

**A QUALITY CONTROL STUDY OF NIFOR BOTTLED PALM WINE  
PRODUCTION USING A CONTROL CHART**

**BY**

**EGBUJOR EMMANUEL CHINEDU**

**ENG1904921**

**DEPARTMENT OF AGRICULTURAL ENGINEERING**

**FACULTY OF ENGINEERING**

**UNIVERSITY OF BENIN**

**BENIN CITY**

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**CERTIFICATION**

This is to certify that this project was carried out by Egbujor Emmanuel of the Department of Agricultural Engineering, University Of Benin, Benin City, Edo State.

.....

**Engr. Dr. F. O. Uwoghiren**  
**Supervisor**

.....

**Date**

.....

**Engr. Dr. E.M. Etuk**  
**Project Coordinator**

.....

**Date**

.....

**Prof. R.O. Edokpia**  
**Head of Department**

.....

**Date**

## **DEDICATION**

This research work is dedicated to God Almighty

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My gratitude goes to God Almighty for giving me the opportunity to come this far in my Degree programme.

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## ABSTRACT

Companies must carry out various businesses, one of which is by supervising each production process in order to produce quality products. Quality control is required within a company to minimize operational costs in products. Good quality control will assist in the fluency of the production process, so that the production activity will reach its target. Companies will find means to implement a quality control system that is capable and reliable. One of the methods is using Statistical Process Control (SPC).

The case studied in this project was the bottled palm wine product in NIFOR palm wine bottling unit. This research is centered on the quality of nifor bottled palm wine due to breakages during pasteurization. The SPC used is the Control chart (p chart).

Based on the analysis of control chart, it is indicated that the process is in control. This can be seen in the control charts where there is the absence of outliers. In the month of January, February, March and April, there are zero out of bounds. Thus the Enterprise can take to maintain and monitor current processes by regular quality checks and statistical monitoring to ensure that the process remains in control.

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## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 Background of the study**

Quality of Statistics Using a variety of statistical tools, control is essential to every production process. Additionally, it is essential in every aspect of life, from the home to large engineering and service sectors. It lowers overall costs while enhancing the quality of completed goods and services. For a corporation to limit operating expenses in its products, quality control is necessary. In order for the production activity to achieve its goal, effective quality control will help the production process run smoothly. The goal of the company's quality control is to reduce the quantity of faulty or damaged goods.

Because product quality is the primary determinant of consumer decisions when selecting and evaluating a product, quality control can prevent products from being damaged before they reach consumers, preserving the company's reputation. It can also help the company satisfy customer demands for the desired product.

The quality control analysis process will have an influence on the company's reputation and increase consumer confidence in the company's performance. Companies that are aware of it always carry out quality control activities in every process of producing goods or services.

In our day-to-day life, we use different products and services from the time we get up until we get back to bed. For example, we use different types of products such as toothpaste, soap, detergent, clothes, food, gas stove, vehicle, phone, computer, TV, electric bulb, etc. and we also use different types of services such as water supply, electricity, transportation, health care, education, etc.

A comprehensive system for quality control fundamentally requires outlining the necessary specifications and creating a product that adheres to these specifications. Inspection ensures that the product meets established standards, and we must remember that production, which involves creating goods and services for people, is not complete until those products reach the end consumer. In this regard, reaching the end consumer means that the consumer accepts the product.

The concept of applying Statistical Quality Control in manufacturing started in 1924, introduced by Walter Shewhart at the Bell Telephone Laboratory. Organizations that create goods and services for the public generally strive to produce offerings that consumers will find acceptable. Quality serves as a competitive advantage.

Nowadays, quality control is an essential practice for all organizations aiming to succeed and stay operational. This need arises because the quality of any product or service is a key indicator of its ability to meet or exceed what consumers expect, whether these expectations are implicit or explicit. The American Standard Institute describes quality control as encompassing all the features and traits of a product or service that contribute to its capacity to fulfill a specific need.

Therefore, to achieve the required quality, it is crucial to manage all elements that influence the necessary quality of the product or service. Furthermore, the aim of quality control is to ensure quality that meets standards for safety, adequacy, reliability, and costeffectiveness, especially during this era of significant industrial progress that emphasizes product standards.

In some industries measurement, inspection and testing are done frequently by people or with devices to ascertain that the required quality is sent into the market. Statistical quality control method enables us to obtain maximum benefit out of production and inspection at lowest cost. It is one of the most useful economic applications of the theory of sampling and is significant in industries. Most business organisations have rather leaned on quality policies inclined towards the end of production to detect product defects (Krishnamoorthi, et al 2018). This is product quality control with grave consequences in the form of internal failure and external failure costs such as scrap, rework or salvaged, retest and penalty for not meeting schedule and complaint adjustment, product return and warranty charges respectively (Krishnamoorthi, et al 2018).

Furthermore, it is apparent of the danger associated with dependent on a mono-cultural type of economy which is characterised in most of the developing countries since worldwide out of 1982, it has become totally clear that petroleum oil is a major export commodity and cannot salvage the entire economy of the country. Thus, concerted effort has to be made for diversification; this entails generating foreign exchange. This could only be done effectively by making our locally manufactured product more competitive in terms of quality and price hence, the need for a dynamic quality control system is needed.

Manufacturing companies are continuously facing the challenge of operating their manufacturing processes and systems in order to deliver the required production rates of high quality products, while minimizing the use of resources. *Production quality* is proposed in this paper as a new paradigm aiming at going beyond traditional six-sigma approaches. This new paradigm is extremely relevant in technology intensive and emerging strategic manufacturing sectors, such as aeronautics, automotive, energy, medical technology, micro-manufacturing, electronics and

mechatronics. Traditional six-sigma techniques show strong limitations in highly changeable production contexts, characterized by small batch productions, customized, or even one-of-a-kind products, and in-line product inspections. Innovative and integrated quality, production logistics and maintenance design, management and control methods as well as advanced technological enablers have a key role to achieve the overall *production quality* goal. (Colledani et al 2014).

## **1.2 Statement of the Problem**

In the production process, quality control has to be conducted on the product. The quality control has a huge impact on the product, whether it is defective or not. For any organisation to achieve its objectives of profit maximisation, it is required that its products must be of high quality, so as to satisfy its customers and be able to compete with any other product in the market. To obtain quality products and reduce defects, some control measures such as statistical quality control methods (using p charts) are needed in the production process of any organisation.

This research work centres on the application of statistical quality control (using p chart) in bottled palm wine production to ensure that the quality of the product does not deviate from the set standards. Viewed from the current conditions where well preserved palm wine products are an important product for the people. Palm wine is a traditional alcoholic beverage made from the sap of various palm tree species, such as the date palm, coconut palm, or oil palm. It's widely consumed in parts of Africa, Asia, and South America. The sap ferments naturally, producing a

mildly alcoholic drink with a sweet, tangy flavour. Palm wine plays cultural and social roles in many communities, and it's also used in traditional medicine.

### **1.3 Aim and Objectives of the study**

#### **1.3.1 Aim**

The aim of the study is to conduct a quality control on NIFOR Bottled palm wine production using a Control chart.

#### **1.3.2 Objectives**

To achieve this aim, the objectives pursued are as follows:

- i. Collect data from NIFOR Bottling unit;
- ii. Find the upper control limit
- iii. Find the lower control limit
- iv. Plot the defective fraction on the chart.
- v. Carry out analysis and render interpretation to the results obtained.

### **1.4 Significance of the study**

This research is significant in the sense that it will provide the production unit and operators with the intelligent guidelines that will ensure continuous quality of the Bottled palm wine produced. The importance of this study aimed at detecting if there is need for improvement on customer satisfaction and increased profit with respect to the production of NIFOR palm wine.

