implementation of the basic principles of Good Agricultural Practice (GAP), Good Manufacturing Practice (GMP), and Hazard Analysis and Critical Control Point (HACCP), both for on- farm and after harvest.

Despite of the domination of low quality and non-fermented cocoa bean production, a number of cocoa production centers in Indonesia have taken initiation to produce quality fermented cocoa beans since the last 4-5 years. Since the issues of tax policy up to 15 % for cocoa beans exported, effectively since 2011, and the downstream policy of agroindustry, including cocoa in 2010 by the Goverment of Indonesia, the domestic demand for quality fermented cocoa beans shows a tendency to increase. The aim of the policies itself is to increase the domestic added value of cocoa, and to provide sufficient supply of cocoa beans to the domestic cocoa processing and chocolate industry as well.

Among those cocoa production centers is located in District of Larompong, Luwu Regency of South Sulawesi Province, Indonesia. *Resopammase,* called as *gapoktan* has organized around 21 cocoa farmer groups, called as "*poktan*", such village cooperative to produce quality fermented cocoa beans. For quality and food safety assurance, steps of production process follows standard operation procedures (SOPs) under *Resopammase* assistance and supervision. Cocoa beans produced are bought by *Resopammase,* as a sole buyer, which in turn sell the cocoa beans to *PT. Bumi Tangerang Mesindotama* in Banten Province, Indonesia under a MOU (Yunus, *et al*., 2012). As reported by Nuddin *et al.* (2015) from their research, farmer group is one of the three key institutions (among 33 institutions identified) that have a high power driver in the institutional production of cocoa in Indonesia.

HACCP system does a systematic and structured approach to identifying hazards (biological, chemical, and physical) and the likelihood of these occurring at all stages of food production from raw materials to the final product, and define preventive measures for their control to ensure that the safety control is integrated into the design of the process, rather than testing of the end-products (Ropkins and Beck, 2002; Yunus and Yulismulianti, 2010).

Implementation and effective functioning of the HACCP system require knowledge of the hazards inherent to the infrastructures, tools, and human resources. The HACCP system that really works in practice will depend on the competency of the people who both develop and operate it and the pre-requisite programs (PREP) that support it (Mortimore, 2001). The PREP provides foundation for effective HACCP implementation and should be in operation before HACCP. As a general rule, the PREP is required to control hazards associated with the food services environment, while HACCP is required to control hazards associated directly with the food processes. PREP consists of (a) infrastructures and their main-

tenance programs (plant, equipment, tools, and buildings), and (b) operational PREP (Bolton and Maunsell, 2004; Marques *et al.,* 2012).

HACCP in cocoa processing and chocolate manufacture has been the subject of some studies. Potential contamination of Salmonella has been emphasized by Cordier (1994) on the manufacture of chocolatres, and by Nascimento *et al.* (2010) on fermentation, drying, and storage of cocoa beans. Yunus and Yulismulianti (2012) identify *Aspergillus* spp. molds, and Salmonella and E. Coli bacteria, as the potential biological hazards during the manufacturing process of cocoa liquor, butter, and cakes. The CCPs controlled by HACCP include reception of raw cocoa beans from farmers and cocoa nib roasting. Another study of HACCP in after harvest of cocoa farmings, who are hold by smallholders has been conducted by Munarso and Miskiyah (2014). Steps of process include cocoa pod harvesting, cocoa pod picking, cocoa pod splitting, cocoa bean fermentation, cocoa bean drying, sortation of dried cocoa beans, and bagging and storage of dried cocoa beans. The CCPs identified include those harvesting, fermentation, drying, sortation, and bagging and storage.

The objective of this research is to develop HACCP in cocoa bean fermentation at farmer level, especially from harvesting of cocoa pods until storage of dried-fermented cocoa beans. The case study was conducted at *Fajar Mas* and *Mandar Jaya,* two cocoa farmer groups, members of *Gapoktan Resopammase,* District of Larompong, Luwu Regency of South Sulawesi Province, Indonesia.

## 2. Materials and Method

This research uses descriptive-analysis method. Data required for this research were obtained from field observation and published literatures on the matters. *Fajar Mas* and *Mandar Jaya,* where the case study was conducted is located in *Bukit Sutera* Village, District of *Larompong, Luwu* Regency of South Sulawesi Province, Indonesia. This *Fajar Mas* and *Mandar Jaya* case study was choosen by purposive sampling. Data collection herein was held between 2009 and 2011.

