Revamping Hill Brother's Packaging Area

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Abstract *— This paper addresses the challenges faced by (Hill Brothers), a fruit and vegetable distribution company, particularly in its (packaging operations). Issues such as a lack of performance indicators, underutilization of machinery, and (manual processes) hinder (efficiency). Employing (DMAIC methodology) (Define, Measure, Analyze, Improve & Control), the study aims to enhance the efficacy and efficiency of Hill Brother's packaging area. This involves assessing current processes, identifying areas of improvements, and implementing specific solutions. Objectives include creating performance (Dashboards), applying (Lean Six Sigma principles), managing change, and providing staff training. The results demonstrate significant improvements, including reduced labor costs, better machinery utilization, and increased production. Hill Brothers benefits from automated packaging solutions and (standardized operating procedures), enhancing long-term operational excellence and market competitiveness.*

Key Terms *— Automated Packaging, DMAIC Methodology, Lean Manufacturing, and Packaging Efficiency*

INTRODUCTION

One of the major fruit and vegetable distributors to the wholesale and retail markets, Hill Brothers, a family-owned company, has a lot of obstacles in its packaging processes. These difficulties include the company's reliance on human procedures, underuse of machinery, and lack of Key Performance Indicators (KPI's) all of which make it more difficult for it to remain efficient and competitive in the ever-changing market. To address these issues, Hill Brothers started a redesign of its packaging division with the goal to improving effectiveness and efficiency by putting focused interventions and initiatives into place.

This study aims to explore the complexities of Hill Brother's packaging operations, evaluate the existing plans into action to promote operational excellence, through a systematic and methodical adoption of the DMAIC methodology (Define, Measure, Analyze, Improve & Control), the study seeks to enhance productivity, streamline processes, and optimize packaging procedures.

In this Introduction, we will give a summary of the main problems that Hill Brothers is facing in the packaging operations, talk about how important it is to solve these problems, and lay out the methodology and goals of the research. We will also go into additional subtopics that will be addressed in later sections, like the value of staff training and development, the implementation of Lean Six Sigma principles, the significance of Change Management, and the significance of Performance Dashboards.

By means of an all-encompassing evaluation and execution strategy, Hill Brothers aims to attain a concrete enhancement in its packaging processes, which will ultimately lead to reduced labor costs, optimized machinery use, and increased productivity. In the end, these developments will boost the business's competitiveness and long-term success. As Shigeo Shingo noted, "The most dangerous kind of waste is the waste we do not recognize". This quote serves as a reminder of the importance of identifying inefficiencies and waste within the packaging processes to drive meaningful improvements. Other topics that will be discussed in this research are the following.

Importance Of Dashboards

The significance and importance of performance Dashboards in business operations cannot be overstated.

- Discuss the significance of performance Dashboards in enabling data-driven decision-making.
- Explore how performance Dashboards can provide insights into operational metrics and facilitate continuous improvement.

Application Of Lean Six Sigma Principles

Utilizing Lean Six Sigma principles is essential for optimizing processes and enhancing efficiency.

- Describe how Lean Six Sigma principles might be used to reduce inefficiencies and streamline packaging processes.
- Discuss how Lean Six Sigma methodologies can help identify and prioritize improvement opportunities.

Role of Change Management

Change management is crucial for ensuring smooth transitions and organizational readiness.

- Emphasize the role that Change Management plays in promoting organizational preparedness and easing transitions.
- Discuss strategies to deal with change and get past people's opposition to new projects.

Importance Of Employee Training

Investing in employee training is vital for developing skills and fostering continuous improvement.

- Examine how staff development and training affect the packaging team's ability to improve skills and capacities.
- Talk about how training initiatives may support an innovative and continuous improvement culture.

METHODOLOGY

As it assists in identifying problems inside an organization, a diagnostic is a crucial stage in every project. It involves observation, identification, and analysis to establish connections between relevant variables. In this case, a Lean assessment was used to evaluate the company's operations and determine indicators related to cost, quality, and timelines. Lean assessments are based on the "Genchi Genbutsu" approach which means going to the source to check the situation for yourself and emphasizes Gemba processes, a Japanese word meaning "where reality is". The Gemba walk is an activity for Managers which consists of going into the field to look for waste and opportunities for improvement that are at the origin of added value. [1]

This chapter provides a thorough explanation of the study project's methodology, with a focus on the DMAIC technique. DMAIC is utilized as a methodical and organized methodology that is the foundation for supporting ongoing improvement in Hill Brother's packaging processes. This methodological framework, which starts with define and ends with control, directs the five major phases that are executed one after the other. By using a scientific approach, DMAIC makes it easier to examine and optimize the packaging processes to improve overall performance and operational efficiency.

