Order Picking Efficiency: A Case Study of Warehouse Operations

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Abstract

The objectives of this research are 1) To study the order picking efficiency through the analysis and calculation of standard time before improvement at each step of the picking process in warehouse operations; 2) To reduce the time required for product searching and storage processes. Baseline and standard times were analyzed and calculated prior to implementing improvements at each stage of the picking process. The workflow in the item retrieval stage can be summarized using a Flow Process Chart (FPC). The study found that the picking and searching of goods were delayed due to inappropriate storage methods, lack of categorization, and fixed storage location allocation. This research utilizes concepts of work study, warehouse layout improvement, storage space allocation, and order-picking time reduction. Data collection included product types, product quantities, storage characteristics or methods, and warehouse area size. The improvement actions involved categorizing and rearranging products, defining storage areas, creating location identification signs, and organizing database records of storage locations. To improve the picking method, unnecessary work steps were eliminated. As a result of the improvements implemented in this study, the working time decreased from 36 minutes to 9 minutes, resulting in a reduction of 27 minutes and an improvement in work efficiency by 75% compared to the previous method.

Keywords*: *efficiency, warehouse operations, storage space allocation

1. Introduction

The logistics service industry is highly competitive and increasingly diverse. To meet customer satisfaction, logistics services must ensure the delivery of the correct goods in the correct quantity, delivery to the right location, and on time, while minimizing warehouse management costs. This involves numerous activities, including receiving and storing goods, retrieving items for export, packaging, and shipping. This research therefore aims to identify guidelines for improving the efficiency of warehouse management activities. It also aims to examine approaches that can be applied to improve warehouse management processes. In this study, a distribution warehouse that stores and exports various types of cosmetic packaging was selected as the case study. This study identifies several key problems related to warehouse management. The operational procedures of the warehouse department during the product retrieval stage can be categorized into several processes, including product handling and movement, product arrangement and quantity verification, transferring items to the dispatch area, and internal material handling. The processes of item searching and product arrangement require a considerable amount of time due to the large volume of products stored in the warehouse and the lack of systematic categorization. Based on the collected data on the frequency of item searching, which corresponds to the number of orders per picking list referenced from the Sales Order (SO) documents, the data compiled from the SO (picking lists) in October 2024 indicated an average of approximately 10 searches per day. Each search process required approximately 36 minutes to locate the products. This situation results to operational delays and highlights the need for appropriate improvement strategies, consistent with previous research on warehouse management (Kittithreerapronchai, 2021), including: (1) Product searching take longer than 30 minutes. (2) The problem of disorganized storage

within the warehouse due to the lack of clear allocation of storage space for each type of goods, making it difficult to locate items and resulting in delays in goods dispatch.

Therefore, to improve warehouse management efficiency, this study examines the problems of this distribution company as a case study by applying the frequency-based analysis and statistical management techniques, in line with the approach proposed by Polpanichjaroen (2005). The aim is to implement improvements to reduce product search time and minimize errors in storage and dispatch within the warehouse.

2. Objectives

1) To study the order picking efficiency in a case study by analyzing and calculating the standard time at each step of the picking process before improvement in warehouse operations.
2) To reduce the time required for product searching and storage processes.

3. Materials and Methods

This research aims to optimize inventory storage and warehouse layout, consistent with the study by Sorat (2019), which examined a distribution warehouse. The methodology is divided into two parts. The first part involves surveying the location and general environment of the case study warehouse, including basic operational data. The second part involves analyzing data on goods issuance and retrieval.

3.1 General Information about a Warehouse: A Case Study

1. Basic information about the distribution center. The selected distribution center provides warehouse management services and operates as a logistics distribution hub. It is located in Lam Sai Subdistrict, Wang Noi District, Phra Nakhon Si Ayutthaya Province, Thailand.

2. Terms and conditions regarding the delivery time to customers: The operational process between the studied distribution center and the customer is as follows: The distribution center receives orders from customers via email or through sales representatives. The distribution center is then responsible for preparing items according to the customer orders. The case study warehouse serves as a distribution center and as a storage facility to accommodate increasing customer demand, as shown in Figure 1.

