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Establishing Relationship of the Variation in Raw Material Quality on Productivity

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Abstract: *Present days consumers demand consistent, defect free, high quality products. One of the key areas for production of high quality food is the quality of the raw materials and ingredients used. Raw materials can bring a significant variation to the process. The variability and sources of raw material may look marginal, but it has profound consequences. The physical and chemical composition of raw materials can have a drastic impact on the operating efficiency of the plant. A defective raw material can lead to the process being out of control and the product being outside specifications. Seven QC tools used for data collection, discussion and problem analysis and they are the important and effective methods for quality improvements. The study is designed to analyze the variation in the raw materials used in the manufacturing of confectionery products and the impact of variation on the quality of the products and productivity in the manufacturing processes. Considering if the quality of the raw materials which is used for the product manufacturing is improved then it is perceived that it could improve the overall product quality and productivity of an Organization reducing rework wastages and unnecessary stoppages. For this reason the basic quality tools will be used to evaluate the quality of raw materials and simultaneously process and productivity will be analyzed. The research will be aimed at exploring the different problems associated with the product quality and productivity due to the variations in the raw materials quality on the basis of the hypothesis and will be analyzed by the use of QC tools. Productivity can be greatly reduced by the incompetent quality of the raw material and this can be analyzed systematically with the help of Seven QC tools. Variability in confectionery food items due to substandard raw material significantly reduces the efficiency of plant and value of product also decreased in competent market environment. The study is designed to analyze the variation in the raw material quality used in the manufacturing of confectionery products and the impact of variation on the quality of the products and productivity in the manufacturing processeswith the help of seven QC tools.*

Keywords : *Confectionery Industry, Problem Solving, 7QC Tools, Center Filled Bubble Gum, Impact of Raw Material, Quality.*

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I. Introduction

Food industry, especially manufacturing of confectionery items like chocolate, bubble gum, sweet candies has distinct market segment and production of these items required continuous innovation in design with quality characteristics to appeal customer's satisfaction. Food industry in this paradigm possesses both product and service quality dimensions. Manufacturing setup of such confectionery products required proper quality control and assurance and definitely total quality management philosophy explicitly applicable to run production efficiently. Quality of product is desired property for food industry and particular quality characteristics of the food product can be evaluated by various means of visual examination and testing methods. Moreover, in visual inspection appearance of a confectionery product after objective test analysis found not satisfactory and the poor appearance of the product lead to initiate this study to determined actual phenomena causing such problems. In this regard statistical process control (SPC) and statistical quality control (SQC) techniques have been used for quality of process and product. Seven quality control tools specifically used to understand the overall behavior of raw material in different technical perspectives in online and offline process. Generally, decisions taken in food industry are based on test results and total quality management guru Ed Ward Deming in his proposed six diseases mentioned that decisions based on numbers and figures are not valid until proper quality control and assurance tools and techniques not applied for finding actual causes of variation with preventive approach to control probable occurrence of same variability in future outcomes. In this connection seven quality control tools are usually considered fundamental quality control tools were used for verification, moreover, statistical quality control techniques like nonparametric hypothesis testing is also used for inferential evaluation. Moreover, particular attention was given to each quality control tool out of pool for capturing maximum possible aspects may relate to the variation in the final product. In these perspectives, flow chart has been drawn to display the ongoing flow of material through different distinguished processes particularly related to the production of confectionery food products. Flow charts are simple way of tracing the fault line in continuous process, then check sheets being a quality control tool contain list of all necessary parameters deliberated to each stage of process already illustrated by flow chart or flow diagram. Subsequently statistical data belong to critical processes measured by physical and chemical testing are collected to draw histograms and control charts to understand actual variability along with its frequency. Variability found in control charts out of control or under control required proper evaluation and directly impact on executive decision for process parameters. Simultaneously, on the basis of observed variation, cause and effect diagram is very important tool used to analyzed possible causes related to particular effect. For example in this case crack appearance on the confectionery item "center filled bubble gum" is effect which may be due to substandard material of the product, and in detail defective material will consider as an effect which may be due to the improper chemical composition, inadequate material handling, operating conditions, machine settings or inherent problems in whole manufacturing process of such material. Similarly Pareto chart and scatter diagram also used to identify the particular factors which required to be controlled. Whole quality control practice initiated to provide defect free products to final consumer without compromising on quality of confectionery items. It is also mentioned that previously no research study has been done in Pakistan's confectionery food industry particularly by using SPC and SQC tools to evaluate quality of confectionery food products.

Significance of the Study

Quality of product with process approach system required some inputs and raw material is basic input of the process significantly impact on product quality and ultimately influenced the company sustainable growth. It has been appraised the research significance is for the organization to be in the market with major share among the competitors with superior quality and high product output leading to profit margin and reduce rework and wastage. This study will also help the organization in identification of the causes due to raw material quality which leads to processing problems, product problems, high rework/wastage and quality issues. In the conducted research it is also investigated the possibilities of applications of 7QC tools in the confectionery industry for the problem solving.

Objectives

The objective of this study is to establish the impact of raw materials quality on productivity in chocolate and confectionery industry by using seven basic quality tools for the quality evaluation of raw materials and to establish the relationship of variations in raw material quality and its impact on product quality and productivity.