Stages of the research are as follows: (1) identification of processing steps, (2) hazard analysis, (3) identification of CCPs referring to decision tree (BSN, 1998) in conjuction with risk assessment (Batista *et al.,* 2003; Marques *et al.,* 2012), and (4) outlining HACCP plan.

Table 1 shows matrix table of the risk assessment, while Table 2 shows the hazard control of the risk (Batista *et al.,* 2003 and Marques *et al.,* 2012).

**Table 1.** Matrix table of the risk assessment

| | Severity | | | |
|---|---|---|---|---|
| Probability | N (1) | L (2) | M (3) | H (4) |
| H (4) | SR | LR | IR | CR |
| M (3) | SR | LR | IR | IR |
| L (2) | SR | SR | LR | LR |
| N (1) | SR | SR | SR | SR |

Note: SR= satisfactory risk; LR=lower risk, IR=incresed risk, CR=critical risk.H(4) = severe consequences for human (high probability of occurrance), M(3)= moderate consequences (moderate probabilty of occurrances), L(2)= zero or very small effect (low probability of occurrences), N(1)= without consequences (neglectable)

For HACCP verification, samples of the dried fermented-cocoa beans produced by *Fajar Mas* and *Mandar Jaya* were taken randomly at the end of the field observation periods. The samples were then tested for

compliance to SNI 2323-2008 standard (BSN, 2008), in Laboratory of Center for Plantation Based Industry, in Makassar, Indonesia.

**Table 2.** Hazard control

| Risk index (IR) | Remark | Control |
|---|---|---|
| IR ≤ 4 | Satisfactory risk | • Risk managed by PREP |
| 4 < IR ≤ 8 | Lower risk | |
| 8 < IR ≤ 12 | Increased risk | • Risk managed by HACCP |
| 12 < IR ≤ 16 | Critical risk | |

Note: Index of risks (IR)= severity times probability of occurrence.

## 3. Results and Discussion

### *3.1 Steps of process*

In this research 11 steps of process practiced by *Fajar Mas* and *Mandar Jaya* to produce dried fermented cocoa beans, have been identified. Those include: (1) harvesting of cocoa pods, (2) sortation of cocoa pods (separating infected, unripe, and over ripe pods from the mature, fresh, and healthy ones), (3) opening of cocoa pods, (4) sortation of wet cocoa beans (separating the wet cocoa beans from adhering pulp and placenta, and the infected, insect-damaged, plat, and cluster beans from the fresh and healthy ones), (5) delivering of wet-cocoa beans from farms to the processing center (PC), (6) weighing of wet cocoa beans, (7) fermentation of cocoa beans, (8) drying of cocoa beans, (9) sortation of dried cocoa beans, (10) weighing and bagging of dried cocoa beans, and (11) storage of dried cocoa beans in the warehouse. In general, all steps of the process are conducted by manual means.

The steps of process from harvesting of cocoa pods to sortation of wet cocoa beans take place in the farms' areas, while from weighing of wet cocoa beans to storage of dried cocoa beans in the warehouse take place in the processing center (PC) area.

Placed in around the middle of farmers' farm locations, the PC is facilitated with a permanent building of 48 $m^2$ floor, terrace, and ground land for cocoa bean sun-drying. The building is shared for fermentation, cocoa bean weighing, and warehousing activities. The PC is operated by farmers (who have received special technical training) under management of an administration and operation manager.

The cocoa pods are harvested and delivered for opening to remove the wet cocoa beans and adhering pulp from cocoa shell. In this case, the cocoa pods must be physiologically ripe, fresh and free from molds, insects, and other infected parts. Similarly, the wet cocoa beans for fermentation should be fresh, healthy, and free from any physical damage. For cocoa pod harvesting cycle, *Fajar Mas* and *Mandar Jaya's* farmers do the harvest for around every ten days.

The pods are cracked with wooden clubs for opening. The cocoa beans covered in a white pulp are separated from the majority of this pulp and from infected, and physically damaged cocoa beans by hands. The moisture content of the cocoa beans at this step is about 65 %. The wet cocoa beans are put and collected in plastic sacks or containers.

The wet-cocoa beans are then transferred to two-level fermentation boxes in the PC. There are around 22 sets of fermentation boxes, each with 80 kg wet-cocoa beans capacity. Fermentation starts at around 16.00-

18.00 o'clock after the amount of the wet-cocoa beans required have been delivered by farmers from their farms. This fermentation process takes place for five days, two days in the first level box and three days in the second level box. Fermentation is finished in the morning time after the five days of fermentation.