Figure 1 Warehouse of the Case Study

3.2 Study of Goods Issuance and Retrieval Procedures within the Warehouse

Warehouse staff are divided into four main sections as follows:

Part 1 involves counting goods and issuing a Sales Orders (SOs) (Picking Slips). Once all SOs are completed, the picking slips are submitted to the supervisor for verification.

Part 2 involves searching for and organizing products according to delivery orders which are categorized by customer type, such as online customers, large corporate customers, small corporate customers, and international customers. This is done by sorting goods in the shipment zone into separate SOs (Picking slips). The items in each SO are then checked for accuracy.

Part 3 involves preparing the shipment. The customer's shipping address is retrieved from the customer list and attached to the shipping box, along with the total number of boxes. After taking photos of each pallet of goods, the goods are loaded onto the truck.

Part 4 involves cleaning the warehouse area. The cleanliness and orderliness of products in each zone are maintained, ensuring that all items are properly organized. Empty pallets should be grouped together, not placed in product zones, and stacked to a maximum height of 15 pallets per stack. Plastic wrapping must be applied to all pallets.

Among the four aspects mentioned above, the product preparation process was identified as the most significant issue affecting product delivery.

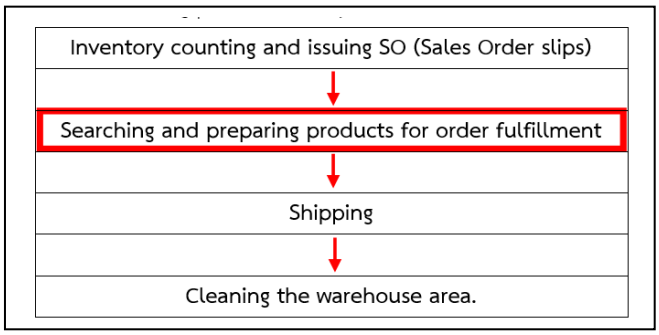

Figure 2 Steps in the work process

3.3 Warehouse Area and Layout

The warehouse layout is characterized by non-specific storage locations without clearly defined areas. Goods can be placed in any available space, as shown in Figure 3 (Warehouse Layout).

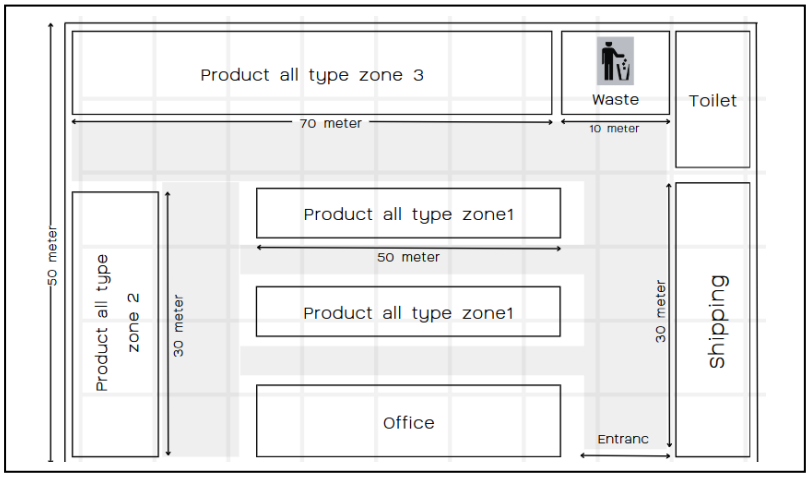

Figure 3 Warehouse layout plan

3.4 Number of Times in Searching Products (Before Improvements)

Field visits and interviews with employees responsible for product preparation revealed that searching for and organizing products takes a considerable amount of time due to the large volume of goods and the lack of proper categorization in the storage area. The collected data indicate the number of product searches, which corresponds to the number of orders processed per day based on Sales Orders (SOs). Data collected from SO lists for October 2024 showed an average of 10 searches per day, with each search taking approximately 30 minutes.