II. Literature Review

1. Introduction to SPC

Statistical Process Controls is comprehensive term which can be elaborated in detail by defining what is meant by process, what and how will be control and which statistical technique will be used to measure controls by using SPC methodology organizations can sustain their growth in competitive market effectively and easy to provide quality product at reasonable cost (Woodall & Montgomery, 1999). We often collect data from process and it has been known from that data, variation always occurred due to inherent causes and special causes (Florac & Carleton, 1999). Generally SPC is referred to the W.Edward Deming who also known as father of total quality management and innovation (Ahmed, 2015). In view of above detail it is concluded that SPC is method for monitoring the process variability, controlling the variation and further improving the process through statistical analysis (Nomikos & MacGregor, 1995). Different studies shows that intrinsic variations in the processes chart being an outlier usually consider undesirable if appear outside the control limits and identification of this phenomenon can only be possible by the use of SPC which will enhance the target value in context of optimization and minimization of variability (Harris & Ross, 1991). SPC is not a new philosophy in food industry; it has been used in various industries since 1920, however after 1970Ss its importance and effectiveness has been realized being a necessity of process optimal performance to obtain products within specified limits (Lim, Sarina Abdul Halim, Antony, & Albliwi, 2014a). In 1924s Dr.Walter A Shewhart first time introduced his fundamental approach for SPC and Plan-Do-Study and Act model for quality of product was new philosophy at that time. However W.Edward Deming modified this approach into Plan-Do-Check and Act or PDCA cycle (Elghamrawy & Shibayama, 2008). Moreover, Control charts were developed by Dr.Walter A Shewhart is effective part of SPC also declared as basic tool for quality control suggested by ASQ in seven quality control tools (Senge, 1994). Descriptive statistics usually used for measurement of central tendency, measurement of dispersion, analysis of symmetry and skewness and further more graphical techniques including histogram, box plot, dot plots, normal probability plots etc. In these views data is basic requirement and generally has collection of data from two sources are used, one is primary data and other is secondary data.

In this study primary data will be used to describe behavior of raw material in different lots. Moreover, data can be differentiated into categorical and numerical types, where categorical data included color, language, designation, organization, gender etc. However, numerical data can be further distributed into discrete and continuous data (Isaac & Michael, 1971). Furthermore, coefficient of variation also short form CV is used to measure relative variation to the mean value in percentage, generally this practice used to compare more than two data set may be measure in different units but their percentage will provide how much process variability occurred (Samuels, Witmer, & Schaffner, 2012). 7QC tools containing flow chart, check sheets, histogram, Pareto chart, cause& effect or Ishikawa fishbone diagram, scatter charts and control charts are famous graphical tools used for quality control of process performance parameters (Straker, 1995).

1.1. Flow Chart Flow chart just provide visual representation of the process steps that a product or service follows and shows each step in process regarding decision and input and output of the process (Burbidge, 1963). Various researchers with similar thoughts also contributed to define types of flow charts, for example (Böhm & Jacopini, 1966) has distinctively define these flow chart types with different opinions according to the nature of business and organizational operational functions these categorical orders of flow charts can be expanded or may appeared with different name due to logical order, decision, product, process and relevant activities performed in business. In view of above details we can obtain variety of purposes successfully by adoption of this generic tool known as flowchart or flow diagram (Oakland, 2007). Frank and Lillian Glibrethto were pioneers of operational management philosophy and members of the American Society of Mechanical Engineers (ASME) had study the work flow and in 1921 presented first structured technique for simple process flow of documents to control documentation movement in standardized manner (Price, 2003). In 1947 innovative efforts of Gilbreth's in terms of proposed set of symbols officially reviewed by ASME and adopted as ASME Standardized operational flow process charts (Osten, 2006). Furthermore, in 1949 induction of computers being an emerging technology and development of flow chart in computer program was planned by Herman Goldstine and John von Neumann reported by Douglas Hartree. However, part II; Volume1 is unpublished report pertaining to computer programming flowcharts developed by Herman Goldstine and John von Neumann. Computer programmers realized the effectiveness of this tool and it has been adopted to write computer program algorithms by flowcharts with more result oriented approach and flow charts are now primarily based on building blocks of flow chart (Haigh, Priestley, & Rope, 2014). For continual improvement in process and to enhance the process understating can also managed with flowchart (Tague, 2005). Diamond is symbol used in flowchart to exhibit the point at which decision will be made by the management to handle the process in right direction (Tague, 2005).

1.2.Checklist Checklist of all requisite resources or documentation in a multistep procedure will be accomplished to keep the process on track (Bamford & Greatbanks, 2005). when collection of data initiated or finalized with predefined purpose or reason illustrate why data has been collected (Tague, 2005).

1.3. Histogram Statistical data of different observations occurs is often distributed according to frequency of events. To understand data distribution and frequency of incidents in the form of pictorial view, histogram is very important quality control tool for better process management and effective decisions. Thus, this tool make possible to communicate distribution of data with promptness and with ease (Lim, Sarina Abdul Halim, Antony, & Albliwi, 2014b).

