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5

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4 Good agricultural and postharvest handling practices of Cocoa pods in Lombok to meet Cocoa bean quality for the global market

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6
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18
Abstract. Despite being the third-largest cocoa export country globally, the quality of cocoa beans produced in Indonesia, including in West Nusa Tenggara, is low. This paper presents the critical role of good agricultural and postharvest handling practices on local cocoa beans' quality. This paper's source of information was obtained from the survey, laboratory trials, and secondary sources. Supporting information was also obtained through reviews of related literature. Good agricultural practice with no chemical application to support sustainable agriculture and postharvest handling practices to produce cocoa pods and cocoa beans that meet the international quality standard is critical. Postharvest handling of the pods, which covered the fresh cocoa beans' fermentation process, produced a significantly better flavor of the dried cocoa beans. However, these practices have not yet been adopted by farmers in Lombok. Price incentives for the fermented beans may not be promising at the farmer's level. Another reason is related to the fermentation technology itself, which is not appropriate for small-scale farmers' conditions. Innovative technology for applying fermentation on the cocoa pods is essential to enhance the technology's adaption by cocoa farmers.

9 1. Introduction

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Cocoa is one of the plantation commodities and has a vital role in the national economy of Indonesia. Indonesia is the third-largest cocoa export country in the world and the largest exporter country in Asia-Oceania. West Nusa Tenggara (Nusa Tenggara Barat, NTB) has a vast potential for cocoa development, which is more than 18,000 hectares but has not been used maximally [1]. Within the 6,778.56 hectares of cultivated area, the production reached about 3,963.35 tons in North Lombok or 8,387.82 tons in NTB [2]. With this condition, the cocoa business can play a significant role in providing job alternatives and reducing poverty in NTB. To fasten cocoa development in the region, local government support through a sustainability program is needed. Cocoa development in NTB, which is focused on North Lombok and East Lombok area, is supported by the Indonesian government [3].

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Cocoa has high economic value and increasing market demand. However, the main obstacle for cocoa exports is the quality of the cocoa beans produced. The quality of cocoa made in Indonesia in general, including in West Nusa Tenggara, is low. This is related to the unfermented beans leading to a lack of flavor or aroma of the cocoa beans. The fermentation process is a vital and absolute stage of processing cocoa beans to ensure a pleasing chocolate aroma. Fermentation can also reduce bitter taste



3
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14
and improve the appearance of cocoa beans [4]. The low quality of cocoa beans is also associated with a high incidence of insects and diseases. There is a slight price difference between the high and low quality received by farmers. Thus, in general, farmers are not interested in improving the quality of cocoa beans [5]. This paper presents research findings on the crucial role of good agricultural and postharvest handling practices on local cocoa beans' quality.

15 2. Materials and Methods

This study combined the qualitative method [6,7,8] and the quantitative approach [9,10,11] as the nature of this research needs substantial explanations and descriptions about the topic, with quantitative measures. This study's data were collected from three sources, including data from cocoa farmers, laboratory trials, and secondary sources. Data were collected from cocoa growers through surveys, i.e., by interviewing ten growers in Genggelang Village, Gangga District. Ten growers in Santong Village, Kayangan District, North Lombok Regency, and field observation to the sites (farms and around), and these data were mainly related to farmers' practices to their crops, its harvest, and its handlings. Laboratory data were collected through experiments designed in an entirely randomized design [12]. The experiment consisted of five treatments and three replications. Data from cocoa growers and laboratory were then complemented with secondary sources such as literature and used for discussions. Data from cocoa growers were analyzed in a descriptive way [13,14,15] or qualitative way [6,8], while laboratory data were analyzed using analysis of variance [12]. Findings from these data and their studies were discussed in the following section.