Also, it is hoped that this study will serve as a clue to manufacturers while producing for

consumers to:

- i. Enable manufacturers to accept only standard quality material during production
- ii. Help the company in maximising profit
- iii. Enable bottled palm wine to meet specification

### **1.5 Scope of the study**

This study is restricted to the application of a P chart for quality control in the manufacturing process of NIFOR Bottled Palm Wine, with a specific focus on monitoring defects such as breakages during the pasteurization process. A four-month production report will serve as the basis for how long the data will be analyzed.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 The Concept of Quality

Quality is a relative term, generally used with reference to the end use of the product (Jayakumar and Raju 2016). This is corroborated, according to (Summers, 2018), by the American Society for Quality, which defines quality as a subjective term for which each person has his or her own definition.

Palm wine is the fermented sap of various palm trees especially Palmyra, silverdatepalm and coconut palms Palm wine can be obtained from the young inflorescence either male (or) female ones palm wine is alcoholic beverage that are made by fermenting the sugary sap from various palm plants. It is collected by tapping the top of the trunk by felling the palm tree and boring a hole into the trunk it is a cloudy whitish beverage with a sweet alcoholic taste and very short shelf life of only one day (Chandrasekhar, et al 2012). The microbiological quality of different palm wine samples were investigated and it was found to harbour microorganisms such as Lactobacillus sp, Micrococcus sp, Staphylococcus sp, Streptococcus sp and Bacillus sp. This had a count of  $0.8 \times 10^3 - 1.8 \times 10^3$  CFU/ml and  $1.2 \times 10^3 - 3.8 \times 10^3$  CFU/ml for different samples. The isolation of these microorganisms from these products is of public health concern because this product is on high demand in this area and beyond. With the result of this study, public awareness has to be created on the risk factors involved in the consumption of palm wine and the need to imbibe proper sanitary hygienic practice in tapping, processing, diluting and distribution of the product. (Uzoh et al 2024).

The incorporation of bottled palm wine (fermented palm sap) into the local beverage market is currently gaining wide acceptability in Nigeria. Palm wine is a popular traditional African beverage which is obtained by tapping *Raphia palm* (*Raphia hookeri* G. Mann and H. A. Wendl.) and oil palm (*Elaeis guineensis* Jacq.) trees. Palm sap ferments easily, and becomes sour within a few hours of collection. When fresh it is sweet, refreshing, nourishing and a nutritious drink containing sugar, vitamins and minerals. *Raphia palm* wine has a sugar content of about 6-8%, an acidity (calculated as acetic acid) of about 0.47% and protein (% w/v) of about 0.05% (Ojomo, 1987). Within 24 hours of fermentation, sugar content reduces to 0.5 - 1% while acidity increases to 0.5 - 0.6%. Present in the wine are various microorganisms (mainly bacteria and yeasts) which originate from the indigenous flora of the palm trees and from equipment used in collecting the sap (Ojomo, 1987).

The length of preservation and bacteria associated with the variation in the components of palm sap during fermentation were investigated at room temperature. The fermenting palm sap at room temperature deteriorated after two days of storage; while its counterpart treated at 75° C for 30 minutes stored well at room temperature for 12 months.

The Nigerian Institute for Oil Palm Research (NIFOR) has successfully designed and made its own general Purpose Water-bath for pasteurization of bottled palm wine.

pasteurization is a process of food preservation in which packaged foods in this case, Palm wine are treated with mild heat, usually to less than 100 °C (212 °F), to eliminate pathogens and extend shelf life. Pasteurization either destroys or deactivates microorganisms and enzymes that contribute to food spoilage or the risk of disease, including vegetative bacteria. Pasteurization is used to destroy any micro-organisms that may be present in the palm wine (essentially yeast cultures). Nifor uses a

temperature-controlled discontinuous pasteurization method, which preserves the nutritional qualities and flavor of the wine.

Before pasteurizing, the palm wine is poured into bottles manually with the aid of the dispensing machine and corked and then kept inside a water bath. The water bath's temperature is then raised to an average temperature of about 80 - 85°C and the bottles are kept in the water bath for about 2 to 3 hours. The bottles were not opened to prevent air from entering the palm wine. The bottled palm wine is then allowed to cool for some time and then, is ready for consumption.

During the pasteurization process of palmwine, not all bottles may be able to survive the heating process which leads to breakages. Breakages may occur in the pasteurizer (reactor) due to the following;

#### 1. The Amount of Heat Applied

In the pasteurization process, applying heat is critical for killing microbes and ensuring the safety of the beverage. However, if the heat exceeds the bottle's tolerance, the glass or plastic can become structurally compromised. For glass bottles, heating too quickly can cause thermal shock. This happens when the bottle's outer surface expands faster than the inner surface, leading to cracking or even breakage. The pasteurization process typically involves a temperature range between 60°C and 80°C, but if the heat distribution is uneven, the stress created by rapid expansion or contraction can shatter the bottle. To withstand such temperature, the bottle's silica content has to be high. For a NIFOR bottle with specifications 33cl 43mm :: [Beta] :: 04 :: B21 3

Since the bottle has a small volume (33cl), it heats up and cools down faster during pasteurization compared to larger bottles. This rapid temperature change increases the risk of thermal shock in glass bottles, where the inner and outer parts of the bottle experience different rates of expansion. For plastic bottles, smaller volumes mean they are also more prone to deformation or softening if the material is not heat-resistant.

## 2. The Chemical Properties and Composition of the Packaging Bottle

The material composition of the bottle plays a significant role in its ability to withstand the heat of pasteurization. Bottles can be made from different types of glass or plastic, each with distinct chemical compositions. Glass bottles, for example, may be composed of different levels of silica, soda, and lime, which affects their thermal resistance. Low-quality glass bottles may contain impurities that weaken their structural integrity under heat.

High silica content makes the glass more resistant to thermal shock, while soda-lime glass is more prone to cracking under heat stress. Variations in the thickness of the bottle also influence its ability to withstand high temperatures.

The wider neck (43mm) could make the bottle more prone to thermal stress because the broader opening can cause more uneven heating or cooling between the top and bottom parts of the bottle.

## 3. The Number of Times the Bottle Has Undergone Pasteurization

Repeated exposure to heat can cause wear and tear on the bottle. In the case of glass bottles, each cycle of heating and cooling introduces stress, leading to the formation of microscopic cracks. Over time, these cracks grow and compromise the bottle's strength, making it more prone to breaking during subsequent pasteurization processes.

### **2.1.1 Function of Production process**

The main objective of any production process is to control and maintain the quality of the manufactured product so that it conforms to certain specified quality standards. Any production process consists of two stages : process control and product control. Process control- The concept of process control was pioneered by W. A. Shewhart of Bell telephone laboratories in 1924 by using the concept of theory of probability and sampling. A typical control chart consists of three horizontal lines. They are

- i. A central line (CL), indicates the desired standard or the level of the process
- ii. Upper Control Limit (UCL)
- iii. Lower Control Limit (LCL)

Product control- The concept of product control was pioneered by Dodge and Romig by using the concept of sampling inspection plans. It means controlling the quality of the product by critical examination at strategic points. It attempts to ensure that the product marketed by sale department does not contain a large number of defective items.

## Function of Quality Control

In SQC there is a term called quality. It plays a vital role in statistical quality control. Quality control technique is a powerful tool or productive technique for effective diagnosis of lack of quality in any one of them like material, machine, or management, etc. It is essential that the finished products must possess the optimum quality that the consumer expects of them. In quality control the term quality depends upon four M's.

They are as follows.

- i. Quality of material-Good quality of material, reducing waste, smooth processing and increasing output. It will also provide better end to end products
- ii. Quality of manpower- Well qualified and skilled personnel will increase efficiency of the any production process due to better quality production through the application of their skills and also reduce the production cost and time.
- iii. Quality of machine - Good quality of machine will increase the production, reduce breakdown situation and reduce the cost of finished product.
- iv. Quality of management- A good management is imperative to increase in efficiency, harmony in relations, growth of business and their related markets.