DMAIC Methodology Overview

The DMAIC methodology provides a framework for problem-solving and process improvement, guiding the process through five key phases. This process ensures continuous improvement and has proven to be highly beneficial for numerous organizations.

- **Define Phase:** This stage outlines project's scope, objectives, and goals, while pinpointing problems and establishing success metrics.
- **Measure Phase:** Data is gathered to establish a baseline performance of current packaging processes, identifying KPI's to quantify issues.
- **Analyze Phase:** Collected data undergoes analysis to pinpoint root causes of inefficiencies and bottlenecks, utilizing

techniques like fishbone diagrams and statistical analysis.

- **Improve Phase:** Focuses on generating and implementing solutions, this phase addresses identified root cause leveraging experimentation and statistical techniques to optimize packaging processes.
- **Control Phase:** This final stage involves implementing measures to sustain improvements achieved in the Improve phase. It establishes Procedures and monitoring mechanisms to ensure continued adherence to optimized processes.

The DMAIC problem-solving methodology has been selected to improve packaging processes in Hill Brothers. Figure 1 demonstrate all the stages of the DMAIC methodology in Hill Brothers.

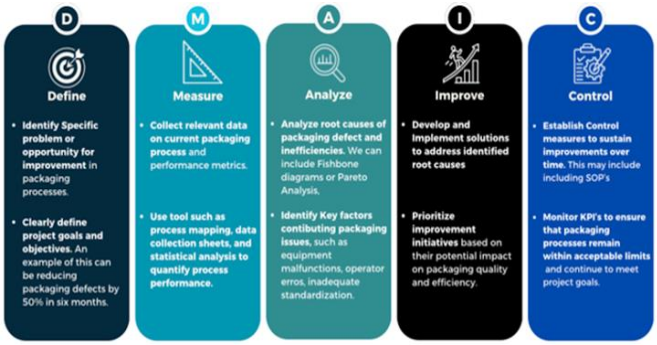

Figure 1
DMAIC Problem Solving Methodology

DMAIC Implementation

Each step of the DMAIC technique must be carried out methodically in order to ensure complete analysis and effective improvement implementation. The following describes how each stage was used in relation to Hill Brother's packaging operations.

DMAIC Define Phase

The project's goals and scope were well-defined during this early stage. Improving the efficacy and efficiency of Hill Brother's packaging processes was the main objective. Important issues were excessive labor expenses, manual procedures, machinery underuse, and a dearth of performance measures. The optimization project's goals, stakeholders, timetable, and scope were all outlined in a project charter. Through the establishment of precise objectives and success criteria, this phase laid the groundwork for the entire project. "The SIPOC methodology provides a structured approach for identifying the Suppliers, Inputs, Processes, Outputs, and Customers involved in a given process, enabling organizations to gain clarity and insights into their operations" [2]. Figure 2 demonstrates SIPOC model illustrating the key elements of Hill Brother's packaging operations.

Figure 2
SIPOC for Hill Brothers Operations

In order to determine the current packaging procedures baseline performance, data was gathered during the Measure phase. The identification and measurement of key performance indicators (KPI's), as demonstrated in Figure 3, included manual picking time, error rates, scrap rates, and machinery utilization rates. Tools and data gathering forms were used to accurately capture pertinent data, including Fishbone diagrams and t-test analysis. This stage served as a foundation for additional investigation by offering insightful information on the packaging operations status. Data was collected from the current Packaging process to understand the baseline performance of the process. Table 1 represents the studied variables and Key performance indicators measured to find solutions and improvement to them. Another challenge faced by Hill Brothers, aside from the lack of standardization in the packaging area, was the absence of Dashboard or centralized data for the Management Team, hindering effective decisions.

Table 1
Data Collected from Current Packaging Operations

Studied Variable	Result
Overtime Hours in %	3.93 % per Month
Overtime Hours in $	$1,000 per Month
Packaging Operators in Manual Tomato Process	7.5 Operators
Average Hourly Rate of Packaging Area	$9.52 per hour
Monthly Packaging Area Waste	3.5 % per Month
Hourly Output of Actual Manual Process	17 Cases per hour
Daily Operating Machine Hours	1 hour per day

Figure 3
Packaging Area Dashboard for Data-Driven Decisions

DMAIC Analyze Phase

In the analyze phase we identified the underlying reasons of inefficiencies and bottlenecks in the packaging operations by carefully examining the data that had been gathered. To determine the causes of packing inefficiencies, such as ineffective workflow design, a lack of automation, and inadequate training, brainstorming sessions and statistical methods like Fishbone diagrams, Spaghetti diagrams, and t-test analysis were employed. Opportunities for improvement were ranked according to how they would affect important performance indicators. The foundation for creating focused remedies to address found core causes was established at this phase. The Fishbone diagram customized for Hill Brothers activities is shown in Figure 4, referencing significant variables elucidated within the diagram.

