

PET FOOD INDUSTRY APPLICATION OF LEAN AND ECRS TECHNIQUES TO IMPROVE PROTEIN POWDER DELIVERY PROCESS

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Abstract

This study aimed to improve the product delivery process by focusing on a case study of a protein powder manufacturer in the pet food industry. Various steps in the process were examined, on a questionnaire, participatory observation, and a process flow chart. Pareto analysis was used to evaluate activity value and prioritize issues needing improvement. In addition, the causes of delays in the delivery process were assessed using the Why-Why analysis tool. The ECRS tool was applied to improve the product delivery process. The efficiency of the process was compared before and after this improvement using descriptive statistics. Based on the study result, batch and pooled sample quality analysis steps, along with associated waiting times, accounted for 99.68 percent of the total delivery process duration. The study achieved a 50.29 percent reduction in total delivery process time by improving the quality analysis process to facilitate better communication of results and organizing the sample pickup logistics. This also resulted in a 69.0 percent reduction in time spent on non-value-added (NVA) steps and a 34.61 percent reduction in time spent on non-value-added but necessary (NNVA) steps, along with a 51.02 percent decrease in the amount of minimum cash required to support operations, allowing the company to reallocate working capital toward value-added activities. These improvements enhanced customer satisfaction, as demonstrated by internal audit feedback and the repeat purchase behavior observed during the post-implementation period, indicating a positive shift in service perception.

Keywords: Lean ECRS; Pet Food Industry; Product Delivery Process; Why-Why analysis

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Introduction

In 2022, Thailand was ranked as the world's 6th largest pet food exporter and the 3rd largest exporter of dog and cat food, with an export value of USD 2,803 million, representing 3.36% of global pet food exports a 16.46% increase compared to 2021. The top-five global exporters were the Netherlands, Germany, the United States of America, France, and China, respectively. Specifically, for dog and cat food (HS Code 230910), Thailand was the world's 3rd largest exporter after Germany and the United States, with an export value of USD 2,434 million, accounting for 5.51% of global exports in this category and growing by 19.33% compared to 2021.

According to Beyond Securities (2024), citing data from the Ministry of Commerce, Thailand's pet food export advantages include abundant raw materials, a strong food processing industry and free trade agreements (FTAs) covering over 50% of its major export markets, particularly within ASEAN, where pet food imports from Thailand are duty-free. Thailand has positioned itself country as a leader in innovative pet food manufacturing based on its adoption of advanced food production technologies, such as biotech foods, probiotics, enzymes, and functional ingredients with antioxidant, anti-inflammatory, cholesterol-lowering, and antimicrobial properties. In addition, the industry has expanded into alternative protein sources, including insect protein, seafood protein, and aquamarine products, as well as premium pet food segments.

Protein powder is one of the raw materials for the production of pet foods, with production plants selling their products to customers from both domestic and international markets, such as France, the United States of America, and China. The production plan runs continuously as a joint operation between the manufacturers and customers due to the nature of purchasing products that must meet all quality criteria. At the same time, the plants manage their resources to support production. In 2023, there was a plan to export 60% of production. For protein products, key physical properties in trading are the fineness of the protein powder and its color, while chemical properties include the protein and ash contents, and biological properties involve microbial testing, especially for *Salmonella* bacteria that are pathogens and very dangerous to pets, causing severe diarrhea and even death (Thapthiang, 2023). Therefore, the analysis must be performed by a suitable accredited laboratory that is credible to customers. In the analysis process, the production batches are checked first, followed by selecting the batches that have passed the quality criteria and arranging them as a shipment, where, normally,

20 batches are combined as one shipment. The analysis must mix all 20 batches of samples into a single sample that is sent for further quality analysis as a representative of that shipment. When the quality criteria of both batches and shipments are met, co-ordinated planning determines the delivery of the products. The 2023 customer audit reported of long waiting times for delivery confirmation after the products had been packed, reducing the shelf life of the products from the specified 2 years after the manufacturing date. In addition, the company had to commit cash for the production process before receiving any payments from customers.

