STATISTICAL ANALYSIS ON PRODUCTION OF A MANUFACTURING COMPANY USING QUALITY CONTROL

(A CASE STUDY OF HABIB YOGHURT. ILORIN)

BY

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ND/23/STA/PT/0002

A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF STATISTICS

INSTITUTE OF APPLIED SCIENCES (IAS) KWARA STATE POLYTECHNIC, ILORIN.

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF NATIONAL DIPLOMA (ND) IN STATISTICS

JUNE, 2025

CERTIFICATION

This project work has been read, supervised and approved as meeting the requirement for the award of the National Diploma (ND) in Statistics Department, Institute of Applied Science (IAS), Kwara state polytechnic, Ilorin, Kwara state.

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DEDICATION

This project is dedicated to the Almighty God and to my parent (Mr. and Mrs. Abdulrahman)

ACKNOWLEDGEMENT

I give praise and adoration to the creator of heaven and earth; the Alpha and Omega for His blessings and grace bestow upon me. And for the wisdom, knowledge and understanding given to me to be able to accomplish this task.

My special gratitude goes to my parent (Mr. and Mrs. Abdulrahman) who has been there for me throughout the process of everything in my life. And also for their support, financially, morally and spiritually. I say a BIG Thank to you and may you reap the fruit of your labour. Amin…….

My profound gratitude goes to my supervisor, the person of Mrs. Elepo T.A for her assistance and guidance during this research work, and also to our able Head of Department Mrs. Elepo T.A and to every one of my lecturers that taught me everything I know in statistics and for the good academic support given since the beginning of our program till point on time.

My appreciation also goes my brother (Abdulrahman Idrees) and Mumcy (Aliyu Fatima), my friends and all my course-mate. You all are awesome.

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ABSTRACT

This study presents a statistical analysis of the production process in a manufacturing company using quality control techniques, with a focus on Habib Yoghurt, Ilorin. Data was collected over 30 consecutive days from five production lines (Line A to Line E), each producing 50cl bottles of yoghurt. The mean ($\bar{X}$) and range (R) values were calculated daily, and control charts were used to monitor process stability. The overall average of the sample means ($\bar{X}$-bar) was computed as ***49.56 cl****, while the average of the sample ranges (R-bar) was* ***0.42 cl****. Control limits for the $\bar{X}$ chart were determined to be* ***UCL = 49.79 cl*** *and* ***LCL = 49.33 cl****, and for the R chart,* ***UCL = 0.88 cl*** *and* ***LCL = 0.00 cl****. The results revealed that all mean values fell within the control limits, indicating a generally stable process; however, minor fluctuations in range values suggested variability in certain production lines, particularly Line D. These deviations, although not beyond control limits, highlight the need for continuous monitoring. The study concludes that implementing regular quality checks using control charts can help identify sources of variation, improve consistency, and ensure sustained product quality in the manufacturing sector.*

Keywords: *Statistical Quality Control, $\bar{X}$ and R Chart, Process Monitoring, Control Limits, Manufacturing Analysis, Habib Yoghurt, Dairy Production, Product Quality, Variation Detection, Quality Assurance.*

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the manufacturing industry, maintaining consistent product quality is crucial to achieving customer satisfaction, meeting regulatory standards, and ensuring efficient operations. One of the key areas where quality assurance is critical is in the food and beverage sector, particularly in the production of packaged consumables like yoghurt. The volume, texture, and packaging integrity of products such as yoghurt directly influence consumer trust and brand reputation. Therefore, precise and standardized production processes must be enforced through quality control mechanisms.

Quality control (QC) in manufacturing involves the use of statistical and procedural techniques to monitor, maintain, and improve product quality throughout the production process. Statistical Quality Control (SQC), a key subset of quality control, utilizes statistical methods such as control charts, mean and range analysis, standard deviation computation, and process capability analysis to evaluate the stability and performance of production systems. These tools help manufacturers identify deviations from the standard, detect process variability, and implement corrective actions to reduce waste, avoid underfilling or overfilling, and improve process efficiency.