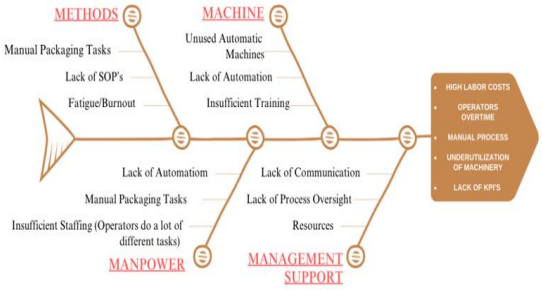

Figure 4
Fishbone Diagram for Operations

Among the significant variables identified were the reliance on manual packaging tasks, the absence of standardized procedures, and the prevalence of fatigue and burnout among our workforces. Additionally, the lack of automation, insufficient staffing levels, and the tendency for operators to multitask emerged as notable contributors to Hill Brothers challenges. Furthermore, the underutilization of available machinery, coupled with inadequate training, underscored the importance of addressing machine-related variables. The absence of established methods, the reliance on manual packaging chores, and the frequency of weariness and burnout among our staff were among the important characteristics that were identified. "Identification of significant

variables within the DMAIC methodology, as depicted in the Fishbone diagram, illuminates key factors contributing to process inefficiencies and bottlenecks, facilitating targeted interventions for organizational improvements." [3]

The t-test analysis was introduced in the Analyze phase to dig deeper into the specifics of our packaging processes. We were able to evaluate the variation across several factors and pinpoint any noteworthy distinctions between them thanks to this statistical technique. The t-tests gives important insights into the elements causing inefficiencies and bottlenecks in our processes by evaluating the data. For this test we took the total time required for packaging operations using manual methods versus the Gold Pack model TTK 550000 machine. For manual packaging operations, we evaluated the time total time taken to package 100 crates of fruits, wrap 200 individual packages, and label and seal 50 boxes manually. In the other part, for machine packaging operations using the Gold Pack model TTK 550000 machine, we analyzed the same tasks but on the manual side, the only thing did by operators were the input of the fruits to the machine. We took 5 samples of both operations and took the total time to complete all the tasks represented in Table 2.

Table 2
Time Taken to Complete Operations

No. of Sample	Manual Operations (Minutes)	Gold Pack TTK 55000 (Minutes)
1	298	154
2	303	153
3	293	152
4	300	155
5	295	153

Null Hypothesis (H0) = There is no significant difference in the time taken to complete packaging tasks between manual and machine packaging methods.

$$H0 : \mu1 = \mu2 \quad (1)$$

Alernative Hypothesis(H1) = There is a significant difference in the time taken to complete packaging tasks between manual and machine packaging methods.

$$H1 : \mu1 \neq \mu2 \quad (2)$$

We developed the alternate hypothesis to propose a considerable difference in the amount of time needed for packaging jobs between manual and machine methods considering the research issue and the study objectives. This choice was made after giving careful thought to operational inefficiencies and the possible effects of automation on process effectiveness.

Sample Statistics like the Sample Mean and Sample Standard Deviation were calculated for both Manual Operations and Machine Operations.

For Manual Packaging:

Sample Size n = 5

Sample Mean: $\overline{X}1 = 297.8$

Standard Deviation: $S_1 = 4.007$

For Machine Automatic Packaging:

Sample Mean: $\overline{X}2 = 153.4$

Standard Deviation: $S_2 = 1.292$ (3)

We then proceeded to calculate the t value with the data of both Manual Packaging and Automatic Packaging:

Calculated t value ≈ 76.686 (4)

After comparing the result of the calculated t-value with any practical critical t-value, we can confidently reject the null hypothesis. Based on the comparison of the calculated t-value with the critical t-value, we can reject the null hypothesis and conclude that there is significant difference in packaging times between manual and machine methods.

