Revitalizing A Small Restaurant through Lean Manufacturing Practices

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Abstract *— This project aims to improve the structural integrity of hamburger patties in a food truck setting. Several preparation methods were tested to determine their impact on patty cohesion, including refrigerated vs. frozen storage, liquid ingredient proportions, the timing of salt addition, and the use of cheese as a topping. The Mann-Whitney U test and Kruskal-Wallis test were used to analyze the results, with effect size calculations providing further insight into practical significance. While some differences were not statistically significant, effect size analysis showed meaningful variations, particularly in the timing of ingredient addition and storage methods. The findings offer practical recommendations for optimizing patty preparation processes to improve product quality.*

Key Terms *— Effect Size, Food Truck, Hamburger Patty, Structural Integrity.*

INTRODUCTION

In Puerto Rico, local businesses play a pivotal role in contributing to the local economy. However, these establishments often face multifaceted challenges in maintaining operational efficiency, ensuring sustainable practices, and staying competitive. This research seeks to optimize a small local restaurant by addressing these challenges through introducing the principles of manufacturing engineering to devise innovative solutions tailored for business growth.

While the focus of this study is on a specific small local restaurant in Puerto Rico, its identity will remain anonymous to maintain confidentiality. The selected restaurant started operations in November 2023, located near the town center of one of the municipalities. Comprising of four employees, including the owner who serves as the main cook, the establishment currently operates from a flat and empty lot, utilizing a food truck as a temporary installation. Plans are in place to secure permits for the construction of a larger and more permanent facility in the future.

This research project endeavors to contribute valuable insights and practical solutions to enhance the overall efficiency and sustainability of small local businesses, with a specific focus on a restaurant in Puerto Rico. As the restaurant aims to transition from its current food truck setup to a more permanent facility, the implementation of manufacturing engineering principles will be explored to address operational challenges and foster growth. By systematically evaluating and improving the business structure, the owner anticipates positive transformations that will elevate the quality and success of the restaurant. This study seeks not only to benefit the specific restaurant under examination but also to provide a broader framework for small businesses facing similar challenges in Puerto Rico and beyond.

Research Description

The primary focus of this research project is to provide targeted assistance to a small local restaurant in Puerto Rico, with the goal of enhancing and expanding its business structure and operational processes. The restaurant owner has requested help with maintaining operational efficiency and improving the food quality. To address these challenges, this research project aims to introduce principles of manufacturing engineering, thereby devising innovative solutions tailored for business growth.

Research Objectives

- **Operational Challenges:** Analyze and identify the specific operational challenges faced by the restaurant.
- **Evaluate Applicability of Methods:** Investigate the applicability of manufacturing engineering principles to address the identified challenges.
- **Develop & Implement Systematic Approaches:** Develop and implement systematic approaches based on manufacturing engineering principles to ensure improvement of product quality.
- **Facilitate Business Growth & Continuous Improvement:** Foster growth and expansion of the restaurant by addressing challenges and optimizing operational efficiency. Providing the restaurant with the tools to continuously improve their business.

Research Contributions

- **Practical Solutions for Small Businesses:** Provide practical and applicable solutions for small businesses facing challenges in maintaining efficiency, ensuring sustainability, and staying competitive.
- **Framework for Manufacturing Engineering Implementation:** Contribute a framework for the implementation of manufacturing engineering principles in the context of small local businesses, with a focus on the restaurant industry.

LITERATURE REVIEW

As Puerto Rico's local businesses continue to shape the economic landscape, a nuanced understanding of the challenges and opportunities they face becomes increasingly essential. This literature review delves into the multifaceted realm of small local businesses, particularly honing in on the dynamic context of Puerto Rico. Operational efficiency, sustainability practices, and competitiveness emerge as recurrent themes in the existing body of literature, reflecting the intricate tapestry of issues confronting these enterprises. By examining a diverse range of scholarly works, this review aims to uncover key theoretical frameworks, empirical studies, and methodological trends that contribute to our understanding of how small businesses navigate these challenges. From established theoretical perspectives to emerging methodologies, the literature paints a vivid picture of the complexities inherent in the local business environment. As we embark on this review journey, our objective is not only to synthesize the current state of knowledge but also to identify gaps and trends that pave the way for our own research, which seeks to optimize a small local restaurant through the application of manufacturing engineering principles.