Upon completion of fermentation, the cocoa beans are delivered for sun-drying. It is an advantage that the weather in this area permits the cocoa beans sun dried in most harvest times, including in the peak harvest season of May to August. The cocoa beans are spread out on the ground land with plastic or polythene sheet base, and some on drying tables with a depth of about 5 cm and raked periodically to expose fresh surface. Some are placed in two simple solar dryers. Drying step will reduce the beans water content to about 6 to 7 %. The time period of drying depends on the weather. Under clear condition with 7 to 8 hour solar radiation per day, the drying will last for 7 to 9 days.

To prevent the cocoa beans from night and early morning dew, the cocoa beans are covered by plastic sheet before the night. Under cloudy weather or rain, the beans are replaced to the PC building, and other in shaded places. An artificial dryer is used

**Table 3a.** Hazard analysis (from cocoa pod harvesting until delivering of wet cocoa beans)

| No | Step of process | Hazard | Source of hazard | Risk assessment | | | Control measure |
|---|---|---|---|---|---|---|---|
| | | | | P | S | IR | |
| 1 | Harvesting of cocoa pods | •Biological: mold, insect | •Growth of and contamination with microbial pathogen. | 2 | 3 | 6 | •Harvest only ripe pods.<br>•Use clean tools<br>•Follow SOP |
| 2. | Sortation of cocoa pods | •Biological: mold, insect | •Growth and contamination with microbial pathogen | 3 | 4 | 12 | •Separate infected, immature and overripe pods<br>•Follow SOP |
| 3. | Opening of cocoa pods | •Biological: mold, insect, Salmonella, E. Coli | •Recontamination with microbial pathogen | 2 | 2 | 4 | •Keep wood clubs clean<br>• If using knives, make sure they are sharp and clean<br>•Follow SOP |
| | | | •Cross contamination by workers | 2 | 2 | 4 | |
| 4 | Sortation of wet cocoa beans. | •Biological: mold, insect, Salmonella, E. Coli.<br>•Physical: waste and foreign matters | •Growth and recontamination with microbial pathogen, | 3 | 4 | 12 | •Keep scoops, containers and pads clean<br>•Obligate personnel hygiene.<br>•Follow SOP |
| | | | •Cross contamination by workers. | 2 | 3 | 6 | |
| | | | •Contamination with waste and foreign matters. | 1 | 2 | 2 | |
| 5 | Delivering of wet cocoa beans to PC | •Biology: mold, Aspergillus spp, Salmonella, E. Coli<br>•Physical: waste and foreign matters. | •Cross contamination by workers. | 1 | 2 | 2 | •Keep containers and bags clean<br>•Deliver wet cocoa beans soon<br>•Follow SOP |
| | | | •Growth and recontsmination with microbial pathogen | 2 | 2 | 4 | |
| | | | •Contamination with waste and foreign matters | 1 | 2 | 2 | |

