Improvement of The Food Safety Management System for Tea-Producing SMEs Based on HACCP

Ellia Kristiningrum[1*], *Ajun* Tri Setyoko[1], *Teguh* Pribadi Adinugroho[1], *Danar* Agus Susanto[1], *Febrian* Isharyadi[2], and *Meilinda* Ayundyahrini[1]

[1]Research Center for Testing Technology and Standard, National Research and Innovation Agency of Indonesia, Indonesia
[2]Research Center of Sustainability Production and Life Cycle Assessment, National Research and Innovation Agency of Indonesia, Indonesia

Abstract. Tea is a beverage product that has many health benefits. The growth of the small and medium scale industry (SMEs) is able to push this industry sector to become the second largest beverage industry after mineral water in Indonesia. Controlling the risk of food safety hazards is very important for this sector to produce products that are safe for consumption. Focusing on prevention, Hazard Analysis and Critical Control Points (HACCP) can assist change including designing treatment equipment and procedures. This work provides an overview of the development of a HACCP system in a teaproducing SME-scale industry. The methodology used is based on the guidelines for developing a HACCP system. The results of the work found four critical control points (CCP) in the tea production line and as a recommendation, it is necessary to take corrective actions in receiving raw materials, chopping, grinding and drying tea.

1 Introduction

Tea is a drink that contains natural polyphenols, flavanols, pectins, alkaloids, chlorophyll, tannins, and fluorides. Tea drinks are made by brewing the leaves, shoots, or dried stalks of the Camellia sinensis plant. Tea is a drink that has many health benefits [1]. Tea has been used as a health product or medicine to prevent and treat various diseases. Previous studies have demonstrated the many benefits of tea, such as antioxidant, bacteriostatic, and anti-cancer activities and regulation of lipid metabolism [2]. Tea contains many bioactive compounds, one-third of which are polyphenols. Polyphenols in tea are in the form of catechins and flavanols, which function as antioxidants to capture free radicals in the body and can prevent the development of cancer cells in the body [3].

Along with the times and technology, more and more tea processing industries produce various end products such as dry tea, tea bags, and packaged tea. The packaged tea industry is the second largest beverage industry after the mineral water industry [4]. The percentage of the packaged tea beverage industry is 5.7% of the total beverage industry in Indonesia. The large market share of the beverage industry has resulted in increased growth in the tea industry, both large and small and medium enterprises. This is also because the production process is simple and does not require complicated technology [5].

Food production that is safe for consumption needs to use food safety standards. One recognized food safety standard is the Hazard Analysis and Critical Control Point (HACCP). HACCP is a tool or system used to assess hazards and establish control systems focusing on prevention. HACCP is applied to the entire food product xprocessing chain [6]. Previous research identified a critical point in black tea production: drying. This research developed drying methods, environmental conditions, settings, and procedures in the black tea drying process [7].

HACCP is known as a system that can control quality and hazards that may arise during processing in the industry. Often small and medium-scale industries still need to use the HACCP system in managing their production processes. Quality control has also yet to be carried out optimally, so the product quality could be more consistent and meet the required standards [8]. Previous studies have explained that HACCP is an effective management tool in ensuring the safety of food/beverage products [9].

The basic requirements program is a good food production method (Good Manufacturing Practice) or good hygiene practice (Good Hygiene Practice), which aims to ensure that the food provided to consumers is food that is healthy and safe. The quality management system functions as a frame of reference for activities in the production process, including the HACCP system [10]. Therefore, to improve food safety in the tea production process, it is necessary to apply HACCP. This study aims to develop a HACCP system in tea-producing SMEs by identifying, analyzing, and controlling hazards in the tea production process.

2 Literature

* Corresponding author: ellia004@brin.go.id

Hazard Analysis and control critical points Hazard Analysis Critical Control Point (HACCP) is a scientific, rational, and systematic approach to identifying, assessing, and controlling hazards. The purpose of HACCP is to prevent known hazards (biological, chemical, and physical hazards) and reduce the risk of hazards by exercising control at every critical point in the production process (from the production of raw materials, procurement and handling of raw materials, processing, distribution to consumption of finished products). HACCP is a food safety assurance system in the food industry that is known and applies internationally [11].