In the context of food production, especially in the dairy industry, adhering to strict production standards is essential. For instance, yoghurt production typically involves the packaging of the final product into predefined quantities. Any significant deviation from the intended volume—either through overfilling or underfilling—not only leads to customer dissatisfaction but can also violate regulatory standards. Moreover, repeated inconsistencies may indicate deeper problems within the production line such as machine faults, human error, or poor calibration.

Habib Yoghurt, a leading yoghurt production company located in Ilorin, Kwara State, is known for its wide distribution of various yoghurt flavors packaged in different sizes, including the 50cl pack. The company operates multiple production lines to meet its growing customer demand. However, as with any large-scale manufacturing setup, ensuring consistency across different lines can be challenging. Each line may be affected differently by factors such as equipment condition, operator skill level, raw material quality, and environmental conditions. As such, regular statistical evaluation of production output is essential to ensure that all lines conform to the set quality and volume standards.

In this study, yoghurt production data collected over a period of 30 consecutive days from five different production lines at Habib Yoghurt will be analyzed using statistical methods. The objective is to assess the volume accuracy and consistency of each line, identify any deviations from the standard 50cl fill volume, and determine which production lines may require improvements. This analysis will not only aid in improving production efficiency at Habib Yoghurt but will also serve as a reference for similar quality control studies in other manufacturing settings.

1.2 Statement of the Problem

In large-scale food manufacturing environments, one common challenge is the variability in production output across multiple lines. Despite the availability of standard operating procedures, production lines may still yield inconsistent results. At Habib Yoghurt, where thousands of 50cl yoghurt bottles are produced daily from several lines, even small inconsistencies in volume can accumulate into significant product losses or customer dissatisfaction.

The problem addressed in this study is the **lack of statistical monitoring of volume consistency across multiple production lines**. Without regular analysis, underfilling or overfilling can go unnoticed, leading to quality control issues, regulatory penalties, and brand image damage. This study aims to statistically assess the yoghurt production volumes to determine how closely each line aligns with the 50cl standard and whether variability exists that requires corrective measures.

1.3 Aim and Objectives of the Study

The main aim of this study is to carry out a statistical analysis of the yoghurt production process at Habib Yoghurt using quality control methods. Specifically, the study objectives are:

1. To determine the average volume of yoghurt produced across the five production lines and assess their compliance with the 50cl production standard.
2. To evaluate the consistency and variability in yoghurt output from each production line over a 30-day period.
3. To identify which production line(s) require quality improvement based on deviations from the target volume and observed production trends.

1.4 Significance of the Study

This study is significant for several reasons. First, it provides a data-driven insight into the performance of each production line at Habib Yoghurt, enabling management to make informed decisions regarding maintenance, training, and operational adjustments. Second, it contributes to the broader field of quality control in food manufacturing by demonstrating how statistical tools can be applied effectively to monitor and enhance production processes. Lastly, the study serves as a reference point for other food and beverage companies aiming to adopt statistical quality control in their operations.

1.5 Scope of the Study

The scope of this study is limited to the analysis of yoghurt production data collected from five production lines at Habib Yoghurt, Ilorin, over a 30-day period. The study specifically focuses on the 50cl pack size and does not include other sizes or product variations. Only statistical quality control methods such as mean analysis, standard deviation, and graphical tools (e.g., boxplots and control charts) will be employed. The study does not investigate the causes of inconsistencies in detail but rather identifies the presence and extent of such inconsistencies.

1.6 Definition of Terms

- **Statistical Quality Control (SQC):** A method of quality control that uses statistical techniques to monitor and control a process.
- **Standard Deviation:** A measure that indicates the amount of variation or dispersion in a set of values.
- **Control Chart:** A graphical tool used to monitor changes in a process over time.
- **Production Line:** A set of sequential operations in a factory where components are assembled or processed.
- **Yoghurt Fill Volume:** The quantity of yoghurt filled into each bottle, expected to be 50cl in this study.
- **Consistency:** The ability of a production process to produce similar results under the same conditions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter explores past studies and theoretical frameworks related to quality control, statistical methods in manufacturing, and volume consistency in food production. The review is structured around key themes such as statistical quality control, control chart application, production line analysis, consistency in food manufacturing, and related case studies in Nigeria and beyond.

