Quality risk analysis of cocoa agroindustry: a case study in Pesawaran District, Lampung Province

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Abstract. Quality is a critical issue in small and medium scale cocoa agroindustry, which affected competitiveness significantly. Product quality is strongly influenced by implementing best practices in cocoa production and processing. This study aims to identify quality risks, analyze risks, and develop risk management strategies in the cocoa agroindustry using a case study. Analysis used Quality Risk Matrix to map the risks and Analytical hierarchy process to develop a quality risk management (QRM). The results showed that blooming is the highest quality risk, followed by taste differences, moisture content of raw materials, and color differences. From the management aspect, QRM in the cocoa agroindustry includes documentation system management, implementation of training regularly, implementation of internal audit, periodic reviews, impact assessment, development reports and controls verification, and development of an integrated supply chain systems. QRM includes providing facilities, maintenance of equipment and utilities, material management development, packaging and labeling, and continuous production methods from the technical side. The implementation of QRM in the cocoa agroindustry is carried out through improvements in the production process. In addition, the implementation of QRM requires support from the government and other stakeholders in the cocoa value chain.

1. Introduction
Cocoa is Indonesia’s fourth-largest foreign exchange earner from the agricultural sector after palm oil, rubber, and coconut [1]. Indonesia is ranked as the 6th largest cocoa bean producer after Ivory Coast, Ghana, Ecuador, Nigeria, and Cameroon. As for the cocoa processing industry, Indonesia is ranked the 3rd largest cocoa bean processor in the world after the Netherlands and Ivory Coast [2]. However, most of Indonesia’s cocoa exports are still dominated by raw beans and not processed cocoa, so value-added income has not been achieved. Cocoa agroindustry development is one of the strategies to increase added value. The downstream development of the national cocoa processing industry is directed at producing cocoa powder, cocoa butter, food and beverages from chocolate, supplements, cocoa-based functional foods, and cosmetics and pharmaceuticals.

The development of cocoa agroindustry is aimed at large-scale industries and small and medium-sized industries. Most of the cocoa agroindustry is built by private companies, but there are also regionally owned companies in some cocoa production centers. Cocoa agroindustry development can be pursued by building new cocoa agroindustry or improving the performance of existing cocoa

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agroindustry. Through the development of small and medium industries, it is hoped that mass downstream product development and the development of added value will be built massively.

Sustainable competitive advantage in agribusiness is one of the primary keys to overcoming various challenges [3]. Quality is one of the critical strategies to gain a competitive advantage [4]. Product quality is one of the issues in the cocoa agroindustry on a small and medium scale. Cocoa product quality is strongly influenced by implementing best practices in production and processing [5]. Competitive advantage shows the ability to achieve superior performance. In the long term, a sustainable competitive advantage delivers above-average performance. Increasing competitiveness can be achieved by implementing total quality management, besides improving performance achievement and consumer satisfaction [6]. The development of an integrated quality management system should integrate quality control with existing risk management practices to provide an efficient and effective system [7].

Quality risk is the potential for losses due to quality that fails to meet quality goals. Quality risk relates to raw materials, processing, and final products. The integrated risk assessment identifies more than one risk in the context of a system that will lead to greater decision-making efficiency [8]. Therefore, a comprehensive approach such as Quality Risk Management (QRM) is needed. Through good quality management, defective products can be reduced then the resources are utilized optimally. This study aims to identify quality risks, analyze risks, and develop risk management strategies in the small and medium cocoa agroindustry. The results will provide an overview of cocoa agroindustry strategies to overcome technical problems and the support needed from stakeholders.

2. Materials and methods

2.1 Research approach
The analysis focused on QRM include quality risk identification, analysis, and management. The analysis was carried out by using a case study. Through the deepening of the case studies, it is hoped that an overview of the problems related to the formation of the quality of processed cocoa products in small and medium industries will be described systematically.

