Streamlining Packaging and Raw Material Handling in Pharma Manufacturing using Data Driven Analysis

A Final Submission report for the BDM capstone Project

Submitted by

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Content:

1 Executive Summary:

This project was carried out at **Carewell Steuart Pharma Private Limited**, a medium-scale pharmaceutical company located in Kakkalur Industrial Estate, Thiruvallur District, Tamil Nadu, that manufactures tablets and supplies them to the Tamil Nadu Government. The project was aimed to analyse two key operational inefficiencies observed during the production and dispatch of Frusemide Tablets IP 40 mg across 11 batches manufactured in the year 2024. The first problem statement focused on delays in dispatch due to carton handling and packing inefficiencies, while the second addressed gaps in raw material usage post-QA (Quality Assurance Department) approval and associated losses.

The data used in this study was collected from physical **Batch Manufacturing Records (BMRs)** maintained by the company. These records were digitized and cleaned using **Microsoft Excel**, and all analysis were performed using Excel's functions and charting tools and Python pandas and matplotlib. The dataset included information on batch dates, packing material usage, yield %, raw material quantities, and process gaps. Descriptive statistics and delay analyses were conducted to extract meaningful insights. Some graphs were also created using **Python** for deeper comparisons of raw material usage.

The findings revealed an **average dispatch delay of 4.3 days**, with one batch experiencing a delay of **14 days**, which could be treated as an **outlier**. This indicates that while dispatch timelines are generally manageable, there is still considerable **inconsistency in scheduling**, potentially due to the delayed arrival of packaging materials or inadequate planning. In terms of packaging material usage, the analysis showed a **consistent trend of under-consumption** when compared to the quantities initially planned. This may point to **buffer-based overordering** or inefficiencies in estimation during procurement.

For raw material handling, only **18% of the batches** used materials on the **same day of QA approval**, while the remaining batches experienced **delays ranging from 2 to 4 days**. Such lags suggest a lack of synchronization between QA clearance and production readiness, which can contribute to **inventory pile-up and cold storage overheads**. Despite these delays, the **average manufacturing yield remained high at around 98%**, which indicates good overall process execution. However, **compression losses**, though not excessive, were present in most batches and had a **mild but noticeable impact on the yield percentage**, hinting at possible room for optimization in that stage of production.

Based on these findings, **recommendations** include better synchronization between production and dispatch planning, tracking carton arrival timelines, improving real-time usage of raw materials, and reducing buffer-based overestimations. These changes can help optimize operations and reduce idle time and inventory cost. However, ⚠️ **profit or cost savings could not be quantitatively estimated** due to the company's policy of not disclosing financial figures, as it is a government-contracted facility.

Overall, this report provides a structured, data-driven analysis of operational gaps and suggests actionable improvements within the limits of available data access and the author's technical background.

2 Detailed Explanation of Analysis Process/Method:

2.1 Tools and Environment

For this project, Microsoft Excel was used as the primary tool for all stages of analysis.

i. The data collected from physical Batch Manufacturing Records (BMRs) was first digitized and organized in structured Excel sheets.

ii. Excel functions such as AVERAGE, MAX, MIN and STDEV were used to derive descriptive statistics.

iii. All graphs and charts in the project were created using Excel's built-in chart tools (bar charts, line charts, and comparison visuals) and python pandas and matplotlib.

iv. The use of Excel was appropriate given the size of the dataset and the familiarity of both the analyst and organization with the tool.

⚠️ Note: The company is engaged in supplying to a government organization and, due to confidentiality agreements and internal policy restrictions, is not authorized to disclose profit and loss details externally.

2.2 Data Cleaning and Preprocessing

All batch records were originally in physical format as handwritten BMRs. These were manually transcribed into Excel. Dates like Manufacturing Date, Dispatch Date, QA Approval Date, etc., were standardized into DD-MM-YYYY format. Missing or inconsistent values (such as same-day dispatch and packing) were treated as a 0-day delay for calculation consistency.

For each batch, a unique row was created in the Excel sheet, with clear column headers for all relevant operational metrics. The raw material usage sheet (PS 2-2) had many entries per batch. To maintain clarity, materials were structured batch-wise across rows with columns for each material.

Data quality was ensured by cross-verifying a sample of 3–4 entries per batch against the original scanned BMRs.