The HACCP concept combines the principles of food microbiology, quality control, and risk assessment to achieve the highest possible level of safety. Even so, applying HACCP does not mean stopping the growth of bacteria to zero but rather minimizing it to a level that can be considered safe. This system assesses control over the quality of raw materials, processing systems, the environment in which the process takes place, personnel involved, and storage and distribution systems [12]. Theoretically, there are seven important basic principles in applying the HACCP system in the food industry [13]. The important basic principles of HACCP are the basic philosophy of HACCP, namely:

2.1 Perform a hazard analysis.

Hazard analysis is the most crucial stage that requires indepth knowledge of the food products produced, the materials used, and the processes and technology applied to each production procedure. This is done to identify potential hazards, including their causes, and determine the chance of occurrence or risk and the level of severity at each stage of the process [14].

2.2 Determine the critical control points (CCPs)

Critical Control Point (CCP) is defined as a point, stage, or procedure in food processing that can be controlled so that hazards can be prevented or reduced to a safe level. Determination of CCP can be in the form of process stages, formulations, or raw materials that contain hazards that cannot be controlled at the processing stage. Every raw material needs to be tested to determine whether it carries a critical hazard, so it is necessary to consider giving CCP treatment to this raw material. If it is decided that the raw material has a critical hazard that needs to be handled by a stage or process, then the stage or process that controls the hazard is the CCP. [13].

2.3 Establish one or several critical limits.

Critical limits are one or more parameter limits that must be met for each CCP. This limit separates safe and unsafe based on microbiological, chemical, and physical hazards. This critical limit will be monitored in real time so that the critical limit must be selected based on a criterion that can be measured or observed easily and quickly. Critical limit parameters need to be determined as a means of preventing the occurrence of hazards, such as maximum temperature and time for thermal processing, maximum temperature to maintain cooling conditions, specific temperature and time for commercial sterilization processes, amount of pesticide residues that are allowed to exist in foodstuffs, maximum pH allowed, maximum filling weight, maximum allowable viscosity and so on. In addition to the critical limits for pesticide residues originating from agricultural commodities, the critical limits for other chemicals that have the potential to become chemical hazards must also be determined [15].

2.4 Establish a CCP monitoring system

Monitoring or monitoring is a set of scheduled observations implemented on the CCP to ensure that the critical limits are met. If the critical limits of a CCP have been established, then monitoring of critical limits must be implemented. Procedure monitoring includes what will be monitored, who is tasked with monitoring, when monitoring was carried out, where monitoring is carried out, and how monitoring is carried out. Establishment of monitoring procedures to prevent the condition of a CCP from getting out of control which results in an increased risk of producing hazardous products, identifying problems before they arise, finding the root cause of a problem, and assisting the process of verifying and demonstrating the feasibility of the HACCP system. [15].

2.5 Establish Corrective Action to be taken if monitoring indicates that a specific CCP is no longer under control.

Corrective action is a procedure when a deviation from a critical limit occurs or the process goes beyond a critical limit. The occurrence of deviations from the critical limit can be known from monitoring activities. Corrective action must be taken immediately when the critical limit is exceeded. These actions are planned, so corrective procedures have been defined and documented in the HACCP plan. The repair procedure that will be carried out has ensured no impact on product safety. If, during monitoring, it is found that the CL is not met, it is necessary to plan a corrective action to ensure that the food product produced is safe. There are two kinds of corrective actions in question, namely, actions that are immediate (correction) and those that are prevention of deviation (deviation control) [13].

2.6 Establish procedures of verification to confirm the successful working of the HACCP system.

The verification procedure is an activity of implementing methods, testing, and analysis procedures, as well as other evaluation actions, as an addition to the monitoring system to identify and ensure compatibility with the HACCP system. To ensure that the HACCP system can control food safety, product

testing, equipment calibration, and monitoring results are reviewed [13].

2.7 Introduce a documentation system considering all processes and records following the principles and the latest application.

Documentation procedures and document storage have several purposes, namely evidence of product safety relating to existing procedures and processes, assurance of compliance with regulations, facilitating tracking/tracing and review of records, documentation of measurement data towards a permanent record of food product safety, sources of necessary data reviews in the HACCP audit process, HACCP records/documents can be more focused on food safety issues thereby speeding up the problem identification process [13].

