ST.MARY'S UNIVERSTITY

SCHOOL OF GRADUATE STUDIES

INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT

ASSESSMENT ON SPC IMPLIMENTATION AT THE BEVERAGE INDUSTRY FOR IMPROVING PRODDUCT QUALITY: THE CASE OF BGI ETHIOPIA

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A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT FOR THE DEGREE OF MASTERS SCIENCE IN QUALITY AND PRODUCTIVITY MANAGEMENT.

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ENDORSEMENT

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LIST OF ACRONYMS AND ABREVIATIONS

CO_2 - Carbon Di Oxide

CL - Center Line

CTQ - Critical to quality

DMAIC- Define, Measure, Analyze, Improve and Control

Ea - Apparent extract

ISO - International Organization for Standards

LCL - Lower control limits

OG - original extract

PH - Power of Hydrolyses

SPC - Statistical process control

SPSS -Statistical Package for Social Science

SQC- Statistical Quality Control

TQM -Total Quality Management

UCL- Upper control limits

Abstract

In order to survive in a competitive market, improving quality of product or process is must for any company. The principal aim of this study is about to investigate the assessments on SPC implementation at the beverage industry for improving Product Quality. The approach used in this study is direct observation, thorough examination of process lines, and information has been collected from quality control sections and from company's workers working in the area of quality control process through interview and questionnaire. Control chart was constructed in order to prioritize the major defects occurred and to suggest a suitable control limits for each main product parameters. From the analysis of the data, it has been found that the company has many good practice such as information exchange in the manufacturing process with in each shift, the impact in the manufacturing process on key quality characteristics of final product is well-known by the chemist, Quality characteristics associated with manufacturing process is being monitored via control charts, based on control sample every machines in quality control section of the company calibrated and adjustment made with in regular period, Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools and only calibrated measuring devices are being used to take measurements on critical process characteristics are some of the good practices of the company so as in the implementation process of SPC all these are very basic to improve the process and the quality of the product. Even if the company has many constraints to implement all suggestion for improvement within short period of time, but it is important to give priority for training of employees in quality control and production department and management commitment is important and the company recognized that the suggestion will provide significant continuous improvement in the long run SPC implementation.

Key words:-control chart, continuous improvement, SPC tools, SPC implementation, quality control, quality, quality characteristics

Table of Contents

List of Figures

List of Tables

CHAPTER ONE

INTRODUCTION

This chapter consists of background of the study, statement of the problem, research questions, general and specific objective of the study, limitation of the study, scope of the study, organization of the study and company background.

1.1 Background of the Study

In today's complex and dynamic business world, organizations are expected to perform well in their line of business in order to stay competent and be profitable. This study shows that how statistical process control can help an organization to improve the quality of their products. Quality is a concept whose definition has changed overtime. The traditional definition of quality is based on the viewpoint that products and services must meet the requirements of those who use them. In the past "Quality means fitness for use." That is, as long as an output fell within acceptable limits, called specification limits, around a desired value, called the nominal value, or target value, it was deemed conforming, good, or acceptable. We refer to this as the "goalpost" definition of quality (Deming, 1950). "Quality should be aimed at the needs of customer, present and future" (Deming). "The totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs" (ISO).Quality has become one of the most important consumer decision factors in the selection among competing products and services Montgomery (2005). Therefore, quality leads to business success, growth, and increases competitiveness, as well as improves the work environment. Understanding and improving quality are key factors leading to business success, growth, and enhanced competitiveness. According to Montgomery (2005), Quality improvement is the reduction of variability in processes and products. Quality control and improvement involve the set of activities used to ensure that the products and services meet requirements and are improved on a continuous basis. Variability is often a major source of poor quality, statistical techniques, including SPC is the major tools of quality control and improvement.

This paper will concerns of quality improvement techniques using statistical process control method for quality improvement in BGI Ethiopia Brewing industry , identification and analysis of existing quality problems, and to propose a better quality improvement method that will improve overall performance of the factory process.

1.2 Background of the Organization

BGI-Ethiopia is a large-scale brewery and beverage production wing of Castel Group operating internationally in more than 53 countries. BGI, operating in Ethiopia since 1998 as BGI Ethiopia PLC has been engaged in the production and distribution of beer, wine and beverage products. BGI owns five breweries including the St. George Brewery in Addis Ababa, the Kombolcha Brewery in Kombolcha city, the Hawassa Brewery in Hawassa city, the Raya Brewery in Machew city and the Zebidare Brewery in Weilkite city. This combined production capacity is 3.6 million hectoliters of bottled and draft beer annually. BGI Ethiopia PLC also owns and operates the Castel Winery and Vineyard located in the town of Ziway. St. George Brewery was established in 1922. It was nationalized in 1974/75 and had been operating as a state owned enterprise. Since December 1998, it became part of BGI Ethiopia through the privatization program. The known brands products are St. George bottle and draft beer, Castel bottle beer, Doppel bottle beer, Zebidare bottle beer, Raya bottle beer and Senq alcohol free malt drink. At present, the company is providing jobs for more than 1300 employees.

1.3 Statement of the Problem

Quality improvement is the key factor for the success and growth of any business Organization. Thus it is important to focus on the process; how it proceeds, how to control and how to improve the process. Even if, the company uses SPC as a good practice for quality improvement, in doing this the company faces challenges like training in statistical process control (SPC) implementation in the organization, including the data collection system for further investigation of the problem, and even in interpretation of the data for quality improvement . To answer all of these, decisions must be made on facts and data must be gathered and analyzed in order to help the decision making process and as such statistical process control (SPC) technique would help in analyzing the process quality. Due to these and other reasons the company has products out of specification limit. So as to monitor the variability's such as OG, PH, Ea and alcohol v/v of the BGI Ethiopia Brewing industry product occurs in industry and the sampling technique specifically for one of the product of a company having high market share with a brand name called St. George. Implementing a proper SPC technique can resolve all the practical challenges that the company faces and reduces all the variations that affect the product quality.

1.4 Research questions

- Which SPC tools implemented in the brewing process to reduce quality related problems of product?
- What are the possible causes of variation for the different quality parameter of beer product?
- How statistical process control helps the brewing process to improve the quality of the product?
- What are the benefits gained from the implementation of statistical process control in the brewing process?

1.5 Research Objectives

The study was addressing the following general and specific objectives.

1.5.1 General Objective

- To investigate the assessments on SPC implementation at the beverage industry for improving Product Quality.

1.5.2 Specific Objectives

The specific objectives are:

- To assess employee awareness about SPC tools concepts and importance in brewing industry.
- To assess the quality related problems of the company
- To have through understanding of the basics of statistical process control and its effective application in the company.
- To recommend a possible solution for the identified causes of variation for achieving quality improvement.

1.6 Definition of Basic Terms

Control chart-is a graphical display of a quality characteristic that has been measured or computed from a sample versus the sample number or time.

PH- quantitative measurement of the acidity or basicity of aqueous solution.

Statistical Process Control-is measure and analysis of Process variation by using statistical techniques namely controls charts.

Quality -is conformance to requirements /specifications (Crosby).

Quality Improvement -is the reduction of variability in processes and products**.**

Target value-is the value of a measurement that corresponds to the desired value for that quality characteristic.

Lower specification limit-The smallest allowable value for quality characteristic.

Upper specification limit-The largest allowable value for a quality characteristic.

Total quality management (TQM) -is a strategy for implementing and managing quality improvement activities on an organization wide basis.

1.7 Significance of the Study

This study Assessment on SPC implementation at the beverage industry for Improving Product Quality has different significances when it will apply in practice. Some of the significances are:

1. Enables to showing the importance of implementing SPC for improving the quality of beer product and by implementing SPC then the company getting in a competitive advantage.

2. Helps to find out the problems present in the implementation of SPC for quality improvement in brewing industry.

3. Important for making improvement actions for beverage industry that do not well implement SPC tools.

4. It can also serve as a reference document for further studies on quality improvement techniques using SPC in brewing industry.

1.8 Scope of the Study

This study is geographically limited to selected beer manufacturing industries of BGI Ethiopia in Addis Ababa (Mexico).Despite the fact that BGI Ethiopia has different beer production sites including Addis Ababa, Hawassa, Kombolcha, Raya and Welkite. This study was conducted in Addis Ababa plant where production of SG.george bottle and draft beer, Dopple bottle beer and SEN, Q alcohol free malt drink production would be carried out. The scope of this study report covers only the quality control line of the brewing process i.e. all the quality of ingredients, intermediate and finished product of beer and due to lack of time the research not cover production and packing section of the brewing process. This study was conducting the quality control section of the brewing process carried out. Beer quality product parameter includes OG, PH, color, Ea, alcohol v/v and many others. However, the technique could be extended and applied to other process lines and other divisions of the brewing process where it is necessary.

1.9 Limitation of the Study

The limitation for the current research was the exclusion of other brewing Industries which could have a quality improvement using SPC tools application throughout the brewing industries in the country. The rationale behind the quality control selection of brewing industry due to constraints of time as well as convenience and limited budget of the research. There are also resource constraints, in terms of time and logistics as well as the difficulties in accessing data.

CHAPTER TWO

REVIEW OF THE RELATED LITRATURE

2.1 Quality

2.1.1 Definition of Quality

Different scholars give different interpretations and definition for quality. But, from the definitions given by most quality can be seen as meeting customer requirements effectively. A Comprehensive definition of quality is that product or service which fulfills an aggregate requirement of customers, in all aspects, at present and in the future and which customers can buy it.

Some definitions of Quality that are defined by different groups/people:-

Fitness for purpose or use (Juran). The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs .The total composite product and service characteristics of marketing, engineering, manufacture, and maintenance through which the product and service in use will meet the expectation by the customer (Feigenbaum).According to the definition of ISO 9000 quality is defined as 'The totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs'. American Society for Quality (ASQ) opines that quality denotes an excellence in goods and services, especially to the degree they conform to requirements and satisfy the customers. All the definitions of quality stated above implies that quality can be defined in many ways depending on who is defining if and what product or service it is related to.

Quality is important because a successful business means when the organization can produce a higher quality product or service than its competitors. Therefore, when quality is the main important factor for the company's success, statistical quality control allow organizations to improve the quality of the product levels, meet the consumer's requirement for quality and to remove defects of the product.

2.1.2 Quality planning, Quality Control, Quality Assurance and Quality Improvement

According to Montgomery (2005) Quality planning is a strategic activity, and it is just as vital to an organization's long term business success as the product development plan, the financial plan, the marketing plan, and plans for the utilization of human resources. Without a strategic quality plan, an enormous amount of time, money, and effort will be wasted by the organization dealing with faulty designs, manufacturing defects, field failures, and customer complaints and identifying customer needs, this is sometimes called listening to the voice of the customer (VOC).The terms Quality Control (QC) and Quality Assurance (QA) are often used interchangeably. But, according to International Standard of Organization (ISO) for Quality Management often referred to as IS0 9000:2005 distinguished the subjects as follows: “QC is a part of quality management focused on fulfilling quality requirements” while “QA is a part of quality management focused on providing confidence that quality requirements will be fulfilled”. The standard further reiterated that QA involved all the planned and systematic activities implemented within the quality system that can be demonstrated to provide confidence that a product or service will fulfill requirement for quality. Conversely, QC was seen as operational techniques and activities used to fulfill requirements for quality. In other hands, QA is concerned with defects prevention while QC is concerned with defects identification and quality improvement is a continuous improvement process and a proactive approach to improve processes and systems.

2.1.3 Inspection-Based Quality Control vs. Prevention-Based Quality Control

The traditional approach to manufacturing is to rely on production to make the product and on quality control to inspect the final product and screen out items not meeting specifications. This involves a strategy of “detection” or “inspection”. Inspection is an activity which is often expensive, unreliable and provides very little information as to why the defects or errors occurred and how they can be corrected.

2.1.4. Quality Control for Defect Prevention and Defects Identification

Typically, product quality measurements are performed both in the laboratory and process environment, their focus is however shifting. While quality assurance is process oriented and focuses on defect prevention, quality control is product oriented and focuses on defect identification. In this light, laboratory measurements are now viewed more as a verification measurement to ensure the inline measurement is correct. The laboratory sampling frequency is reduced, thus saving time and allowing operators to perform other tasks. As a result of this development, the need for real-time process monitoring for continuous quality control and assurance has significantly increased. While the laboratory measurements remain the reference for process instrumentation the continuous measurement of key parameters directly inline provides means for detecting quality problems immediately and enables appropriate actions to be made. Additionally, production parameters are continuously tracked and stored for reporting and statistical process control. In other words, the importance of data connectivity between inline and laboratory beverage analyzers is more important than ever and a complete solution is needed.

2.1.5. Operational Demands to Comply with Quality Standards

Beverage manufacturers now face a complex range of operational demands, from the need to comply with exacting quality standards, the ability to measure new and different components, meeting rigorous production schedules, all while satisfying consumers' ever-evolving tastes and preferences. The only solution to manage all these criteria is to initiate a comprehensive quality control program, a key component of which is the measurement of the critical quality parameters of beer, OG, PH, Ea, alcohol v/v, and many others. Manufacturing products within the specified limits of these parameters is essential for consistent product quality and taste.

2.2 The recent research findings on application of SPC for improving product quality

Grigg, N. P. 1998, The Implementation of Statistical Process Control in the Food Industry in UK, to illustrate a systematic review application in investigating common issues emerging from Statistical Process Control (SPC) implementation in the food industry. This review indicates that SPC is applied in the food industry with huge benefits in the business to diverse stakeholders Reduction of variation, Prediction of process behavior, Increase knowledge and awareness in statistics and process. Although there are limitations and barriers impeding the implementation Lack of statistical thinking culture, SPC are too advanced for non-statistician, Lack of useful and practical guidelines and challenges in the review are Resistance to change, Lack of sufficient knowledge of SPC, Lack of management support. New developments of the research are it provides detailed discussion information of implementation teams (top management, steering committee and process action team) with different respected roles and tasks. According to Burns J. and King R. (Eds) (1993) SPC implementation frameworks has depicted training material appropriate for each step, Team members will be able to increase their understanding of the mechanism of each step due to the training session with prior the execution of each step, Awareness of the SPC technique with an SPC introduction into the organization is suggested to be initiated with the establishment of suitable culture such as statistical thinking culture which will provide the needs for data in decision making, Setting vision in the initial stage the project will provide a clearer view where the project headed, In problem solving activities, this framework emphasizes it should be carried out using seven tools of quality and subsequently a framework of reaction plan was provided if the process is detected to be not capable. According to Xie, M. and Goh, T. (1993) the implementation was done correctly and greatly facilitated, SPC can be a versatile technique for managing quality improvement in the food industry and sustaining the quality of food products.

2.3 Statistical Process Control

Definition and history

SPC is defined as a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability (Montgomery, 2012). Attempts have been made to expand the concept of SPC beyond the process monitoring technique. SPC is categorized into several types of topics such as:

- Process management technique (Bissell, 1994)
- control algorithm (O, H ,1997)
- A component of total quality management (TQM) (Barker, 1990)
- One of the quality management systems in the food industry (Caswell et al., 1998).