2.3 Analysis Method – Problem Statement 1: Packaging Carton Delays

Objective:

To analyze how delays in dispatch occur due to packaging carton availability and identify how material usage efficiency might impact timelines.

Step-by-Step Process:

i) Dispatch Delay Calculation

Dispatch Delay is defined as (Dispatch Date - Packing Date). For all 11 batches, this value was calculated to understand the time gap between the end of production and when goods were dispatched.

ii) Descriptive Statistics

Calculated the average delay, minimum and maximum delay, and standard deviation using Excel. Batches with 0-day delay were counted separately to identify best-case scenarios.

iii) Packing Material Usage Analysis

Compared Quantity Required vs Quantity Used for key materials.

→ Printed Foil, Plain Foil, Carton Boxes, and Shipper Boxes.

Identified whether underuse or overuse trends existed.

iv) Yield and Strip Packing Loss

Yield % = (Actual Yield ÷ Theoretical Yield) × 100.

Strip packing loss (in kg) was recorded from reconciliation sheets.

v) Insights Derived

Linked delay patterns with packing material mismatch and packing loss.

Why This Method is Appropriate:

Descriptive analytics like averages, variance, and yield are appropriate for structured, historical data where the goal is to identify operational inefficiencies, not make forecasts.

2.4 Analysis Method – Problem Statement 2: Raw Material Usage Gaps

Objective:

To understand the delay between QA-approved raw material and its actual use in production, and whether this impacts efficiency.

Step-by-Step Process:

i) 'Approval' to 'Usage' Delay Calculation

Usage Gap = (Raw Material Usage Date – QA Approval Date). This was calculated for each batch to see how long approved materials waited before being used.

ii) Statistics on Delay

Min, Max, Avg, Standard deviation of delay values was calculated. Counted no. of batches with a 0-day delay to check real-time consumption feasibility.

iii) Yield and Compression Loss Review

Compared delay durations with yield percentages and compression loss (in kg) to see if there was any correlation.

iv) Material Matching Analysis

In the PS 2-2 sheet, Quantity Required vs Quantity Used was compared for each raw material. Slight under-usage in some ingredients was observed across batches.

v) Inventory Handling Insight

The delay in usage can put pressure on storage (especially for sensitive materials), and inconsistent material handling could affect future stock rotation.

Why This Method is Appropriate:

Simple delay tracking and variance checking are sufficient to uncover planning and consumption inefficiencies in a non-predictive context.

2.5 Summary of Methodology

The analysis used a straightforward, systematic method to transform handwritten batch records into actionable insights.

- Excel was used for all cleaning, organizing, calculation, and visualization needs.
- The two core problems dispatch delay and raw material overstocking were broken down using date-based analysis, material usage checks, and yield tracking.
- No predictive or advanced statistical modeling was required since the focus was purely diagnostic.

→ This approach ensures that the results are interpretable by both technical and non-technical stakeholders and can directly inform improvements in the company's production and dispatch processes.

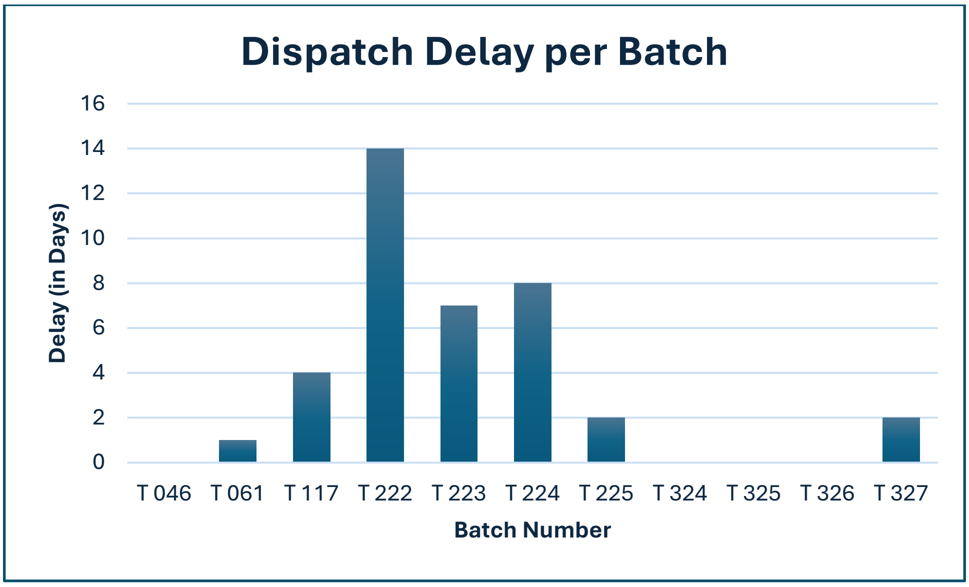
3 Results and Findings:

