

HACCP system design and GMP/SSOP evaluation for meatball production: A case study at Bakso Solo Jatimulyo

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ABSTRACT

This study aimed to develop a Hazard Analysis and Critical Control Point (HACCP) plan for meatball production at UMKM Bakso Solo Jatimulyo to ensure food safety and quality compliance with SNI 01-4852-1998. The research involved a comprehensive evaluation of Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP) through document reviews, on-site audits, and employee interviews. The production process, which handles approximately 50 kg of beef daily, was mapped to identify biological, chemical, and physical hazards. Results indicated an 82% compliance rate for GMP and successful implementation across 13 GMP and 8 SSOP criteria. Hazard identification highlighted *Salmonella*, *E. coli*, and *Staphylococcus aureus* as primary risks. The cooking stage was determined to be the sole Critical Control Point (CCP), with established critical limits of $\geq 100^{\circ}\text{C}$ for at least 20 minutes. A practical framework was designed such as covering monitoring, corrective actions, and documentation that providing the facility with a tailored system to enhance product safety and minimize contamination risks.

Keywords: *critical control point; GMP; HACCP; meatball*

INTRODUCTION

Food safety is a fundamental prerequisite for quality (Sartika, 2020), ensuring products remain free from contaminants that cause illness. These hazards typically originate from poor sourcing, unhygienic processing, or improper storage Lestari (2020). For instance, chemical contaminants such as borax and formalin pose significant risks in the industry. Saputrayadi (2018) confirmed the presence of these substances in meatball snacks (bakso) sold in Mataram City using rapid test kits. To mitigate these hazards, comprehensive quality control measures must be implemented using the Hazard

Analysis and Critical Control Points (HACCP) system.

The HACCP implementation spans the entire production lifecycle, from raw material receipt to finished product storage Kristiningrum et al., (2023) in order to identify and control hazards that may affect food safety Awuchi (2023). The determination of Critical Control Points (CCPs) is a key step in the implementation of the HACCP principles within a food safety management system. CCPs is a stage in the production process at which effective control is essential to prevent, reduce, or eliminate a hazard. Once hazards are identified, CCPs are established at specific points in the process to ensure the



safety of the final product Mortimore & Wallace (2013).

In the implementation of HACCP, the application of Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP) is also required as prerequisite programs to ensure that production conditions meet hygiene and safety standards. GMP comprises a set of principles and procedures governing production, packaging, and storage processes to ensure that pharmaceutical and health-related products are manufactured consistently, safe for consumption, and compliant with established quality standards Commission (2022). Meanwhile, SSOP consist of a set of sanitation procedures and practices aimed at ensuring food hygiene and safety throughout the production process, including the sanitation of equipment and facilities, water quality control, handling of raw materials, employee hygiene and health, process monitoring and control, management of finished products, as well as systematic documentation and reporting of sanitation activities to ensure consistency in food safety implementation (Susanto et al., 2023).

Maharani & Rahayu (2017) previously analyzed bacterial contamination in beef meatball production in Sleman, Yogyakarta, identifying boiling, draining, and storage as critical control points (CCPs). While their work emphasized the necessity of monitoring cooking parameters, there remains a need for

practical HACCP frameworks tailored to the specific operational constraints of Micro, Small, and Medium Enterprises (MSMEs). Furthermore, this study addresses this gap by developing a HACCP plan for UMKM Bakso Solo Jatimulyo in South Lampung, based on SNI 01-4852-1998.

The objective of this study is to ensure compliance with Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP) while designing a streamlined system from raw material procurement to final storage that is feasible for MSME resources. By utilizing scale-appropriate verification and validation methods, this framework serves as a practical guide to ensure product quality and safety standardization in local meatball production.

METHODOLOGY

1. GMP, SSOP Evaluation and HACCP Development Procedure

The GMP evaluation was conducted by establishing an audit team, reviewing documents (SOPs, quality manuals, production records, and previous inspection reports), performing on-site audits of facilities, equipment, raw materials, and finished products, interviewing employees, and preparing an audit report. The SSOP evaluation included forming a team, reviewing SSOP documents, inspecting sanitation practices in production areas and equipment, interviewing employees regarding sanitation procedures, reviewing cleaning records, and compiling an evaluation

report. The next stage involved identifying HACCP system requirements through observation of raw materials, equipment, personnel, production process quality, and final products, followed by the development of a HACCP method for meatball products in accordance with the Commission (2022) guidelines.