3.5 Work Procedures of Treasury Officer (Before Improvements)

Warehouse department workflow: The product search process can be summarized based on the study by Leephaijaroen (2020) on improving work efficiency using a Flow Process Chart (FPC) as shown in Figure 4. Flowchart illustrating the workflow (before improvement).

Flow process chart					
	Activity	Present	Process	Saving	
Activity: Finding product	Operation	2			
Solution: Present / Propose	Transport	2			
At: Storage	Delay				
	Inspection				
	Storage				
	Total	4			
	Distance (m.)	9			
	Time (min)	32.00			

Flow process chart				
Activity	QTY DIST m	Time (min)	SYMBOL	REMARKS
Move the obstructing items out of the way	3	15.00		
Sort and count	3	5.00		
Moving goods	2	5:00		
Place the goods at the designated delivery area.	1	7:00		
Total	9	32.00		

Figure 4 Flowchart of the workflow (before improvement)

The warehouse department's product retrieval process can be divided into four sub-steps, as described below:

1. Process of moving obstructing goods: In the storage area, goods are not categorized, separated by type, or properly positioned. As a result, employees receiving Sale Order (SOs) often find that items are mixed with other product types. Therefore, the obstructing goods must be moved first in order to retrieve the correct item according to the SO.

2. Product sorting and counting: This process involves checking the goods against the Sales Order (SO) to ensure the correct item list, quantity, and customer details, thereby preventing incorrect shipments.

3. Process of moving goods to the delivery point: This process involves transporting the prepared goods and verifying their accuracy. An inspector confirms that the arranged goods match the Sales Order (SO) before they are moved to the delivery area.

4. Process of returning obstructing goods: This process involves storing goods that were temporarily removed during the item retrieval process according to the Sales Order (SO).

The experimental design of storage space allocation aimed at reducing order picking time focuses on positioning fast-moving items closer to the dispatch dock area. This approach employs slotting

optimization in warehouse layout planning, which helps reduce the travel time of warehouse personnel. The experimental design procedure consists of the following steps; **1) The current situation was analyzed** by collecting order history data to examine the frequency of order picking and by measuring the time spent by warehouse personnel under existing operational conditions. **2) A new storage allocation design (TO-BE) was developed** by applying visual control principles, including clear labeling of storage locations and products, and arranging items according to the workflow sequence to minimize backtracking. **3) The experiments and evaluation were conducted** by comparing the order picking time (minutes per order) before and after the implementation of the improved layout. 4**) The results were analyzed** to determine whether the new storage allocation could effectively reduce order picking time. Additional controllable techniques to further reduce picking time include processing multiple orders simultaneously and assigning specific zones to individual workers.

3.6 Warehouse Staff Working Hours (Before Improvement)

In the warehouse picking process, the researchers measured the total time required, from retrieving the goods to storing them. The process was measured a total of 10 times to determine the standard time for picking operations. In studying the warehouse work processes, it is necessary to use measurement and timing tools to identify the steps that cause the greatest delays and to determine appropriate improvements, as shown in Table 1.

Table 1 shows the processing times for product searching

No	Sub-tasks	1	2	3	4	5	6	7	8	9	10	Average
1	Move the obstructing items out of the way	17	14	16	15	14	18	15	15	14	13	15
2	Sort and count	5	6	6	5	7	4	4	5	6	5	5
3	Moving goods	5	6	7	5	5	5	3	4	5	4	5
4	Put the products back in their place	7	8	7	6	7	9	7	6	7	9	7

Note: The times shown in Table 1 represent the product searching times in minutes

Table 2 Shows the time required to move obstructing items

No	Time (minutes)		No	Time (minutes)	
	x	x^2		x	x^2
1	17	289	6	18	324
2	14	196	7	15	225
3	16	256	8	15	225
4	15	225	9	14	196
5	14	196	10	13	169
$\sum x$		151	$\sum x^2$		2,301

Example of working time calculation

This step determines the required sample size for measuring the time taken to move obstructing items.