SPC is defined by Montgomery (2009) as a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability. The primary purpose SPC implementation is to detect and reduce special cause variations for process stability. Statistical Process Control (SPC) is an analytical decision making tool which allows you to see when a process is working correctly and when it is not. Variation is present in any process, deciding when the variation is natural and when it needs correction is the key to quality control. Statistical Process Control (SPC) is a statistical approach for assisting operators, supervisors and managers to manage quality and to eliminate special causes of variability in a process. The initial role of SPC is to prevent rather than identify product or process deterioration, but Xie and Goh (1999) suggest for its new role to actively identifying opportunities for process improvement. The main tools in SPC are control charts. Control chart is a graphical method for displaying control results and evaluating whether a measurement procedure is in control or out-of-control. Control charts are used for process monitoring and variability reduction. By continuously monitoring the process, the manufacturing organization could prevent defect items to be processed in the next stage and to take immediate corrective action once a process is found to be out of control. Wallace et al. (2012) and Davis and Ryan (2005) viewed SPC as a participatory management system teamwork efforts, employee involvement and enable real-time decisions were made (Deming, 1986, et al., 2008).

Walter Shewhart, at the Bell Telephone Laboratories, introduced the control chart in the1920s to distinguish between inherent or normal variability, known as common cause variation, and variation due to a special cause which was popularized worldwide by Dr Edwards Deming, Shewhart charts are typically used to distinguish between variations due to special causes from variations due to common causes. Special causes are changes in the pattern of data that can be assigned to a specific cause. They are referred to unnatural variation due to events, changes, or circumstances that have not previously been typical or inherent in the regular process. Common causes are problems inherent in the manufacturing system as a whole which are natural and expected. Processes that exhibit only common cause variation are said to be stable, predictable, and in statistical control. The process is said to be in statistical control when the special causes have been identified and eliminated. Shewhart charts can be used to monitor the process for the occurrence of special causes and to measure and reduce the effects of common causes. These techniques include control charts, histogram distribution, and Pareto analysis.

If a product is to meet or exceed customer expectations, generally it should be produced by a process that is stable or repeatable. More precisely, the process must be capable of operating with little variability around the target or nominal dimensions of the product's quality characteristics. Statistical process control methods extend the use of descriptive statistics to monitor the quality of the product and process. Using statistical process control we want to determine the amount of variation that is common or normal. Then we monitor the production process to make sure production stays within this normal range. That is, we want to make sure the process is in a state of control. The most commonly used tool for monitoring the production process is a control chart. Different types of control charts are used to monitor different aspects of the production process. A control chart (also called process chart or quality control chart) is a graph that shows whether a sample of data falls within the common or normal range of variation. A control chart has upper and lower control limits that separate common from assignable causes of variation. A control chart consists of central line, Upper control limit and Lower control limit. Characteristic values plotted on the chart which represents the state of a process. If all these values are plotted within the control limits without any particular tendency, the process is regarded as being in the controlled state; however, otherwise it is out of control.

2.3.1 Statistical Process Control (SPC) versus Statistical Quality Control (SQC)

Statistical process control (SPC) is the application tools to control Process inputs (independent variables).Statistical quality control (SQC) is the application statistical and analytical tools to monitor process outputs (dependent variables).

2.3.2. The Seven Quality Control Tools

In 1974 Dr. Kaoru Ishikawa brought together a collection of process improvement tools in his text guide to quality control. Kaoru Ishikawa developed seven basic visual tools of quality so that the average person could analyze and interpret data. These tools have been used worldwide by companies, managers of all levels and employees. The seven quality control tools are:

Check-sheets

A form on which quality characteristics to be checked have already been printed so that data can be collected easily. It is used for tallying the occurrences of the defects or causes being addressed by graphing or charting them directly. Check sheet is a powerful data recording tool.

Cause and effect diagram

It is sometimes called Ishikawa Diagram because it was invented by Dr. Karou Ishikawa in the 1943. It is also called fish-bone diagram because it looks like fish bone. Cause and effect diagram is a tool that identifies, sort and display possible cause of a specific problem or effect. Its main use is to pick up and arrange all possible causes without any omissions. And it allows many factors to be seen at the same time, and can be used by everyone from beginners to experienced workers. Picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes and Effect (characteristics that need improvement) on the right and causes on the left.

Histograms

Histograms or frequency distribution Diagrams are the most commonly used graphs to show frequency distributions in convenient class intervals and arranged in order of magnitude. They are useful in studying patterns of distribution or shape of a distribution and comparing it with specifications or standard values. It organizes bulk data in an easy manner to understand the population or data.

Pareto Charts

First developed in 1906, by Italian economist, Vilfredo Pareto, then Joseph M. Juran applied it in classifying problems of quality. The Pareto Principle also known as the 80/20 rule states that only a "vital few" 20% causes are responsible for producing most of the 80% problems (trivial many). It is used to detected problems by classifying them, showing their frequency in the process and set their priority. Pareto Charts allows the user to focus attention on a few important problems in a process and makes it easy to see which of many problems have the most serious effect on quality, productivity, cost, safety, morale, delivery time, surrounding etc. together with their relative proportions process and set their priority.

Scatter Diagrams

A scatter diagram shows the correlation between two variables in a process. Also called scatter plot, X–Y graph. Its purpose is to find if there is correlation between paired sets of data to identify the correlations that might exist between a quality characteristic and a factor that might be affecting it. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line.

Flow Charts

It is a diagram showing the development of something through different stages or processes. Flow chart is a pictorial representation showing all of the steps of a process.

Control charts

The control chart is a graph used to study how a process changes over time. It is used to analyze a process and to determine whether a process will process a product with consistent measurable properties. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether a process is in control or is unpredictable (out of control, affected by special causes of variation).

If your process is in control, then

- 99.73% of all the data points will be inside those lines or no sample points outside limits.

- ❖ Most points near process average.
- ❖ About equal number of points above and below center line points appear randomly distributed.

2.3.3 Types and Causes of Variation in SPC

When looking the quality characteristics of beer in the process, it will be notice that the quality characteristics are no exactly the same level. Some are slightly higher and some slightly lower than the standards. This type of difference is completely normal. Wiley et al (2007), says no two products are exactly alike because of slight differences in materials, workers, machines, tools, and other factors. These are called common, or random, causes of variation (Wiley et al, 2007). Wiley further say that common cause of variation are based on random causes that cannot be identify. These types of variation are unavoidable and are due to slight differences in processing.

Wiley et al (2007) further says, the other type of variation that can be observed involves variations where the causes can be precisely identified and eliminated. These are called assignable causes of variation. Examples of this type of variation are poor quality in raw materials, an employee who needs more training, or a machine in need of repair or calibration. In each of these examples the problem can be identified and corrected. Also, if the problem is allowed to persist, it will continue to create a problem in the quality of the product where data falls above and below the preset control limits (LCL and UCL) indicating that a variation due to assignable causes has been developed and can be identified and also be corrected.

2.3.4. SPC Implementation

According to Ignatio Madanhire (2016) in SPC application, it is important to understand and identify key product characteristics which are critical to customers or key process variation as shown in the key steps for implementing SPC are: Identify defined process, Identify measurable attributes of a process, Characterize natural variation of attributes and track variation if the process is controlled, continues process otherwise Identify assignable causes and remove.

The following figure shows examples of steps in SPC implementation in brewing industry.

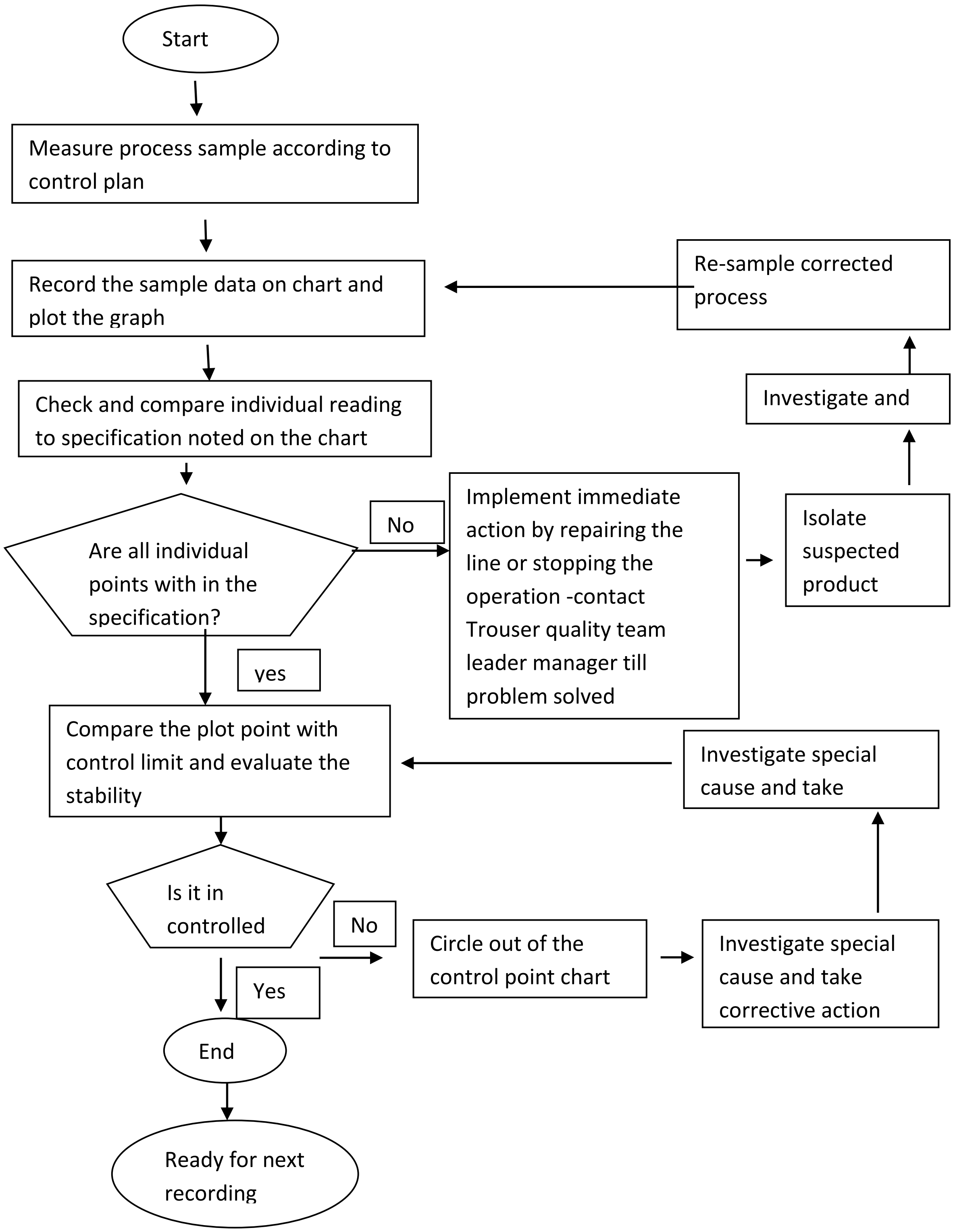


Figure 1: Steps in SPC implementation in brewing industry (source GOLD PRACTICE)

2.3.4.1 Elements that lead to SPC implementation program success in brewing industry

According to Zailani, S., & Fernando, Y. (2001) the core points for the success SPC implementation program in industry are Higher management provides visible support convinced that SPC base for quality improvement program, Establishment of quality improvement teams consisting of employee from quality and production department, Periodic refreshing training is mandated for everyone in the production and quality department about the implementation of SPC, Training of SPC in the company should be more than just once, as SPC involved both technical aspect and managerial aspect where the training is highly suggested to be delivered in level-by level within the organization hierarchy, Measurements of critical parameters of the process and product of documented by operators and chemists in the process regularly, The company Plan SPC implementation to the success vision and mission the organization and a mechanism for communicating successful results throughout the organization.

2.3.5 Aim of Statistical Process Control

The seven quality control tools are simple statistical tools used for problem solving, collecting data, analyzing data, identifying root causes and measuring the results. The primary main function of statistical quality control tools is to effectively collect quality data like various product quality. Compute the fraction defective based on data collected to create a chart with plotting such fraction defective in time sequence, so that the chart may be used as a poster in the office space. Further, it is important for them to confirm that product quality is remaining within a manageable range. If the quality would be out of the range, every worker should discuss about any possible counter measures. These data should be analyzed by certain method to examine counter measure. If the fraction defective improved to that level, narrow down the manageable range to repeat the procedure (Hansen B.I and Gahere P.M 1987).

2.3.6 Statistical Process Control Charts

Statistical process control (SPC) is a statistical procedure using control charts to check a production process to see if any part of it is in some way not functioning properly, which could lead to poor quality. A control chart is a graphical method for displaying control results and evaluating whether a measurement procedure is in control or out of control. Control results are plotted versus time or sequential run number; lines are generally drawn from point to point to accent any trends, systematic shifts, and random excursions. The chart contains a center line that represents the average value of the quality characteristic corresponding to the in control state. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL) are also drawn.

2.3.6.1 Types of Control Charts

Control charts are important statistical tool for quality control. They display the results of inspecting a continuous process and separate random variations due to real assignable causes from normal variations due to chance causes. Such a running commentary as to what is happening in the process provides a convenient and rapid feedback suggesting when adjustments, corrections or overhauls may be needed. Control charts are basically of two types. These are:-

A) Control charts by variables

Those capable of being measured and the product can be classified well or bad, acceptable or non-acceptable based on quantitative measurements of their properties. Typical examples of variables are diameter, volume, length, thickness, weight, temperature, humidity, voltage, hardness, viscosity etc.…

Control charts for variables are the following:-

i. The average chart (X-chart), which measures the central tendency of the process. To calculate control limit of X chart

Center line: CL $=\bar{X}$

Upper control limit UCL$=\bar{X}+A2\,\bar{R}$

Lower control limit LCL$=\bar{X}-A2\,\bar{R}$

ii. The range chart (R-chart), which measures the spread of the process. To calculate control limit of R chart Center line CL= R

Upper control limit UCL=D4 R

Lower control limit LCL=D3 R (Unnecessary) because D3=0

Since average chart and range charts are usually used together, they are commonly known as

Xbar-Rcharts

B) Control charts by attributes

- Properties which are difficult to measure quantitatively.
- These properties are usually measured by comparison and any sample taken is classified good or bad, ok or defective by quality characteristics.
- Typical examples of attributes are surface appearance, color, texture, cracks, imperfections, burns etc.

2.3.7 Importance of SPC in beverage industry

SPC implementation is important as it could improve process performance by reducing product variability and improves production efficiency by decreasing scarp and rework.

According to Benton (1991) and Talbot (2003), the advantages of implementing SPC could be Categorize into the following categories; maintain a desired degree of conformance to design, increase product quality, eliminate any unnecessary quality checks, reduce the percentage of defective parts purchased from vendors, reduce returns from customers, reduce scrap and rework rates, provide evidence of quality, enable trends to be spotted, ability to reduce costs and lead times. In other words, SPC implementation can also help to accomplish and attain a consistency of products that meet customer's specifications and thus fulfill their expectations. In general, SPC can be used to monitor the natural variation of a process and minimize the deviation from a target value and thus play a major role in process improvement. The quality control in the food industry is scientifically related to technology, sensory attributes, physical, safety, chemical make-up and nutritional value (Grigg and Walls, 2007).