The determination of CCPs in HACCP is a systematic process to identify critical points within the food production process that must be controlled to guarantee product safety and ensure food safety. The CCP determination flow is as follows. Mortimore & Wallace (2013).

a. Hazard Identification

The first step in the HACCP process is to identify potential hazards that can affect food safety. Initial identification is conducted based on findings from previous research and guidelines from the Codex Alimentarius Commission regarding the implementation of hazard identification in the HACCP system. These hazards can be physical, chemical, or biological.

b. Hazard Analysis

Once the hazards have been identified, the next step is to analyze each hazard. This analysis aims to determine the level of risk associated with those hazards. It involves evaluating the likelihood of occurrence and the severity of its impact on consumer health Commission (2022).

c. Identification of Control Points

At this stage, points throughout the production process that can be controlled are identified. Their function is to reduce or eliminate hazards. However, not all control points will become CCPs.

d. Determining Critical Control Points (CCPs)

CCPs are critical control points because control at these points is essential to prevent, eliminate, or reduce hazards to an acceptable level. The determination of CCPs typically employs logic-based decisions or tools such as the 'CCP decision tree Mortimore & Wallace (2013).

e. Establishing Critical Limits

Every CCP must establish critical limits that can be measured and monitored. These critical limits serve as clear criteria. A critical limit is the criterion that separates acceptable conditions from unacceptable Mortimore & Wallace (2013).

f. CCP Monitoring

Monitoring is the routine observation or measurement to ensure that a CCP remains within the established critical limits. Monitoring methods must be accurate and timely. This is to allow for immediate corrective action if a critical limit is exceeded Mortimore & Wallace (2013).

g. Corrective Actions

If monitoring indicates that a critical limit has been exceeded, corrective actions must be taken immediately. These actions aim to bring the process back into a controlled state.

Furthermore, this step is essential to prevent hazards from reaching consumers and to maintain product safety Mortimore & Wallace (2013).

h. Verification

Verification involves a checking process to ensure that the HACCP system is functioning effectively. This step may include internal audits to check for compliance with established procedures. Furthermore, verification can also involve product testing and document reviews to ensure that all standards are met Mortimore & Wallace (2013a).

i. Documentation and Record-Keeping

All procedures and records related to CCPs, monitoring, corrective actions, and verification must be well-documented to ensure a reliable audit trail Mortimore & Wallace (2013).

The implementation of the CCP Decision Tree is used to determine

whether a process step is classified as a CCP. This decision tree consists of several questions that must be answered systematically. Each question is directed toward every previously identified hazard Commission (2022). The CCP flow diagram can be seen in Figure 1.

2. Data Collection Methods

Field data collection methods utilize a checklist modified from the Regulation of the Head of the National Agency of Drug and Food Control (BPOM RI) No. HK.03.1.23.04.20.1749 of 2020 and BPOM RI No. HK.02.02.1.2.01.22.63 of 2022 ((BPOM), 2023). The identified aspects consist of 13 criteria for Good Manufacturing Practices (GMP) and 8 criteria for Sanitation Standard Operating Procedures (SSOP). A checkmark (ü) is placed on each corresponding statement, followed by calculating the total number of compliant and non-compliant criteria.

