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Optimizing Fresh Fruit Bunch (FFB) Inventory Control Using the Min–Max Method at PT. XYZ

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ABSTRACT

Fresh Fruit Bunch (FFB) inventory is a critical factor in ensuring the continuity of *Crude Palm Oil* (CPO) production at XYZ Palm Oil Mill. Poorly planned inventory management may lead to shortages or overstocking of raw materials, resulting in increased inventory costs and reduced FFB quality. This study aims to analyze FFB inventory control using the *Min–Max* method and compare the inventory costs between the company's existing inventory system and the proposed *Min–Max* method. The study utilized FFB inventory data collected from December 2025 to February 2026 through observations, interviews, and documentation at PT. XYZ Palm Oil Mill. The results indicate that the company has not established *Safety Stock*, *Minimum Stock*, *Maximum Stock*, or the *Reorder Point* (ROP) as inventory control parameters. Based on the *Min–Max* method, the optimal inventory parameters were determined as follows: a *Safety Stock* of 139 tons, a *Minimum Stock* of 677 tons, a *Maximum Stock* of 1,214 tons, a *Reorder Point* (ROP) of 677 tons, an order quantity of 1,075 tons per order, and an ordering frequency of 43 orders during the study period. In contrast, the company's existing system recorded an average order quantity of 509 tons with an ordering frequency of 91 orders over the same period. Furthermore, the comparison of *Total Inventory Cost* (TIC) revealed that the company's inventory system incurred a cost of IDR 4,551,407, whereas the *Min–Max* method resulted in a cost of IDR 2,169,321, yielding inventory cost savings of IDR 2,382,086. These findings demonstrate that the *Min–Max* method improves inventory control efficiency by establishing appropriate inventory limits, determining optimal reorder points, optimizing order quantities, and reducing total inventory costs compared with the company's existing inventory management system.

INTRODUCTION

Inventory control is one of the most important activities in manufacturing industries because it ensures the availability of raw materials required to support production activities. Proper inventory management enables companies to maintain an appropriate balance between raw material availability and production requirements while minimizing inventory-related costs. Conversely, ineffective inventory control may result in raw material shortages, excessive inventory, increased storage costs, production interruptions, and declining operational efficiency. Therefore, companies

require an inventory control system capable of maintaining optimal inventory levels while supporting uninterrupted production processes [26].

PT. XYZ is a palm oil processing company that uses Fresh Fruit Bunches (FFB) as the primary raw material for producing Crude Palm Oil (CPO). The availability of FFB directly affects the continuity of production because sufficient raw materials are required to achieve daily production targets. Moreover, FFB is classified as a perishable raw material that experiences rapid quality deterioration after harvesting. Delays in processing can increase Free Fatty Acid (FFA) content and reduce the quality of CPO. Consequently, effective inventory management is essential to maintain production continuity and preserve product quality [10]. These characteristics make FFB inventory management considerably more challenging than that of non-perishable industrial raw materials.

Based on inventory records at PT. XYZ during the period of December 2025 to February 2026, the quantity of incoming FFB fluctuated considerably from day to day. On several production days, the quantity of FFB received was lower than the company's production target. For example, on December 2, 2025, the production target was 600 tons, whereas only 534.27 tons of FFB were received. Similar conditions occurred on January 13, 2026, when the production target was 635.29 tons but only 548.75 tons of FFB were available. Likewise, on February 1, 2026, the company planned to process 560 tons of FFB, while incoming supply amounted to only 508.58 tons. These fluctuations indicate that the availability of raw materials was unable to consistently satisfy production requirements. Furthermore, the company's inventory records showed that the ending inventory frequently reached zero after daily production activities, indicating that the company maintained very limited inventory reserves and consequently faced a considerable risk of production disruption whenever unexpected decreases in supply occurred. These conditions demonstrate that the current inventory control system has not yet achieved an optimal balance between inventory availability and operational efficiency.

Currently, inventory replenishment at the company is determined mainly based on operational experience without establishing quantitative inventory parameters such as Safety Stock, Minimum Stock, Maximum Stock, or Reorder Point (ROP). Consequently, purchasing activities tend to be performed more frequently with relatively small order quantities, resulting in higher ordering costs and less efficient inventory management. The absence of a structured inventory control policy also makes it difficult for the company to anticipate fluctuations in supply and production demand [6].

