ST. MARY'S **UNIVERSITY SCHOOL OF GRADUATE STUDIES INSTITUE OF QUALITY AND PRODUCTIVITY MANAGEMENT**

RESEARCH TITLE: PRODUCTIVITY IMPROVEMENT TECHNIQUES USING STATISTICAL PROCESS CONTROL IN DAIRY INDUSTRY CASE OF SEBETA AGRO-INDUSTRY.

BY

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ADDIS ABABA, ETHIOPIA

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DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Mesfin T/ Haymanot(PhD).All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or infull's to any other higher learning for the purpose of earning any degree.

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ENDORSEMENT

This thesis is has been submitted to St. Mary's University college, School of Graduate studies for Examination with my approval as university advisor

Mesfin T/ Haymanot ___________________________

Advisor Signature

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List Of Acronyms And Abbreviations

CEA	Cause and Effect Analysis
CL	Center Line
EANPC	European Association of National Productivity Centers
FMI	Food Manufacturing Industry
GLP	Good Libratory Practice
GMP	Good Manufacturing Practice
JIT	Just In Time
JUSE	Japanese Union of Scientists and Engineering
LCL	Lower Control Limit
PCA	Printed Circuit Assembly
PH	Per Hydrolyses
QC	Quality Control
RII	Relative Important Index
SIA	Sebeta Agro Industry
SPC	Statistical Process Control
SPSS	Statistical Package for Social Science
SQC	Statistical Process Control
TPS	Toyota Production System
TQM	Total Quality Management
UHT	Ultra Heated Treatment

List of Tables

PAGE

List of Figures

PAGE

Abstract

This thesis addresses the concepts of productivity improvement techniques and application of SPC tools in dairy industry.SPC is one the most widely applied technique to control and improve processes in dairy industry, but very few studies have reported on the successful application of SPC in dairy industry. This thesis aims to critically assess the status of SPC in the SAI dairy processing and suggests for future researches. Now a day to survive in competitive market, improving productivity and reducing quality problems products is a must for any company. We need to have better understanding of quality. By improving the quality, the method of optimization reduces process operational cost and product variation. This study is to apply quality control tools in production process to reduce souring, returns, breakages, and damages by identifying where highest souring occur at and to go give suggestions for improvement. The approaches used in this study are Histogram, Check sheet, Pareto diagram, Fish bone diagram, control chart, which have been applied to improve productivity and quality of products and minimization of quality defects. It has been found that the company has many quality problems especially there is highly souring in the production process line. There is a various process parameters such as acidity, temperature, fat, volume, which have influence of the quality of the final products have been controlled in order to reduce defects and there have been observed a need of improvement by using SPC tools.

Key words:- SPC tools, Pareto chart, cause-effect diagrams, control charts, histograms, process performance, Continuous improvement.

Table of contents

CHAPTER ONE

INTRODUCTION

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

1.1. INTRODUCTION

Changes in dairy product distribution patterns, product formulations, the export market, and consumer expectations have all resulted in a greater demand for dairy products that meet high quality standards both initially and over a longer shelf-life. To consistently manufacture high-quality dairy products, processors are demanding higher-quality raw milk, which can be defined as (1) compositionally complete (e.g., protein and fat levels within the norm); (2) free from off-flavors and odors; (3) free from detectable drug residues, added water, or other adulterants;and (4) having low total bacteria counts. To ensure that they are using quality raw milk, processors routinely monitor supplies when they are received at the dairy processing plant and at the producer level.

Eat well and Newman (1991) defined productivity as a ratio of some measure of output to some index of input use. Expressed simply: Productivity = total output/total input which is identical to total results achieved/total resources consumed or effectiveness/efficiency. In effect, productivity becomes the attainment of the highest level of performance with the lowest possible expenditure of resources. Productivity = total output/total input which is identical to total results achieved/total resources consumed or effectiveness/efficiency.

As stated by Kulkarni et al. 2014, productivity is the ratio of output and the input. I.e. Productivity = Output/ Input (Verma et al. 2015). According to Mishra (2013), productivity improvement focuses on: Doing the "right things" (i.e. know "what" to produce and distribute) by continuously reviewing and identifying changing customer and societal needs. Doing "things right" (i.e. know "how" to produce and distribute) by constantly improving production and distribution processes to produce and deliver the goods and services in the most efficient way. The rate at which a company produces goods or services in relation to the amount of materials and number of employees needed (Verma et al. 2015). Input: Material, Machine, Man Hours, Methods, Land. Output: Parts & product, Services, Wastage of any type, Pollutants of any type (Vermaet al.2015).

Productivity improvement is one of the core strategies towards manufacturing excellence and it also is necessary to achieve good financial and operational performance. It enhances customer satisfaction and reduce time and cost to develop, produce and deliver products and service. Lim and Hoffmann (1997) found that improved layout of the workplace increased productivity of the workers, through more economical use of hand movements by conducting an experiment on hacksaws assembly. Womack et al. (1990) developed from the massively successful Toyota Production system(TPS), focusing on the removal of all forms of waste from a system. Krafcik, (1998) describes the Japanese style manufacturing process pioneered by Toyota, which uses a range of techniques including JIT inventory systems, continuous improvement, and quality circles.

Productivity has a positive and significant relationship to performance measurement for process utilization, process output, product costs, and work-in process inventory levels and on-time delivery. Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing through put, reducing cost, improving quality or responsiveness and reducing set-up time.

Measurement of productivity needs to consider various inputs and outputs of the products or services produced to be adequate and appropriate. In order to measure the effectiveness of any maintenance system, we need to measure its productivity and identify the areas where improvements can be made Raouf and Ben-Daya, (1995).Maintenance systems operate in parallel to production systems to keep them serviceable and safe to operate at minimum cost. One way to reduce the operation cost and production cost is to optimize utilization of maintenance resources Duffuaa and Al-Sultan, (1997), which enhances maintenance productivity. In order to measure the effectiveness of any maintenance system, we need to measure its productivity and identify the areas where improvements can be made Raouf and Ben-Daya, (1995).

Statistical process control (SPC) has been used to great effect in the manufacturing industry to increase productivity in processes by specifically identifying and reducing variation, Deming; (2000). Generally, the Seven QC tools are check sheet, Pareto chart, flowchart, cause and effect diagram, histogram, scatter diagram and control chart . These tools are also known as Total Quality Management (TQM) tools .Paul and Rabindra (2006) used subjective assessment through questionnaire, direct observation method, and archival data to improve productivity, quality, increasing revenue and reducing rejection cost of the manual component. Brown and Mitchell (1998) investigated operators, engineers and managers of PCA (Printed circuit assembly) factories to determine the work environment parameters that inhibited their performance and they recommended opportunities to improve production and quality.

1.2. Organization Of The Study

This study is divided into five chapters. The first chapter provides background about the study problems and objectives and its approach. The second chapter discuss in relevant literatures on the topic to gain understanding productivity improvement techniques, application of SPC tools. Chapter three gives an account of the research methodology description and justification of the design and researcher procedures followed in this study. Chapter four presents and analyses data find out results which could answer the research questions. Chapter five focuses on drawn conclusion based on findings, and making pertinent recommendation.

1.3. Background Of The Organization

Sebeta Agro industry dairy manufacturing PLC was chosen to use SPC tools and concepts in order to improve productivity and reduce process defects. Sebeta Agroindustry is ,established in 1991E.C .The Company is located in Sebeta Town, Oromia Regional state , Ethiopia. The company produces different dairy products like pasteurized milk, Yoghurt, cream, Butter, Cheeses, UHT and fruit Juices, , fulfill the needs of different local dairy farms in Ethiopia. By using a sophisticated technological set up, company is producing different dairy products and Fruit in a nonstop manufacturing environment. A company utilizes raw materials that are available locally in different areas of the country especially Oromia region from local farmers. The main components used to manufacture dairy products and fruit juices are raw milk and various fruit juices mainly they used to flavor yoghurts.

1.4. Statement Of The Problems

There are many ways to deal with quality problems in manufacturing company. Quality principles in dairy production are to prevent unnecessary breakage, damages, clotting and returns, improve process visibility and understanding and control quality problems in dairy industry. This study will look at variations and their causes, and how to improve and control a process using Statistical Process Control (SPC).

The study would find out the effective way of Improving the Quality and Productivity of milk production in dairy industry. The study apply the terminology and methods of SPC and strong commitment to solve problems to reduce defects, improve the yield of acceptable products, increase customer satisfaction, continuous cost reductions and deliver best in-class organizational performance. This study would use a multiple measure design where the mean productivity rate of dairy products and processes under normal operating conditions would be compared to the mean productivity rate of the same dairy products under the application of statistical process control.

1.5. Research Questions

Following the research objectives, the research has following specific research questions to be answered.

1. What are the productivity improvement techniques that are used to view waste reduction in SAI?
2. What are the main quality problems that affect productivity improvement in dairy industry?
3. How productivity improvement techniques are applicable to reduce defects in dairy industry?
4. Does defects reduction influences productivity improvement in dairy industry?
5. What are the main root causes of quality problems in dairy industry in case of Sebeta Agro-industry?

1.6. Objectives Of The Study

1.6.1. General Objectives

The general objective of the study is:

- ❖ To investigate quality and productivity improvement techniques through defects reduction in Sebeta Agro-Industry.
- ❖ To identify the major types of the quality problems and defects for dairy industry in case of SAI.
- ❖ To provide guidance to the use of SPC tools in dairy industries on the application and use of Productivity improvement to improve quality and productivity performance.

1.6.2. Specific Objectives Of The Study

Specific objectives of the study are: -

- ➢ To name possible measures to improve the milk quality and productivity performance in the Sebeta Agro-Industry milk manufacturing processes of the plant.

- To analyses the productivity costs of the generated waste product, defects Packaging (raw material packaging), breakages, returns, damages and clotting or souring in the processes of milk production.
- To identify the main causes and effects of quality defects in dairy industry in case of SAI.
- To examine how reduction products defects or quality problems affects productivity improvement in dairy industry in case of SAI.
- To assess the quality related problems in dairy industry and suggest the appropriate solutions.
- To assess employee awareness about SPC tools concepts and importance's in dairy industry.

1.7. Definition Of Terms

PRODUCTIVITY: means different things to different person, ranges from efficiency to effectiveness, to output measures.

MEASURMENT OF PRODUCTIVITY: is the quantification of both output and input resources of a productive system.

KAIZEN: means continuous improvement involving everyone in the organization.

CONTROL CHARTS: Statistical tool used in quality control to analyze and understand process variable.

-it indicates upper and lower limits.

- used to identify acceptable variation of measure.

CHECK SHEETS: used to collect data about an activity in a way that is easy to use and analyse.

HISTOGRAMS: is a bar chart showing the variation or distribution of data.

PARETO CHAR: is a special type of bar chart used to assess the relative importances of different causes of problems.

FISH BONE DIAGRAMS: are simple techniques for dissecting a problem or problems.

JIDOKA: means never letting a defect pass into the next station and freeing people from machine automation with a human touch.

HEIJENKA: means leveling out the production schedule in both volume and variety.

MUDA: means in Japanese waste, non value added activity.

WASTE: activity that takes time, resources, or space but doesn't add value to the end products.

POKA-YOKA: prevent defects from occurring.

1.8. Significance Of The Study

The company can be more productive by minimizing defective products which in turn minimize wastes consumption. The research work can also be used as a source of literature review by other researchers.

The benefits of improving productivity with SPC tools could be translated to dairy Manufacturing companies that have few employees and lack access to the advanced technologies that drive productivity gains in the top firms. By taking random samples of output, variability in a process could be evaluated objectively by managers, as opposed to using subjective techniques to identify activity inefficiencies.

The result of this review pointed that the highest cited benefit is defective products reduction, food safety and financial advantage. Most of the articles reported that variation reduction of the product is achievable due to the effective application of control charts. However, the applications of other SPC tools have rarely been discussed. Such practice is argued to be against the definition of SPC ―SPC is a combination of statistical and problem-solving technique where control chart is one of the tools listed in SPC' (Montgomery, 2009). Variation reduction enables the SPC users to achieve other SPC benefits as depicted by the Deming's chain reaction model – a range of advantages which includes reduction of defects, wastage, breakages, returns, damages, the cost of quality, improving process efficiency, compliance to food law and regulatory and improvement in the business image (Barker, 1990).

Purpose of this study is to find an objective way to spot inefficiency and fix the problem using the combined expertise of the personnel involved. This tactic could not only keep products on schedule, but maybe even possibly show that the estimated activity durations were inflated due to consistently inefficient operations in the past. A SPC is essentially a visual aid that objectively reveals where improvement efforts should be directed. The output will provide the alternative waste or defects reduction mechanisms and productivity improvement tools for dairy industry. This study can be used as an input for further study for similar future researchers and to forward suggestions, conclusions, and recommendations based on the finding.

1.9. Scope Of The Study

Despite the fact that, SAI have different sites including Debre Zeit, Debre Tsigie, Chancho, Sululta, Holeta, Kara kore and Sebeta. This study would be conducted Sebeta plant where only production and pasteurize milk packaging activities would be carried out. Dairy products in case of SAI, include Cheeses, Yoghurts ,creams ,Butter, whey, Fruit juices and Pasteurize milk or plastic milk in this study, would only include pasteurize milk or packaging milk products that is why the study only takes place in Sebeta main production sites . Pasteurize milk processes would include volume, fat contents, PH(Titration/Acidity/), Temperature, nutrient contents, labeling and expire date of plastic milk. Of the basic seven types of SPC tools available, only individuals charts would be used. The data used to identify defects in pasteurize milk products or packaging milk products the SPC tools should be identified batch manufacturing activities and cycle times for the pasteurize milk products activity, and an index ratio actual productivity to estimated productivity for the forming and reinforcing process.

1.10 Limitation of the Study

The limitation for the current research is the exclusion of other dairy Industries which could have a negative impact in inferring conclusion on the level of productivity improvement using SPC tools application throughout the dairy industries in the country. The rationale behind the selection of participants 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. Besides there was also limitations as to which types of methodology to use that could briefly help in analyzing data.

CHAPTER TWO

THEORETICAL FRAME WORK OF REFERENCES

LITERATURE REVIEW

This chapter provides an overview of literature that is related to the research problem presented in the previous chapter. Definitions of Productivity, the concepts of Statistical Process Control, application of SPC tools, some Techniques for Measurements' of Productivity, Productivity Improvement Indices, Characteristics of productivity measurements, the success of process control in manufacturing, Methods of productivity improvement.

2.1.Productivity Concepts

Productivity is the ratio between output and input. It is quantitative relationship between what we produce and what we have spent to produce. According to Bernolak (1997) productivity means "how much and how good we produce from the resources used," whereas The European Association of National Productivity Centers (EANPC, 2005) defines productivity as "how efficiently and effectively products and services are being produced." Efficiency in this context can be seen as "doing things right" or utilizing resources to accomplish desired results (Grünberg, 2004). Productivity statistics also assume that if more input were available, output would increase at the same rate. This may not be true, as there may be limits to output other than those on which the productivity calculations are based. Furthermore, productivity emphasizes output produced, not output sold. If products produced are not sold, inventories pile up and increases in output can actually accelerate a company's decline.

Effectiveness, on the other hand, is often described as "doing the right thing"; it refers to the extent to which customer requirements are met (Neely et al., 1995). Thus, effectiveness highlights the importance of reaching a desired objective, whereas efficiency focuses on the process or means involved. Definitions of productivity seem to be dependent on the reviewer's point of view and the context in which it is used. Studies on technology, engineering and economics, three broad industry categories, all examine productivity from slightly different viewpoints (Ghoabadian and Husband, 1990). Productivity = total output/total input which is identical to total results achieved/total resources consumed or effectiveness/efficiency. In effect, productivity becomes the attainment of the highest level of performance with the lowest possible expenditure of resources. It represents the ratio of the quality and quantity of products to the resources utilized.

Profitability is defined as output volume times output unit price, over input volume times input unit costs (Bernolak, 1997), or profitability = productivity + price recovery (Miller, 1984). Van Loggerenberg and Cucchiaro (1981) explain how changes in profitability are caused by changes in productivity, price recovery, or in both of these factors. A significant point to consider is that the profitability of a company can change for reasons that have nothing to do with productivity (Bernolak, 1997). A company can increase its profits and at the same time decrease its productivity because of market mechanism (Grunberg, 2004).