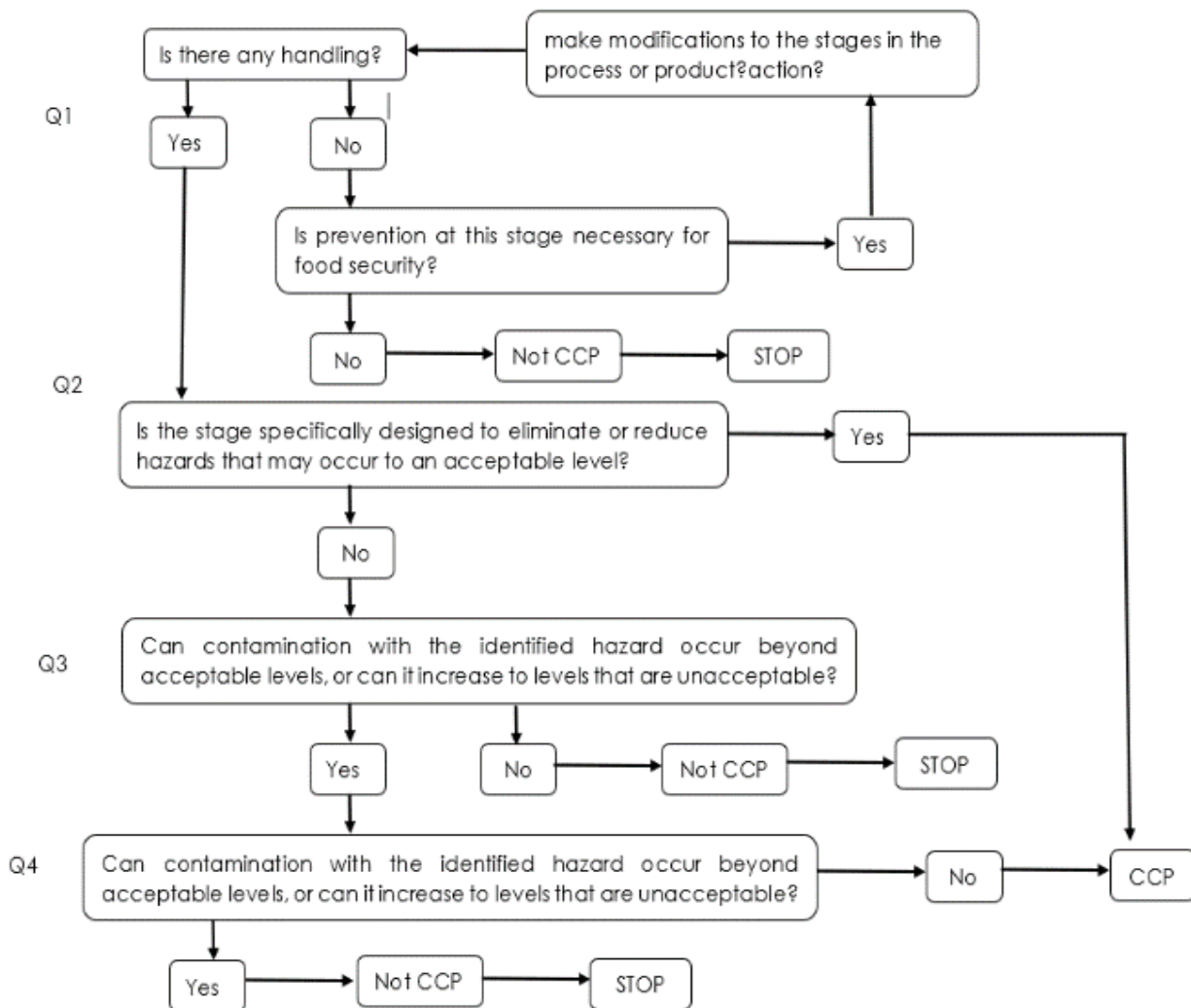


Figure 1. CCP decision tree diagram (SNI 01-4852-1998)

RESULTS AND DISCUSSION

We conducted field observations to characterize the manufacturing process, benchmarking against standard literature. Production initiates with off-site ingredient grinding and proceeds through distinct processing stages, as illustrated in Figure 2. The facility processes approximately 50 kg of

beef daily. Grinding occurs at a public facility in SMEP Market (Tamin Street, Kelapa Tiga Village, Tanjungkarang Pusat District), shown in. The formulation includes beef, tapioca flour, garlic, pepper, MSG, and salt. Following grinding, the facility receives the mixed dough in packaged units.