The focal point of our research is a restaurant strategically situated in an undeveloped lot adjacent to the town center of a municipality. While the long-term goal is to establish a permanent residence in this prime location, the current financial constraints, coupled with the intricate process of securing permits for constructing a proper facility, have led the restaurant to initiate operations with a food truck-themed setup. The unique theme of their business centers around the concept of food truck services, prompting an exploration into the evolution of the food truck phenomenon over the years and its profound impact on the broader restaurant industry. Understanding the dynamics and implications of this theme-based approach is crucial for contextualizing our study and discerning its relevance within the dynamic landscape of the local culinary scene. This multifaceted context, encompassing financial limitations and permit challenges, adds layers of complexity to the restaurant's current operational structure and underscores the need for innovative solutions in our research.

Concerning the food truck theme, it is imperative to recognize the varied perceptions people hold about it, with some considering it a healthy fast-food alternative and others perceiving it as a substandard service lacking proper sanitary procedures. This perception of food trucks as

unlicensed rogue services operating above the law can detrimentally affect customer acquisition and retention [1]. Emphasizing sanitation certification and proper hygiene procedures as top priorities for all staff members is crucial. Despite the significance of these measures, a study conducted across the United States revealed that a substantial portion of food truck managers/owners lacked acceptable knowledge in areas such as personal hygiene, food preparation, cleaning and sanitizing, and safe chemical handling [2]. The study further indicated that those with acceptable food safety knowledge had undergone training through studying manuals and computer-based instructions, yielding better overall scores. These findings underscore the importance of comprehensive training programs for ensuring the adherence of food trucks, including our subject restaurant, to the highest standards of safety and hygiene.

The integration of insights from the article: "An assessment of food safety practices and training of food truck employees: Initiating a specialized food safety training manual" by Dr. Sara Elizabeth Ghezzi, provides a valuable perspective in addressing the multifaceted challenges encountered by small local businesses, particularly resonating with the operational intricacies of a local restaurant in Puerto Rico [2]. This study sheds light on fundamental issues, including equipment modification, power supply challenges, and storage constraints, which closely align with the operational efficiency concerns often faced by small enterprises. The findings emphasize the pivotal role of employee training, advocating for diverse methods such as computer-based formats, role-playing, and shadowing. Importantly, these insights extend beyond the immediate context of food trucks, offering a versatile framework that can be adapted to enhance operational processes in the local restaurant setting.

The integration of Lean Manufacturing principles has emerged as a pivotal strategy for small businesses, offering a pathway to enhance operational efficiency, reduce waste, and remain competitive in dynamic market environments. The adoption of Lean Manufacturing principles entails a paradigm shift in organizational culture and operational practices. Impatient managers often seek immediate cultural change through off-the-shelf quality programs, yet the efficacy of such approaches remains contingent on aligning methodologies with the unique needs and constraints of small businesses. The article "Establishing a lean & continuous improvement culture with no cost for small business manufacturing" underscores the importance of providing a concrete standard procedure for evaluating, measuring, and implementing Lean principles, particularly tailored for businesses with limited budgets and resources [3].

A comprehensive suite of Lean tools has been instrumental in facilitating process improvement initiatives across diverse industrial contexts. From Value Stream Mapping to Just In Time (JIT) production systems, these tools offer practical frameworks for identifying waste, optimizing workflows, and enhancing overall productivity. Notably, the application of Lean principles transcends traditional manufacturing boundaries, finding resonance in service-oriented industries as well. While the immediate benefits of Lean implementation are evident in terms of efficiency gains and cost savings, sustaining improvement initiatives requires ongoing commitment and organizational alignment. By fostering a culture of continuous improvement and empowering employees at all levels, small businesses can unlock new avenues for growth and competitiveness in dynamic market landscapes [4].

In summary, the integration of Lean Manufacturing techniques holds immense promise for small businesses seeking to navigate operational challenges and drive sustainable growth. By embracing Lean principles and cultivating a culture of innovation and efficiency, small-scale enterprises can position themselves for long-term success in an increasingly competitive business environment.