Therefore, the current study focused on reducing the delivery time for protein powder products by using a Lean tool to improve and increase the efficiency of the work process. Furthermore, uniquely, in this study, Lean ECRS was specifically applied to bottlenecks in the quality analysis and shipment approval processes in the pet food industry, which has not been clearly addressed in previous research. The developed tool is essential for reducing work processing times and steps, increasing profitability, and enhancing the quality of work. The approach aimed to eliminate waste in the work process and focus on value-added work, with the expected results of reduced delivery times and costs, and increased employee empowerment. In addition, this approach should help to improve work efficiency through a continuous process flow. One of the Lean tools is ECRS (Eliminate, Combine, Rearrange, Simplify), which analyzes and improves the work process by focusing on meeting customer needs for a product of the highest quality and the lowest cost in the least time. Some industries use Lean manufacturing and Work-Study to improve their processes, while in the food industry, the Just In Time concept is used to improve the supply chain. In addition, such concepts have been used with various strategies in the food industry to improve the production process and supply chain.

Recent studies have demonstrated the effectiveness of Lean manufacturing and the ECRS (Eliminate, Combine, Rearrange, Simplify) methodology in enhancing food production and delivery processes by reducing lead times, eliminating waste, and streamlining workflows. Baqleh *et al.* (2024) applied value stream mapping (VSM) to a thyme production line, achieving a 13.6 percent reduction in lead time by removing transport-related inefficiencies. Kittichotsatsawat *et al.* (2025) used VSM, line balancing, and ECRS in a frozen shrimp supply chain, resulting in a 48.8 percent decrease in lead time and a 61.7 percent

improvement in cycle time efficiency. Similarly, Neisyafitri *et al.* (2023) utilized ECRS and Work-Study methods in a chilled beef production line, increasing line efficiency from 46.2 to 79.7 percent by rearranging and reallocating tasks. In a food service context, Delgado-Garcés and Jalire-Machicado (2024) implemented a Lean Service Model in a fast-food restaurant, reducing order cancellations by 36.9 percent and overdue inventory by 45.9 percent through workload balancing and layout optimization. While Suhardi *et al.* (2019) focused on a furniture factory, their use of ECRS and 5W1H to reduce motion waste could offer applicable insights for food logistics, especially in reducing unnecessary handling and improving flow. Collectively, these studies affirmed that Lean and ECRS principles can greatly enhance the efficiency of food delivery systems by targeting non-value-added activities and optimizing process flow without the need for heavy investment.

Materials and Methods

The sample used was a case study of a protein powder manufacturer in the pet food industry, which distributes its products both domestically and internationally. The informants were the seven adult employees involved in the production of protein powder, representing the entire workforce of the factory.

This study involved non-invasive observation and interviews with the seven employees who voluntarily participated after being informed of the study's purpose. No personal or sensitive data were collected and all information was anonymized. As the research posed minimal ethical risk, formal approval was not required; however, general ethical principles were strictly followed.

Procedures

1. The steps in each batch were observed, and recorded, starting from when the products are packed until they are delivered to customers. Data were collected from 60 batches, which were consecutively selected over a specific production period to ensure process consistency and to represent actual operational conditions without sampling bias. The average time spent in each step was summarized.

2. The sequence and number of steps, as well as the associated distances and time spent, were recorded and analyzed using a flow process chart. The analysis encompassed five types of processes,

with each step evaluated to determine whether it constituted value-added (VA), non-value-added (NVA), or necessary but non-value-added (NNVA) activity.

3. The minimum cash amount was calculated that was necessary to sustain business operations prior to the implementation of improvements. Subsequently, corresponding cash turnover was analyzed.