## 2.2 Quality Improvement

(Montgomery, 2009) defined quality improvement as the reduction of variability in processes and products. Quality has many dimensions (Jayakumar and Raju, 2016), which could be objective and subjective as well. Dimensions of Quality are the various features / aspects of a product or service, which the customer uses to evaluate the product or service (Jayakumar and

Raju,2016).

As quoted by (Krishnamoorthi, et al 2018), Garvin expressed quality in several dimensions

1. Performance—the product’s ability to do the work it is supposed to do.
2. Features—things that add to convenience and comfort.
3. Reliability—the ability to perform without failure over time.
4. Conformance—the degree to which the product meets codes of a state or a community.
5. Durability—the length of time the product will last until it is discarded.
6. Serviceability—the ability for making repairs easily, quickly, and at a reasonable cost.
7. Aesthetics—sense appeal, such as colour, sound, feel, and comfort.
8. Perceived quality—the impression the product creates in the customer’s mind.

### **2.3 Statistical Quality Control (SQC)**

The Statistical Quality Control Method (SQC) focuses more on preventing issues in production rather than just identifying defective products and quantifying their numbers. Its aim is to address problems early on to reduce the occurrence of poor quality items. When there are flaws and damaged items, operational expenses rise, leading to increased costs related to repairs, rework, waste, replacements, warranties, and extensive inspections, all of which can cause significant manufacturing challenges.

The idea of quality in products is closely linked to methods and strategies for improving that quality, including the practice of quality control. Statistical quality control employs analytical techniques to manage, study, and enhance both products and processes through statistical approaches ensuring

better product standards.

There are seven key statistical tools within Statistical Quality Control used for maintaining quality. The control chart most commonly utilized is the p-chart, which monitors the proportion of items that do not meet specified criteria (classified as defective). The rejected proportion,  $p$ , is calculated as the number of noncompliant items found during inspection compared to the total number assessed.

Control charts deliver information about variations in quality characteristics, allowing observation of whether processes are under control. Essentially, control charts graphically represent a quality feature that has been either measured or calculated from a sample in relation to the sample number or a timeline (Montgomery, 2009).

According to Conceição et al. (2018), these charts function as hypothesis tests, indicating that when a plotted point falls within the established control limits, the statistical control hypothesis remains valid, whereas points outside these limits suggest it has been rejected. This concept was developed by Dr. Shewhart to facilitate the analysis of processes by illustrating their performance over time (Summer, 2018).

The control chart plots a quality characteristic over time and typically includes a center line (CL) along with an upper control limit (UCL) and a lower control limit (LCL). These lines help identify central tendency and natural process variability. Usually, the center line aligns with the arithmetic mean of the reported statistics, ensuring that roughly half of the subgroup values lie on each side.

Control limits are generally determined by combining the center line with three theoretical standard deviations of the plotted data (Benneyan, 1998).

Control charts are represented on a rectangular coordinate system, where the vertical axis shows statistical measures  $\bar{X}$  and  $\bar{R}$ , while the horizontal axis displays sample numbers. Time indicators such as hours, dates, or lot numbers can also be included on the horizontal axis.

Sample points, either the mean or range, are shown on the chart with points that may or may not be

connected (Bhasin et al, 2016). Control charts are utilized in two different stages. The initial stage involves using control charts to look back at historical data to check if a process has been statistically controlled. The second stage focuses on using control charts with samples collected in order over time to identify any changes from a controlled process (Smeti et al, 2007, Montgomery, 2009).

## **2.4 Purpose of Control charts**

As indicated by (Benneyan, 1998 and Krishnamoorthi, et al 2018), control charts are valuable for several purposes throughout the process improvement cycle. These are:

- a. Testing for and establishing a state of statistical control;
- b. Monitoring an in-control process for changes in process and outcome quality;
- c. Identifying, testing, and verifying process improvement opportunities.
- d. To maintain a process at its current level
- e. To control a process at a given target or nominal value
- f. As a troubleshooting tool
- g. As an acceptance tool

## **2.5 Merits of Previous Researches**

SQC is already utilized in various sectors to meet quality objectives. In healthcare, SQC helps lessen infections related to hospitals (Limaye et al. , 2008). It is used in the analysis of DNA microarray data (Chimka and Oden, 2008) for assessing the expression of individual genes and in manufacturing to minimize variations in processes (Xiang and Tsung, 2008). Additionally, it supports the management of relationships between buyers and suppliers (Morgan and Dewhurst, 2007), oversees the quality of products made to specific geometric requirements (Colosimo et al. , 2008), identifies faults in manufacturing (Zantek et al. , 2007), and is applied in automotive machining processes (Zhou et al. , 2003).

SQC has numerous advanced applications, establishing a solid presence in quality research. Nonetheless, chronological documentation of SQC in existing literature remains scarce. Appalasaamy P. et al. (2012) analyzed wine quality using physicochemical data. This research also aimed to find anomalies or outliers in a wine sample set to identify any wine adulteration. The study used two extensive datasets, which included 1,599 examples of red wine and 4,989 examples of white wine, along with 11 physicochemical attributes like alcohol, pH, and sulphates. Two classification methods, Decision tree and Naïve Bayes, were applied to the datasets, and their performance was compared. The outcome indicated that the Decision tree (ID3) surpassed the Naïve Bayesian methods, especially with red wine, which is the most prevalent type. The study also revealed that alcohol and volatile acidity are significant factors influencing wine quality. White wine shows greater sensitivity to physiochemical changes compared to red wine, requiring more careful handling. The findings suggest that classification methods can facilitate corrective actions aimed at enhancing wine quality during its production.

Dooley (2000) explored how the field of quality has developed through various paradigms, suggesting there are three main paradigms: a preindustrial view known as 'caveat emptor', an industrial focus on quality control, and a postindustrial approach termed total quality management (TQM). Oluwole O. et al. (2023) investigated the microbial makeup and nutritional features of palm wine obtained from different palm varieties. Their analysis covered fermentation methods, product durability, and spoilage, underscoring quality inconsistencies arising from spontaneous fermentation. The study highlighted the necessity for improved quality control methods to

guarantee product safety and uniformity in packaging.

Smeti et al. (2007) utilized statistical process control methods to enhance the quality of treated water at the Athens Water Supply and Sewerage Company. The focus was on turbidity, residual chlorine, and aluminium measurements from the Polydendri tank in 2004, as these values showed possible variations during that year. They discovered that, while most chemical parameters of the treated water in the Polydendri tank met the criteria set by the 98/83/EEC Directive—except for one turbidity measurement—statistical process control methods can help improve water quality. This is because control charts are designed to identify unusual variability, allowing for process investigations and corrective measures before issues become serious.

Lu X. S. (1998) created a Shewharttype control chart known as the multivariate np chart (MNP chart) to manage processes involving multiple attributes. This control chart calculates a weighted total of nonconforming unit counts across all quality attributes as the data points. It improves the ability to pinpoint critical causes when an outofcontrol situation is detected. Additionally, it is easy to understand when evaluating out of control signals.

Ieren et al. (2020) also applied statistical quality control methods to assess process stability in a sachet water production company. Various quality control tools, including pcharts, ucharts, Xbar and R charts, as well as process capability charts, were employed to analyze field data collected from the sachet water manufacturing operations over 30 working days. This analysis aimed to determine if the processes were under control or out of control and to evaluate whether the

marketing process was capable of meeting established standards.

Nwaiwu, O. , & Itumoh, M. (2017) investigated the presence of chemical pollutants in palm wine and their potential impacts on consumer safety, stressing the importance of enhanced quality control during the packaging and distribution stages.

Ihunwo and Kinigoma (2016) studied how the production process at a water bottling facility is managed to enhance quality, using a water bottling company as a case example. The main goals of the study were to implement statistical process control (SPC) to oversee the production process for quality improvement and to optimize the production system to minimize waste.

