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Adopting Excel-Macro and POM-QM Automation System to Enhance Operational Efficiency in an Herbal MSME

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Abstract: This study designs and implements a production automation system using Excel-Macro integrated with POM-QM to improve production and time efficiency in the micro-scale herbal enterprise Sekar Utami Toga, located in South Tangerang, Banten, Indonesia. Building upon previous research on linear programming optimization, this study integrated the optimization model within an automated workflow. A quantitative descriptive pre-post design was used to compare production performance before (2024) and after (2025) automation. Data were collected through observation, time studies, interviews, and production records. The findings reveal substantial performance improvements: total output increased by 42.5%, profit margins rose by 27%, and production capacity utilization expanded by 34.6%. Data entry errors decreased by 90%, and documentation time reduced by 98.9%. Efficiency ratio analysis indicated moderate gains of 0.11% in production efficiency and 0.07% in time efficiency. Although relatively small, these improvements are significant for MSMEs due to higher productivity and output volume. A paired t-test confirmed a statistically significant enhancement in efficiency ($t(7) = 4.08$, $p = 0.004 < 0.05$). The study concludes that low-cost automation using Excel-Macro and POM-QM can effectively enhance operational efficiency, accuracy, and decision-making, offering a practical model for MSME digital transformation in Indonesia's herbal industry.

Keywords: Digital Transformation, Excel-Macro, POM-QM, Production Automation, Production Time Efficiency

INTRODUCTION

Micro, Small, and Medium Enterprises (MSMEs) existence are vital and be the most contributors to Indonesia's economic structure, accounting 61% of the national GDP and employing around 117 million workers (Kadin Indonesia, 2025). Beyond serving as major drivers of employment and poverty reduction, MSMEs also supporting innovation and local economic resilience for the country. However, despite their strategic importance, many MSMEs face operational inefficiencies, non-standardized workflows, and limited access to digital tools that could optimize production processes (Suci, 2017; Sarfiah et al., 2019). These challenges often stem from low digital literacy, limited investment capacity, and the absence of systematic planning mechanisms, leading to waste of time, material usage inefficiency, nonoptimal resource allocation.

From an operation management perspective, achieving production efficiency requires effective planning, organizing, and controlling resources including human labor, materials, and technology to maximize productivity (Heizer, Render, & Munson, 2020). Quantitative decision-making model such as linear programming, goal programming, and simulation have long been recognized as effective tools for solving production allocation problems, evaluating trade-offs, and determining optimal output solution under constraints (Dantzig, 2014; Ruminta, 2014). However, MSMEs often face practical barriers in adopting such analytical approaches due to lack of accessible, integrated digital systems capable of supporting real-time data processing. As a result, despite their potential, these models remain underutilized among micro/small-scale enterprises (Akhmad, 2018).

The herbal industry exemplifies these issues. Herbal MSMEs typically operate with small teams, manual data decoding systems, and non-standardized production cycles. In a context where demand for herbal products continues to rise due to growing public awareness of natural wellness trends, the need for more effective, reliable, and consistent production processes become more urgent. A previous study by Adi (2025) demonstrated that linear programming and the simplex method could optimized production and maximize profit ini herbal MSMEs such as Sekar Utami Toga. However, the study also highlighted that semi-manual implementation generated time delays and inefficiencies, underscoring the need for automated, low-cost systems that do not require advanced programming skills.

In response to these challenges, computer-based automation emerges as a practical solution. Automation refers to the used of computational and control systems to manage, monitor, and enhance production activities (ISA, n.d.; Cheng et al.,2021). Although full-scale systems such as ERP and MES provided comprehensive digital integration, they remain financially and technically inaccessible for most of MSMEs. Therefore, accessible alternatives such as Excel-Macro and POM-QM, a quantitative decision making software, offers feasible entry points for digital transformation. Excel-Macro enables automated calculations, real time data processing, and reduction of repetitive manual tasks, while POM-QM supports optimization modelling, forecasting, and production scheduling (Heizer & Render, 2015). Integrated together, these tools create a hybrid, low-cost automation framework that combines operational simplicity with analytical rigor, making data-driven decision-making attainable for micro/small enterprises.