1.4. Cause and Effect Diagram Cause and effect diagram proposed by Kaoru Ishikawa in 1968 is very famous tool in basic quality controls and due to its name, shape and purpose known as Ishikawa diagram, fishbone diagram, herringbone diagram and cause & effect diagram respectively. This tool through brainstorming techniques comprehensively covers/ collect possible aspects that may cause of problem or defects found in confectionery product manufacturing process. Generally typical categories has been made by the experts and observed in managerial practices (Malinowska, 2010). So exploring more causes will provide complex but comprehensive and precise list of possible cause pertains to problem statement (Tague, 2005).

1.5. Scatter diagram is illustration plot on Cartesian coordinates to display relationship between two variables. If pair of numerical data of variables is correlated, the points will accumulate along a line or curve. Trend line drawn to illustrate the relationship established between variables by using best fit procedures to determined correlation and this techniques in detail analysis known as regression analysis (Montgomery, Runger, & Hubele, 2009). Shape of data or dispersion of data helps to initiate cause and effect analysis through brainstorming to provide resolution for specific variability observed (Tague, 2005).

1.6. Pareto chart is quality control tool refers to the name of Vilfredo Pareto for his effective development. Occurrence of events depicted in diagram helpful to mitigate process ambiguity through effective decisions and obtain normalization of typical factors or defects reported in quality control (Sokovic, Pavletic, & Fakin, 2005). Pareto analysis for data pertains to defects frequency in a process by sorting most significant problem may affecting the process and required special focus to analyze particular components induces the variation in a process (Tague, 2005).

1.7 Control Chart Walter A.Shewhart studied and designed the behavior of processes and proposed controls charts also known as process behavior of Shewhart charts ("Control Charts," 1979). In 1920s this invention was basically deployed to improve transmission system's reliability of the Bell Labs by reducing variation in process quality generally due to common and special causes illustrated on schematic control chart (Murdoch, 1979). If process found under control or within upper and lower control limits then process will be considered as stable and there is no need to alter the such process; while in case of performance parameters has observed out of control limits then technical analysis for understanding the root cause will be needed to obtained process in consistency (Evans & Lindsay, 2002). Stability of the process or statistical control process with data pattern examination for quality of product or services to prevent non conformity (Tague, 2005).

III. Research Methodology

1. Research Design

Research analysis of any sciences required appropriate design for data collection and interpretation of the results. Design of this study is basically hypothetical study of confectionery products of a manufacturing unit in Karachi, Pakistan. In order to establish the relationship of the variation in raw material quality on productivity the quantitative approaches including empirical and applied research being used as a case study to understand the behavior of five lots / tested piece" of center filled bubble gum in terms of "three types of defects". Furthermore, design of this study has brief methodology for the data collection and analysis. This study consists of qualitative and quantitative methodology or fixed and flexible in nature by analytical perspectives. In fixed viewpoints we know that dependent variables are required to be investigated or measured quantitatively as number of defects in this case. However, qualitative nature of variables also inherently existed as three types of defects observed or not observed (Yes / No) being a leaked, cracked or de-shaped pieces of center filled bubble gum. Occurrence of these qualitative attributes measured as discrete values in SPSS as "yes=1" and "No=0" and similarly quantification of defects calculated as number of 1s and 0s for each type of defect respectively. It has been assumed that quality of material is cause of variation in final product and reduces the plant efficiency due to defective output.

2. Research Methodology

Simply methodology implies to statistical analysis to collect data, analyze descriptively and or test hypothesis by using intended methods or techniques like in this project data has been collected through oven test results of center filled bubble gum and seven quality control tools are applied to obtained data being a descriptive analysis as well as inferential statistical techniques used to measure the significance of product variation occurred in degraded quality of selected lots. In this perspective nonparametric hypothesis testing used for understanding the correlation and variance of the variables "defects" in order to conclude significance. Prior to applying data measurement statistical quality control tools theory and procedures are elaborated in detail literature review. Moreover, existing collected works on study method demonstrate positivism in data collection and interpretation, likewise investigation and interpretation of data at all stages is free from biasness. In addition, systematically descriptive scrutiny and numerical conclusions are pronounced to realize authentic condition of the products being tested from five distinct lots. This perception about research is primarily distributed into two sets existed as experimental and interpretative manner and individually techniques associated to the deductive and inductive methodologies. This study based on primary and secondary data and instrument for secondary Data collection is internet resources specially research articles and books available on statistical quality control relevant to the food industry. However, primary data is a result of scientific equipment generally used to measure accelerated shelf life is oven and the results were analyzed by seven QC tools. Design of data collection instrument used contains multiple aspects generally considered important parameters for product quality. Furthermore, interpretation of collected data will be evaluated on statistical software like SPSS, Excel to provide data behavior on different statistical models and specifically seven quality control tools to conclude the results of data.

2.1 Population Confectionery food products have various types however, center filled bubble gum is a population of the study. The population is aggregate of items representing totality with respect to all characteristics like in this study color, taste, shape, weight etc. However, objectives of this study focused on defective bubble gums instead of other characteristics related to the population.

2.2 Sampling In this study total n=300 samples were selected from 05 lots of center filed bubble gum being a test piece where 60 samples were selected from each lot. The process of sampling distributed into two separate categories as production samples were main focus of this project but data from 05 standard lots were also taken on the same rate as n=300 and 60 samples from each lot after the replacement of gumbase as it was observed from the fish bone and other QC tools that problems were due to the incompetent quality of the gumbase. However, purpose of standard sample is to compare the defective lot variability from standard lot products.