2.2.The Concepts Of Statistical Process Control (SPC) Tools

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:

- Technological innovation (Bushe, 1988, Roberts et al., 1989)
- 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).

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).

The focus of SPC is understanding the variation in values of quality characteristic (Woodall, 2000). The process stability refers to the stability of the underlying probability distribution of a process over time and these very often can be described as the stability of the distribution parameters overtime (Mahalik and Nambiar, 2010). The process stability extremely crucial as it is one of the pre-requirement condition prior to the process capability indices determination (Brannstrom-Stenberg, 1999, Motorcu and Gullu, 2006, Sharma and Kharub, 2014).

There is no standard set of tools within SPC, however, Gaafar and Keats (1992) and Duffuaa and Ben-Daya (1995) argue that there is a general agreement on the seven tools which includes data gathering, Histogram, Pareto chart, cause and effect analysis (CEA)/fishbone diagram, scatter diagram, check sheets and control charts. However, it is generally agreed that control chart is a primary tool within SPC. Table 2.1 describe the SPC tools and its examples in the food manufacturing industry (FMI) application.

SPC is arguably involved more than its mathematical literacy issues. According to Rungtusanatham et al. (1997), the term SPC implementation requires a clear understanding of the procedures to be adopted and activities to be performed using a set of tools ─ indicating participatory management. Therefore, such argument is seconded with the implications from the dual concepts of SPC — "the operation of statistical control" and "the state of statistical control" suggested by Shewhart (1939).According to Pena-Rodriguez (2013), Lim et al. (2014), Grigg (1998), there is a crucial need to develop customize guideline for the food industry to apply and integrating all these tools in a systematic manner at the correct problem.

PARETO CHART

Main purpose: Prioritization by ranks the data, in descending order, from the highest frequency of occurrences to do laws frequency of occurrences. Principle 8020: Emphasise the need to focus first on the 20% of the causes that matter, without totally ignoring the remaining 80%. Question: which are the big problems?.(Cravener 1993, Varzakas and Arvanitoyannis, 2007, Dalgiç et al., 2011, Fotopoulos et al., 2011)

SCATTER DIAGRAMS

Main purpose: to illustrate the relationship or correlation between different variables. Principle: demonstrates the results of a series of experiments applied to document the relationship between the variables. Question: what are the relationships between factors? Knowels et al., 2004, Grigg, 1998, Pluta, 2014)

CEA/ ISHIKAWA DIAGRAMS

Main purpose: to identify possible causes for problem, uncover bottlenecks in the processes, identify where and why the process is working Principle: Identify all possible relationships among input and output variables, there is, five or six categories of the following skeleton (machines, methods, materials, manpower, measurements, environments) Question: What are the relationships between factors? Why does this happen? (Varzakas and Arvanitoyannis, 2007, Saini et al., 2011, Hubbard, 2013, Desai et al., 2015)

HISTOGRAMS

Main purpose: To illustrate and identify the distribution of the observations from a set of data. Principle: A graphical representation of the frequency of occurrence process that the points or a class that represents a set of data points. Question: what does the observation look like? Ooi and McFarlane, 1998, Srikaeo et al., 2005, Mertens et al., 2009, Mataragas et al., 2012, Dalgiç et al., 2011, RábagoRemy et al., 2014)

FLOW CHARTS

Main purpose: to Endeavour understanding of the process flow, a process for improvement, to communicate to others on how the process is done and to document the process. Principle: brainstorming activities (arranged activities in the process in proper sequence) Question: what are the steps and process involved? Dalgic,et al.,2011, Mertens et al., 2009, Cinar and Schlesser, 2005, Srikaeo and Hourigan, 2002)

CHECK SHEETS

Main purpose: To provide a simple means for recording data and enable the analyst to determine the relative frequency of occurrence of the various categories of the data. Principle: brainstorming activities (arranged activities in the process in proper sequence) Question: how often is it done? (Bidder, 1990, Hubbard, 2013)

CONTROL CHARTS

Main purpose: To study process changes over time, control on-going processes by finding and correcting problems as the current, to predict the expected range of outcomes from a process, to determine whether a process is table, to analyse evidence of process variation from special causes or common causes, whether the quality improvement project should be to prevent spastic problems or to make fundamental changes to the process. Principle: The graft of process characteristics plotted in sequence, it includes the calculated process mean of statistical control limits. Question: Which variations to control and how? ((Grigg, 1999, Grigg and Walls, 2007a, Ittzes, 2001, Hayes et al., 1997).

Improvement of productivity and Quality by Statistical Process Control (SPC) in Food Processing Systems:

Table 2.1: Number of observations in each sample, UCL: upper control limit, LCL: lower control limit, A2, D3, and D4 are constants.

UCL & LCL	Mean	n*	A2	D3	D4
		2	1.88		3.27
X-Chart		3	1.02		2.57
	$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$	4	0.73		2.28
	$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R}$	5	0.58		2.11
	$\frac{\sum_{i=1}^{n} xbari}{n}$	6	0.48		2
	R-chart	7	0.42	0.08	1.92
	$UCL_R = D_4\bar{R}$	8	0.37	0.14	1.86
	$LCL_R = D_3\bar{R}$	9	0.34	0.18	1.82
R bar= $\frac{\sum_{i=1}^{n} Ri}{n}$		10	0.31	0.22	1.78

In our examples of control charts, sample sizes varied significanltly. For p-charts and c-charts, we used sample sizes in the hundreds and as small as one item for a c-chart, whereas for X - and R-charts we used samples of four or five. In general, larger sample sizes are needed for attribute charts because more observations are required to develop a usable quality measure. S (standard deviation) charts are an alternative to the R chart and are used as the sample size increases because they provide a better estimate of the variability of a set of data than the R chart. R charts are commonly used because the calculations are simpler than those for s charts .X-double bar-R chart is applicable when the sample size (n) is between 2 to 10 and X-double-S chart is applicable when the sample size(n) is more than 10.

2.3.Some Techniques For Measurement Of Productivity

Measuring productivity is a complex statistical process which includes numerous steps that aim at making data comparable over time and across enterprises and countries (O'Mahony & Timmer, 2009). At higher levels of analysis, interest in productivity has predominantly focused on labor productivity; in many cases, productivity is expressed and measured in monetary units per input as this seems to be the only practical way (Stainer, 1997). Various problems have been identified with productivity measurements that have led to doubts about the reliability and validity of measuring productivity at the macro level (Rojas &Aramvareekul, 2003).Productivity may be measured either on an aggregate basis or individual basis. On aggregate basis, output is compared with all inputs taken (added) together. This is called as total productivity. On individual basis, output is compared with any one of the input factor and this is called as partial productivity or factor productivity.

$$\text{Total Productivity Indices}=\frac{\text{Total Output}}{\text{Total Input}}=\frac{\text{Total Production of Goods }\&services}{\text{Labour+Material+Capital+Energy}}$$

Total productivity = Output quantity / Input quantity

This formula showed which changes in input and output must to be measured inclusive of both quantitative changes and qualitative changes. (Jorgenson, D. W. &Guilloches, Z. 1967)

There are many quantitative and qualitative changes which take place when relative and quantities prices of different output and input factors alter. If you want to accentuate qualitative changes in input and output, the formula of total productivity represented as follows: Total productivity = Output quantity and quality / Input quantity and quality, (Saari, S. 2006). Productivity has a positive and significant relationship to performance measurement for process utilization, process output, product costs, and work-in process inventory levels and on-time delivery. Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time.

2.4.Characteristics Of Productivity Measurement

Productivity can be measured at different levels: from broad economy and industry levels to very specific process or employee levels. Measuring productivity is a complex statistical process which includes numerous steps that aim at making data comparable over time and across enterprises and countries (O’Mahony & Timmer, 2009). At higher levels of analysis, interest in productivity has predominantly focused on labor productivity; in many cases, productivity is expressed and measured in monetary units per input as this seems to be the only practical way (Stainer, 1997). Various problems have been identified with productivity measurements that have led to doubts about the reliability and validity of measuring productivity at the macro level (Rojas & Aramvareekul, 2003).

An all-inclusive “total-factor” productivity measure is not a viable alternative to these methods, since no such factor exists that is meaningful for companies (Bernolak, 1997). The essence of performance measurement in general is the production of useful information with reasonable effort; the information produced should fulfill the criteria of validity, reliability and relevance (Hannula, 2002). In addition to the difficulty of meeting these criteria, practitioners implementing productivity measures always face the commensurability problem, wherein each variable in the process is not measurable against the same standard or in the same units (Broman, 2004).

Finding an appropriate way to solve the commensurability problem has resulted in various types of productivity measures and ways to aggregate inputs and outputs, for example, by use of weightings (Tangen, 2005). The other problems that characterize productivity measurement include broadness, allocation, comparability, value and methods of measurement (Uusi-Rauva, 1997): The problem of broadness involves determining which levels of input and output should be taken into account when evaluating productivity.

Developing some form of indices is by far the most common procedure for assessing productivity changes (Singh et al., 2000). Although partial productivity ratios are also widely used in industry, as such they are too narrow to give a comprehensive picture of the productivity improvement at the business units level (Hannula, 2002). In many cases, productivity is measured and indicated as labor productivity. This fact implies that industries characterized as labor intensive may not be treated equally in relation to low labor intensive industries. Comparing only labor productivity may not reveal productivity development in other areas (e.g., capital, material and energy).

2.5.The Success Of Process Control In Manufacturing

By 1947, Deming had become involved with the 1951 Japanese census. While in Japan, Deming was recognized by the Japanese Union of Scientists and Engineers (JUSE) for his wealth of understanding of production process and quality techniques refined during the war. With some working knowledge of Shewhart, JUSE invited Deming to become a key consultant in the rebuilding of Japan’s manufacturing sector (Mann, 2010). Deming would speak to groups of managers and engineers across Japan, and soon his techniques of using control charts to spur the continuous improvement process lead Japanese manufacturers to achieve the highest standards of production efficiency in the history of manufacturing (Mann, 2010). Deming continued to expand his principles to find a focus on finding the root cause of waste or defects in processes whether managerial or production orientated.

Q (quality rate) = (total production – defective quantity or number)/total production;

Quality of the process (QP)=$\frac{\textbf{output}-\textbf{defects}}{\textbf{output}}$

Quality cannot have different meaning to different people. Its concepts may be easy to grasp but formulating a universal definition is difficult. Several quality masters have defined quality in different ways considering different attributes of a product.

Badiru (1990) points out that “good quality is every body's responsibility while bad quality is every body's fault ". What is quality? Several definitions have been offered for quality in recent years. Quality refers to the combination of characteristics of a product, process, or service that determines the product's ability to satisfy specific needs. Some definitions are given below.

❖ Quality is fitness for purpose or use. Or quality is customer satisfaction. Juran J. M. (1998).
❖ Quality is conformance to requirements. Crosby Phillip,(1979).
❖ Quality is 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).
❖ Quality should be aimed at the needs of the customer, present and future..Deming 1986, et al., 2008

2.6.Methods Of Productivity Improvement

A basic important assumption at Toyota is that people are the sources for the development of production Liker,(2004) and people development has been seen as a key success factor by Toyota leaders since the company’s founding Liker and Hose us,(2008).Toyota, a giant Japanese automobile company was pioneer in development and application of various productivity improvement techniques under Toyota Production System (TPS). By the late 1950s, others were beginning to build on the work of Deming, such as Kichiro Toyoda the founder of what would become the Toyota Motor Corporation. Toyoda had a unique view of the factors that hampered efficiency in manufacturing. These factors were distilled into three words “muri” (overburden), “mura” (inconsistency), and “muda” (waste). TaiichiOhno developed the Toyota Production System (TPS) after World War II. Some of the selected Japanese Productivity Improvement techniques are presented in this section as below:

A) JIDOKA

Jidoka is a Toyota concept aimed at describing the man-machine interface such that people remain free to exercise judgment while machines serve their purpose. The jidoka system shows faith in the worker as a thinker and allows all workers the right to stop the line on which they are working. Jidoka is often referred to as "automation with a human mind". The jidoka way of working consists of following three principles- Do not make defects, do not pass on defects, and do not accept defects. jidoka—the authority to stop the production line if quality problems were encountered.

B) Heijunka

Heijunka focuses on achieving consistent levels of production. It is defined as "distributing the production of different body types evenly over the course of a day" It incorporates the principles of line balancing by attempting to equate workloads, leveling demand out by creating an inventory buffer and replenishing that buffer. It believes in providing even work load for all employees. Heijunka has the capability of reducing lead times by minimizing time losses due to frequent process changeovers.

C) Kaizen Techniques:

Kaizen (Continuous improvement) is a management supported employee driven process where, employees make a great number of continuous improvement efforts. Kaizen: a system of continuous improvement; "change for the good of all."

D) Muda elimination:

Muda means "Waste". Here muda elimination implies an "ongoing" and systematic reduction or elimination of waste. There are seven kinds of major waste: Overproduction Muda, Stock Muda, Transport Muda, Defects Muda, Delay Muda, Motion Muda, over processing Muda. It helps to eliminate redundant processes or parts of processes, delete non-value added activities, simplify motions, minimize fatigue, reduce wait time, etc. Waste, or muda, was defined as "anything other than the minimum amount of equipment, materials, parts, space, and time which are absolutely essential to add value to the product

E) Poka-Yoke:

It is powerful and comprehensive method of „error proofing‟. A work process is to eliminate inadvertent errors to ensure quality products and services. It helps in defect prevention and defect detection. A poka-yoke is any foolproof device or mechanism that prevents defects from occurring.

F) AUTOMATION AND INFORMATION TECHNOLOGY

The role of information and automation technology (IT) in productivity improvements was frequently discussed. Conventional wisdom is that the pickup in productivity growth in the U.S. in the 1990s and, continuing to the present is due primarily to the widespread application of computers and information technology (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2002). One example could be the introduction of automatic 3R systems. System 3R's automation concept gives: - Increased utilization of existing machine, Increased productivity, Increased flexibility,- Lower production costs, Lower until costs, Shorter depreciation time.

CHAPTER THREE

RESEARCH METHODOLGY

This chapter presents the activities and processes that were undertaken to gather data for the research work. It gives full details of how data are collected and processed for this research work. The discussion was centered on the following: Research approach, case study, interviews, Observations, Data analysis, Literature studies, Making Experiments, Research designs, Validity, Reliability and generalizations, population under study, sampling techniques and sample size determination, data sources and data collection tools, Data gathering techniques and defects of instruments, SPC tools.

3.1.Research Approach

Denzin& Lincoln (2000) State that different paradigms of research and theoretical perspectives on research that the researcher believes in influence how the researcher looks at the world and acts in it; Moreover, all research was conducted on the basis of a determined pre understanding of paradigms and theoretical conceptions, whether it was conscious or unconscious, concerning what was important, interesting and relevant. (Bjereld, 1999) The term “methodology” focuses on the best means for gaining knowledge about the world. (Denzin& Lincoln, 2000) Methodology refers to the way in which we approach problems and seek answers. (J.Taylor&Bogdan, 1984).

3.1.1. Case Study

Rather than using samples and following a rigid protocol to examine limited number of variables, case study methods involve an in-depth, longitudinal examination of a single instance or event: a case. They provided a systematic way of looking at events, collecting data, analyzing information, and reporting the results. Case studies lend themselves to both generating and testing hypotheses. A case study may employ multiple data collection methods (e.g. observations, interviews and documentation) to assess a phenomenon in its natural setting (that is, without experimental controls or manipulations) (Meredith, 1998, Voss et al., 2002). (Wikipedia-Case Study) The different ways employed to run the case study in this project were coming here:

INTERVIEWS

Most information would be gathered by interviewing different employees. Quality manager, Production and Processing manager and responsible person for repairing the apparatus were our sources to be acquainted with the whole processes through the related details. Having a holistic view of the whole project was obtained by the guidance of quality manager while his consultations were leading us through every vague situation. Questioning from the appropriate operators was really helpful since they were pretty familiar with the machine's details, parameters and problems. Contacting with the manufacturer of production line machines helped us to know more about the structure of the study machine showing us the effective controllable factors on the products.