According to Attaran (2000), in their attempts to remain competitive, US business had embarked on TQM techniques such as SPC that leads to higher quality product by reducing-variability and defects; rework, failure, scrap, warranty claims and product recall costs, thus improving their overall business competitiveness (Booker, 2003). Most of the production and quality cost that SPC aims to minimize such as rework, loss of sales and litigation are measurable. The success and failure in SPC implementation does not depend on company size or resources, but it relies on appropriate planning and immediate actions taken by workers with regards to problem solving.

2.3.8 Implementing SPC in a Quality Improvement Program

The methods of statistical process control can provide significant payback to those companies that can successfully implement them. Although SPC seems to be a collection of statistically based problem-solving tools, there is more to the successful use of SPC than learning and using these tools. SPC is most effective when it is integrated into an overall, companywide quality improvement program. It can be implemented using the DMAIC approach. Indeed, the basic SPC tools are an integral part of DMAIC. Management involvement and commitment to the quality improvement process are the most vital components of SPC's potential success. Management is a role model, and others in the organization look to management for guidance and as an example. A team approach is also important, as it is usually difficult for one personal one to introduce process improvements. Many of the magnificent seven are helpful in building an improvement team, including cause and-effect diagrams, Pareto charts, and defect concentration diagrams. This team approach also fits well with DMAIC. The basic SPC problem-solving tools must become widely known and widely used throughout the organization. Ongoing education of personnel about SPC and other methods for reducing variability are necessary to achieve this widespread knowledge of the tools. Today's food manufacturing businesses are heavily challenged by consumer-oriented markets that require continuous improvement and development in food product quality (Pable et al., 2010).

The objective of an SPC-based variability reduction program is continuous improvement on a daily, weekly, monthly, and annual basis. SPC is not a one-time program to be applied when the business is in trouble and later abandoned. Quality improvement that is focused on reduction of variability must become part of the culture of the organization. The control chart is an important tool for process improvement. Processes do not naturally operate in an in-control state, and the use of control charts is an important step that must be taken early in an SPC program to eliminate assignable causes, reduce process variability, and stabilize process performance. To improve quality and productivity, we must begin to manage with facts and data, and not simply rely on judgment. Control charts are an important part of this change in management approach. (Douglas C. Montgomery, 1997)According to different researches and books, in implementing a companywide effort to reduce variability and improve quality, several elements are usually present in all successful efforts.

Steps to set up statistical process control (SPC) on production process

SPC can help control processes and ensure consistent output. To understand how this tool works, it is best to follow the logical steps in its implementation in factory. These steps are Select critical-to-quality (CTQ) product characteristic, select critical processes, Gather data and process knowledge of what impacts the output of the process, Control independent variables that have a sizeable impact on the process output, Look for ways to reduce variation and Keep it up in the long term

2.4 Conceptual framework

Conceptual framework as a framework that is structured from a set of broad ideas and theories that help a researcher to properly identify the problem they are looking as frame their questions and find suitable literature (Smyth, 2004). Conceptual frameworks of the study consist of independent variable; skills of chemist/ operators, training of the production process operators and chemist, quality of raw materials, management commitment and periodically calibration of machines. Dependents variable; quality of beer product parameter includes OG, PH, Ea and alcohol v/v. The independent variables (the cause) of SPC implementation in the process well implemented it enables to prevent problem, control the production process and reduce the variation in the process and product and all the dependent variables (the effect) of process and product of quality parameters with in the specification limit (between USL and LSL). The dependent variable depends on changes in the independent variables and the independent variables of the process are control, all the dependent variables of the process and product controlled otherwise the process out of control. Independent variables are the baseline to control process in factory. Based on the insights gained from review of the literature the following conceptual framework showing the relationship between the dependent and independent variables.

Independent variables

- skills of chemist/ operators
- training of the production process operators and chemist
- quality of raw materials,
- management commitment
- periodically calibration of machines

→

Dependent variables

Quality parameters of beer product

- OG
- PH
- Ea
- alcohol v/v

CHAPTER THREE

RESEARCH METHODOLGY

This chapter presents the activities and processes that were undertake to gather data for the research work. It gives full details of how data was collect and processes for this research work.

3.1 Research Strategy

The strategy of the research was being descriptive since it allows the collection of data through questionnaires on the bases of sample, which helps to find out the view of the population.

3.1.1 Qualitative research method

Qualitative research is consists of an investigation that, seeks answers to a question, systematically uses a predefined set of procedures to answer the question, collects evidence, produces findings that were not determined in advance and produces findings that are applicable beyond the immediate boundaries of the study. Qualitative methods, explained in detail in their respective modules, are participant observation, in-depth interviews, and focus groups.

3.1.2 Quantitative research method

Quantitative research method deals with quantifying and analysis variables in order to get results. It involves the utilization and analysis of numerical data using specific statistical techniques to answer questions. Expatiating on this definition, Aliaga, and Gunderson (2002), describes quantitative research methods as the explaining of an issue or phenomenon through gathering data in numerical form and analyzing with the aid of mathematical methods.

3.2. Types of sources and methods of data collection

3.2.1 Data source

To acquire data on the nature and extent of quality control tools usage such as SPC in BGI Ethiopia brewing industry the researcher was used both primary and secondary data sources. Self-administered close ended questionnaire, semi structured interview, focus group discussion was held to quality control department and with the others who are working in the area of production process as a team leader and a direct observation of the process as a primary source of data gathering tools.

3.2.2. Primary data collection

Primary data was being collected from the BGI Ethiopia brewing industry. In this study, interviews were being conducted on a one to-one open-ended basis with a single participant, and scientific honesty was maintain for the validity of the data that was manipulation of design and methods of the research. For the data analysis of the primary data questioners, interview and direct observation various statistical techniques such as, mean, standard deviation, maximum percentage scale and Cronbach's alpha for reliability test was being used depending upon the requirements.

3.2.3 Secondary data collection

At present, a lot of secondary data were being collected and archived by researchers all over the world for research that were becoming more widespread (Andrews et al. 2012). Secondary data were collected by someone else for his primary research purposes which provided basic research principles. The researchers who limit time and resources, they were used the secondary data for their researches.

For the collection of secondary data ware used both published and unpublished data. Published data were collected from:

i) Various research reports are prepared by research scholars, universities, etc. in different fields

ii) Books of various authors, magazines, and newspapers

iii) Various publications of the organization (e.g statistical statement, Reports of quality control departments)

iv) Various sources from university libraries

v) Websites, statistics, historical documents and other sources of published information.

3.3 Sample Size and Sampling Technique

Employing convenient sampling technique, all the quality control staffs ware choice as respondents. So as per the information obtained from BGI Ethiopia brewing industry a total of 30 employees are working in the area of the quality control section. Therefore the researcher employee purposive convenient sampling method and all the quality control staffs were taken for the research. The researchers select the respondents based on their knowledge about the study and the population. Purposive sampling is to focus on particular characteristics of the population that are interest, which are best enable to answer the research question.

3.4. Data Analysis Methods

As long as the quantitative and qualitative data was required being gathering, present, analyzing and interpreting different ways of presenting data was use. For the presentation of the quantitative data control charts, tables and figure was used. Whereas for presenting qualitative data the researchers summarize comments or responses in to X number of people commented that.

In order to make the analysis and interpretation, the researcher explores key themes – what answers does it give to the research question? And identified what is surprising about the information, and then discusses the interpretation of the findings and links it back to the terms of reference, the project objectives and the literature review.

3.5. Validity, Reliability and Generalizability

In any research, the concern of an investigator is how to minimize possible errors and bias by maximizing the validity and reliability of data. This requires that the tool for the collection of data is valid and reliable. Validity is concerned with the extent to which scale accurately represents the contracts of interest (Marshal, 2006). With this regard, as mentioned earlier, the questionnaire was distributed to a total of 30 participants members of the quality control section, those participants have information about quality improvement techniques and include interview participants in the manager levels of the section in order to increase the content validity of the questionnaires. Reliability means to what extent a methodology of investigation or fact collection method gives the same results under the same conditions at different occasions. The research reliability is the degree to which research method produces stables and consistent result achieved by using the same methods under the same conditions at different occasions by different researchers. Generalizability of the research is a measure of how useful the results of the study area for broader groups of people or situation after generalization of the research in a good situation. In addition to this, internal consistency of this study was checked by Cronbach’s alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of patterns, mean, standard deviation and maximum percentage of the frequency scale of the respondents answer.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.912	0.933	64

Internal consistency of the whole questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability, scales of tools and patterns, it indicates an alpha value greater than 0.7 so the data internal consistency of these questionnaires was checked by Cronbach's alpha, so the data is reliable.

3.6. Ethical Consideration

In order to have permission for the study and to avoid unnecessary reluctance, suspicion and dishonesty the researcher was ethical and informed the participants about the objective and purpose of the study that it is only for academic purpose and confidentiality of their response be strictly maintain. Every person involve in the study was entitle to the right of privacy and dignity of treatment, and no personal harm cause to subjects in the research. Information obtains was held in strict confidentiality by the researcher.

CHAPTER FOUR

4. DATA PRESENTATION, ANALYSIS AND INTERPRETATION

This chapter presents an overview of data analysis and discussions that related to the research problems and objectives in the previous chapter. Profile of the organization, demographic characteristics of Employees, results of the questionnaires, experimental data collection using control charts, application of control charts using beer quality parameters OG, PH, Ea and alcohol v/v in brewing industry and Descriptive data analysis from questionnaire and interview.

4.1. Data collection and analysis

4.1.1. Profile of the organization

The first part of the questionnaire was used to gather demographic information on the respondents and the Organization. Data obtained from the questionnaires and secondary data sources are summarized.

BGI Ethiopia brewing Industry is the most recognized private beer processing company in Ethiopia. It processed different beer products such as St. George draft and bottle beer, Dopple bottle beer Castel bottle beer and Sen'q bottle beer (alcohol free malt drink). The company currently has about 1300 employees out of which 30 are the target or directly involved in beer product quality processing, which were taken as a target population in the research. 30 questionnaires distributed all of them were filled and returned which were made ready for the analysis.

Demographic characteristics of the respondents, analyses and interpretation based on the data collected from the respondents of the study area are presented in this chapter. Moreover, summarized results of the demographic profile of respondents and the response towards the items included in the questionnaire as well as descriptive statistics were described, analyzed and synthesized in tables, control charts ,figure and higher percentage, mean and standard deviation with the help of Statistical Package for Social Science (SPSS).

4.1.2 Beer production process

Brewing is the process of production of malt beverages. Brewing is a complex fermentation process. It differs from other industrial fermentation because flavor, aroma, clarity, color, foam production, foam stability, PH, OG, Ea and percentage of alcohol v/v are the factors associated with finished product.

Steps involved in beer production are:

1. Mailing

The dried malt barley grains are then crushed between rollers to produced coarse powder called grist

2. Mashing

Grist is mixed with warm water and the resulting materials are maintained at 65°C for about 1 hour. The liquid obtained by mashing is called wort. The husks and other grains residue as well as precipitated proteins are removed by filtration.

3. Boiling of wort

The filtrate is then boiled with stirring for 2-3 hours and Boiling helps for sterilize and concentrate the wort.

4. Fermentation

Beer production utilizes strain of S. cerevisiae which is top fermenting yeast.

During fermentation yeast converts glucose mainly into ethanol and CO2.

5. Finishing, Maturation and Carbonation

The young and lagered beer is stored in at 0°C for several weeks. During this period, precipitation of protein, yeast, resin and other undesirable substances take place and beer become clear.

Ester and other compounds are also produced during ageing which gives taste and aroma.

The beer is then cooled, clarified, filtered and packed in bottles and cans.

4.1.3. Demographic Characteristics of the Employees

Demographic characteristics including: gender, Work position, Work Experience, current educational background and response towards all variables is summarized using frequencies and percentages.

Table 4.1: Demographic characteristics of the respondents

Variables	Groups	Frequency	Percent
Gender	Male	24	80%
	Female	6	20%
	Total	30	100%
Work position	Quality control manager	1	3.33%
	chief chemist,	2	6.66%
	Polyvalent chemist,	4	13.3%
	Chemist	18	60%
	Microbiologist	2	6.66%
	lab assistance	3	10%
Work Experience	≤ 2years	2	6.66%
	3-5 years	15	50%
	More than 5 years	13	43.3%
Educational back ground	Diploma	2	6.66%
	Degree	22	73.33%
	MSC/MA	7	23.33%
	Total	30	100%

Table 4.1 above Presents gender, work position, work experience and education background of the respondents who are working in the quality section of the brewery.

Besides, 3.33% of the respondents are control manager, 6.66% are chief chemist, 13.3% are polyvalent chemist, 60% are chemist, 6.66% are microbiologist whereas and 10% of the respondents are lab assistance. This implies that participants in this research work are well aware of the SPC implementation. On the other hand, 50% of the respondents have a work experience of 3-5 years, 43.33% of the respondents are More than 5 years and 6.66% of the respondents are less than 2 years whereas. It is plausible to assume that most of the respondents can exactly know the implementation of statistical process control to improve quality of the product. In addition, 23.33% of them have a master's degree and 73.33% of the respondents have degree and 6.66% respondent has a diploma. This indicates all the respondents can understand all the questionnaire questions and respond properly.

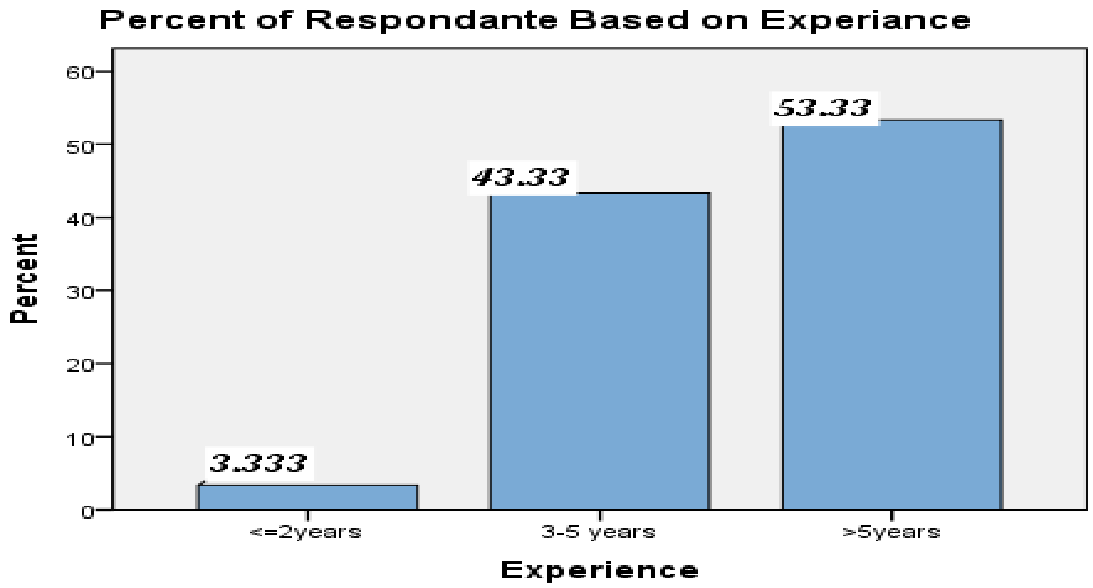


Figure 2: percent of respondent based on experience

4.1.4. Managerial actions to support the implementation program

Table 4.2 Frequency, mean and Standard deviation score of respondents on managerial actions to support the implementation program

		No of respondent							
Statement	N	1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1. Higher management provides visible support for the use of control charts throughout the organization	30	5	2	7	12	4	3.27	1.29	40% Moderate
2. Higher management uses control chart information in planning	30	3	2	10	6	9	2.3	1.51	33.33% Somehow
3. Higher management permits sharing of control chart information with either suppliers or customers	30	14	5	3	4	4	3.53	1.28	46.67% Not at all
4. Higher management regularly spearheads quality improvement effort identification	30	4	2	10	12	2	3.2	1.13	40% Moderate
5. The management is willing to accept any suggestions, comments and complaints from employee	30	4	12	8	5	1	2.57	1.04	40% Low

Based on the above table, 40 % of respondents said that the higher Mgt gave visible support for implementation of the program where as noticeable number of respondents, 46.67 % said there was not enough support. Thus, the data revealed that the organization was not experiencing the required amount of support.