3. Results and Discussion

3.1. GAP for Cocoa Production and Farmer's Practices in Lombok

There are many aspects of good agricultural practice (GAP), yet some fundamental GAP is highlighted here, as described below. Good agricultural practice and good handling practice to produce cocoa pods and cocoa beans that meet the international quality standard is essential [16]. One aspect of good agricultural practices is pruning. Pruning to remove unnecessary branches will improve the sunlight penetration into the trees, or adequate sunlight passes through the branches and creates good air circulation inside the tree. This condition can help to reduce insects and disease pressure [17]. Farmers in Lombok have not fully applied pruning practice. This condition caused a high incidence of insects and diseases. Data from this research shows that the infected pods were more than 45% of the samples when sampling for the trial. The local government has initiated an integrated training program to improve farmers' knowledge regarding GAP through farmer field school and training for the farmers in Lombok [18].

Sanitation is another aspect of good agricultural practices. Adequate sanitation in the orchard or around the plantation area will help to reduce insect and pathogen pressure. Cocoa pod borers (*Conopomorpha cramerella*) and sucking insect (*Helopeltis antonii*) infesting young and mature pods also have caused heavy losses of cocoa production worldwide [19], including in NTB. Poor orchard sanitation was also recorded during this research. Dead branches that were left under the trees created the right environment for the insect and disease, leading to low quality of the plants' pods and low productivity.

In the condition of high insect and disease pressure, pesticide control is often needed. However, an environmentally friendly and safe way to control insects and disease must support sustainable agriculture development in the region. Fruit wrapping or bagging at the early stage of fruit development is a secure alternative method for controlling insects and may prevent insect or moth egg laying on the fruit [20]. Previous research demonstrated that pod wrapping was sufficient to control cocoa pod borer [21]. Wrapping technology is not easy to be applied on big and tall trees that have not been pruned, which commonly found in a cocoa orchard in Lombok.

3.2. *Harvesting and Postharvest Handling Practices of Cocoa Pods*

The harvesting and postharvest handling system are closely associated with cocoa quality. To obtain optimum quality beans, the time of harvest is crucial. Early harvest resulted in low quality as the beans are not fully developed and have low-fat content and not enough sugar, which is not suitable for fermentation. On the other hand, late harvest or overripe pods are susceptible to disease, and the bean can become germinated [22]. Optimal maturity can be identified from the color changes. For the yellow cultivar, the fruit color will change from green to yellow, while the red cultivar will change from red to orange [23].

Postharvest handling practice also contributes to the cocoa bean quality. Poor postharvest handling practice leads to low pod quality. After harvesting the pods, the optimal handling system involves the whole process, including the pod breaking or removing the bean from the placenta and sorting the excellent bean from the insect and disease infected bean, fermentation, drying, grading, and packaging. The main critical postharvest handling stages are fermentation and drying [24].

3.3. *Fermentation Process for Better Cocoa Bean Quality*

Fermentation is one of several aspects that determine the cocoa bean quality. Therefore the presence of the fermentation process in the postharvest handling system is very crucial. Fermentation triggers the biochemical changes inside the beans, including breaking down sugar and other chemical components

that contribute to the decrease in bitterness and astringency of the beans, further resulting in the development of flavor [25].

Data from our research indicated that fermentation of fresh cocoa beans resulted in a better aroma of dried cocoa beans (Table 1). The longer the fermentation time, up to 6 days, the scent was better or more substantial of the cocoa flavor. However, when the fermentation was prolonged to 8 days, the aroma was decreased and became a dominant acidic aroma. Fermentation also affected the percentage of slaty beans. Although the rate of slaty beans among the treatments was not significantly different, there was a trend that a more extended period of fermentation resulted in a lower percentage of slaty beans. Unfermented beans will result in slaty nibs with grey color rather than the brown or purple-brown color expected for good quality dried cocoa beans.

Table 1. The average and means test (HSD 5%) of the aroma, slaty beans, moldy beans, moisture content, and pH of unfermented and fermented cocoa beans.