OBSERVATIONS

Observations were based on visits to the field of the case study. (Yin, 1994) notes that there were two types of observations; "direct" and "participant" ones. The difference between the two was that in a participant observation, the researcher was not only a passive observer. (Creswell, 1994) A "complete participant" was a participating researcher, who completely conceals her/his role as an observer, while with an "observer as participant" the observing role of the researcher was known to those observed. When the researcher was a participant as observer" the participation was primary while observation was secondary. Finally, a "complete observer" means that the researcher observed openly, but without participating. In this study our role can judge as a "completed observer".

3.1.2. Data Analysis

A data bank gathering within the years in the company was a document having the company specifications e.g. company strategy, company manner and company products inherently. Extracting the needed information from such a great source I was a way should be taken by different analysis devices. Applying the tools such as SPC could facilitate showing the way of act of company concluding great achievements as the result of true analysis.

3.1.3. Literature Studies

There was a need for a literature study since it was a necessity as a starting point of every research as a deductive approach. Reference books, E-Books, E-journals and Articles were our guidance to walk through that way.

3.1.4. Making Experiments

In order to make reasoning, running experiments was an inevitable affair leading to prove the achievement of literature studies. Some of them were routine as the ordinary processes in the manufacturing line need just supervision, observation and recording the results. Some other ones were needed to be run as some innovative and individual experiments. The result could be the conclusive proof of our theoretical knowledge or provide evidence on a new belief or an unforeseen fact.

3.2.Research Design

A researcher could approach a study item in different ways, in the form of induction or deduction.

3.2.1. Inductive

The Inductive reasoning, was the process of reasoning in which the premises of an argument were believed to support the conclusion but do not entail it; i.e. they did not ensure its truth. Induction was a form of reasoning that makes generalizations based on individual instances. (Wikipedia-Inductive Reasoning) A process of thought could be happened using known facts in order to achieve the rules or ideas in general.

3.2.2. Deductive

Inference in which the conclusion about particulars follows necessarily from general or universal premises was called deductive. (Merriam Webster) Using the knowledge or information you had an opinion could be formed or an event could be understood. This work was built to a large extent on a deductive reasoning since it aims to analyze quality aspects within the production line and comparing the analysis with the theory then trying to make conformity with the help of running experiments.

3.3.Validity, Reliability And Generalization In The Thesis

Reliability means to what extent a methodology of investigation or fact collection method gives the same results under the same conditions at different occasions.(Bell, 1993) Validity could be divided in to three different meanings: External validity means to what extent the results from the current study could be suitable even for occasions other than those studied. Internal validity means to what extent the achieved results correspond with “reality”.

Construct validity means whether one actually studies the context or issue one wants to study for validity and for external, internal and construct validity. (Yin, 1994)

Efforts had been made to increase the validity and reliability of the results in the thesis. It was however, inappropriate to make statistical generalizations, since it was important to understand, gain knowledge and interpret the opinions and experiences of a limited number of persons.

Reliability and Validity test: The reliability and Validity test of the response data collected through distributing questionnaire was checked computing Cronbach's alpha 0.9910 Minitab18version. In addition, the information collected using Good Libratory Practice(GLP) ,Good Manufacturing Practice(GMP),and onsite observation was triangulated with the response data for the purpose of assuring data consistency and reliability in representing and defining the issue under the research.

RII=$\sum_{i=1}^{5} Fi, \frac{(W1+W2+W3+\_\_Wn)}{AxN}$

(Source:CronbachL.J,1951)

Where: Fi=Factor(initial-1-5

RII=Relative Important Index

W=the wearing (score give to each scale) given to each factor by the respondent such as: Strongly Agree=5, Agree-4, Neutral=3, Disagree=2 and strongly disagree=1.

A=Total number of respondent

N=Total number of questionnaire.

Cronbach's alpha=0.9881

3.4.Types, sources and methods of data collection

3.4.1. Primary data collection

Primary data would be collected from the Dairy product workers of the SAI. Sample size of the study was 188. Furthermore, the surveys data were given in the tables reflect the opinions of the dairy product workers in the industries of SAI. In this study, interviews had been conducted on a one to-one open-ended basis with a single participant, and scientific honesty was maintained for the validity of the data, that was, manipulation of design and methods would not applied in the research.

To calculate the results we had used Statistical Package for Social Sciences (SPSS) 23.0 and Minitab 18, e.g. calculating mean, standard deviation, ranges, Economic analysis of defective products, generally control charts, and Cost of Quality of products and defect. The SPSS and Minitab18 were a commercial computer software package that had been used in research since the early 1960s. For the data analysis of the primary data various statistical techniques such as, mean, median, standard deviation, Cost of quality of products and defects etc., have been used depending upon the requirements.

3.4.2. 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 had limited time and resources, they could use the secondary data for their researches.

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

i) various publications of the organization(e.g., census reports, annual reports and financial statements of companies, statistical statement, reports of departments),
ii) various research reports are prepared by research scholars, universities, etc., in different fields,
iii) books of various authors, magazines, and newspapers,
iv) various sources from university libraries,
v) technical and trade journals,
vi) Websites, and Public records and statistics, historical documents and other sources of published information.

3.5.Research strategy

Research strategy may be defined as a systematic orientation to conduct data collection and data analysis, in order to collect reliable information to answer the research questions (Bryman and Bell, 2015, Saunders et al., 2011, Caruth, 2013).

3.5.1. Qualitative and quantitative research

Quantitative research, which is generally associated with positivism, takes an objective view of the world (Collis et al., 2003, Saunders et al., 2011). The causal relationships between variables are investigated within a value-free framework using a range of statistical techniques. Theory is generally tested deductively, but an inductive approach is also possible; in this case, the data are used to develop theory (Meredith et al., 1989).

Qualitative research is associated with the interpretive paradigm. In this case, the researcher seeks to make sense of the subjective, socially constructed meanings attached to the phenomenon under investigation (Denzin and Lincoln, 2005, Bryman and Bell, 2015). As part of this study‘s pragmatic approach, both quantitative and qualitative methods were employed as appropriate to the research questions.

3.5.2. Mixed-method

Tashakkori and Teddlie (2010) explain that in the mixed-method approach, the combination of quantitative and qualitative methods allows the researcher to compensate for their individual weaknesses and to select the most appropriate technique to address the research questions as the study unfolds (Johnson and Onwuegbuzie, 2004, Johnson et al., 2007).

3.6.Data gathering technique

3.6.1. Statistical process control tools

Statistical process control had been formally defined as a methodology for monitoring a process to identify special causes of variations that signals the need to take corrective action when it was appropriate (Evans and Lindsay, 2005). Statistical tools allow measurement and evaluation of the performance in a process to improve its quality. The tools frequently used to support decision making. According to Montgomery (2005), statistical tools could be helpful in developing activities previous to manufacturing, in measuring process variability, in analyzing this variability relative to product requirements or specifications, and in eliminating or greatly reducing variability in process.

Most processes would be studied in an organization could be described reasonably accurately using two variables: I. the arithmetic mean value of the process measure being used. II. The statistical term for this value is the expected value, and the expression for it is:

A. The standard deviation of the process—that was, a variable that says some‐ thing about how much variation would be expected from the process. They both aim at meeting customers' expectations by providing use of statistical principles and techniques to improve productivity and quality through waste or defect reduction in the industry. In SQC, samples would taken from the production line, define, weighed or measured as the case may be and statistical test would be applied to see whether the process was performing satisfactorily or not.

B. A check sheet is a table or form used for registering data as they were collected. One of the main applications was registering how often different problems or incidents occur. This would be provided important information about problem areas or probable causes of errors, or defects and thus would provide a good foundation for deciding where to concentrate during improvement.

3.6.2. Sampling frame and techniques

A sampling frame is a complete list of target population members (Bethlehem and Biffignandi, 2011). The sampling frame for this study was compiled from the Financial Analysis Made Easy (FAME) database. This ensured that the list was accurate and up to date (Dillman, 2011). The list identified 1608 food companies. Probability sampling was chosen over nonprobability because of the fundamental problem associated with the latter: the validity of the inferences drawn from such a sample is neither assured nor testable, making any generalisation questionable (Pfeffermann and Rao, 2009, Dillman, 2011, Marsden and Wright, 2010). Probability sampling, which may take the form of systematic sampling, simple random sampling, stratification or multi-stage cluster sampling, aims to minimize survey costs while controlling the uncertainty associated with key estimates (Pfeffermann and Rao, 2009). In this case, systematic random sampling was applied; starting at a random point and selecting every fourth company, 400 companies were invited to participate the survey, from the original 1608 companies (Malhotra and Grover, 1998).

The sampling frame was a source material from which the sample was selected. In this research, the participants of the study would professional and some was not professional employees of Sebeta Agro- Industry working in Sebeta.

The study would conduct in Sebeta Town productivity improvement Techniques using SPC in dairy industry in case of Sebeta Agro-Industry. SAI had 8 sites which 3 were in sebeta town and the remaining 5 were located in other cities and towns of the country. The study woulddo branches in Sebeta which was the main production of planting area. Random sampling was techniques of was used to select employee or respondent and purposive sampling techniques would used to select the branch. Sample size was determined using solving formulas. Sebeta agro-industry would select due to their greater importance and provides valuable and relevant information to the study. The employees from the selected branch had at least one working experience. The researcher would get better information from their experience of productivity improvement techniques using SPC.

$n={}^{N}/_{1+Ne^{2}}$------------------(1)

Where n=number of samples

N=Total population

e=error tolerance or the margin of error n=$^{355}/_{1 + 355 * 0.05}$ ^2

n=188

Sample Proportion (%) =$\frac{188x100}{355}$ =53%

Since the population under study is considered to be finite, the following formula is employed to calculate the sample size (Kothari, 2004).

n=$\frac{z^2}{e^2},\frac{p.q.N}{(N-1)+z^2.p.q}$---------------------(2)Where, n=sample size

p=proportion of the population containing the major interest, q=1-p

z = number of standard deviation at a given confidence level (α= 0.05),

e = acceptable error (precision) and

N is the total population size

Hence the sample size computed out of the 355employees (with the exception of casual and/or daily laborers, Human resources) was 45 respondents in total. The number of questionnaire prepared was 45 accordingly.

16 Quality Control departments, 6 Production departments, 10Maintenance department,

5 Auditing and Inspection department, and 6 Marketing departments.

CHAPTER FOUR

EMPIRICAL WORK OF THE STUDY

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, Experimental data collection using control charts, application of control charts using milk temperature, weight, acidity and fat contents, application of Pareto and cause and effects in dairy industry, Descriptive data analysis from questionnaire and interview, quality and productivity improvement problems, causes of poor quality products, Basic quality and productivity improvement tools, and economic analysis of defective dairy products.

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.

Sebeta Agro- Industry is the most recognized private dairy processing company in Ethiopia. It processed different dairy products such as liquid milk, butter, cheeses, yoghurt, UHT, cream and fruit juices. The company currently has about 355 employees out of which are 188 are the target or directly involved in dairy product processing, which were taken as a target population in the company. From the sample size computation we have observed a result of 45 samples to be collected that would represent the entire population .45 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, percentage and charts with the help of Statistical Package for Social Science (SPSS) in23 and Minitab 18.

4.1.2. Demographic Characteristics Of The Employees

Demographic characteristics including: gender, current educational background, and response towards all variables are summarized using frequencies and percentages.

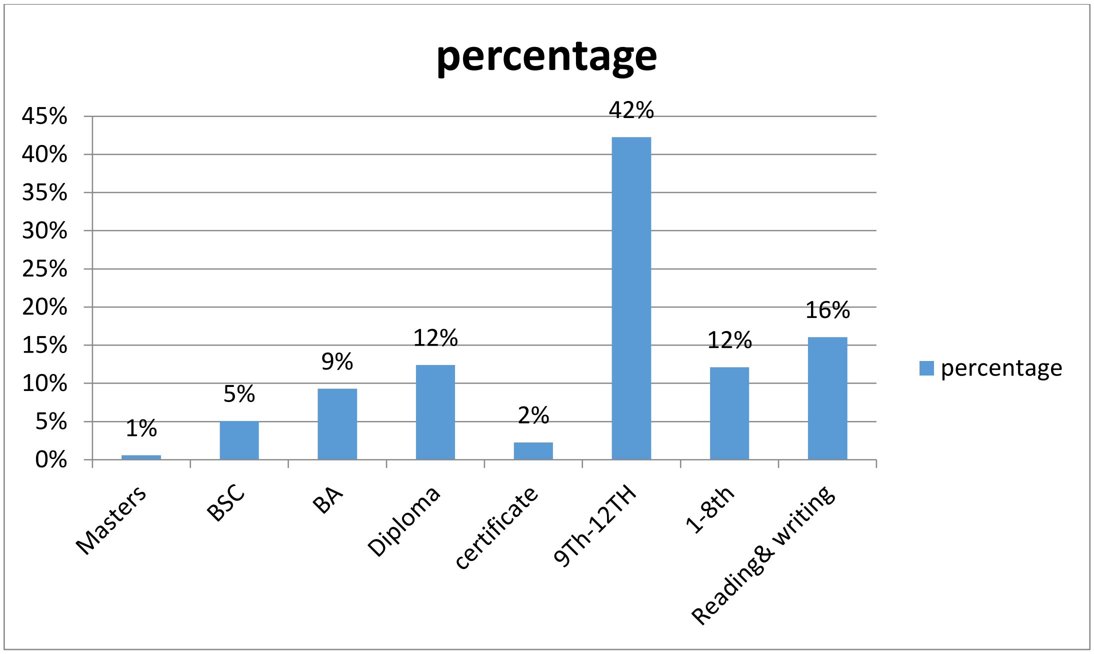

Figure 4.1 Histogram for educational level of employees

*Sources: Own computation based on data collected (Minitab 18), (2019)

The educational level of the Organization employees were 42% grade 9-12th ,16% reading and writing,12% 1-8th and diploma, 9% BA degree holders, 5% BSC degree holders,2% certificate and only 1% masters holders . It can be seen from the graph, the most of employees i.e. 42%9-12th educational level . Surely the educational level of employees positively affects productivity improvement and defects analysis using SPC tools in dairy industry. But most of SAI employees are below the average of educational level. By these conditions, it is impossible to reduce defective products and improve productivity in the Company.

