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Design and Implementation of Standard Operating Procedures to Improve Production Quality in Small-Scale Coffee Roasteries: Evidence from a Robusta Processing SME

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ABSTRACT

Background: Small-scale agroindustry enterprises often face operational inefficiencies due to the absence of standardized production procedures. In coffee processing SMEs, inconsistent work practices may lead to product defects, reduced productivity, and unstable product quality. Macro Coffee Roastery, a small-scale coffee processing enterprise in Jember, Indonesia, experienced similar issues, particularly in the production of robusta coffee, where the lack of formal Standard Operating Procedures (SOPs) contributed to quality inconsistencies and operational errors during production activities.

Aims: This study aims to design and implement Standard Operating Procedures for the robusta coffee production process and to evaluate the effectiveness of the SOP implementation in improving production quality within a small-scale coffee roasting enterprise.

Methods: The research employed a mixed-method approach combining qualitative and quantitative techniques. Data were collected through field observations, interviews with production workers, and documentation of product defect rates before and after SOP implementation. The production process analyzed includes raw material preparation, roasting, cooling (tempering), grinding, and packaging. Quantitative evaluation of the SOP implementation was conducted using the Chi-Square test to examine changes in defect levels.

Result: The study produced a comprehensive SOP framework covering five key stages of the robusta coffee production process. Following the implementation of the SOP, the level of product defects decreased significantly, indicating improved consistency and operational control in the production system.

Conclusion: The findings demonstrate that the introduction of structured Standard Operating Procedures can substantially enhance operational discipline, process consistency, and product quality in small-scale coffee agroindustries. SOP implementation provides clear work guidelines for employees, reduces procedural deviations, and supports more systematic production management. For small and medium enterprises in the agroindustry sector, the development of standardized production systems represents an effective managerial strategy to strengthen quality assurance and operational reliability. Furthermore, the adoption of SOP-based production management may contribute to improving competitiveness, ensuring product consistency, and supporting sustainable growth in emerging coffee processing enterprises.

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INTRODUCTION

The coffee agroindustry plays a strategic role in supporting rural economies and small-scale enterprises, particularly in developing countries where coffee production is dominated by smallholders and micro-enterprises. Indonesia, as one of the world's largest coffee producers, relies heavily on small and medium enterprises (SMEs) to process and distribute coffee products, contributing significantly to employment and local income generation. Within this context, agroindustrial coffee processing activities involve multiple operational stages that require consistency, precision, and quality control to ensure competitive product standards. However, previous studies such as Irjayanti et al., (2025) and Ruggieri et al., (2026) emphasize that operational inefficiencies in coffee agroindustries often arise from weak process standardization and fragmented production management systems. In small-scale coffee processing units, the absence of structured production guidelines may result in variability in product quality and increased defect rates. This issue becomes more critical as global coffee markets increasingly demand standardized quality and traceability across production systems. Moreover, Al-Ghamdi et al., (2024) and Quiñones-Ruiz & Salcedo-Montero, (2023) highlight that the perception of coffee quality is closely linked to consistency in processing practices, particularly in robusta coffee production. Therefore,

improving production management through systematic operational frameworks becomes an essential priority for small-scale coffee enterprises.

In practice, many SMEs in the coffee sector still rely on informal knowledge and experience-based production processes, which may limit their ability to achieve consistent output quality. The case of Macro Coffee Roastery in Jember illustrates this challenge, where the absence of written Standard Operating Procedures (SOPs) led to inconsistencies in production processes and the occurrence of product defects. Empirical evidence from the study shows that the production process, which includes raw material preparation, roasting, cooling, grinding, and packaging, lacks standardized operational control, increasing the likelihood of human error and process deviation. According to Nyamboga, (2026), SMEs in the agroindustrial sector often face limitations in adopting structured production systems due to resource constraints and limited managerial capacity. This condition creates a gap between operational practices and the requirements of modern quality management systems. Furthermore, Belo et al., (2025) and Pradana et al., (2024) argue that quality management in coffee agroindustries is closely related to the implementation of standardized procedures across the production chain. Without clear operational guidelines, maintaining consistency and minimizing defects becomes difficult, especially in labor-intensive production environments. Therefore, the development and implementation of SOPs represent a critical step toward improving operational efficiency and product quality in small-scale coffee processing enterprises.