On the other managerial action usage of control charts for planning 33.33% of the respondents ticked under somehow the Mgt uses control chart information for planning. However, 30% of the respondents said that there was very extremely usage of control charts for planning and 20% of the respondents said that there was very moderate usage of control charts for planning and the remaining 16.67% of the respondents said that there was low management practice in usage of control chart in planning activity.

According to the data presented in the above table, 46.67 % of the respondents agreed by saying not at all, 16.67% said low whereas 13.3 %, 13.3%, and 10% of the respondents respectively agreed there is a moderate, Very extremely and somehow higher management sharing of control chart information with either suppliers or customers.

Regarding higher management regularly spearheads quality improvement effort identification, 40% of the respondents ticked under moderate and 33.33% selected under somehow, this indicates that higher management regularly identifying quality improvement methods and 40% of the respondent ticked under low in case of higher management willing to accept any suggestions, comments and complaints from employee.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.719 greater than 0.7 so the data is reliable.

4.1.5 Identification of critical measurement characteristics

Table 4.3 Frequency Mean and Standard deviation score of respondents on identification of critical measurement characteristics.

		No of respondent							
Statement	N	1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1. The quality characteristic (s) associated with this process has been documented by the chemist	30	2	0	0	4	23	4.27	1.388	76.67% Always
2. The impact the manufacturing process on key quality characteristics of final product is well-known	30	0	2	1	2	25	4.57	0.898	83.33% always
3. Quality characteristics associated with manufacturing process is being monitored via control charts	30	2	0	6	8	14	3.97	1.63	46.67% always
4. No one has bothered to identify and define how or why this process affects the quality of the final product delivered to our customers	30	17	6	5	2	0	1.22	1.066	56.67 % Never
5. Quality problems with final product have been related back to particular parameters of this process	30	7	3	2	4	14	3.97	1.63	46.67% always
6. Process parameters affecting the quality of the final product delivered to our customers have been documented for the process chemist	30	2	1	1	4	12	1.22	1.066	40% always
7. Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools	30	2	2	5	3	15	3.97	1.63	50% always

As shown in the above table the identification of critical measurement characteristics has been evaluated with different variables. Based on the result with an average mean value of 4.57 always most of the critical measurement characteristics are identified always. According to the above data compared to other variables customers have been surveyed to identify those quality characteristics associated with this process have the least mean value which is 1.217.

Regarding documentation by the chemist, 76.67 % of respondents witnessed that the quality characteristic associated with the process were always documented by the chemist. In addition to this, the impact of the key quality characteristics up on final products was known by the manufacturing process. This was revealed by 83.33% of respondents as cited above. This indicates that continuous documentation of the process result is important to reduce and identified the quality problems in finished product.

Associated with customers surveying, 56.67% of the respondents showed that how or why this process affects the quality of the final product delivered to our customers have never been surveyed to identify those quality characteristics associated with the process while 20% and 16.67% the respondents respectively said that the company have been rarely surveyed and sometimes surveyed.

Associated with data documented by the chemist before the product delivered to customer, the respondent selected 40% always ,this implies that the if problem occurred in the process the problem can be identified due to continuous follow up in the process . About quality of finished product delivered to customer controlled by SPC 50% of the respondent says Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools and 10% of the respondents said that quality of finished product often controlled by SPC.

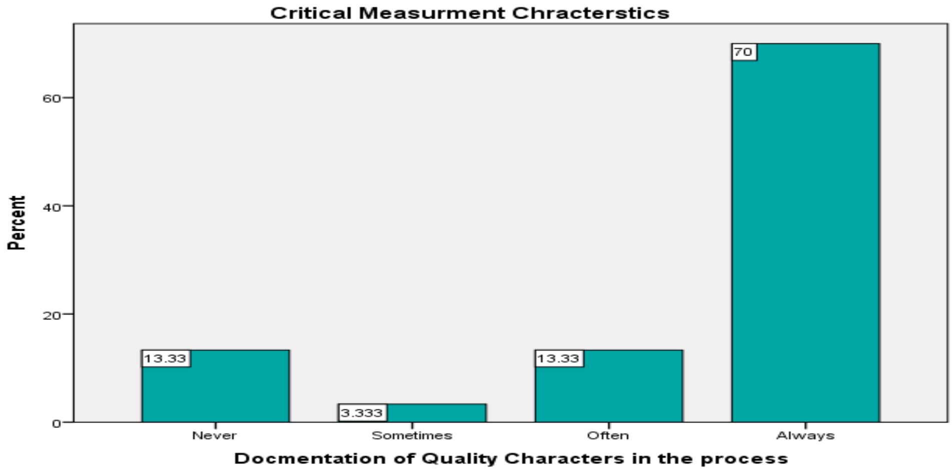


Figure 3: Graphes of majore quality characterstics recored in the process

As indicated in the above graph 70% of the respondent said continuous documentation of the brewing process.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value greater 0.834 than 0.7 so the data is reliable.

4.1.6 Technological sophistication and soundness of measurement devices

Table 4.4 Frequency, Mean and Standard deviation score of the respondents on technological sophistication and soundness of measurement devices.

		No of respondent							
Statement	N	1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1. Measurements of critical process characteristics are automated	30	2	2	8	13	5	3.53	3.53	43.33% Moderate amount
2. Computer controlled devices are employed to measure critical process characteristics	30	2	6	2	7	13	3.73	1.01	43.33% great deal
3. Data in the form of measurements of critical process are collected by computerized sensors	30	4	3	2	6	15	3.89	1.33	50% great deal
4. Measurement data are entered electronically into a data base	30	2	5	6	9	8	3.37	1.19	30% Moderate amount
5. Only calibrated measuring devices are being used to take measurements on critical process/product characteristics	30	3	0	5	5	17	4.27	1.17	56.67% great deal
6. measuring devices are calibrated in real time via computer control	30	4	2	2	10	12	3.8	1.24	40% great deal

As shown from the above table technological sophistication and soundness of measurement device has evaluated with different variables. The respondents was ticked 43.33% of moderate amount for measurement of critical process of product characteristics automatically. Based on the result most of the respondents replied that the organization use technology for measuring different parameters of the product via computer in great deal. It implies that the organization had a good practice by using computerized devices to control critical process parameters.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.906 greater than 0.7 so the data is reliable.

4.1.7 Major quality related problems/obstacles in the company

Table 4.5 Frequency, Mean and Standard deviation score of the respondents on major quality related problems/obstacles in the company.

		No of respondent							
Statement	N	1	2	3	4	5	Mean	Standard	% of the maximum frequency scale
1. Lack of management commitment for quality improvement	30	5	7	4	10	4	3.7	3.31	33.33%Majore obstacle
2.Low skill of operators of machine production process	30	6	8	3	11	2	2.83	1.32	36.67%Majore obstacle
3. Unable to identify customer requirements	30	11	11	2	4	2	2.17	1.26	36.67%No obstacle &minor obstacle
4. Company does not plan for quality and process improvement	30	9	1	11	4	5	2.83	1.44	36.67%Moderate obstacle
5. Old technology of machines, methods.	30	4	0	11	15	0	3.23	1.01	50%Majore obstacle
6.Poor quality of raw materials	30	18	5	2	2	3	1.9	1.37	60% No obstacle
7. Low awareness of workers/ operators on quality of process and product improvement	30	10	13	1	2	4	2.23	1.36	43.33% Minor obstacle
8. Inadequate training of the production process operators	30	4	9	8	4	5	2.9	1.3	30% Minor obstacle
9. Poor maintenance and handling of machines	30	6	4	12	6	2	2.83	1.12	40% Moderate obstacle
10. Low awareness of SPC tools by the operators and chemist	30	6	4	12	6	2	2.8	1.19	40% Moderate obstacle
11. Company implements all SPC tools to control and improve process	30	3	7	18	2	0	2.63	0.77	60% Moderate obstacle
12. Unable to identify quality related defects in the production process	30	12	5	7	5	1	2.27	1.26	40%No obstacle
13. Unable to diagnose the causes of quality defects in the production process	30	7	13	4	6	0	2.3	1.06	43.3%Minor obstacle
14. Unable to take correction action for defects in the process	30	12	8	2	4	4	2.33	1.47	40% No obstacle
15.lack of consistency to take corrective action for defects	30	8	5	12	3	2	2.53	1.2	40% Moderate obstacle
16. Company does not regularly check the status of production capability	30	14	3	5	4	4	2.37	1.52	46.67% No obstacle

Based on the above table, lack of management commitment for quality improvement is figured out as 33.33% of the respondent said that it was major obstacle, 23.33% of the respondent said that it was a minor obstacle, 16.66% said that it was a no obstacle while, the remaining 13.33% and 6.67% of the respondents said that it was a moderate obstacles and very sever obstacle for the company respectively. This implies that lack of management commitment for quality improvement was one of the major obstacles for the company.

Regarding operator skill, the data showed that low skill of machine operators for production process was not an obstacle as it was ticked by 20% of respondents. Besides, 26.67% of respondents said that it was a minor obstacle, although 36.67% and 10% of respondents respectively addressed that it was major and moderate obstacle.

Associated with identification of customers' requirement, 36.66% of the respondents indicated that being unable to identify customers' requirements was a no obstacle and minor obstacles for the company sharing equal percent each as cited in the above table.

For the question "Does not the company plan for quality and process improvement?'' 36.67% of the respondents said that it was not moderate obstacle, 30% of them said that it was a no obstacle.

Regarding technologies of machine, methods and so forth, the data gathered insured that the company should considered as it had major obstacle on these issues. This was figured out by 50 % of respondents indicating that old technology and methods were major obstacles and 36.67% of the respondent ticked under moderate obstacles.

Regarding poor quality of raw materials, 60 % and 16.66 % of respondents said that it was not obstacle and it was minor obstacle respectively. Thus, poor quality of materials might not be considered as an obstacle for the company as the respondent said but the interviewee said that the factor for the variation of product quality parameter are quality of the raw material .

Related to awareness of workers to the quality of process and product improvement, very noticeable number of respondents, 33.33% and 43.33%, of respondents respectively said that it was not an obstacle and minor obstacle. Awareness of the workers to the quality of process and product improvement might not be considered as an obstacle for the company.

Regarding trainings, the data presented above in table indicated that 30 % of respondents said that inadequate training was minor obstacle. Besides, 26.67 % of respondents said that it was a moderate obstacle.

More over the data gathered through the questionnaire, the interview witnessed that inadequate training was a moderate obstacle to the company.

Regarding poor maintenance and handling of machines 40% of respondents ensured that poor maintenance and handling of machines were minor obstacles to the company. Even though, 26.67% of respondents said that these were moderate obstacle whereas the remaining 16.67% of respondents ticked major obstacles.

Related to awareness of operators and chemist to SPC tools, 40% of respondents said that it was moderate obstacle where as 20% of respondents saying no obstacle and major obstacle sharing equal percent each as cited in the above table. This reveals that awareness of operators and chemist to SPC tools was noticeably an obstacle to the company. Besides, the interview investigated that it was really an obstacle to the company.

On the subject of implementation of all SPC tools to control and improve production process product, 60% of the respondents said that it was moderate obstacle. Besides, 23.33% of the respondents said that it was minor obstacle. Very large number of respondents said that it was very noticeable obstacle to the organization to implement all tools of SPC. Besides, the interview investigated that only control chart used in the company.

Related to identification of quality related defects in the production process, 40 % of respondents said that it was not an obstacle and 23.33% of the respondent said that it was a minor obstacle.

Beside identification of defects, diagnosing the cause of quality defects in the production process was labeled as it was considerably a minor obstacle by 43.33% of respondents.

In turn, corrective actions up on defects were not as such an obstacle to the company as said by more number of respondents, 40 %. Besides, it is simple to understand that when there is no identification and diagnosis of defects of quality in production process, taking corrective action won’t be consider as an obstacle.

Related to consistency of taking corrective action, the data gathered through the questionnaire said that lack of consistency as obstacles of the company, and 40% of the respondent said that lack of consistency of taking corrective action as moderate obstacles.

Related to regular check up on the status of production process capability, 46.67 % of respondents labeled not obstacles.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.901 greater than 0.7 so the data is reliable.

4.1.8. Usage of control chart information for continuous improvement

Table 4.6 Frequency, Mean and standard deviation score of respondents for usage of control chart information for continuous improvement.

Statement	N	No of respondent 1	2	3	4	5	Mean	Standard deviation	maximum frequency scale
1. Decision rules are in place to allow the detection of out-of-control situations	30	4	4	3	15	4	3.37	1.27	50%Almost every time
2. Whenever a manufacturing process goes out of control, special causes of variation are identified and removed	30	4	2	7	11	6	3.43	1.28	36.67% Almost every time
3. various off-line tools (e.g., Pareto charts, histograms, etc.) are used to identify special causes of variation when a manufacturing process goes out of control	30	9	6	13	0	2	2.33	1.12	43.33%Some time
4. A stable manufacturing process is frequently checked to see if it is capable of meeting product specifications	30	4	2	5	16	3	3.4	1.19	53.33% Almost every time
5. Control charts are not being used to monitor this process	30	17	5	3	3	2	1.93	1.31	56.67% Never
6. Control charts are displayed simply to satisfy customer demands	30	4	10	12	3	1	2.57	0.97	33.33%Some time
7. Control charts are used only to identify out-of-control situations ; no corrective actions are taken to bring the process back into control process	30	15	2	5	4	4	2.33	1.54	50% Never
8. Control charts are used not only to identify out-of-control situations for corrective action but also to identify opportunities for reducing common cause variation affecting the process	30	4	2	5	18	1	3.33	1.12	60% Almost every time

As shown in the above table, 50% of the respondents said that decisions were in place almost every time while, 13.33% of the respondents said that decisions almost never, never and every time with the equal value and the remaining 10% said that decision was in place sometimes. This implies, decision rules properly placed to allow the detection of out of control situations.

For the second statement given under usage of control charts, 36.67% of the respondents said that whenever a manufacturing process goes out of control, special causes of variations were identified and removed almost every time.

43.33% of the respondents labeled sometime for the usage of various off line tools (Pareto charts, histograms, etc.) to identify special causes of variation when a manufacturing process goes out of control. However, the researcher investigated the fact that the company only used X-bar R-chart control charts to identify causes of variation through the interview conducted.

Based on the data cited in the above table, 53.33% of the respondents said that the manufacturing process was checked frequently almost every time to see whether the process is capable of meeting product specifications. However, the researcher observed the checking system of the company is more frequent enough. Not only the intervals of checking the process parameter but also the samples taken for consideration are more in numbers so it is good to say the sampling is convenient to identify the variations.