1. Sample size calculation

$$N = \left[\frac{40\sqrt{n'(x^2-(\sum x)^2}}{\sum x}\right]^2 \quad \text{.....Equation 1}$$

$$N = \left[\frac{40\sqrt{10(2301-(151)^2}}{151}\right]^2$$

$$N = 14.66 \approx 15$$

2. Calculation of normal time

$$NT=\frac{\sum_{i=1}^{n} x}{N} \quad \text{.....Equation 2}$$

$$NT=\frac{17+14+16+15+14+18+15+15+14+13}{10}$$

$$NT = 15.1 \text{minutes}$$

Note: The calculated sample size is 15, whereas only 10 observations were recorded. Therefore, the 10 observations are used to represent the sample at a 95% confidence level.

3. Calculate the standard time

ST = NT + (NT × AF)
ST = 15.1 + (15.1 × 0.1)
ST = 16.6 minutes

Table 3 Shows the standard process times before improvement the warehouse area

No	Workflow	Basic time (minutes)	Standard Time (minutes)
1	Move the obstructing items out of the way	15	17
2	Sort and count	5	6
3	Moving goods	5	5
4	Put the products back in their place	7	8
	Total Standard Time	**32**	**36**

3.7 Problem Analysis and Solutions

Table 3 shows that the warehouse product retrieval process requires a standard time of 36 minutes. The most time-consuming activity is moving obstructing items out of the way.

The researchers therefore analyzed the causes of the problem using a fishbone diagram by applying a quality tool known as the cause-and-effect diagram, which is one of the seven basic quality control tools. This approach is consistent with the study by Wannasathit (2022) and was used to classify the contributing factors, as shown in Figure 5.

Based on the fishbone diagram, delays occur in the product searching and preparation process. Four problems were identified: people, area, methods, and products. In this study, the researchers focused on addressing three factors-area, methods, and products.- as issues related to personnel cannot be easily changed. The selected causes are as follows:

1) Area: The workspace is unsuitable for operations;
2) Method: Time is wasted searching for products, and storage locations are unclear; and
3) Products: Items are scattered throughout the workspace.

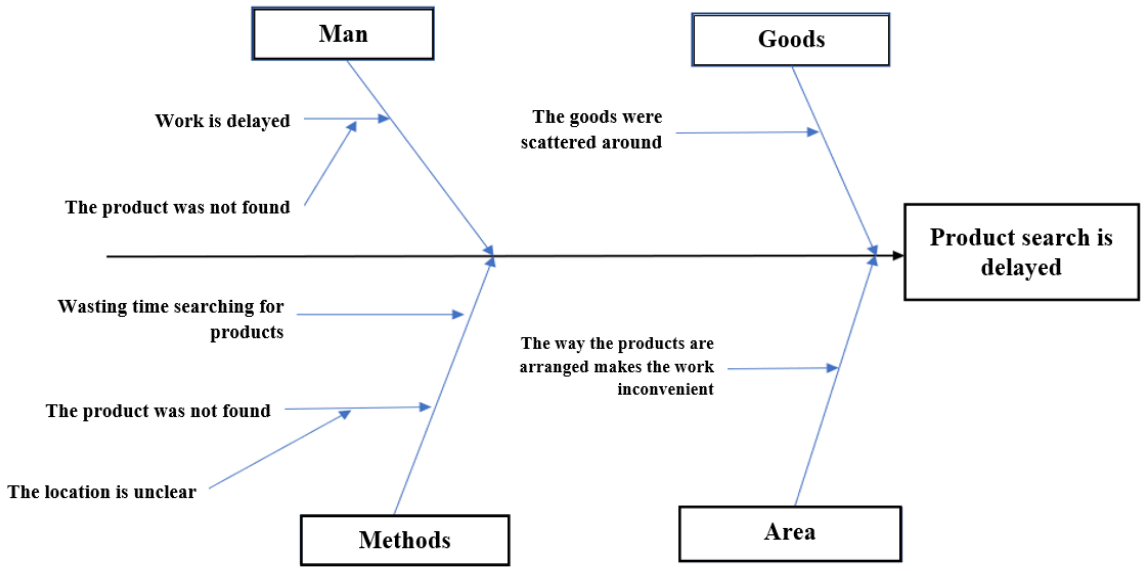

Figure 5 Fishbone diagram illustrating the factors causing delays in product search within the warehouse

4. Results and Discussion

4.1 Warehouse Layout Planning using Frequency Signal Analysis (FSN Analysis)

In a study aimed at improving inventory management, the researchers analyzed collected data on product lists, quantities, and prices to analyze and explore relevant theories that could help address the identified problems. Therefore, the warehouse layout was improved using FSN Analysis based on the frequency of exported product groups. The criteria for product grouping using FSN Analysis are presented in Table 4.