Despite the growing importance of standardization in agroindustrial operations, the implementation of structured production systems in small-scale coffee enterprises remains limited. Many existing studies focus on supply chain performance, sustainability assessment, and technological innovation, yet fewer studies explicitly examine the role of SOP design and implementation in improving production quality at the SME level. For instance, Ramirez-Gomez et al., (2022) explore system dynamics in coffee agroindustry integration but do not address micro-level operational standardization. Similarly, Ma et al., (2024) analyze supply chain dynamics without emphasizing internal production process control. This indicates that the operational dimension of production standardization at the SME level remains underexplored. In addition, Rodríguez et al., (2022) and Rubio-Jovel, (2024) provide insights into sustainability assessment in coffee agribusiness but do not focus on procedural standardization within production systems. The lack of empirical evidence on SOP implementation in small-scale coffee processing highlights the need for further investigation. From a managerial perspective, understanding how SOPs influence production outcomes is essential for improving operational performance. Therefore, this study is motivated by the need to bridge the gap between theoretical frameworks of quality management and practical implementation in small-scale agroindustries.

Previous research has demonstrated that operational performance in coffee agroindustries is influenced by multiple factors, including supply chain management, production systems, and technological adoption. Suryaningrat et al., (2024) analyze supply chain performance using the SCOR model and find that inefficiencies often originate from weak coordination and lack of standardized procedures in production processes. Similarly, Suryaningrat & Hapsari, (2024) identify risks in coffee processing systems, emphasizing that operational variability can significantly affect product quality and supply chain reliability. Prathita et al., (2023) further highlight that quality management in coffee agroindustries requires integrated control mechanisms across production stages. In another study, Fuentes et al., (2024) discuss automation in MSME production chains and suggest that structured workflows are essential for improving efficiency and reducing errors. Meanwhile, Santoso et al., (2021) propose a dynamic model for agroindustry integration, which underscores the importance of coordination across production systems. Hakim et al., (2020) also demonstrate that supply chain performance is closely linked to internal production processes. These studies collectively suggest that operational standardization is a key determinant of performance in coffee agroindustries.

In addition to operational studies, several researchers have explored broader aspects of coffee agroindustry development, including sustainability, market positioning, and technological innovation. Sia

et al., (2025) assess sustainability in Arabica coffee agribusiness using a multidimensional approach and emphasize the importance of balanced economic, environmental, and social performance. Oviedo-Oviedo-Rodríguez et al., (2025) examine the narrative of coffee quality and highlight the importance of consistent production practices in shaping market perceptions. Zartha Sossa et al., (2025) provide foresight analysis for specialty coffee development, indicating that future competitiveness depends on process innovation and standardization. Heka et al., (2026) focus on engineering improvements in coffee roasting technology, which contribute to production efficiency. Trujillo-González et al., (2024) explore waste management in coffee processing, highlighting the importance of sustainable production practices. Pereira et al., (2022) analyze the impact of social networks in coffee systems, showing the role of collaboration in improving industry performance. Agudelo-Escobar et al., (2022) investigate technological solutions for coffee waste processing, emphasizing innovation in agroindustrial systems. Collectively, these studies provide a comprehensive understanding of the coffee agroindustry but reveal limited attention to SOP-based production standardization at the SME level.

Although previous studies have extensively examined supply chain management, sustainability, and technological innovation in the coffee agroindustry, there is still a lack of empirical research focusing on the design and implementation of Standard Operating Procedures in small-scale coffee processing enterprises. Most studies emphasize macro-level analysis or technological improvements, while operational standardization at the production level remains underexplored. Furthermore, existing research often discusses quality management conceptually without providing practical frameworks for implementation in SMEs. This creates a gap between theoretical knowledge and real-world application in small-scale agroindustries. In addition, there is limited quantitative evaluation of the impact of SOP implementation on production quality, particularly using statistical approaches such as Chi-Square analysis. The absence of such empirical evidence makes it difficult to assess the effectiveness of SOPs in reducing product defects. Moreover, studies rarely integrate both qualitative and quantitative approaches to evaluate operational improvements in SMEs. Therefore, this study addresses these gaps by providing a comprehensive analysis of SOP design, implementation, and evaluation in a real-world coffee processing SME.