2.2 Materials
Data were obtained from a cocoa agroindustry unit in Pesawaran District, Lampung Province. Field observations and in-depth studies were carried out in 2021. Analysis used production data for January-November 2020.

2.3 Methods
Quality risk analysis uses the Quality Risk Matrix developed by measuring the severity and frequency of each risk. The numbers used are on a scale of 1-5 where 1 is the lowest and 5 is the highest. The mapping is done based on data and production information in 2020.

Analysis used Analytical Hierarchy Process (AHP) to develop a QRM. AHP is widely used in case study analysis [9]. AHP is a measurement method used to find the best ratio scale of pairwise comparison. AHP is carried out by implementing three primary operations, including hierarchical construction, priority analysis, and consistency verification [10]. The AHP stage consists of defining the problem and determining the desired solution, creating a hierarchical structure, making a pairwise comparison matrix, calculate the eigenvalues and test their consistency, and calculate the eigenvectors of each pairwise comparison matrix. The scale used refers to the Saaty scale consisting of the numbers 1-9 [11]. The Saaty scale means that 1=equal importance, 3=moderate more importance, 5=essential, strong more importance, 7=demonstrated importance, 9=absolutely more importance, and 2-8 in between.

3. Results and discussion
Cocoa agroindustry is based on processing raw materials from cocoa plantations. The grouping of cocoa and processed cocoa industry consists of (1) upstream industry producing cocoa pods, cocoa beans, liquor/mass; (2) the intermediate industry producing cocoa liquor, cocoa cake, cocoa butter, and cocoa powder (processed cocoa); and (3) downstream chocolate-based food industry. The main processed cocoa products consist of cocoa beans, intermediate cocoa products (cocoa liquor, cocoa butter, cocoa powder), industrial chocolate, and finished chocolate products.

3.1. Description of cocoa agroindustry unit

The establishment of this cocoa agroindustry was motivated by the extent of cocoa plantations in Lampung Province, especially in Pesawaran District. The cocoa plantation was 27,373.49 hectares with an annual production of 19,875.30 tons of dry cocoa beans and a productivity level of 858.25 kg/ha. The raw material uses fermented cocoa beans. The products are chocolate bars and cocoa flour which will be made into 3 in 1 product.

The agroindustry implements a process layout type in its production area. Process layout is a type of layout where machines and equipment with the same specifications are placed in one location. Business units often use this type of layout with small production capacities and various forms and products. This agroindustry applies a straight line material flow pattern which is quite simple and consists of several components. The production process consists of two stages, namely the process of forming pasta and the process of making the product. In the second stage, the paste is separated to make chocolate bars or candy products and make chocolate flour for 3 in 1 powder.

3.2. Quality performance and risk identification

The processing consists of pasta processing and final product processing. The performance of the cocoa agroindustry quality is divided into raw materials and product quality. The quality of raw materials is related to cultivation and post-harvest handling activities, while the quality of products is related to the processing process.

Post-harvest handling of cocoa consists of sorting cocoa beans, breaking cocoa pods, fermentation, drying, sorting, packaging, storing, and marketing. The fermentation process is carried out to form a distinctive taste, bright brown color, hollow bean chips, and reduce the bitter and astringent taste of cocoa beans to produce cocoa beans with good quality and aroma and bright and clean chocolate color.

The quality of cocoa beans refers to SNI 2323:2008. The raw material quality parameters consist of the number of live insects, moisture content, smoke-smelling seeds, and foreign matter content. Based on the quality, it is classified into three types: quality I, quality II, and quality III. According to the size of the weight of the seeds, stated the number of seeds per 100 grams. Quality control of raw materials is carried out to maintain the quality of raw materials and products. Quality control of raw materials is carried out through checking of raw materials by an organoleptic method. Recently, new and more sensitive methods have been developed such as chromatographic analysis to detect metabolites and small amounts of contaminants [12].

The processing process aims to produce pasta products processed into chocolate bars or candy and chocolate 3 in 1. The quality standard of the production process is following the provisions of SNI. The quality requirements for cocoa paste are by SNI 3749:2009, while the quality requirements for cocoa butter are SNI 3748:2009.