Note: P= probability of occurrence, S= health severity, IR= risk index

**Table 3b.** Hazard analysis (from weighing of wet cocoa beans until storage of dried fermented cocoa beans).

| No | Step of process | Hazard | Source of hazard | Risk assessment | | | Control measure |
|---|---|---|---|---|---|---|---|
| | | | | P | S | IR | |
| 1. | Weighing of wet cocoa beans | •Biological: mold, Aspergillus spp., insect. Salmonella, E.Coli •Physical: foreign matters | • Recontamination with microbial pathogen | 1 | 2 | 2 | •Keep weight clean. •Follow SOP |
| | | | • Cross contamination by workers | 2 | 2 | 4 | |
| | | | • Contamination with foreign matters. | 1 | 2 | 2 | |
| 2. | Fermenta-tion of cocoa beans | •Biological: mold, Aspergillus spp., insect, Salmonella, E.Coli. •Physical: waste and foreign matters. | • Recontamination with microbial pathogen | 2 | 3 | 6 | • Keep fermentation boxes, and devices clean and in good condition • Obligate personnel hygiene • Follow SOP |
| | | | • Cross contamination by workers | 2 | 3 | 6 | |
| | | | • Contamination with waste and foreign matters. | 1 | 2 | 2 | |
| 3. | Drying of cocoa beans | •Biological: mold, Aspergillus spp., insect, Salmonella, E. Coli. •Physical: foreign matters. | • Recontamination with microbial pathogen. | 4 | 4 | 16 | • Do not delay drying process. • Keep drying equipment clean and in good condition. • Follow SOP |
| | | | • Cross contamination by workers | **2** | 2 | 4 | |
| | | | • Contamination with foreign matters | 2 | 2 | 4 | |
| 4. | Sortation of dried cocoa beans. | •Biological: mold, Aspergillus spp., Salmonella, E. Coli •Physical: foreign matters | • Cross contamination by wotkers | 2 | 3 | 6 | • Keep devices clean. • Keep worker hands clean and dry • Follow SOP |
| | | | • Contamination with foreign matters | 1 | 2 | 2 | |
| 5. | Weighing and bagging of dried cocoa beans | •Biological: mold, Aspergillus spp., insect, Salmonella, E. Coli. | •Recontamination by microbial pathogen | 2 | 2 | 4 | • Keep weights clean • Use only clean bags. • Follow SOP |
| | | | •Cross contamination by workers. | 2 | 3 | 6 | |
| 6. | Storage of dried cocoa beans. | •Biological: mold, Aspergillus spp., insect, pest | •Growth and recontamination with microbial pathogen | 2 | 3 | 6 | • Keep ware-house clean and dry. • Follow SOP |

Note: P= probability of occurrence, S=health severity, IR= risk index.

very rare only when there is a successive rain for several days. If the drying is done in the dryer, the drying temperature should not exceed 60°C for a minimum drying time of at least 48 hours (the minimum time for excess acids to volatilize and a certain degree of oxidation occurs) to produce optimal quality cocoa beans (ICMSF, 2000). The next, the

dried cocoa beans are sorted primarily from foreign matters during drying (stone, sand, dried leave etc.) before the cocoa beans are weighed and packaged using plastic bags layered by PE plastic. Finally, they are placed in the warehouse waiting for transport to *Resopammase.*

*3.2 Hazard analysis*

Resume of the hazard analysis in the cocoa bean fermentation is shown in Tables 3a for the steps of harvesting of cocoa pods until delivering of wet cocoa beans to the PC, and Table 3b for weighing of wet-cocoa beans until storage of dried cocoa beans in the warehouse.

For each step includes specific potential hazards, source or cause of hazards, risk assessment, and control measures required to prevent, reduce, or eliminate those the likely occurrence of the hazards to acceptable levels. The specific potential hazards in this research, have been identified as biological hazards i.e. molds especially *Aspergillus* spp., insects, E. Coli, Salmonella and pest, and physical hazards i.e. foreign matters (stones, sand, bag plastic fibers etc.), and wastes (placenta, clusters, bean shell, flat beans, damaged beans etc.).

Contamination by those hazards may occurs in each step of process including when the wet cocoa beans are delivered from farms to the PC area. Biological hazard agents may also grow and multiply in the periods. According to Djuanda (2009), most of the food-borne diseases is caused by pathogenic microorganisms of bacteria, molds, and yeast. In addition, contamination by hazardous metal, toxin, sanitazer residue, insect, wood, glass fractions and hair may also cause the non-safety foods.

*3.3 Identification of CCPs*

Table 4 shows worksheet for CCP identification. Of 11 processing steps identified, three are indicated as CCPs. Those are (1) sortation of cocoa pods, (2) sortation of wet cocoa beans, and (3) drying of cocoa beans. In fact, those three steps are classified as increased or critical risks (IR= 12-16), which should be controlled or managed by HACCP. Other eight steps are considered as non-CCPs, which are controlled or managed by PREP (IR= 2-6). For *Fajar Mas* and *Mandar Jaya*, PREPs are performed referring to GAP (on farm) and GMP principles, wherein the operational PREPs are principally performed in SOPs.

*3.4 HACCP plan*

Table 5 shows the HACCP plan. As the general strategy to prevent from contamination and recontamination with molds, all those infected, overripe, and damaged cocoa pods must be discarded from the fresh and healthy others in the cocoa pod sortation step (Amesqueta *et al.,* 2009), as the CCP-1. Similarly, infected, unfresh, and physically damaged cocoa beans must also be discarded completely from the fresh and healthy beans in the wet cocoa bean sortation step, as the CCP-2. The damaged and immature cocoa beans may be processed separately. Though it managed by PREP, attention should be placed on the worker hygiene from cross contamination with Salmonella, E. Coli, and other pathogenic bacteria, since in this step there is an intensive and direct contact be-

tween the worker hands and the wet-cocoa beans being sorted.