4. Steps that take a long time were prioritized according to the Pareto principle, while important topics were determined as the improvement topics according to the 80:20 principle.

5. Root causes of process inefficiencies were identified through the application of the Why-Why analysis technique, which was subsequently used to develop appropriate improvement guidelines.

6. Feasible improvement strategies were evaluated and implemented according to the Lean ECRS methodology, focusing on the elimination of NVA activities and the enhancement of process flow efficiency.

7. The steps in each batch of products were observed, examined, and recorded, starting from when the products are packed until they are delivered to customers, and the flow process chart was used to analyze the process after improvement.

8. The minimum amount of cash required to operate the business after improvement was calculated and cash turnover was considered.

9. Descriptive statistics were used to compare pre- and post-Lean data, the number of steps, the average total time, and cash turnover.

10. The process improvement results were summarized.

Statistical Analysis Methodology

An independent-samples t-test was applied to compare total process times between two independent groups ($n = 60$ before; $n = 60$ after the Lean ECRS implementation). The mean differences were reported using 95% CI levels.

Results and Discussion

Based on the results from the study of the protein powder delivery process for 60 batches from the participatory interview with the employees, the process could be divided into 20 sub-steps as shown in Table 1, with a total time of 69,966.60 minutes and a total distance of 690.00 meters, including five VA (180 minutes), four NVA steps (32,064.00 minutes), and 11 value-added but necessary steps (37,722.43 minutes), as shown in Table 5.

Table 1. Pre-Lean flow process chart

No.	Working Station	Activity Process	Event	Time (minute)	Distance (meter)	Value analysis		
						VA	NVA	NNVA
1	Packaging	Change the packaging	Operation	10.07	5	×		
2	Packaging	Move the product to wrap area	Transport	2.1	20			×
3	Wrap area	Product label, Wrap plastic and Stretch film	Operation	5.07	5	×		
4	Warehouse	Move product to rack storage	Transport	15.02	40			×
5	Laboratory room	Inhouse quality test	Inspection	60.25	20			×
6	Laboratory room	Prepare analysis sample for third party	Operation	15.03	0	×		
7	Office	Waiting for 3rd party to pick up sample	Delay	5520	0		×	
8	3rd Party analysis	3rd party laboratory quality test	Inspection	18720	0			×
9	3rd Party analysis	Batch sample analysis report	Inspection	15.05	0			×
10	Laboratory room	Wait for 20 batch complete	Delay	9264	0		×	
11	Laboratory room	Pool 20 batch mix sample	Operation	30	0	×		
12	Office	Waiting for 3rd party to pick up shipment sample	Delay	5760	0		×	
13	3rd Party analysis	3rd party laboratory quality test (shipment sample)	Inspection	18720	0			×
14	3rd Party analysis	Shipment sample analysis report	Inspection	15.02	0			×
15	Office	Product COA report	Operation	30	0			×
16	Office	Information to customer about transportation booking	Operation	10	0			×
17	Warehouse	Hold to delivery date	Delay	11520	0		×	
18	Warehouse	Move product from rack to loading area	Operation	120	200			×
19	Office	Shipment document support	Operation	15	2			×
20	Warehouse	Loading products into the container	Operation	120	400	×		

The classification of process activities into value-added (VA), non-value-added (NVA), and necessary but non-value-added (NNVA) categories followed established Lean Manufacturing guidelines (Womack & Jones, 1996).

VA: Activities that directly transform the product in a way that the customer is willing to pay for.

NVA: Activities that consume resources but do not create value (pure waste).

NNVA: Activities that do not directly create value but are necessary under current regulatory, quality, or operational constraints.

The observed VA percentage (0.257%) reflected the nature of the studied process, where most activities involved regulatory quality checks and logistics coordination rather than direct transformation of the product. This was consistent with high-compliance manufacturing sectors (Yin, 2018).