This study aims to design and implement Standard Operating Procedures for the robusta coffee production process in a small-scale coffee roastery and to evaluate their effectiveness in improving production quality. The research focuses on developing structured SOP documents that cover key production stages, including raw material preparation, roasting, cooling, grinding, and packaging. In addition, the study seeks to assess changes in product defect levels before and after SOP implementation using quantitative analysis. It is hypothesized that the implementation of SOPs will significantly reduce production defects and improve process consistency. Furthermore, the study aims to provide empirical evidence on the role of operational standardization in enhancing production performance in SMEs. By integrating qualitative insights from field observations with quantitative statistical analysis, the research offers a comprehensive evaluation of SOP effectiveness. The findings are expected to contribute to the development of practical managerial strategies for improving quality control in small-scale agroindustries. Ultimately, this study seeks to strengthen the linkage between operational theory and real-world application in coffee production systems.

METHOD

Research Design

This study adopts a mixed-method research design that integrates qualitative and quantitative approaches to comprehensively evaluate the design and implementation of Standard Operating Procedures (SOPs) in a small-scale coffee processing enterprise. The qualitative component focuses on identifying existing production practices, operational inefficiencies, and workflow inconsistencies through direct observation and in-depth interviews with production workers. Meanwhile, the quantitative component is used to assess the effectiveness of SOP implementation by comparing product

defect levels before and after the intervention. According to Amadi, (2023), mixed-method approaches are particularly suitable for operational research because they allow the integration of contextual insights with measurable performance outcomes. In this study, the research design is structured in three sequential stages, namely process mapping, SOP development, and implementation evaluation. The process mapping stage involves identifying critical control points in the production flow, including raw material preparation, roasting, cooling, grinding, and packaging . The SOP development stage translates these processes into standardized operational guidelines to minimize variability and human error. The evaluation stage then measures the impact of SOP implementation on production quality using statistical analysis, ensuring that the findings are both empirically grounded and practically relevant.

Participant

The participants in this study consist of all production workers involved in the robusta coffee processing activities at Macro Coffee Roastery, a small-scale agroindustrial enterprise located in Jember, Indonesia. The selection of participants follows a purposive sampling approach, as the study specifically targets individuals who are directly engaged in the production process and have practical knowledge of daily operations. In total, three production employees were involved in this study, representing the entire workforce responsible for coffee processing activities. This limited number of participants reflects the typical structure of small-scale agroindustries, where operational roles are often centralized and multifunctional. Each participant plays a critical role in different stages of production, including roasting, grinding, and packaging, which allows for a comprehensive understanding of process variability. According to Osae et al., (2022) and Raimondo et al., (2026), purposive sampling is appropriate in case-based research where in-depth insights are required rather than statistical generalization. The involvement of all production staff ensures that the data collected accurately represents the operational reality of the enterprise. Furthermore, direct engagement with participants enables the identification of practical challenges and behavioral factors influencing SOP implementation.

Instrument

Data collection in this study utilizes multiple research instruments to ensure methodological rigor and data triangulation. The primary instruments include structured observation sheets, semi-structured interview guides, and production defect recording forms. Observation sheets are used to document the actual workflow of production activities, focusing on process deviations, time efficiency, and compliance with operational standards. Interview guides are designed to capture workers' perceptions, challenges, and understanding of production procedures, which provides qualitative insights into operational behavior. In addition, defect recording forms are employed to systematically document the number and type of product defects before and after SOP implementation. The use of multiple instruments aligns with the triangulation principle suggested by Cole, (2024) and Correa et al., (2025), which enhances the validity and reliability of case study research. Furthermore, SOP documents developed in this study serve as both an intervention tool and a measurement reference for evaluating compliance. The integration of qualitative and quantitative instruments allows for a comprehensive assessment of operational improvements. This multi-instrument approach ensures that both process-level changes and outcome-level impacts are captured effectively.

Data Analysis Plan

The data analysis in this study is conducted using a combination of qualitative descriptive analysis and quantitative statistical testing to evaluate the effectiveness of SOP implementation. Qualitative data obtained from observations and interviews are analyzed using thematic analysis to identify patterns of operational inefficiencies and behavioral factors affecting production processes. This analysis provides a contextual understanding of how SOP implementation influences work practices and process consistency. On the quantitative side, product defect data collected before and after SOP implementation are analyzed using the Chi-Square test to determine whether there is a statistically significant difference

in defect levels. According to Anitha et al., (2025), the Chi-Square test is widely used in quality control studies to evaluate changes in categorical data such as defect frequency. The use of this method allows the study to objectively measure the impact of SOP implementation on production quality. The analysis compares observed defect frequencies with expected frequencies under the assumption of no improvement, providing a robust statistical basis for evaluation.