Minifie (1999) states that microbial pathogen often attact cocoa beans are molds, insects, Salmonella, and E.coli. Here, the primary origin of Salmonella is the intestinal tracts and faeces of humans and animals (Engel *et al.,* 2001), so good hygiene and working practices should be implemented (Nascimento *et al.,* 2013).

The discarding strategy, as a prevention strategy, has been also recommended by Miskiyah and Widaningrum (2008) to control Aflatoxin in after harvest of corns. Here, the infected, damaged, and immature corns should be completely separated from the healthy and mature ones.

Bastide *et al*. (2006) reported that the OTA levels are dependent on the physical condition of the cocoa pods. The pods damaged by insects, fermented pods, rotting pods, and mummified pods exhibited greater OTA contamination compared to the healthy pods. A research conducted by Djedje Dano *et al*. (2013) concludes that cocoa beans from healthy pods generally lacked OTA contamination or contained OTA in trace quantity only.

**Table 4.** Worksheet for CCP identification

| Processing step | Hazards | Decision tree | | | | IR | CCP | PREP |
|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | | | |
| Harvesting of cocoa pods | Biological | Yes | No | No | - | 6 | - | PREP |
| Sortation of cocoa pods | Biological | Yes | Yes | - | - | 12 | CCP-1 | --- |
| Opening of cocoa pods | Biological | •Yes | •No | •No | -- | 4 | | PREP |
| | | •Yes | •No | •No | -- | 4 | | |
| Sortation of wet cocoa beans | Biological | •Yes | •Yes | -- | -- | 12 | CCP-2 | -- |
| | Physical | •Yes | •No | Yes | Yes | 6 | | PREP |
| | | •Yes | No | No | - | 2 | | |
| Delivering of wet cocoa beans | Biological | •Yes | •No | •No | -- | 2 | - | PREP |
| | Physical | •Yes | •No | •No | -- | 4 | | |
| | | •Yes | •No | •No | -- | 2 | | |
| Weighing of wet cocoa beans | Biological | •Yes | •No | •No | -- | 2 | | PREP |
| | Physical | •Yes | •No | •No | -- | 4 | - | |
| | | •Yes | •No | No | -- | 2 | | |
| Fermentation of cocoa beans | •Biological | •Yes | •No | •No | -- | 6 | - | PREP |
| | •Physical | •Yes | •No | •No | | 6 | | |
| | | Yes | No | No | | 2 | | |
| Drying of cocoa beans | •Biological | •Yes | •Yes | -- | -- | 16 | CCP-3 | -- |
| | •Physical | •Yes | •No | No | | 4 | | •PREP- |
| | | Yes | No | No | -- | 4 | | |
| Sortation of dried cocoa beans | •Biological | Yes | No | No | | 6 | - | PREP |
| | •Physical | Yes | No | No | | 2 | | |
| Weighing and bagging of dried cocoa brans | •Biological | Yes | No | No | -- | 4 | -- | PRRP |
| | •Physical | Yes | No | No | -- | 6 | -- | |
| Storage of dried cocoa beans | Biological | Yes | No | No | -- | 6 | -- | PREP |

Note: Q1= Do control measure(s) for hazard exist at the step?; Q2= Is this step specifically designed to prevent, reduce, or eliminate the likely occurrence of the hazard to an acceptable level ?; Q3=Could contamination with identified hazard(s) occur in excess of the safe of acceptable level(s) or could it increase to unacceptable level(s) ?; Q4= Will a subsequent step eliminate identified hazard(s) or reduce its likely occurrence to a safe level ?;

Basically, fermentation promotes mold reduction in benefit of yeast and induces pulp elimination, an important substrate for fungal growth. Therefore, this step can prevent the mycotoxin formation (FAO/WHO/UNEP, 1999; Joosten *et al*., 2001). To prevent from external contamination, working area and equipment must be clean and the environmental condition must be well controlled (Wilkinson, 1999); for those can be handled by PREP.

According to Bonvehi (2004), OTA has been found to occur essentially during post-harvest period, and the initial stage of sun-drying. Mold- infected cocoa beans during the after harvest processing is commonly associated with the beans which have been mishandled and improperly dried. In relation to the final moisture content of the dried cocoa beans, Minifie (1999) warns moisture of 8 % as the crucial level, and recommends moisture of 6 to 7 %.