The times spent on various steps were prioritized and considered according to the 80:20 Pareto principle, consisting of the batch quality analysis step at the external analytical laboratory,

the pool quality analysis step of 20 batches at the external analytical laboratory, and the times waiting for the delivery date for 20 batches, as the primary important topics for consideration in improving the Pareto diagram. The analysis resulted in grouping of the steps with similar characteristics of waiting for external analysis results for each batch and for the sample pool. Therefore, these steps were grouped to investigate the causes further. In addition, considering steps 5 and 6, similar work groups were waiting for the vehicle to pick up the samples for analysis. Notably, the times in these six steps accounted for 99.68 percent of the total time; consequently, all three groups of steps were analyzed to identify their components. show in Figure 1.

The causes of the above problem were analyzed using the Why-Why analysis tool to obtain a clearer picture of the phenomena. Then, the survey topic was analyzed to identify the causes by asking the questions shown in Table 2.

According to the analysis, the causes of the delayed product delivery process were:

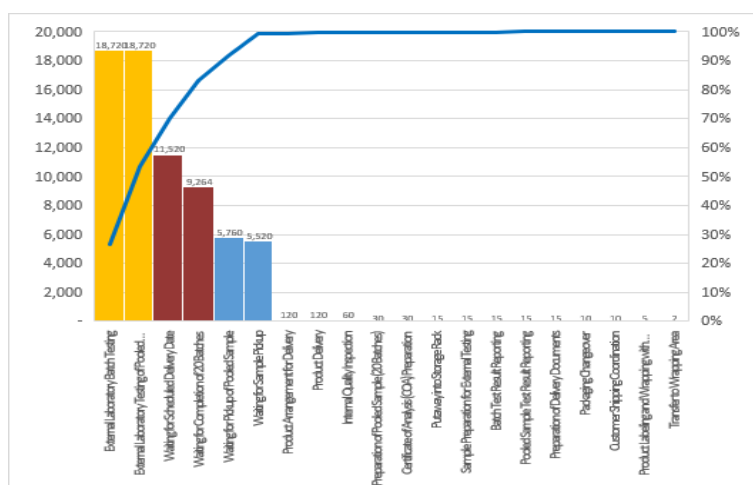
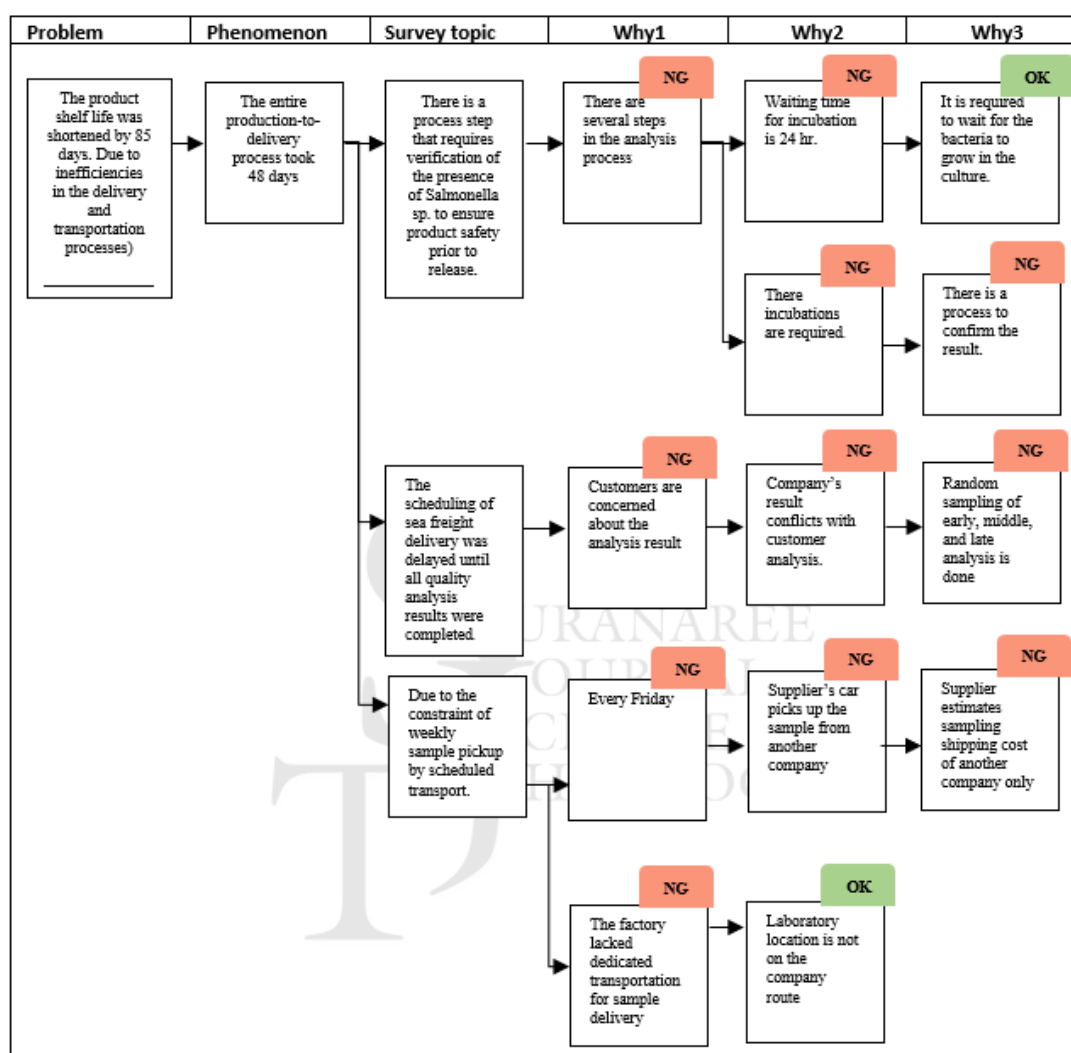