4.2.Data Collection For Control Charts Using Experiments

4.2.1. Application Of Control Charts In Dairy Industry using Milk Temperature

The Plastic milk temperature in degree centigrade Dairy manufacturing company in case of SAI was monitored. During the base period 28 samples are observed the sample size is 4. The measurements of individual Temperatures are as Follows:

Table 4.1 Data for *X* double bar –*R* chart of Plastic milk temperature in degree centigrade

Sample1	Sample2	Sample3	Sample4	X bar
6	7	8	10	7.75
7	7	6	8	7
7	7	8	8	7.5
7	8	8	8	7.75
8	6	6	7	6.75
10	7	7	8	8
7	7	6	6	6.5
5	8	7	8	7
7	7	7	6	6.75
4	8	8	8	7
7	8	10	8	8.25
6	8	8	7	7.25
7	8	8	8	7.75
7	7	3	8	6.25
10	8	6	8	8
8	8	8	8	8
7	7	7	8	7.25
6	8	9	7	7.5
7	8	7	10	8
7	8	8	5	7
8	7	8	9	8
7	8	8	7	7.5
6	7	8	7	7
8	9	8	8	8.25
7	6	8	5	6.5
8	8	10	7	8.25
7	8	7	8	7.5
8	7	8	8	7.75

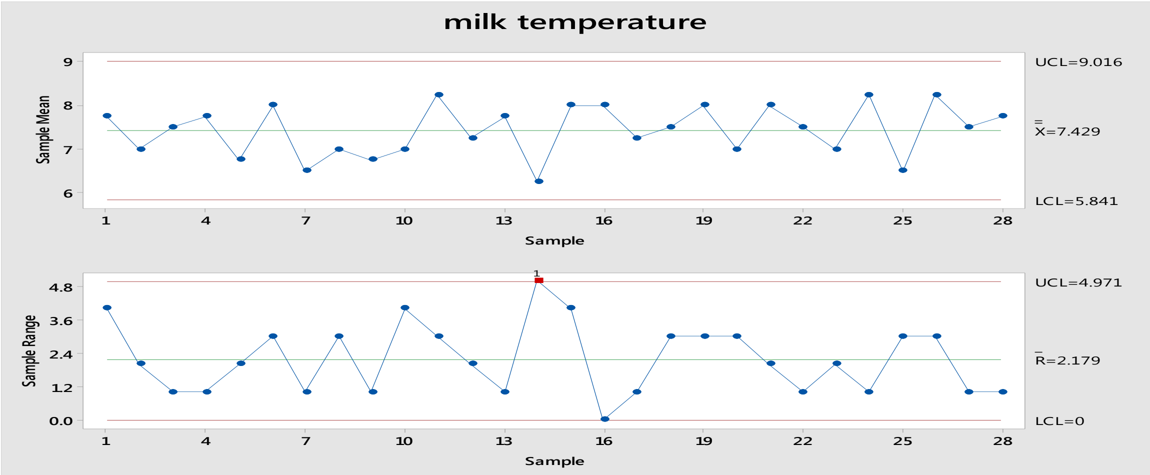

Figure 4.2: A control chart showing milk Temperature in SAI production line

*Sources: Own computation based on data collected (Minitab 18), (2019) After observing and calculating the following data we found that,

•CONTROL LIMITS FOR X-DOUBLE CHARTS

Upper Control Limit, UCL = 9.016

Center Line, CL = 7.429

Lower Control Limit, LCL = 5.841

•CONTROL LIMIT FOR R-CHART (RR-CHART)

Upper Control Limit, UCL = 4.971

Center Line, CL = 2.179

Lower Control Limit, LCL = 0

The milk temperature analysis in production of milk is one of quality parameters. Milk temperature should be around 7.4 degree centigrade. The x-bar(X) and R- chart graphics in table – are created from the Titration acidity of 28 samples of 4 runs. The control limits drawn in both plots were obtained by using equations given in table- from review literature of study. From the above milk Temperature of plastic milk X-bar chart of the graph, the processes are takes place at normal conditions or at optimum temperature of plastic milk production in SAI. All samples are takes places closest to the average value of the samples.

From the above milk temperature of plastic milk in case of SAI production line, R- charts, out of 28 samples, one (1) sample takes place above the range of the samples. Most samples are takes place around the ranges of the mean, that means most are controlled and none samples are takes place below the ranges of the samples.

4.2.2. Application Of Control Charts In Dairy Industry Using Weight

The volume or weight in the production of dairy is one of the quality parameters. The average weight or volume of plastic milk should be around 500gm. The X-bar (x) and S-chart graphics in Table are created from the weight or volume of 28 samples of 11 runs. The control limits drawn in both plots were obtained by using equations given in Table2.1.

Table 4.2Sample of plastic milk weights or volume (n=12) with means and standard deviations

Sam. 1	Sam. 2	Sam. 3	Sam 4	Sam 5	Sam 6	Sam 7	Sam 8	Sam 9	Sam 10	Sam 11	Sam 12	x bar	std
508	505	506	500	502	500	506	508	502	505	0	0	504.2	3.011091
502	501	509	509	0	0	0	501	500	504	0	503	352.6	243.3371
501	501	500	501	0	0	500	508	508	508	500	0	402.7	212.2687
498	502	502	499	502	501	499	504	502	503	501	513	501.2	1.932184
505	502	503	501	504	501	498	508	497	498	496	496	501.7	3.465705
495	510	520	495	495	515	501	498	491	498	494	509	501.8	9.761603
505	507	505	509	503	505	497	507	510	508	509	500	505.6	3.687818
505	505	494	501	500	511	505	504	508	499	497	493	503.2	4.848826
506	503	510	506	502	499	503	501	501	505	498	497	503.6	3.204164
505	501	496	498	504	503	0	0	502	504	501	497	401.3	211.522
503	494	508	505	498	500	0	0	0	0	0	0	300.8	258.9147
505	501	499	496	505	501	0	0	498	493	506	496	399.8	210.7451
510	498	501	492	496	499	0	0	0	0	0	0	299.6	257.8941
508	500	502	509	505	508	0	0	0	0	0	0	303.2	260.9673
505	502	501	498	505	502	494	502	501	0	500	505	451	158.4978
502	503	501	0	0	0	506	496	498	492	0	0	349.8	241.4156
505	503	505	505	493	510	499	500	500	499	502	494	501.9	4.701064
503	504	502	0	501	505	507	503	0	510	497	491	403.5	212.6788
0	0	0	506	501	496	510	501	500	0	0	0	301.4	259.4298
505	499	496	505	504	502	500	502	504	500	504	500	501.7	2.945807
508	501	500	507	501	504	504	500	503	504	502	503	503.2	2.780887
510	502	493	494	498	498	499	500	500	505	500	502	499.9	4.976612
507	503	496	502	497	490	505	502	500	501	503	500	500.3	4.900113
500	505	502	497	494	493	505	502	500	500	0	0	499.8	4.104198
501	499	500	502	501	500	503	505	504	512	505	504	502.7	3.772709
500	500	520	490	495	510	500	505	490	495	502	500	500.5	9.264628
506	506	498	495	493	516	509	496	500	508	497	0	502.7	7.409453
510	505	503	507	504	500	500	496	500	502	0	0	502.7	4.029061

*Source: Own computation based on data collected (Minitab 18), (2019)

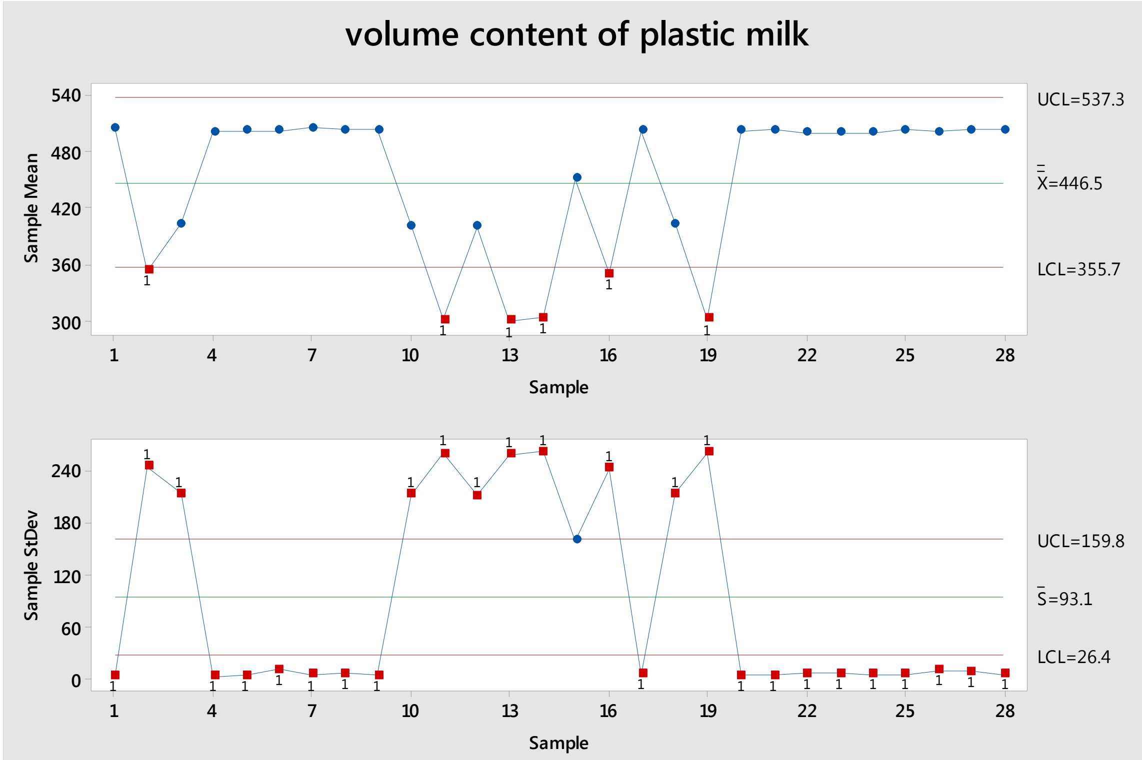

Figure 4.3 A control chart showing volume/Weight/ of Plastic milk in SAI production line

Source: Own computation based on data collected (Minitab 18), (2019)

After observing and calculating the following data we found that,

•CONTROL LIMITS FOR X-DOUBLE CHARTS

Upper Control Limit, UCL= 537.3gm

Center Line, CL = 446.5gm

Lower Control Limit, LCL = 355.7gm

•CONTROL LIMIT FOR S-CHART (Standard deviation)

Upper Control Limit, UCL = 159.8

Center Line, CL = 93.1

Lower Control Limit, LCL = 26.4

Data analysis from control limits for x-double charts

The volume or weight of plastic milk analysis in production of milk is one of quality parameters. Amount or weight of plastic milk should be around446.5gm.The x-bar(X) and S- chart graphics in table – are created from the Volume of 28 samples of 11 runs. The control limits drawn in both plots were obtained by using equations given in table- from review literature of study.

From the above control charts out of twenty eight (28) samples, six (6) samples are below the mean value of the samples. Most the samples are closest to the mean of the central value of the samples. But out of 28 total samples none are above the average of the samples.

Data analysis of weight of plastic milk from control limits of Standard deviations

From out of 28 samples of volume contents of plastic milk, ten (10) samples are distributed below the samples of the mean of standard deviation of the samples. And out of 28 samples of 17 samples are distributed out of the standard deviation of the samples.

4.2.3. Application Of Control Charts Using Milk Acidity

Table 4.3 Data for Xbar $-R$ charts of Plastic milk acidity or Titration (n=4) with means and Ranges in SAI

Sample 1	Sample2	Sample3	Sample4	x bar	Maximum	Minimum	Range
13	12	13	13	12.75	13	12	1
13	12	12	13	12.5	13	12	1
11	12	12	12	11.75	12	11	1
13	14	13	13	13.25	14	13	1
13	12	13	14	13	14	12	2
13	13	13	12	12.75	13	12	1
13	13	15	16	14.25	16	13	3
13	15	14	14	14	15	13	2
13	15	15	14	14.25	15	13	2
13	14	15	14	14	15	13	2
13	14	13	16	14	16	13	3
12	16	15	15	14.5	16	12	4
13	14	15	12	13.5	15	12	3
13	13	14	15	13.75	15	13	2
14	14	14	15	14.25	15	14	1
13	15	15	15	14.5	15	13	2
14	13	15	15	14.25	15	13	2
13	14	15	14	14	15	13	2
13	14	14	13	13.5	14	13	1
12	15	15	13	13.75	15	12	3
15	12	14	14	13.75	15	12	3
12	15	14	13	13.5	15	12	3
14	13	14	15	14	15	13	2
15	13	14	14	14	15	13	2
13	12	15	15	13.75	15	12	3
13	14	14	13	13.5	14	13	1
13	14	14	14	13.75	14	13	1
13	14	14	16	14.25	16	13	3

Source: Own computation based on data collected (Minitab 18), (2019)

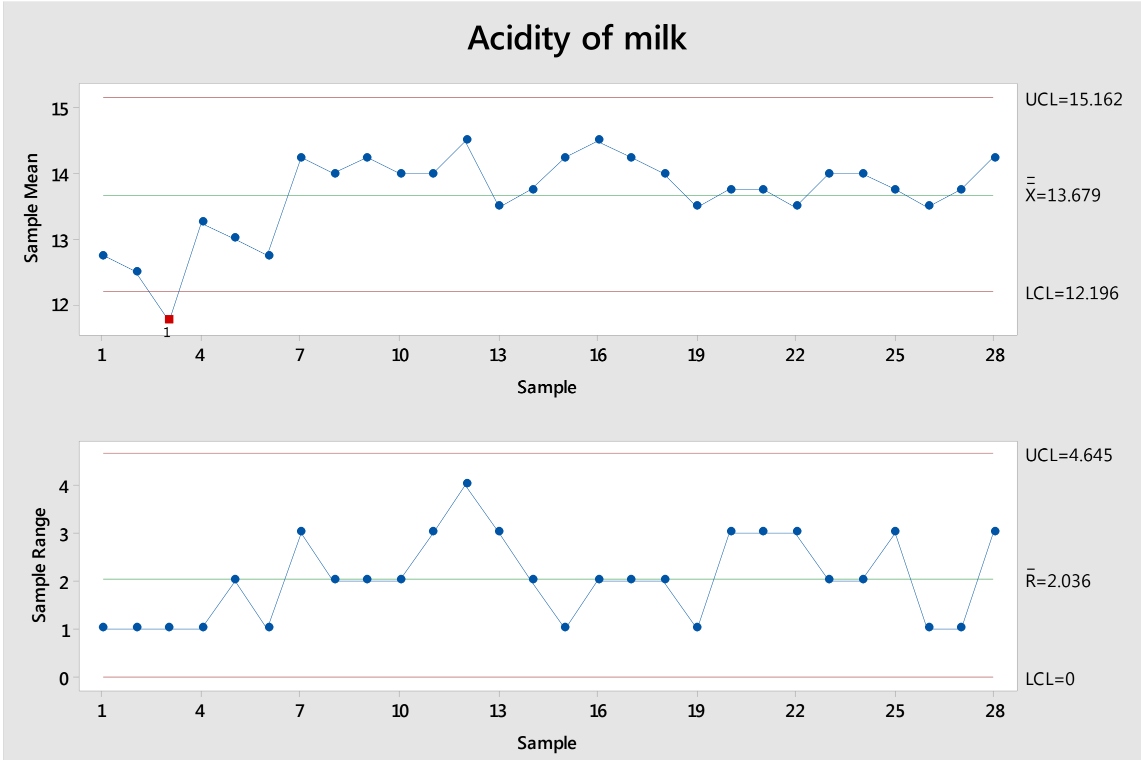

Figure 4.4 A control chart showing milk Acidity in SAI production line

Source: Own computation based on data collected (Minitab 18), (2019)

After observing and calculating the following data we found that,

•CONTROL LIMITS FOR X-DOUBLE CHARTS

Upper Control Limit, UCL= 15. 162

Center Line, CL = 13.679

Lower Control Limit, LCL = 12.196

•CONTROL LIMIT FOR R-CHART (RR-CHART)

Upper Control Limit, UCL = 4.645

Center Line, CL = 2.036

Lower Control Limit, LCL = 0

The acidity analysis in production of milk is one of quality parameters. Acidity or titration analysis should be around 13.67%.The x-bar(X) and R- chart graphics in table – are created from the acidity analysis of 28 samples of 4 runs. The control limits drawn in both plots were obtained by using equations given in table- from review literature of study. From the above titration or acidity of plastic milk production line, only one sample is takes place below the average of acidity of plastic milk production in case of SAI .All are takes place at normal acidity of plastic milk production.