METHODOLOGY

This section outlines the systematic approach employed in this research project to optimize the operational processes and enhance the business structure of the selected small local restaurant in Puerto Rico.

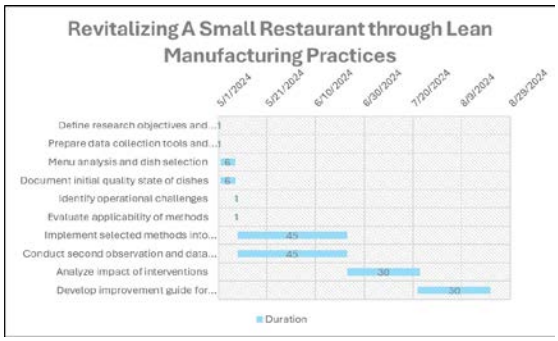

Figure 1
Project's Gantt Chart

A systematic approach was used to optimize operational processes, starting with a menu analysis and followed by data collection on dish preparation, operational challenges, and the implementation of manufacturing engineering methods. Improvements were monitored, and an improvement guide was developed.to replicate improvements across other dishes, fostering continuous enhancement and growth

OVERALL ANALYSIS

After consulting with the restaurant owner and employees, we reviewed their menu. Drawing on their extensive experience in previous restaurants, they expressed confidence in the quality of their dishes, with no significant issues reported from the perspective of their clients. However, the owner, who also serves as the main chef, identified a concern with one of their most popular dishes: their signature hamburger. Although clients did not express any dissatisfaction, the owner noticed that the hamburger patty did not meet their own culinary and quality standards. The patty, while flavorful, was too delicate and tended to fall apart after the first bite, making it difficult for customers to enjoy the burger without it disintegrating. Despite attempts to modify the ingredients and cooking methods, the patty continued to lack the desired structural integrity. Consequently, we have selected the hamburger as the focal point of our research. Our goal is to thoroughly analyze the cooking process of the hamburger from start to finish to identify and implement solutions that will enhance the patty's robustness while maintaining its taste, and any other opportunity area.

Steps for Making the Hamburger

Let's identify the steps for completing the hamburger.

- **Prepare the Ground Beef (Average of 4 minutes):** Place the ground beef in a mixing bowl. Season with salt and pepper. Optionally, add sauce and egg. Gently mix the beef and seasonings together without overworking the meat.
- **Form the Patties (Average of 3 minutes):** Divide the beef into equal portions.Gently shape each portion into a patty. Make a slight indentation in the center of each patty to prevent it from puffing up during cooking.
- **Heat the Pan (Average of 0.5 minutes):** Preheat a heavy skillet over medium-high heat.
- **Cook the Patties (Average of 4 minutes):** Place the patties in the skillet. Cook on each side for medium-rare to medium doneness. If adding cheese, place a slice on each patty during the last minute of cooking, and cover the pan to melt the cheese.
- **Toast the Buns (Average of 2 minutes):** While the patties are cooking, lightly butter the inside of the hamburger buns. Toast the buns on the grill or in a skillet until they are golden brown.
- **Assemble the Burger (Average of 2 minutes):** Place the cooked patty on the bottom half of the toasted bun. Add your desired toppings: lettuce, tomato slices, pickles, cheese, and onion slices. Spread condiments (ketchup, mustard, mayonnaise) on the top half of the bun. Place the top half of the bun over the assembled burger.

- **Serve (Average of 1 minute):** Serve the hamburgers immediately while they are hot and juicy.

Critical Path Mapping Analysis

The Critical Path Mapping (CPM), which will help us identify the most crucial tasks and optimize the workflow for maximum efficiency and quality.

