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A FRAMEWORK FOR WASTE REDUCTION IN HONEY SUPPLY CHAIN

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Abstract

Honey is a key raw material in the traditional medicine industry, processed through a supply chain that involves various stakeholders, such as suppliers, producers, and distributors. However, the management of the honey supply chain faces several challenges, particularly related to waste, including overproduction, excess inventory of raw materials, and defective products. This study aims to develop a framework for reducing waste in the honey supply chain using a Seven Wastes approach to identify problems, conduct root cause analysis through a fishbone diagram, and map the roles and classifications of stakeholders in implementing solutions. The results indicate that waste is caused by various factors, and the roles of stakeholders are classified based on supply chain drivers. This classification includes the management of machine capacity and maintenance at facilities, the implementation of Economic Order Quantity (EOQ), Just-in-Time (JIT), safety stock systems, as well as improvements in raw material quality in inventory management and procurement, and information classification using a forecasting system based on historical data. The implementation of these solutions is expected to optimize supply chain management and reduce waste.

Keywords: *Supply Chain Management; Waste Reduction; Stakeholder Management; Framework Supply Chain*

1. Introduction

Indonesia, with its tropical climate, is endowed with abundant natural resources, including a wide range of forest products. Among these, honey stands out as a non-timber forest product (NTFP) with significant potential for development. According to the Central Statistics Agency, (Badan Pusat Statistik, 2022) honey production in Indonesia reached 220,062.82 liters. Honey is widely used in the food, pharmaceutical, and cosmetics industries, and has long been valued in various cultures as a traditional remedy due to its natural properties. Rich in active compounds such as antioxidants and antibacterials, honey is increasingly recognized as a key ingredient in the production of high-quality traditional medicines, (Abdullah et al., 2023).

One of the businesses in the traditional medicine manufacturing sector located in Bantul Regency, Special Region of Yogyakarta, utilizes honey as its main raw material. This business manufactures supplements intended for children. The process of transforming honey into the final product involves a series of stages integrated within the supply chain system. A supply chain refers to a series of interconnected activities and relationships between companies that govern the flow of goods, money, and information. Generally, goods flow from upstream to downstream, money flows in the opposite direction, and information can flow in multiple directions (Punjawa, 2017; Mentzer et al., 2001). In the honey supply chain, the entities involved include honey raw material suppliers in the upstream, manufacturing businesses that process the raw materials into finished products in the middle, and distributors who deliver the finished products to consumers downstream, as shown in **Figure 1.**

The honey supply chain presents unique waste-related challenges due to its perishable nature and reliance on traditional processing techniques. These aspects lead to supply variability, quality inconsistencies, and a higher risk of product loss. Furthermore, fluctuating consumer demand, shaped by cultural and medicinal preferences, adds complexity to inventory control and production planning. These distinct characteristics highlight the need for a waste management approach tailored specifically to the honey supply chain context.

Effective supply chain management faces significant challenges, particularly in minimizing total costs while maintaining optimal service levels throughout the system. This challenge is evident in the waste issues that arise at various stages of the honey supply chain. At the raw material procurement stage, waste manifests as excessive raw material inventory,

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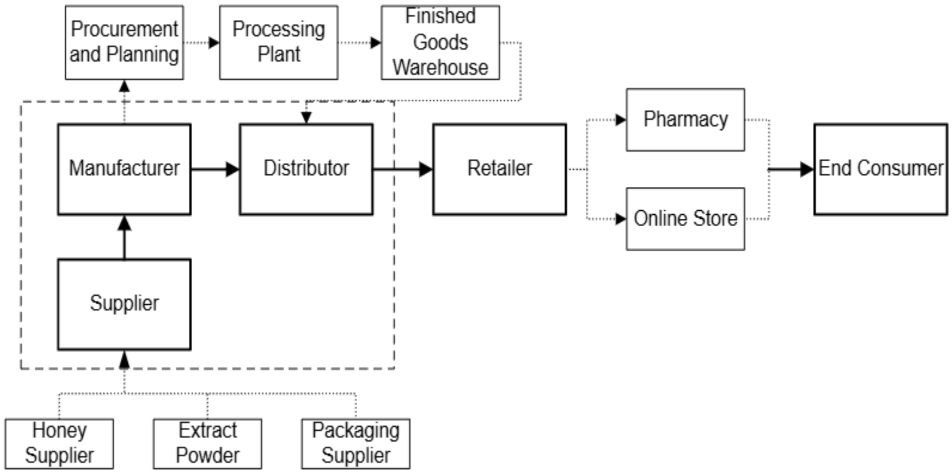

Figure 1. Honey Supply Chain

resulting from ordering more materials than needed, thereby increasing inventory costs.

At the production planning and distribution stages, involving distributors, Sales & Operations Planning (S&OP), and Production Planning and Inventory Control (PPIC), waste occurs when production exceeds sales capacity or market demand. This leads to the accumulation of unsold stock, increased inventory costs, and decreased overall production efficiency. Additionally, waste arises from products that fail to meet quality standards or are damaged during production or shipment.