Results of Hypothesis test:

Sample Size n = 5Sample Mean: $\overline{X}1 = 297.8$

Standard Deviation: S1 = 10.4

Sample Mean: $\overline{X}2 = 153.4$

Standard Deviation: S2 = 10.4

Pooled Standard Deviation: Sp Approx. = 10.4

t-value = 22

Degrees of Freedom: 5 + 5 – 2 = 8

After finding the critical t-value at the desired significance level, for a two-tailed test at @=0.05 and df = 8, the critical t-value is approximately ±2.306.

Since the calculated t-value (22.0) is much larger than the critical t-value ±2.306, we can reject the null hypothesis and conclude that there is a significant difference in packaging times.

DMAIC Improve Phase

To address the found core causes of inefficiency, solutions were created and put into practice during the improve phase. Introducing and using automated packing equipment, more especially the Gold Pack type TTK 5500 machine represented major advancement in reducing operational defects. Initiatives for skill development and training were also put in place to improve the productivity of packaging staff. Prior to complete implementation, a pilot study was carried out to confirm the efficacy of the suggested modifications. During this stage, the main goal was to make noticeable advancements in efficiency and lower costs. A Return on Investment (ROI) analysis was conducted to assess the potential benefits associated with bringing the Gold Pack model TTK 5500 machine back to operations, presented in Table 3 and Table 4.

Table 3

Hill Brothers KPI's before Implementation

Input Description	Inputs	Details
Overtime hours Identified (January 2023) for packaging Process	3.93% per month	Versus regular hours - please refer to data within sheet titled " January 2023 Warehouse data
Overtime Percentage Identified converted in $$	$999 per month	please refer to data withi sheet title " January 2023 Warehouse dada
Packaging Area Operators identified in Tomato Packaging Process	7.5 operators	Step 2 of 5 required 2-3 operators, represented as 2.5 (avarage). The rest of the steps required one operator. See page 18 of presentation (Current Situation Analysis) for reference.
Avarage hourly rate of Packaging Area Operators identified in Tomato Packaging Process 3	$9.52 per hour	Taken from avarage of hoursly rate within the packaging area operators - please refer to data within sheet titled "January 2023 Warehouse data"
Hourly output of unistalled machine (Goldpack TK 5000) in units	up to 1200 units	Output confirmed with Goldpack representative
Hourly output of unistalled machine (Goldpack TK 5000) in cases	up to 100 cases per hour	Assumption -> 1 case = 12 units
Hourly output of actual process	17 cases per hour	.28 cases per minute - please refer to sheet titled as "Daily Prod of November 2023
Daily Operating Machine hours	1 hour per day	Assumption - no data granted as to how long machinery is used. Assumed 1 hour taking into consideration the avarage of minutes per day of tomato packaging production (42 minutes) - please refer to sheet titled as "Daily Prod of November 2023
Work days per year	242 days per year	Assumed standard Puerto Rico yearly 2024 working days.

Table 4

Hill Brothers ROI Calculations

Investments	
Revamping Packaging Consultants	$55,000.00
Other Investments**	$20,000.00

**Assumption: Other investments may or may not include: Vendor support, certified machine instaler, vendor setup, vendor specific training, & others.

ROI Data

Data Description	Data	
Annual New Machinery Overtime Cost reduction in one year	$5,994	$999 Assuming to be reduced by 50% (divided by 2) multipled by 12 months
New Machinery Production Improvement	6 times faster than actual manual packaging	Based on machine output, you will able to do 17 cases in 10 minutes instead of 17 cases per hour
Annual New Machinery Labor Cost Reduction	$55,292	Assumption - daily prodution goal is 136 cases (17 cases multiplied by 8 hours). If new machinery can help package up to 200 cases per hour, it is assumed that instead of 7.5 operators for 8 hours, you will instead need these resources 1 hour per day instead of 8 hours per day. These operators could be respoitioned to the other tasks, of be dismissed. This calculation is assuming 3 operators will be dismissed. The calculation is explained as the following: **-> 3 (packaging operators) * 9.52 (average hourly rate) * 8 (hours per day) * 242 (avarege work days per year) = annual cost labor reduction due to new machinery**
Total Annual Savings (3-6)	$62,286	

	Year 1 2024	Year 2 2025	Year 3 2026
Total Annual Savings	$61,286	$61,286	$61,286
Initial Investment	$75,000	-	-
ROI in $	($13,714)	**$61,286**	**$61,286**

The packaging team's regular participation in Hill Brother's picking operations is one of the factors contributing to their overtime % and hours. It affected overtime for the packaging team because of the non-efficient flow they had in their dispatch operations, operators from the packaging team covered picking tasks too. To mitigate this issue, a dispatch flow improvement that is more efficient for Hill Brothers was created to stop packaging staff from working overtime on duties that are not related to their duties in the packaging area. In conclusion, we improved the picking operation flow to avoid relying on packaging operators for these tasks. Spaghetti diagrams were conducted in all Hill Brothers coolers, like presented in Figure 5, to visualize current and projected flow for picking operations.