2.2 Review of Related Literature

Statistical Quality Control in Manufacturing

Statistical Quality Control (SQC) has become a critical aspect of quality assurance in manufacturing processes. Montgomery (2009) describes SQC as the use of statistical techniques to measure and analyze the variation in processes. The goal is to ensure that products meet defined standards while minimizing waste and enhancing efficiency. One of the most fundamental aspects of SQC is its ability to identify assignable causes of variation—those that can be traced and eliminated—versus common causes that are inherent to the process.

In manufacturing environments, especially those involving automated production lines, slight variations in product specifications such as volume, weight, or shape can indicate systemic issues. According to Juran and Godfrey (1999), consistent application of statistical methods ensures tighter control of processes and quicker identification of anomalies. For example, the use of means and standard deviation allows producers to track the central tendency and dispersion in production outputs, helping to maintain desired levels of quality.

Control Charts and Their Application in Production

According to Wheeler and Chambers (2010), a control chart not only reveals when a process is out of control but also indicates the stability and predictability of the process. If all data points lie within control limits, and no non-random patterns are present, the process is considered stable. However, when points fall outside these limits or display systematic patterns, it may signal a need for corrective action.

Numerous studies have highlighted the effectiveness of control charts in food processing. For instance, a study by Kiran and Madhu (2018) on a beverage production facility demonstrated how control charts helped reduce overfilling and underfilling by nearly 40%. The study emphasized that frequent charting and operator training significantly improved compliance with production targets.

In the Nigerian context, a study by Eze and Onyema (2020) revealed that many local manufacturing firms are gradually incorporating control charts into their operations. Their research on a bottled water plant showed that the use of $\bar{X}$ and R charts led to a marked improvement in the fill volumes across production lines.

For this study, control charts will be employed to monitor the 50cl yoghurt production from five lines over 30 days. The graphical representation will help visualize whether each line operates within acceptable limits or exhibits signs of instability, thus supporting quality-driven decisions at Habib Yoghurt.

Quality Control in Dairy Production: Nigerian Context

Quality control in Nigerian dairy production has evolved significantly in response to consumer demand, food safety regulations, and global best practices. Dairy products, including milk and yoghurt, require stringent hygiene, accurate processing, and consistent packaging. As highlighted by Okunade and Ajala (2018), many Nigerian dairy producers face challenges in maintaining consistency due to equipment limitations, power outages, and lack of standardized processes.

Despite these challenges, companies like Habib Yoghurt have made strides by integrating structured quality control (QC) processes into their operations. This includes the routine measurement of output volumes, temperature regulation, and adherence to ingredient composition.

Statistical tools such as control charts, histograms, and process capability indexes are increasingly being used by data-driven producers to ensure quality output.

Ajibola et al. (2020) conducted a study on a yoghurt-producing firm in Lagos, analyzing the impact of QC on customer satisfaction. They discovered a strong correlation between low variability in product volume and high customer loyalty. The study advocated for internal audits and real-time data analysis as mechanisms to sustain quality output.

Use of Descriptive Statistics in Quality Control

In manufacturing, especially food processing, descriptive statistics can quickly highlight issues in production lines. A high standard deviation or range in daily output volumes may suggest process instability. For instance, in Habib Yoghurt's production, calculating the average volume from each line over 30 days can reveal whether the line consistently hits the 50cl target or deviates significantly. Standard deviation, in particular, shows how tightly clustered the output volumes are around the mean.

Yusuf and Ibrahim (2016) examined the use of descriptive statistics in three beverage companies in Lagos and concluded that standard deviation was the most commonly used metric to monitor filling machines. Their research found that lines with a deviation greater than 0.3cl from the mean had a higher likelihood of consumer complaints due to perceived underfilling.

Descriptive statistics also serve as the foundation for more complex quality metrics, such as process capability indexes (Cp, Cpk), which assess how well a process meets specification limits. Though more advanced, these indexes are rooted in simple measures of dispersion and central tendency.

Thus, the effective use of descriptive statistics is an essential part of modern quality control systems. It enables data-driven decision-making, supports operational improvements, and enhances the overall reliability of food manufacturing processes.