The waste that occurs can impact the performance of the supply chain and the overall company. Previous studies have developed various supply chain governance frameworks to reduce waste. (Bandyopadhyay & Kim, 2022) developed a supply chain coordination framework emphasizing the importance of long-term relationships between producers and suppliers, which can build trust, flexibility, and reduce the risk of waste caused by supply uncertainties. (Balouei Jamkhaneh & Safaei Ghadikolaei, 2022) developed a process maturity measurement framework for service supply chains using the PDCA (Plan, Do, Check, Act) cycle, which aids in evaluating operational efficiency and identifying areas for improvement. (Almutairi et al., 2020) presented a framework for implementing Lean principles, focusing on the reduction of non-value-adding activities. Additionally, (Hou & Zhao, 2020) developed a risk identification framework in supply chains using a systemic approach, which facilitates risk management contributing to waste. (Mueller et al., 2023) developed the Gleaning Innovation Framework, which emphasizes product innovation to reduce waste and develop new products from waste materials. In other sectors, Guerreiro et al. (2022) developed a two-phase framework for evaluating waste-based bioenergy projects, integrating algorithmic analysis and multi-criteria methods (AHP, TOPSIS) to optimize biomass assessment, site selection, and operational efficiency. (Kesuma et al., 2019) developed a framework for analyzing traffic congestion risks caused by heavy vehicles. This study developed a framework to understand non-recurrent (NRC) congestion, which is dynamic and unpredictable, including the identification and measurement of risks, root cause analysis, and stakeholder role analysis.

Various frameworks have been developed to reduce waste in supply chain management, focusing on coordination, process efficiency, Lean principles, and risk management. However, most of these frameworks are designed for general or large-scale supply chains and do not adequately consider the specific characteristics of the honey supply chain. Honey's perishability, fluctuating market demand, and widespread traditional processing practices present unique challenges that limit the effectiveness of these general frameworks when applied to the honey sector.

Moreover, previous studies tend to focus on process improvement tools without adopting a holistic approach that involves stakeholder engagement, root cause analysis, and practical implementation tailored to the specific context of honey. The literature on honey supply chains lacks integrated frameworks that combine waste classification, fishbone diagram-based root cause analysis, and stakeholder role mapping according to supply chain drivers. This study aims to fill this gap by developing an integrated framework that combines the Seven Wastes approach, fishbone diagram analysis, and stakeholder classification. The findings are expected to provide meaningful contributions to the effective and practical management of honey supply chains for both academics and industry practitioners.

2. Methods

This research on the honey supply chain was conducted on a business entity located in Bantul Regency, Special Region of Yogyakarta, which operates in processing honey into traditional medicinal products. The products include dietary supplements for children, available in various formulations. The supply chain involves several interconnected stakeholders, from upstream to downstream, including raw honey suppliers, manufacturers responsible for processing the honey into final products, and distributors who deliver the products to consumers through retail networks. Each stage in this supply chain is interdependent and contributes to the overall efficiency of the system.

This study employed both primary and secondary data (Sulung & Mohamad Muspawi, 2024). Primary data were collected directly by the researcher through observations and interviews with managerial-level personnel and coordinators across the supply chain, including distributors, S&OP managers, PPIC coordinators, production team leaders, procurement heads, and raw material suppliers. The interviews aimed to explore the causes of waste and assess the roles and contributions of each stakeholder in enhancing supply chain efficiency. Secondary data were obtained from internal company documents, such as production reports, inventory data, and defective product records, which were utilized to identify key sources of waste in the honey supply chain, namely overproduction, excess inventory, and defective products. Overproduction was defined as production exceeding actual demand, excess inventory as stock levels surpassing optimal usage capacity, and defective products were primarily associated with labeling issues during packaging. The selection of managerial respondents ensured the validity and accuracy of the information collected.

The data collected in this study were used to identify and analyze waste, as well as to develop a supply chain governance framework aimed at reducing such waste. This study adapted the framework developed (Kesuma et al., 2019), which was originally used to analyze non-recurrent congestion (NRC) risks, which are dynamic and unpredictable. In the context of this research, the approach was modified to focus on waste reduction within the honey supply chain, consisting of several stages: (1) waste identification, (2) root cause analysis, (3) stakeholder roles in the activities carried out, and (4) stakeholder classification for the proposed solutions.

Waste identification was conducted using the Seven Wastes approach in Lean Manufacturing, which includes overproduction, defective products, excessive inventory, unnecessary movement, waiting time, improper processing, and excessive transportation (Febianti et al., 2023). This Seven Wastes approach was applied at each stage of the supply chain to identify waste and improve efficiency by eliminating non-value-added activities (Rahmalia Putri et al., 2024; Ravizar & Rosihin, 2018). Once waste was identified, the next step involved root cause analysis using the fishbone diagram (Ishikawa). This tool was employed to examine the underlying factors contributing to the previously identified waste, enabling the development of targeted solutions. Additionally, an analysis of stakeholder roles and classifications was conducted to facilitate the effective implementation of these solutions aimed at waste reduction.