4.2.4. **Application Of Control Charts Using Fat Percentage Of Milk**

Table 4.4 Data for Xbar $-R$ charts of Plastic milk Fat content (n=4) with means and Ranges in SAI

Sample1	Sample2	Sample3	Sample4	X-bar	maximum	Minimu	Range
2.8	2.6	2.7	2.7	2.7	2.8	2.6	0.2
2.7	2.6	2.6	2.6	2.625	2.7	2.6	0.1
2.6	2.6	2.6	2.6	2.6	2.6	2.6	0
3	2.5	2.7	2.6	2.7	3	2.5	0.5
2.7	2.8	2.7	2.7	2.725	2.8	2.7	0.1
2.7	3	2.8	2.5	2.75	3	2.5	0.5
3	2.7	2.5	2.6	2.7	3	2.5	0.5
2.7	3	2.5	2.4	2.65	3	2.4	0.6
2.5	2.7	2.6	2.7	2.625	2.7	2.5	0.2
2.7	2.7	2.7	2.6	2.675	2.7	2.6	0.1
2.7	2.6	2.5	2.1	2.475	2.7	2.1	0.6
2.7	2.6	2.5	2.5	2.575	2.7	2.5	0.2
2.7	2.5	2.6	2.5	2.575	2.7	2.5	0.2
2.6	2.6	2.5	2.5	2.55	2.6	2.5	0.1
2.6	2.8	2.8	2.6	2.7	2.8	2.6	0.2
2.6	2.7	2.5	2.7	2.625	2.7	2.5	0.2
2.7	2.6	2.8	2.5	2.65	2.8	2.5	0.3
2.6	2.6	2.8	2.5	2.625	2.8	2.5	0.3
3	2.7	2.6	2.6	2.725	3	2.6	0.4
3	2.7	2.4	2.6	2.675	3	2.4	0.6
2.6	2.9	2.9	2.4	2.7	2.9	2.4	0.5
2.6	2.8	2.6	2.7	2.675	2.8	2.6	0.2
2.7	2.7	2.8	2.6	2.7	2.8	2.6	0.2
2.6	2.6	2.8	2.6	2.65	2.8	2.6	0.2
2.7	2.5	2.6	2.6	2.6	2.7	2.5	0.2
2.6	2.8	2.8	2.6	2.7	2.8	2.6	0.2
2.6	2.6	2.6	2.6	2.6	2.6	2.6	0
2.6	2.6	2.6	2.6	2.6	2.6	2.6	0

*Source:own computation from expermental collected data (2019)

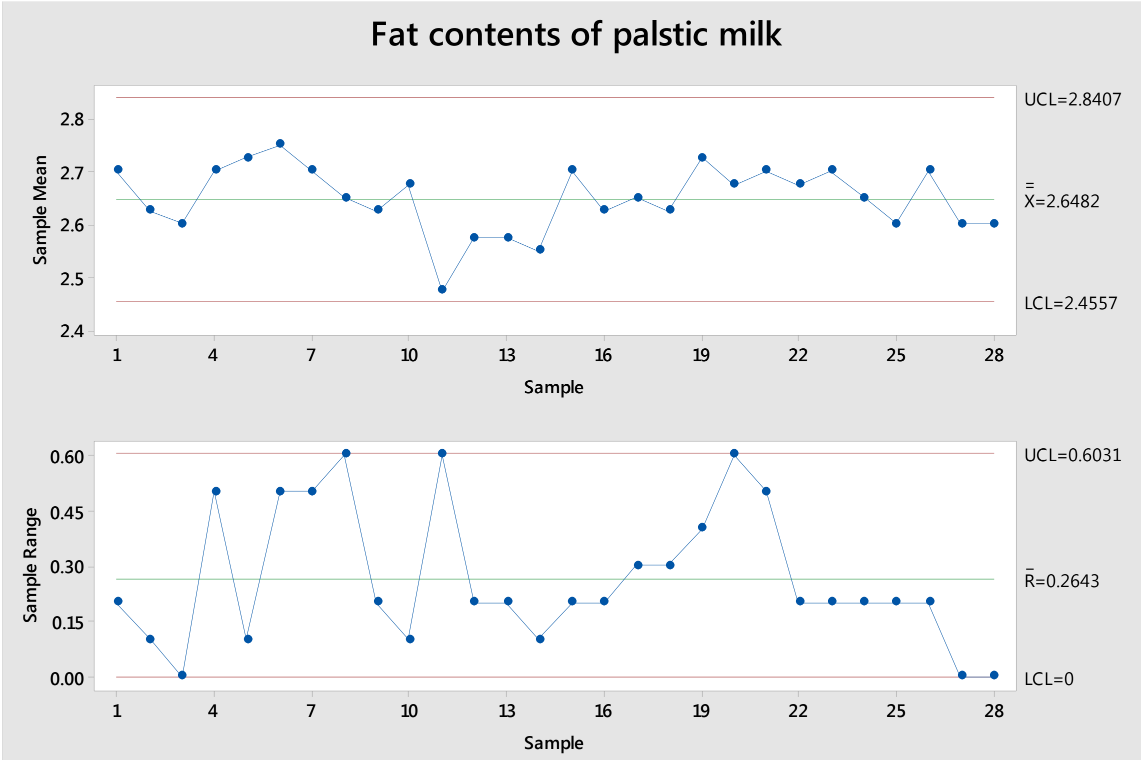

Figure 4.5 A control chart showing fat content of plastic milk in SAI production line

Source: Own computation based on experimental data collected (Minitab 18), (2019)

After observing and calculating the following data we found that,

•CONTROL LIMITS FOR X-DOUBLE CHARTS

Upper Control Limit, UCL= 2.8407%

Center Line, CL = 2.6482 %

Lower Control Limit, LCL = 2.4557 %

•CONTROL LIMIT FOR R-CHART (RR-CHART)

Upper Control Limit, UCL = 0.6031%

Center Line, CL = 0.2643%

Lower Control Limit, LCL = 0%

The fat content analysis in production of milk is one of quality parameters. Fat content should be around 2.6%.The x-bar(X) and R- chart graphics in table – are created from the fat content of 28 samples of 4 runs. The control limits drawn in both plots were obtained by using equations given in table- from review literature of study. From the above x-R bar chart of the graph, the Fat contents of plastic milk production takes place at mean value of x-R chart.

4.3.Application Of Pareto Diagrams Or Charts In Dairy Industry

Pareto chart is a special type of bar chart where the plotted values are arranged from largest to smallest. A Pareto chart is used to highlight the most frequently occurring defects, the most common causes of defects. To identify the main problems which cause frequent defects of Dairy production, a two months data had been collected (viz., January, and February, 2019). We have performed our Pareto Analysis based on four months combined defect data of 5 production lines from the sewing section for woven pants. From this analysis we can identify the "Vital few" areas where maximum defects occur. The Pareto principle states that it is possible for much performance measure, such as breakages, returns, damages, and Clotting or Titration to separate the vital few causes resulting in unacceptable performance from the trivial many causes. Historically, this concept has also known as the 80/20 rule, which states that the performance measure can be improved 80% by eliminating only 20% of the causes of unacceptable performance.

Table 4.5 Data collected for number of visual defects (Dairy products) over the past two months (January to February, 2019)

S.No.	Types of Defects	Number of Defectives		Total number of defective
		January	February	
1	Breakages	7,390	5706	13096
2	Returns	62,781	484	63265
3	Damages	12,137.5	9416.5	21554
4	Clotting/Souring/	17947	19171	37118
				Total=134549

*Sources: Own computation based on recorded data (2019)

Notice :all the above mentioned defects except clotting or souring expressed in packaging of plastic milk in pieces, that means Two pieces of packed plastic milk=one(1) Liter.

It is apparent that from this short list that Returns are the main problem. However, real applications typically have many defects categories and many parts, all of which monitored over time. It is convenient to represent these data graphically as in (Figure4.6). This graph has been prepared using the work sheet in (Table4.6). The defects are arranged in rank order in column-1. The number of defects appears in column-2. The percentages that each defects represents of the total number of defects appears in column-3. The cumulative percentage of column-3 appears in column-4. One difficulty in collecting data by such categories as Returns, Clotting and Damages is that a particular part or item being evaluated may fit into several categories. In this case the preferred approach is to mark each defects. In (Figure4.6) all defects are shown graphically to find out a most effective defect over these defects.

Table 4.6 Example Pareto analysis worksheet

Column-1	Column-2	Column-3	Column-4
Types of Defect	No of defects	% Composition	Cumulative %
Returns	62781	46.66	46.66
Clotting/Souring/	37118	27.59	74.25
Damages	21554	16.02	90.27
Breakages	13096	9.73	100

*Source: own computation from collected data (2019)

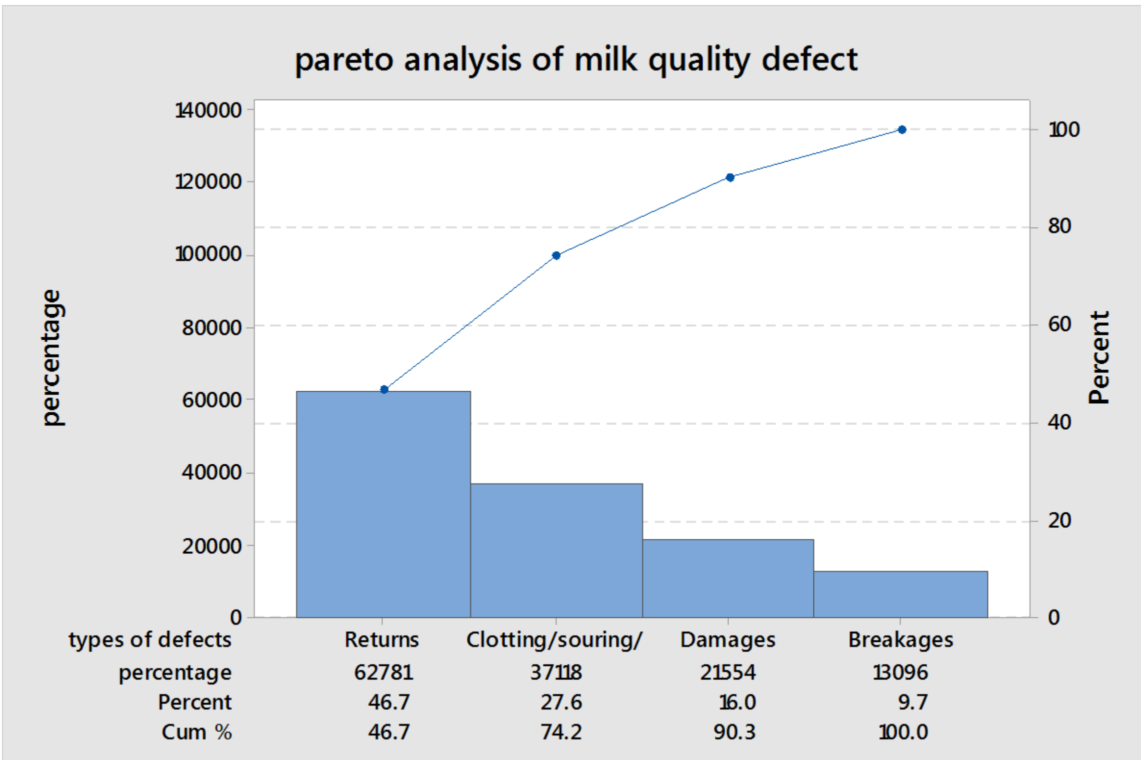

Figure 4.6 Pareto analysis of milk quality defects

*Source: Own computation based on data collected (Minitab 18), (2019)

Pareto chart was constructed based upon number of defects collected from (table-) and to identify the most common defects as shown in fig- .The Pareto chart revealed that 4 defects such as returns 46.7%,souring 27.6%,damages 16.0% and breakages 9.7%, only the major defects identified are chosen for the cause study. Therefore, at this stage, it is obvious that most of all defects will decrease, if the causes for these major defects are reduced.

Total number of defects = 134549

Total number of defects in major concerning area = 62781

Percentage of defects in major concerning area = $\frac{62781X100}{134549} = 46.7\%$

There are 4 defects types of which Returns, Clotting or Souring and Damages are individually counted together for 50 positions. Rest of the 1 defect types can occur in 50 different positions of the plastic milk products. So the number of total concerning area is [1*50 + 50 (Returns) + 50 (Clotting) + 50 (Damages)] = 200.4 which is responsible for total amount of defects. But we have identified total 13096 concerning areas by Pareto Analysis which is responsible for 46.7% defects.

Total number of concerning area = 200.4

Total number of major concerning area = 13096

Percentage of major concerning area = $\frac{200.4x100}{13096} = 1.53\%$ so by concentrating only on 1.53% areas most of the defects can be reduced.

4.4.**Application Of Cause And Effects Diagrams In Dairy Industry**

From Pareto Analysis we have identified top defect positions and by further analyzing we have also identified top four defect types in those positions. Those defect types are Returns, Clotting or souring, Damages, and Breakages. 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.

Brainstorming is a technique used to elicit a large number of ideas from a team using its collective power. It normally takes place in a structured session involving between three to twelve people, with five to six people being the optimal group size. The team leader keeps the team member focused, prevents distractions, keeps ideas flowing, and records the outputs (or make sure that team members record their own outputs). The brainstorming session should be a closed-door meeting to prevent distractions. In analyzing the dairy product defect or quality problem, we elected to lay out the major categories of plastic dairy products defects as man, machine, material, methods, measurement and environment. The quality and productivity improvement team identify the root causes of quality defects by asking or raising the following brainstorming questions;

Questions to Ask When Performing RCA:

- PEOPLE(MAN)
- Was the document properly interpreted?
- Was the information properly disseminated?
- Was the proper training to perform the task administered to the person?
- Were guidelines for judgment available?
- Did the environment influence the actions of the individual?
- Is fatigue a mitigating factor?
  - MACHINES
  - Was the correct tool used?
  - Is the equipment affected by the environment?
  - Is the equipment being properly maintained (i.e., daily/weekly/monthly preventative maintenance schedule)
  - Was the machine properly programmed?
  - Was the tooling used within its capabilities and limitations?
  - Are all controls including emergency stop button clearly labeled and/or color coded or size differentiated?
  - Is the machine the right application for the given job?
- MEASUREMENT
    - Does the gage have a valid calibration date?
    - Was the proper gage used to measure the part, process, chemical, compound, etc.?
    - Was a gage capability study ever performed?
    - Do measurements vary significantly from operator to operator?
    - Does the gage have proper measurement resolution?
    - Did the environment influence the measurements taken?
    - MATERIAL
    - Was the material properly tested?
    - Was the material substituted?
    - Is the supplier's process defined and controlled?
    - Were quality requirements adequate for part function?
    - Was the material contaminated?
    - Was the material handled properly (stored, dispensed, used & disposed)?
    - ENVIRONMENT

- ❖ Is the process affected by temperature changes over the course of a day?
- ❖ Is the process affected by humidity, vibration, noise, lighting, etc.?
- ❖ Does the process run in a controlled environment?
- ➢ METHODS
- ❖ Was the canister, barrel, etc. labeled properly?
- ❖ Were the workers trained properly in the procedure?
- ❖ Was the testing performed statistically significant?
- ❖ Have I tested for true root cause data?
- ❖ Has a capability study ever been performed for this process?
- ❖ Is the process under Statistical Process Control (SPC)?
- ❖ Are the work instructions clearly written?
- ❖ Are mistake-proofing devices/techniques employed?
- ❖ Are the work instructions complete?
- ❖ Is the tooling adequately designed and controlled?
- ❖ Is handling/packaging adequately specified?