2.3 Data Collection Procedures Following procedure was adopted to collect the data of defective products appeared on oven test:-

- Start the oven and set the temperature at 45°C.
- Place the thermometer inside the oven for counter checking of the temperature.
- Accurately count 60 pieces of the product samples and place it inside the oven for 24 hours at 45°C.
- After 24 Hours take the sample from the oven and place it inside the desiccators.
- Examine each pieces for leakage, cracking and D-shaping.
- If rejection percentage is below 10 % the product is acceptable or otherwise not acceptable.

IV. Data Analysis

1. Check Sheets

In the light of available literature and best practices followed in confectionery product manufacturing plants, a comprehensive check sheet is prepared including all necessary aspects shown in table 4.1 . Furthermore, check sheet is divided into two distinct parts of production floor process of central filled bubble gum are line clearance checks and pre-production checks. First part of check sheet about line clearance containing queries about placement of cartons, pouch rolls, display boxes, wrapper rolls and segregation of packaging material with proper labeling as shown in Table 4.2. Second part of the designed check sheet contain all pre-production operational checks to ensure quality of the raw material not affected by any resource or desired characteristics as well as environmental condition of the operational unit. Initial part of the check sheet is related to health and safety purposes included waste removal, floor/bins/doors/drains cleanliness. Staff uniform cleanliness and adoption of safety standards by the staff like hair cover, safety shoes, gloves and mask etc. Similarly, cleanliness of process equipment for productivity enhancement, separate stacking of rework material, validity of material, availability of personal protection (PPs), proper labeling, maintenance of environmental temperature for processing etc. are in detail mentioned in table 4.3.

Table 4.1 Check Sheet Heading Information

AREA/ OPERATION: ____________________	**DATE: __________________**
PRODUCT NAME : ____________________	**SHIFT: __________________**

Table 4.2 Line Clearance Checks

S. NO.	Line Clearance Checks	Yes	No	N/A
1.	All products cartons from previous batch/product were removed.			
2.	All products pouch rolls from previous batch/product were removed.			
3.	All products wrapper rolls from previous batch/product are removed.			
4.	All products display boxes from previous batch/product are removed.			
5.	All packaging material is properly segregated and labeled.			

Table 4.3 Pre-Production Operational Checks

Ser.	Pre-Start Up Operational Checks	Yes	No	N/A
1.	All waste is removed from the area.			
2.	All waste bins are cleaned, washed, dried and available.			
3.	Floor is cleaned and free of any foreign matter			
4.	All drains are cleaned, washed and dried			
5.	All doors, windows and walls are cleaned			
6.	All process staff has wore hair cover; beard mask and safety shoes as per GMP defined standards.			
7.	Uniforms of all staff are cleaned and washed as per defined standards.			
8.	All re-worked product has been enclosed in poly bags and stacked properly with identification.			
9.	All processing equipment and tools are properly cleaned, washed, sanitized and dry as per required cleaning method and schedule.			
10.	Raw material / packaging material to be used for batch is approved and the required quantity is issued from store as per requirements and available.			
11.	All raw materials to be used have valid expiry dates.			
12.	Temperature and humidity of the area has been recorded in the temperature record sheet as per defined schedule.			
13.	All PPE's required are cleaned, washed and dried and available.			
14.	Documentation required for the process is available and ready for use.			
15.	All metal detectors are calibrated with the specified standards and recorded on the metal detector record sheet as per defined schedule.			
16.	All raw materials are properly labeled by store for identification and traceability purpose.			
17.	All weighing scales are checked and records are well maintained.			
18.	All Rodent traps/trays are inspected and free of rodents.			
19.	Ensure correct Best Before Date printed on wrapper/pouch/display box and attach the sample.			

2. Flow Charts

Gum products manufactured in a continuous production environment and flow of entire production process is deliberately shown in figure 4.1. Flow chart of the manufacturing processes often displayed in production units for the understanding of the process by staff or operators to handle process efficiently.