3.1 Results and Findings for Problem Statement 1 - Packaging Carton Delays

Recap:

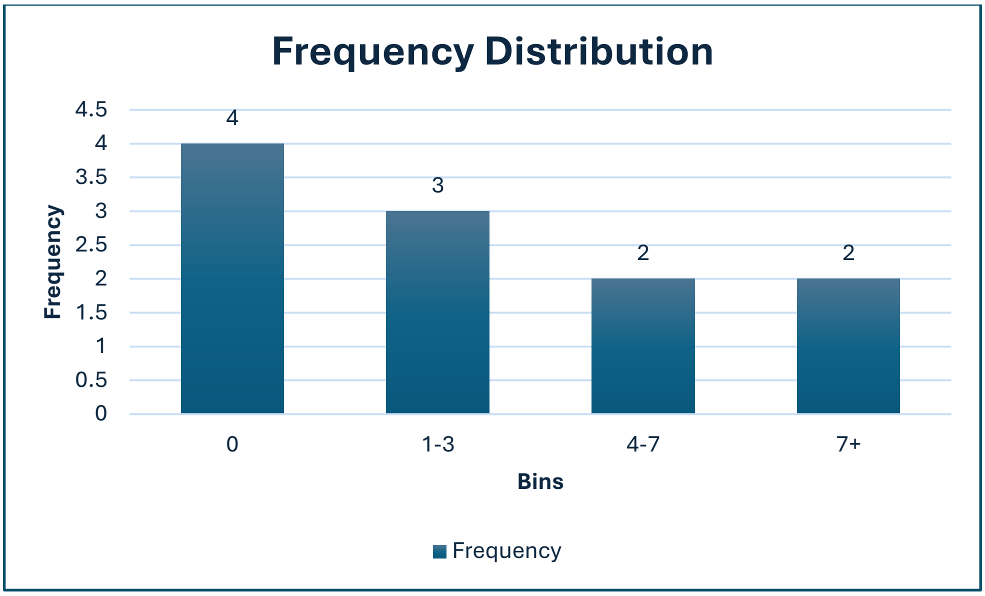
This section analyzes the delays between packaging completion and dispatch of Frusemide Tablets IP 40 mg for 11 batches manufactured in 2024, using batch-level operational data extracted from BMRs. The goal is to understand how carton availability affects dispatch, quantify the delays, and examine related yield or packing inefficiencies.