3. Result & Discussion

3.1 Identification of Waste

The seven waste approach in lean manufacturing is applied in this study to map the waste present in each activity across the supply chain, including entities and actors involved such as suppliers, manufacturers, and distributors. In the production planning phase, particularly between Sales & Operations Planning (S&OP), PPIC, and distributors, waste in the form of overproduction is identified, where production exceeds the market or distributor's absorption capacity. Based on the data, the average planned production reaches 205,237 units per month, while actual demand is only 151,902 units per month, resulting in an overproduction of 53,335 units per month, equivalent to approximately 26%. This overproduction constitutes part of inventory waste, as the company produces more than required, leading to significant costs and the accumulation of unsold stock (Nurwulan et al., 2021).

In the raw material procurement phase, which involves both suppliers and manufacturers, waste is identified due to the ordering and storage of raw materials exceeding actual needs. For instance, the average inventory of raw honey as the primary raw material is 70,835 kg per month, whereas the actual average usage is 55,414 kg per month, indicating an excess inventory of 15,421 kg per month or about 21.8% above actual requirements. This is classified as inventory waste, resulting in the accumulation of raw materials that are not immediately used in the production process. Additionally, in the distribution phase, where finished products are delivered from the manufacturer to the distributor, waste is identified in the form of defects, including products that do not meet quality standards during production or are damaged during the shipping process. During the observation period, a total of 5,950 defective units were recorded.

3.2 Root Cause Analysis

Root cause analysis is conducted using the fishbone diagram to investigate the problems previously identified. The following is the root cause analysis for overproduction, excessive inventory, and defective products.

a. Producing More Than Required (Overproduction)

Overproduction occurs due to an imbalance between demand and production capacity. This leads the company to produce more goods than required by the market or consumers, resulting in waste. As shown in **Figure 2**, the fishbone diagram illustrates the root causes of overproduction.

Based on the Fishbone diagram above, overproduction is caused by several interrelated factors. In the method factor, the primary issue arises from reliance on manual forecasting methods that are unresponsive to market demand changes, leading to overproduction. In the human factor, the lack of understanding in utilizing data and performing accurate analyses in production planning serves as the root cause. The machine factor indicates that the existing system is not optimized to monitor machine usage efficiently. The root cause in the material factor is the inaccurate procurement of raw materials. In the environmental factor, the issue stems from the inflexibility of production to respond to fluctuations in market demand. Finally, in the measurement factor, the root cause is the system's inability to update demand data in real-time, which leads to a mismatch between production capacity and market needs.