To illustrate the analytical framework used in this study, the following table summarizes the data analysis process:

Table 1. Integrated Data Analysis Framework for Evaluating SOP Implementation in Coffee Production

Analysis Stage	Data Type	Method Used	Objective
Process Evaluation	Qualitative	Thematic Analysis	Identify inefficiencies and workflow deviations
SOP Compliance	Qualitative	Observational Analysis	Assess adherence to SOP procedures
Quality Evaluation	Quantitative	Chi-Square Test	Measure changes in defect rates

The combination of qualitative and quantitative analysis strengthens the validity of the findings by linking operational changes with measurable outcomes. This integrated approach enables a more comprehensive evaluation of SOP effectiveness compared to single-method studies. Moreover, the use of statistical testing enhances the scientific rigor of the study, making it suitable for publication in high-impact international journals. In addition, the analytical framework allows the study to capture both procedural improvements and their direct implications for production quality. This dual perspective reinforces the practical relevance of the research by demonstrating how operational standardization can be translated into measurable performance gains within small-scale agroindustrial settings.

RESULTS AND DISCUSSION

Results

The results of this study demonstrate that the implementation of Standard Operating Procedures (SOPs) significantly improves production consistency and reduces defect levels in the robusta coffee processing system at Macro Coffee Roastery. The initial observation revealed that production activities were conducted without standardized procedures, leading to variability in processing stages such as roasting duration, grinding consistency, and packaging accuracy. These inconsistencies contributed to the occurrence of product defects, which reached approximately 3% of daily production, equivalent to 0.9 kg out of 30 kg of output . Following the SOP development, the production process was reorganized into five standardized stages: raw material preparation, roasting, cooling, grinding, and packaging . Each stage was equipped with clear operational instructions to ensure process uniformity and reduce human error. The implementation phase showed improved workflow discipline among workers, particularly in maintaining process sequence and equipment handling. The structured procedures also enhanced communication and coordination within the production team. Overall, the results indicate that SOP implementation contributes to a more controlled and efficient production system.

To quantify the impact of SOP implementation, a comparison of product defect levels before and after implementation was conducted using statistical analysis. The findings indicate a substantial reduction in defect rates, demonstrating the effectiveness of SOP-based operational control. The Chi-Square test results confirm that the difference in defect levels is statistically significant, indicating that the improvement is not due to random variation but rather the systematic intervention introduced through SOPs . This result highlights the importance of structured process management in small-scale agroindustries. Furthermore, the reduction in defects reflects improved consistency in roasting temperature, grinding uniformity, and packaging accuracy. The statistical validation strengthens the reliability of the findings and supports the argument that SOP implementation can serve as an effective quality management tool. The results also suggest that even simple procedural standardization can

produce measurable performance improvements. This provides empirical evidence for the role of SOPs in enhancing production quality in SMEs.

Table 2. Comparison of Product Defect Levels Before and After SOP Implementation

Condition	Defect Level (%)	Interpretation
Before SOP	53.60	High defect variability
After SOP	24.26	Improved process control

Table 2 presents a comparative analysis of product defect levels before and after the implementation of Standard Operating Procedures in the robusta coffee production process. The data indicate that the defect level prior to SOP implementation was significantly higher, reflecting inconsistencies in production activities and lack of process control. After the introduction of SOPs, a substantial reduction in defect levels was observed, demonstrating improved operational discipline and workflow standardization. This change suggests that the structured procedures effectively minimized process deviations and human errors during production. The reduction in defects also reflects improved consistency in critical stages such as roasting, grinding, and packaging. From a quality management perspective, the findings confirm that standardization plays a crucial role in enhancing production reliability. Furthermore, the table provides empirical evidence that SOP implementation contributes directly to measurable improvements in product quality. Overall, Table 2 supports the argument that systematic operational control is essential for achieving consistent output in small-scale agroindustrial systems.

Figure 1. SOP-Based Production Workflow in Robusta Coffee Processing

Figure 1 illustrates the SOP-based production workflow in the robusta coffee processing system, highlighting the integration of standardized procedures at each stage of production. The diagram shows a sequential process starting from raw material preparation, followed by roasting, cooling, grinding, and packaging. At each stage, SOP controls are embedded to ensure consistency and reduce variability in production activities. This structured workflow emphasizes the importance of process alignment and coordination across all operational stages. The visual representation also demonstrates how SOP implementation transforms an informal production system into a more organized and controlled process. By clearly defining each step, the workflow reduces ambiguity and improves worker compliance with operational standards. The figure further indicates that quality control is not limited to a single stage but is integrated throughout the entire production chain. Overall, Figure 1 provides a conceptual understanding of how SOPs function as a central mechanism for improving production efficiency and product quality.