Figure 1: Delay (in days) between packaging and dispatch across 11 batches



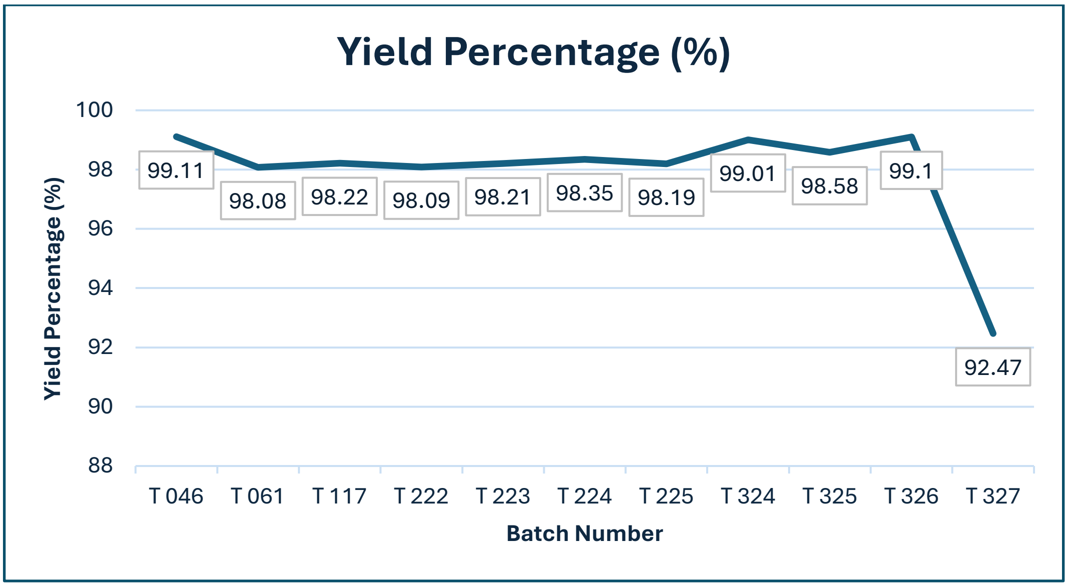
This bar chart shows the number of days delayed between packing and dispatch. While 4 batches had no delay (0 days), others had delays ranging from 2 to 14 days. Batch T-046 had the highest delay of 14 days. This inconsistency could be due to the late arrival of packaging cartons, storage bottlenecks, or misalignment in dispatch planning.

Figure 2: Frequency distribution of dispatch delay durations



Most batches experienced a delay of 1–3 days, while 36% (4 out of 11) had no delay. However, 2 batches had a delay of over 7 days. This variation suggests a lack of uniformity in dispatch readiness and highlights potential storage space wastage for finished goods.

Figure 3: Yield percentage observed across 11 batches



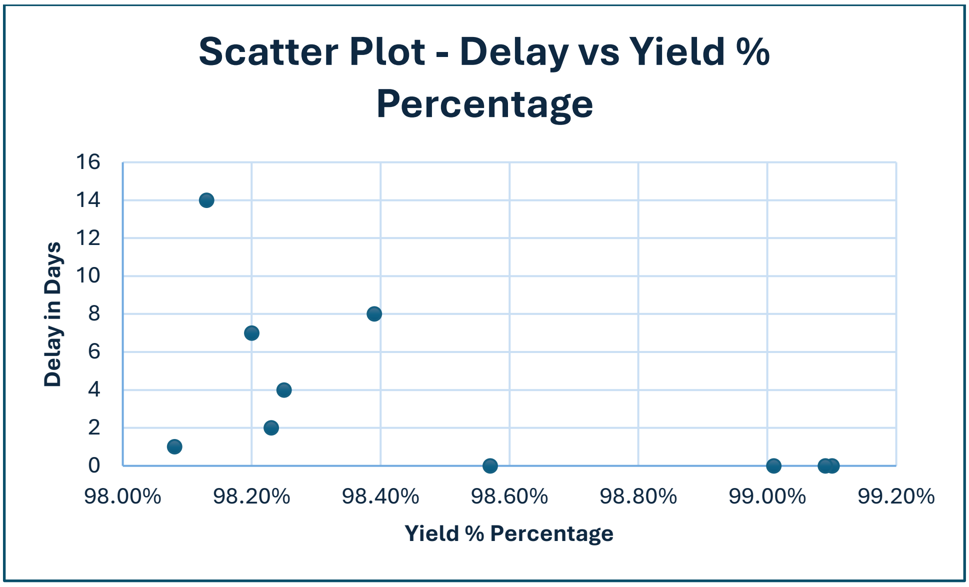
Yield remains consistent across batches (except the 1 outlier), ranging around 98.5%, with an average of 97.96%. While the high yield indicates good manufacturing performance, delays in dispatch don't appear to affect product quality but may affect warehouse turnover and delivery timelines.

Figure 4: Comparison of avg packaging material quantity required and used

Material	Avg. Required	Avg. Used	Difference
Printed Foil	150.76 kg	145.48 kg	-5.28 kg
Plain Foil	150.77 kg	146.35 kg	-4.42 kg
Carton Boxes	37,648 nos	37,139 nos	-509
Shipper Boxes	188.82 nos	186.09 nos	-2.73

This table shows that actual usage of materials is slightly less than required, possibly due to estimation buffers or minor wastage. The difference in carton count (~500 per batch) may impact inventory or dispatch preparation if not accounted for, especially in large-scale manufacturing.