Fermentation time (days)	Average value*			
	Aroma (Score)	Slaty beans (%)	Moisture content (%)	pH Value
0	2.75 b	0.17	5.93 ab	4.28 b
2	3.30 ab	0.13	6.09 a	4.32 b
4	3.75 a	0.12	6.06 a	5.45 a
6	3.95 a	0.09	5.69 bc	5.79 a
8	1.90 c	0.06	5.48 c	6.11 a
7 HSD (5%)	1.67	-	9.35	0.74

*Value is the mean of three replications. Means followed by the same letter within the same column are not significantly different (p<0.05).

Data in the table also showed that fermentation significantly reduced the moisture content but increased the dried bean's pH. The pulp's breakdown causes a decrease in moisture content with longer fermentation during the fermentation process. The destruction of the pulp that contained mucilage and other components from the seeds causes the beans' pores to open, facilitating water evaporation from the bean air from the beans during the drying process [26]. Fresh cocoa pods contain a lot of moisture (about 85%) and sugar content (8-14%) [27]. This condition is perfect for the growth of microorganisms that play a significant role in the fermentation process.

The fact that almost all farmers in NTB do not apply the fermentation process for their products. Not doing fermentation is due to several factors, including lack of knowledge and lack of facilities. On top of that, there is no significant price difference between the fermented and unfermented beans at the local market at the farmer's level. On the other hand, fermentation determines the ultimate product quality to fulfill the global market's bean quality standard. To obtain good organoleptic characteristics (good flavor) of chocolate, the fermentation process is an essential step in cocoa bean processing [28].

Therefore, fermentation needs to be applied to achieve the required standard for the international market. Before applying the fermentation, the cocoa demand must be sought to ensure it will run as expected.

3.4. Possibility To Compete, International Market,

Cocoa from NTB has the potential to be marketed globally. Competition in the international market is foreseen very high. However, the capacity to compete in such demand can be built. In general, preparation needs to be directed to better quality and competitive price.

Better quality than current can be achieved through the well-controlled implementation of good agricultural and postharvest handling practices [22]. Both good practices have been just described above and indicate that excellent quality cocoa can be produced. NTB cocoa can be better quality in the aspects of organic or natural products as the plants grow without chemical application. This excellent or high-quality cocoa becomes a source of competitive advantage in the international market. Awareness of the harm of chemical application in crops and foods has been increasing [29,30,31,32], and NTB should benefit from this right movement.

Complementing better quality of cocoa is its price. Better quality and cheaper prices have been strategic in business, not excluding the cocoa business. In general, consumers prefer goods and services of high quality and low price [33,34,35,36]. The lower price of NTB cocoa is achievable, given that workers' cost (worker wage) is still lacking. Also, innovation and technology can be sought for an efficient production system. NTB cocoa can be offered at lower prices with a lower production cost while still has high quality. All of these (better quality and lower price) become sources of competitiveness in the market, locally or globally [37, 38, 39].

Looking at the international market should not overlook the national market of Indonesia itself. In this regard, what is needed is to look for all market opportunities anywhere continuously: local, national, and international. This task will need facilitation from a body that can do it, presumably the central or provincial government. It would be difficult to imagine that this market intelligent to be done by cocoa producers of NTB. Besides, this move to the competition will need support from several related stakeholders, not only for market survey, but also for other business aspects, from farm production, postharvest and handling, and skills for the entrepreneurs. This movement's support, clarity of who does what needs to be specified, and commitment need to be built and maintained throughout.

4. Conclusion

2
Cocoa bean quality is affected by preharvest and postharvest management. Good agricultural practice and postharvest handling practices to produce cocoa pods and cocoa beans using safe and friendly technology to support sustainable agriculture are crucial to meet the international quality standard.

Postharvest handling of the pods, covering the fresh cocoa beans' fermentation process, produced a significantly better quality of the dried cocoa beans. However, farmers in Lombok have not fully adapted fermentation technology. This may be related to the price that is not much difference between the non-fermented and fermented beans at the farmer's level. Another reason may also be associated with the fermentation technology itself, which is not appropriate with the small-scale farmer's condition. Innovative technology for applying fermentation on the cocoa pods is essential to be developed to enhance the technology's adaption by cocoa farmers.

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