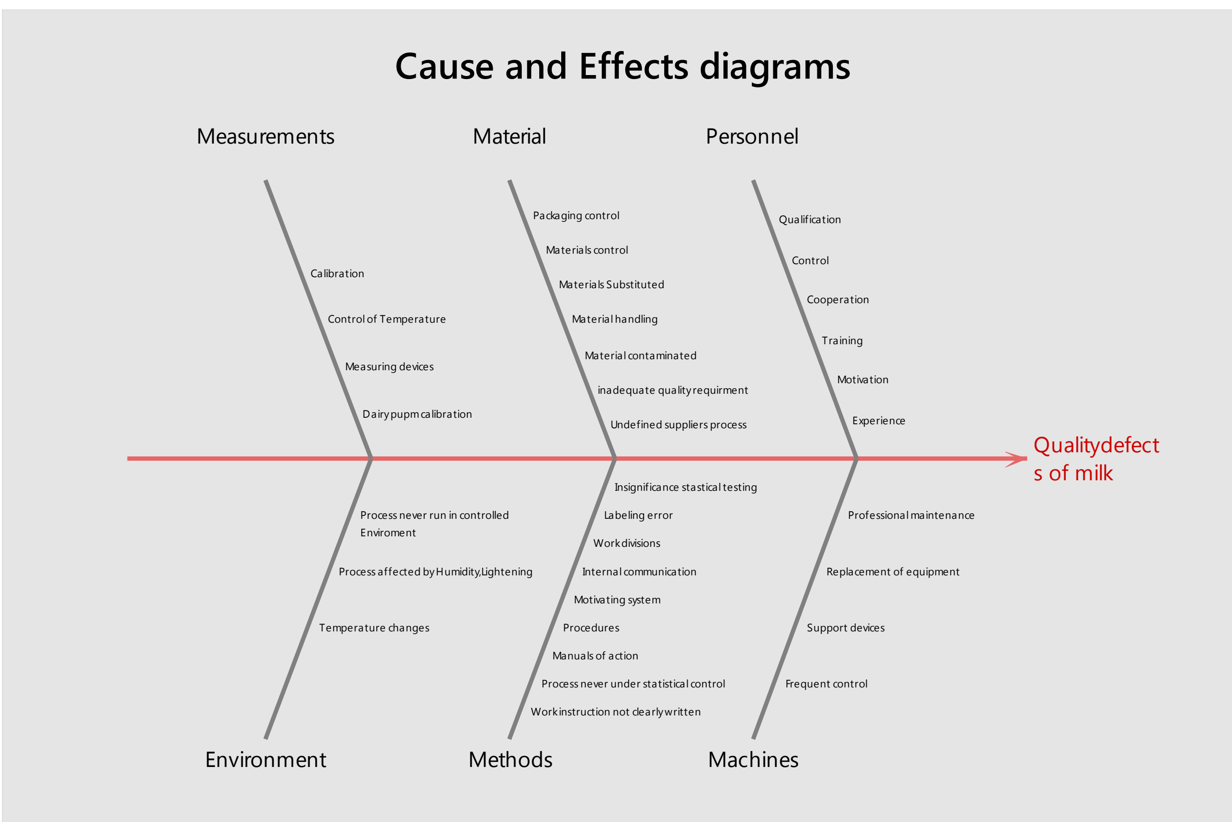

Figure 4.7 Overall fish bone diagrams for quality defects of milk

*Sources: Own computation based on data collected (Minitab 18), (2019)

4.5.Results Of Experimental Analysis

We have found that up to 46.7% defects can be reduced by concentrating only on1.53% areas. We have provided some suggestions related to these defect types. It is almost impossible to achieve zero defects. But by taking effective measure it is possible to reach near zero defects. So the more successfully those suggestions can be applied, the more the defects can be minimized.

We have also found that, six samples are out of control limits, and also 27 samples of weight/volume / of plastic milk, distributed out of control limits of standard deviation. This indicates that, there are special causes of variation in the processes. We have provided some suggestions related to these weight/ volume/ variation of plastic milk. It is possible to reduce or completely eliminate the existence variations using automation packaging plastic milk machine and reducing labor work or manual work.

4.6.Summary Of Experimental Data Analysis

In this chapter, the most effective way of quality control and productivity improvements has tried to find experimenting on dairy processing industry in case of SAI. Using all quality tools and sampling plan is an expensive procedures for any dairy industry, using the control chart is the best way for quality testing, cause and effects diagrams, histograms and Pareto diagrams are used to determine the causes and effects of production processes. Acceptance sampling is used to determine the errors in control charts. Statistical process control tool is a powerful tool used to achieve productivity, reduce defects, and increase profitability of the company by identifying the root causes of quality problems through brain storming methods.

4.7.Descriptive Data Analysis From Survey Questionnaire

The researcher has designed the survey questionnaires for assessing the productivity improvement techniques using SPC in dairy industry in case of SAI. This questionnaire was distributed to some persons in Sebeta Agro- Industry for its comments and suggestions before finalizing it. Furthermore, the researcher has discussed with some quality control and production departments on quality defects that affects productivity improvements and application of SPC tools to reduce dairy defective products. The questionnaire was finalizing taking into account the above suggestions under the guidance of the advisor.

The composition of the persons who were participated in the response of the questionnaire includes: Production Supervisors’, Production Manager, Quality control head, quality control department, production department, Marketing department, Maintenance department and auditing and Inspection department

The general objectives of the questionnaire are:

1. To determine the main quality defects that affects productivity improvement of dairy products
2. To assess attitudes, tendency and commitment of all workers towards SPC tools.
3. To ascertain the level of awareness of managers and workers on quality defects.
4. To propose the appropriate SPC tools usages in dairy industry in case of SAI.

   The survey questionnaire contains about 9(Nine) questions requiring three types of answers.

1. Comparative scale, Frequently/Not occurring, very good/Moderate, High/Low, Expert/ Not familiar/low, SD/SA.
2. Subjective type questions, which need brief answer.
3. Uses a normal scale, yes or No.

Furthermore, the questions in this survey questionnaire are categorized into five different sections with reference to Dairy Industry in case of SAI.

A. To assess the awareness of main quality problems was designed to investigate the awareness levels and basic understanding the main causes of quality problems in dairy industry.

B. To assess the respondents awareness about the basic quality improvement tools.

C. Causes of quality defects and the usages of SPC tools in dairy industry, the main objective is to evaluate the impact of quality defects on dairy industry.

D. Status of training, documenting and understanding of information about quality defects.

E. To identify the main causes that affects the productivity improvement in dairy industry.

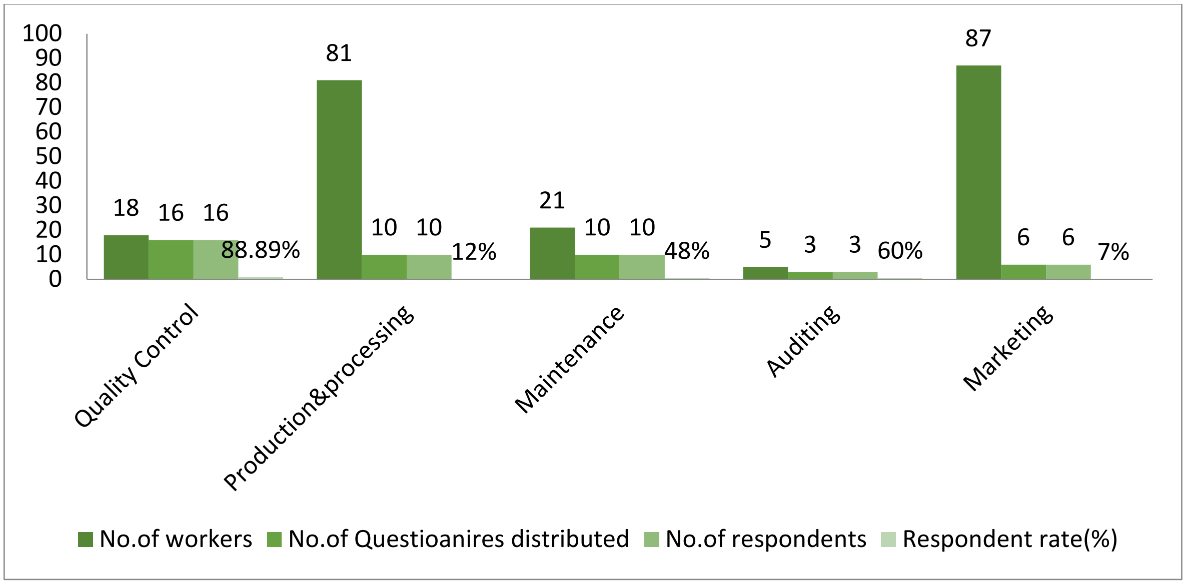

Figure 4.8 Histogram of respondents rates in SAI

*Source: Own computation based on data collected (Minitab 18), (2019)

STRUCTURE INTERVIEWS

Structured interviews (face to face) conducted with Quality control head, Production supervisors and production manager in SAI .Most of the interview questions conducted are similar to the questions in the questionnaire. This helped me to cross-check the response given by the respondents on both methods of assessment.

The general objectives of conducting the interviews are:

1. To determine the main quality defects that affects productivity improvement of dairy products
2. To assess attitudes, tendency and commitment of all workers towards SPC tools.
3. To ascertain the level of awareness of managers and workers on quality defects.
4. To propose the appropriate SPC tools usages in dairy industry in case of SAI.

DIRECT OBSERVATION

The researcher has also used this method for collecting the required data and information from the Sebeta Agro- Industry. The important documents of the respective companies such as monthly reports, Supervisors reports, quality control and production department daily reports have been also used for the assessment. Furthermore, the statistical process control and others defective products have observed.

4.8.Data Analysis And Interpretation

The collected data through the means of interviews, questionnaires, direct observation and using documents are analyzed & interpreted. The results of the statistical analysis are presented in this section. The researcher believed that the current situation of the dairy industry towards productivity improvement techniques using SPC has exactly reflected in these questionnaires and interviews.

4.8.1. Survey Finding

As described above, the total 9(Nine)questions of the questionnaire are divided into five sections for suitability of the study. The results of these questionnaires (for the above Five department SAI) are discussed below.

The general attitudes of the employees of the company towards the quality improvement basic tools have been assessed using question number Five. The company cannot be defined the quality improvement basic tools that means SPC tools. The SPC tools awareness level and understanding of basic concepts of quality improvement tool is little and the participation of the employees in quality improvement using SPC tools is also low. Most employees do not understand that quality improvement tool is the responsibility of everyone in the company. The company does not have the quality improvement basic tools objectives. Moreover, their intention to recognize and solve the quality related problems or defects using SPC tools are less.

4.8.2. Quality And Productivity Improvement Problems In SAI

The next question assessed the main quality problems that affect productivity improvement of pasteurized plastic milk in SAI. About 89%of the respondents agree on that Clotting or Souring is the main quality problems. Even though, clotting/souring/ is the main quality problem, there is no demonstrated SPC tools practical application. The company doesn't have quality improvement SPC tools manual. The company didn't listen employees and encourages ideas and suggestions.About87 % of the respondents agreed on Temperature changes is another quality problem that affects productivity of the Company. The output of the respondents result on quality problem is shown in Fig below:

Question4: What is the main pasteurize plastic milk quality problems in SAI?

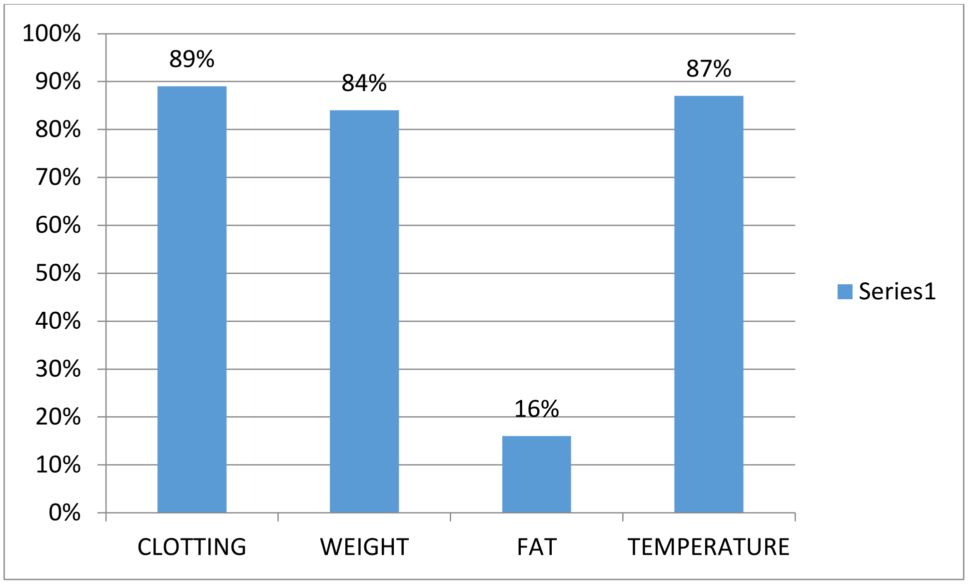

Figure 4.9 Histogram for milk quality problems in SAI respondents' rates

*Source: own computation from survey data (2019), (Minitab 18)

Table 4.7 Quality and productivity Defects' in Pasteurized plastic milk in SAI

Quality and productivity Defects	Rating of Results			
	Low	Moderate	High	Very High
Which Quality defects mostly occurs in pasteurized plastic milk in SAI?				
A. Breakages	8	28	7	2
B. Returns	10	10	21	4
C. Damages	7	32	4	2
D. Clotting/Souring	8	8	24	5

* Sources: own computation from survey data (2019)

The sixth question has focused on the main quality defects pasteurized plastic milk in SAI. The respondents' response (about 53%) indicated that clotting is the main quality defects that mostly occur in pasteurized plastic milk products in SAI. And 50% of the respondents suggested that Return of dairy product is the second quality defects that occur in SAI.

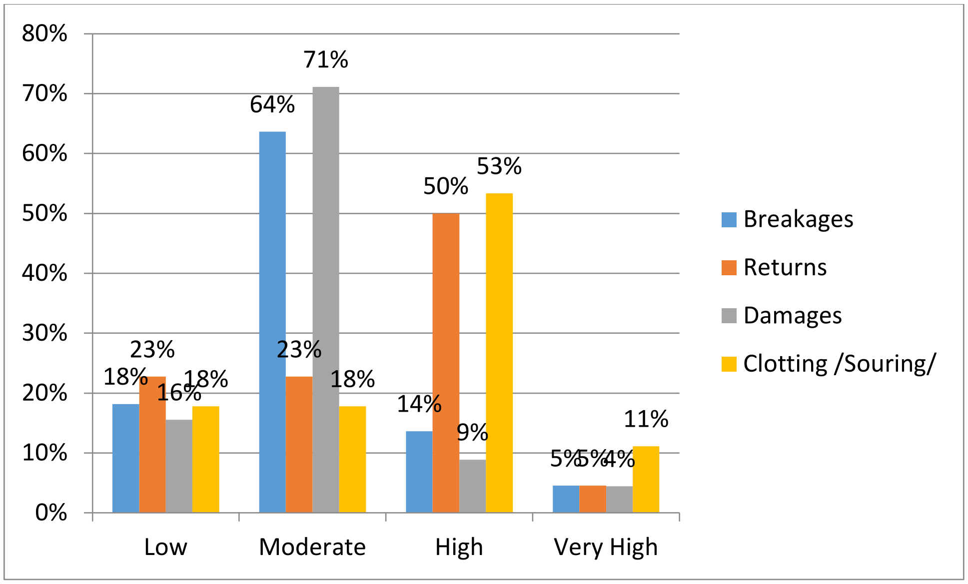

Figure 4.10 Histogram for milk quality defects in SAI respondents

*Source: own computation from survey data(2019),(Minitab 18)

- ❖ The main quality and productivity problems that mostly occurs in pasteurized plastic milk in dairy industry in case of SAI, that the researcher assessed the defects through interview with different interviewer as follows:

1. souring/clotting/, Breakages, damages and returns:

   These are the main factors that affect quality and productivity improvements in dairy industry in case of SAI.

2. Insufficient raw milk supply for milk processing plant

   This has forced the milk processing plants limited the production of pasteurized milk and another dairy products.

3. Inadequate know-how with regard to good hygiene practices in processing of milk and milk products. This results in higher wastage of milk and public health hazards.

By nature milk is perishable and extremely challenging products, it needs very close attention from every stakeholder.

4.There is insufficient or/lack of private sectors inputs such as artificial insemination technicians', community animal health workers, business development service providers, animal feed suppliers, etc for milk value chain sectors.

5. Poorly developed dairy market infrastructure for collection and distribution of milk. This has limited accessibility /physical/ to market or collection point.

6. Culturing and tradition or religious that exists in Ethiopia.

There are more than 200 days that the believers of Orthodox Christians abstain from eating and drinking any animal products whether processed or raw .This has its own effects on milk producers and processors as the demand for milk and other dairy products reduces during this fasting seasons. The Orthodox believes constitute nearly half of the population of Ethiopia, and hence fall in demand has significant impact milk marketing.

4.8.3. Causes Of Poor Quality Milk Products In SAI

Table 4.8 Causes of poor quality products that related to internal customers in SAI.