Figure 5: Scatter Plot – Delay vs Yield %



Excluding one outlier batch with a significantly low yield (92%), a slight correlation is observed between higher yield percentages and same-day packing and dispatch (0-day delay). Batches with delayed dispatch tend to have marginally lower yields. However, as the analysis is based on limited data (11 batches of a single product over one year), this observation is not conclusive.

Summary:

The analysis of 11 batches shows that dispatch delays are a recurring issue, with an average delay of 4.3 days and a maximum of 14 days. About 36% of the batches experienced no delay, while the rest showed inconsistencies in dispatch timelines. Although manufacturing yield remains high at approximately 98%, the analysis of packaging material consumption reveals that the actual quantities used are consistently lower than the quantities planned. This underconsumption suggests a trend of over-ordering or buffer estimation issues.

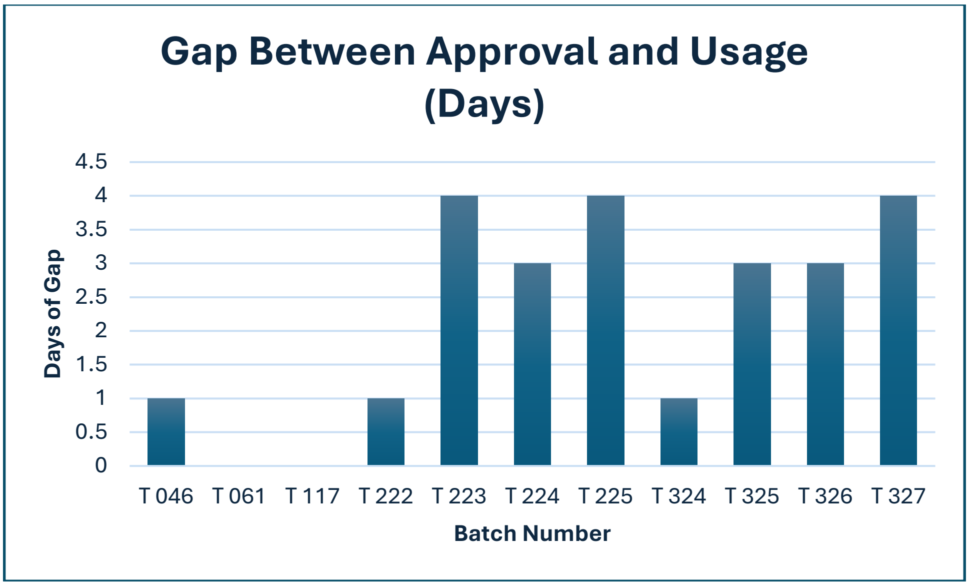
These patterns reflect operational inefficiencies that could lead to unnecessary inventory build-up, storage congestion, and higher handling costs. Improving carton procurement planning and aligning dispatch schedules more closely with production timelines could help streamline post-production logistics and reduce inefficiencies.

3.2 Results and Findings for Problem Statement 2 - Packaging Carton Delays

Recap:

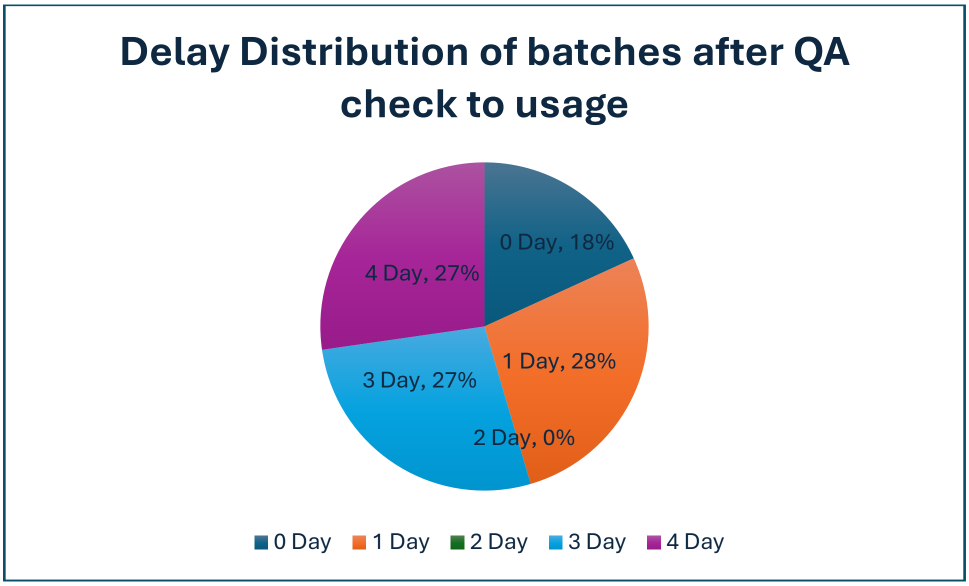
This section analyzes the delays in utilizing raw materials after QA approval and examines inconsistencies in the quantities dispensed for 11 batches of Frusemide tablets manufactured in 2024. Using batch-level operational data extracted from BMRs, the objective is to understand inefficiencies in raw material handling processes, quantify usage delays, and identify potential process gaps that may impact production efficiency or material accountability.