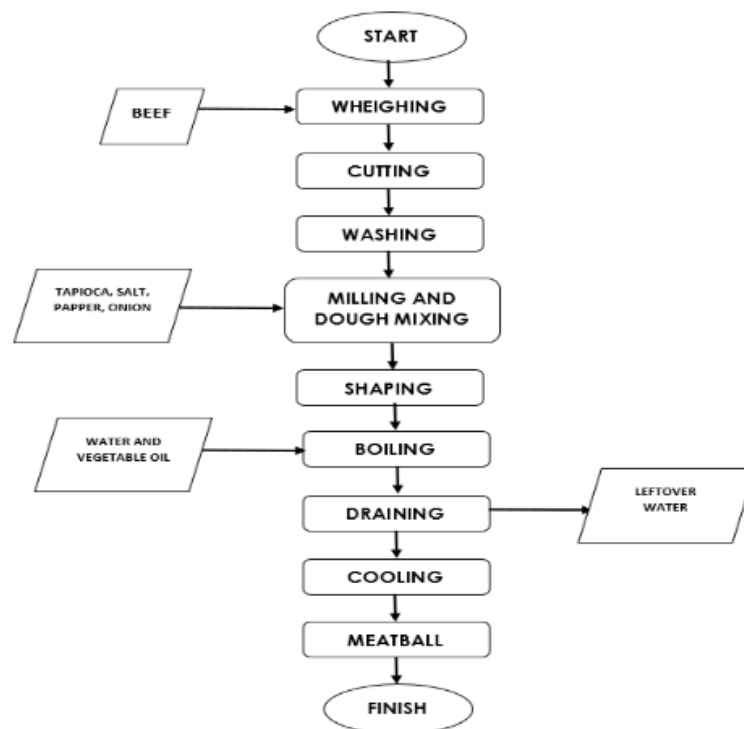


Figure 2. Flowchart of the meatball production process at UMKM Bakso Solo Jatimulyo

Upon receipt, the dough undergoes manual shaping prior to the heating stage. Operators transfer the mixture to a basin, molding it into spheres of varying dimensions. Subsequently, the formed meatballs are immersed in a water bath maintained at 30–40°C to facilitate setting.

This boiling phase ensures complete thermal processing and pathogen elimination. Post-boiling, operators drain the product using a woven bamboo tray (tampah or nyiru). Since water, fat, and carbohydrate levels dictate texture Anindyajati et al., (2022), efficient draining is critical for product quality.

This aligns with (Mariana et al., 2018), who stated that meatball production essentially consists of four stages: (1) meat grinding, (2)

mixing the meat batter, (3) shaping the meatballs, and (4) boiling.

1. Good Manufacturing Practices (GMP)

The implementation of GMP at MSME Bakso Solo Jatimulyo must be carried out in accordance with the Regulation of the Head of the National Agency of Drug and Food Control (BPOM RI) No. HK.03.1.23.04.20.1749 of 2020 concerning the Guidelines for Good Manufacturing Practices (GMP) for Processed Food. The assessment result for the GMP implementation at MSME Bakso Solo Jatimulyo is 82%. The GMP assessment results did not meet the required standard, as Indonesian regulations stipulate a minimum compliance threshold of $\geq 85\%$ for an implementation to be classified as acceptable in audits or evaluations, as regulated under the

Ministry of Industry Regulation No. 75/M-IND/PER/7/2010 on Good Manufacturing Practices for Processed Food.

Table 1 presents the audit calculation results of the GMP implementation at MSME Bakso Solo Jatimulyo. The GMP aspects implemented at UMKM Bakso Solo Jatimulyo include production location and environment, buildings and facilities, production equipment, water supply or water provision facilities, employee hygiene and sanitation facilities and activities, employee health and hygiene, maintenance and employee sanitation programs, storage, process control, food labeling, supervision by responsible personnel, product recall, documentation recording, and employee training.

The location and environmental aspect of UMKM Bakso Solo Jatimulyo showed a noncompliance rate of 25%. The business location, situated approximately 10 meters from the road, equipped with fencing, and surrounded by a concrete-paved road, helps reduce the potential entry of dust and contaminants into the production area. However, improvements are still needed for uncovered waste disposal facilities to enhance compliance with GMP requirements (Mawan, 2009).

Based on the audit results, production equipment showed a noncompliance rate of 28.5%. The noncompliance was related to the material requirements of production equipment, as surfaces in direct

contact with food had gaps and were easily absorbent. The equipment identified was a bamboo tray (nyiru); therefore, it is recommended to replace it with equipment made of stainless steel or other non absorbent materials.

Employee hygiene and sanitation facilities and activities showed a 16% non-conformity in the GMP audit at UMKM Bakso Solo Jatimulyo. The non-conformity was found in toilet facilities, where no warning sign instructs employees to wash their hands with soap after using the toilet. The recommended corrective action is to install handwashing reminder signs in the toilets.