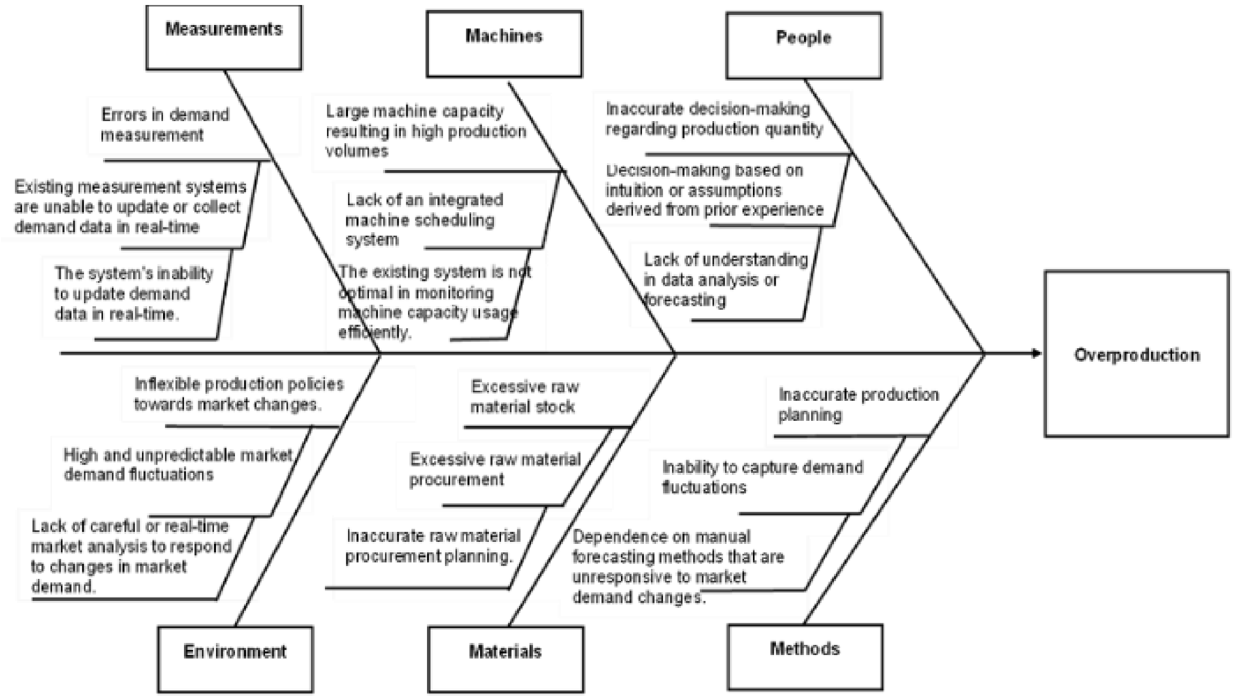

Figure 2. Fishbone of Overproduction

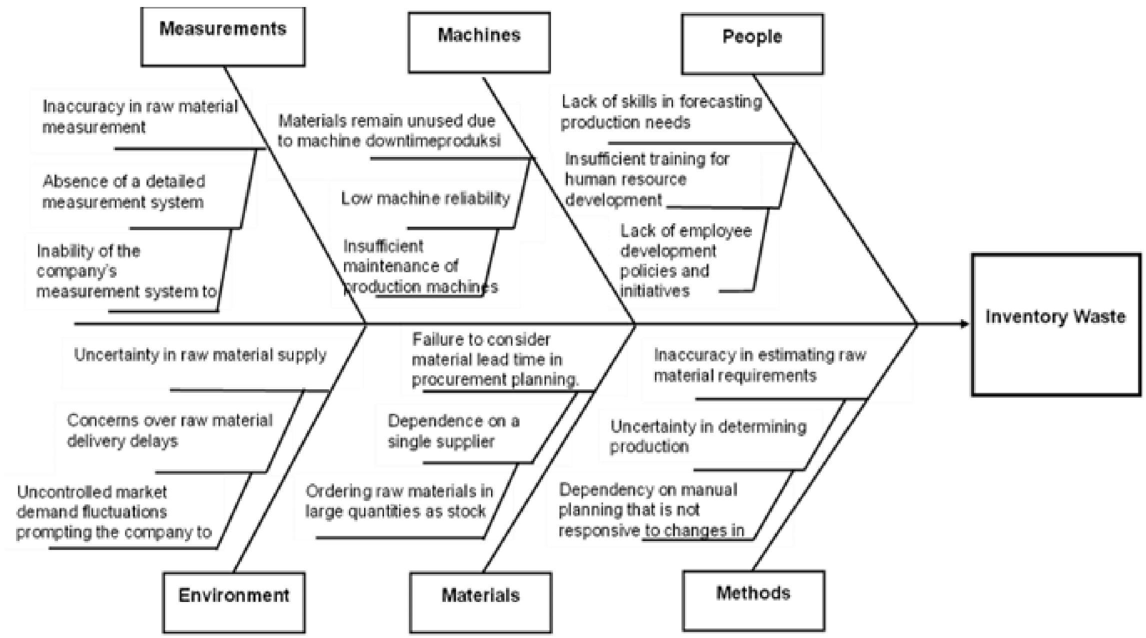

Fig. 3 Fishbone of Inventory Waste

b. Inventory Waste

This inefficiency arises from the ordering and storage of raw materials in quantities that exceed actual demand, leading to increased storage costs and the risk of material deterioration over time (Pradana & Jakaria, 2020). The fishbone diagram illustrating the contributing factors to inventory waste is presented in **Figure 3**.

Based on the analysis of excessive raw material storage using the fishbone diagram, the main problem is caused by various factors, such as methods, people, machines, materials, measurements, and the environment. In the method factor, the root cause is the company's reliance on manual planning, which is unresponsive to changes in raw material demand, resulting in inaccurate forecasting of required raw material quantities. In the people factor, the root cause is the lack of adequate skills and training in raw material planning, leading to inaccurate estimates and excessive ordering of raw materials. In the machine factor, the problem stems from inadequate maintenance of production machinery, causing delays in raw material usage and inefficient stock accumulation. In the material factor, the root cause is the dependency on a single supplier, forcing the company to order larger quantities of raw materials than necessary. The environment factor is driven by uncontrolled market demand fluctuations, prompting the company to order