Chero (2019) employed Statistical Process Control (SPC) techniques by utilizing statistical control charts in processes within the chemical and food industries, emphasizing the benefits these charts provide for process management.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 Research Design**

This research employs quantitative analysis and detailed interviews to gather data, with the quality and production managers serving as informants.

Quality control aims to uphold the product's standards defined by the company while minimizing defective goods. Analyzing the research subject necessitates thorough examination of the gathered data. The initial method used is the CChart, which helps determine whether the company's quality control measures are effective. Quality control analysis at the NIFOR bottling facility is performed using the Control Chart (CChart) technique.

The C chart assessment is utilized to identify and classify the extent and nature of defects in the final products. This includes checking if the damage is within allowable limits and whether it meets the established control criteria.

Regardless of the precision in outlining production processes, manufacturers understand that identical products cannot be guaranteed for every unit. This acknowledgement points to the presence of unmanageable variations in product quality. Factors like humidity, temperature fluctuations, machinery wear, and the mental and physical states of workers engaged in

production can introduce these uncontrollable disparities. Aware of this, manufacturers focus on creating products that are consistent and regulated—ensuring that variations from one production cycle to another remain within limits that can be attributed to randomness or other factors that do not relate to time. (Shewhart 1926).

### **3.2 Method of data collection**

The approach used to gather information for this study was secondary. Data was obtained straight from the palm wine production unit. This choice was made because the project is applied research, which means it needs precise data to minimize potential errors during collection; thus, accurate data ensures reliable results. Information on the amount of palm wine produced was retrieved from well maintained records through secondary data collection methods.

### **3.3 Method of Data Analysis**

Analysis is performed utilizing mean charts and changes in range. To conduct the analyses, including the creation of control charts and other statistical tests that support decision making, we rely on the StatistiXL ® Statistical software package. This choice was made based on references regarding its use (Krishnamoorthi, et al 2018) and its accessibility. Additionally, this software is userfriendly and can complete the required analyses effectively.

#### **Pchart:**

The Pchart serves to assess and track processes that generate defective or nonconforming products. The items counted are variable, and the size of the samples can vary as well.

A control chart, also known as a Shewhart chart, statistical process control chart, or SPC chart, is

one of the graphical tools used in quality control analysis to observe how processes evolve over time. Walter A. Shewhart created control charts during his tenure at Bell Labs in the 1920s, and these tools have since been utilized across numerous industries as a part of process improvement strategies. Shewhart realized that every well designed process experiences some degree of variation, and this variation can have adverse effects if it prevents meeting deadlines or quotas. This graphical tool assists in quality control analysis and also in tracking processes that change over time. Such changes can occur in various sectors, including manufacturing, services, healthcare, and nonprofit organizations. It offers insights into how the processes may shift over time.

Control charts find applications in multiple statistical control functions.

Control charts can assist you in the following ways:

Identify the variations consistently found within processes. Variations that remain within control limits suggest the process is functioning correctly. Conversely, variations that exceed control limits signal issues needing attention.

Detect when problems are occurring or are likely to arise. These indicators inform you that action is required to correct the situation.

Recognize trends within plotted data points. These trends can hint at potential causes, aiding in discovering possible solutions.

Forecast future outcomes.

Spark new ideas for enhancing quality based on your findings.

There are several types of control charts that are quite similar but tailored to specific features of the quality characteristic being examined. Charts are categorized broadly based on whether the monitored data is classified as “variable” or “attribute. ”

### **i. Variable control chart**

These charts aim to establish and sustain an acceptable quality level for processes where the output can be measured quantitatively or dimensionally, such as the diameter or depth of a hole, the length of a screw or bolt, or the wall thickness of a pipe. They are used for measurable quality traits. The quality characteristics for all products should be evaluated in subgroups, which are samples consisting of a fixed number of items, products, or components taken randomly over a specified time period.

Variable control charts are categorized into three types: X bar control chart, Range ‘R’ control chart, and Standard deviation ‘S’ control chart.

### **ii. X bar control chart:**

This chart displays the averages of a group of samples, arranged to track the average of a specific variable, such as the lengths of steel rods, the weights of bags of compounds, or the intensity of laser beams, among other things. To create this chart, samples of the output from a process are collected at regular intervals, the averages of each set are calculated, and these values are then plotted onto the X bar control chart. This chart can be used to compare the actual average of the

process with a standard average and will show whether the average output of the process is changing over time.

### **iii. Range 'R' control chart**

This type of chart demonstrates the variability within a process. It is suited to processes where the sample sizes are relatively small, for example  $<10$ . Sets of sample data are recorded from a process for the particular quality characteristic being monitored. For each set of data the difference between the smallest and largest readings are recorded. This is the range "R" of the set of data. The ranges are now recorded onto a control chart. The center line is the averages of all the ranges.

### **iv. Standard deviation 'S' control chart**

The "S" chart is useful for observing variable data. It works well in cases where many samples are collected. The "S" stands for standard deviation from the sample groups and provides a clearer picture of variation in a large dataset compared to using a range calculation. One benefit of using standard deviation is that it takes into account all the data in a set to find the variation, instead of just considering the highest and lowest values.

### **V. Attribute control chart**

These charts are used to achieve and maintain an acceptable quality level for a process whose output products are not subjected to dimensional or quantitative measurement but can be classified as good or bad or acceptable and non-acceptable, for example surface finish of a product brightness of an item is either acceptable or not acceptable.

The four most commonly used control charts for attributes are:

- i. P charts (Control charts from fraction defectives )
- ii. NP charts (Control charts for number Defectives)
- iii. C-chart (Control charts for number of defects per unit) .

**vi. P charts (Control charts from fraction defectives)**

A P chart is a type of control chart for attributes, specifically designed for data gathered from subgroups that can differ in size. Since the sizes of these subgroups can change, it reflects a ratio of defective items instead of the total number. P charts illustrate how the process evolves over a certain period. The process characteristic is always indicated in a yes/no format or as pass/fail. Generally, a preliminary set of samples is gathered to estimate the nonconforming proportion of the process. This estimated proportion is then applied to set control limits for the proportions. After establishing the control limits for the P chart, these limits can be utilized to keep track of the nonconforming proportion of the ongoing process.

The P chart relies on the binomial distribution. The binomial distribution is associated with the standard deviation  $\sigma_p$ , which is defined by the following relationship:.

$$\sigma_p = \sqrt{\frac{p(1-p)}{n}}$$

where:

n is the sample size

Let samples of size n be taken randomly from the production process or output at different time

intervals. If  $d$  is the number of defectives in a sample, then the fraction defective in the sample.

$P = d/n = \text{Number of defective unit in a sample} / \text{Total number of unit or items in a sample}$

Or Actual number of defectives

$$d = n.p$$

$\underline{P}$  is the Total number of defective items in all the samples inspected / Total number of items in all samples.

Thus, the control limits for the P chart are :

Central Line  $CL = \underline{P}$

$$\text{Upper control limit } UCL_p = \underline{P} + 3 \sqrt{\frac{\underline{P}(1-\underline{P})}{n}}$$

$$\text{Lower control limit } LCL_p = \underline{P} - 3 \sqrt{\frac{\underline{P}(1-\underline{P})}{n}}$$

Since the number of defective products cannot be negative if LCL sometimes comes out to be negative, it is taken as zero, P chart is used to plot and control fraction defectives when the sample size remains uniform or it varies.

**CHAPTER FOUR**  
**RESULTS AND DISCUSSION**

**4.1 Presentation of Data**

This section shows the data that were obtained from the Enterprise and the analysis that has been carried out.