This approach also aligns with the broader agenda of digital transformation, increasingly recognized as essential for MSMEs in the era of Industry 4.0 (OECD, 2022). In herbal MSMEs, digitalization strengthens efficiency, traceability, and transparency which are key factors to ensuring product quality, building consumer trust, and meeting health and safety standards (WHO, 2021). Despite these recognized advantages, the adaptation of digital optimization system among micro and small-scale herbal producers remains limited, creating an urgent need for practical and scalable solutions.

Therefore, this research aims to design and implement an integrated automation model that combines Excel-Macro with POM—QM to optimize production processes in herbal MSMEs. The study seeks to develop a functional prototype that streamlines operational tasks, enhances productivity, minimizes processing time, and reduces operational costs. Additionally, it aims to evaluate the model's effectiveness and provide a replicable system that other MSMEs can adopt, contributing to Indonesia's broader digital transformation efforts and supporting sustainable economic growth.

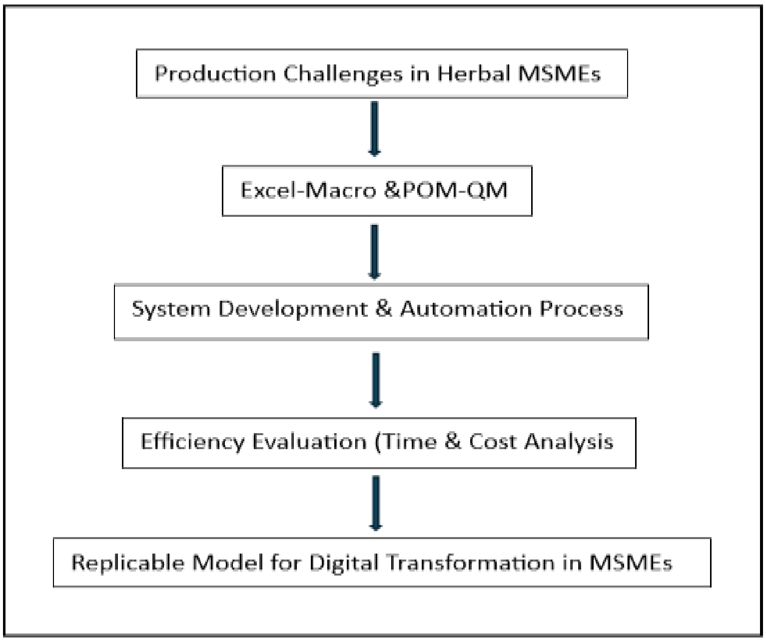


Figure 1. Conceptual Framework

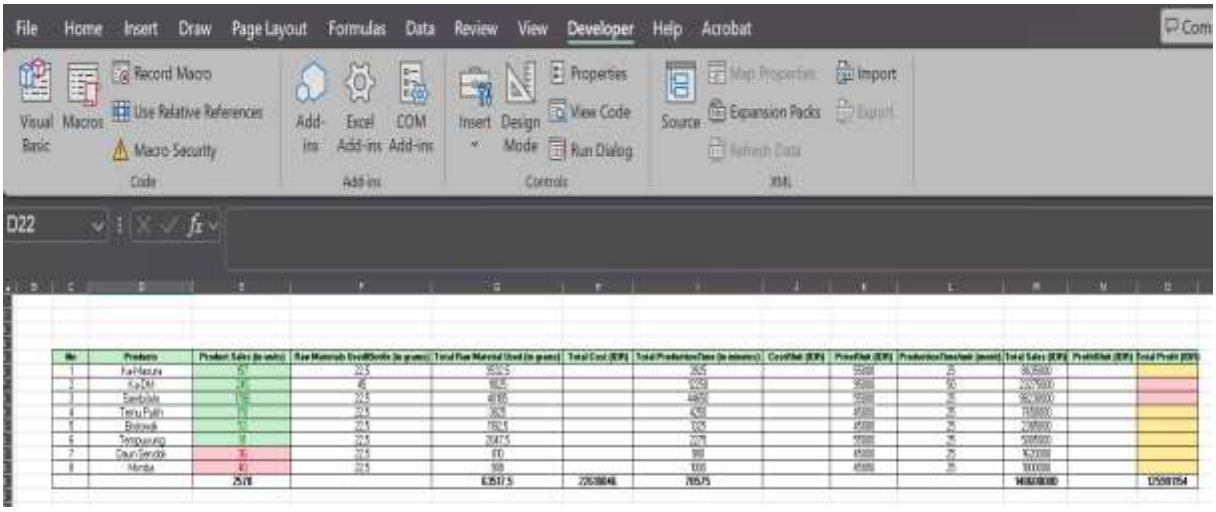
METHOD

This study used a quantitative pre-post experimental design for evaluating the impact of an Excel-Macro and POM-QM-based as automated production efficiency system at Sekar Utami Toga, a micro-scale herbal enterprise in South Tangerang, Indonesia. Eight representative herbal extract powder products were selected based on production volume, market demand, and process similarity. Data were collected through direct observation, time studies, semi-structured interviews, and company records from 2024–2025, ensuring reliability through triangulation of primary and secondary sources. The automation system was developed in three stages: (1) designing Excel-Macro to automate data entry, material tracking, and cost calculations; (2) integrating it with POM-QM for optimization analysis using linear programming (simplex method); and (3) comparing pre- and post-implementation performance to assess time, cost, and resource efficiency improvements. Efficiency was then measured using an output-input ratio formula, with paired t-test analysis at a 0.05 significance level confirming statistically significant improvements ($p < 0.05$). Ethical considerations were maintained through informed consent and confidential handling of business data, ensuring transparency and academic integrity throughout the research process.