Table 4 Product grouping criteria using FSN analysis.

Product grouping classification criteria			Description
F	10 +	time	Products with a high turnover rate.
S	5 +	time	Products with a low turnover rate.
N	0	time	Products with non-moving

The improvements are as follows:

Table 5 Classification of similar product groups; before and after improvement

Before Improvement	After Improvement
Total List of items	**Product categorization list**
1. De Leaf Thanaka Powder	1. De Leaf Thanaka Powder
2. De Leaf Thanaka Powder	2. De Leaf Thanaka Cream
3. De Leaf Thanaka Powder	3. De Leaf Cream Gel
4. De Leaf Thanaka Cream	4. De Leaf Thanaka Soap
5. De Leaf Thanaka Cream	5. De Leaf Thanaka Body Serum
6. De Leaf Thanaka Cream	6. De Leaf Thanaka Duo Go Peach Powder
7. De Leaf Cream Gel	
8. De Leaf Cream Gel	
9. De Leaf Thanaka Soap	
10. De Leaf Thanaka Soap	
11. De Leaf Thanaka Body Serum	
12. De Leaf Thanaka Duo Go Peach Powder	

Grouping products using Frequency Signal Analysis (FSN)

They are arranged according to turnover rate: fast-moving, slow-moving, and non-moving. frequency of product exports. Details include product type, quantity per item, and export frequency. A detailed analysis is presented in Table 5.

Table 6 Product classification by export frequency for spatial planning analysis

Product Category	Stock quantity (packs)	Export frequency/day	Rotating Goods
1. De Leaf Thanaka Powder	300	10	Fast turnover
2. De Leaf Thanaka Cream	260	1	Slow turnover
3. De Leaf Cream Gel	360	10	Fast turnover
4. De Leaf Thanaka Soap	450	15	Fast turnover
5. De Leaf Thanaka Body Serum	400	5	Fast turnover
6. De Leaf Thanaka Duo Go Peach Powder	200	1	Slow turnover
Total	**1970**	**42**	

Table 6 shows that products are classified into six categories based on export frequency. This provides information on products with high export rates, allowing for analysis of storage locations to reduce product retrieval time and expedite export processes.