3 Methodology

This research uses a qualitative descriptive approach with a case study on a tea-producing UKM in Solo, Indonesia. The selection of SMEs is based on the fact that these SMEs have product marketing areas at home and abroad. The data collection process was carried out by observing, interviewing, and processing document data to get an overview of the tea production process and how the prerequisite programs, namely Good Manufacturing Practices (GMP) and Sanitation Standard Operational Procedure (SSOP), were implemented. The research methodology follows the HACCP principles contained in SNI 01-4852-1998 concerning Hazard Analysis Systems and Critical Point Control (HACCP) and the Guidelines for Their Application [16].

The stage of this research begins with analyzing the flow of the production process and identifying the hazards that might arise during the tea production process. Furthermore, in the second stage, an analysis of the application of HACCP principles is carried out by determining hazard analysis, determining critical control points, determining critical limits, establishing a CCP monitoring system, and determining corrective actions. In the final stage, an investigation is carried out to produce recommendations for overcoming gaps and a HACCP implementation plan [15].

4 Result And Discussion

In principle, tea processing converts fresh tea shoots into dry tea with quality characteristics set by SMEs. In an effort to change the character of fresh tea shoots into the nature of dry tea ready for consumption, processing activities are required with several determining factors, including raw materials, processing processes, and equipment/machines used.

4.1 Tea Production Flow

The tea production process flow is analyzed by compiling a flow chart based on field observations. A flow chart is made and directly verified on the actual conditions in the field. The flow of the tea production process is presented in Figure 1, which begins with receiving raw materials, withering, chopping, grinding, drying, sorting, and packaging. Determination of production flow diagrams is carried out to analyze the hazards that can occur at each stage of the process.

According to Nurhayati, tea production generally is withering, grinding, drying, and sorting [17]. Withering is done until the tea leaves are rolled, and the water content is reduced. Good withering results are marked by withered shoots that are yellowish-green in color, not dry, and flower stalks become flexible. After the withering process, SMEs carry out the chopping process before grinding. This process is done using a chopping machine to get a predetermined size. The chopped tea is then ground in a machine at room temperature for 40-60 minutes to obtain a wet powder. After the tea is ground, it is dried in the oven and sorted and packaged.

4.2 HACCP Food Safety Management System Analysis

There may be food safety hazards, food quality, and economic losses in the tea production process, so it is necessary to identify hazards [16]. The potential hazards that can occur are the presence of microorganisms, pests, foreign body pesticides (iron rust, dust, sand flakes), and crosscontamination from employees [18]. Identification of potential hazards in the tea production process is presented in Table 1.

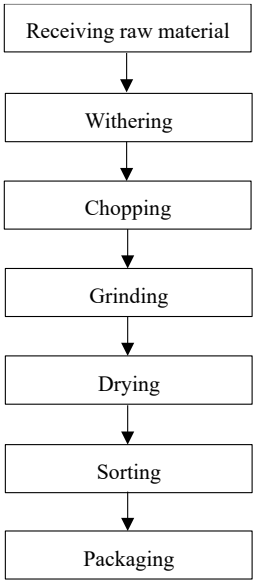

Fig. 1. Tea production flow

Manufacturing products, especially food products, must determine and understand each critical control point in each process. Monitoring of deviations and critical control points has the goal of being able to control and prevent any hazard that may or may occur. At the critical point, deviation of each process will affect

the result of the product. The list of CCPs in the tea production process is presented in Table 2.

Based on the table, the critical control points in tea production are receiving raw materials, chopping, grinding, drying, and grinding. The process of receiving raw materials is a crucial initial process before the raw materials for tea are further processed. This process significantly affects the quality of tea products. While chopping, grinding, and drying, it is necessary to ensure that the tea must be free from physical hazards such as dust, rust, and sand because this process uses chopping machines, grinding machines, and ovens. To implement a tea product quality assurance system, these critical control points must be the focus of SMEs' attention because there is a possibility of potential hazards in the process. The withering, sorting, and packaging processes are separate from the CCP [19].