Figure 1. Steps in ordering results for protein delivery, based on Pareto principle

Table 2. Why-Why analysis



1. In the analysis of Salmonella, the analyst had one step to obtain (on the 5th day) and confirm the experimental results. However, the results had to be analyzed and confirmed, so they were only available on the 9th day;

2. On receiving samples for analysis, the analyst assessed the transportation costs. The first phase of the assessment considered the route to collect samples from another company. Therefore, the sample collection round was considered according to the specified round;

3. In each batch, samples were randomly collected at the beginning, middle, and end of production in each batch and then combined to represent the samples for analysis in each batch. However, germs in products may not have been detected based on this sampling procedure.

Improvements to protein powder delivery process

In the context of protein powder production for the pet food industry, major inefficiencies were identified in the external quality assurance and logistics processes. These inefficiencies were addressed using the Lean ECRS methodology, resulting in reduced lead times and improved operational flow. The improvement initiatives were categorized into three activity groups:

Group 1: 3rd Party Laboratory Quality Testing

The original quality control process included a prolonged waiting period for third-party laboratory testing, particularly to confirm the presence of Salmonella species, which took up to 18,720.00 minutes per testing process. The ECRS analysis suggested that full species-level confirmation was not necessary for preliminary decision-making.

Corrective Action: The protocol was modified to allow initial screening results to support release decisions, eliminating the delay caused by extended species confirmation. As a result, product release decisions could be made more swiftly without compromising safety standards.

Group 2: Sampling and Batch Holding result

Two critical delays were identified in this group: 1) There was a 9,264.00-minute waiting period to complete sampling across 20 batches. Previously, samples were collected at the beginning, middle, and end of each batch to ensure representativeness; and An additional 11,520.00-minute delay was incurred while holding the products until the delivery date after sampling.