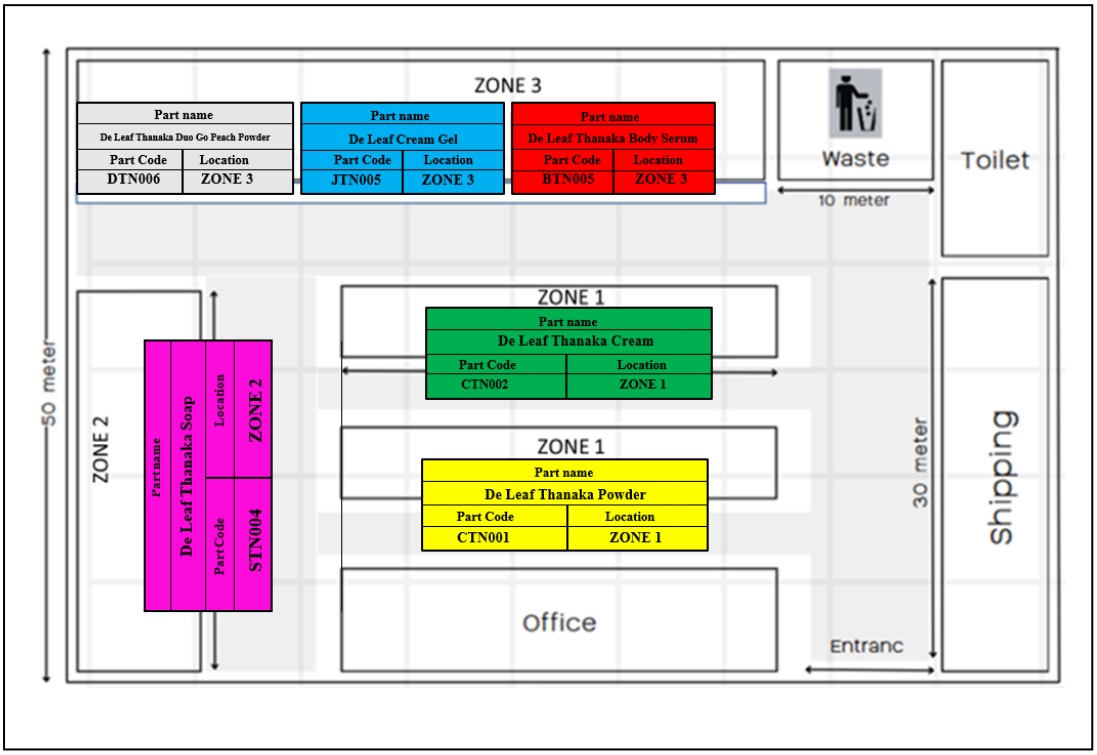

Figure 6 Warehouse layout after improvement

4.2 Creating Signage or Sign Models

This study applied visual control principles to the new warehouse layout, as the previous storage method lacked designated locations for items.

4.3 Creating a Data Storage System using Excel

The researchers created a product database using Excel to improve the efficiency of product searching and inventory management.

4.4 Improving the Workflow of Warehouse Staff

After designing the storage layout, signage, and database system, the researchers analyzed the work processes in accordance with the industrial work study approach proposed by Kanchanapanyakom (2018). The warehouse staff's workflow has been modified by adding product codes and locations to the picking slips. The information from the picking slips was then recorded in Excel. A stock check report was generated using the Excel database, which included item quantities and storage locations, and the report was subsequently printed. The picking process can be summarized using a Flow Process Chart (FPC), as shown in Figure 7, which illustrates the workflow.

Flow process chart

	Activity	Present	Process	Saving	
Activity: Finding product	Operation	2	1	1	
Solution: Present / Propose	Transport	2	1	1	
At: Storage	Delay				
	Inspection				
	Storage				
	Total	4	2		
	Distance (m.)	9	5		
	Time (min)	32.00	8	24.00	

Flow process chart

Activity	QTY DIST m	Time (min)	SYMBOL	REMARKS
Sort and count	3	4.00		
Moving goods	2	4.00		
Total	5	8.00		

Figure 7 Flowchart illustrating the workflow after improvement.

The warehouse inventory process can be divided into two steps as follows:

1. The product sorting and counting process involves searching for items based on the product list.
2. The product delivery process involves transporting the prepared items and verifying the associated information.

4.5 Warehouse Staff Working Hours (After Improvement)

The warehouse data were analyzed using a fishbone diagram to identify the root cause, revealing that the delays occurred in product retrieval and preparation. The problems stem from four main factors: people, area, methods, and products. This study focused on addressing three root causes: area, methods, and products. The issue was addressed by developing a database for warehouse management and implementing strategies to reduce the time required for item searching. The use of operational tools improved warehouse management efficiency. The process of problem resolution and warehouse layout design is consistent with the study by Khaongern (2024) on improving inventory management efficiency. The implementation of signage and data storage in Excel reduced the workflow from four steps - moving obstructing items, sorting and counting, transporting items, and arranging items to only two steps, as shown in Table 7-8.

Table 7 shows the working times of warehouse staff

No.	Sub-tasks	1	2	3	4	5	6	7	8	9	10	Average
1	Sort and count	4	6	3	5	4	3	4	5	6	3	4
2	Moving goods	5	4	3	4	3	4	5	3	4	5	4

Table 8 shows the time spent by warehouse staff on sorting and counting after improvement

No	Time (minutes)		No	Time (minutes)	
	x	x^2		x	x^2
1	4	16	6	3	9
2	6	36	7	4	16
3	3	9	8	5	25
4	5	25	9	6	36
5	4	16	10	3	9
$\sum x$			$\sum x^2$		

Example of time calculation This section demonstrates the time required for warehouse staff to perform sorting and counting tasks.