Table. 1. HAZARD ANALYSIS IN THE TEA PRODUCTION PROCESS

Process	Potential hazard	Risk Category			Potential to Be Important		
		Hazard	Quality	Economy	Frequency	Severity	CCP
Receiving raw materials	Biological hazards: microorganisms, pests, Chemical hazards: pesticides, Physical hazards: Cross-contamination, physical hazards of improper handling	√	√		often	high	yes
Withering	Physical hazard: cross-contamination from employees	√			rarely	low	no
Chopping	Physical hazards: foreign bodies (iron rust, dust, sand flakes) and cross-contamination from employees,	√	√	√	often	high	yes
Grinding	Physical hazards: foreign bodies (iron rust, dust, sand flakes) and cross-contamination from employees,	√	√	√	often	high	yes
Drying	Physical hazards: foreign bodies (iron rust, dust, sand flakes) and crosscontamination from employees	√	√	√	often	high	yes
Sorting	Physical hazard: contamination employees cross-from	√			rarely	low	no
Packaging	Physical hazard: contamination employees cross-from	√	√	√	rarely	low	no

The specified critical limits must not be exceeded because these limits are tolerable to ensure that each hazard can be controlled. The criteria used include foreign body contamination according to SNI 4296:1996, chemical contamination, microbiology, foreign body contamination, ash content, and water content according to SNI 3945:2016 [20]. Tea products have a critical limit setting which can be seen in Table 2.

The HACCP plan analyzes some basic HACCP principles, such as critical limits, corrective actions, and monitoring procedures. Critical limits will provide a standard level of safety for a product if the level of critical limits according to standards will be able to prevent potential hazards. HACCP plan validation

includes internal and external verification. Internal verification is carried out through a review by the HACCP team formed by the UKM— external verification by certification bodies, consultants, and related agencies. External verification can be carried out by submitting a letter to the relevant agency to obtain certification. This external verification is carried out with a frequency of once a year [16].

Table. 2. DETERMINATION OF CRITICAL LIMITS, CORRECTIVE ACTIONS, AND MONITORING PROCEDURES ON TEA PRODUCTION

CCP process	Reason	Critical Limit	Corrective Action	Monitoring Procedure
Receiving raw materials	Poor quality of raw materials	Organoleptically, there is no physical hazard, namely foreign body contamination, according to SNI 4296-1996. In terms of quality, color, smell, taste, criteria for chemical contamination, biology, water content, and ash content, according to SNI 3945: 2016	Physical checks and Certificate of Analysis (CoA) documents of incoming raw materials	Officers receiving raw materials always check the physical condition and Documents of Certificate of Analysis (CoA) of incoming raw materials.
Chopping	Sanitation of employees, equipment, and presence of physical hazards	Organoleptically there are no physical hazards such as rust, dust, and foreign matter, according to SNI 4296-1996	Checking the condition of the chopping machine and also employee sanitation	The production staff continuously checks the cleanliness of the employee's tools and sanitation during each chopping process
Grinding	Sanitation of employees, equipment, and presence of physical hazards	Organoleptically there are no physical hazards such as rust, dust, and foreign matter, according to SNI 4296-1996	Checking the condition of the grinding machine and also employee sanitation	The production staff continuously checks the cleanliness of the tools and sanitation of the employees during each grinding process
Drying	Sanitation of employees, equipment, and presence of physical hazards	Organoleptically there are no physical hazards such as rust, dust, and foreign matter, according to SNI 4296-1996	Checking the condition of the oven and also employee sanitation	The production staff continuously checks the cleanliness of the tools and sanitation of the employees during each drying process

From the table above, it can be seen that the determination of critical limits at the stage of receiving raw materials, namely contamination of foreign bodies such as dust and sand and the quality of tea raw materials must comply with SNI 3945: 2016 regarding color, smell, taste, criteria for chemical contamination, biology, water content, and levels ash. The potential physical hazards in raw materials can be controlled by wearing gloves, masks, and hair nets [16].

Determination of critical limits at the chopping and grinding stages, namely physical hazards such as contamination of foreign bodies such as dust and metal rust due to unhygienic choppers and employees who have not implemented sanitation. The drying stage also needs to set critical limits for physical hazard contamination. This drying stage is crucial because it is one of the final stages of the tea production process. It is necessary to ensure that the dried tea is free from contamination by foreign objects before sorting and packaging.