The evaluation of GMP implementation in the health and hygiene aspect showed a 13% non-conformity. The issue was incomplete use of personal protective equipment (PPE) by employees, such as gloves, aprons, masks, and head covers. Improvements are required to prevent contamination risks, in accordance with Indonesian Ministry of Health Regulation No. 1098/MENKES/SK/VII/2003, which mandates full PPE for food production workers.

The evaluation of GMP implementation in maintenance and hygiene programs showed a 21% non-conformity. This was due to the absence of hygiene and sanitation records and uncovered drains, holes, and waste bins. The lack of records hinders monitoring and compliance, while open drains and holes increase contamination, disease vector, and safety risks, requiring proper closure

to prevent cross-contamination and accidents.

Storage protocols for both raw materials and finished products achieved full GMP compliance (0%

deviation). In contrast, process control evaluations revealed a minor non-compliance rate of 4%.

Table 1.
Audit calculation of GMP implementation at Bakso Solo Jatimulyo

No	Aspects of GMP	Average Score of GMP Aspects (%) (A)
1	Production location and environment	75%
2	Buildings and facilities	63%
3	Production equipment	71,5%
4	Water supply or water provision facilities	100%
5	Employee hygiene and sanitation facilities and activities	84%
6	Employee health and hygiene	87%
7	Maintenance and employee sanitation hygiene program	79%
8	Storage	100%
9	Process control	96%
10	Food labeling	100%
11	Supervision by the person in charge	100%
12	Product recall	75%
13	Documentation recording	40%
14	Employee training	50%
Total GMP Compliance		82%

2. Analysis of SSOP Implementation Conditions at MSME Bakso Solo Jatimulyo

Table 2 details the observed SSOP implementation deviations along with required immediate corrective actions. The assessment evaluates the eight standard key sanitation conditions. The results show that non-compliance still occurs in several of the eight categories. The eight categories in the SSOP system are water safety, cleanliness of food-contact surfaces, prevention of cross-contamination, sanitation facilities, protection of food from

contaminants, labeling, proper use and storage of toxic substances, employee health control, and pest prevention.

The evaluations of SSOP implementation for water safety showed a 50% compliance rate. Non-compliance was due to the use of water that did not meet drinking water standards and the absence of microbiological testing. Therefore, laboratory testing and water treatment are required to ensure drinking water quality, as production water must be equivalent to potable water standards.

Table 2.
Audit calculation of SSOP implementation at Bakso Solo Jatimulyo

No	Aspects of SSOP	Average Score of SSOP Aspects (%)
1	Water Safety	50%
2	Cleanliness of Food Contact Surfaces	33%
3	Sanitation Facilities	60%
4	Prevention of Cross-Contamination	33%
5	Protection of Food from Contaminants	67%
6	Proper Labeling, Use, and Storage of Toxic Materials	100%
7	Employee Health Control	0%
8	Pest Control	50%
Total Compliance with SSSOP Implementation		49,1%

Evaluations of food contact surface cleanliness revealed a 67% non-compliance rate. Susanto et al., (2023) note that surface contamination stems not only from equipment but also from personnel; behaviors such as smoking and excessive conversation act as indirect contaminant vectors. Mariana et al., (2018) the absence of contaminants in food requires the use of clean and well-maintained serving equipment.

The evaluation of SSOP implementation in cross contamination prevention showed a 40% non compliance rate, mainly due to the absence of dedicated production clothing and complete personal protective equipment (PPE) for employees. Therefore, providing uniforms, masks, head covers, aprons, and gloves is necessary to reduce the risk of cross contamination.

The implementation for sanitation facilities showed a 67% non-compliance rate. The main issues were the lack of proper changing facilities separating street and production clothing and the absence of a foot bath at the production entrance. Improvements include providing dedicated changing rooms

with separate lockers and installing disinfectant foot baths to prevent external contamination.

SSOP evaluation showed 33% non compliance in food protection due to uncovered trash bins and 100% non compliance in employee health control caused by the absence of medical check ups and health records, increasing the risk of food contamination from poor personal hygiene.