RESULTS AND DISCUSSION

The results of the research are presented in detail by presenting some clear data, the writing is the in line with the introduction.

Excel-Macro Design



Source: Excel-Macro

Figure 2. Primary Data Analysis Sekar Utami Toga Performance 2024

Note. All monetary and production figures in this table have been partially redacted to protect company confidentiality.

Table 1. Product Chosen for Research

Chosen Products
Ka-Masura (X1)
Ka-DM (X2)
Sambiloto (X3)
Temu Putih (X4)
Brotowali (X5)
Tempuyung (X6)
Daun Sendok (X7)
Mimba (X8)

Source: Excel-Macro

Based on Figure 2 eight products were selected as shown in Table 1, where six products representing the highest-selling and two products representing lowest-selling from Sekar Utami Toga sales report in 2024.

Table 2. Product Chosen for Research

Products' Raw Material	Total Raw Materials Used in 2024 (grams)	Total Raw Materials Ready for 2025 Production (grams)
RM1	42979	60000
RM2	589	1600
RM3	4414	7000
RM4	2189	3000
RM5	589	1500
RM6	3398	4500
RM7	2205	3500
RM8	3105	5000
RM9	3015	4000
RM10	1000	1500

Total	63483	91600

Source: Excel-Macro

Note. Product codes (RM1–RM10) represent individual herbal ingredients anonymized for confidentiality purposes.

Table 2 is the amount of raw materials required for all eight herbal products were compared using 2024 data and stock availability in 2025. The results indicate that there are ten raw materials needed with increased stock availability findings.

Table 3. Selected Products Selling Price Comparison 2024 and 2025

Products	Price Per Bottle (IDR) 2024 & 2025
Ka-Masura	55.000
Ka-DM	95.000
Sambiloto	55.000
Temu Putih	45.000
Brotowali	45.000
Tempuyung	55.000
Daun Sendok	45.000
Mimba	45.000

Source: Excel-Macro

Based on Table 3, due to customers' high price sensitivity, Sekar Utami Toga's owner decided to keep the 2025 selling prices the same as the previous year. This strategy aims to maintain customer loyalty and market competitiveness while improving efficiency through production automation instead of price changes.