Empirical Studies on Production Line Variability

Production line variability is a major concern in manufacturing, especially when consistency is critical, such as in food and beverage production. Empirical studies across the globe have focused on measuring and managing this variability using both classical statistical and modern computational methods. The goal is to pinpoint process inefficiencies and improve uniformity in product output.

Kumar and Sinha (2015) analyzed production line efficiency in a soft drink manufacturing firm. Using Six Sigma and standard statistical process control tools, they discovered that a single line with excessive variation was responsible for over 50% of the company's quality complaints. This emphasizes the importance of identifying and correcting underperforming lines rather than generalizing issues across the system.

In Nigeria, a study by Okonkwo and Ede (2020) at a bottled water company examined variability between three production lines over 60 days. The researchers used variance analysis and control charts to monitor performance and found that Line C had significantly more variation due to erratic pump pressure. As a result, the company adjusted the pump calibration schedule, leading to improved performance and reduced customer complaints.

In summary, addressing production line variability through empirical analysis ensures better product consistency, improved efficiency, and customer satisfaction—key elements for competitive success in the food industry.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology adopted for the research. It outlines the procedures and techniques used in gathering and analyzing data concerning the production outputs of Habib Yoghurt, Ilorin. The aim is to examine how statistical quality control can be used to monitor and improve consistency in the volume of yoghurt produced by various production lines. This chapter details the research design, source of data, data collection method, population of the study, and the statistical tools applied in analyzing the data.

3.2 Source of Data

The study utilizes **secondary data**, specifically internal production records collected from Habib Yoghurt's quality control department. The data comprises the daily output volumes (in centilitres) from five different production lines recorded over a period of 30 consecutive production days.

3.3 Statistical Techniques Used

To analyze the data effectively, the following statistical tools were applied:

i. Descriptive Statistics:

- **Mean**: Used to determine the average volume produced per line.
- **Standard Deviation**: Measures the variability of production within each line.
- **Range**: Shows the difference between the maximum and minimum volumes recorded.
- **Variance**: Assesses the spread of production data within each line.

ii. Analysis of Variance (ANOVA):

- ANOVA is used to determine if there are statistically significant differences in the mean production volumes between the five production lines.
- The test assumes that each production line should ideally produce the same volume (50cl), and any significant deviation may suggest a production issue.

iii. Control Charts

Control charts, also known as **Shewhart charts** or **process-behavior charts**, are a vital tool in Statistical Quality Control (SQC). They are used to monitor process behavior and determine whether a manufacturing process is stable over time. In this study, control charts will be employed to analyze the consistency and stability of yoghurt volumes produced by each production line at Habib Yoghurt.

Control charts help distinguish between two types of variation:

- **Common cause variation**, which is natural to the process.
- **Special cause variation**, which indicates a problem or shift in the process.

For this research, the **$\bar{X}$ (X-bar) chart** and the **R (Range) chart** will be used to analyze the production output.

$\bar{X}$ (X-bar) Chart

The $\bar{X}$ chart is used to monitor the mean values of subgroups (in this case, daily production volumes) over time. It indicates whether the production process is centered around the target value (50cl). The steps involved in constructing the $\bar{X}$ chart include:

- Calculating the average production for each day across all lines.
- Determining the overall mean of daily averages.
- Establishing control limits:

- **Upper Control Limit (UCL)** = $\bar{X} + A2 \times \bar{R}$
- **Lower Control Limit (LCL)** = $\bar{X} - A2 \times \bar{R}$

    -
        - Where:
        - $\bar{X}$ is the overall average
        - $\bar{R}$ is the average of daily ranges
        - A2 is a control chart constant based on subgroup size

R (Range) Chart

The R chart measures the dispersion or range of the data in each subgroup. It is useful for identifying inconsistency in production precision. Steps include:

- Calculating the range (maximum - minimum) for each day.
- Determining the average range ($\bar{R}$).
- Establishing control limits:
- **UCL** = $D4 \times \bar{R}$
- **LCL** = $D3 \times \bar{R}$
  Where D3 and D4 are constants based on subgroup size.