One inventory control technique that can be applied to overcome this problem is the Min-Max method. This method establishes minimum and maximum inventory levels to determine when replenishment should be performed and how much inventory should be maintained. Through the determination of Safety Stock, Minimum Stock, Maximum Stock, Reorder Point (ROP), Order Quantity, Ordering Frequency, and Total Inventory Cost (TIC), the Min-Max method enables companies to improve inventory planning, reduce the risk of stock shortages and excessive inventory, and minimize total inventory costs [16].

Several previous studies have demonstrated that the Min–Max method is an effective inventory control approach for reducing inventory costs and improving inventory efficiency [22]. reported that the Min–Max method successfully minimized stock shortages and excessive inventory by determining Safety Stock, Minimum Stock, and Maximum Stock [28]. also showed that the Min–Max method improved inventory

planning efficiency by reducing unnecessary inventory levels. In addition, concluded that the Min–Max method provides a practical decision-making tool for determining reorder timing and inventory quantities in manufacturing industries. These studies indicate that the Min–Max method has been successfully implemented in various industrial sectors. However, most previous studies focused on manufacturing materials, auxiliary materials, or finished products, while studies on Fresh Fruit Bunch (FFB) inventory in palm oil mills remain limited. Furthermore, previous studies generally evaluated only selected inventory parameters. Comprehensive analyses integrating Safety Stock, Minimum Stock, Maximum Stock, Reorder Point (ROP), Order Quantity, Ordering Frequency, and Total Inventory Cost (TIC) using actual operational data from palm oil mills are still scarce.

Unlike previous studies, this research comprehensively evaluates all major Min–Max inventory parameters, including Safety Stock, Minimum Stock, Maximum Stock, Reorder Point (ROP), Order Quantity, Ordering Frequency, and Total Inventory Cost (TIC), using actual operational data from a palm oil mill. This comprehensive evaluation provides a more complete assessment of inventory control performance under real operating conditions.

This study contributes to the inventory management literature by providing empirical evidence of the applicability of the Min–Max method to Fresh Fruit Bunch (FFB) inventory, which has unique characteristics as a perishable agricultural raw material. The findings also provide practical recommendations for improving inventory efficiency, reducing ordering costs, minimizing stockout risk, and supporting decision-making in palm oil mill inventory management.

MATERIALS AND METHODS

Research Location and Time

This research was conducted at PT. XYZ, a company engaged in the Palm Oil Mill (POM) industry. The company is located on Jl. Rantau, Gedong Biara Village, Seruway District, Aceh Tamiang Regency, Aceh. The object of this research was the inventory control of Fresh Fruit Bunches (FFB) used as the main raw material in the production of Crude Palm Oil (CPO). The research used historical FFB inventory data for a period of three months, from December 2025 to February 2026.

Research Object and Data

The object of this research was the inventory of Fresh Fruit Bunches (FFB) at PT. xyz Palm Oil Mill. FFB is the main raw material used in the CPO production process. The inventory data used in this research consisted of initial stock, daily production targets, incoming FFB, processed FFB, and ending stock during the research period. Based on the company data, the total incoming FFB during the research period was 45,800 tons, while the total processed FFB was 46,245.17 tons.

In addition to inventory data, this research also used data on raw material ordering and costs required to calculate the Total Inventory Cost (TIC). FFB procurement at PT. xyz Palm Oil Mill is carried out regularly according to production requirements and the availability of FFB supplied by the company's plantations and suppliers. The amount of FFB received may vary depending on harvest yields and the availability of raw materials.

Data Collection

Data collection in this research was conducted through observation, interviews, and documentation. Observation was carried out to determine the actual conditions of FFB procurement and inventory control at PT. XYZ Palm Oil Mill. Interviews were conducted with parties involved in the procurement process to obtain information regarding the procurement system, raw material requirements, ordering activities, and costs related to inventory. Documentation was conducted by collecting historical company data related to FFB inventory and ordering during the research period.

The inventory control analysis in this research used the Min-Max method. The Min-Max method was used to determine the minimum and maximum inventory levels so that the company could determine when to reorder and how much inventory should be maintained. The method was applied to determine Safety Stock, Minimum Stock, Maximum Stock, Order Quantity, Reorder Point (ROP), Ordering Frequency, and Total Inventory Cost (TIC).

The calculation stages of the Min-Max method used in this research are described as follows.