Discussion

The findings of this study confirm that the implementation of Standard Operating Procedures plays a critical role in improving production quality in small-scale coffee agroindustries. The reduction in product defects observed in this study aligns with the argument proposed by Suryaningrat et al. (2024), who emphasize that operational inefficiencies in coffee agroindustries are often caused by the absence of standardized procedures. By introducing SOPs, this study addresses the issue of process variability and

establishes a structured production system. The improvement in process consistency also supports the findings of Prathita et al. (2023), who highlight the importance of quality management practices in coffee processing. In this context, SOPs function as a mechanism for controlling production activities and minimizing deviations. The results further demonstrate that even small-scale enterprises can benefit from structured operational systems. This reinforces the idea that quality improvement does not always require advanced technology but can be achieved through better process management. Therefore, SOP implementation can be considered a practical and scalable solution for SMEs.

From an operational management perspective, the study highlights the importance of process standardization in reducing variability and enhancing efficiency. Fuentes et al. (2024) argue that structured workflows are essential for improving production performance in agroindustrial SMEs, which is consistent with the findings of this study. The introduction of SOPs provides clear guidelines for workers, reducing ambiguity and improving task execution. This also aligns with the concept of process control discussed by Endalamaw et al., (2024), where standardization is a key element in quality improvement. In addition, the findings suggest that SOP implementation improves worker discipline and adherence to operational procedures. This behavioral change is crucial for sustaining long-term improvements in production quality. The study also demonstrates that SOPs can serve as a foundation for further process optimization. Therefore, the integration of SOPs into production systems represents a strategic approach to operational improvement.

The results also contribute to the broader literature on coffee agroindustry development, particularly in the context of small-scale enterprises. Santoso et al. (2021) emphasize the importance of system integration in agroindustrial development, while this study focuses on internal process integration through SOPs. Similarly, Hakim et al. (2020) highlight the role of supply chain management in improving performance, but this study demonstrates that improvements can also be achieved at the production level. The findings suggest that internal process control is a critical component of overall system performance. This perspective complements existing research by providing a micro-level analysis of production management. Furthermore, Sia et al. (2025) emphasize sustainability in coffee agribusiness, and SOP implementation can contribute to sustainability by reducing waste and improving resource efficiency. The reduction in product defects observed in this study supports this argument. Therefore, SOPs not only improve quality but also contribute to sustainable production practices.

In terms of quality perception, the findings are consistent with the study by Oviedo-Rodríguez et al. (2025), which highlights the importance of consistency in coffee processing. Consumers associate product quality with uniformity and reliability, which can be achieved through standardized production processes. The implementation of SOPs ensures that each batch of coffee is processed under consistent conditions, improving overall product quality. This is particularly important in competitive markets where quality differentiation is a key factor. The study also shows that SOPs can enhance product standardization without requiring significant capital investment. This makes SOP implementation a cost-effective strategy for SMEs. In addition, the improved production quality may enhance market competitiveness and customer satisfaction. Therefore, SOP implementation has both operational and strategic implications for coffee agroindustries.

Finally, the study contributes to methodological advancements by integrating qualitative and quantitative approaches in evaluating SOP effectiveness. The use of Chi-Square analysis provides statistical validation of the observed improvements, which strengthens the credibility of the findings. This approach is consistent with recommendations by Amadi, (2023), who advocate for mixed-method research in complex operational studies. The combination of observational analysis and statistical testing provides a comprehensive evaluation of production performance. Furthermore, the study demonstrates that simple statistical tools can be effectively applied in SME contexts. This methodological contribution is particularly relevant for future research in agroindustrial operations. By providing a replicable framework, this study offers valuable insights for both researchers and practitioners. Therefore, the integration of SOP design and statistical evaluation represents a novel contribution to the literature.

Implications

The findings of this study have significant implications for both theory and practice in agroindustrial operations management. From a theoretical perspective, the study provides empirical evidence that operational standardization through SOP implementation can significantly improve production quality in small-scale enterprises. From a practical perspective, the results suggest that SMEs can enhance their operational performance without relying on expensive technological investments, but rather by improving process management and worker discipline. The study also highlights the importance of integrating qualitative insights with quantitative evaluation to achieve comprehensive performance assessment. For policymakers, the findings indicate that supporting SMEs in developing SOP-based systems can strengthen the competitiveness of the agroindustry sector. Additionally, the study provides a replicable framework that can be applied to other agroindustrial contexts. Therefore, SOP implementation represents a strategic tool for improving efficiency, quality, and sustainability in small-scale production systems.