Corrective Actions: The sampling method was simplified by transitioning from discrete point sampling (beginning middle end) to continuous sampling throughout batch production. This increased the accuracy and consistency of results while reducing labor intensity. In addition, parallel processing was introduced, enabling vessel booking and pooled sample preparation to commence as soon as quality confirmation for the 20 batches was available, rather than waiting for the pooled result.

Group 3: Sample Logistics

Delays due to sample pickup logistics were considerable, with 5,520.00 minutes lost while waiting for third-party pickup of product samples and 5,760.00 minutes required for shipment samples. The original logistics plan failed to account for the new sampling volume from the protein powder facility.

Corrective Action: Annual testing of volume forecasts was utilized to renegotiate the pickup frequency with the third-party laboratory. The frequency was increased from once (Fridays) to twice per week (Tuesdays and Fridays), thereby reducing wait times and aligning sample logistics with operational throughput, as shown in Table 3.

When following the guidelines and observing the delivery process, the number of delivery steps remained at 20. Knowing the results of the germ analysis on the 5th day of the analysis allowed for reductions in the waiting times for pool shipment, from 18,720.00 to 12,960.00 minutes, and in batch processing, from 18,720.00 to 11,424.00 minutes. The customer coordination step for booking a shipping line took less time. The waiting step for the delivery due date was still necessary, and there was still time for this step; however, the time in this step could be reduced from 11,520.00 to 2,280.00 minutes. Increasing the collection of samples for analysis from once to twice a week allowed the sample rounds to arrive at the analysis site more quickly, reducing the time for the vehicle to collect samples for analysis from 5,520.00 to 3,216.00 minutes and the waiting time for the vehicle to collect samples for analysis for the pool sample round from 5,760.00 to 1,441.67 minutes, while the total time for the protein powder delivery process was reduced from 69,966.60 to 34,782.88 minutes, as shown in Table 4 and Table 5.

Table 3. Action plan with ECRS

No.	Activity Process	Time minutes	Survey topic	ECRS	Conceptual corrective action
1	3rd party laboratory quality test	18,720	There is a process step that requires verification of the presence of <i>Salmonella</i> sp. to ensure product safety prior to release.	Eliminate Combine Rearrange Simplify	The presence or absence of <i>Salmonella</i> sp. can be identified without waiting for full species-level confirmation, enabling quicker decision-making.
	3rd party laboratory quality test (shipment sample)	18,720			
2	Wait for 20 completion of batches	9,264	To ensure the representativeness of the sample, specimens were collected from the beginning, middle, and end of each batch	Eliminate Combine Rearrange Simplify	The sampling method was improved from random spot checks (beginning, middle, end of batch) to continuous sampling, enhancing the reliability of results. Vessel booking and pooled sample preparation for external analysis can be initiated immediately after quality results for 20 batches are confirmed, without waiting for pooled sample results.
	Hold until delivery date	11,520			
3	Waiting from 3rd party to pick up sample	5,520	The supplier estimated sample logistics based on the original transportation route, without accounting for the additional samples introduced from the protein powder facility.	Eliminate Combine Rearrange Simplify	Annual testing volume data was used to negotiate an increased sample pickup frequency from once a week (Fridays) to twice a week (Tuesdays and Fridays).
	Waiting from 3rd party to pick up shipment sample	5,760			

Table 4. Comparison of pre-and post-lean times spent in key processes

No.	Activity process	Pre-LEAN Time (minutes)	Post-LEAN Time (minutes)
7	Waiting from 3rd party to pick up sample	5,520.00	3,216.00
8	3rd party laboratory quality test	18,720.00	18,720.00
10	Wait for 20 batch complete	9,264.00	2,400.50
12	Waiting from 3rd party to pick up shipment sample	5,760.00	1,440.67
13	3rd party laboratory quality test (shipment sample)	18,720.00	12,960.00
17	Hold until delivery date	11,520.00	2,880.00