Moreover, as stated by Minifie (1999) and Magan and Aldred (2003), adequate drying is vital to preserve good flavor and food safety of the beans, otherwise molds will develop that will impart an unpleasant flavor and promote mycotoxin that no subsequent steps in the process will remove. Therefore, as the CCP-3, this step is spesifically designed to prevent or eliminate the likely occurrence of the hazards to acceptable levels, especially for moisture and moldy beans (and slaty beans for fermentation quality, beside control in the fermentation step itself). Mycotoxins are of concern for two reasons, their acute toxicity and their potential carcinogenicity (Motarjemi *et al.,* 1999).

For sun-drying method, both the weather condition and drying time to render cocoa beans safe necessary, are very critical, while for artificial drying method, those are drying temperature and duration. Cited from

**Table 5.** HACCP Plan.

| No. | Step of process | Hazard | Control measure | CCP parameter | Critical limit | Monitoring procedure | Corrective action |
|---|---|---|---|---|---|---|---|
| 1 | Sortation of cocoa pods. | Biological | •Physiological condition | Physiological condition of cocoa pods. | •Ripe enough. •No infected, overfermented, and damaged cocoa pods | •Visual inspection (each processing run). | Resorting |
| 2 | Sortation of wet cocoa beans | Biological | •Physiological condition. | Physiological condition of cocoa beans. | •No infected, unfresh, and damaged cocoa beans. | •Visual inspection (each processing run). | Resorting |
| 3 | Drying of cocoa beans | Biological | •Weather (sun drying), | Sunny, drying period | •7-9 days, with 7-8 hours solar radiation per day. | •Observe weather (each processing run) | •Prolong sun-drying period. •Use artificial dryer |
| | | | •Correct design and operation (artificial drying) | Drying temp. and time | •max. 60°C, min. 48 hours. | •Record drying temp. and time (each processing run) | •Adjust the temp. •Calibrate temperature device |

Selamet *et al*. (1991), flavor assessment of cocoa beans dried using different drying methods, i.e. sun- drying, air blowing, shade drying, and oven drying demonstrated that sun-dried samples rated higher in flavor development and had fewer off-notes.

To minimize contamination by entropathogens (Salmonella and E. Coli) during fermentation, drying, and storage, Nascimento *et al.* (2010) recommend to reduce the cocoa bean storage time on the farms, prohibit farm workers from the practice of treading on the beans to remove mucilage on the bean surface, carry out pest control regularly, and storage the dried cocoa beans in bags appropriately sealed and on pallets, through GAP and GMP procedures (as PREPs).

Different from Munarso and Miskiyah's study (2014), which identified fermentation and sortation, bagging and storage of dried cocoa beans as CCPs, this research *(Fajar Mas and Mandar Jaya's* case) suggests that those steps can be controlled by applying PREPs.

Keeping the devices, tools, and facility used in the four processing steps in clean and good conditions, is sufficient to prevent cocoa beans from recontamination by microbial pathogens. It is similar for the workers to keep strictly their basic personnel hygiene, i.e. cleanliness of body and clothing, to prevent from cross- contamination in process. Those have been stressed by Burndred (2009) and Thomas (2010); and in this case, they are covered by GMP as PREPs.