Reasons/guidelines for defects

- i. Poor packaging
- ii. Poor labelling
- iii. Leakage
- iv. Faulty or broken bottle cover cap

**Table 4.1: Bottled Palm wine Production report for January 2024**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
4/01/2024	500	75	0	75	0
5/01/2024	500	450	0	450	2
6/01/2024	500	300	173	473	1
8/01/2024	500	225	0	225	0
9/01/2024	500	525	0	525	3
10/01/2024	500	675	0	675	8
11/01/2024	500	825	0	825	6

12/01/2024	500	900	0	900	3
13/01/2024	500	450	334	784	1
15/01/2024	500	450	0	450	1
16/01/2024	500	825	251	1076	3
17/01/2024	500	1050	0	1050	4
18/01/2024	500	1050	0	1050	3
19/01/2024	500	975	0	975	13
20/01/2024	500	375	0	375	2
22/01/2024	500	975	0	975	4
23/01/2024	500	1050	0	1050	3
24/01/2024	500	600	0	600	2
25/01/2024	500	825	0	825	0
26/01/2024	500	750	0	750	3
27/01/2024	500	375	0	375	3
29/01/2024	500	300	0	300	1
30/01/2024	500	750	84	834	2
31/01/2024	500	900	84	984	3
<b>TOTAL</b>	<b>12,000</b>	<b>15,675</b>	<b>926</b>	<b>16,601</b>	<b>71</b>

**Table 4.2: Bottled Palm wine Production report for February 2024**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
1/02/2024	500	825	0	825	2
3/02/2024	500	450	0	450	1
5/02/2024	500	450	0	450	2
6/02/2024	500	900	0	900	1
7/02/2024	500	525	0	525	0
8/02/2024	500	375	0	375	1
9/02/2024	500	525	0	525	1
19/02/2024	500	150	124	274	1
20/02/2024	500	375	124	499	6
21/02/2024	500	525	0	525	4
22/02/2024	500	525	0	525	1
23/02/2024	500	525	0	525	2
24/02/2024	500	300	84	384	4
/02/2024	500	75	42	112	1
27/02/2024	500	375	0	375	1
28/02/2024	500	450	0	450	1
29/02/2024	500	375	0	375	1
<b>TOTAL</b>	<b>9,000</b>	<b>8,550</b>	<b>374</b>	<b>8,924</b>	<b>32</b>

**Table 4.3: Bottled Palm wine Production report for March 2024**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
1/03/2024	500	375	0	375	0
6/03/2024	500	450	293	743	2
7/03/2024	500	525	0	525	5
8/03/2024	500	225	0	225	1
9/03/2024	500	225	0	225	1
11/03/2024	500	150	0	150	1
12/03/2024	500	225	0	225	0
13/03/2024	500	375	42	417	1
15/03/2024	500	75	0	75	1
16/03/2024	500	450	84	534	6
19/03/2024	500	525	42	567	1
21/03/2024	500	450	84	534	7
22/03/2024	500	375	42	417	1
23/03/2024	500	525	42	567	5
26/03/2024	500	225	125	350	2
27/03/2024	500	525	0	525	1
28/03/2024	500	675	0	675	5
29/03/2024	500	300	0	300	4
30/03/2024	500	450	0	450	8
<b>TOTAL</b>	<b>9,500</b>	<b>7,125</b>	<b>754</b>	<b>7,879</b>	<b>52</b>

**Table 4.4: Bottled Palm wine Production report for April 2024**

DATE	EXPECTED PRODUCTION	PRODUCTION		TOTAL PRODUCTION	NO OF BREAKAGE
		33Cl	65Cl		
1/04/2024	500	150	0	150	2
4/04/2024	500	375	0	375	2
5/04/2024	500	375	0	375	4
8/04/2024	500	225	0	225	2
9/04/2024	500	375	0	375	7
10/04/2024	500	300	0	300	5
11/04/2024	500	300	0	300	8
15/04/2024	500	150	0	150	2
16/04/2024	500	150	0	150	1
17/04/2024	500	225	0	225	5
19/04/2024	500	375	0	375	14
24/04/2024	500	300	126	426	3
26/04/2024	500	225	168	393	3
29/04/2024	500	75	42	117	4
30/04/2024	500	75	84	159	3
<b>TOTAL</b>	<b>7,500</b>	<b>3,675</b>	<b>420</b>	<b>4,095</b>	<b>65</b>

## 4.2 DATA RATIO

**Table 4.5: Bottled palm wine production report for January 2024**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
4/01/2024	100	15	0	15	0
5/01/2024	100	90	0	90	0
6/01/2024	100	60	34	94	0
8/01/2024	100	45	0	45	0
9/01/2024	100	105	0	105	1
10/01/2024	100	135	0	135	2
11/01/2024	100	165	0	165	1
12/01/2024	100	180	0	180	1
13/01/2024	100	90	66	156	0
15/01/2024	100	90	0	90	0
16/01/2024	100	165	50	215	1
17/01/2024	100	210	0	210	1
18/01/2024	100	210	0	210	1
19/01/2024	100	195	0	195	3
20/01/2024	100	75	0	75	0
22/01/2024	100	195	0	195	1
23/01/2024	100	210	0	210	1
24/01/2024	100	120	0	120	0

25/01/2024	100	165	0	165	0
26/01/2024	100	150	0	150	1
27/01/2024	100	75	0	75	1
29/01/2024	100	60	0	60	0
30/01/2024	100	150	16	166	0
31/01/2024	100	180	16	196	1
<b>TOTAL</b>	<b>2,400</b>	<b>3,135</b>	<b>182</b>	<b>3,317</b>	<b>16</b>

**Table 4.6: Bottled Palm wine Production report for February 2024**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
1/02/2024	100	165	0	165	0
2/02/2024	100	165	0	165	0
3/02/2024	100	90	0	90	0
5/02/2024	100	90	0	90	0
6/02/2024	100	180	0	180	0
7/02/2024	100	105	0	105	0
8/02/2024	100	75	0	75	0
9/02/2024	100	105	0	105	0
19/02/2024	100	30	24	54	0
20/02/2024	100	75	24	99	1
21/02/2024	100	105	0	105	1

22/02/2024	100	105	0	105	0
23/02/2024	100	105	0	105	0
24/02/2024	100	60	16	76	1
26/02/2024	100	15	8	23	0
27/02/2024	100	75	0	75	0
28/02/2024	100	90	0	90	0
29/02/2024	100	75	0	75	0
<b>TOTAL</b>	<b>1,800</b>	<b>1,710</b>	<b>72</b>	<b>1,782</b>	<b>3</b>

**Table 4.7: Bottled Palm wine Production for March 2024.**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
1/03/2024	100	75	0	75	0
6/03/2024	100	90	58	148	0
7/03/2024	100	105	0	105	1
8/03/2024	100	45	0	45	0
9/03/2024	100	45	0	45	0
11/03/2024	100	30	0	30	0
12/03/2024	100	45	0	45	0
13/03/2024	100	75	8	83	0
15/03/2024	100	15	0	15	0

16/03/2024	100	90	16	106	1
19/03/2024	100	105	8	113	0
21/03/2024	100	90	16	106	1
22/03/2024	100	75	8	83	0
23/03/2024	100	105	8	113	1
26/03/2024	100	45	25	70	0
27/03/2024	100	105	0	105	0
28/03/2024	100	135	0	135	1
29/03/2024	100	60	0	60	1
30/03/2024	100	90	0	90	2
<b>TOTAL</b>	<b>1,900</b>	<b>1,425</b>	<b>147</b>	<b>1,572</b>	<b>8</b>

**Table 4.8: Bottled Palm wine Production for April 2024.**

DATE	EXPECTED PRODUCTI ON	PRODUCTION		TOTAL PRODUCTIO N	NO OF BREAKAG E
		33CI	65CI		
1/04/2024	100	30	0	30	0
4/04/2024	100	75	0	75	0
5/04/2024	100	75	0	75	1
8/04/2024	100	45	0	45	0
9/04/2024	100	75	0	75	1
10/04/2024	100	60	0	60	1

11/04/2024	100	60	0	60	2
15/04/2024	100	30	0	30	0
16/04/2024	100	30	0	30	0
17/04/2024	100	45	0	45	1
19/04/2024	100	75	0	75	3
24/04/2024	100	60	25	85	1
26/04/2024	100	45	33	78	1
29/04/2024	100	15	8	23	1
30/04/2024	100	15	16	31	1
<b>TOTAL</b>	<b>1,500</b>	<b>735</b>	<b>82</b>	<b>817</b>	<b>13</b>