Table 5. Pre-Lean and post-Lean data summary

Event	Unit	Pre-LEAN	Post-LEAN
Operation	Amount	9	9
	Time	355.17	354.92
Transport	Amount	2	2
	Time	17.12	17.03
Delay	Amount	4	4
	Time	32,064.00	9,937.17
Inspection	Amount	5	5
	Time	37,530.32	24,473.77
Storage	Amount	0	0
	Time	0	0
VA	Amount	5	5
	Time	180.17	179.92
NVA	Amount	4	4
	Time	32,064.00	9,937.17
NNVA	Amount	11	11
	Time	37,722.43	24,665.80
Total Distance	Meters	690.00	690.00
Operator	Persons	6	6
Total Process time	Minutes	69,966.60	34,782.88

Conclusions

This study has limitations as it is based on a single-company case, so the findings may not be generalizable to the broader industry. Therefore, the results should be interpreted within the specific context of the studied organization. Future research should involve multiple case studies to enhance generalizability. Considering the protein powder delivery process before and after the improvement using the ECRS tool, NVA and NNVA times were reduced by 69.01% and 34.61%, respectively. This led to an overall process time reduction of 50.29%, with the average total time decreasing substantially from 69,966.60 minutes (SD = 3,767.42, SE = 486.29) before improvement to 34,782.88 minutes (SD = 3,694.49, SE = 476.95) after improvement, as shown in Table 6.

An independent-samples t-test (equal variances not assumed) was conducted to compare the mean total process times between the two independent groups of batches ($n = 60$ before improvement, $n = 60$ after improvement). Based on these results, there was a significant difference between the means (t value = 51.66, $p < 0.001$, 95% CI [33,834.00, 36,532.00]), confirming that the observed reduction was unlikely due to chance. These findings provided strong statistical evidence that the ECRS-based improvements had a substantial and reliable impact on process efficiency, as illustrated in Figure 2.

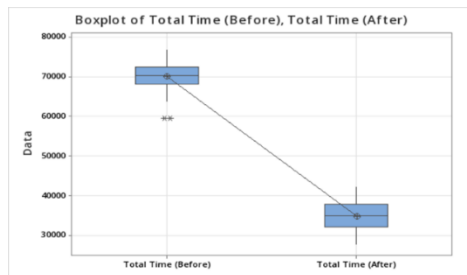


Figure 2. Boxplot of total process time before and after Lean ECRS

Table 6. Efficiency of delivery process time

Group	Pre lean		Post lean		Difference		
	Number of steps	Time (minutes)	Number of steps	Time (minutes)	Number of steps	Time (minutes)	%
VA	5	180.17	5	179.92	-	0.25	-0.14%
NVA	4	32,064.00	4	9,937.17	-	22,126.83	- 69.01%
NNVA	11	37,722.43	11	24,665.80	-	13,056.00	- 34.61%
Total	20	69,966.60	20	34,782.88	-	35,183.72	- 50.29%

Table 7. Reduction in minimum cash requirement for business (based the Pre-Lean amount = 100%)

	Pre-LEAN	Post-LEAN	Difference
Minimum Cash	100.00	48.98	- 51.02

The implementation of Lean ECRS resulted in a 51.02 percent reduction in the minimum cash requirement necessary to support the protein powder delivery process. Due to the sensitivity of financial data, the outcome was presented as a relative percentage rather than absolute monetary values. This reduction in working capital requirements is a notable financial benefit, as it enables the reallocation of excess cash toward more strategic or revenue-generating activities. Consequently, the organization can enhance liquidity, improve financial flexibility, and potentially reduce opportunity costs associated with idle capital, as shown in Table 7.

Despite the fact that the post-implementation measurements suggested significant reductions in the processing time and currency requirements, follow-up data beyond the immediate implementation period were not collected. However, early internal audits at three months post-implementation continued to identify reduced delays, suggesting potential sustainability of the improvements. Longer-term monitoring is recommended.

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