1. Safety Stock (SS)
   Safety Stock is determined to anticipate uncertainties in demand and lead time.
   $SS = Sd \times Z \times \sqrt{LT}$ .....(2.1)
   where Sd is the standard deviation of demand, Z is the service level factor, and LT is the lead time.
2. Minimum Stock
   Minimum Stock represents the inventory level at which a replenishment order should be placed based on the average demand during the lead time.
   Minium Stock = (T x LT) + SS .....(2.2)
   where T is the average demand and SS is the Safety Stock
3. Maximum Stock
   Maximum Stock is the highest inventory level that should be maintained after replenishment.
   Maximum Stock = 2 x (T x LT) + SS .....(2.3)
4. Order Quantity (Q)
   The order quantity indicates the amount of inventory that should be ordered in each replenishment cycle.
   Q = 2 x T x LT .....(2.4)
5. Reorder Point (ROP)
   The Reorder Point indicates the inventory level at which a new order should be placed.
   ROP = (T x LT) + SS .....(2.5)
6. Ordering Frequency (F)
   The ordering frequency is determined by dividing the total annual demand by the order quantity.
   $F = \frac{D}{Q}$ .....(2.6)
   where D is the total demand during the study period.
7. Total Inventory Cost (TIC)
   The Total Inventory Cost consists of ordering cost and holding cost, which can be calculated as follows:
   $TIC = \left(\frac{D}{Q} \times S\right) + \left(\frac{Q}{2} \times H\right)$.....(2.7)

where D is the total demand, Q is the order quantity, S is the ordering cost per order, and H is the holding cost per unit.

Notation :

T	= Average demand
LT	= Lead time
SS	= Safety Stock
Sd	= Standard deviation
Z	= Service level factor
Q	= Order quantity
ROP	= Reorder Point
F	= Ordering frequency
D	= Total demand
S	= Ordering cost
H	= Holding cost

Data Analysis

Data analysis was conducted by processing historical FFB inventory data during the research period using the Min-Max method. The analysis began by determining the average demand, followed by the calculation of Safety Stock, Minimum Stock, Maximum Stock, Order Quantity, Reorder Point (ROP), Ordering Frequency, and Total Inventory Cost (TIC).

The results of each calculation were then analyzed to evaluate the FFB inventory control conditions at PT. XYZ Palm Oil Mill. Furthermore, the results obtained using the Min-Max method were compared with the company's actual inventory control conditions. The comparison was conducted to determine differences in order quantity, ordering frequency, and inventory costs. The results were then used as a basis for recommending a more effective FFB inventory control system for PT. XYZ Palm Oil Mill.

Research Procedure

The research procedure began with the identification of the FFB inventory control problem at PT. XYZ Palm Oil Mill. The next stage was collecting FFB inventory and ordering data for the period from December 2025 to February 2026. The collected data were then processed to determine FFB usage and the parameters required for the Min-Max method.

The next stage involved calculating Safety Stock, Minimum Stock, Maximum Stock, Order Quantity, Reorder Point, Ordering Frequency, and Total Inventory Cost. The results obtained from the Min-Max method were then analyzed and compared with the inventory control system currently implemented by the company. Finally, conclusions and recommendations were formulated based on the results of the

Flow diagram

The research flowchart is presented in Figure 1.