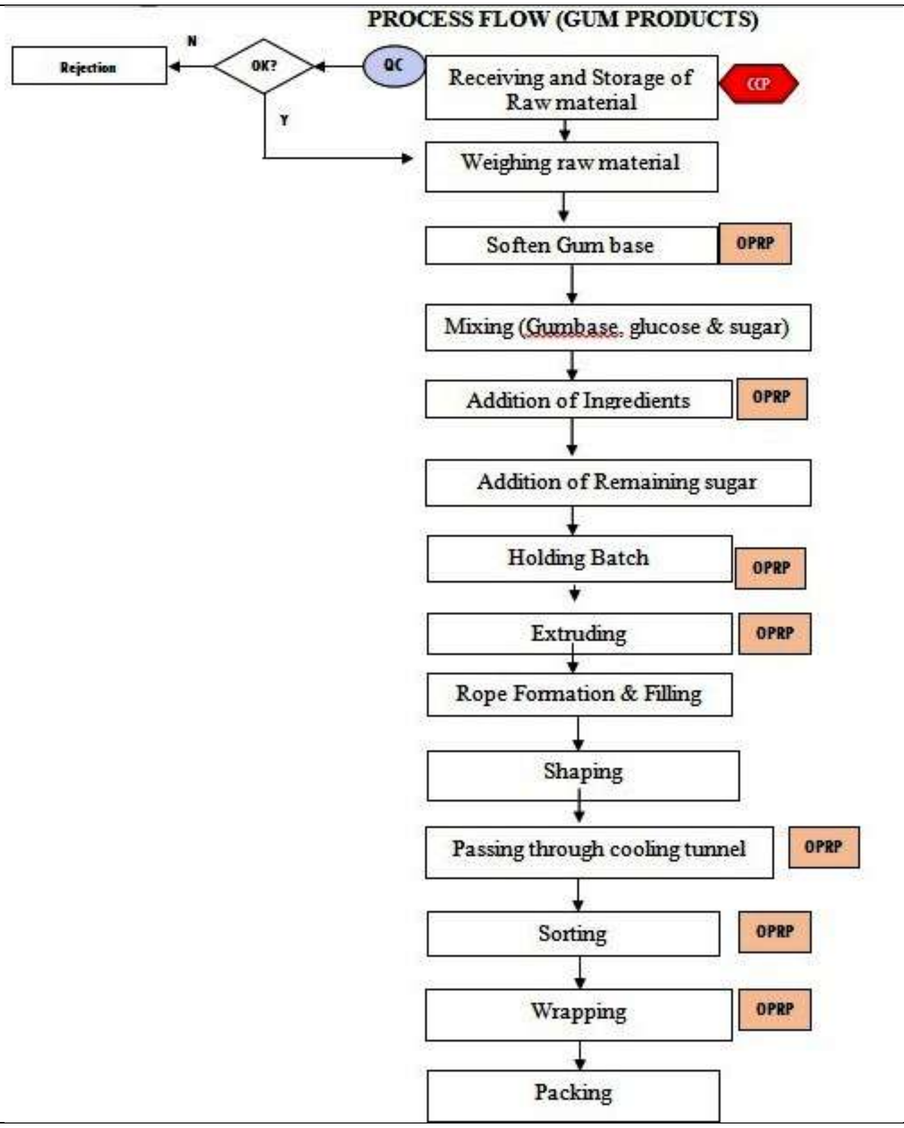


Figure 4.1 Flow Chart for Center Filled Bubble Gum Product

3. Histograms

From histogram figures 4.1, 4.2. 4.3, 4.4. 4.5, 4.6. of production and standard lots respectively we can easily conclude that the histogram of the production lots found negatively skewed whereas the histogram of the standard lots is positively skewed which clearly shows that after the replacement of the gum base in center filled bubble gum recipe the leakage,cracking and de-shape problem is controlled. In standard lots only 28 pieces found leaked which is 9.33% of the total while production sample is 35.67% of the totals found defective being leaked products shown in figure 4.7and figure4.8. In standard lots only 28 pieces found cracked which is 9.33% of the total while production sample is 29.7% of the totals found defective being cracked products shown in figure 4.9 and figure 4.10. In standard lots only 07 pieces found de-shaped which is 2.3% of the total while production sample is 27.7% of the totals found defective being cracked products shown in figure 4.11 and figure 4.12.