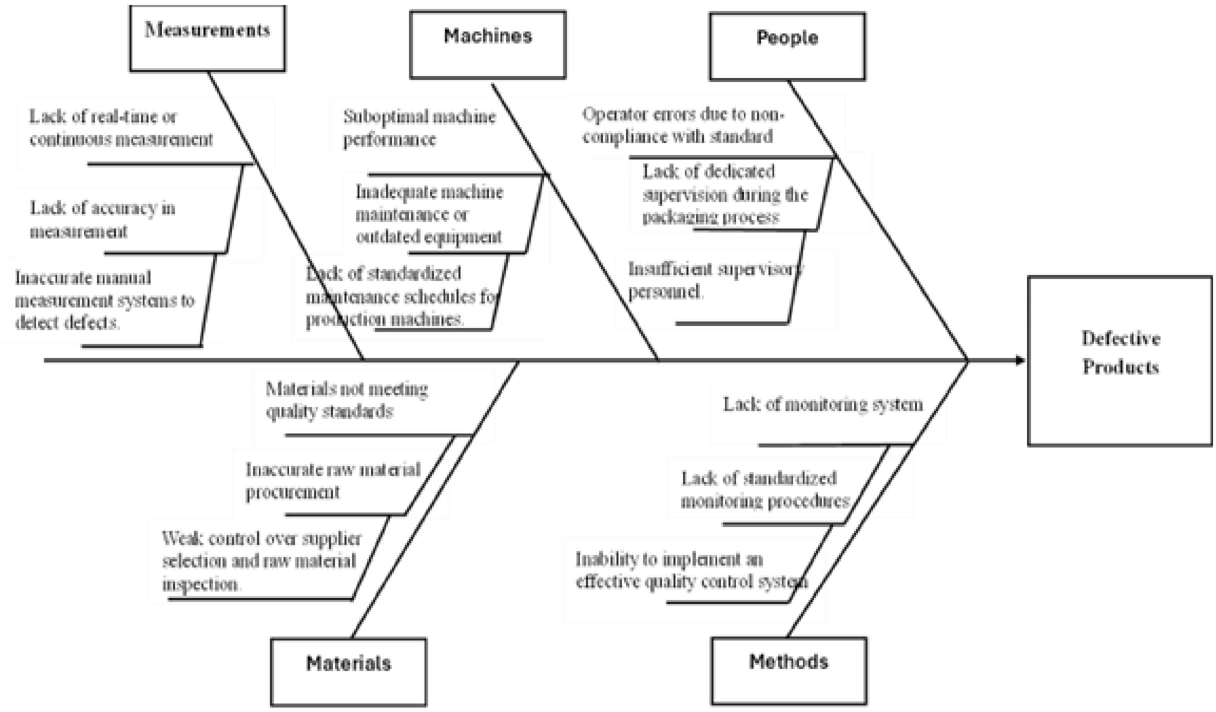

Figure 4. Fishbone of Defective Products

more raw materials than needed as a form of anticipation against market uncertainty. Finally, the measurement factor's root cause lies in the company's inability to provide accurate, real-time data on raw material needs, resulting in over-ordering and stockpiling that does not align with actual demand.

c. Products That Do Not Meet Quality Standards (Defective)

Defective products represent a form of waste resulting from failures to meet quality standards during the production process. This includes issues such as improper label placement, inadequate sealing of packaging, and other errors that compromise the quality of the product packaging, as well as damage occurring during shipment. The fishbone diagram depicting the factors contributing to defective products is presented in **Figure 4.**

Based on the root cause analysis using the fishbone diagram, defective products are caused by several interrelated factors. In the method factor, the primary issue is the company's inability to implement a standardized quality control system, resulting in ineffective monitoring and the production of defective products. The people factor is driven by the insufficient number of quality control personnel during the production process, which affects product quality. In the machine factor, the absence of a standardized maintenance schedule leads to suboptimal machine performance, causing a decline in product quality. The material factor is due to weak control in supplier selection and raw material inspection, which worsens product quality. Finally, the measurement factor stems from the use of an inaccurate manual measurement system for detecting defects.

3.3 Role of Stakeholders

Based on the analysis of the root causes that have been identified, several factors contribute to the occurrence of overproduction, excessive raw material storage, and defective products. These factors involve the roles of various stakeholders in each activity within the supply chain flow.

a. Producing More Than Required (Overproduction)

Overproduction is driven by several factors involving the roles of various stakeholders, as outlined in **Table 1**. The root cause in the method factor involves the role of the Distributor, who places orders and distributes products, S&OP, which forecasts product demand, and PPIC, which plans and coordinates the production process. Similarly, in the people factor, S&OP is responsible for forecasting demand or receiving orders from the distributor, after which PPIC plans production and manages raw material requirements.

In the machine factor, the root cause involves the role of the production team, who use machines to carry out the production process according to the quantities provided by PPIC. For the material factor, the root cause involves PPIC planning raw material requirements based on forecasts, after which the procurement department orders raw materials, and suppliers deliver the orders.

In the environment factor, the root cause involves the roles of S&OP and PPIC. S&OP adjusts the forecast to market conditions, while PPIC adjusts production plans based on market analysis and distributor demand. Similarly, in the measurement factor, S&OP and PPIC evaluate demand and production data to adjust production policies and planning.

Table 1. The Role of Stakeholders in Overproduction

Factor	Root Cause	Stakeholders	Activity Relationship	Stakeholder Roles
Method (F1)	Dependence on manual forecasting methods that are unresponsive to market demand changes.	Distributor, S&OP, and PPIC	The distributor places product orders, or S&OP forecasts product demand, and then PPIC receives targets and coordinates the production process based on these forecasts.	The distributor orders and distributes products, S&OP is responsible for forecasting product demand, PPIC plans and coordinates the production process.
People (F2)	Lack of understanding in utilizing data and proper analysis in production planning.	Distributor, S&OP, and PPIC	The distributor places product orders, or S&OP forecasts demand, and then PPIC plans production and raw material requirements.	S&OP is responsible for forecasting demand or receiving orders from distributors, PPIC plans production and manages raw material needs.
Machine (F3)	The existing system is not optimal in monitoring machine capacity usage efficiently.	PPIC and Production Team	The production team uses machines to execute the production process according to the quantity assigned by PPIC.	The production team ensures machines are used efficiently as per the targets set by PPIC.
Material (F4)	Inaccurate raw material procurement planning.	PPIC, Procurement Department, Supplier	PPIC plans raw material requirements based on forecasts, then the Procurement team orders raw materials, and suppliers deliver the materials.	PPIC plans raw material needs, the Procurement Department orders materials from suppliers according to production needs planned by PPIC.
Environment (F5)	Lack of careful or real-time market analysis to respond to changes in market demand.	Distributor, S&OP, and PPIC	S&OP and PPIC adjust production policies based on distributor demand or market conditions.	S&OP adjusts forecasts based on market conditions, PPIC adjusts production plans based on market analysis and distributor demand.
Measurement (F6)	The system's inability to update demand data in real-time.	S&OP and PPIC	S&OP and PPIC evaluate production volume and market demand data.	S&OP and PPIC evaluate demand and production data to adjust production policies and planning.