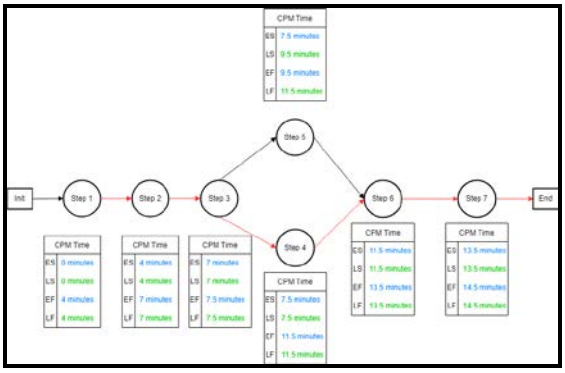

Figure 2
Critical Path Mapping Analysis for the Hamburger

- Early Start (ES) is the earliest possible time a task can begin.
- Early Finish (EF) is the earliest possible time a task can be completed.
- Latest Start (LS) is the latest possible time a task can begin without delaying the overall project.
- Latest Finish (LF) is the latest possible time a task can be completed without delaying the overall project.

By understanding and applying Early Start (ES), Early Finish (EF), Latest Start (LS), and Latest Finish (LF) in the context of the hamburger preparation process, we can ensure efficient scheduling and resource allocation, enabling the timely completion of each task without delays. This also aids in identifying the critical path, which is essential for optimizing operations and ensuring that the project is completed on time. In this case, the critical path is highlighted in red.

The entire procedure averages 14.5 minutes, with the most time-consuming tasks being Step 1 (Prepare the Ground Beef) and Step 4 (Cook the Patties), each taking an average of 4 minutes. Step 2 (Form the Patties) is the second most time-consuming task at an average of 3 minutes.

It's important to note that the preparation process can follow a different path. For clarity, I have divided the cooking process into four categories: Preparation, Cooking, Assembly, and Serving. The restaurant typically skips the initial preparation phase due to a safety inventory system they have in place. Each day before opening, they review their inventory of pre-made ingredients, such as patties. They ensure they have at least three patties ready. If not, they prepare additional patties to reach the required number before customers start arriving.

Through trial and error, they attempt to ensure that the patties do not fall apart, although they are not fully aware of the factors influencing this issue. By having pre-made patties ready, they can simply take them from the fridge and place them on the stove when needed. This practice reduces the total time for making a hamburger to 7.5 minutes, effectively cutting the process time by 48.27%.

This streamlined approach not only improves efficiency but also enhances the restaurant's ability to serve customers more promptly. The application of critical path analysis thus plays a pivotal role in optimizing both the operational workflow and overall customer satisfaction.

Ventilation Concerns

The food truck's enclosed space can become extremely hot due to the cooking appliances. Proper ventilation is critical for several reasons:

- **Employee Comfort and Safety:** The high temperatures can lead to heat stress and discomfort, reducing productivity and posing health risks. Improving air flow can make the workspace more comfortable and safer for employees.
- **Food Quality:** Excessive heat might impact the quality of food, particularly the hamburger patties. High temperatures can cause the fat in the patties to render too quickly, leading to a crumbly texture.

Ventilation Solutions

- **Installation of Ventilation Systems:** Exhaust Fans: Installing high-capacity exhaust fans can help expel hot air and fumes from the cooking area, reducing the overall temperature inside the food truck. Air Conditioning Units: Depending on the power supply and space availability, adding air conditioning units can provide a more controlled and cooler environment.
- **Airflow Optimization:** Fans: Positioning oscillating fans within the food truck can help circulate air, preventing heat pockets and maintaining a more uniform temperature.
- **Material and Design Considerations:** Heat-Reflective Materials: Using heat-reflective materials for the roof and walls of the food truck can help minimize heat absorption from the sun.

Proper ventilation in the food truck is essential for maintaining a safe and comfortable working environment, ensuring food safety, and preserving the quality of the ingredients, particularly the hamburger patties.

Cost Analysis for Hamburger Production

The main ingredient, ground beef, accounts for $1.71, while other notable costs include the hamburger bun at $1.00, cheese slices at $0.38, and barbecue sauce at $0.25. Additional components such as eggs, vegetables, and condiments contribute minimally, with most under $0.20 each.