	Causes of poor quality products related to people	Frequency	Percentage
A	Lack of document properly interpreted	37	82.2%
B	Lack of training	39	86.7%
C	Lack of understanding information	24	53.3%
D	Lack of guideline judgment available	30	66.7%

*Source:own computation from survey data (2019)

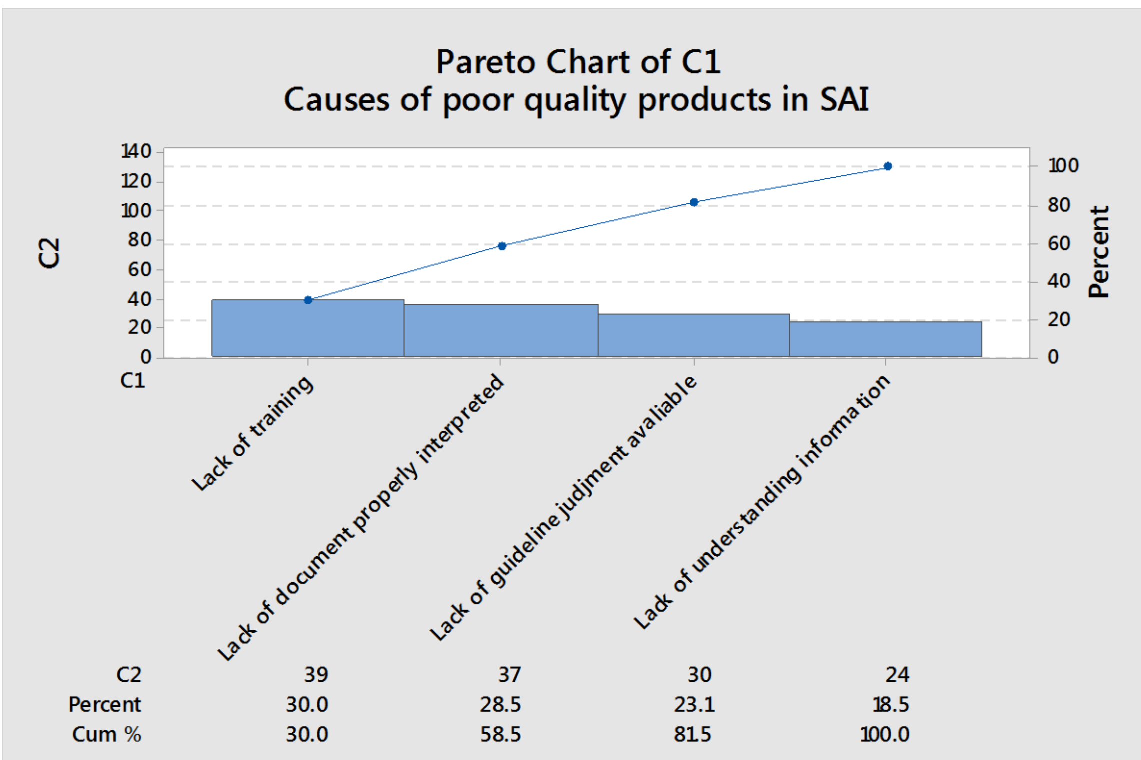

Figure 4.11 Pareto analysis for causes of milk quality defects for respondents

*Source: own computation from survey data (2019), (Minitab 18)

About ninety six percent of the respondents have agreed that main causes of poor quality dairy products that related to internal customer in SAI, are 30.0% due to lack of training for employees. Secondly lack of document properly interpreted 28.5% is another core problem of dairy products in SAI .Thirdly,23,1% of respondents are responds lack of guideline judgment available is another quality problems in case of SAI.Fourthly,18.5% of respondents responds that lack of understanding information is another quality and productivity improvement obstacle in Dairy industry in case of SAI. Few persons from quality control and production and processing departments took the training by external body, but the training took very long period of time. But never took by internal training in SAI. But the training program that took by external body does not provide appropriate training and it is not related with the company's objectives.

Table 4.9 Causes of quality problems in SAI respondent rates

Question	Rating Results			
What are the causes of quality problems in SAI?	Low	Moderate	High	Very High
Instructions	1	2	33	9
Environment	3	10	24	8
Materials	2	5	31	7
Measurements	7	30	6	2
Machines	28	17	6	4

*Source: own computation from survey data (2019)

The fourth question has focused on the causes of poor quality milk problems in SAI. About 60% of Quality Control department and 73.33% of production and processing department respondents suggested as Instruction. The respondents' response (about 76.66%) indicated that the first main current obstacle for productivity improvement in quality is the absences of Instructions (policy, rules and procedures). And 73.33% of the respondents suggested that the material as the second obstacle for productivity improvement. The causes of quality problems have been assessed in SAI and the results are shown in table 4.9.

7. Assess the main factors that affect productivity of pasteurize plastic milk in Sebeta Agro Industry

Table 4.10 Causes of defective dairy products in SAI for respondents

General approaches) Strongly Disagree(SD) (2)Disagree(D) (3)Neutral(N) (4)Agree (A) (5) Strongly Agree(SA)					
MACHINE RELATED FACTORS	1 (SD)	2 (D)	3 (N)	4 (A)	5 (SA)
Was the correct tool used?	30	10	5	0	O
Is the equipment affected by the environment?	4	10	3	20	8
Is the equipment being properly maintained (i.e., daily/weekly/monthly preventative maintenance schedule	5	15	3	19	3
Is the machine the right application for the given job	2	20	4	18	1
Are all controls including emergency stop button clearly labeled and/or color coded or size differentiated?	21	16	2	3	3
MEASURMENT RELATED FACTOR					
Does the gage have a valid calibration date?	31	4	3	3	4
Does the gage have proper measurement resolution?	20	10	5	6	4
Did the environment influence the measurements taken	35	5	2	2	1
Was the proper gage used to measure the part, process, chemical, compound, etc.?	5	20	10	5	5
MATERIALS RELATED FACTORS					
Was the material properly tested?	2	30	5	2	6
Were quality requirements adequate for part function?	25	10	5	3	2
Was the material contaminated?	3	15	10	10	7
Was the material handled properly (stored, dispensed, used & disposed)?	26	4	5	5	5
ENVIROMENT RELATED FACTORS					
Is the process affected by temperature changes over the course of a day?	4	18	9	10	4
Is the process affected by humidity, vibration, noise, lighting, etc.	3	20	8	9	5
Does the process run in a controlled environment?	10	15	10	5	5
METHODS RELATED FACTORS					
Were the workers trained properly in the procedure?	35	2	4	2	2
Is the process under Statistical Process Control (SPC)?	33	5	3	2	2
Are the work instructions clearly written?	36	2	3	2	2
Are mistake-proofing devices/techniques employed?	23	7	10	3	2

*Source: own computation from survey data (2019)

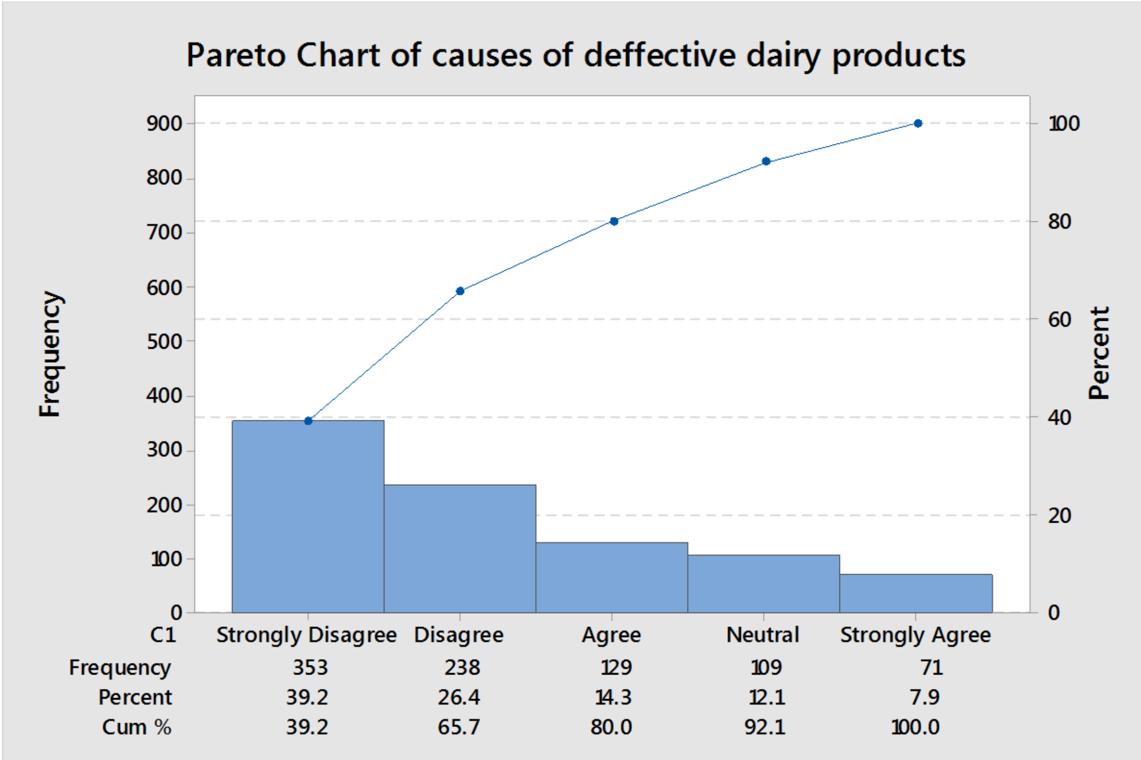

Figure 4.12 Pareto analysis of causes of defective dairy products for respondents

Source: own computation from survey data (2019),(Minitab18).

By considering the availability of more defective products as a proxy measure of quality improvement, it was found in the above table that the number of those respondents with strongly disagree, disagree, neutral, agree and strongly agree response are 353(39.2%), 238(26.4%), 109(14.3%), 129(12.1%) and 71(7.9%) respectively. Therefore, the SPC tools have resulted in an improved benefit in terms of quality service provision for its customers during the study period.

4.8.4. Basic Quality And Productivity Improvement Tools

The fifth group questions have focused on the basic quality Improvement SPC tools in SAI. About 26 of respondents of responses' that ,they have basic understanding about Check sheets & Scatter diagrams and 20% of Quality control department responses that ,they have basic understanding about Flow charts. The respondents responses about39 respondents suggested that Pareto diagram basic quality Improvement SPC tool is not familiar us. In addition to Pareto diagrams, about 35 respondents suggested that Fish bone diagram is another unique and peculiar SPC tools in SAI. The basic Quality Improvement SPC tools have been assessed in SAI and the results are shown in Table4.11-below:

Table 4.11 Basic Quality and productivity Improvement Tools

Basic Quality Improvement Tools	Rating of Results			
	Not familiar	Basic understanding	Well Familiar	Expert
Basic Statistics calculations(mean, median, mode, standard deviations, range and defect counts)	34	6	4	1
Check Sheets	10	26	6	3
Histograms	36	6	2	1
Pareto Analysis	39	5	1	0
Cause and effect/Ishikawa/Fishbone /diagrams	35	8	1	1
Scatter diagrams	28	26	1	0
Flow Charts	29	12	3	1
Run charts	32	10	3	0
Control charts	34	11	0	0

*Source: own computation from survey data (2019)

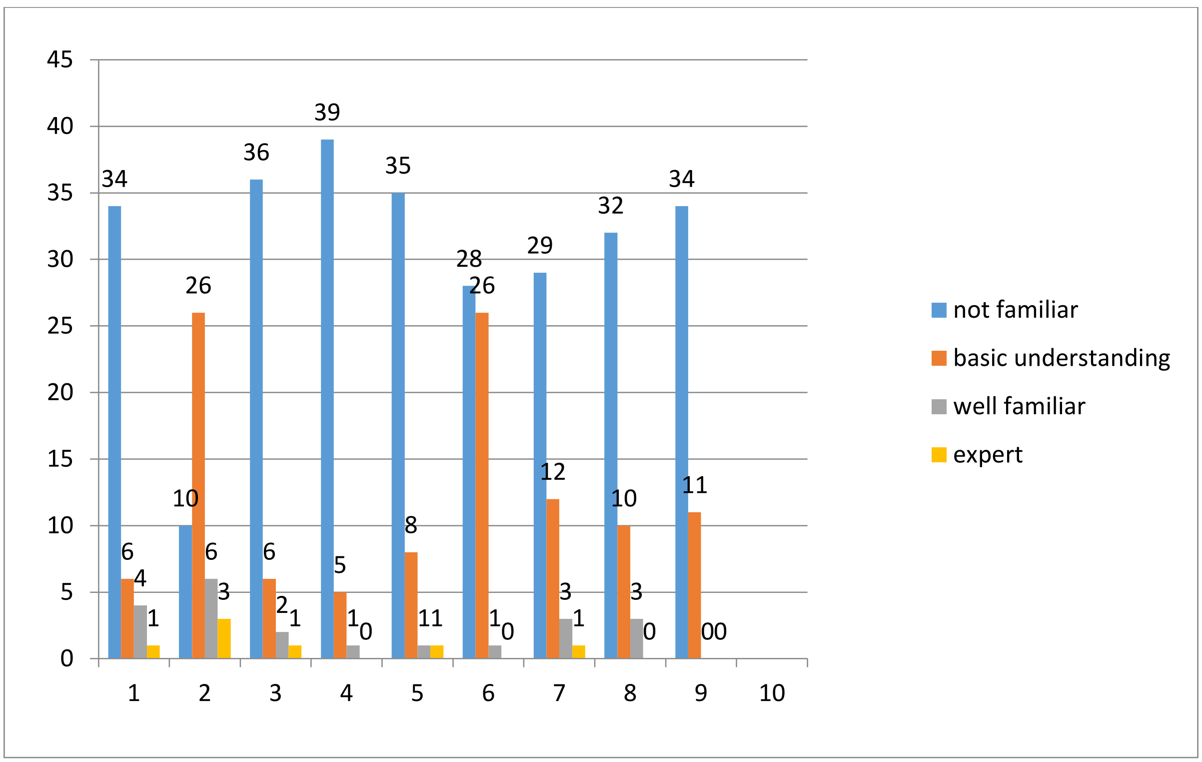

Figure 4.13 Histogram for basic quality and productivity improvement tools in SAI respondents numbers

Source: own computation from survey data (2019), (Minitab 18).

4.9.Economic Analysis Of Defective Dairy Products

Average production cost of pasteurized plastic milk is 24.50 Birr per liter (company's information).Actual packaging production of plastic milk is 2560013 liters that means

January=1250400 liters and February month =1309613 Liters of milk produced in case of SAI. As a result total loss from non-conforming product or defective pasteurized plastic milk was 134113 liters at January and February months. We calculated quality rates as follows:

Q (quality rate) = (total production – defective quantity or number)/total production; Quality of the process (QP)=$\frac{\textbf{output}-\textbf{defects}}{\textbf{output}}=\frac{2560013x24.5-134113x24.5}{2560013x24.5}$ **=568.804** quality of processes that means, 5.68% quality rate of defective products produced in process of plastic milk production line**..**

Productivity = total output/total input which is identical to total results achieved/total resources consumed or effectiveness/efficiency.

In effect, productivity becomes the attainment of the highest level of performance with the lowest possible expenditure of resources. It represents the ratio of the quality and quantity of products to the resources utilized.

Productivity= effectiveness/efficiency

Quality products=2560013-134113=2425900

Productivity=2425900/2560013=0.947=9.47%,productivity rate of the organization.

Profitability is defined as output volume times output unit price, over input volume times input unit costs (Bernolak,1997),or profitability=productivity+ price recovery(Miller, 1984).(134113/2560013=0.0524=0.524%, Van Loggerenberg and Cucchiaro (1981) explain how changes in profitability are caused by changes in productivity, price recovery, or in both of these factors.

Therefore profitability of the organization=0.999=9.99%, profitability rate of the organization. Annual total loss from non-conforming or defective pasteurized plastic milk was equal to 568.804x24.5x60x12 =10,033,702.56 Birr. Where; 568.804=number quality defective products, 24.5 unit price per liter,60=number of two months day, and 12 = number months per year. This loss will ultimately affect the total profit of the company. So in today's competitive manufacturing, this is of outmost importance to reduce total non-conforming pasteurized plastic milk or defective pasteurized plastic milk by continuous monitoring production through SPC tools.

4.10. Results Of Descriptive Data Analysis

We have found that, 89% of the organizations quality and productivity improvement problems is souring or clotting of milk. We have provided some suggestions related to souring quality problems. 39% of poor quality problems occurs due to lack of training for employees in the organization.76.66% , the first main current obstacle for poor quality and productivity improvement problem is due to absence of instruction(policy, rules and work procedures).39.2% causes of souring quality problems is related to the equipment affected by the environment, or the environment influence the measurements, this raise due to improper material handling ,the process never run in a controlled environment, the work instruction never clearly written.39 respondents responds that , they are not familiar about SPC tools in the company.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter mainly consists of Summery, Conclusion and Recommendation of the study.