Regarding usage of control charts for monitoring product process 56.67% of respondents said that the control chart was used for monitoring the product process and satisfies customer demands.

Besides, significant number of respondent, 60% of revealed that the control charts were not only used to identify out-of-control situations but also to identify opportunities for reducing common causes of variation almost every time.

Generally according to the responses gathered from the questioner, interview and observation, the overall performance of the quality control section in usage of control chart information for continuous improvement was good.

The internal consistency of these questionnaires was checked by Cronbach’s alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.711 greater than 0.7 so the data is reliable.

4.1.9 Training in statistical and cognitive methods for process control and improvement

Table 4.7 Frequency, Mean and standard deviation scores of respondent's on training in statistical and cognitive methods for process control and improvement.

Statement	N	No of respondent							
		1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1. Almost everyone in quality control section received training in the construction of control charts	30	11	3	12	1	3	2.4	1.303	36.67% Never
2. Almost everyone in quality control section can describe what a control chart is saying about the performance of a critical process/product characteristics	30	2	7	3	7	11	3.6	1.38	36.67% Every time
3. Almost everyone in quality control section has received training in applying various off-line tools to	30	11	12	4	3	0	1.97	0.964	40% Almost never
4. There are on-going refresher classes in the application of control charts and/or various off-line tools	30	11	19	0	0	0	1.63	0.49	63.33% Almost never
5. Periodic refresher training is mandated for everyone in the section	30	12	11	6	1	0	1.87	0.86	40% Never

From the table above under training in statistical and cognitive methods for process control and improvement, 40% (the maximum frequency scale) of the respondents labeled sometimes to "almost everyone in the department has received training in the construction of control charts". While 36.67% of the respondents said never the training has been given to everyone. The presented data from the questionnaire coincided with the observation revealed that the control chart was applied align with the production process every day by everyone this implies that every members of the section adapted in control chart constriction.

As cited above in the table, 36.67% of the respondents approved that almost everyone in the department can describe what a control chart is by labeling every time. While the 23.33% of the respondents labeled almost every time everyone capable to describe the control chart properly.

36.67% of the respondents agreed that there were never ongoing training classes given almost every time on the application of control charts, 63.33% respondents agreed that there were almost never ongoing training classes given but, the researcher investigated through the interview that there was problem in respect to training either in control chart usage or in any other various off-line tools. Lowest mean value from the other variables, it means that training was never given for everyone.

Although periodic refreshing training classes is mandated for everyone in the organization had a lowest mean value from the other variables, In this regard, 40% of the respondents agreed that there was not any periodic refreshing training given for anyone in the organization.

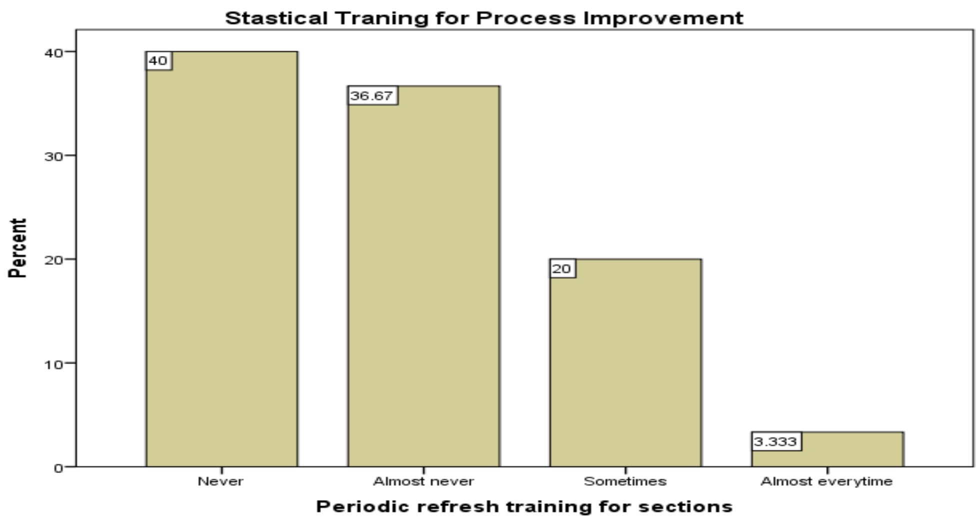


Figure 4: Periodic training in the section for process improvement

As indicated in the above graph 40% of the respondent said that periodic refresh training in the organization is very low.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.715 greater than 0.7 so the data is reliable.

4.1.10. Technical support for SPC implementation and practice

Table 4.8 Frequency, Mean and standard deviation scores of respondents on technical support for SPC implementation and practices.

		No of respondent							
Statement	N	1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1. Technical staff experts are able to answer technical questions arising from the use of control charts.	30	6	7	12	4	1	2.57	1.07	40%Good
2. When a problem arises from the application of control charts that I assigned, as a process operator, am unable to resolve, technical staff personnel comes to my aid.	30	12	9	5	3	1	2.07	1.14	40% Poor
3. How available and accessible are in-house knowledgeable technical staff experts to you, a process operator, when a problem arises from the implementation and use of control charts	30	6	14	9	0	1	2.2	0.79	46.67%Fair

From the above table, technical support for SPC implementation & practices; 40% of the respondents said that technical experts are good at answering technical questions that were raised from the use of control charts. When problem arises from the application of control charts that I assigned, 40% of the respondents ticked under poor. Process operator, when a problem arises from the implementation and use of control charts 46.67% of the respondent said that fair, this indicates that the support of technical staff to SPC implementation is need to improvement; this idea is supported by the interviews.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.853 greater than 0.7 so the data is reliable.

4.1.11 Quality improvement team support of SPC practice

Table 4.9 Frequency, Mean and standard deviation scores of respondents on quality improvement team support of SPC practices.

Statement	N	No of respondent					Mean	Standard deviation	% of the maximum frequency scale
		1	2	3	4	5			
1. Quality improvement teams, meet regularly to discuss progress on improvement.	30	6	7	2	12	3	2.97	1.38	40%Usually true
2. Quality improvement teams, recommendations for improvement to higher management.	30	4	6	14	6	0	2.73	0.94	46.67%Neutral
3. As a process quality control team, I often work with a team of other operators, management to resolve out-of-control	30	6	3	5	13	3	3.13	1.33	43.33% Usually true
4. Quality improvement teams, consisting of at least one process quality control	30	7	0	6	16	1	3.1	1.28	53.33% Usually true

Based on the above table, 40% of the respondents labeled usually true to the quality improvement teams, consisting of at least one process operator, meet opportunities regularly to discuss for improvement.

Quality improvement team consisting of at least one process operator, submit a large number of recommendations for improvement to higher management was labeled neutral with a maximum frequency percentage score of 46.67.

Besides, 43.33% of the respondents indicated there was a usual team work in between process operators and managers to resolve out of control situations. Thus, the researcher is highly compelled to say that the company experienced less team work and management support in SPC practice at large by observation and interviews.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.730 greater than 0.7 so the data is reliable.

4.1.12 Update of knowledge of processes

Table 4.10 Frequency, Mean and Standard deviation scores of respondents for update of knowledge of a process.

	N	No of respondent							
Statement		1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1. The capability of this manufacturing process, to which I am assigned, is continually documented	30	3	0	2	8	17	4.2	1.243	56.67%All the time
2. The nuances of this manufacturing process are well understood by me, an operator on this process	30	2	4	1	7	16	4.03	1.33	53.33% All the time
3. Control chart limits for parameters associated with this manufacturing process are updated as the process is changed	30	2	2	3	3	20	4.23	1.28	66.67% All the time
4. In the manufacturing process changes, information descriptive of the process is updated	30	1	2	4	4	19	4.17	1.29	63.33% All the time
5. Knowledge of this manufacturing process, to which I am assigned, is easily retrievable	30	2	0	5	8	15	4.13	1.14	50% All the time
6. It is easy to update information about this manufacturing process, to which I am assigned	30	2	4	4	12	8	3.67	1.21	40% Often

As indicated on the above table, for update of knowledge of processes, 56.67% of the respondents approved the capability of the manufacturing process continually documented all of the time. While 26.67% of the respondents agreed the process is continually documented often.

As indicated on the above table 53.33% of the respondents the nuances of this manufacturing process are well understood by an operator on this process all of the time.

As cited above in the table, 66.67% of the respondents said that control chart limits for parameters associated with the manufacturing process are updated all of the time. However, the researcher identified through observation of the process control limits was cited as in different CL, UCL and LCL of the process parameters.

Besides, 50% of the respondents revealed that knowledge of the manufacturing process was easily retrieved all the time.

On the other hand for the issue mentioned on the above table, 40% with the maximum frequency scale of the respondents revealed that the information about a manufacturing process was easily updated often. However, the researcher investigated the fact that the company updating knowledge of the process any parameters changed through the interview conducted.

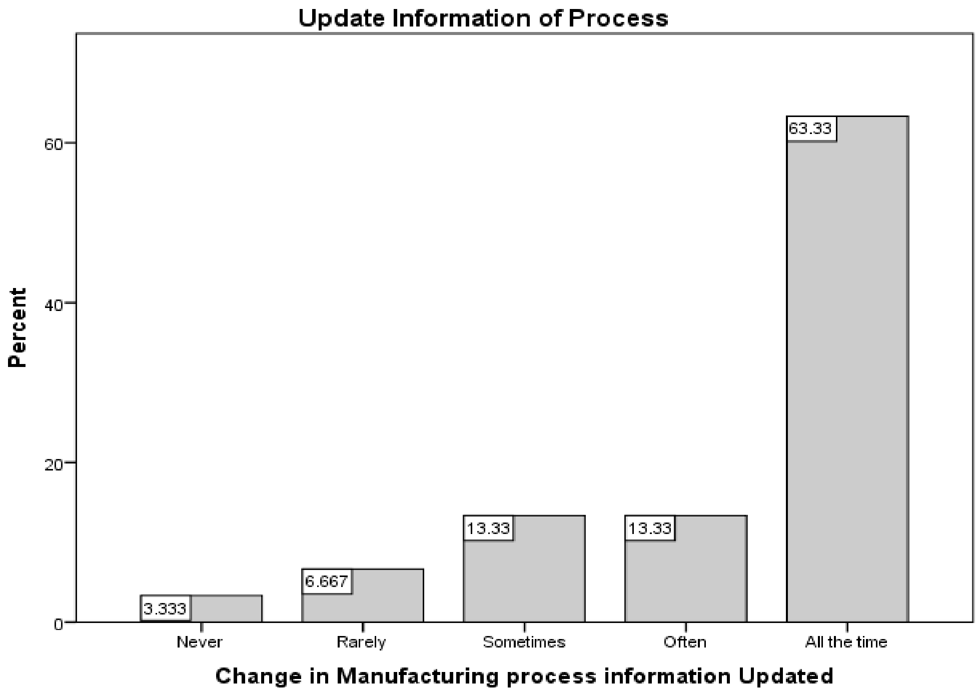


Figure 5: Information update in manufacturing process

As indicated in the above graph 63.33% of the respondent said that exchange of information in the manufacturing process when process parameters updated.

The internal consistency of these questionnaires was checked by Cronbach’s alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.917 greater than 0.7 so the data is reliable.

4.1.13 Audit and review of SPC practice and performance

Table 4.11 Frequency Mean and standard deviation scores of respondents on audit and review of SPC practices and performance

		No of respondent							
Statement	N	1	2	3	4	5	Mean	Standard deviation	% of the maximum frequency scale
1.The SPC intervention is periodically audited to identify opportunities for improvement	30	2	2	12	13	1	3.3	0.92	43.33%Almost every time
2.An audit of SPC activities is regularly conducted	30	2	2	7	15	4	3.57	1.04	50% Almost every time
3.The organization continually monitors SPC activities	30	4	0	1	23	2	3.63	1.10	76.67%Almost every time
4.All aspects of the SPC intervention undergo frequent checkups to ensure that all is going well	30	2	4	0	21	3	3.63	1.07	70%Almost every time

From the table above under audit and review of SPC practice and performance, 43.33% of the respondents ladled almost every time to “the SPC intervention is periodically audited to identify opportunities for improvement”.

As indicated above in the table, 50% of the respondents approved that almost every time an audit of SPC activities was conducted regularly.

Besides, the organization continual monitoring of SPC activities, 76.67% of the respondents approved every time this process is conducted in the organization.

Regarding all aspects of the SPC intervention undergo frequent checkups to ensure that all is going on, 70% of the respondents labeled almost every time.

The internal consistency of these questionnaires was checked by Cronbach's alpha. The data obtained were analyzed by using SPSS software to say the reliability and scales of tools and patterns, it indicates an alpha value 0.885 greater than 0.7 so the data is reliable.

4.2 Application of control chart data gathered through document review

This part is dedicated to present and discuss the data that was gathered from the case factory which is BGI Ethiopia brewing industry in Addis Ababa plant with respect to the objectives of the thesis. After using the methodologies like questioner, interviewing, visiting and personal contact, the following one month report real data has been identified from the quality control department of the company starting from April 1 to 30 has been recorded.

To establish control chart we need the average of the mean, the average of the range, UCL, CL and LCL for each X-bar and R-chart. The formulas for both X and R chart as follow:

For X-bar chart: UCL=X Double Bar + A2Rbar, Center line (CL) = X-Double bar and

LCL= X Double Bar –A2RBar

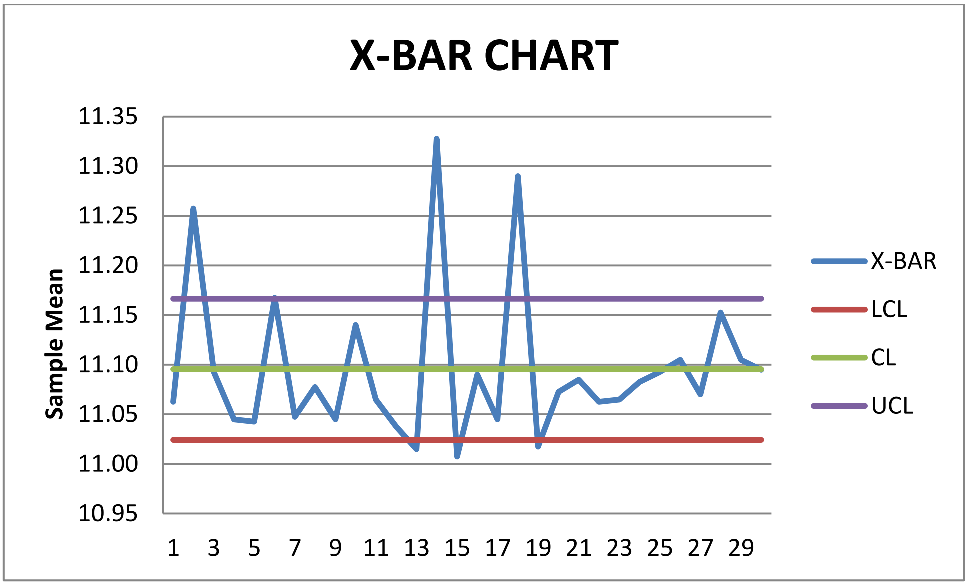
For R-chart: UCL =D4R Bar, Center line (CL) = R Bar and LCL =D3RBar

To contract both X and R chart we need the following constants depend on the sample size, in this research the sample size for all parameters is four. **n=4, A2=0.729, D3=0 and D4=2.282**

X-bar charts are plotted as mean of sample against the sample day and the R-bar chart is plotted as a sample range against sample days.