The monitoring procedure periodically observes or measures the CCP to compare it to its critical limit.

Monitoring procedures have the aim of assisting in collecting data, providing early warning when deviations occur, preventing or reducing losses from a product, and can help resolve problems that arise. In receiving raw materials, chopping, grinding, and drying, it is necessary to place officers who check the receipt of raw materials and the machines' cleanliness and ensure good employee sanitation.

Curently, many small and medium-sized organizations (SMEs) have implemented standards and recognized the benefits to the firm. These advantages include assistance with competition with major firms, assisting with export market access, assisting with best business practices, and assisting with corporate operations, become more efficient and flourish [21]. Food and beverage companies need to apply food safety standards to be able to produce food products that are safe for consumption [22].

Recommendations for providing work attributes or uniforms for employees during the production process. Work attributes include clothing, head coverings, masks, gloves, and head coverings to protect raw materials from contamination and build a clean culture in the production environment [20]. Hair is the most potential contaminant in food and beverage products. For this reason, using a head covering when in contact with food and drink is an effort to prevent hair from entering as a contaminant [21].

5 Conclusion

Technical limitations, such as finance, information, and human resources, are obstacles for food SMEs in implementing HACCP. The main obstacle are the need for more understanding of system documentation, the minimum number of staff, limited staff with the skills to implement HACCP, and low food safety knowledge for controlling microbiological contamination hazards. The government needs to provide guidance and assistance to food SMEs to implement a food safety system. HACCP implementation can provide added value and increase consumer confidence in the product. In addition, SMEs will have increased opportunities for export market share to other countries

We thank the National Standardization Agency for funding this research. We also thank the Research Center for Testing Technology and Standards - BRIN researchers who have provided input and supported this research.

References

1. M. Da Silva Pinto, “Tea: A new perspective on health benefits,” Food Res. Int., **vol. 53**, no. 2, pp. 558–567, (2013), doi: 10.1016/j.foodres.2013.01.038.
2. Z. Yan, Y. Zhong, Y. Duan, Q. Chen, and F. Li, “Antioxidant mechanism of tea polyphenols and its impact on health benefits,” Anim. Nutr., **vol. 6**, no. 2, pp. 115–123, (2020), doi: 10.1016/j.aninu.2020.01.001.
3. D. Türközü and N. Şanlier, “L-theanine, unique amino acid of tea, and its metabolism, health effects, and safety,” Crit. Rev. Food Sci. Nutr., **vol. 57**, no. 8, pp. 1681–1687, (2017), doi: 10.1080/10408398.2015.1016141.
4. D. Indrasti and F. Siliyya, “Atribut Minuman Teh Kemasan Siap Minum yang Memengaruhi Persepsi Konsumen di Kabupaten Tegal,” J. Mutu Pangan Indones. J. Food Qual., **vol. 8**, no. 2, pp. 70–79, (2022), doi: 10.29244/jmpi.2021.8.2.70.
5. L. S. Safitri and D. Triastuti, “Kesadaran Merek dan Atribut Mutu Sensori Minuman Teh dalam Kemasan,” Paradig. Agribisnis, **vol. 5**, no. September, pp. 11–22, (2022).
6. A. T. Setyoko, “Identifikasi Bahaya Dan Penentuan Titik Kendali Kritis Pada Ukm Keripik Nangka Di Jember,” J. Stand., **vol. 20**, no. 3, p. 171, (2019), doi: 10.31153/js.v20i3.715.
7. M. Januar, R. Astuti, and D. M. Ikasari, “Analisis pengendalian kualitas pada proses pengeringan teh hitam dengan metode six sigma: studi kasus di PTPN XII (persero) Wonosari, Lawang,” J. Teknol. Pertan., **vol. 15**, no. 1, pp. 37–46, (2014).
8. A. T. Setyoko and E. Kristiningrum, “Pengembangan Desain Sistem Keamanan Pangan Menggunakan Hazard Analysis Critical Control Point (HACCP) Pada UKM Produsen Nugget Ikan,” J. Stand., **vol. 21**, no. 1, pp. 1–8, (2018).
9. F. Liu, H. Rhim, K. Park, J. Xu, and C. K. Y. Lo, “HACCP certification in food industry: Trade-offs in product safety and firm performance,” Int. J. Prod. Econ., **vol. 231**, no. December 2019, p. 107838, (2021), doi: 10.1016/j.ijpe.2020.107838.
10. H. Herawati, “Potensi pengembangan produk pati tahan cerna sebagai pangan fungsional,” J. Limbang Pertan., **vol. 30**, no. 024, pp. 31–39, (2011), doi: 10.1016/j.foodhyd.2016.06.020.
11. I. Surono, A. Sudibyo, and P. Waspodo, Pengantar Keamanan Pangan untuk Industri Pangan. Yogyakarta: DeePublish, (2016).
12. Arisman, Buku Ajar Ilmu Gizi “Keracunan Makanan.” Jakarta: Buku Kedokteran EGC, (2009).
13. R. Rauf, Sanitasi Pangan & HACCP. Yogyakarta: Graha Ilmu, (2013).
14. M. Brown, HACCP in Meat Industry, 1st Editio. Cambridge: Woodhead Publishing, (2000).
15. W. Dzwolak, “Assessment of HACCP plans in standardized food safety management systems – The case of small-sized Polish food businesses,” Food Control, **vol. 106**, no. March, p. 106716, (2019), doi: 10.1016/j.foodcont.2019.106716.
16. I. Marvie and A. T. Putri, “Evaluasi cara produksi pangan yang baik (CPPB) dan rekomendasi hazard analytical critical control point (HACCP) pada UKM teh sereh di Metro, Lampung,” Agrointek J. Teknol. Ind. Pertan., **vol. 17**, no. 1, pp. 169–176, (2023), doi: 10.21107/agrointek.v17i1.12989.