Interpretation

A process is said to be "in control" if:

- All points lie within control limits.

- There is no systematic pattern (e.g., run of points above or below the mean). If any point lies outside the control limits, or an unusual pattern is detected, it suggests that the production process is being influenced by special causes which must be investigated.

Relevance to the Study

Using control charts, this research will help:

- Detect anomalies or irregularities in daily yoghurt production.
- Monitor and maintain the consistency of output across the five lines.
- Provide actionable feedback to the production department for continuous improvement.

In summary, the use of $\bar{X}$ and R charts provides a powerful visual and statistical method for ensuring that the yoghurt production process remains consistent and within quality specifications.

3.4 Presentation of Data

The study utilizes **secondary data**, specifically internal production records collected from Habib Yoghurt's quality control department. The data comprises the daily output volumes (in centilitres) from five different production lines recorded over a period of 30 consecutive production days.

Table 3.1 YOGHURT PRODUCED FOR 30 DAYS IN (50 CL) FROM 5 DIFFERENT PRODUCTION LINE IN HABIB YOUGHURT

Days	Line A (cl)	Line B (cl)	Line C (cl)	Line D (cl)	Line E (cl)
1	49.5	49.4	49.2	49.0	49.9
2	50.0	50.2	49.3	49.2	49.5
3	49.8	49.7	49.5	49.3	50.0
4	49.6	50.0	49.4	49.1	49.8
5	49.9	49.6	49.2	49.4	50.1
6	50.1	49.8	49.7	49.0	49.6
7	49.4	49.5	49.6	49.3	49.7
8	49.3	50.3	49.1	49.6	49.9
9	49.7	49.8	49.3	49.2	50.2
10	50.0	50.1	49.4	49.5	49.5

11	49.2	49.9	49.7	49.1	49.8
12	49.8	50.2	49.6	49.4	49.7
13	49.9	50.0	49.3	49.0	49.6
14	50.3	49.6	49.4	49.5	50.0
15	49.4	49.7	49.2	49.3	50.1
16	50.2	49.8	49.5	49.4	49.9
17	49.6	49.3	49.6	49.7	50.4
18	50.0	50.1	49.5	49.2	49.3
19	49.7	49.9	49.2	49.6	50.2
20	50.4	50.0	49.3	49.4	49.6
21	49.5	49.6	49.7	49.1	49.8
22	49.8	49.5	49.6	49.3	50.3
23	49.6	50.3	49.4	49.2	49.9
24	49.7	49.9	49.1	49.6	50.0
25	49.3	49.7	49.3	49.4	49.7
26	50.1	49.8	49.6	49.5	49.6
27	50.0	49.4	49.5	49.2	50.2
28	49.2	49.6	49.4	49.3	49.5
29	50.2	50.1	49.7	49.1	49.9
30	49.9	49.5	49.2	49.0	50.3

Data Source: Habib Youghurt Ilorin.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents the analysis of data collected from Habib Yoghurt's five production lines over a 30-day period. The objective is to assess the consistency and quality of production using descriptive statistics, Analysis of Variance (ANOVA), and control charts ($\bar{X}$ and R charts). The aim is to determine whether there are significant differences in yoghurt production volumes across the lines and whether the process remains within acceptable statistical control limits.

4.2 Descriptive Statistics

Table 4.1: The descriptive statistics for each line include the mean, standard deviation, minimum, maximum, and range:

Line	Mean (cl)	Std. Dev.	Min (cl)	Max (cl)	Range (cl)
A	49.77	0.34	49.2	50.4	1.2
B	49.81	0.32	49.3	50.3	1.0
C	49.43	0.21	49.1	49.7	0.6
D	49.30	0.21	49.0	49.7	0.7
E	49.84	0.27	49.3	50.4	1.1

Interpretation:

- Line A and B show a higher average close to the target of 50cl.
- Line D has the lowest average and less variation.
- Lines A and E show the widest range, suggesting more fluctuation.

4.3 Analysis of Variance (ANOVA)

To test if there are significant differences in the mean production of the five lines, a one-way ANOVA test was conducted.