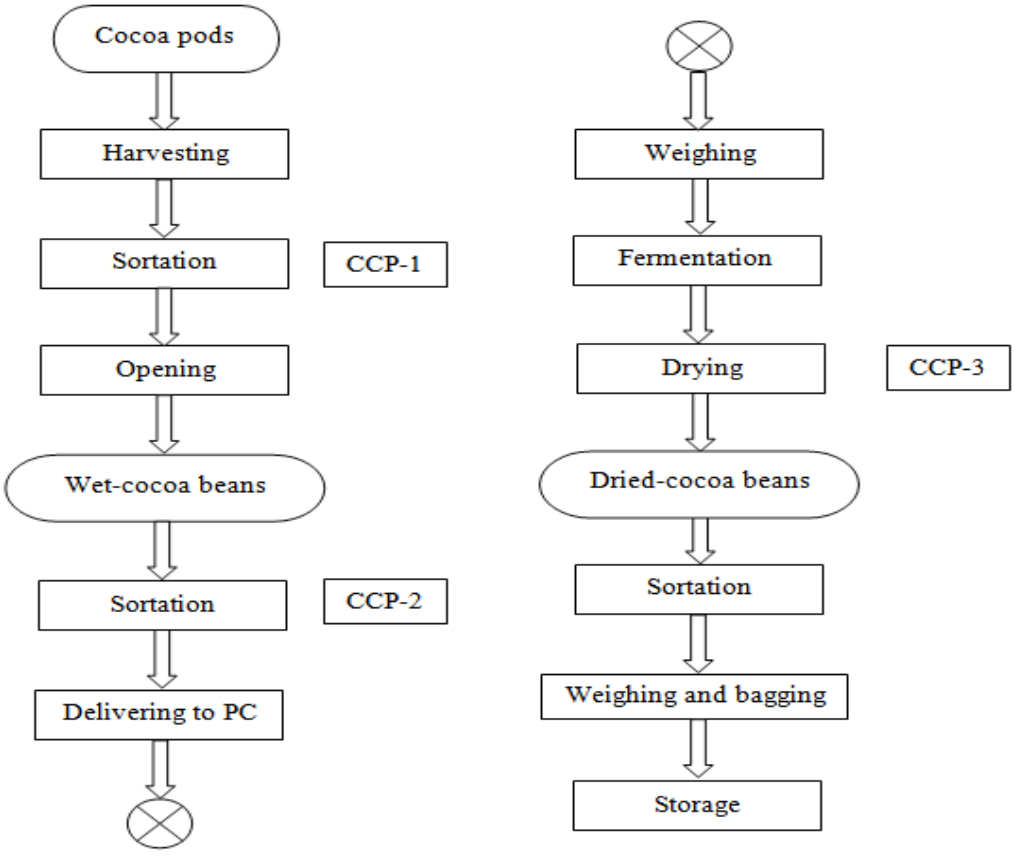


**Figure 1.** CCPs in producing the dried fermented cocoa beans.

**Table 6.** Results of cocoa beans testing

| No. | Parameter | Fajar Mas and Mandar Jaya cocoa beans | SNI 2323 : 2008 standard | | | |
|---|---|---|---|---|---|---|
| | | | | I-B | II-B | III-B |
| 1 | Moldy beans, % | none | max | 2 | 4 | 4 |
| 2 | Insect damaged beans, % | none | max | 1 | 2 | 3 |
| 3 | Germinated beans, % | none | max | 2 | 3 | 3 |
| 4 | Slaty beans, % | 1.33- 4.33 | max | 3 | 6 | 20 |
| 5 | Waste, % | None | max | 1.5 | 2.0 | 3.0 |
| 6 | Moisture, % | 6.15 - 6.26 | max 7.5 | | | |
| 7 | Insect (life) | none | none | | | |
| 8 | Foreign matters | none | none | | | |

*3.5 Cocoa bean testing*

Quality of the dry fermented cocoa beans produced by *Fajar Mas* and *Mandar Jaya* is shown in Table 6. Parameters include water, moldy, insect damaged, and slaty beans contents, insects, foreign matter and waste. As mentioned before the cocoa bean samples were taken at the end of the field observation periods for testing, for HACCP verification. In every day production, this product testing is done occasionally.

Referring to SNI 2323-2008 (BSN, 2008), the cocoa beans have complied with the standards for moisture content, germinated, insect damaged, and moldy beans, insects, waste, and foreign matters, as well as relatively fully fermented for their low slaty beans contents. One indication of the presence of molds if the cocoa beans are not dried enough.

Moisture contents of 6 to 7 % is considered enough to prevent from mold grow. However, the beans must not be over dried. Those of the moisture contents of less than 6 % become very brittle causing the subsequent handling and processing much more difficult (Fowler, 2009).

## 4. Conclusion

Of the 11 steps of process in producing the dried fermented cocoa beans at farmer level, practiced by *Fajar Mas* and *Mandar Jaya,* three steps i.e. sortation of cocoa pods, sortation of wet-cocoa beans, and drying of cocoa beans are considered as CCPs. Other steps are considered as non- CCPs, which can be controlled by pre- requisite programs (PREPs). As the proper HACCP system, including pre- requisite programs has been implemented, it will improve quality and food safety of the dried fermented cocoa beans produced, whereas product testing can be done occasionally, only for HACCP verification.

**Acknowledgment**

The sampling and testing of the dried fermented cocoa beans in this research, was helped by Mrs. Kalsum Firman, engineering staff at Center for Plantation Based Industry, Agency for Research and Development of Industry, Makassar, Indonesia.

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