17. H. Nurhayati, “Analisis Produksi Teh Hitam Jenis Bop Di Pt. Perkebunan Nusantara Viii Goalpara Kabupaten Sukabumi,” ECONEUR (Journal Econ. …, pp. 1–9, (2020), [Online]. Available: https://econeur.polteksmi.ac.id/index.php/econeur/article/view/20%0Ahttps://econeur.polteksmi.ac.id/index.php/econeur/articl e/download/20/14
18. W. Dzwolak, “HACCP in small food businesses - The Polish experience,” Food Control, **vol. 36**, no. 1, pp. 132–137, (2014), doi: 10.1016/j.foodcont.2013.07.043.
19. E. W. Asih, L. Ode, R. Rain, A. Pohandry, T. Industri, and T. Industri, “Analisis Pengendalian Kualitas Produk Teh Hitam dengan Pendekatan Lean-Six Sigma Method di PT. Teh XY,” J. Ind. Eng. Syst., **vol. 2**, no. 2, pp. 136–145, (2021), [Online]. Available: https://ejurnal.ubharajaya.ac.id/index.php/JIES/article/view/86 3
20. Direktorat Jenderal Perkebunan, “Statistik Perkebunan Non Unggulan Nasional 2020-2022,” (2022).
21. E. Kristiningrum, A. T. Setyoko, and F. Isharyadi, “Improving soy milk quality with development of technical standard parameters,” IOP Conf. Ser. Earth Environ. Sci., **vol. 828**, no. 1, (2021), doi: 10.1088/1755-1315/828/1/012054.
22. A. T. Setyoko, E. Kristiningrum, D. A. Susanto, A. Achmadi, and M. Ayundyahrini, “Economic Benefits of Standard in SME Laundry Equipment Producer Using ISO Methodology,” AIP Conf. Proc., **vol. 2664**, no. November, (2022), doi: 10.1063/5.0108798.
23. Andi Fachruddin, “Evaluasi Penerapan Cara Produksi Pangan Yang Baik Untuk Industri Rumah Tangga (CPPB-IRT) Pada UMKM Mentari Bulan Malang,” J. Ilm. Mhs. FEB, **vol. 8**, no. 2, (2020).
24. A. D. Moelyaningrum, “Hazard analysis critical point (HACCP) pada produk tape singkong untuk meningkatkan keamanan pangan tradisional indonesia,” Indones. J. Heal. Sci., **vol. 3**, no. 1, pp. 41–49, (2012).