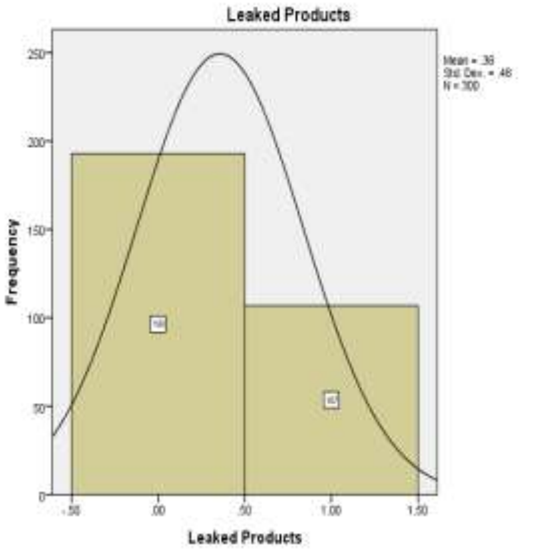


Figure 4.1 Production Lots

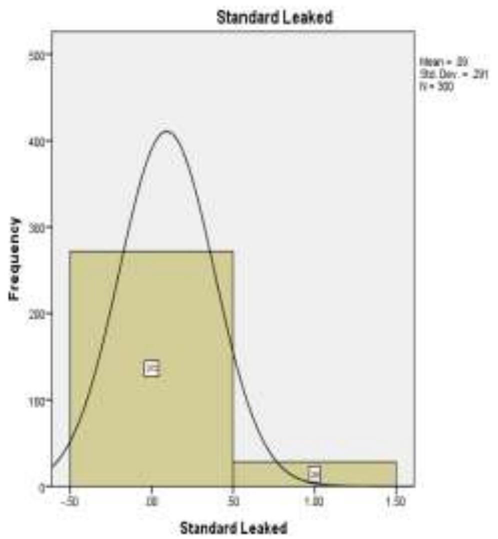


Figure 4.2 Standard Lots

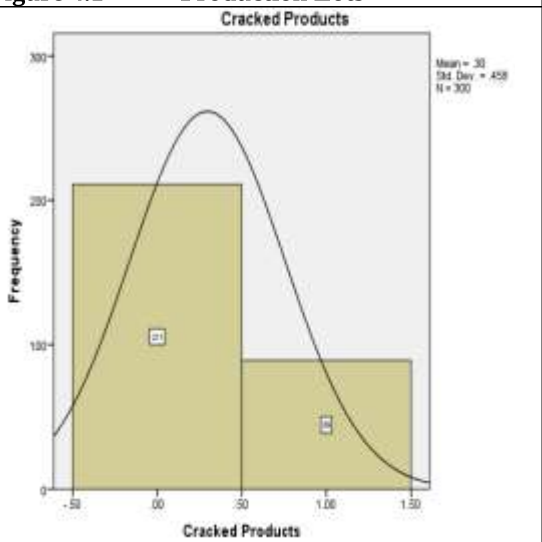


Figure 4.3 Cracked Products

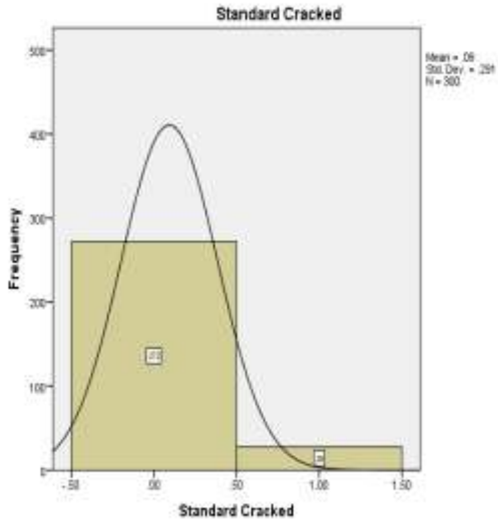


Figure 4.4 Standard Cracked Products

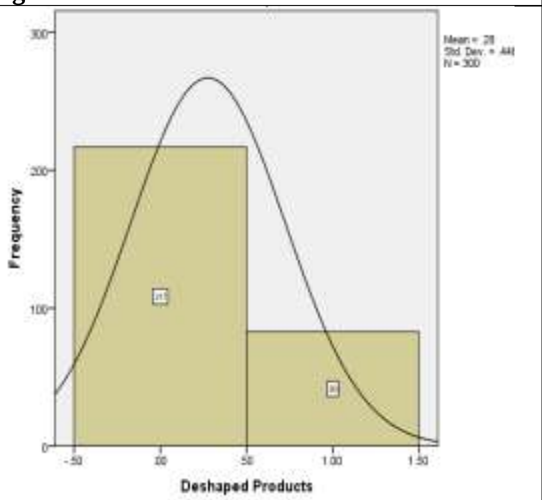


Figure 4.5 De-shaped Products

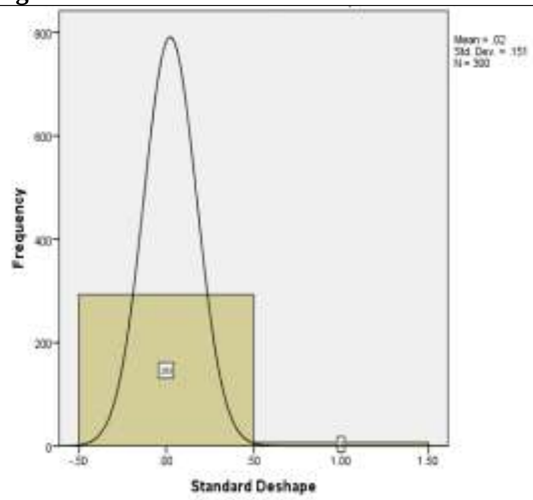


Figure 4.6 Standard De-shaped Products

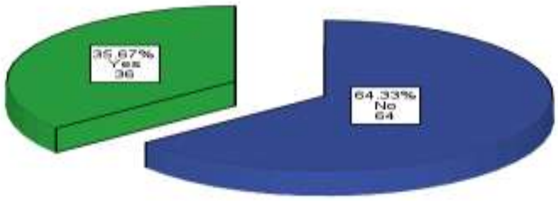


Figure 4.7 **Production Leaked Products**

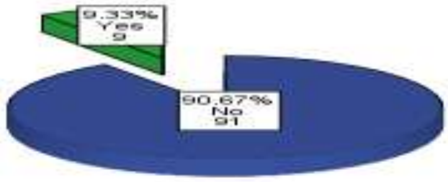


Figure 4.8 **Standard Leaked Products**

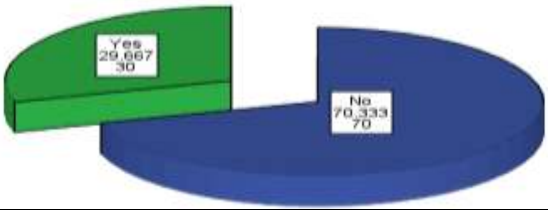


Figure 4.9 **Production Cracked Products**

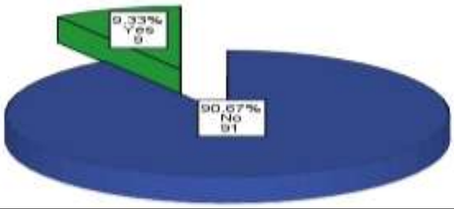


Figure 4.10 **Standard Cracked Products**

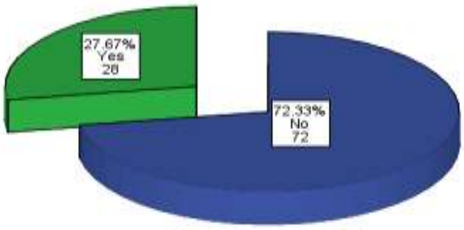


Figure 4.11 **Production De-ShapedProducts**

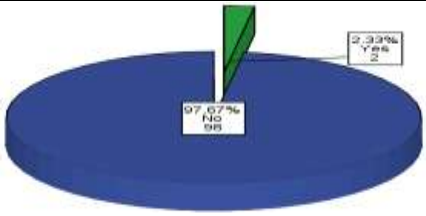


Figure 4.12 **Standard De-Shaped Products**

4. Pareto Analysis

Pareto chart for each production lot data is illustrated in figure 4.13, 4.14, 4.15, 4.16, and figure 4.17. However, figure 4.18 shows cumulative results for defective pieces of all lot in summarized form. From visual illustration of Pareto diagram it has been found that most of the products are leaked and dominantly appeared in all charts on the left with highest frequencies; whereas from cumulative Pareto chart we found that crack products are second largest defect appear in the production lots. Although the Pareto charts are used to evaluate the vital few to control the defect but in this case the Pareto chart used to compare the results of the production and standard samples shows that the leakages, cracking and de-shaping have no relationship with each other but these defects were minimized in the standard samples after the replacement of gum base in the recipe of the center filled bubble gum. Hence, it is concluded that incompetent quality of gum base results leakage, cracking and de-shaping in the production samples.