Data taken for OG

The following graph of X -bar and R charts shows the data taken from the company documented report for the month of April for one of the major quality affecting parameters of beer product (OG)



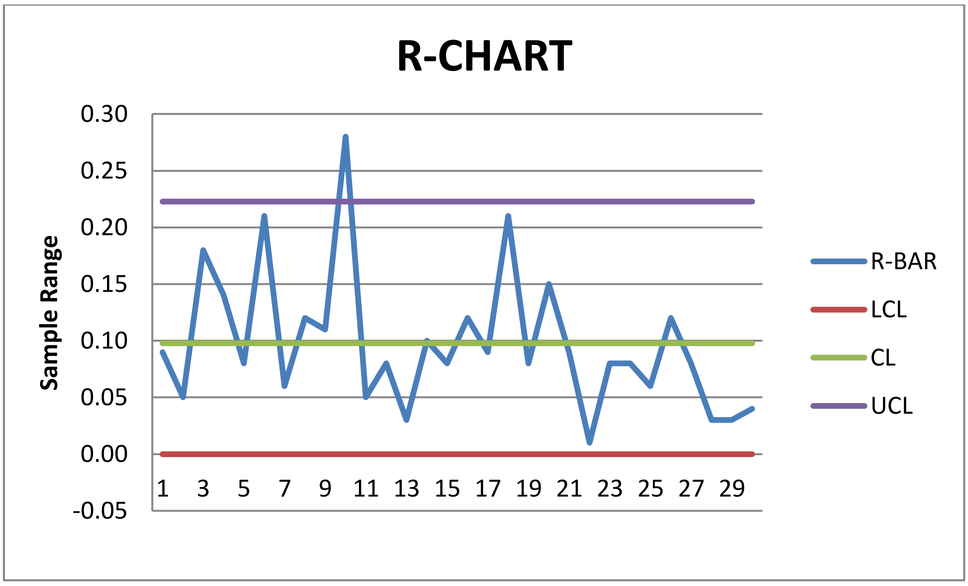
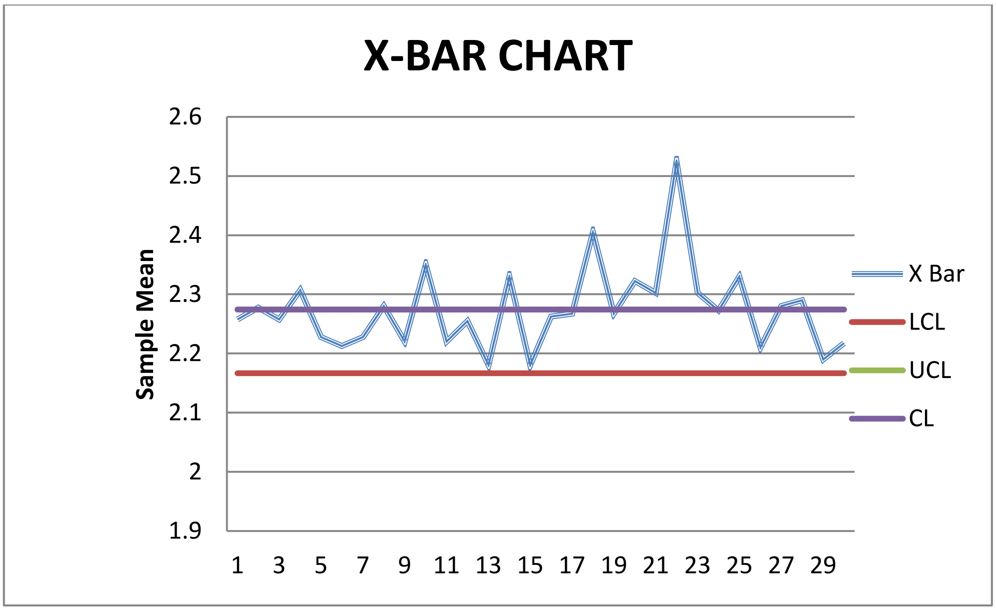


Figure 6: Graph for X-bar R chart of OG

From the above X bar graph, 3 points are above the UCL and other three points are below the LCL. For the OG of the mean chart shows those six points are out of control, whereas one point was out of control on the range chart. However the process is not fully in control. Such kind of variation still occurred due to the variation of raw materials and machine adjustment.

Data taken for Apparent Extract

The following graph of X -bar and R charts shows the data taken from the company documented report for the month of April for one of the major quality affecting parameters of beer product (Ea).



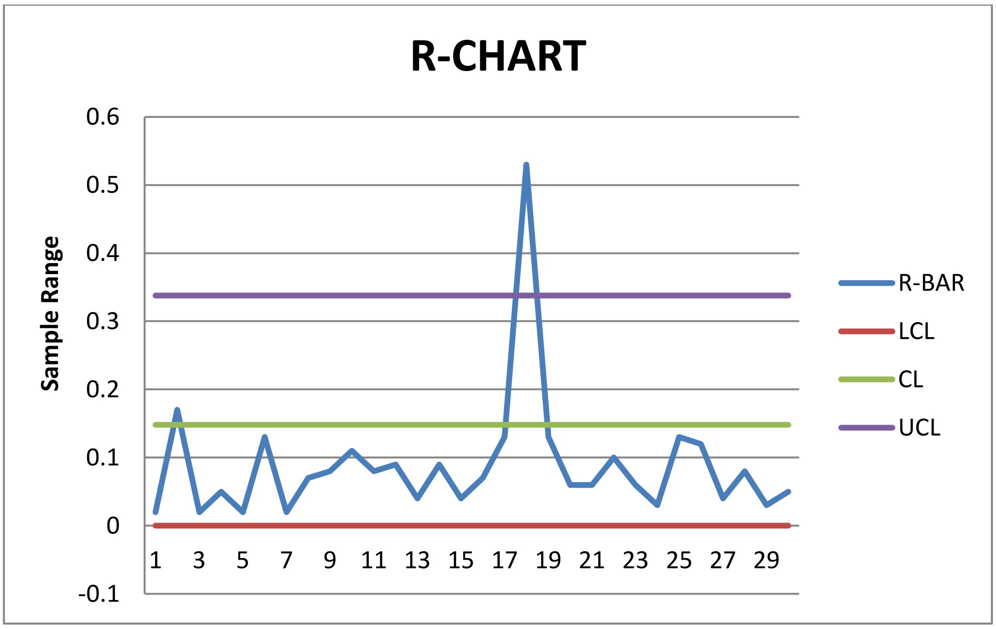
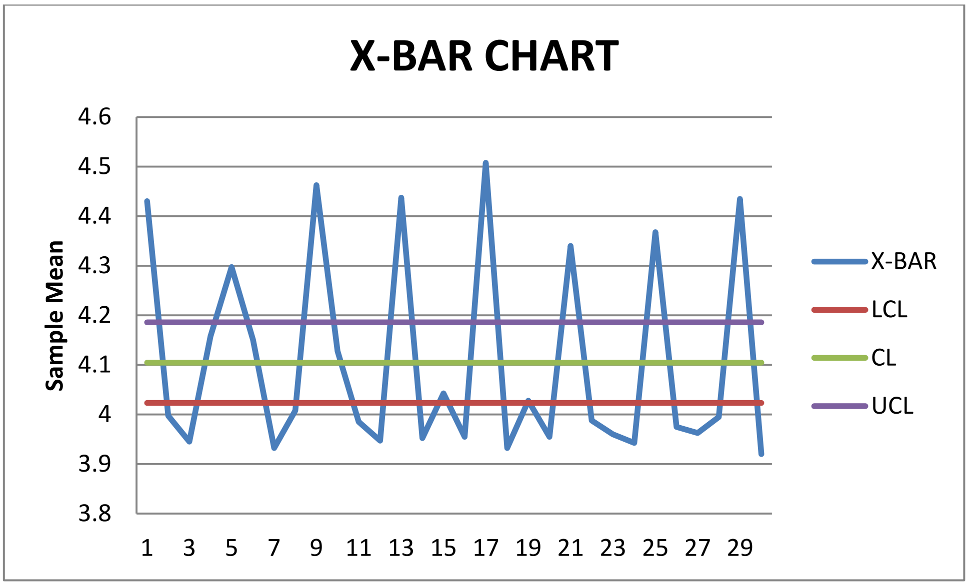


Figure 7: Graph for X-bar R chart of Ea

From the above X bar graph, some points are above the UCL and no points are below the LCL. For the Ea of the mean chart shows that some points are out of control, whereas one point was out of control on the range chart. However the process is not fully in control. Such kind of variation still occurred due to the variation of raw materials and machine adjustment.

Data taken for PH

The following graph of X -bar and R charts shows the data taken from the company documented report for the month of April for one of the major quality affecting parameters of beer product (PH).



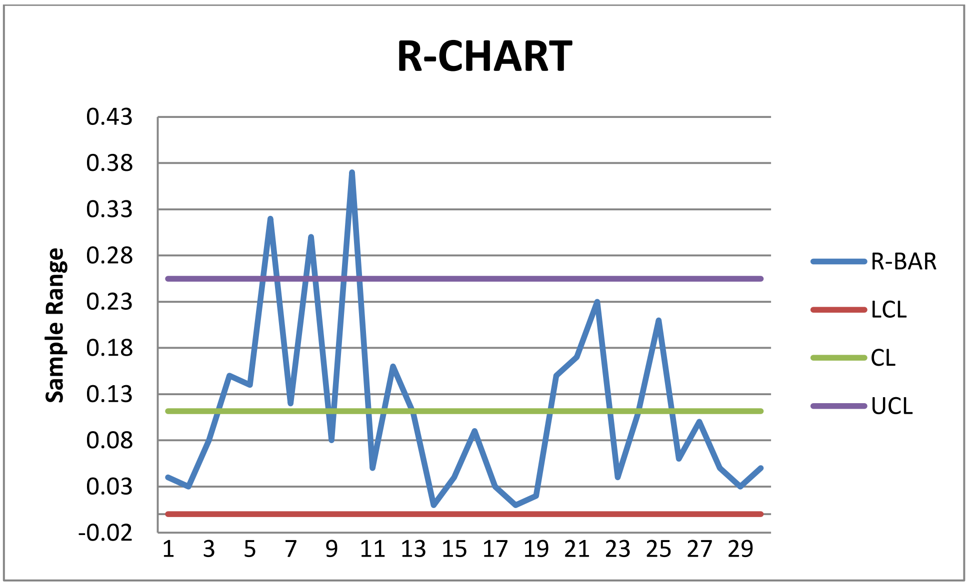
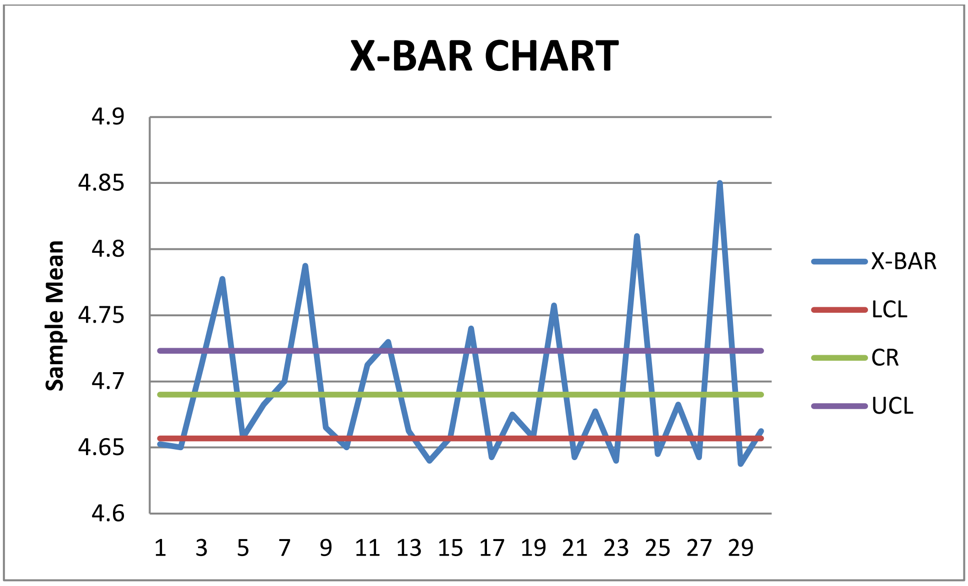


Figure 8: Graph for X-bar R chart of PH

From the above X bar graph, most points are above the UCL and below the LCL. For the PH of the mean chart shows that most of the point are out of control, whereas three points was out of control on the range chart. However the process is not fully in control. Such kind of variation still occurred due to the variation of raw materials, operators and machine adjustment.

Data taken for ALC v/v

The following graph of X -bar and R charts shows the data taken from the company documented report for the month of April for one of the major quality affecting parameters of beer product (Alcohol v/v).



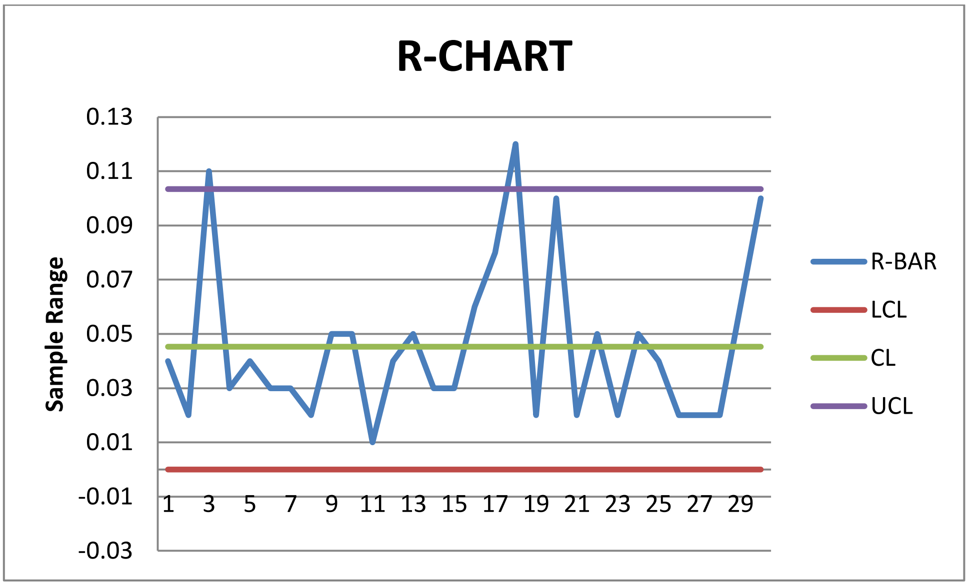


Figure 9: Graph for X-bar R chart of alcohol v/v

From the above X bar graph, most points are above the UCL and below the LCL. For the alcohol of the mean chart shows that most of the point are out of control, whereas two points was out of control on the range chart. However the process is not fully in control. Such kind of variation still occurred due to the variation of raw materials, operators and machine adjustment.