The implementation in pest prevention showed a 50% non compliance rate, caused by unmet pest control requirements. The non conformities included the absence of mesh screens on ventilation openings and the lack of air filters. Corrective actions include installing ventilation screens and using air filters to prevent pests from entering the production area.

3. HACCP System Planning

HACCP implementation initiates with the establishment of a multidisciplinary team. Comprising three key personnel, the committee includes the business owner (Leader), the production head (Secretary), and operational staff

(Table 3). Subsequently, we defined the product specifications (Step 2), detailing the name, formulation, processing methodology, and shelf life.

Table 3.
HACCP team membership at Bakso Solo Jatimulyo

No	Name	Position	Membership in the HACCP Team
1	Widodo	Business Owner	Chairperson
2	Sarmin	Production Manager	Secretary
3	Kamelia Zuchri Bukit	Consultant	Member

Preparing an HACCP plan requires a clear product description, as presented in Table 4. The product Bakso Solo Jatimulyo is categorized as beef meatballs, consisting of beef, water, tapioca flour, salt, pepper, and MSG. The meatballs are round, light brown, chewy, and savory, reflecting consistent product quality. The processing stages include raw material reception, meat grinding, ingredient mixing, forming, cooking, cooling, distribution, and storage, with cooking identified as a Critical Control Point (CCP) for microbiological hazard control. The product is packaged in PE plastic, using fresh, undamaged raw materials, and stored below -18°C to maintain safety and extend shelf life for 1–2 months. No special labeling is applied, while the product is ready-to-eat and can be further prepared by frying or as soup. These specifications comply with SNI 01-4852-1998, GMP, and HACCP principles, ensuring both food safety and product quality.

At UMKM Bakso Solo Jatimulyo, several raw materials pose

significant biological hazards due to potential cross contamination from employees and market sources, including pathogenic and spoilage microorganisms such as Salmonella, E. coli, Listeria monocytogenes, and Pseudomonas spp.

The decision tree diagram (Figure 1) is used to identify potential hazards at each stage of the production process and to determine whether a point meets the criteria to be classified as a Critical Control Point (CCP) Atambayeva et al., (2022). To determine Critical Control Points (CCPs), we assessed process stages requiring intervention to guarantee consumer safety. Hazard significance was evaluated based on the probability of occurrence versus severity. Consequently, the analysis identified the cooking stage as a significant hazard point due to the potential persistence of biological pathogens like Salmonella, E. coli, and Staphylococcus aureus Mariana et al., (2018). To control this hazard effectively, specific Critical Limits (CL) define the specific maximum or minimum

thresholds necessary to ensure hazard control. As detailed in Table 5, the Critical Limit for the cooking

CCP dictates a temperature of $\geq 100^{\circ}\text{C}$ (boiling point) sustained for a minimum of 20 minutes.

Table 4.
Product description of Bakso Solo Jatimulyo

Specification	Description
Product name	Bakso Solo Jatimulyo
Product type	Beef meatballs
Ingredients composition	Beef, water, Tapioca flour, salt, black pepper dan MSG
Product characteristic	Round, light brown in color, chewy and savory
Processing stages	The processing begins with the receipt of raw materials, meat grinding, addition of ingredients and mixing, meatball shaping, cooking, cooling, distribution and storage of the finished product
Primary packaging	Plastik PE
Raw material quality	Fresh undamaged
Storage temperature	Store below -18°C
Shelf life	1-2 months
Special labeling	No special labeling
Consumer preparation	Ready to eat meatballs that can be further processed, such as frying or cooking in soup

Among the entire production process, only one stage is designated as a Critical Control Point (CCP), namely cooking. This finding differs from the observation reported by Mariana et al., (2018), which identified meat reception, manual meatball formation, meatball separation, storage of cooked products, distribution, and serving to consumers as Critical Control Points. At these stages, the most dominant potential hazard is microbiological contamination. On the other hand, Atambayeva et al., (2022)'s study indicates that the "acceptance of raw materials" stage constitutes the most critical CCP, and that its control, particularly in small-scale meat processing enterprises, is capable of preventing various negative outcomes. This discrepancy arises from differences in conditions, situations, and cultural contexts.