Figure 6: QA Approval vs Usage Delay (per Batch)



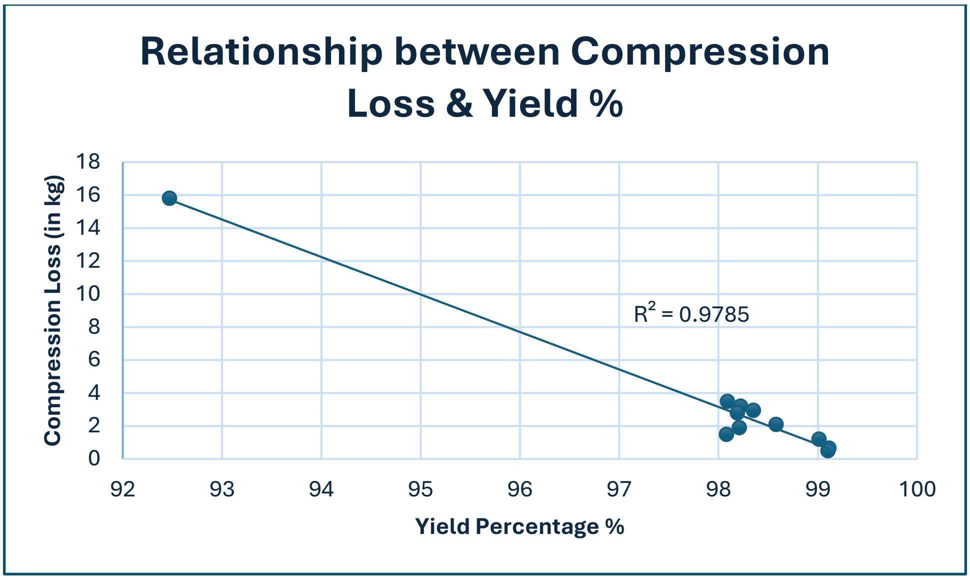
This chart visualizes the number of days between QA approval and actual raw material usage across 11 batches. Most batches exhibit a 2–4 day lag, while only two batches had immediate (0-day) usage. The inconsistency suggests there is scope to streamline raw material movement post-approval.

Figure 7: Pie Chart – % of Batches by Usage Delay



The pie chart illustrates how quickly raw materials are used after QA clearance. Only 18% of batches are used on the same day (0-day delay), while a significant 54% experience usage delay of 3 day or more. Such delays can increase cold storage costs and lead to inventory accumulation, highlighting a potential inefficiency in the material usage workflow.