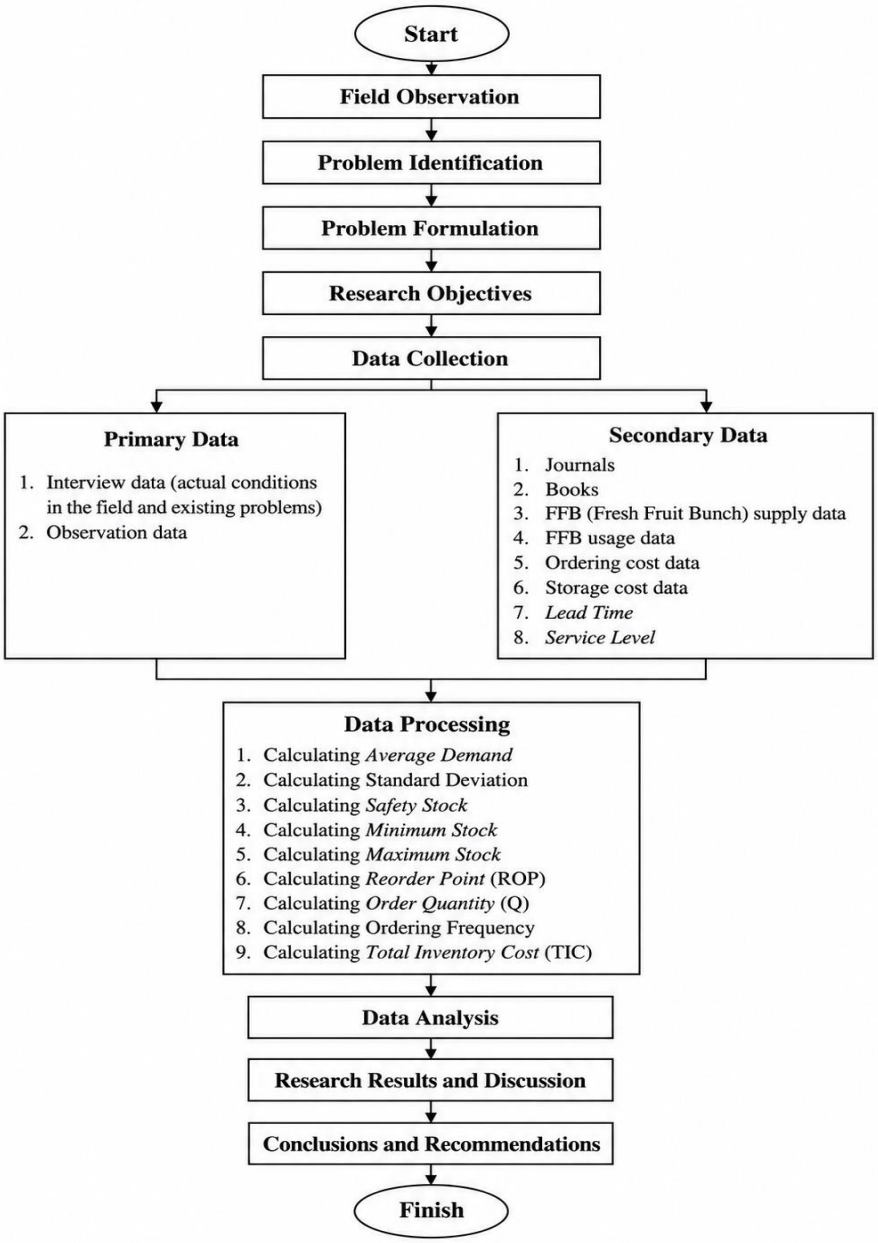


Figure 1. Research Flowchart

RESULTS AND DISCUSSIONS

1. Results of FFB Inventory Control Using the Min-Max Method

The results of FFB inventory control using the Min-Max method were obtained based on the average daily raw material usage, lead time, Safety Stock, and total FFB requirements during the research period. The analysis was conducted to determine the appropriate inventory levels and ordering policies for FFB at PT. XYZ Palm Oil Mill.

Based on the calculation, the average usage of FFB was 537.73 tons per day, with a lead time of one day. The Min-Max method resulted in a Safety Stock of 139 tons, a Minimum Stock of 677 tons, a Maximum Stock of 1,214 tons, a Reorder Point (ROP) of 677 tons, and an order quantity of 1,075 tons per order. Furthermore, based

on the total FFB requirement of 46,245.17 tons, the resulting ordering frequency was 43 times during the research period from December 2025 to February 2026.

Table 1. Results of FFB Inventory Control Using the Min-Max Method

Inventory Control Component	Result
Safety Stock	139 tons
Minimum Stock	677 tons
Maximum Stock	1,214 tons
Reorder Point (ROP)	677 tons
Order Quantity	1,075 tons/order
Ordering Frequency	43 times

The results indicate that the Min-Max method provides specific inventory parameters that can be used by the company as a reference in controlling FFB inventory. These parameters provide limits for inventory levels and a reference for determining when procurement should be carried out.

2. Safety Stock

The calculation using the Min-Max method resulted in a Safety Stock of 139 tons. Safety Stock represents the amount of reserve inventory that should be maintained to anticipate uncertainty in FFB supply and fluctuations in the amount of FFB received. The availability of Safety Stock allows the company to have a reserve of raw materials that can be used when there is a delay in delivery or a decrease in FFB supply from suppliers. Therefore, the existence of Safety Stock is intended to support the continuity of the production process and prevent shortages of raw materials.