4.3 Application of Cause and Effects Diagrams in brewing Industry

From the interview of the quality managers we have identified top quality problems in beer production process and by further analyzing we have also identified top four quality parameters in the process. Those problems are below and above the specification limit of OG, Ea, PH and Alcohol v/v. Cause-Effect (CE) analysis is a tool for analyzing and illustrating a process by showing the main cause and sub-causes leading to an effect (symptom). It is sometimes referred to as the fishbone diagram because the complete diagram resembles a fish skeleton. The fishbone is easy to construct and interactive participation.

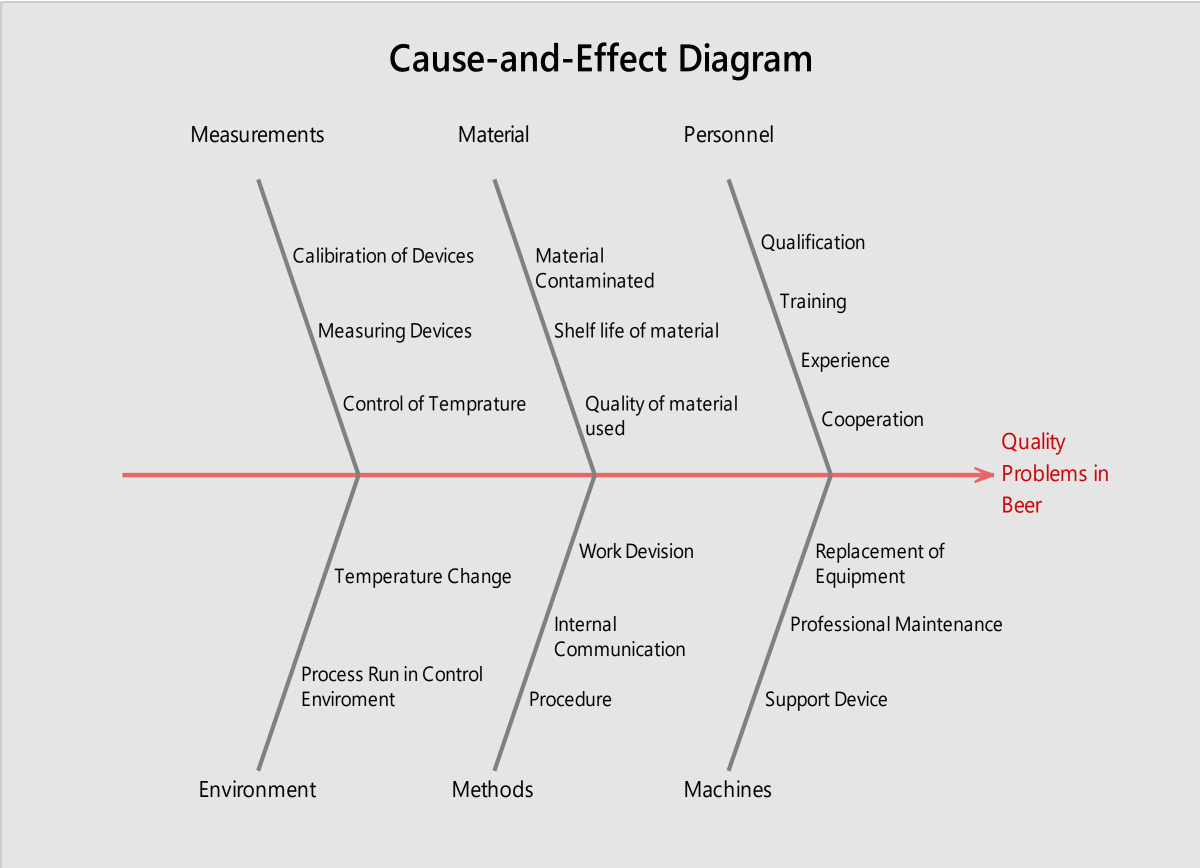


Figure 10: Overall fish bone diagrams for quality problems in beer

*Sources: Own computation based on data collected from interview (Minitab 19)

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMENDATION

5.1 Summary of Findings

This part of the section tries to summarize the key findings of the study. The objectives of the study were to investigate the assessments on SPC implementation at the beverage industry for improving Product Quality in BGI Ethiopia. In order to meet the objectives of the study the researcher collected primary data by the use of Questionnaire, interview and observation. Thus from a population of 30 employees, all questionnaires were retrieved from the respondents and analyzed. Accordingly, the findings of the study are summarized as follows.

Regarding to background of the respondent, 50% of the respondents have a work experience of 3-5 years, 43.33% of the respondents are More than 5 years and 6.66% of the respondents are less than 2 years whereas. It is plausible to assume that most of the respondents can exactly know the implementation of statistical process control to improve quality of the product. In addition, 23.33% of them have a master's degree and 73.33% of the respondents have degree and 6.66% respondent has a diploma and all they were working in the area of the quality control. This indicates all the respondents can understand all the questionnaire questions and respond properly.

From the different dimensions shown, findings revealed that the assessments on SPC implementation at the beverage industry for improving Product Quality were investigated.

The responses from the questionnaire showed that the company had a good practice in every aspect in SPC implementation at the beverage industry for improving Product Quality, Even if, there were still certain limitations investigated such as lack of management commitment for quality improvement tools, unable to identify customer requirement, Old technology of machines and methods used, Low skill of machine operators in production process cause for lack of consistency of basic parameters of the product, sometimes the management is unwilling to accept suggestions, comments and complaints from the employee related to the parameter fluctuation of process, absence of Periodic refresher training for everyone in the section about SPC implementation tools, lack of consistency to take corrective action for defects, Company unable to implements all SPC tools to control and improve production process/products (only control chart used), Inadequate training of the production process operators, Decision rules are not in place to allow the detection of out-of-control situations, Quality improvement teams not meet regularly to discuss progress on improvement and Quality improvement teams not consisting process quality control (chemist) and process operator. As the data collected from the quality control department in the month of April some parameters are not in control as the data shows. It shows that the quality characteristics are no exactly the same level. Some are slightly higher and some slightly lower than the standards. This type of difference is completely normal in production process. No two products are exactly alike because of slight differences in materials, workers, machines, tools, and other factors. These are called common, or random, causes of variation. As the company successfully implemented SPC the variation of product parameters can reduced.

Due to the good practices implemented and identified from the data gathered through documentation review, from interview as well as from the questionnaire revealed that the company was benefited after the implementation of the SPC as the findings exhibited. These benefits are mention as; reduced non-conforming products, minimize the risk of product recalls, minimize the customer complain and improved process visibility.

5.2 Conclusion

Based on the findings of the study, the following conclusions are drawn by the researcher. Practices like documentation of quality characteristic associated with manufacturing process parameters by the chemist, control chart limits for parameters associated with the manufacturing process are updated as the process is changed and information update with a time, good practice of information exchange in the manufacturing process with in each shift, the impact in the manufacturing process on key quality characteristics of final product is well-known by the chemist, Quality characteristics associated with manufacturing process is being monitored via control charts, based on control sample every machines in quality control section of the company calibrated and adjustment made with in regular period, Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools and only calibrated measuring devices are being used to take measurements on critical process characteristics are some of the good practices of the company so as in the implementation process of SPC all these are very basic to improve the process and the quality of the product.

Practices and challenges of the company on SPC implementation for improving quality product like lack of management commitment for quality improvement tools, unable to identify customer requirement, Old technology of machines and methods used, Low skill of operators of machine in production process cause for lack of consistency of basic parameters of the product, absence of Periodic refresher training for everyone in the section about SPC implementation tools, lack of consistency to take corrective action for defects**,** Company unable to implements all SPC tools to control and improve production process**,** Inadequate training of the production process operators and Quality improvement teams not consisting process quality control (chemist) and process operator. As a result, it is very difficult to think effective implementation of SPC for quality improvement without all the required parameters mentioned above. Therefore a company should take corrective actions for the successful implementation of SPC.

Company was benefited after the implementation of the SPC as the findings exhibited. These benefits are reduced non-conforming products, minimize the risk of product recalls, minimize rework on the process, minimize the customer complain and improved process visibility.

Generally it can be concluded that if a statistical process control Practices are implemented effectively, the company can improve the quality of the process and product in organizational performance by considering the customer requirement product and meeting the interest of them.

5.3. Recommendation

Based on the above findings and conclusions for sustainable quality improvement in the brewing company the following recommendations are suggested.

Implementation of SPC for the improvement of product quality in brewing industry is planned at the organizational level by the general manager for increasing the quality of product and satisfying the customer of the company.

1. Higher management provides visible support convinced that SPC has the ability to improve the company product quality.

Top level management to be known about the effect of SPC implementation in the organization.

- SPC requires changes of leadership style
- SPC used to increase process quality
- SPC is technique to control and reduce the process variation

2. Establishment of Quality improvement teams, consisting of employee from quality, production and technique department.

3. Continuous planning for SPC Training, company is highly in need of consistent training provision.

- SPC implementation training is highly suggested to be delivered in all level-by level within the organization for all employees.
- SPC training includes other quality tools and technique to improve quality of the process and product.
- Continues training session and awareness creating to all employees could help the company to achieve objectives

4. Quality of raw material always checked by batch before accepted and not accepts the raw materials that are out of the standards (quality of raw material is the main factor for variation of product parameters).

5. Periodic refreshing training is mandated for everyone in the production and quality department about the implementation of SPC.

6. Continuous calibration of production and quality control machines within regular period of time.

REFERENCES

Aliaga, M. and Gunderson, B. (2002) Interactive Statistics. [Thousand Oaks]: Sage Publications.

Attaran.M.(2000). Why does reengineering fail. A practical guide for successful implementation. Journal of Management Development, 19(9), pp. 794-801.

Barker, 1990 A component of total quality management (TQM).

Benton, W. C. (1991). Statistical process control and Taguchi method. International

Journal of Production Research, 29(9), 1761-1770.

Bissell, 1994 Process management technique.

Booker, J. D. (2003). Industrial practice in designing for quality. International Journal of Quality and Reliability Management, 20(3), 288-303.

Burns J. and King R. (Eds) (1993), Training in the Food and Beverages Sector in the United Kingdom, European Centre for the Development of Vocational Training, Berlin.

Bushe, 1988, Roberts et al., 1989 Technological innovation.

Caswell et al., 1998).One of the quality management systems in the food industry. Wallace et al. (2012) and Davis and Ryan (2005) viewed SPC as a participatory management system.

Deming W.E. (1950). Some theory of sampling. Third, edition, New York : John Wiley.

Douglas C. Montgomery (1997) “Introduction to Statistical quality control” New Delhi.

Grigg, N. P. 1998. Statistical process control in UK food production: an overview. International Journal of Quality & Reliability Management, 15, 223-238.

Grigg, N. & Walls, L. 2007a. The role of control charts in promoting organizational learning: New perspectives from a food industry study. The TQM Magazine, 19, 37-49.

Hansen B.L &Gahare P.M (1987).Quality Control and its Application, 6 th edition, Prentice Hall of India.

Ignatio. Madanhire (2016), Charles Mohwa Application of SPC in manufacturing industry in a developing country.

International Standard of Organization for Quality Management (ISO), (2005). Quality Assurance Vs Quality Control

Kaoru Ishikawa," Introduction to quality control " Chapman &Hall , 1994

Montgomery, D.C (1997) Introduction to statistical quality control,3rd Edition, New York:

Montgomery, D. (2005) Introduction to statistical quality control. 5th Edition, New York:

Montgomery, D. (2009) Introduction to statistical quality control. 6th Edition, New York:

Pable, A., Lu, S. &Auerbach, J. 2010. Integrated qualitative/quantitative techniques for food product quality planning. Journal of Food Quality, 33, 112-129.

Pareto principle 80/20 rule.

Smyth,R. (2004). Exploring the usefulness of a conceptual frame work as a Research tool: A Research Reflection .Issues in Educational Research .14.

Talbot, N. (2003).The use of automated optical testing (AOT) in statistical process control (SPC) for printed circuit board (PCB) production. Circuit World, 29(4), pp.1922.

Xie, M. and Goh, T. (1993), "Improvement detection by control charts for high yield processes", International Journal of Quality & Reliability Management, Vol. 10 No. 7, pp. 24-31.

Xie, M. and Goh, T.N.(1999), "Statistical techniques for quality", The TQM Magazine, Vol. 11 No. 4, pp. 238-41.

Zailani, S., & Fernando, Y. (2001). The Role of Cultural Change in the Relationship between Critical Factors with the Success of Statistical Process Control (SPC) Projects. Quality, 1–11.

APPENDIX- A

ST MARY'S UNIVERSITY

School of Graduate Studies

Institute of Quality and Productivity Management

Survey on Assessment on SPC implementation at the beverage

Industry for Improving Product Quality

QUESTIONNAIRE

This questionnaire is prepared to collect data regarding the practices of the company in using statistical process control for quality improvement and also to identify the main challenges faced in the implementation process. Survey questionnaires for study the Assessment on SPC implementation at the beverage industry for Improving Product Quality in BGI Ethiopia. Dear Sir/Madam, I am student of Master of Quality Control and Productivity Management in St. Mary's University. The following research is part of my study and conducted for purely academic purposes. The purpose of the research is to find out the productivity improvement techniques using SPC tools in brewing industry. All the Information collected through the questionnaire will be used only for contribution to knowledge and kept secret/ confidential. Please ensure that you mark all the given statements otherwise incomplete responses will not fulfill researcher requirements. To this end, kindly request you to answer the following short questions regarding with the stated objective. It will take no longer than 15 minutes of your time. Your response is utmost important to me. Therefore, you're genuine, honest and prompt response is available input for the quality and successful completion of the project research paper.

General Instruction

- There is no need of writing your name.
- In all case where answers options are available, please make mark(X) in the appropriate place.

Part one : Personal Information

1. Gender of the respondent ☐ Male ☐ Female

2. Work position ____________ (like quality control manager, chief chemist, polyvalent chemist, chemist, microbiologist, lab assistance and other worker, etc.)

3. Work Experience; ☐ ≤ 2years ☐ 3-5 years ☐ More than 5years

4. Educational back ground ☐ Diploma ☐ Degree ☐ MSC/MA ☐ PhD

Part Two: Rate the following questions and put "X" in the respected area.