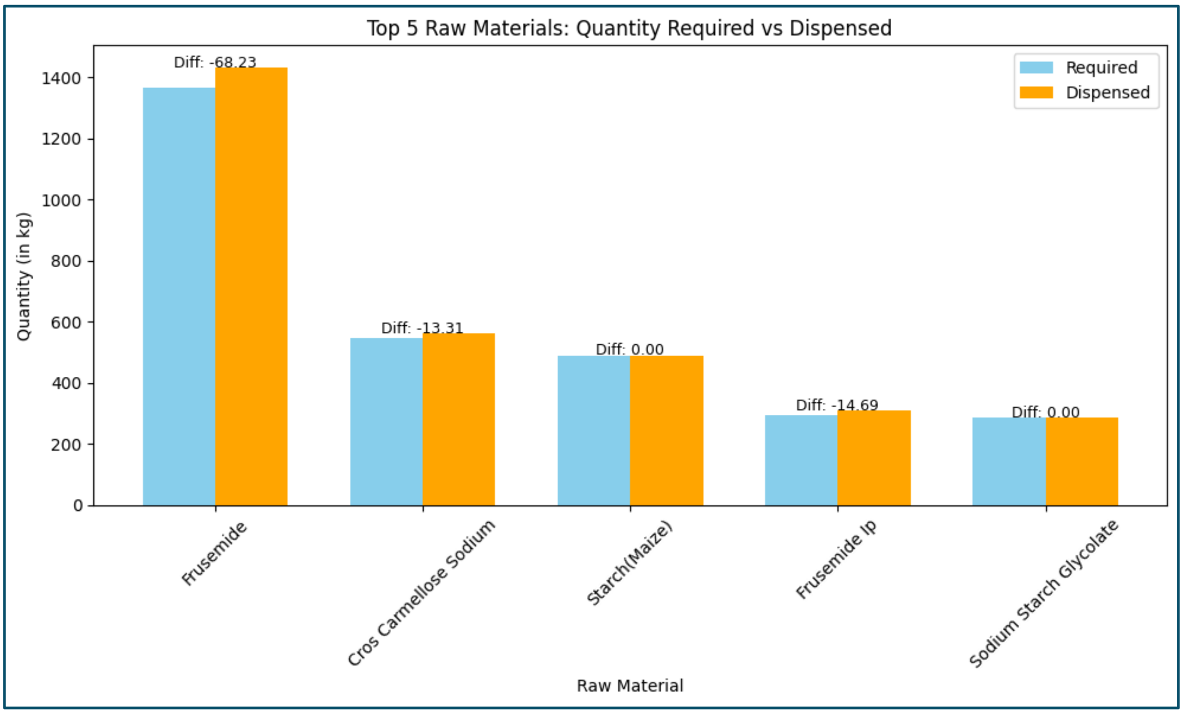
Figure 8: Relationship between Compression Loss and Yield %.



The scatter plot compares compression loss (kg) with the corresponding yield percentages across batches. A negative correlation is observed, indicating that batches with higher compression loss consistently show reduced yield efficiency.

Even though the number of data points is limited, the trend clearly suggests that yield percentage decreases as compression loss increases as we have a high R^2 score, highlighting the impact of compression stage inefficiencies on overall output.

Figure 9: Top 5 Raw Materials – Quantity Required vs Dispensed (Using Python):



This chart presents the top five raw materials based on total quantity required across 11 batches of Frusemide Tablets IP 40 mg. Each material shows both the planned (required) and issued (dispensed) quantities, with a difference label displayed above each pair. The chart was generated using a custom Python script for efficient data grouping and visualization. The observed differences, although mostly small highlight minor underestimations or dispensing variations, which may stem from buffer planning, rounding practices, or manual entry variations.

Summary:

The analysis of raw material usage patterns revealed notable inefficiencies in how materials are handled post-approval. Delays between QA clearance and actual usage were observed in most batches, pointing to opportunities for better coordination between Production and QA department in production scheduling. Additionally, minor differences between required and dispensed quantities across multiple raw materials suggest inconsistencies in planning. These findings highlight process gaps in raw material management that, if addressed, can improve inventory turnover, reduce storage strain, and maintain consistent production efficiency.

3.3 Comparative Overview

While both problem statements stem from operational inefficiencies, they impact different stages of the manufacturing lifecycle. Problem Statement 1 focuses on delays after production, specifically between packing and dispatch, which affects downstream logistics, turnaround time, and customer delivery schedules. In contrast, Problem Statement 2 targets upstream inefficiencies, such as raw material overstocking and delays in usage post-approval, which may lead to increased storage cost and potential material wastage.