Inventory Waste

Excessive inventory is caused by several factors involving the roles of various stakeholders, as described in **Table 2**. Regarding the method factor, the root cause is the manual planning system, which is unresponsive to changes in demand. This activity involves the role of PPIC in planning raw material requirements, the Procurement Department in placing orders, and the Supplier in delivering the required raw materials as per the order. Similarly, in the human factor, PPIC, the Procurement Department, and the Supplier have the same role, with the root cause being the lack of skills in raw material planning.

In the machine factor, the root cause is insufficient maintenance of production machines, which leads to delays in raw material usage and stockpile accumulation. The relationship in this activity involves the Production Team in using machines for the production process and the Maintenance Department ensuring proper machine usage to prevent downtime, thus avoiding raw material accumulation or production delays.

For the material factor, the root cause is the ordering of raw materials in large quantities as stock. This activity involves the Procurement Department in placing raw material orders and the Supplier in delivering the materials according to the demand. In addition, in the measurement factor, PPIC and the Procurement Department also play a role in measuring or evaluating raw material inventory levels.

Lastly, in the environment factor, PPIC, the Procurement Department, and the Supplier share the same role, with the root cause being market demand fluctuations that drive the company to order more raw materials in large quantities as stock.

b. Defective Products

Based on the analysis conducted, several key factors contribute to the occurrence of products that do not meet quality standards or are defective. These factors involve stakeholders in the activities performed, with their respective roles outlined in **Table 3.**

Based on the **Table 3** above, several factors contribute to products not meeting quality standards or being defective. In the method factor, the root cause is the inability to implement an effective quality control system. This activity involves stakeholders such as the QA Team, which develops and implements quality standards; the Production Team, which ensures the product quality meets the established standards; and the Distributor, which manages product distribution to ensure quality is maintained until it reaches the destination. Similarly, in the human factor, the lack of supervisory personnel during the production process is a cause of defective products. Stakeholders play a role in supervising each stage of production and distribution to detect and prevent product damage or defects.

In the machine factor, the absence of standardized maintenance schedules leads to machine breakdowns that affect product quality. Stakeholders such as the Maintenance Department, Production Team, and Distributor are responsible for developing and implementing routine maintenance schedules to ensure the optimal functioning of machines and delivery vehicles.

In the material factor, weak control over supplier selection and raw material inspection also contributes to defective products. This activity involves the Procurement Department in selecting suppliers and raw materials that meet quality standards, while the Supplier is responsible for providing the raw materials.

Additionally, in the measurement factor, the inaccuracy of manual measurement systems and the limited ability to detect defects in real-time are root causes. This activity involves the QA Team in developing and implementing an accurate measurement system, while the Production Team measures product quality, and the Distribution Team monitors product quality during shipping.

3.4 Classification of Stakeholder Roles

The classification of stakeholder roles in the supply chain aims to understand the contribution of each party to the overall system performance. The following table presents the classification of stakeholder roles in the supply chain based on these drivers.

Stakeholders are classified based on key supply chain drivers that influence overall performance, (Dinata Yulia & Kempa Sesilya, 2017). These drivers

Table 2. Stakeholder Roles in Inventory Waste

Factor	Root Cause	Stakeholders	Activity Relationship	Stakeholder Roles
Method (Q1)	Dependency on manual planning that is not responsive to changes in demand.	PPIC, Procurement Department, and Supplier	PPIC plans raw material requirements, followed by Procurement Department ordering, and the Supplier delivering the required raw materials.	PPIC determines raw material requirements, Procurement Department places orders, and the Supplier delivers the materials as per the order.
People (Q2)	Lack of skills in raw material planning.	PPIC, Procurement Department, and Supplier	PPIC plans raw material requirements, followed by Procurement Department ordering, and the Supplier delivering the required raw materials.	PPIC determines raw material requirements, Procurement Department places orders, and the Supplier delivers the materials as per the order.
Machine (Q3)	Insufficient maintenance of production machines, leading to delays in raw material usage and stockpile accumulation.	Production Team, Maintenance Department	Raw materials are processed into products using production machines, while machine maintenance is performed.	Ensuring proper machine usage to prevent downtime, thus avoiding raw material accumulation or production delays.
Material (Q4)	Ordering raw materials in large quantities as stock.	Procurement Department, Supplier	Procurement Department places raw material orders based on forecasts, and the Supplier supplies materials accordingly.	Procurement Department is responsible for raw material procurement, and the Supplier is responsible for delivery and provision of materials.
Environment (Q5)	Uncontrolled market demand fluctuations prompting the company to order more raw materials than necessary.	PPIC, Procurement Department, Supplier	PPIC calculates raw material requirements, followed by the Procurement Department ordering and Supplier delivering materials as ordered.	PPIC determines raw material needs, Procurement Department handles procurement, and the Supplier ensures delivery of the materials.
Measurement (Q6)	Inability of the company's measurement system to provide accurate, real-time data.	PPIC, Procurement Department	PPIC calculates both planned and actual raw material needs, followed by the Procurement Department calculating remaining inventory.	Both PPIC and Procurement Department measure or evaluate raw material inventory levels.