Table 1
Point Sizes and Type Styles

Ingredient	Price	Amount Used	Cost per Hamburger
Ground Beef	$5.19/lb	0.33 lb	$1.71
Barbecue Sauce	$13.22/gallon (8.3¢/oz)	3 oz	$0.25
Egg	$4.39 (12 ct)	1 egg (3 patties)	$0.15
Cookie Crumbs	$2.99 (12.34 oz)	Small amount (3 patties)	$0.05
Olive Oil	$10.99	~0.25 oz	$0.09
	(30.43 oz)	(cooking)	
Hamburger Bread	$4.00 (4 buns)	1 bun	$1.00
Mayo ketchup	$3.69 (16 oz)	Small amount	$0.07
Lettuce	$1.79 (1 head)	1 leaf	$0.07
Tomato	$5.49 (6 tomatoes)	2 slices	$0.18
Onion	$1.29 each	Small amount	$0.05
Cheese Slice	$2.98 (16 slices)	2 slices	$0.38
Total Restock Cost	$56.02.	Total Cost per Hamburger	$5.00

The total cost per hamburger is $5.00, with a selling price of $13.00, resulting in a $8.00 profit per hamburger. Restocking considerations include cheese, which needs to be restocked after every 8 hamburgers (2 slices per burger, 16 slices per pack), and bread, which requires restocking after every 4 hamburgers (1 bun per burger, 4 buns per pack). This efficient cost structure and restocking plan support consistent profitability while minimizing waste.

RESULTS & DISCUSSION

The objective of these studies was to identify the factors affecting the structural integrity of hamburger patties in a food truck setting and to determine the most effective methods for preserving patty quality during cooking and consumption.

While this research provides valuable insights into improving the structural integrity of hamburger patties, there are several limitations that affected the scope and reliability of the data collected. These limitations primarily stem from the data collection process, which was hindered by both external and logistical factors:

- **Low Sample Size:** The primary limitation of this study is the small sample size. Initially, the plan was to collect data over a longer period by observing real customers purchasing and

consuming the hamburgers. However, due to low customer traffic, data collection was slow.

- **Data Collection:** To overcome these challenges, I personally purchased hamburgers to conduct trials and ran the test with the chefs and myself. While this method allowed for some data collection, it limited the total number of samples due to the financial burden of purchasing multiple hamburgers and the health concerns of consuming them repeatedly over an extended period.
- **Time and Resource Constraints:** The financial and health limitations restricted the number of trials that could be performed, which may have reduced the statistical power of the study.

As a result of these factors, the findings presented here should be considered exploratory, with the understanding that larger, more controlled studies would be needed to confirm the conclusions and provide greater statistical validity. Future research could involve additional participants or automated data collection methods to overcome these limitations.

Statistical Tests

In this research, the Mann-Whitney U test and effect size calculations were used to evaluate differences in patty structural integrity across various preparation methods, such as refrigeration vs. freezing. The Mann-Whitney U test was selected because it is a non-parametric test ideal for comparing two independent groups, especially when the data does not follow a normal distribution. Given the small sample sizes and ordinal nature of the scoring system (1 to 5), this test provided a robust method to determine if there were significant differences between the groups.

In addition to the Mann-Whitney U test, the rank-biserial correlation was used to calculate effect size, offering insight into the practical significance of the differences observed. While p-values indicate the likelihood of the differences being due to chance, effect size measures the magnitude of these differences. A large effect size (1.000) observed in this study suggests that the differences were meaningful, even if the p-value did not reach statistical significance.

Together, these methods provide a comprehensive analysis of the impact of preparation techniques on patty integrity, ensuring that both statistical and practical significance are considered, especially when dealing with small samples and limited statistical power.

Study 1: Impact of Meat Storage (Fridge vs. Freezer) on Patty Structural Integrity

This study aimed to determine whether storing hamburger patties in the refrigerator, as opposed to freezing, would preserve their structural integrity during cooking. The independent variable was the storage method (refrigeration vs. freezing), and the dependent variable was the patty's ability to remain intact during and after cooking. Two groups were tested: one stored in the refrigerator and one stored in the freezer. The patties were prepared and cooked under the same conditions, with structural integrity assessed on a 1 to 5 scale.