1. Sample size calculation

$$N = \left[\frac{40\sqrt{n'(x^2-(\sum x)^2}}{\sum x}\right]^2$$

$$N = \left[\frac{40\sqrt{10(197-(43)^2}}{43}\right]^2$$

$$N = 104.7$$

$$N \approx 105$$

2. Calculation of normal time (NT)

$$NT = \frac{\sum_{i=1}^{n} x}{N}$$

$$NT = \frac{4+6+3+5+4+3+4+5+6+3}{10}$$

$$NT = 4.3 \text{ minutes}$$

Note: The sample size calculated using the formula is 105, while the sample size determined by timing is smaller. Therefore, a total sample size of 10 values is used to represent the sample at a 95% confidence level.

3. Calculation of standard time

$$ST = NT + (NT \times AF)$$

$$ST = 4.3 + (4.3 \times 0.1)$$

$$ST = 4.7 \text{ minutes}$$

The analysis and calculation of normal time and standard time after improvement are shown in Table 9.

Table 9 shows the standard times for work processes after warehouse improvement

No	Workflow	Basic time (minutes)	Standard time (minutes)
1	Sort and count	4	5
2	Moving goods	4	4
	Total Standard time	**8**	**9**

4.5.1 Comparison of Results Before and After Improvement

The operational results of this study were evaluated by comparing performance before and after the improvement. The standard time required for item searching prior to the improvement was 36 minutes. After the implementation of the improved procedures, the time required for item searching decreased to 9 minutes. This represents a reduction of 27 minutes, corresponding to a 75% decrease in operational time.

Table 10 Comparison of Operational Results Before and After the Improvement.

Item Lists	Before Improvement(minutes)	After improvement(minutes)	Time Reduction (minutes)	Percentage
Order Picking Time	36	9	27	75.00

Table 11 Summary of Results Before and After Process Improvement.

Before Improvement	After improvement
The analysis of the item searching process in October 2024 revealed delays in searching products. The delays in the searching process were observed on every day when items were prepared according to customer orders.	The analysis of the item searching process in November 2024 indicated that no delays were observed in locating the required items.
A non-fixed storage allocation system results in longer item searching time for warehouse personnel.	A fixed storage allocation system allows warehouse personnel to clearly recognize product locations, resulting in reduced order picking time.
The standard time required for the four-step order picking process before the improvement was 36 minutes.	After the improvement of the order picking process, the procedure was reduced to two steps, resulting in a reduced standard time to 9 minutes.

5. Conclusion

5.1 Summary of Research Results

This section compares the results before and after the improvement.

The researchers identified the root cause of the problem using a Fishbone diagram analysis method. Three main causes of delays were identified: 1) the work area is unsuitable for the task; 2) product searching is time-consuming due to unclear storage locations; and 3) products are scattered due to a lack of designated storage areas. As a result, the warehouse product retrieval process required a standard time of 36 minutes. Therefore, several improvement methods were proposed, consistent with the study by Jitsunthonchaikul (2018) on improving inventory management efficiency, as follows:

1. Define storage areas based on the frequency of use of each product type.
2. Design the warehouse layout and create identifying signage.
3. Develop a data storage system using Excel.

The results of this study can be summarized and compared before and after the improvement as follows: Before the improvement, the operational process consists of four steps: removing obstructing items, arranging and counting the products, transporting the items, and returning them to their original storage locations. The standard time required for product searching was 36 minutes. After the improvement, the operational procedure was reduced to two steps: sorting and counting the items, and transporting products. Consequently, the time required for product searching decreased to 9 minutes, representing a reduction of 27 minutes or 75%.

5.2 Recommendations

5.2.1 The analysis primarily focuses on a single performance indicator. Considering additional operational factors, such as productivity, labor effort, or travel distance would enhance the practical interpretation of the results.

5.2.2 Future research should incorporate information technology systems into warehouse management, such as a Warehouse Management System (WMS), barcodes, and RFID technologies.

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