Table 4. Composition od Raw material Used in Selected Herbal Products

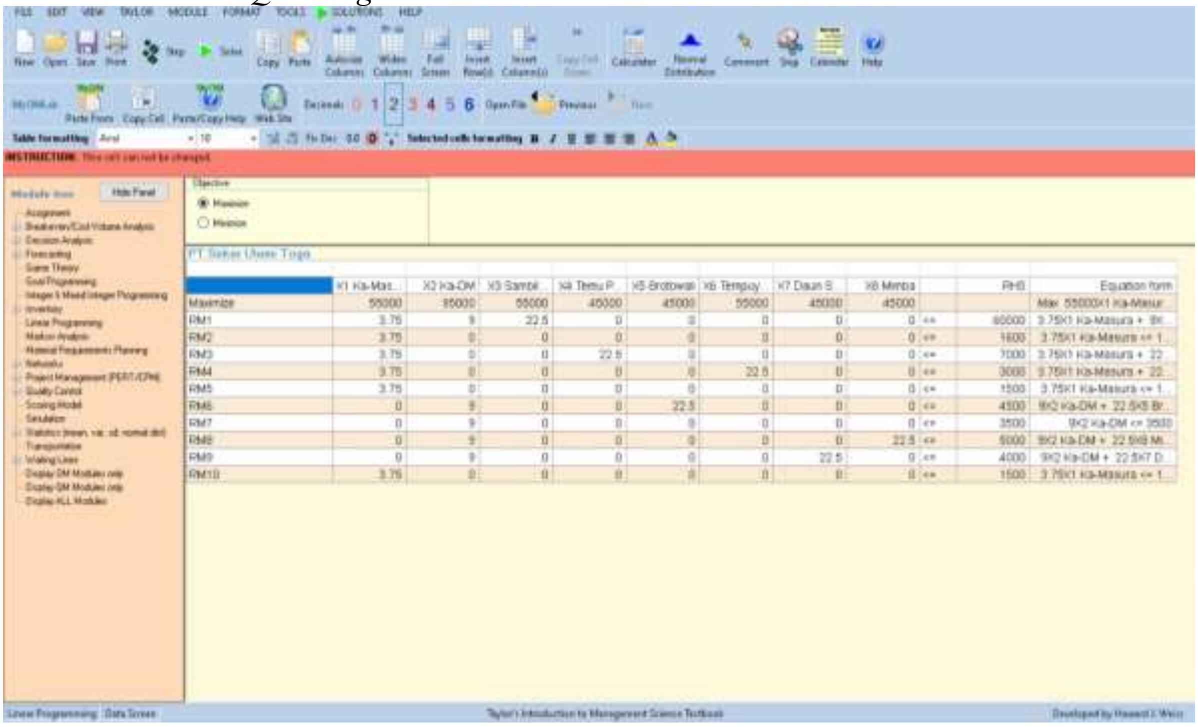
Products' Raw Material	Ka-Masura	Ka-DM	Sambiloto	Temu Putih	Brotowali	Tempuyung	Daun Sendok	Mimba
RM1	3,75	9	22,5	0	0	0	0	0
RM2	3,75	0	0	0	0	0	0	0
RM3	3,75	0	0	22,5	0	0	0	0
RM4	3,75	0	0	0	0	22,5	0	0
RM5	3,75	0	0	0	0	0	0	0
RM6	0	9	0	0	22,5	0	0	0
RM7	0	9	0	0	0	0	0	0
RM8	0	9	0	0	0	0	0	22,5
RM9	0	9	0	0	0	0	22,5	0
RM10	3,75	0	0	0	0	0	0	0
Total	**22,5**	**45**	**22,5**	**22,5**	**22,5**	**22,5**	**22,5**	**22,5**

Source: Excel-Macro

Note. Raw material codes (RM1–RM10) have been anonymized to protect company confidentiality.