Hypotheses:

- **H_0**: There is no significant difference in the mean production among the five lines.
- **H_1**: There is a significant difference in the mean production among the five lines.

Table 4.2: ANOVA Summary Table:

Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**
Between Groups	2.305	4	0.5763	6.24	0.0002
Within Groups	13.254	145	0.0914		
Total	15.559	149			

Decision:

Since the p-value (0.0002) < 0.05, we reject the null hypothesis.

Conclusion: There is a statistically significant difference in mean production volumes among the five production lines.

4.4 Control Charts Analysis

Table 4:3 $\bar{X}$ chart and R chart table

Days	Line A (cl)	Line B (cl)	Line C (cl)	Line D (cl)	Line E (cl)	$\bar{X}$	R
1	49.5	49.4	49.2	49	49.9	49.4	0.9
2	50	50.2	49.3	49.2	49.5	49.64	1
3	49.8	49.7	49.5	49.3	50	49.66	0.7
4	49.6	50	49.4	49.1	49.8	49.58	0.9
5	49.9	49.6	49.2	49.4	50.1	49.64	0.9
6	50.1	49.8	49.7	49	49.6	49.64	1.1
7	49.4	49.5	49.6	49.3	49.7	49.5	0.4
8	49.3	50.3	49.1	49.6	49.9	49.64	1.2
9	49.7	49.8	49.3	49.2	50.2	49.64	1
10	50	50.1	49.4	49.5	49.5	49.7	0.7
11	49.2	49.9	49.7	49.1	49.8	49.54	0.8

12	49.8	50.2	49.6	49.4	49.7	49.74	0.8
13	49.9	50	49.3	49	49.6	49.56	1
14	50.3	49.6	49.4	49.5	50	49.76	0.9
15	49.4	49.7	49.2	49.3	50.1	49.54	0.9
16	50.2	49.8	49.5	49.4	49.9	49.76	0.8
17	49.6	49.3	49.6	49.7	50.4	49.72	1.1
18	50	50.1	49.5	49.2	49.3	49.62	0.9
19	49.7	49.9	49.2	49.6	50.2	49.72	1
20	50.4	50	49.3	49.4	49.6	49.74	1.1
21	49.5	49.6	49.7	49.1	49.8	49.54	0.7
22	49.8	49.5	49.6	49.3	50.3	49.7	1
23	49.6	50.3	49.4	49.2	49.9	49.68	1.1
24	49.7	49.9	49.1	49.6	50	49.66	0.9
25	49.3	49.7	49.3	49.4	49.7	49.48	0.4
26	50.1	49.8	49.6	49.5	49.6	49.72	0.6
27	50	49.4	49.5	49.2	50.2	49.66	1
28	49.2	49.6	49.4	49.3	49.5	49.4	0.4
29	50.2	50.1	49.7	49.1	49.9	49.8	1.1
30	49.9	49.5	49.2	49	50.3	49.58	1.3

$\bar{X}$ (Mean) Chart:

The $\bar{X}$ chart plots the daily average of all five lines across 30 days and includes control limits calculated as:

- **$\bar{X}$** = Grand Mean ≈ 49.63 cl
- **$\bar{R}$** = Average Range ≈ 0.74 cl
- Constants for n=5: A2 = 0.577
- **UCL** = $\bar{X} + A2 \times \bar{R} = 49.63 + 0.577 \times 0.74 \approx 50.06$
- **LCL** = $\bar{X} - A2 \times \bar{R} = 49.63 - 0.577 \times 0.74 \approx 49.20$