5.1.Summary

The information provided can be interpreted by the respondents from the approximate value in the state of true value, information gained this survey is also limited and lack of description/reasoning on the results. Therefore, a qualitative study is highly advised to determine more explanations reflected towards the outcome of this survey. The sampling frame work for the survey focused only on dairy processing industry in the case of SAI, quality, in the dairy industry may have faced different challenges, using processes with different parameters and required unique approaches of SPC implication to improve productivity and quality. As some defects like souring, returns, damages, and breakages porosity are depends on lack for employees, lack of document properly interpreted, power interruption, lack of instruction/ procedures, environmental contamination, lack of control including emergency stop button clearly labeled, lack of valid calibration date, inadequate quality requirement, improper material handling.

5.2.Conclusion

The questionnaire survey, interview, direct observation, brain storming, control charts, Pareto chart, histogram, check sheets, and Fish bone diagrams analysis have provided useful information in identifying causes of quality problems products, quality defects such as souring, returns, breakages and damages, remedies and in proposing optimal solution to be implemented for SPC tools and productivity improvement in dairy industry in case of SAI.

Based on a survey result (chapter 4) ,the thesis addresses the current situation of productivity improvement techniques using SPC tools in dairy industry in case of SAI. The survey has indicated that quality and productivity improvement related problems are a serious deal to the survival of dairy industries in case of SAI.The main goal of this study is identify the defect and suggest a better solution to improve the production line performance of Quality control tools in dairy manufacturing process in order to minimize the Souring and Returns. Quality tools i.e. Pareto chart and Cause and effect diagram are used to identify and evaluate different defects and causes for these defects responsible for Souring/returns dairy products of at different stages (In process, Final Stage). Quality tools can be much wider applied with certain success. Quality tools are not so wider spread as expected although they are quite simple for application an easy for interpretations. Quality Control Tools could improve process performance by reducing product variability and improves production efficiency by decreasing souring and returns.

From the study it reveals that SPC techniques can give the significance improvement of quality. In this paper it has found that the SPC tools can be applied to different products for reducing the defects. Thus, the SPC techniques are used globally to improve quality. Although SPC seems to be collection of statistically based problem solving tools, there is more to the successful use of SPC than learning and using these tools, SPC is the most effective when it is integrated into an overall, companywide ,quality improvement program .

Control charts show that the process is in statically control for fat content, acidity of plastic milk and plastic milk Temperature in plastic milk production in case of SAI. Control charts did not show out of control conditions in this study. But control charts in plastic milk volume or weight did show statistically out of control conditions in this study.

Pareto principle and Cause and effect diagrams are used to identify and evaluate different defects and Causes for these defects responsible for souring and returns of components at different stages of plastic milk in dairy products production line in case of SAI. Minimizing defect is very important for ensuring the quality of products. The perceived quality of dairy industry is the result of a number of aspects, which together help achieve the desired level of satisfaction for customers. However, we should bear in mind that 1% defective product for an organization is 100% defective for the customer who buys that defective product.

So manufacturing the quality product is mandatory to sustain in this global competitive market. Our first objective is to identify the top positions where maximum defects occur and second is to identify the top defect types in those positions. Then the hierarchies of causes for each defects type are organized and the causes of those defect types are shown individually using cause-effect diagrams. Minimizing defects important for ensuring the quality of products. We have performed Pareto analysis and identified top four positions, where 46.7% of total defects occur. Then we have performed further Pareto analysis individually in those top positions to identify the defects types. Thus we have identified just four major concerning areas which are responsible for 1.53% defects in total. Then the hierarchy of causes for each defect types is organized and the causes of those defects are shown using cause- effects diagrams.

Acidity of milk, Milk temperature and fat content of plastic milk, all data points are within the control limits, variations in the value may be due to a common causes and process is in control. But weight or volume of plastic milk, data points fall outside the control limits, there is a variation and the variation may be due to a special causes and the process is out of control.

5.3.Recommendation

Souring and returns of plastic milk productive defects in dairy industry are due to manual operation of plastic milk packaging machine. These defects results lose of productivity, quality and profits to organization. Following some remedial issues are suggested for minimization of lose of quality productivity dairy products in case of SAI.

1. Change operating system from manual to automatic.

2.dosing unit adjustment control under and overweight or volume content estimating weight/volume, because under estimating weight is one of the major loses of customers and also overweight estimation is one the major loses of profitability of the company.

3. Proper adjusting packaging, UV light and labeling machine or use automatic packaging production machine.

4. Provide training for employees to avoid improper consistency of defective products of dairy products/plastic milk production line. And also provide training for employees in the field of health and tank purity control because dairy products by nature perishable and sensitive for different pathogenic organisms. Provide training for employees, new work procedures or instructions for weighting plastic milk volume content.

5. The following action plans suggestion for souring, returns and under and overweight estimation:

A. Man/operator/:

- ❖ Must have skill in identifying causes of defects before it occurs or provide training
- ❖ Must have attention and good attitude towards quality.
- ❖ Be able to identify defects quickly and accurately and how to remedy them /must have been provided.
- ❖ Reduce human in raw materials preparation

B. Machine set up and operations: avoid power interruption or must have reserve power supply while interruption occurs.

C. machine and Equipments: Preventive maintenance to ensure machine and equipment always in good conditions and batching scale / balances has correct calibration and improving set up of production changes and improving filling machine installations. Automated production machine and equipment used, not used labor based.

D. Materials:

- ➢ Use appropriate quality raw materials.
- ➢ Use batch correctly proportioned.

- Check contamination of the materials.
- Good preparation of materials must have been properly separated, washed and screened from impurities and dirt, because these factors are the main causes of souring milk occurrences in dairy products.

The following remedial suggestions focused on productivity improvement techniques in dairy industry in case SAI:

- ✓ To improve productivity of dairy products and the company becomes more profitable and competitive, must be up graded technology or new technology development, produce long life products like butter, UHT, Cheeses and produce variety of dairy products. Using SPC tools dairy industries reduce non conforming products, improve cost saving, SPC indirectly generates higher business sales through consistently to produce quality products, provide continuous learning through SPC, improve organizations competitive advantages.
- ✓ The poor application of Histograms, control charts, cause and effects diagrams, check sheets, Pareto diagrams, calls for a need to restructure the policies of the company regarding the use of SPC tools in SAI.
- ✓ Process reviews and operator training have to be undertaken for industry wide appreciation of SPC tools and their benefits to the quality deployment of various dairy industries entities in the country.
- ✓ Approach productivity measurement as an evolutionary process. Start with the inputs and outputs or productivity criteria that are easily quantifiable. Develop surrogate measures for the intangibles. Add quality dimension to the outputs. Periodically refine and revamp those measures. Productivity measures impact performance, care must be taken to ensure the measure does not induce inappropriate behavior.

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INTERNATE RESOURCES OR WEB SITES

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APPENDEX-A

DEFECTS-CAUSE CHECK SHEET

LOCATION:SEBETA AGRO-INDUSTRY PLC

PURPOSE: investigate occurrence of defective pasteurize milk.

STUDY PERIOD: FEB,01-31/02/2019

Data Collected By:----------------------------------DATE--

CHECKED BY:---SIGN---------------------------------------

Approved by---SIGN---------------------------------------

SAI PASTEURIZE MILK DEFECTS ANALYSIS

DATES	ACTUAL PACKAGES	BREAKAGES	RETURNS	DAMAGES	Clotting/Souring/
01/01/2019	34824/Litre	430/Litre	1004.5/Liters	426.5/Litre	40
02/01/19	33585	100	1174	342	____
03/01/19	37590	240	185	454	_____
04/01/19	39191	300	284.5	280.5	58
05/01/19	41293	540	417	324.5	____
06/01/19	42180	250	69.5	431.5	_____
07/01/19	41057	350	98	445	____
08/01/19	41585	270	1169	355	_____
09/01/19	33558	170	6716.5	303	_____
10/01/19	34230	100	4105.5	345.5	____
11/01/19	32895	280	3773.5	335.5	250
12/01/19	37586	370	1581.5	391.5	_____
13/01/19	39516	330	1452.5	399.5	____
14/01/19	43320	400	49.5	548.5	_____
15/01/19	47117	50	20	420.5	____
16/01/19	36060	220	503.5	428.5	___
17/01/19	47684	100	1748	408.5	36
18/01/19	38894	50	296	483	1589
19/01/19	52304	120	142	438.5	802
20/01/19	41877	220	428.5	382.5	619
21/01/19	46440	480	415	382	970
22/01/19	40662	300	286	376.5	1366
23/01/19	46555	120	71	365	724
24/01/19	43208	50	65.5	389.5	___
25/01/19	45583	250	68.5	361.5	2717
26/01/19	44783	100	136	313.5	________
27/01/19	53600	500	86	396	1334
28/01/19	50570	120	75.5	405.5	3365
29/01/19	59567	120	142.5	365.5	440
30/01/19	55712	210	192.5	465	3637
31/01/19	45715	250	24	373.5	____

TOTALS	1,250,400	7,390	62,781	12,137.5	17947
01/02/19	54383	300	146.5	408.5	Clotting/souring
02/02/19	56580	120	222.5	395.5	__
03/02/19	52230	220	40	427	__
04/02/19	51973	320	75	413	__
05/02/19	49800	420	_	428.5	__
06/02/19	52996	170	_	456.5	__
07/02/19	47790	70	_	456.5	210
08/02/19	43834	120	_	377	6907
09/02/19	42868	120	_	292.5	1891
10/02/19	42292	220	_	319	2583
11/02/19	45210	200	_	443	1300
12/02/19	41333	230	_	259	1166
13/02/19	47228	180	_	262.5	__
14/02/19	47224	100	_	288	294
15/02/19	43194	211	_	367.5	458
16/02/19	45800	100	_	336.5	477
17/02/19	45834	270	_	306.5	____
18/02/19	47816	220	_	270	624
19/02/19	46962	150	_	199	111
20/02/19	44779	200	_	164	1431
21/02/19	47059	200	_	197.5	105
22/02/19	43810	150	_	251.5	955
23/02/19	45398	170	_	284.5	260
24/02/19	45216	170	_	348.5	369
25/02/19	44258	150	_	313.5	__
26/02/19	43117	235	_	454	30
27/02/19	44800	250	_	380	_
28/02/19	45829	440	_	317	_
TOTAL	1309613	5706	484	9416.5	19171

TOTAL ACTUAL PRODUCTION=2560013

APPENDEX-B

QUESTIONAIRE

Survey questionnaire for a study on Productivity Improvement Techniques Using Statistical Process Control (SPC) in Dairy industry. Dear Sir/Madam, I am student of Master of Quality Control and Productivity Management (QMP) in St. Marys University. The following research is part of my QMP study and conducted for purely academic purposes. The purpose of the research is to find out the productivity improvement techniques using SPC tools in dairy industry. All the Information collected through the questionnaire will be used only for contribution to knowledge and kept secret/confidencial. 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.

Part1: General Information

This section of questionnaire refers to general information about the respondent. The information will allow me to compare groups of respondent.

1, Gender:-Male___________ Female________________

2. Qualification:- Diploma_____ First Degree_____ Masters______ others more than_____

Part II: GENERAL INFORMATION ON COMPANY

3. What is the main pasteurize plastic milk quality problem in SAI?(Please order the following milk quality problems in their order of occurrence in SAI) (1:Not occurrence, 2:Rarely occur, 3:Sometimes occur, 4:Frequently occur).

	1	2	3	4
A. Clotting /Souring	☐	☐	☐	☐
B. Volume/Weight/Fluctuation	☐	☐	☐	☐
C. Fat content Fluctuation	☐	☐	☐	☐
D. Temperature changes	☐	☐	☐	☐

Others (Please specify)____

4. What is the cause of quality problems in SAI? I*n Your opinion, what is the level contribution of the following causes for milk quality problems in SAI?*

1; Low, 2; Moderate, 3; High, 4; Very high

	1	*2*	*3*	*4*
A. Instructions	☐	☐	☐	☐
B. Environment	☐	☐	☐	☐
C. Materials	☐	☐	☐	☐
D. Measurements’	☐	☐	☐	☐
E. Machines	☐	☐	☐	☐

Others (Please specify)____

5. Please rank your familiarity with the following quality improvement basic tools in your company, 1: Not familiar, 2: Basic understanding, 3: Well Familiar, 4: Expert

Quality Improvement Tools	Rank of Familiarity
Basic statistics calculation (mean, median, mode, standard deviation, range, defect counts)	1 2 3 4 ☐☐☐☐
Cause and effect/Ishikawa/ fishbone diagram	☐☐☐☐
Check sheets	☐☐☐☐
Histograms	☐☐☐☐
Pareto analysis	☐☐☐☐
Scatter diagrams	☐☐☐☐
Flow charts/diagrams	☐☐☐☐
Run charts	☐☐☐☐
Control Charts	☐☐☐☐
Others (If any, please specify,):	

6. Which quality defects mostly occurs in pasteurized plastic milk in SAI? (Please Rank the defects in their degree of occurrence) (1; Low 2; Moderate 3; High, 4; Very High)

	1	2	3	4
A. Breakages	☐	☐	☐	☐
B. Returns	☐	☐	☐	☐
C. Damages	☐	☐	☐	☐
D. Clotting/Souring	☐	☐	☐	☐

Others (Please specify)____

7. What are the causes that related to people or internal Customers in SAI? (Tick for more than one answer is allowed)

☐Lack of document properly interpreted.

☐ Lack of training.

☐ Lack of understanding information.

☐Lack of guideline judgment available

☐ Other (please specify)____.

Part III: 8.Assess the main factors that affect productivity of pasteurize plastic milk in Sebeta Agro Industry

This section of the questionnaires prepared to collect data about the main factors that affect productivity of pasteurized plastic milk in Sebeta agro Industry (SAI). Try to recall as many factors that affect productivity improvement of pasteurized plastic milk as possible in ranking these statements. Please indicate the extent to which you agree or disagree with each statement by Ticking(X) on correspondent number. Higher number indicates higher level of agreements. Choose only one answer for each statement.					
General approaches Strongly Disagree(SD) (2)Disagree(D) (3)Neutral(N) (4)Agree (A) (5) Strongly Agree(SA)					
MACHINE RELATED FACTORS	1 (SD)	2 (A)	3 (N)	4 (A)	5 (SA)
Was the correct tool used?					
Is the equipment affected by the environment?					
Is the equipment being properly maintained (i.e., daily/weekly/monthly preventative maintenance schedule					

Is the machine the right application for the given job					
Are all controls including emergency stop button clearly labeled and/or color coded or size differentiated?					
MEASURMENT RELATED FACTOR					
Does the gage have a valid calibration date?					
Does the gage have proper measurement resolution?					
Did the environment influence the measurements taken					
Was the proper gage used to measure the part, process, chemical, compound, etc.?					
MATERIALS RELATED FACTORS					
Was the material properly tested?					
Were quality requirements adequate for part function?					
Was the material contaminated?					
Was the material handled properly (stored, dispensed, used & disposed)?					
ENVIROMENT RELATED FACTORS					
Is the process affected by temperature changes over the course of a day?					
Is the process affected by humidity, vibration, noise, lighting, etc.					
Does the process run in a controlled environment?					
METHODS RELATED FACTORS					
Were the workers trained properly in the procedure?					
Is the process under Statistical Process Control (SPC)?					
Are the work instructions clearly written?					
Are mistake-proofing devices/techniques employed?					

Thank you for your collaboration and sacrifice of precious time!!!

APPENDEX-C

SAI Interview Protocol

Section 1: Quality and production managers and Supper visors in the Dairy industry

1. What are the main causes of quality problems that affect plastic milk products in SAI?

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

3. What are the qualities problems mostly present in plastic milk products in SAI?

4. How do you identify defective plastic milk products in SAI?

5. What is the role of group or brainstorming activities within problem solving activities? How does an SPC team was developed?

Thank you for your collaboration and sacrifice of precious time!!!