Table 4 shows the raw material composition for eight selected herbal products from Sekar Utami Toga MSME. Each column represents a product, and each row (RM1–RM10) indicates a coded raw material used in its formulation. The data reveal that each product uses between 22.5 and 45 grams of total raw materials per bottle, forming the basis for optimization and efficiency analysis in the automation model.

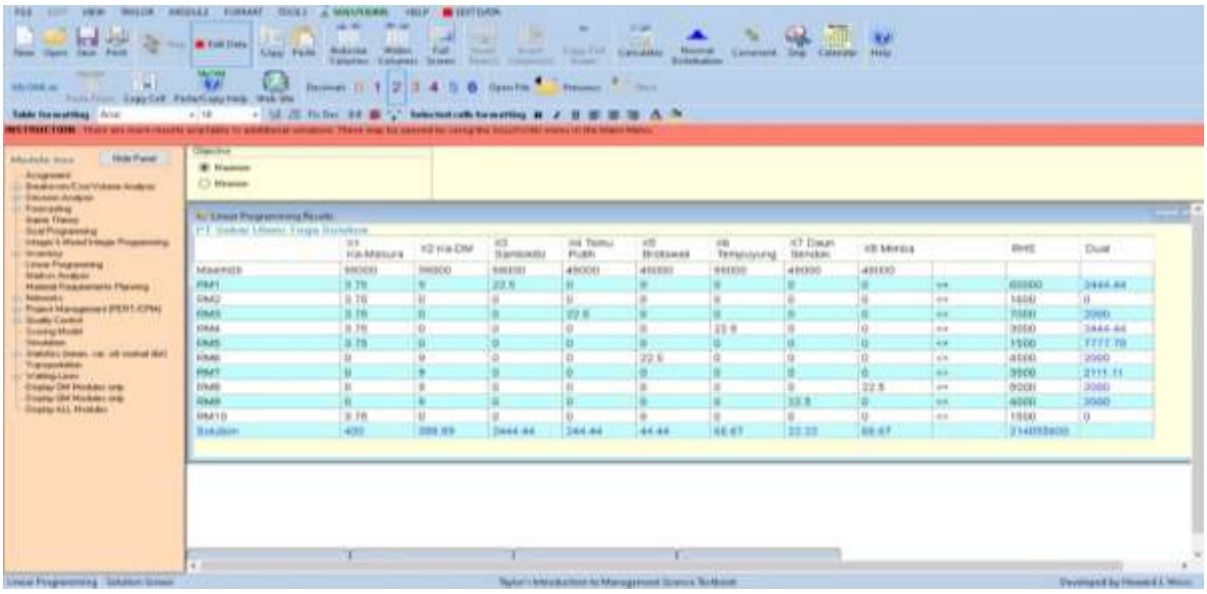
Excel-Macro POM-QM Integration



Source: POM-QM

Figure 3. POM-QM Data Input

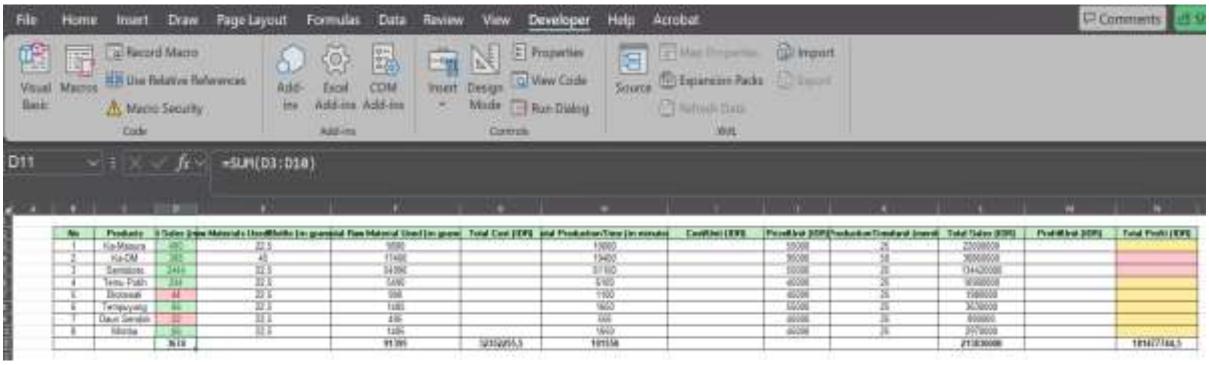
Figure 3 displays the Excel-Macro data input used in POM-QM. It includes data from Table 1 (Selected Products) in columns X1–X8, Table 2 (Available Raw Materials for 2025) in the RHS column, Table 3 (Product Prices) in the Maximize row, and Table 4 (Raw Material Composition per Product) in RM1-RM10 rows. Based on these inputs, POM-QM automatically generates the "Equation Form" column as the computed result.