The primary hazard identified in the meatball production process at the

company under study is the growth of pathogenic microorganisms resulting from improper handling and inadequate control throughout the production process. The microorganisms detected as contaminants in the meatball products include Salmonella, Enterohemorrhagic Escherichia coli, Listeria monocytogenes, Clostridium perfringens, and Staphylococcus aureus Mariana et al., (2018).

Table 6 presents the results of critical limit determination at UMKM Bakso Solo Jatimulyo. For the cooking process, the critical limits are a cooking temperature above 100°C (boiling) for a minimum of 20 minutes, along with the use of full personal protective equipment (PPE) during production and maintaining employee hygiene. For the packaging process, the critical limits are [the

same as stated, though the original text repeats the cooking limits—this may need clarification].

Table 5.
Determination of CCP

Process	Hazard	P1	P2	P3	P4	CCP/Non CCP
Boiling	Biology: <i>E. coli</i> dan <i>Staphylococcus aureus</i>	Y	Y	-	-	CCP
	Chemistry: -	-	-	-	-	-
	physic: -	-	-	-	-	-

Table 6.
Establishment of critical limits

Process	Hazard	Critical Limit
Boiling	Pathogenic microbes, insects, and hair	Using a cooking temperature exceeding 100°C (boiling) for a minimum of 20 minutes.

The monitoring of critical limits in Table 7 identifies the established critical limits to be observed. The purpose of monitoring these critical limits is to ensure that the production process remains safe,

prevent contamination from biological, chemical, and physical hazards, and detect and address any deviations in the production process before the products reach consumers.

Tabel 7.
Monitoring of critical limits


Critical Limit	Monitoring						
	What	Where	When	Who	Corrective Actions	Verification	Doc.
Cooking/Boiling: <i>Minimum time of 20 minutes and temperature exceeding 100°C.</i>	Meatball Boiling Process	At the meatball boiling process area	Every meatball boiling process	Meatball boiling area employees	Visually observe and ensure the meatballs are thoroughly cooked.	Inspected by the business owner and employees during every meatball boiling process.	

Table 8 presents the corrective actions that can be implemented. The cooking process is a key focus in meatball production, requiring a temperature above 100°C and a minimum cooking time of 20

minutes. Employee hygiene is also a critical element to ensure the production process remains free from contamination. Lesmana et al. (2024) state that employee hygiene is important because employees are

responsible for preventing contamination. According to Arfines et al., (2022), employee hygiene includes hygienic habits, personal and clothing cleanliness, and regular health checks.

Table 8.
Determination of corrective actions

No	Determination of Critical Limits	Monitoring of Critical Limits	Determination of Corrective Actions
1	SOP and GMP for Meatball Cooking/Boiling	a. Boiling water temperature exceeds 100°C b. Minimum boiling time of 20 minutes c. All meatballs float evenly	The business owner monitors the boiling process, ensuring the temperature exceeds 100°C using a thermometer, and follows the predetermined cooking time for each meatball size using a wall clock.
2	Complete Personal Protective Equipment (PPE)	a. Completely covering nose and mouth b. Washing hands with soap	All personal protective equipment (PPE) is complete and clean, including aprons, masks, gloves, and head coverings.
3	Personnel Hygiene	a. Washing hands with soap and clean water before entering the production area b. All personal protective equipment (PPE) is worn correctly, clean, and complete c. Physically healthy and showing no signs of illness	a. Accustoming handwashing at the start of each process b. Mandatory use of personal protective equipment (PPE) c. Inspecting the cleanliness of the PPE being used

CONCLUSION

Based on the evaluation results, the facility achieved a Good Manufacturing Practices (GMP) compliance score of 82%, in contrast to the considerably lower compliance with Sanitation Standard Operating Procedures (SSOP) reached only 49.1%. The study identified significant biological hazards, including pathogenic contamination from *Salmonella* spp., *Staphylococcus aureus*, *Listeria*, *Escherichia coli*, *Coliform* spp., and fungi. Additionally, physical hazards

include potential contamination by plastic fragments, hair, sand, wood splinters, and dust. Consequently, we developed a comprehensive HACCP plan encompassing CCP identification, critical limit establishment, monitoring protocols, corrective actions, and verification procedures. This framework is specifically tailored to the MSME's operational scale to enhance food safety standards. We recommend that operators rigorously monitor all production activities, with specific emphasis on the cooking stage as the primary Critical Control Point (CCP).

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