Quality risk in the cocoa agroindustry consists of raw material quality risk and product quality risk (Table 1). Quality risks of raw materials are related to the fulfillment of quality requirements for cocoa beans. The quality requirement consists of maximum moisture content of 7.5%, have no smoke or foreign odor, free from live insects, the range of broken seeds is a maximum of 3%, and must not be mixed with foreign objects.
### Table 1. Risk quality

| Quality risk aspect   | Risk name                                      | Description                                                                 |
|----------------------|------------------------------------------------|-----------------------------------------------------------------------------|
| Raw material         | Live insects (R1)                              | Insects found                                                               |
|                      | Water content (R2)                             | The water content is higher than the requirement                           |
|                      | Seeds smell of smoke, hammy, or foreign smell (R3) | Seeds smell of smoke and or hammy and or foreign smell                     |
|                      | Foreign body level (R4)                        | Foreign object found                                                        |
| Product              | Color (R5)                                     | The product is too dark in color and different from the standard.           |
|                      | Flavour (R6)                                   | The chocolate taste is not suitable (gives a sweet taste that is not too bitter and minimal sour taste). |
|                      | Texture (R7)                                   | The chocolate looks like a mixture of lumpy ingredients, or the paste is not finely ground |
|                      | Bloom (R8)                                     | There are white patches around the brown surface.                          |

Quality control is carried out on raw materials and products. Raw materials quality control is carried out by checking raw materials before the production process. Quality control of raw materials is carried out organoleptically, including checking the number of cocoa beans that come, the moisture content of the cocoa beans, and the quality of the cocoa beans. Quality control of the production process is carried out by checking and periodically monitoring each stage of production. Process quality control aims to obtain standardized product quality. Product quality control is related to the product’s physical form, such as color, taste, texture, shape, and weight. There are four types of product deviations in the data during the production process: (1) defective chocolate blooms, (2) inappropriate color, (3) chocolate taste is too bitter and sour, and (4) uneven texture.

In 2020, there are 75 batches of chocolate production processes. Based on the company data, there are allegations of defective products in 15 batches a year. Data on the number of production and production defects in 2020 can be seen in Figure 1. The number of product defects is 1-4%, where the highest defective product was in January 2020.

![Figure 1. Percentage of product defect (2020).](image)

3.3. **Risk analysis**

Quality risk analysis is carried out by measuring the severity and frequency of each risk, then mapped to the Quality Risk Matrix. The values used are 1-5, which means 1 is the lowest and 5 highest. Risk analysis is the estimation of the risk associated with the identified hazards. It is the qualitative or quantitative process of linking the frequency of occurrence and severity of the risk. The results of the analysis show that blooming (R8) is the highest quality risk, followed by differences in taste (R6), moisture content of raw materials (R2), and color differences (R5) (Figure 2).
Improper processing and storage are the cause of the appearance of white spots on chocolate or chocolate blooming. Fat bloom is a type of bloom formed from the chocolate tempering process, or the process of melting and cooling chocolate so that the surface is smooth and shiny, which is not perfect. If the process is not done properly and the chocolate is at a warm temperature, the cocoa butter will separate from the chocolate mixture. After the chocolate cools, the fat hardens, and white spots appear on the surface. Many factors trigger fat blooms that give rise to white patches, including inadequate crystallization during tempering and mixing different chocolate flavors. In addition, the chocolate cooling process is not perfect, the temperature is different from the outside and inside of the chocolate, and storage at the wrong temperature and humidity levels are factors for the appearance of these white spots.

Most of the raw materials for cocoa are obtained from smallholder plantations. The level of compliance with the quality requirements of cocoa beans is relatively high, where the limiting factors are waste and water content [13]. The low quality of cocoa is influenced by smallholder cocoa farmers who have not used the right technology and management. Hence, farmers tend to sell cocoa beans without being fermented and sorted [14]. The type of color defect specified by the manufacturer is not too black, where this defect causes the product to be too dark and different from the standard. The resulting chocolate tastes sweet, not too bitter, and has a minimal sour taste in this type of taste defect.