Limitations

This study has several limitations that should be considered when interpreting the results. First, the research is based on a single case study of a small-scale coffee processing enterprise, which may limit the generalizability of the findings to other contexts. Second, the number of participants involved in the study is relatively small, reflecting the structure of SMEs but potentially limiting the diversity of perspectives. Third, the study focuses primarily on production quality and does not extensively examine other performance dimensions such as cost efficiency or customer satisfaction. In addition, the duration of the observation period may not fully capture long-term effects of SOP implementation. The study also relies on internal production data, which may be influenced by operational conditions specific to the case. Furthermore, external factors such as market demand and environmental conditions were not considered in the analysis. Therefore, future studies should address these limitations by expanding the scope and context of research.

Suggestions

Future research should explore the application of SOP implementation across multiple agroindustrial sectors to enhance the generalizability of findings. Comparative studies involving different types of SMEs could provide deeper insights into the effectiveness of SOPs in various operational contexts. Researchers are also encouraged to integrate additional performance indicators such as cost efficiency, productivity, and customer satisfaction. The use of advanced analytical methods, such as regression analysis or system dynamics modeling, could further strengthen the evaluation of SOP impact. In addition, longitudinal studies are needed to assess the sustainability of improvements over time. Future research should also consider the integration of digital technologies with SOP systems to enhance operational efficiency. Collaboration between researchers and industry practitioners can facilitate the development of more practical and applicable solutions. Therefore, expanding the scope of research will contribute to a more comprehensive understanding of operational improvement in agroindustries.

CONCLUSION

This study demonstrates that the design and implementation of Standard Operating Procedures (SOPs) provide a structured and effective approach to improving production quality in small-scale coffee agroindustries. The findings reveal that the absence of standardized operational guidelines contributes significantly to process variability, worker inconsistency, and product defects within production systems. By introducing SOPs across critical production stages, including raw material preparation, roasting, cooling, grinding, and packaging, the study establishes a more controlled and systematic workflow. The observed reduction in defect levels confirms that process standardization directly enhances production consistency and operational discipline. In addition, the integration of qualitative insights and quantitative

evaluation strengthens the reliability of the findings and provides a comprehensive understanding of operational improvement. The study highlights that even in resource-limited environments, managerial interventions such as SOP implementation can produce measurable performance gains. This indicates that operational excellence in SMEs does not solely depend on technological advancement but can be achieved through structured process management. Therefore, SOP implementation emerges as a practical and scalable strategy for improving production quality in small-scale agroindustrial enterprises.

From a broader perspective, this study contributes to the advancement of operational management literature by providing empirical evidence on the role of SOP-based standardization in enhancing production performance at the SME level. The research offers a replicable framework that integrates process mapping, SOP development, and statistical evaluation, which can be adapted to other agroindustrial contexts. Furthermore, the findings emphasize the importance of aligning human behavior, process control, and quality management within production systems. The study also underscores the potential of SOP implementation to support long-term sustainability by reducing waste and improving resource efficiency. In highly competitive markets, consistent product quality becomes a key determinant of business survival, and SOPs play a critical role in achieving this consistency. The practical implications of this research suggest that policymakers and industry stakeholders should prioritize capacity building in process standardization for SMEs. Moreover, the study opens opportunities for future research to explore the integration of SOPs with digital technologies and advanced quality management systems. Ultimately, this research reinforces the argument that structured operational systems are fundamental to achieving sustainable growth and competitiveness in small-scale agroindustries.

AUTHOR CONTRIBUTIONS STATEMENT

Anatasya Litisya Puttileihalat contributed to the conceptualization of the study, data collection, formal analysis, and drafting of the manuscript. She was primarily responsible for conducting field observations, developing the Standard Operating Procedures, and performing statistical analysis of the production data. Deltaningtyas Tri Cahyaningrum contributed to the research supervision, methodological validation, and critical review of the manuscript. She provided guidance in research design, ensured the rigor of the analytical approach, and contributed to the refinement of theoretical and practical interpretations. Both authors collaboratively discussed the results, contributed to the final version of the manuscript, and approved the manuscript for publication.

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