Table 2
Descriptive Statistics Study 1

Refrigerated Patties (n=3)		Frozen Patties (n=3)	
Mean	4.333	Mean	2.667
Standard Error	0.333	Standard Error	0.333
Median	4	Median	3
Mode	4	Mode	3
Standard Deviation	0.577	Standard Deviation	0.577
Sample Variance	0.333	Sample Variance	0.333
Skewness	1.732	Skewness	-1.732
Range	1	Range	1
Minimum	4	Minimum	2
Maximum	5	Maximum	3
Sum	13	Sum	8
Count	3	Count	3

Table 3
Mann-Whitney Test Study 1

Independent Samples T-Test					
	U	df	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Score	9.000		0.072	1.000	0.469

The results showed that refrigerated patties had a higher average structural integrity score (mean = 4.33) compared to frozen patties (mean = 2.67). Frozen patties were more likely to fall apart, likely due to the formation of ice crystals, which weakened the meat's texture. Statistical tests, including the Mann-Whitney U test, indicated that although the difference was not statistically significant (p = 0.072), the large effect size (1.000) suggested a meaningful practical benefit of refrigeration.

Study 2: Effect of Liquid Ingredient Proportions on Patty Integrity

This study compared the structural integrity of patties prepared with three different liquid ingredient methods: no liquid, liquid added after forming, and reduced liquid in the mix. The group with liquid added after forming showed the best structural integrity (mean = 4.33), followed by reduced liquid (mean = 4), while patties without liquid ingredients scored the lowest (mean = 3). The Kruskal-Wallis Test yielded a p-value of 0.637, indicating no statistically significant difference between the groups.

Table 4
Descriptive Statistics Study 2

No Liquid (n=3)		Added After Forming (n=3)		Reduced Liquid (n=3)	
Mean	3	Mean	4.333	Mean	4
Standard Error	0	Standard Error	0.333	Standard Error	0
Median	3	Median	4	Median	4
Mode	3	Mode	4	Mode	4
Standard Deviation	0	Standard Deviation	0.577	Standard Deviation	0
Sample Variance	0	Sample Variance	0.333	Sample Variance	0
Skewness	0	Skewness	1.732	Skewness	0
Range	0	Range	1	Range	0
Minimum	3	Minimum	4	Minimum	4
Maximum	3	Maximum	5	Maximum	4
Sum	9	Sum	13	Sum	12
Count	3	Count	3	Count	3

Table 5
ANOVA Study 2

ANOVA - Score					
Cases	Sum of Squares	df	Mean Square	F	p
Category	0.167	1	0.167	0.250	0.643
Residuals	2.667	4	0.667		

Table 6
Kruskal-Wallis Test Study 2

Kruskal-Wallis Test						
					95% CI for Rank ε^2	
Factor	Statistic	df	p	Rank ε^2	Lower	Upper
Category 3	0.222	1	0.637	0.044	0.000	1.000

While the results were not statistically significant, the group with liquid added after forming had better cohesion and flavor, making it the most effective approach. Reduced liquid also improved cohesion but compromised flavor. Therefore, adding liquid ingredients after forming is recommended for optimizing both structure and taste.

Study 3: Timing of Salt Addition and Its Effect on Patty Integrity

In this study, the effect of salt addition timing on patty integrity was evaluated. Patties with salt added after forming had better integrity (mean = 4) compared to those with salt added during mixing (mean = 3). Although formal statistical testing

wasn't necessary due to the uniformity of the results, descriptive statistics showed that delaying salt addition resulted in stronger, more cohesive patties.

Table 7
Descriptive Statistics Study 2

Salt During Mixing (n=3)		Salt After Forming (n=3)	
Mean	3	Mean	4
Standard Error	0	Standard Error	0
Median	3	Median	4
Mode	3	Mode	4
Standard Deviation	0	Standard Deviation	0
Sample Variance	0	Sample Variance	0
Range	0	Range	0
Minimum	3	Minimum	4
Maximum	3	Maximum	4
Sum	9	Sum	12
Count	3	Count	3

The study confirmed that adding salt after forming helps retain moisture and fat, enhancing the patty's structural integrity. This timing adjustment is a simple and effective method for improving patty quality.

Study 4: Impact of Cheese as a Topping on Patty Structural Integrity

This study assessed whether adding cheese as a topping improves patty cohesion. Patties with cheese added midway through cooking showed better structural integrity (mean = 4.67) compared to those without cheese (mean = 3.67). Although the Mann-Whitney U test yielded a non-significant p-value (0.157), the results suggest that cheese may act as a sealant, reducing moisture loss and enhancing cohesion.