Table 3. Stakeholder Roles in Defective Products

Factor	Root Cause	Stakeholders	Activity Relationship	Stakeholder Roles
Method (X1)	Inability to implement an effective quality control system.	QA Team (Quality Assurance), Production Team, and Distributor	QA establishes quality standards, the production team ensures product quality before shipment, and the distributor delivers the product to the customer in good condition.	QA develops and implements quality standards, the Production Team ensures product quality complies with the established standards, and the Distributor manages product distribution to maintain quality until delivery.
People (X2)	Insufficient supervisory personnel.	QA Team (Quality Assurance), Production Team, and Distributor	Quality control supervision at every stage of production by the production team, as well as product shipping through the distributor.	Team QA monitors and evaluates product quality, the Production Team is responsible for managing the production process and ensuring product standards are met, and the Distributor oversees product quality during the distribution
Machine (X3)	Lack of standardized maintenance schedules for production machines.	Maintenance Department, Production Team	Develop and implement a maintenance schedule for production machines to ensure optimal functionality and minimize product defects due to machine failure.	The Maintenance Department is responsible for creating a machine maintenance schedule and ensuring machine suitability, while the Production Team uses the machines according to established operating standards.
Material (X4)	Weak control over supplier selection and raw material inspection.	Procurement Department, Supplier	The Procurement Department selects suppliers, and raw material inspection is performed to ensure quality, followed by suppliers delivering raw materials.	The Procurement Department selects suppliers and raw materials that meet quality standards, and the Supplier is responsible for providing raw materials.
Measurement (X5)	Inaccurate manual measurement systems to detect defects.	QA Team, Production Team, and Distributor	QA develops and implements measurement systems, the Production Team measures product quality according to existing procedures, and the Distribution Team monitors product quality during shipping.	QA is responsible for developing and implementing an accurate measurement system.
Method (X6)	Inability to implement an effective quality control system.	QA Team (Quality Assurance), Production Team, and Distributor	QA establishes quality standards, the production team ensures product quality before shipment, and the distributor delivers the product to the customer in good condition.	QA develops and implements quality standards, the Production Team ensures product quality complies with the established standards, and the Distributor manages product distribution to maintain quality until delivery.

encompass various aspects such as inventory, transportation, facilities, information, procurement, and pricing. Evaluating these drivers enables the company to formulate more optimal management strategies to improve operational efficiency and reduce unnecessary costs (Chopra & Meindl, 2016).

After classifying the roles of stakeholders in the honey supply chain, as presented in **Table 4**, the next step is to formulate corrective actions. The purpose of this process is to develop solutions aimed at reducing waste throughout the supply chain. **Table 5** presents the classification of problems according to their respective drivers, along with recommended solutions to minimize waste.

Based on the table above, several solutions are proposed to reduce waste for each classification of drivers. For the facility, it is recommended that machine capacity be accurately calculated, machine working hours be adjusted to production needs, and preventive maintenance be carried out according to schedule to ensure optimal machine performance. This approach aligns with Mintari, Asbari, & Astuti (2024),

Table 4. Classification of Stakeholder Roles Based on Supply Chain Drivers

Component	Scope and definitions	Classification Process	Case (Honey Supply Chain)
Facilities	Facilities refer to physical locations in the supply chain where products are stored, assembled, or produced.	Entities are classified as Facilities if they function as storage, assembly, or production sites.	Warehouses, factories, including production machines (veling, labeling and injection)
Inventory	Inventory refers to the collection of raw materials, work-in-progress goods, and finished products in the supply chain.	Entities are classified as Inventory if they are involved in managing stocks of raw materials or finished products to facilitate smooth production and distribution.	Raw honey as a material, Vitabumin products that are not yet packaged or labeled, and finished products that have completed all production stages and are ready for shipment.
Transportation	Transportation is the process of moving goods from one point to another within the supply chain using various modes of transport.	Entities are classified as Transportation if they are involved in the movement of goods between locations using transport modes.	Trucks and vehicles used to move or distribute Vitabumin products.
Information	Information refers to the data used to manage and analyze the flow of goods within the supply chain.	Entities are classified as Information if they provide data that support efficient decision-making in the supply chain, such as production planning and inventory control.	Data on Vitabumin product demand from distributors and inventory levels available for production planning and inventory control analysis.
Sourcing	Sourcing refers to the processes involved in purchasing goods and services, as well as determining who will perform activities within the supply chain.	Entities are classified as Sourcing if they are involved in selecting suppliers or sourcing raw materials and components for production.	Honey supplier: Sumber Anugerah Perkasa (SAP), and logistics service provider: Bunda Solusi Indonesia (BSI).
Pricing	Pricing refers to the process of determining the price of goods and services within the supply chain, which impacts both demand and supply.	Entities are classified as Pricing if they are involved in determining the price of products or services within the supply chain.	Fluctuations in the price of raw honey from suppliers, which can affect the production cost of Vitabumin products. For instance, an increase in the price of raw honey may lead to an increase in the selling price of Vitabumin products to maintain profit margins.