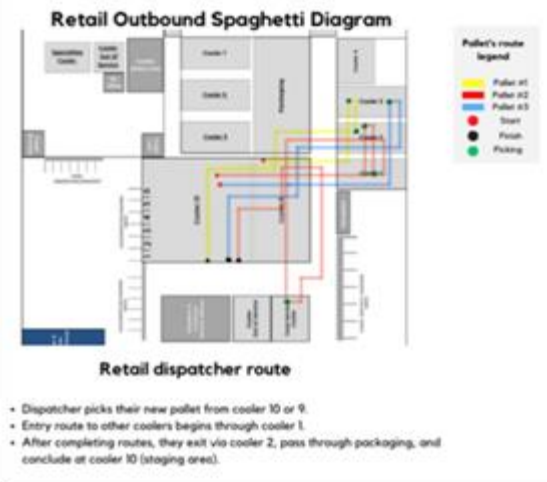

Figure 5
Example of Spaghetti Diagrams Conducted at Hill Brothers

DMAIC Control Phase

Hill Brothers put in place a thorough structure during the Control phase with the goal of maintaining and strengthening the advancements made in packaging process. The creation and application of (SOP's), which describe a sophisticated packaging process, was essential to this strategy. The (SOP's)ensured uniformity and strict adherence to quality standards throughout all operations by providing explicit instructions for tasks, machinery operation, quality assurance, and safety procedures. Also, a Dashboard was conducted as a pivotal tool for facilitating data-driven decision-making by managers. This dashboard provided a comprehensive overview of key performance indicators (KPI's), and production metrics shown in Figure 6.

Figure 6
Hill Brothers Management Dashboard

RESULTS & DISCUSSION

Redesigning Hill Brother's packaging department with the DMAIC methodology produced notable improvements in several packaging-related areas. The following is a summary of the study's findings:

- **Increased Productivity:** With the introduction of automated packing equipment, the was a noticeable increase in productivity. The machine reduced operational defects and streamlined the packaging process, leading to higher output rates compared to manual methods. The average hourly output of the manual process increased from 17 cases per hour to 23 cases per hour with standardization.
- **Improved Efficiency in overall Hill Brother Processes:** The Analysis phase identified key bottlenecks and inefficiencies in the packaging operations, allowing for targeted interventions to address these issues. Solutions such as dispatch flow improvements and standardized operating procedures contributed to smoother operations and reduced downtime. The Spaghetti diagrams conducted in Hill Brothers coolers provided visual insights into workflow optimization, enabling the company to streamline a better picking layout and minimize interruptions in the Packaging Area operators.
- **Enhanced Decision-Making:** The implementation of a Management Dashboard provided real-time visibility into key performance indicators and production metrics. This empowered Managers to make data-driven decisions, identify areas for improvement, and monitor the effectiveness of implanted solutions. By having access to centralized data and KPI's, Manager in Hill Brothers could proactively address issues and drive continuous improvement initiatives within all their operations.

The outcomes of this investigation show how well the DMAIC methodology works to enhance the effectiveness and efficiency of Hill Brother's

packaging operations. Through methodical identification of areas in need of improvement, implementation of focused solutions, and establishment of control mechanisms, the organization realized observable advantages in terms of increased output, reduced expenses, and enhanced operational effectiveness. The implementation of automated packing machinery, together with comprehensive training and skill enhancement programs, substantially improved the organization's packaging capacities. Along with increasing production, the elimination of manual interventions and workflow optimization enhanced the uniformity and quality of the final output. Furthermore, the implementation of defined operating procedures and a strong focus on change management promoted an ongoing improvement culture inside the company. Hill Brothers made sure that the improvements that were adopted would last and established the groundwork for long-term success by including employees in the process of improvement and giving them the resources and assistance, they needed.

To sustain the gains made, Hill Brothers must be vigilant and keep an eye on important performance metrics going forward. Further training and development initiatives ought to be put in place in order to augment the competencies and proficiencies of the packaging staff. To sum up, the packaging department at Hill Brother was successfully redesigned, which is evidence of how well systematic problem-solving techniques like DMAIC can promote operational excellence and a continuous improvement culture in businesses.

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