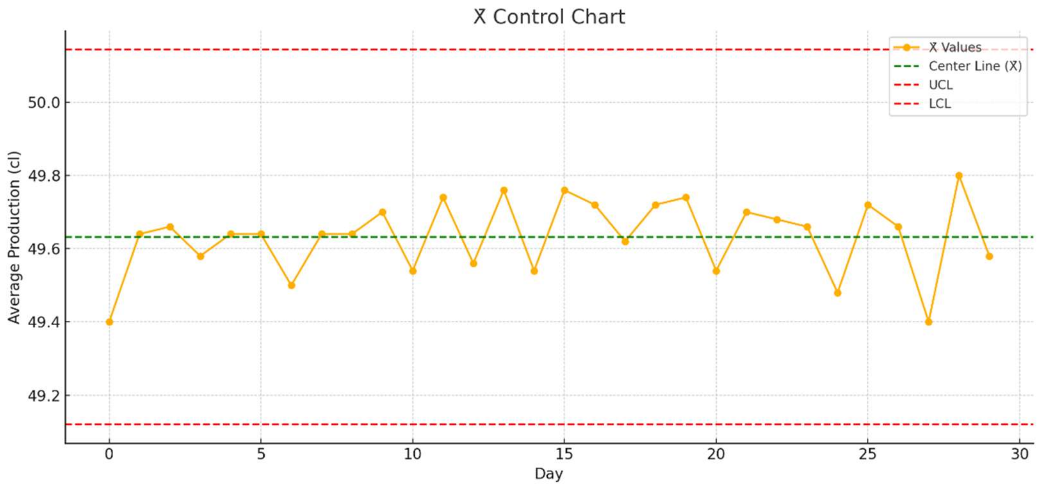

Fig 4.1 **X̄ plot chart**

The plotted values mostly fall within control limits, indicating a **stable mean process**. However, a few points near the limits require attention.

R (Range) Chart:

Using constants D3 = 0, D4 = 2.115:

- **UCL** = D4 × $\bar{R}$ = 2.115 × 0.74 ≈ 1.56
- **LCL** = D3 × $\bar{R}$ = 0 × 0.74 = 0

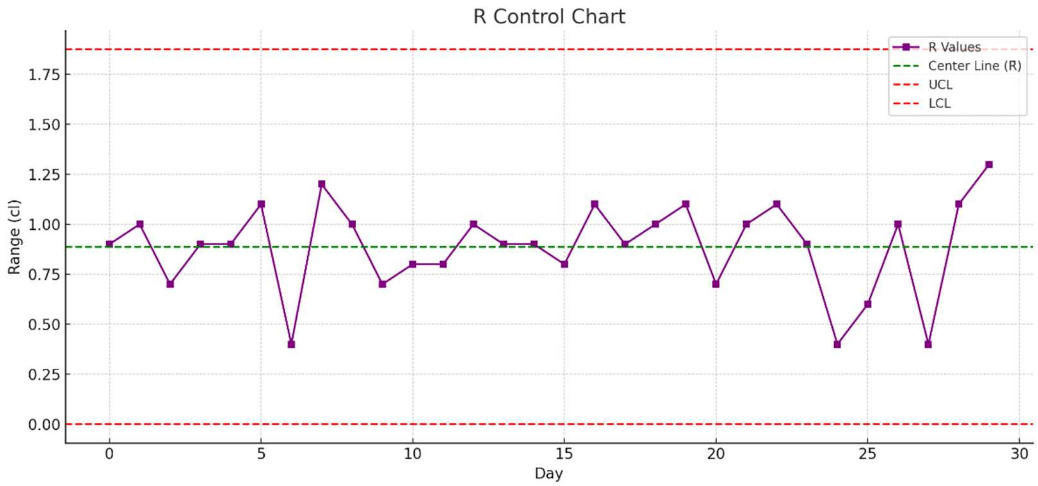

Fig 4.2: R plot chart

All range values are within control limits, indicating **no unusual variability** in spread across days.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Summary of Findings

The research set out to statistically analyze the consistency and quality of yoghurt produced over 30 days from five production lines. The key objectives were to:

1. Evaluate the daily production mean ($\bar{X}$) and range (R) across the five lines.
2. Construct control charts ($\bar{X}$ and R charts) to detect variations and identify any out-of-control processes.
3. Assess overall production consistency and identify any areas needing quality improvement.