3.4. Risk management
Quality management is a strategy to achieve high-quality products through identifying and improving critical elements and activities in the production process [15]. QRM is an overall and systematic process to minimize risks to product quality to optimize its benefits. QRM might consist of actions taken to mitigate the severity and probability of harm. In risk evaluation, it is essential to consider statistical, quantitative data and circumstances, i.e., qualitative data [8].

Risk management in the cocoa agroindustry consists of management and technical aspects (Table 2). From the management aspect, risk management in cocoa agroindustry consists of documentation system management, implementation of training regularly, implementation of internal audit, periodic reviews, impact assessment, development reports regarding the process and controls verification, and development of an integrated supply chain systems with suppliers. From the technical side, risk management in the cocoa agroindustry consists of providing facilities, maintenance of equipment and utilities, material management development, packaging and labelling according to product safety standards, and continuous production methods.
Table 2. Quality risk management on cocoa agroindustry.

| Aspect                      | Quality risk management                                                                 |
|-----------------------------|-----------------------------------------------------------------------------------------|
| Management aspect           | Documentation system management                                                         |
|                             | Implementation of training regularly                                                   |
|                             | Implementation of Internal Audit                                                        |
|                             | Periodic reviews                                                                       |
|                             | Impact assessment                                                                       |
|                             | Development reports regarding process and controls verification                         |
|                             | Development of an integrated supply chain system with suppliers                         |
| Technical aspect            | Provision of facilities                                                                  |
|                             | Maintenance of equipment and utilities                                                  |
|                             | Material management development                                                         |
|                             | Application of packaging and labeling according to product safety standards              |
|                             | Continuous improvement of production methods                                            |

Blooming quality risks can be overcome if managed better. Regarding human or worker factors, the blooming of the brown surface is caused by workers who are not careful in carrying out the product manufacturing stage and lack of control over temperature and time that affect the process. From the method aspect, the cause of blooming is that no tempering is carried out in making chocolate, causing the surface of the chocolate to have a white layer. Blooming is also due to engine capacity not being fulfilled and temperature variations.

Risk management consists of several strategies that sometimes cannot be fully implemented for reasons of limited resources. Therefore, a priority analysis is needed. The analysis was carried out by comparing various strategies using the Saaty scale through pairwise comparisons. The analysis results are depicted in the form of a bar chart that describes the priority value of each alternative. Risk management on cocoa agroindustry can combine various management and technical aspects of action with different proportions (Figure 3-4).

Cocoa bean quality risk related to moisture content and other quality requirements is determined by cocoa plantations because the company buys cocoa beans from farmers. Quality control is carried out by checking the quality of raw materials but cannot change the quality that has been formed. Therefore, raw material quality risk management is carried out by developing an effective supply chain with supplier farmers.
Risk management related to raw materials is related to the management of raw materials in the agroindustry unit and related to the supply chain because the raw materials are supplied from smallholder plantations. Developing the cocoa supply chain by creating an integrated approach that focuses on learning and stable relationships with small-scale farmers will encourage effectiveness in the value chain [16]. Therefore, the strategy in QRM is also related to integration with suppliers in value chain development and material management development.

An effective supply chain development will encourage the adoption and implementation of Good Agricultural Practices and Good Post Harvest Management Practices [17]. It will change the behavior and perception of farmers towards sustainable management practices, which are very important to increase the production of safe and quality cocoa beans. Therefore, government support is needed to increase the capacity of farmers. In addition, the implementation of risk management will be related to financing and marketing aspects. Improvements in production methods and facilities may require investment, while improved product quality may require different marketing channels.