### 4.3 DATA ANALYSIS

**Table 4.9: The analysis for the month of January is presented.**

<b>DATE</b>	<b>BOTTLED PALM WINE INSPECTED (n)</b>	<b>NUMBER DEFECTIVE (np)</b>	<b>FRACTION DEFECTIVE (p)</b>
4/01/2024	100	0	0
5/01/2024	100	0	0
6/01/2024	100	0	0
8/01/2024	100	0	0
9/01/2024	100	1	0.01

10/01/2024	100	2	0.02
11/01/2024	100	1	0.01
12/01/2024	100	1	0.01
13/01/2024	100	0	0
15/01/2024	100	0	0
16/01/2024	100	1	0.01
17/01/2024	100	1	0.01
18/01/2024	100	1	0.01
19/01/2024	100	3	0.003
20/01/2024	100	0	0
22/01/2024	100	1	0.01
23/01/2024	100	1	0.01
24/01/2024	100	0	0
25/01/2024	100	0	0
26/01/2024	100	1	0.01
27/01/2024	100	1	0.01
29/01/2024	100	0	0
30/01/2024	100	0	0
31/01/2024	100	1	0.01

These data are used to construct a P-Control chart. The sub-group size is n=100. The P values for each subgroup (day) have been calculated and are shown in the table.

$$P = \frac{np}{n} \dots\dots \text{Eqn (1)}$$

For instance, for day 1, there were 0 defectives in the 100 inspected. Thus,  $P = \frac{np}{n} =$

$\frac{16}{2400} = 0.007$  or 0.7%. The P values for the other days are calculated in the same way.

### Averages and Control limits

Here, we calculate the average fraction defective. In doing this, we are to add up all the np values and divide by the sum of the n values. The sum of the np values is 16; the sum of the n values is 2400. The average is then calculated as shown below.

$$\underline{P} = \frac{\sum np}{\sum n} \dots \text{Eqn(2)}$$

$$\underline{P} = \frac{\sum np}{\sum n} = \frac{16}{2400} = 0.007 = 0.7\%$$

$$\underline{n} = \frac{\sum n}{k}$$

$$\underline{n} = \frac{\sum n}{k} = \frac{2400}{24} = 100$$

Where k is the number of subgroups here which is 24.

The next step is to determine the average subgroup size. Since the subgroup size is constant, the average subgroup size is 100. This average calculation is shown in Equation 3 where k is the number of subgroup.

Then, the control limits are calculated. The calculations carried out are then shown below;

$$UCL_p = \underline{P} + 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

$$LCL_p = \underline{P} - 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

Therefore,  $UCL_p = 0.007 + 3 \sqrt{\frac{0.007(1-0.007)}{100}} = 0.032 = 3.2\%$

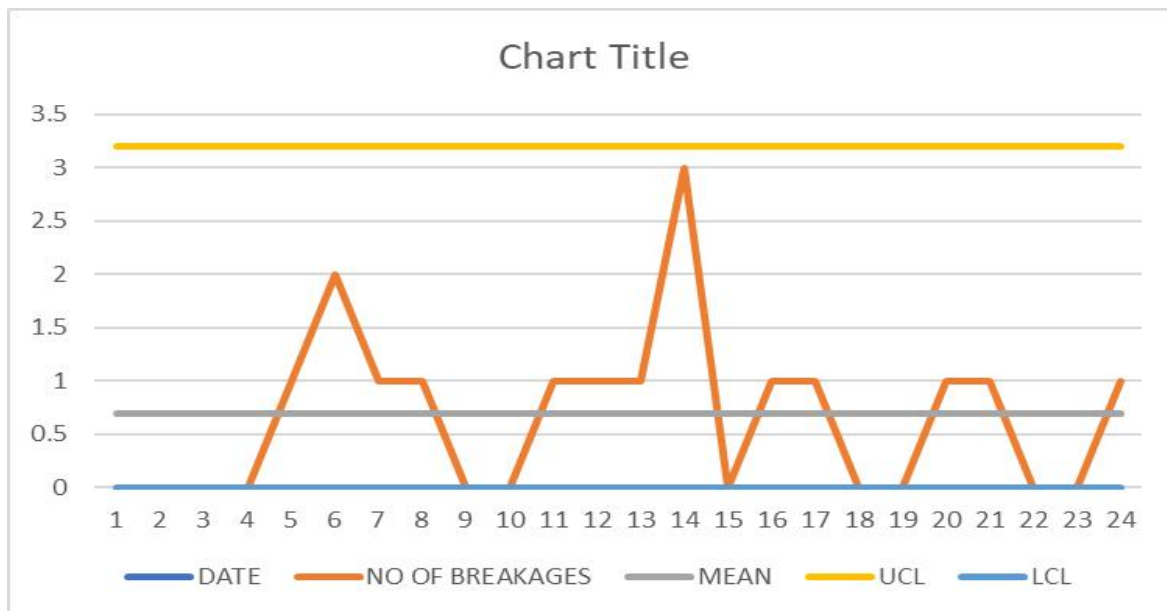
$$LCL_p = 0.007 - 3 \sqrt{\frac{0.007(1-0.007)}{100}} = -0.018. \text{ Since no of breakages cannot be lower than zero,}$$

we assume LCL to be equal to zero.

In summary, Average = 0.7%

UCL= 3.2%

LCL= 0%



**FIG 4.2: CHART FOR THE PRODUCTION IN JANUARY, 2024**

From the data analysis using P-Chart control chart, it can be found the average product damage occurring in Jan 2024, is 0.7%, for upper control limit is 3.2%, and lower control limit is -1.8%.

In this month, there are no outliers seen in the P-Chart graphic in Fig.4.1 above

**Table 4.10: Analysis for the month of February.**

<b>DATE</b>	<b>BOTTLED PALM WINE INSPECTED (n)</b>	<b>NUMBER DEFECTIVE (np)</b>	<b>FRACTION DEFECTIVE (p)</b>
1/02/2024	100	0	0
2/02/2024	100	0	0
3/02/2024	100	0	0
5/02/2024	100	0	0
6/02/2024	100	0	0
7/02/2024	100	0	0
8/02/2024	100	0	0
9/02/2024	100	0	0
19/02/2024	100	0	0
20/02/2024	100	1	0.001
21/02/2024	100	1	0.001
22/02/2024	100	0	0
23/02/2024	100	0	0
24/02/2024	100	1	0.001
26/02/2024	100	0	0
27/02/2024	100	0	0
28/02/2024	100	0	0
29/02/2024	100	0	0

These data are used to construct a P-Control chart. The sub-group size is n=100. The P values for each subgroup (day) have been calculated and are shown in the table.

$$P = \frac{np}{n} \dots\dots \text{Eqn (1)}$$

For instance, for day 1, there were 0 defectives in the 100 inspected. Thus,  $P = \frac{np}{n} =$

$\frac{3}{1800} = 0.002$  or 0.2%. The P values for the other days are calculated in the same way.

### Averages and Control limits

Here, we calculate the average fraction defective. In doing this, we are to add up all the np values and divide by the sum of the n values. The sum of the np values is 3; the sum of the n values is 1800.

The average is then calculated as shown below.

$$\underline{P} = \frac{\sum np}{\sum n} \dots \text{Eqn(2)}$$

$$\underline{P} = \frac{\sum np}{\sum n} = \frac{3}{1800} = 0.002 = 0.2\%$$

$$\underline{n} = \frac{\sum n}{k}$$

$$\underline{n} = \frac{\sum n}{k} = \frac{1800}{18} = 100$$

Where k is the number of subgroups here which is 18.

The next step is to determine the average subgroup size. Since the subgroup size is constant, the average subgroup size is 100. This average calculation is shown in Equation 3 where k is the number of subgroup.