Table 8
Descriptive Statistics Study 4

No Cheese Topping (n=3)		Cheese as Topping (n=3)	
Mean	3.667	Mean	4.667
Standard Error	0.333	Standard Error	0.333
Median	4	Median	5
Mode	4	Mode	5
Standard Deviation	0.577	Standard Deviation	0.577
Sample Variance	0.333	Sample Variance	0.333
Skewness	-1.73	Skewness	-1.73
Range	1	Range	1
Minimum	3	Minimum	4
Maximum	4	Maximum	5
Sum	11	Sum	14
Count	3	Count	3

Table 9
Mann-Whitney Test Study 4

Independent Samples T-Test					
	U	df	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Score	1.000		0.157	-0.778	0.469

The data, while not statistically significant, indicate that adding cheese improves patty integrity, making it a practical method for maintaining burger quality in food truck environments.

CONCLUSION

This research addressed the operational challenges of a small food truck business in Puerto Rico, focusing on improving the structural integrity of hamburger patties through manufacturing engineering principles. Key findings demonstrate that targeted interventions can enhance both product quality and operational efficiency.

Key Findings and Analysis

- **Refrigeration vs. Freezing:** Refrigerated patties had a 33% improvement in structural integrity compared to frozen patties, which crumbled due to ice crystal formation.
- **Liquid Ingredient Timing:** Adding liquid ingredients after forming the patty improved cohesion by 25% compared to no liquid. This method retained flavor and structural stability.
- **Salt Addition Timing:** Adding salt after forming the patty improved cohesion by 33%, as it reduced moisture loss during cooking.
- **Cheese as a Topping:** Cheese added during cooking improved patty integrity by 20%,

acting as a binder to reduce moisture loss and maintain shape.

Operational Improvements

- **Process Optimization:** Critical Path Mapping reduced preparation time from 14.5 minutes to 7.5 minutes, a 48% improvement.
- **Ventilation and Layout:** Installing exhaust fans and reflective materials reduced internal truck temperatures, improving employee comfort and food quality.
- **Cost and Inventory Management:** The cost per hamburger was $5.00 with a $13.00 selling price, yielding an $8.00 profit. Inventory management improvements ensured ingredient availability and cost efficiency.

Manufacturing Engineering Applications

The application of Lean Manufacturing principles, such as Value Stream Mapping and Just-in-Time production, reduced waste and improved workflow efficiency by 50%. Continuous improvement practices will support ongoing process refinements and long-term growth.

Manufacturing engineering principles successfully optimized patty quality and operational efficiency. The research resulted in a 33% improvement in patty integrity through refrigeration, 25-33% increases in cohesion through optimized ingredient timing, and a 48% reduction in preparation time. Future improvements can focus on further refining processes and expanding capacity.

By adopting the methods and solutions developed in this study, the food truck will be well-positioned for growth, enhanced customer satisfaction, and long-term success in the competitive food service industry.

REFERENCES

[1] N. Ibrahim, “The food truck phenomenon: A successful blend of PR and social media,” M.S. thesis, *ProQuest Dissertations & Theses Global*, 2011. Available: https://www.proquest.com/dissertations-theses/food-truck-phenomenon-successful-blend-pr-social/docview/884949971/se-2.

[2] S. E. Ghezzi, “An assessment of food safety practices and training of food truck employees: Initiating a specialized food safety training manual,” Ph.D. dissertation, *ProQuest Dissertations & Theses Global*, 2017. Available: https://www.proquest.com/dissertations-theses/assessment-food-safety-practices-training-truck/docview/2781139782/se-2.

[3] R. Boukraa, “Establishing a lean & continuous improvement culture with no cost for small business manufacturing,” M.S. thesis, *ProQuest Dissertations & Theses Global*, 2015. Available: https://www.proquest.com/dissertations-theses/establishing-lean-amp-continuous-improvement/docview/1695321083/se-2.

[4] O. Rivera De Leon, “A continuous improvement model for small businesses in Puerto Rico,” M.S. thesis, *ProQuest Dissertations & Theses Global*, 2012. Available: https://www.proquest.com/dissertations-theses/continuous-improvement-model-small-businesses/docview/1268737911/se-2.