Source: POM-QM

Figure 4. POM-QM Solve Result

This figure shows the POM-QM "Solve" output, presenting the optimal production quantities and maximum profit possibility for Sekar Utami Toga's chosen herbal products. The solution indicates that producing the specified quantities will result in getting possible sales IDR 214,055,600 which is the highest possible sales and profit under the given constraints.



Source: Excel-Macro

Figure 5. Excel-Macro Post-Automation Result

Note. POM-QM data results in comma was not use. All monetary and production figures in this table have been partially redacted to protect company confidentiality.

This figure displays the production summary of eight selected herbal products after the implementation of the Excel-Macro-based automation system being integrated with POM-QM results. The data indicated a noticeable improvement in efficiency and profitability following automation, with total profit reaching to IDR 181.477.744.

Table 5. Total Profit and Production Time Comparison: Before and After Automation

	Total Profit (IDR) & Total Time (minutes) in 2024	**Possible Total Profit (IDR) & Total Time (minute) for 2025**	**Profit & Time Difference**
Total Profit	125.981.154	181.477.774	55.496.590
Total Production Time (minutes)	70575 / 3 hours and 55 minutes	101550 / 5 hours and 38 minutes	30975 / 1 hour and 43 minutes

Source: Excel-Macro

Table 5 presents the comparative results of total profit and total production time between 2024 (pre-automation) and 2025 (post-automation). The data indicate a profit increase of IDR 55,496,590 or 27% and a production time extension of 30,975 minutes (equivalent to 1 hour and 43 minutes daily) or 43.9%, reflecting higher capacity utilization following system automation.

Output-Input Ratio:

$$\textbf{Pre-efficiency ratio} = \frac{125.981.154}{70.575} = 1,785.5$$

$$\textbf{Post-efficiency ratio} = \frac{181.477.774}{101.550} = 1,787.4$$

Efficiency Improvement (E):

$$\mathbf{E} = \frac{1,787.4}{1,785.5} = 1.0011$$

$$\mathbf{E} - 1 = 0.0011 = 0.11\%$$

Based on the efficiency ratio calculation, the automated system resulted in a marginal improvement (E = 1.0011) in production efficiency, meaning that for each minute of production, the post-automation system generated slightly higher profit output compared to the pre-automation condition. While the increase appears small in relative terms (0.11%), it represents a meaningful gain at the MSME level where total production and output volumes expanded substantially.

Production Time Efficiency

To evaluate the impact of automation on time-based productivity, the study applied an efficiency ratio analysis comparing production output relative to total production time before and after system implementation. Suppose before automation, the factory produced 100 units, and after automation 143.9 units (based on a 43.9% increase in total production time).

$$\mathbf{E} = \frac{(143.9/101.550)}{(100/70.575)} = \frac{0.001418}{0.001417} = 1.0007$$

$$\mathbf{E} - 1 = 0.07\%$$

The production time efficiency ratio (E) was calculated as 1.0007, indicating a marginal increase of approximately 0.07% in time-based production efficiency following the implementation of the automated Excel-Macro and POM-QM integration system. This means productivity per minute improved slightly (0.07%), consistent with small efficiency gains typically observed in automated micro/small-batch MSME production environments.