Then, the control limits are calculated. The calculations carried out are then shown below;

$$UCL_p = \underline{P} + 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

$$LCL_p = \underline{P} - 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

Therefore,  $UCL_p = 0.002 + 3 \sqrt{\frac{0.002(1-0.002)}{100}} = 0.015 = 1.5\%$

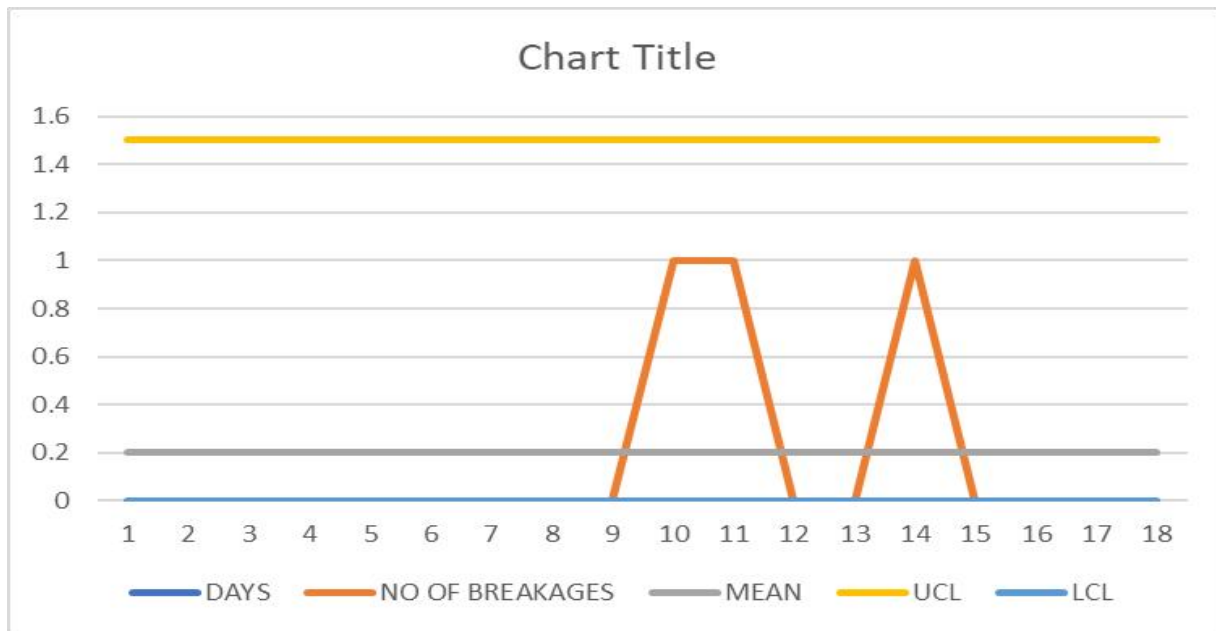
$$LCL_p = 0.002 - 3 \sqrt{\frac{0.002(1-0.002)}{100}} = -0.011. \text{ Since no of breakages cannot be lower than zero,}$$

we assume LCL to be equal to zero.

In summary, Average = 0.2%

UCL= 1.5%

LCL= 0%



**FIG 4.3: CHART FOR THE PRODUCTION IN FEBRUARY, 2024**

From the data analysis using P-Chart control chart, it can be found the average product damage occurring in Feb 2024, is 0.2%, for upper control limit is 1.5%, and lower control limit is -1.1%.

In this month, there are no outliers seen in the P-Chart graphic in Fig.4.1 above

**Table 4.11: Analysis for the month of March.**

<b>DATE</b>	<b>BOTTLED PALM WINE INSPECTED (n)</b>	<b>NUMBER DEFECTIVE (np)</b>	<b>FRACTION DEFECTIVE (p)</b>
1/03/2024	100	0	0
6/03/2024	100	0	0
7/03/2024	100	1	0.001
8/03/2024	100	0	0
9/03/2024	100	0	0
11/03/2024	100	0	0
12/03/2024	100	0	0
13/03/2024	100	0	0
15/03/2024	100	0	0
16/03/2024	100	1	0.001
19/03/2024	100	0	0
21/03/2024	100	1	0.001
22/03/2024	100	0	0
23/03/2024	100	1	0.001
26/03/2024	100	0	0
27/03/2024	100	0	0
28/03/2024	100	1	0.001
29/03/2024	100	1	0.001
30/03/2024	100	2	0.002

These data are used to construct a P-Control chart. The sub-group size is n=100. The P values for each subgroup (day) have been calculated and are shown in the table.

$$P = \frac{np}{n} \dots\dots \text{Eqn (1)}$$

For instance, for day 1, there were 0 defectives in the 100 inspected. Thus,  $P = \frac{np}{n} =$

$\frac{8}{1900} = 0.004$  or 0.4%. The P values for the other days are calculated in the same way.

### Averages and Control limits

Here, we calculate the average fraction defective. In doing this, we are to add up all the np values and divide by the sum of the n values. The sum of the np values is 8; the sum of the n values is 1900.

The average is then calculated as shown below.

$$\underline{P} = \frac{\sum np}{\sum n} \dots \text{Eqn(2)}$$

$$\underline{P} = \frac{\sum np}{\sum n} = \frac{8}{1900} = 0.004 = 0.4\%$$

$$\underline{n} = \frac{\sum n}{k} \dots \text{Eqn(3)}$$

$$\underline{n} = \frac{\sum n}{k} = \frac{1900}{19} = 100$$

Where k is the number of subgroups here which is 19.

The next step is to determine the average subgroup size. Since the subgroup size is constant, the average subgroup size is 100. This average calculation is shown in Equation 3 where k is the number of subgroup.

Then, the control limits are calculated. The calculations carried out are then shown below;

$$UCL_p = \underline{P} + 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

$$LCL_p = \underline{P} - 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

Therefore,  $UCL_p = 0.004 + 3\sqrt{\frac{0.004(1-0.004)}{100}} = 0.023 = 2.3\%$

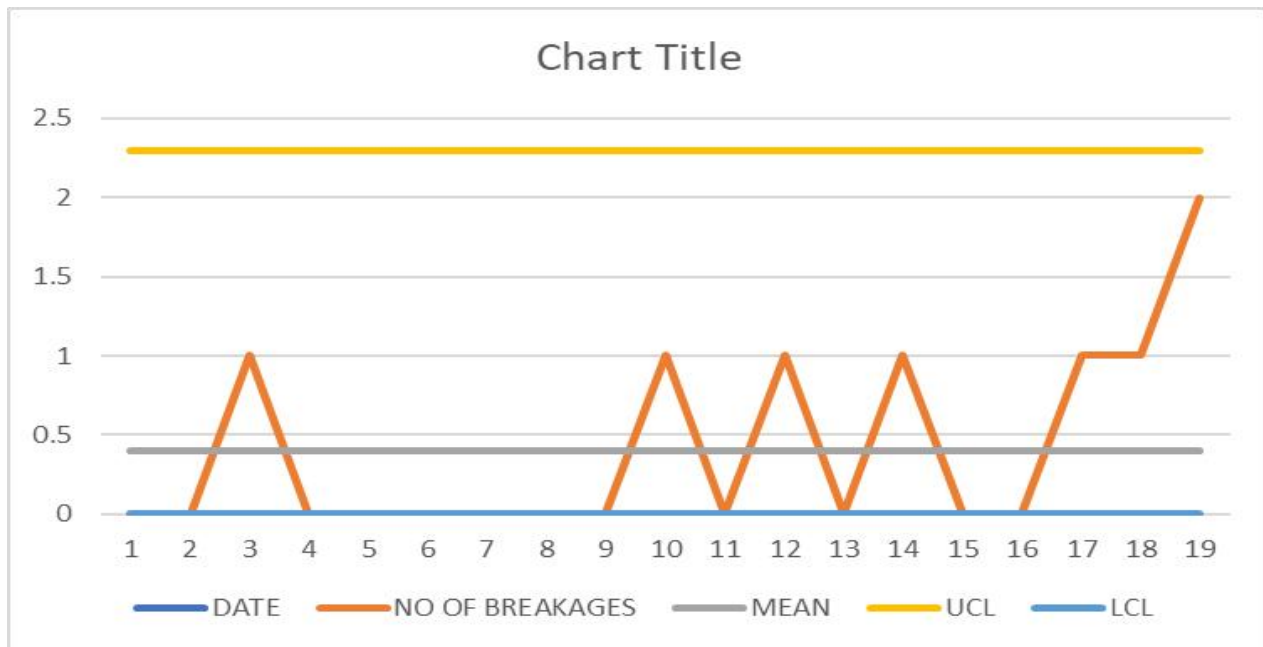
$LCL_p = 0.004 - 3\sqrt{\frac{0.004(1-0.004)}{100}} = -0.015$ . Since no of breakages cannot be lower than zero,

we assume LCL to be equal to zero.