In the existing inventory control system, the company had not established or calculated a specific Safety Stock level. Therefore, the Min-Max method provides a quantitative reference for determining the amount of reserve inventory required by the company.

3. Minimum Stock and Maximum Stock

The Min-Max method resulted in a Minimum Stock of 677 tons and a Maximum Stock of 1,214 tons. Minimum Stock represents the lowest inventory level that should be available before the company makes a reorder, while Maximum Stock represents the highest inventory level that should be maintained to prevent excessive accumulation of raw materials.

The establishment of these two inventory limits provides a clearer guideline for the company in controlling the amount of FFB inventory. Maintaining the inventory within the minimum and maximum limits helps ensure the availability of raw materials while avoiding excessive inventory that may increase storage costs or affect FFB quality due to prolonged storage. The company had not previously established specific Minimum Stock and Maximum Stock levels. The Min-Max method therefore provides clear inventory limits that can be used as a reference in inventory management.

4. Reorder Point (ROP)

The calculation of the Reorder Point (ROP) resulted in 677 tons. The calculation was based on an average FFB usage of 537.73 tons per day, a lead time of one day, and Safety Stock of 139 tons.

The calculation resulted in:

$ROP = (537.73 \times 1) + 139$

$ROP = 676.73 \text{ tons} \approx 677 \text{ tons}$

Thus, the company should reorder FFB when the available inventory reaches approximately 677 tons. This value provides a specific reference for the company to determine the appropriate time to conduct another procurement so that the production process can continue without experiencing a shortage of raw materials.

Unlike the existing system, in which the company had not established a specific reorder point, the Min-Max method provides a more systematic reference for determining the timing of FFB procurement and reducing the risk of shortages during lead time.

5. Order Quantity

The calculation resulted in an order quantity of 1,075 tons per order. This result was obtained using the average FFB usage of 537.73 tons per day and a lead time of one day.

The recommended order quantity under the Min-Max method is greater than the company's average order quantity of 509 tons per order. This indicates that the Min-Max method recommends a larger quantity for each procurement transaction.

The larger order quantity allows the company to reduce the frequency of procurement activities. Thus, although the quantity ordered in each transaction is greater, procurement activities can be carried out less frequently while still considering the FFB requirements for the production process.

6. Ordering Frequency

Based on the total FFB requirement of 46,245.17 tons and an order quantity of 1,075 tons per order, the Min-Max method resulted in an ordering frequency of 43.01 times, which was rounded to 43 times during the research period.

Meanwhile, based on the company's existing policy, FFB procurement was conducted 91 times during the period from December 2025 to February 2026. Therefore, the application of the Min-Max method reduces the ordering frequency from 91 times to 43 times.

The reduction in ordering frequency occurs because the quantity ordered in each procurement transaction is greater. As a result, the required raw material can fulfill production needs for a longer period, making procurement activities more efficient.

7. Comparison of Inventory Control between the Company and the Min-Max Method

The effectiveness of FFB inventory control was analyzed by comparing the company's existing inventory control system with the results obtained using the Min-Max method. The comparison included Safety Stock, Minimum Stock, Maximum Stock, Reorder Point (ROP), order quantity, ordering frequency, and Total Inventory Cost (TIC)

Table 2. Comparison of FFB Inventory Control

Component	Company	Min-Max Method
Safety Stock	–	139 tons
Minimum Stock	–	677 tons
Maximum Stock	–	1,214 tons
Reorder Point (ROP)	–	677 tons
Order Quantity	509 tons	1,075 tons
Ordering Frequency	91 times	43 times
Total Inventory Cost (TIC)	Rp4,551,407	Rp2,169,321

The comparison shows that the Min-Max method provides more specific inventory control parameters. In addition to establishing inventory limits and a reorder point, the method also results in a larger order quantity and lower ordering frequency than the company's existing policy.
The graph of the Min-Max method calculation can be seen in **Figure 4.1:**