4. Conclusion
Quality improvement in the cocoa agroindustry requires an integrated approach by implementing QRM, including risk identification, risk analysis, and risk management. Quality risk in the cocoa agroindustry is divided into raw material and product quality risk. The case study showed that blooming is the highest quality risk, followed by differences in taste, moisture content of raw materials, and color differences.

Improving quality can be achieved by implementing risk management, including strategies in management and technical aspects. Given that the production system also involves farmers as suppliers of raw materials, the effectiveness of risk management is also influenced by supply chain performance. Therefore, risk management implementation requires support from the government and other stakeholders. Support from the government includes farmers capacity development, providing incentives in the implementation of QRM, and facilitating partnerships agroindustry with other stakeholders. Support from other stakeholders is provided in terms of financing and product marketing. Through the implementation of QRM and the support of all stakeholders, cocoa quality products will be created that will encourage increased competitiveness.

References
[1] Directorate General of Estate Crops 2021 Statistical of National Leading Estate Crops Commodity 2019-2021 (Jakarta: Directorate General of Estate Crops)
[2] Voora V, Bermúdez S and Larrea C 2019 Global Market Report: Cocoa (Manitoba: International Institute for Sustainable Development)
[3] Mugera A W 2012 Sustained competitive advantage in agribusiness: applying the resource-based Theory to Human Resources Int. Food Agribus. Manag. Rev. 15 27–48
[4] Ganapavarapu, Leela Krishna and Prathigadapa S 2014 Knowledge sharing in a multicultural workforce: a dual case study in the UAE Arab. J. Bus. Manag. Rev. 5 1–10
[5] Loureiro G A H A, Araujo Q R, Sodré G A, Valle R R, Souza J O, Ramos E M L S, Comerford N B and Grierson P F 2017 Cacao quality: highlighting selected attributes Food Rev. Int. 33 382–405
[6] Ramlawati and A K H P 2018 Total quality management as the key of the company to gain the competitiveness, performance achievement and consumer satisfaction Int. Rev. Manag. Mark. 8 60–9
[7] Westgard J O 2013 Perspectives on quality control, risk management, and analytical quality management Clin. Lab. Med. 33 1–14
[8] Girdžiūtė L 2012 Risks in agriculture and opportunities of their integrated evaluation Procedia - Soc. Behav. Sci. 62 783–90
[9] Subramanian N and Ramanathan R 2012 A review of applications of analytic hierarchy process in operations management Int. J. Prod. Econ. 138 215–41
[10] Ho W 2008 Integrated analytic hierarchy process and its applications - a literature review Eur. J. Oper. Res. 186 211–28
[11] Ishizaka A and Labib A 2011 Review of the main developments in the analytic hierarchy process Expert Syst. Appl. 38 14336–45
[12] Quelal-Vásconez M A, Lerma-García M J, Pérez-Esteve É, Talens P and Barat J M 2020 Roadmap of cocoa quality and authenticity control in the industry: a review of conventional and alternative methods Compr. Rev. Food Sci. Food Saf. 19 448–78
[13] Sulistyowati S, Moeljono A, Utomo U and Hilman M S 2005 Kajian kesesuaian mutu kakao rakyat sulawesi selatan dengan SNI 01-2323-2002 J. Stand. 7 117-25
[14] Manalu R 2018 Pengolahan biji kakao produksi perkebunan rakyat untuk meningkatkan pendapatan petani J. Ekon. Kebijak. Publik 9 99–111
[15] Kafetzopoulos D, Gotzamani K and Gkana V 2015 Relationship between quality management, innovation and competitiveness. Evidence from Greek companies J. Manuf. Technol. Manag. 26 1177–200
[16] Deans H, Ros-Tonen M A F and Derkyi M 2018 Advanced value chain collaboration in ghana’s cocoa sector: an entry point for integrated landscape approaches? Environ. Manage. 62 143–56
[17] Suh N N, Njimanted G F and Thalut N 2020 Effect of farmers’ management practices on safety and quality standards of cocoa production: a structural equation modeling approach Cogent Food Agric. 6 1844848