In summary, Average = 0.4%

UCL= 2.3%

LCL= -1.5%



**FIG 4.4: CHART FOR THE PRODUCTION IN MARCH, 2024**

From the data analysis using P-Chart control chart, it can be found the average product damage occurring in Mar 2024, is 0.4%, for upper control limit is 2.3%, and lower control limit is -1.5%.

In this month, there are no outliers seen in the P-Chart graphic in Fig.4.1 above

**Table 4.12: Analysis for the month of April**

<b>DATE</b>	<b>BOTTLED PALM WINE INSPECTED (n)</b>	<b>NUMBER DEFECTIVE (np)</b>	<b>FRACTION DEFECTIVE (p)</b>
1/04/2024	100	0	0
4/04/2024	100	0	0
5/04/2024	100	1	0.001
8/04/2024	100	0	0
9/04/2024	100	1	0.001
10/04/2024	100	1	0.001
11/04/2024	100	2	0.002
15/04/2024	100	0	0
16/04/2024	100	0	0
17/04/2024	100	1	0.001
19/04/2024	100	3	0.003
24/04/2024	100	1	0.001
26/04/2024	100	1	0.001
29/04/2024	100	1	0.001
30/04/2024	100	1	0.001

These data are used to construct a P-Control chart. The sub-group size is n=100. The P values for each subgroup (day) have been calculated and are shown in the table.

$$P = \frac{np}{n} \dots\dots \text{Eqn (1)}$$

For instance, for day 1, there were 0 defectives in the 100 inspected. Thus,  $P = \frac{np}{n} =$

$\frac{13}{1500} = 0.009$  or 0.9%. The P values for the other days are calculated in the same way.

### Averages and Control limits

Here, we calculate the average fraction defective. In doing this, we are to add up all the np values and divide by the sum of the n values. The sum of the np values is 13; the sum of the n values is 1500. The average is then calculated as shown below.

$$\underline{P} = \frac{\sum np}{\sum n} \dots \text{Eqn(2)}$$

$$\underline{P} = \frac{\sum np}{\sum n} = \frac{13}{1500} = 0.009 = 0.9\%$$

$$\underline{n} = \frac{\sum n}{k} \dots \text{Eqn(3)}$$

$$\underline{n} = \frac{\sum n}{k} = \frac{1500}{15} = 100$$

Where k is the number of subgroups here which is 15.

The next step is to determine the average subgroup size. Since the subgroup size is constant, the average subgroup size is 100. This average calculation is shown in Equation 3 where k is the number of subgroup.

Then, the control limits are calculated. The calculations carried out are then shown below;

$$UCL_p = \underline{P} + 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

$$LCL_p = \underline{P} - 3 \sqrt{\frac{\underline{P}(1 - \underline{P})}{\underline{n}}}$$

Therefore,  $UCL_p = 0.009 + 3\sqrt{\frac{0.009(1-0.009)}{100}} = 0.034 = 3.4\%$

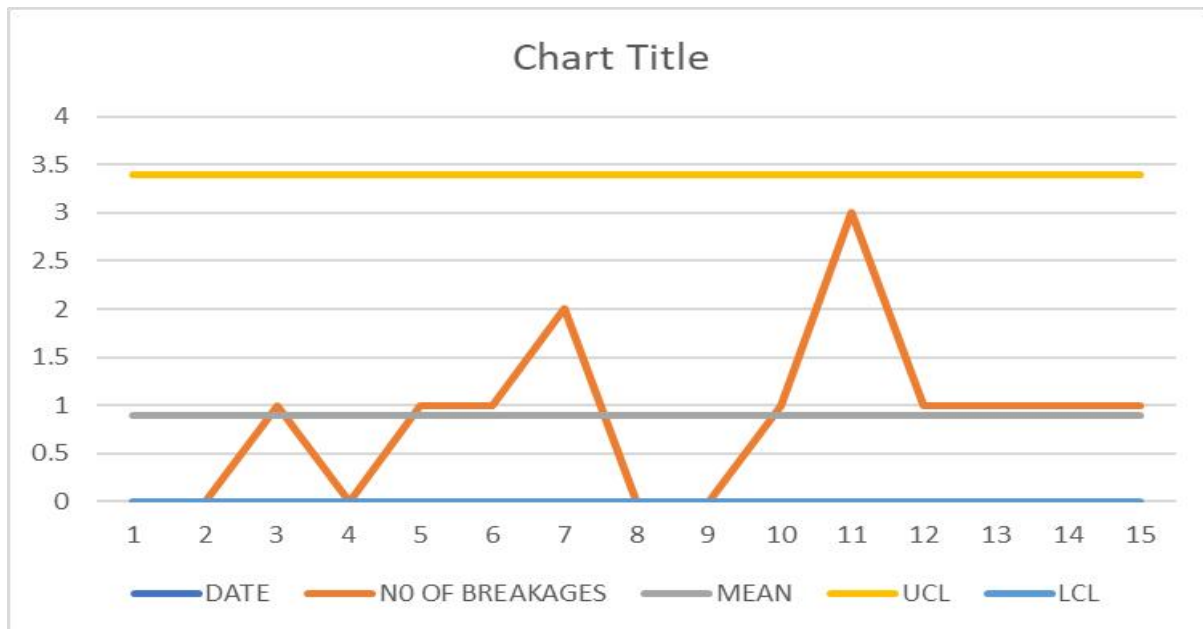
$LCL_p = 0.009 - 3\sqrt{\frac{0.009(1-0.009)}{100}} = -0.016$ . Since no of breakages cannot be lower than zero,

we assume LCL to be equal to zero.

In summary, Average = 0.9%

UCL= 3.4%

LCL= 0%



**FIG 4.5: CHART FOR THE PRODUCTION IN APRIL, 2024**

From the data analysis using P-Chart control chart, it can be found the average product damage occurring in Apr 2024, is 0.9%, for upper control limit is 3.4%, and lower control limit is -1.6%.

In this month, there are no outliers seen in the P-Chart graphic in Fig.4.1 above

**CHAPTER FIVE**  
**CONCLUSION AND RECOMMENDATION**

**5.1 Conclusion**

In this study, we have applied the statistical quality control chart using (p chart) approach to the data collected from NIFOR bottled palm wine. Based on the analysis of quality control, the production process for month of Jan, Feb, Mar and Apr is under statistical control. This is due to the absence of outliers for the various months.

## **5.2 Recommendation**

Continuous improvements of NIFOR bottled palmwine can still be pursued. The following steps should be taken to improve efficiency and minimize loss;

1. NIFOR bottled palmwine should be encouraged.
2. Regular training should be organised for members of staff.
3. Regular preventive maintenance for the machines.
4. For further research, it is recommended to use the other tools of statistical Quality control (SQC) such as X bar R chart to examine process stability since this research only used the P-Chart tool of statistical Quality control (SQC).

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