Table 5. Classification of Drivers and Proposed Corrective Actions

Classification	Overproduction	Inventory Waste	Defective Product	Proposed Solution Based on Classification
Facility	Machine (F3); The existing system is not optimal in monitoring machine capacity usage efficiently.	Machine (Q3); Lack of optimal maintenance for production machines, leading to delays in raw material usage and stockpile accumulation.	Machine (X3); Lack of a standardized maintenance schedule for production machines. Method (X1); Inability to implement an effective quality control system. Measurement (X5); Inaccurate manual measurement system for detecting defects.	Calculating machine capacity and adjusting machine operating hours to match the required production volume, as well as performing regular preventive maintenance based on the scheduled time, frequency, and type of maintenance (Machine)
Inventory	Material (F4);	Material (Q4);	Material (X4);	Managing inventory levels through efficient planning

Classification	Overproduction	Inventory Waste	Defective Product	Proposed Solution Based on Classification
	Inaccurate planning of raw material procurement.	Ordering raw materials in large quantities to be kept as stock	Weak control in supplier selection and raw material inspection	and avoiding overstocking by implementing Economic Order Quantity (EOQ), Just-In-Time (JIT), and safety inventory strategies, as well as enhancing raw material quality inspection prior to warehouse acceptance by strengthening collaboration between suppliers and manufacturers (Material)
Transportation	-	-	-	-
Information	Method (F1); Reliance on manual forecasting methods that are not responsive to changes in market demand. Human (F2); Lack of understanding in utilizing data and proper analysis in production planning. Environment (F5); Insufficient or non-real-time market analysis in responding to demand fluctuations. Measurement (F6); Inability of the system to update demand data in real-time.	Method (Q1); Reliance on manual planning processes that are not responsive to changing requirements. Measurement (Q6); Inability of the company's measurement system to provide accurate and real-time data	-	Implementation of a forecasting system based on historical distributor demand data using Moving Average or Exponential Smoothing to enhance responsiveness to demand changes, reduce reliance on manual methods, and update data in real-time for more accurate production and raw material planning. Additionally, managing inventory levels through efficient planning and avoiding overstocking by applying EOQ and JIT approaches. (Method & Measurement)
Procurement	Material (F4); Inaccurate planning in raw material procurement.	People (Q2); Lack of skills in raw material planning	Material (X4); Weak control over supplier selection and raw material inspection.	Managing inventory levels through efficient planning and avoiding overstocking by using EOQ and JIT, while enhancing raw material quality inspection before acceptance into the warehouse, by strengthening collaboration between suppliers and manufacturers (Material)
Pricing	-	-	-	-

who emphasize the importance of integrating production planning with capacity management to meet customer demand with quality and timeliness, while Marimin & Zulna (2022) highlight the effectiveness of preventive maintenance in improving machine reliability and reducing maintenance costs.

For inventory and procurement, the proposed solutions include the implementation of the Economic Order Quantity (EOQ) system, Just-In-Time (JIT), and safety inventory, as well as improving raw material quality inspection by strengthening cooperation between suppliers and manufacturers. Pradana and Jakaria (2020) demonstrate that EOQ implementation can significantly reduce storage and ordering costs while ensuring material availability aligns with actual production needs.

For information, it is recommended to implement a forecasting system based on historical data, such as Moving Average or Exponential Smoothing, to update data in real-time, which will improve responsiveness to market demand changes and enhance production planning. Kusyanto, K., Suhardi, D., & Awaludin, R. (2020) found that these forecasting methods significantly improve prediction accuracy by minimizing errors, thereby enhancing supply chain responsiveness. The implementation of these solutions is expected to optimize overall supply chain performance, reduce waste, and improve operational efficiency.

4. Conclusion

Based on the analysis conducted, supply chain management using a framework to reduce waste indicates that waste identification, root cause analysis, and stakeholder involvement play a crucial role in reducing waste within the supply chain system. The identified wastes include overproduction, excessive inventory, and defects. These wastes are influenced by the roles of stakeholders at each stage. To mitigate this waste, stakeholders are classified according to the supply chain drivers in the implementation of solutions. Proposed solutions include accurately managing machine capacity, implementing the EOQ and JIT systems, and enhancing raw material quality inspection. Additionally, the use of forecasting systems based on historical data is recommended to improve production planning and responsiveness to market demand changes. The implementation of these solutions is expected to optimize supply chain management and reduce waste.

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