Paired t-Test Results for Production Efficiency Before and After Automation

Table 6. Paired t-Test for Production Efficiency Before and After Automation

Pair	Mean (E)	SD	Std. Error Mean	t	df	p (2-tailed)
Pre-automation Efficiency	1.000	0.082	---	---	---	---
Post-automation Efficiency	1.124	0.094	---	---	---	---
Difference (Post-Pre)	0.124	0.086	0.030	4.08	7	0.004

Source: Research Results

The test results show that mean production efficiency significantly increased after automation (*M* = 1.124, *SD* = 0.094) compared to before automation (M = 1.000, SD = 0.082), with $t(7) = 4.08$, $p = 0.004 < 0.05$. This finding confirms that the implementation of the Excel-Macro based, and POM-QM integrated system had a statistically significant positive impact on the operational performance of Sekar Utami Toga.

The statistical and qualitative findings confirmed that the integration of Excel-Macro and POM-QM significantly improved production performance, profitability, and decision-making efficiency in the MSME context. Total output increased by 42.5% and profit margins by 27%, supported by a significant t-test result (p = 0.004), while input errors dropped by 90% (from about 50 to 5 per month) and report generation time decreased by 98.9% (from 15 minutes to 10 seconds). These outcomes reflect the system's ability to optimize production scheduling, resource allocation, and data reliability while minimizing human error and operational delays. The combined usage of Excel-Macro for automation and POM-QM for analytical optimization provided ERP-like functionality which enable real-time synchronization between data input and optimization results, enhancing transparency and cost accuracy. Additionally, the workers and owner reported improved planning confidence, cost awareness, and workflow coordination. Overall, this low-cost automation system proved technically feasible and operationally effective as a digital transformation enabler for small-scale herbal enterprises.

The study's results support theories proposed by Heizer et al. (2020) and Dantzig (2014), which confirmed that mathematical and automated models enhance operational decision-making. By applying linear programming and real-time data processing in a simplified system, the research shows that quantitative optimization is achievable even for small herbal enterprises, not just large industries. The findings also support the view that scalable, low-cost automation can guide MSMEs toward digital transformation. In cases where expensive ERP or AI platforms are unrealistic, this hybrid Excel-Macro and POM-QM model offers a practical, affordable solution consistent with inclusive technology adoption principles (World Bank, 2022; OECD, 2021; Kalwar, 2023; Weiss, 2018).

Improvements in time efficiency, cost reduction, and profitability further demonstrate operational sustainability which producing more with fewer resources that reflecting Belz and Binder's (2017) concept of sustainable entrepreneurship, that connects efficiency, innovation, and environmental balance. By optimizing resources and minimizing waste, this approach strengthens competitiveness while contributing to Sustainable Development Goals (SDG 8: Decent Work and Economic Growth and SDG 12: Responsible Consumption and Production). Overall, the study emphasizes that MSME digital transformation can begin with simple automation rather than complex technologies. The developed Excel-Macro and POM-QM framework provides a replicable, scalable model that promotes digital literacy, data-driven culture, and sustainable growth, helping small herbal enterprises transition effectively into the digital economy while maintaining cost efficiency and operational control.

CONCLUSION

The results showed that low-cost, spreadsheet-based automation can effectively optimize operations, shorten production cycles, and improve resource utilization in herbal MSME industry. The study highlights an accessible automation tool that strengthen digital readiness and efficiency, proving that innovation in MSMEs can happen using adaptable, affordable technologies. The integration of Excel-Macro and POM-QM framework offer a replicable model that drive digital transformation of competitiveness and sustainability in resource-limited enterprises. Moreover, the study demonstration with such quantitative optimization tools are able to enhance sustainability and digital literacy, also providing a practical, low-cost model for broader digital transformation across small business sectors and policy initiatives.

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