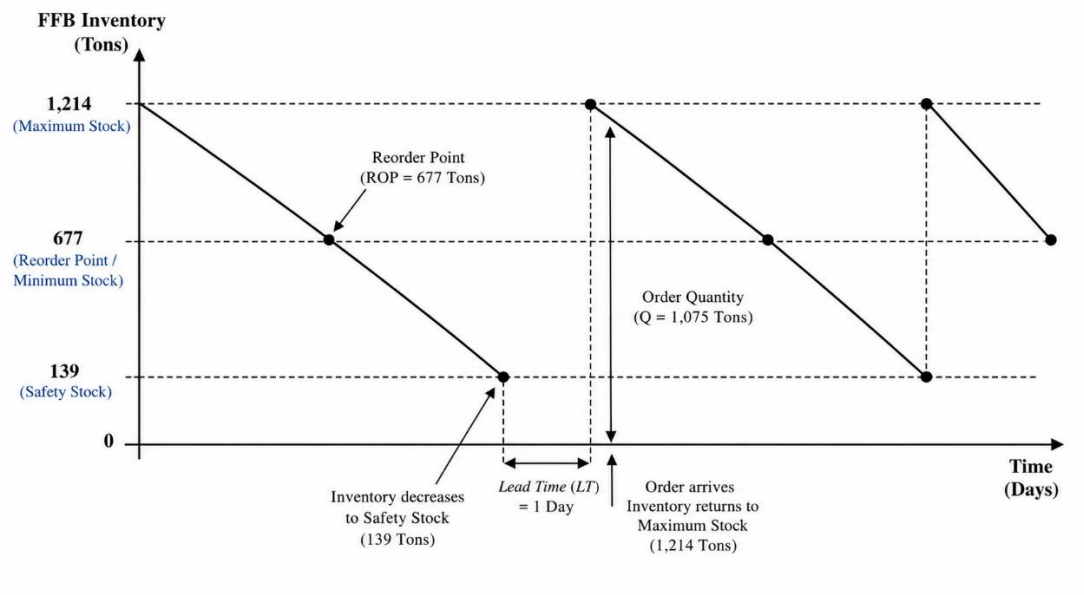


Figure 2. Min-Max Calculation Chart

8. Total Inventory Cost Analysis

The Total Inventory Cost (TIC) was analyzed to determine the efficiency of FFB inventory costs under the company's existing system and the Min-Max method.

Table 3. Comparison of Total Inventory Cost

Inventory Control System	Total Inventory Cost (TIC)
Company	Rp4,551,407
Min-Max Method	Rp2,169,321

Based on Table 3, the company's Total Inventory Cost during the period from December 2025 to February 2026 was Rp4,551,407, whereas the Total Inventory Cost using the Min-Max method was Rp2,169,321. The difference between the two inventory control systems was Rp2,382,086.
The reduction in inventory cost indicates that the Min-Max method provides more efficient inventory control through the determination of Safety Stock, Minimum Stock, Maximum Stock, Reorder Point, order quantity, and ordering frequency.

Discussions

The application of the Min–Max method reduced the ordering frequency from 91 to 43 orders during the study period, indicating that procurement activities became more efficient because larger order quantities reduced the need for frequent replenishment. As a result, the Total Inventory Cost decreased from IDR 4,551,407 to IDR 2,169,321, representing a cost saving of IDR 2,382,086. These findings suggest that the Min–Max method improves inventory efficiency by optimizing procurement planning while maintaining sufficient FFB availability for continuous production.

This finding is consistent with [22], who reported that the Min–Max method effectively minimizes stock shortages and excessive inventory. Similarly, [28] found that the method improved inventory efficiency by reducing unnecessary inventory costs.

CONCLUSION

Based on the findings, the Min–Max method provides a more systematic and effective approach to Fresh Fruit Bunch (FFB) inventory control than the company's existing inventory policy. By establishing clear inventory control parameters, the proposed method supports better procurement planning, maintains adequate raw material availability, and improves inventory management efficiency while reducing unnecessary inventory-related costs. This study contributes to the application of the Min–Max method for managing perishable agricultural raw materials in the palm oil industry by demonstrating its effectiveness using actual operational data from a palm oil mill. The findings provide empirical evidence that a structured inventory control policy can enhance procurement efficiency and support more reliable inventory management.

From a managerial perspective, the proposed inventory policy can serve as a practical guideline for determining appropriate replenishment timing and procurement quantities. Its implementation is expected to reduce the risk of stock shortages and overstock, improve production continuity, and support more efficient inventory planning and decision-making in palm oil mills.

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