Figure 10: Comparative Overview Table

Aspect	PS 1: Packaging Delay	PS 2: Raw Material Handling
Focus Area	Post-production (Packing to Dispatch)	Pre-production (QA Approval to Usage)
Key Issue	Carton arrival & dispatch date misalignment	Delay in raw material usage & overstocking
Avg Delay	4.3 days from packing to dispatch	2.18 days from QA approval to usage
Efficiency Impact	Inventory buildup, late delivery	Storage strain, reduced yield potential
Insights Derived	Underconsumption of packing materials	Minor quantity mismatches, usage delay
Visual Evidence	Delay bar chart, material comparison	Approval–usage lag, yield vs. loss trends
Improvement Suggestion	Better dispatch planning & buffer stock	Real-time tracking & usage prioritization

4 Interpretation of Results and Recommendation:

The analysis of operational data from 11 batches of *Frusemide Tablets IP 40 mg* revealed process-level inefficiencies across both upstream (raw material handling) and downstream (dispatch delays) stages of manufacturing.

In **Problem Statement 1**, dispatch delays were a recurring issue, with an average lag of 4.3 days and a maximum of 14 days between packing and dispatch. These inconsistencies highlight weaknesses in coordination between production completion and dispatch readiness. Additionally, discrepancies between planned and consumed packaging material quantities suggest conservative buffer estimation or underutilization, potentially leading to increased material holding cost and procurement misalignment.

In **Problem Statement 2**, the average delay between raw material QA approval and actual usage was 2.18 days, with only 2 out of 11 batches utilizing materials immediately. This indicates inefficiencies in production planning or inventory rotation. The compression loss trend showed a mild inverse relationship with yield percentage, implying that delays or handling issues might have indirect consequences on output quality. Minor mismatches between quantity required and dispensed across raw materials further reinforce the need for tighter control and documentation in pre-production planning.

Overall, the insights show that although the yield and quality of the final product are stable, underlying inefficiencies exist in material movement, timing, and resource planning.

Recommendations:

The following **SMART (Specific, Measurable, Achievable, Relevant, Time-bound)** recommendations are proposed to improve process performance:

4.1 For Problem Statement 1 – Packaging Delay:

i) **Set Minimum Buffer Stock Thresholds**

- Define minimum levels for cartons, foils, and shippers based on average monthly consumption.
- *Impact:* Prevents delays due to last-minute shortages.

ii) **Link Packing and Dispatch Planning**

- Align dispatch scheduling with final packing date through a shared sheet between production and dispatch departments.
- *Impact:* Reduces idle storage and ensures timely customer deliveries.

4.2 For Problem Statement 2 – Raw Material Usage

i) **Standardize Quantity Dispensing Practices**

- Introduce tolerance thresholds for required vs. dispensed material to identify over/under-issuance.
- *Impact:* Ensures accountability and better resource tracking.

ii) **Digitize Material Movement Logs**

- Replace handwritten movement records with Excel-based logs across batches.
- *Impact:* Reduces data entry errors and supports analysis readiness.

Expected Outcome:

By following these recommendations, the company can:

- Reduce average dispatch delay from 4.3 to below 2 days.
- Minimize overordering of packing materials by 3–5%.
- Improve raw material turnover efficiency, reducing delay to <1 day.
- Enhance traceability of raw material usage and packaging trends.

These changes can ultimately lead to faster delivery cycles, lower inventory holding costs, and a more agile manufacturing process all of which align with the organization's goals of operational excellence and regulatory compliance.

With a background in computer science and data analytics, my observations are derived exclusively from the operational data shared. The recommendations presented are data-driven and intended to highlight potential areas for efficiency improvement. However, they should be reviewed and validated by pharmaceutical domain experts for better improvement in the industrial process.

Conclusion:

This project aimed to identify operational inefficiencies in packaging and raw material handling using internal production data from Carewell Steuart Pharma Pvt. Ltd. Through systematic data extraction and analysis of 11 batches of Frusemide Tablets IP 40 mg, key patterns and delays were identified that impact dispatch timelines and raw material usage. While the insights and recommendations provided are based on data analysis techniques using Excel, they are intended to support informed decision-making within the company's operational workflows.

Although domain-specific decisions must be taken by the pharma experts, this study demonstrates how even basic data management tools can uncover actionable trends within routine manufacturing records. With better digital tracking and cross-departmental coordination, the company can continue improving its production agility and overall efficiency. This submission marks the culmination of my Business Data Management capstone project and reflects both analytical learnings and practical understanding gained through industry exposure.

---------------End of the report--------------