1-Not at all 2-Low 3- Somehow 4- Moderate 5- Very extremely

1. Managerial actions to support the implementation program

1. Higher management provides visible support for the use of control charts throughout the organization					
2. Higher management uses control chart information in planning					
3. Higher management permits sharing of control chart information with either suppliers or customers					
4. Higher management regularly spearheads quality improvement effort identification					
5. The management is willing to accept any suggestions, comments and complaints from employee					

1-Never 2- Rarely 3-sometimes 4-often 5- always

2. Identification of critical measurement characteristics

1. The quality characteristic (s) associated with this process has been documented by the chemist					
2. The impact the manufacturing process on key quality characteristics of final product is well-known					
3. Quality characteristics associated with manufacturing process is being monitored via control charts					
4. No one has bothered to identify and define how or why this process affects the quality of the final product delivered to our customers					
5. Quality problems with final product have been related back to particular parameters of this process					
6. Process parameters affecting the quality of the final product delivered to our customers have been documented for the process operator					
7. Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools					

1-Never 2- Rarely 3-Occasionally 4- A Moderate amount 5- A great deal

3. Technological sophistication and soundness of measurement devices

1. Measurements of critical process/product characteristics are automated					
2. Computer controlled devices are employed to measure critical process/ product characteristics					
3. Data in the form of measurements of critical process are collected by computerized sensors					
4. Measurement data are entered electronically into a data base					

5. Only calibrated measuring devices are being used to take measurements on critical process/product characteristics					
6. measuring devices are calibrated in real time via computer control					

1-No obstacle 2-Minor obstacle 3-Moderate obstacle 4-Major obstacle 5-Very severe obstacle

4. Major quality related problems/obstacles in the company

1. Lack of management commitment for quality improvement					
2.Low skill of operators of machine production process					
3. Unable to identify customer requirements					
4. Company does not plan for quality and process improvement					
5.Old technology of machines, methods, etc					
6.Poor quality of raw materials					
7. Low awareness of workers/ operators on quality of process and product improvement					
8. Inadequate training of the production process operators					
9. Poor maintenance and handling of machines					
10. Low awareness of SPC tools by the operators and chemist					
11. Company implements all SPC tools to control and improve production process/products					
12. Unable to identify quality related defects in the production process					
13. Unable to diagnose the causes of quality defects in the production process					
14. Unable to take correction action for defects in the production process					
15. lack of consistency to take corrective action for defects					
16. Company does not regularly check the status of production process capability					

1-Never2-Almost never 3-Occasionally/Sometimes 4-Almost every time 5-Everytime

5. Usage of control chart information for continuous improvement

1. Decision rules are in place to allow the detection of out-of-control situations					
2. Whenever a manufacturing process goes out of control, special causes of variation are identified and removed					
3. various off-line tools (e.g., Pareto charts, histograms, etc.) are used to identify special causes of variation when a manufacturing process goes out of control					
4. A stable manufacturing process is frequently checked to see if it is capable of meeting product specifications					
5. Control charts are not being used to monitor this process					
6. Control charts are displayed simply to satisfy customer demands					
7. Control charts are used only to identify out-of-control situations ; no corrective actions are taken to bring the process back into control process					
8. Control charts are used not only to identify out-of-control situations for corrective action but also to identify opportunities for reducing common cause variation affecting the process					

1-Never 2- Almost never 3-Sometimes 4-Almost every time 5-Everytime

6. Training in statistical and cognitive methods for process control and improvement

1. Almost everyone in quality control section received training in the construction of control charts					
2. Almost everyone in quality control section can describe what a control					

chart is saying about the performance of a critical process/product characteristics					
3. Almost everyone in quality control section has received training in applying various off-line tools to quality improvement					
4. There are on-going refresher classes in the application of control charts and/or various off-line tools					
5. Periodic refresher training is mandated for everyone in the section					

1-Poor 2-Fair 3-Good 4-Very good 5-Excellent

7. Technical support for SPC implementation and practice

1. Technical staff experts are able to answer technical questions arising from the use of control charts.					
2. When a problem arises from the application of control charts that I assined, as a process operator, am unable to resolve, technical staff personnel comes to my aid.					
3. How available and accessible are in-house knowledgeable technical staff experts to you, a process operator, when a problem arises from the implementation and use of control charts					

1-Never true 2-Rarely true 3-Neutral 4-Usually true 5 -Always true

8. Quality improvement team support of SPC practice

1. Quality improvement teams, consisting of it least one process quality control person, meet regularly to discuss progress on improvement.					
2. Quality improvement teams, consisting of at least one process quality control person, submit a large number of recommendations for improvement to higher management.					
3. As a process quality control team, I often work with a team of other process					

operators, and/or management to resolve out-of-control situations on my process.					
4. Quality improvement teams, consisting of at least one process quality control, implement recommendations for improvements that have been approved.					

1-Never 2-Rarely 3-Sometimes 4-Often 5-All of the time

9. Update of knowledge of processes

1. The capability of this manufacturing process, to which I am assigned, is continually documented					
2. The nuances of this manufacturing process are well understood by me, an operator on this process					
3. Control chart limits for parameters associated with this manufacturing process are updated as the process is changed					
4. In the manufacturing process changes, information descriptive of the process is updated					
5. Knowledge of this manufacturing process, to which I am assigned, is easily retrievable					
6. It is easy to update information about this manufacturing process, to which I am assigned					

1-Never 2-Almost never 3-Sometimes 4-Almost every time 5-Everytime

10 .Audit and review of SPC practice and performance

1.The SPC intervention is periodically audited to identify opportunities for improvement					
2.An audit of SPC activities is regularly conducted					
3.The organization continually monitors SPC activities					
4.All aspects of the SPC intervention undergo frequent “checkups” to ensure that all is going well					

Thank you very much to respond questions in the Questionnaire.

APPENDIX-B

INTERVIEW QUESTIONS

1. What are the main causes of quality problems that affect beer products in BGI Ethiopia?

2. What are the quality improvements are you undertaking at the moment?

3. Are objectives of the company linked to customer needs and expectations?

4. Does the company focused on the production process improvement to satisfy its customers?

5. Does the company recognize and solve the quality related problems?

6. Which statistical process control (SPC) are applied and used in the company to monitor, inspect, and control the process: Histogram , Pareto analysis , Control charts , Scatter diagram , Check sheet , Cause and effect diagram and Flow chart?

7. Does the company have procedures for continuous improvement and preventive action?

APPENDEX-C

BGI ETHIOPIA BREWING INDUSTRY DOCUMENTED REPORT ON APRIL THE MAIN BEER QUALITY PARAMETRES OG, EA, PH AND ALCOHOL V/V

Table shows data from documented report on April for original gravity (OG)

			OG			
sample date	shift 1	shift 2	shift 3	shift 4	$\bar{X}$	R
4/1/2021	11.04	11.04	11.04	11.13	11.06	0.09
4/2/2021	11.24	11.23	11.28	11.28	11.26	0.05
4/3/2021	11	11.18	11.13	11.06	11.09	0.18
4/4/2021	11.13	11.05	11.01	10.99	11.05	0.14
4/5/2021	11	11.03	11.06	11.08	11.04	0.08
4/6/2021	11.29	11.2	11.08	11.1	11.17	0.21
4/7/2021	11.08	11.05	11.04	11.02	11.05	0.06
4/8/2021	11.03	11.04	11.09	11.15	11.08	0.12
4/9/2021	11.11	11.01	11	11.06	11.05	0.11
4/10/2021	11.04	10.99	11.26	11.27	11.14	0.28
4/11/2021	11.04	11.06	11.07	11.09	11.07	0.05
4/12/2021	11.03	11.01	11.02	11.09	11.04	0.08
4/13/2021	11	11.02	11.03	11.01	11.02	0.03
4/14/2021	11.27	11.33	11.34	11.37	11.33	0.10
4/15/2021	11.02	11.05	10.99	10.97	11.01	0.08
4/16/2021	11.1	11.13	11.12	11.01	11.09	0.12
4/17/2021	11.1	11.06	11.01	11.01	11.05	0.09
4/18/2021	11.36	11.35	11.15	11.3	11.29	0.21
4/19/2021	11.01	10.98	11.02	11.06	11.02	0.08
4/20/2021	11.05	11.15	11	11.09	11.07	0.15
4/21/2021	11.15	11.07	11.06	11.06	11.09	0.09
4/22/2021	11.06	11.06	11.06	11.07	11.06	0.01
4/23/2021	11.08	11.11	11.04	11.03	11.07	0.08
4/24/2021	11.1	11.09	11.03	11.11	11.08	0.08
4/25/2021	11.11	11.12	11.08	11.06	11.09	0.06
4/26/2021	11.04	11.16	11.08	11.14	11.11	0.12
4/27/2021	11.04	11.06	11.06	11.12	11.07	0.08
4/28/2021	11.15	11.14	11.15	11.17	11.15	0.03
4/29/2021	11.11	11.12	11.1	11.09	11.11	0.03
4/30/2021	11.12	11.08	11.08	11.1	11.10	0.04

					∑$\bar{X}$=333	**∑R=3**
					X DB=11.10	**R B=0.10**

Table shows data from documented report on April for apparent extract (Ea)

			Apparent Extract			
sample number	Shift 1	Shift 2	Shift 3	Shift 4	$\bar{X}$	Range
4/1/2021	2.25	2.26	2.25	2.27	2.26	0.02
4/2/2021	2.31	2.33	2.31	2.16	2.28	0.17
4/3/2021	2.25	2.26	2.25	2.27	2.26	0.02
4/4/2021	2.34	2.3	2.29	2.3	2.31	0.05
4/5/2021	2.23	2.22	2.22	2.24	2.23	0.02
4/6/2021	2.23	2.17	2.16	2.29	2.21	0.13
4/7/2021	2.23	2.22	2.22	2.24	2.23	0.02
4/8/2021	2.3	2.29	2.3	2.23	2.28	0.07
4/9/2021	2.26	2.23	2.21	2.18	2.22	0.08
4/10/2021	2.36	2.42	2.31	2.31	2.35	0.11
4/11/2021	2.26	2.23	2.21	2.18	2.22	0.08
4/12/2021	2.2	2.27	2.29	2.26	2.26	0.09
4/13/2021	2.16	2.18	2.18	2.2	2.18	0.04
4/14/2021	2.50	2.27	2.29	2.26	2.33	0.09
4/15/2021	2.16	2.18	2.18	2.2	2.18	0.04
4/16/2021	2.26	2.24	2.24	2.31	2.26	0.07
4/17/2021	2.23	2.23	2.25	2.36	2.27	0.13
4/18/2021	2.26	2.24	2.77	2.35	2.41	0.53
4/19/2021	2.23	2.23	2.25	2.36	2.27	0.13
4/20/2021	2.32	2.33	2.35	2.29	2.32	0.06
4/21/2021	2.3	2.27	2.31	2.33	2.30	0.06
4/22/2021	2.58	2.55	2.48	2.49	2.53	0.10
4/23/2021	2.3	2.27	2.31	2.33	2.30	0.06
4/24/2021	2.28	2.28	2.28	2.25	2.27	0.03
4/25/2021	2.3	2.29	2.31	2.42	2.33	0.13
4/26/2021	2.18	2.14	2.26	2.26	2.21	0.12
4/27/2021	2.3	2.27	2.29	2.26	2.28	0.04
4/28/2021	2.34	2.27	2.29	2.26	2.29	0.08
4/29/2021	2.17	2.2	2.2	2.19	2.19	0.03
4/30/2021	2.2	2.19	2.24	2.24	2.22	0.05
					∑**$\bar{X}$**=68.23	∑**R**=2.65
					X Double Bar=2.27	**R BAR**=0.15

Table shows data from documented report on April for PH.

			PH			
sample number	Shift 1	Shift 2	Shift 3	Shift 4	$\bar{X}$	R
4/1/2021	4.44	4.44	4.44	4.4	4.43	0.04
4/2/2021	4.01	4	4	3.98	4.00	0.03
4/3/2021	3.99	3.94	3.94	3.91	3.95	0.08
4/4/2021	4.1	4.11	4.17	4.25	4.16	0.15
4/5/2021	4.32	4.24	4.25	4.38	4.30	0.14
4/6/2021	3.96	4.18	4.18	4.28	4.15	0.32
4/7/2021	3.9	3.9	3.91	4.02	3.93	0.12
4/8/2021	4.08	4.15	3.85	3.95	4.01	0.30
4/9/2021	4.5	4.5	4.43	4.42	4.46	0.08
4/10/2021	4.29	4.32	3.95	3.95	4.13	0.37
4/11/2021	3.96	3.97	4	4.01	3.99	0.05
4/12/2021	4.04	3.88	3.93	3.94	3.95	0.16
4/13/2021	4.4	4.44	4.4	4.51	4.44	0.11
4/14/2021	3.95	3.96	3.95	3.95	3.95	0.01
4/15/2021	4.03	4.06	4.06	4.02	4.04	0.04
4/16/2021	3.94	3.99	3.99	3.9	3.96	0.09
4/17/2021	4.53	4.5	4.5	4.5	4.51	0.03
4/18/2021	3.94	3.93	3.93	3.93	3.93	0.01
4/19/2021	4.04	4.02	4.03	4.02	4.03	0.02
4/20/2021	4.02	4	3.93	3.87	3.96	0.15
4/21/2021	4.35	4.42	4.25	4.34	4.34	0.17
4/22/2021	3.92	3.93	4.15	3.95	3.99	0.23
4/23/2021	3.98	3.96	3.94	3.96	3.96	0.04
4/24/2021	3.89	4	3.92	3.96	3.94	0.11
4/25/2021	4.38	4.27	4.34	4.48	4.37	0.21
4/26/2021	3.96	3.98	4.01	3.95	3.98	0.06
4/27/2021	3.95	3.94	3.93	4.03	3.96	0.10
4/28/2021	3.98	4.01	4.02	3.97	4.00	0.05
4/29/2021	4.44	4.42	4.45	4.43	4.44	0.03
4/30/2021	3.92	3.9	3.91	3.95	3.92	0.05
					$\sum\bar{X}$ =333	**∑R=3**
					X Double Bar=4.10	**R BAR=0.11**

Table shows data from documented report on April for alcohol v/v

sample number	Shift 1	Shift 2	Shift 3	Shift 4	$\bar{X}$	R
4/1/2021	4.65	4.64	4.64	4.68	4.65	0.04
4/2/2021	4.64	4.64	4.66	4.66	4.65	0.02
4/3/2021	4.65	4.76	4.73	4.71	4.71	0.11
4/4/2021	4.8	4.77	4.77	4.77	4.78	0.03
4/5/2021	4.63	4.66	4.67	4.67	4.66	0.04
4/6/2021	4.67	4.68	4.68	4.7	4.68	0.03
4/7/2021	4.72	4.69	4.7	4.69	4.70	0.03
4/8/2021	4.78	4.78	4.79	4.8	4.79	0.02
4/9/2021	4.68	4.65	4.64	4.69	4.67	0.05
4/10/2021	4.68	4.65	4.63	4.64	4.65	0.05
4/11/2021	4.71	4.72	4.71	4.71	4.71	0.01
4/12/2021	4.76	4.72	4.72	4.72	4.73	0.04
4/13/2021	4.69	4.65	4.67	4.64	4.66	0.05
4/14/2021	4.64	4.62	4.65	4.65	4.64	0.03
4/15/2021	4.68	4.65	4.65	4.65	4.66	0.03
4/16/2021	4.73	4.73	4.72	4.78	4.74	0.06
4/17/2021	4.68	4.66	4.63	4.6	4.64	0.08
4/18/2021	4.64	4.64	4.66	4.76	4.68	0.12
4/19/2021	4.65	4.65	4.66	4.67	4.66	0.02
4/20/2021	4.69	4.79	4.76	4.79	4.76	0.10
4/21/2021	4.65	4.64	4.65	4.63	4.64	0.02
4/22/2021	4.66	4.65	4.7	4.7	4.68	0.05
4/23/2021	4.65	4.65	4.63	4.63	4.64	0.02
4/24/2021	4.83	4.81	4.78	4.82	4.81	0.05
4/25/2021	4.64	4.67	4.63	4.64	4.65	0.04
4/26/2021	4.67	4.68	4.69	4.69	4.68	0.02
4/27/2021	4.63	4.64	4.65	4.65	4.64	0.02
4/28/2021	4.86	4.85	4.85	4.84	4.85	0.02
4/29/2021	4.66	4.6	4.64	4.65	4.64	0.06
4/30/2021	4.6	4.66	4.69	4.7	4.66	0.10
					$\sum\bar{X}$=140.7	**$\sum$R=1.3599**
					X D B=4.69	**RBAR=0.05**