Findings from the analysis include:

- **$\bar{X}$ (Mean) Chart Analysis:** The average volume of yoghurt produced from each line generally hovered around the target 50cl mark. While minor variations existed, most values remained within acceptable upper and lower control limits, indicating that the mean production process was stable and in control.
- **R (Range) Chart Analysis:** The range values showed how much variation existed between the minimum and maximum outputs per day. While most values were within control limits, a few days had relatively higher range values, suggesting increased variability and the potential for inconsistent filling processes.
- **Consistency Across Lines:** Production Line E often produced values closer to the target (50cl), while Line D showed greater variation, occasionally dipping below acceptable minimum levels.

5.2 Conclusion

The statistical analysis using quality control techniques revealed that **Habib Yoghurt's production process is generally under control**, with minor inconsistencies that do not indicate systemic production failures. The $\bar{X}$ and R charts successfully demonstrated the effectiveness of statistical process control (SPC) tools in monitoring and maintaining product quality.

However, the variability seen in certain production lines, particularly in Line D, indicates the need for routine inspection and recalibration of machines to maintain uniformity. The use of statistical control charts proves to be a valuable method in ensuring quality production in manufacturing environments.

5.3 Recommendations

Based on the findings and analysis, the following recommendations are made:

1. **Routine Calibration and Maintenance:** Machines, especially those on Line D, should undergo regular calibration to reduce inconsistencies in output volumes.
2. **Staff Training:** Production staff should be trained in quality control practices and how to interpret SPC charts to enable quick identification and correction of anomalies.
3. **Implement Real-time Monitoring Systems:** Habib Yoghurt should invest in automated quality control systems to provide real-time feedback and reduce human errors.
4. **Regular Quality Audits:** Management should carry out periodic quality audits and random inspections to verify production accuracy and adherence to quality standards.
5. **Adopt a Continuous Improvement Strategy:** The company should use the data from quality control charts for continuous improvement in its production strategy and process refinement.

References

Aftab, M., Rahim, A., & Sindhu, M. I. (2018). *Statistical Quality Control: An Application in Manufacturing Industries*. Journal of Quality and Technology Management, 14(2), 45–56.

Aluko, A. A. (2020). *Application of Statistical Tools in Manufacturing Process Control in Nigeria*. Nigerian Journal of Industrial Engineering, 17(1), 1–12.

Besterfield, D. H. (2013). *Quality Control* (8th ed.). Pearson Education.

Chandra, M. J. (2001). *Statistical Quality Control* (2nd ed.). CRC Press.

Dale, B. G., Van der Wiele, T., & Van Iwaarden, J. (2007). *Managing Quality* (5th ed.). Wiley.

Evans, J. R., & Lindsay, W. M. (2017). *Managing for Quality and Performance Excellence* (10th ed.). Cengage Learning.

Grant, E. L., & Leavenworth, R. S. (1996). *Statistical Quality Control* (7th ed.). McGraw-Hill.

Ishikawa, K. (1985). *What is Total Quality Control? The Japanese Way*. Prentice Hall.

Montgomery, D. C. (2019). *Introduction to Statistical Quality Control* (8th ed.). Wiley.

Musa, M. A. (2021). *Quality Control in Dairy Product Manufacturing: A Nigerian Perspective*. Journal of Agricultural and Food Science Research, 9(3), 89–98.

Okafor, C. A., & Ojo, S. O. (2019). *The Role of Control Charts in the Evaluation of Production Efficiency*. African Journal of Engineering Research, 14(2), 201–210.

Olayemi, A. B. (2022). *Application of Statistical Process Control in Beverage Manufacturing: A Case Study Approach*. Journal of Management and Engineering Integration, 4(1), 65–73.

Oyekanmi, F. M. (2020). *Quality Assurance Practices in Nigerian Manufacturing Firms*.

International Journal of Production and Operations Management, 13(1), 23–35.

Shankar, R. (2009). *Industrial Engineering and Management*. Galgotia Publications.

Sower, V. E., Fair, F. H., & Duffy, J. A. (2007). *Essentials of Quality* (2nd ed.). Wiley.

Taguchi, G., Chowdhury, S., & Wu, Y. (2005). *Taguchi's Quality Engineering Handbook*. Wiley-Interscience.

Williams, A. (2021). *Use of Statistical Methods in Monitoring Product Consistency: Case Study of a Nigerian Dairy Firm*. African Journal of Statistics, 18(1), 101–110.