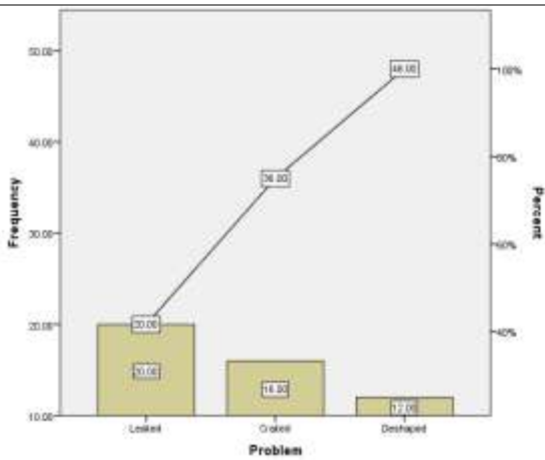


Figure 4.13 **Pareto Chart Lot-1**

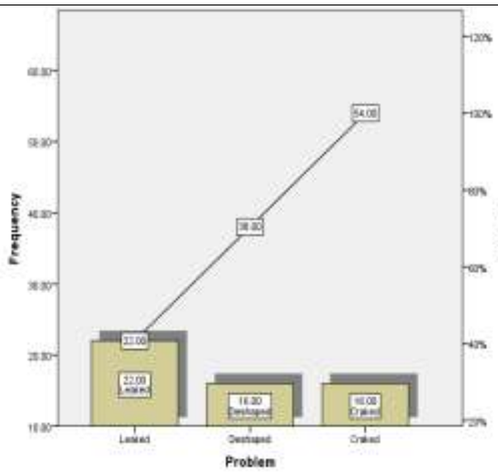


Figure 4.14 **Pareto Chart Lot-2**

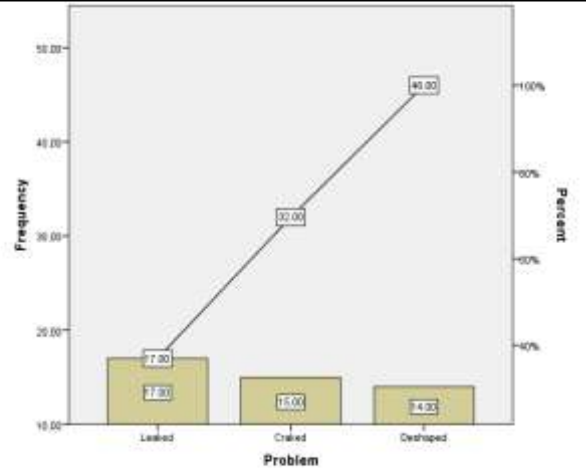


Figure 4.15 Pareto Chart Lot -3

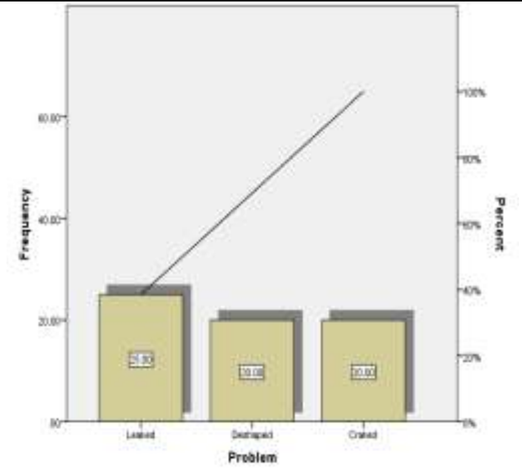


Figure 4.16 Pareto Chart Lot -4

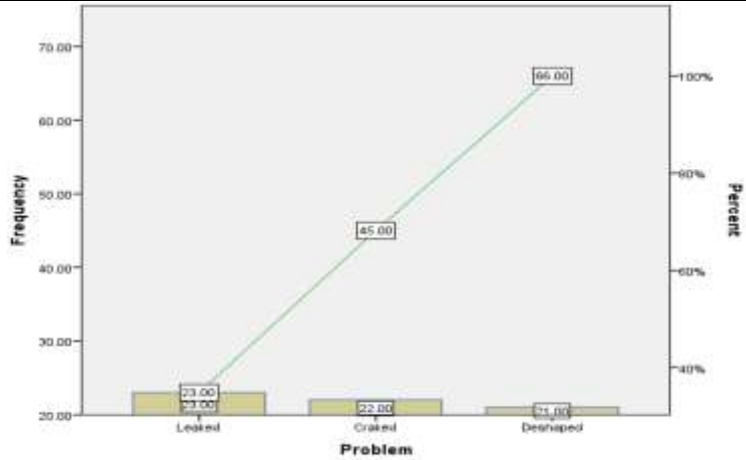
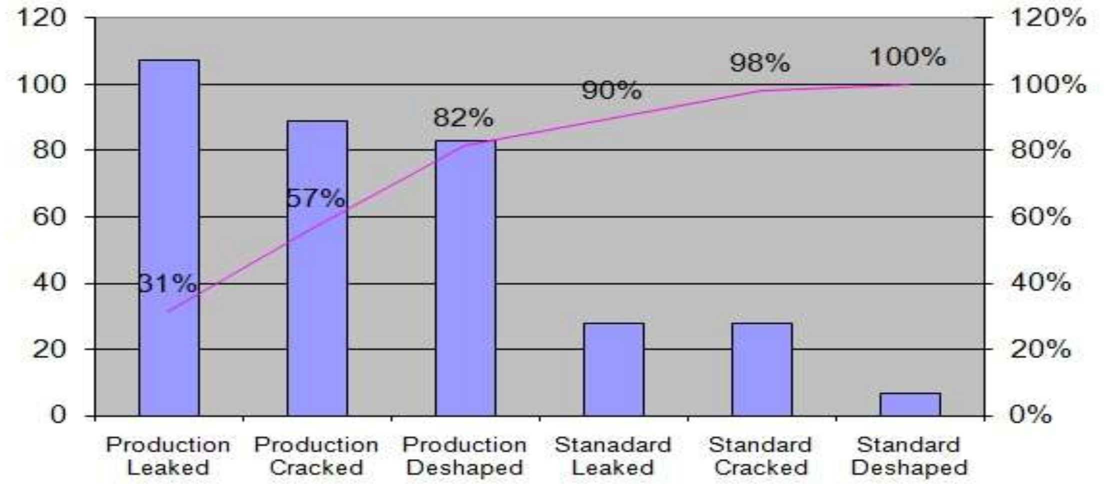


Figure 4.17 Pareto Chart Lot -5



	107	89	83	28	28	07	Total=342
Cumulative	107	196	279	307	335	342	
Percentage	31%	57%	82%	90%	98%	100%	

Figure 4.18 All Production lots Pareto chart

V. Cause and Effect Diagram

Brain storming session was conducted to evaluate the possible causes behind these three defects frequently occurred as collected through oven test results. In this perspective team of experts and general workers of the production process has been selected to express their valuable statements for investigation of problem with appropriate possible effective solution. In order to effect of product variation and causes relationship information related 5M was collected. The team had identified the root cause. The team of experts observed that incompetent quality of gum base leads to the leakage,cracking and dents problems in the center filled bubble gum. The team decided to change the gum base supplier in order to avoid the future problems.

VI. Control Charts

There are many types of control charts are used for process control to attain quality characteristics of final yield. In this study attribute control charts (C Chart) and variable control charts (individual with moving range charts) are used for analysis of non-conformity as cumulative and for individual sample behavior of observation.

6.1. Attribute Control Charts (All Lots Standard Vs Production)

In figure 4.19 attribute control chart for production lots has shown that at centerline average defects observed in all production lots at each test. Moreover, as shown in figure 4.20the results of the standard sample were found under the acceptable limits after the replacement of the gum base in the recipe of the center filled bubble gum.

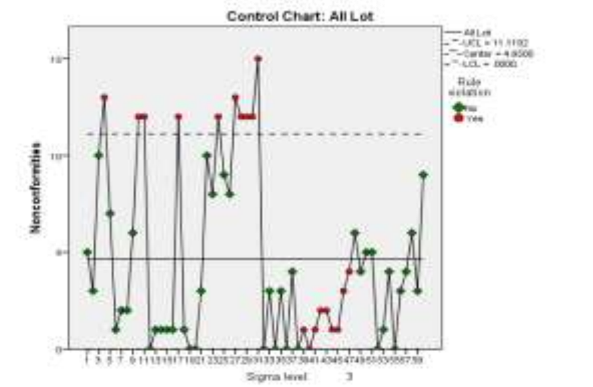


Figure 4.19 Attribute Control Chart (C Chart) – All Production Lots

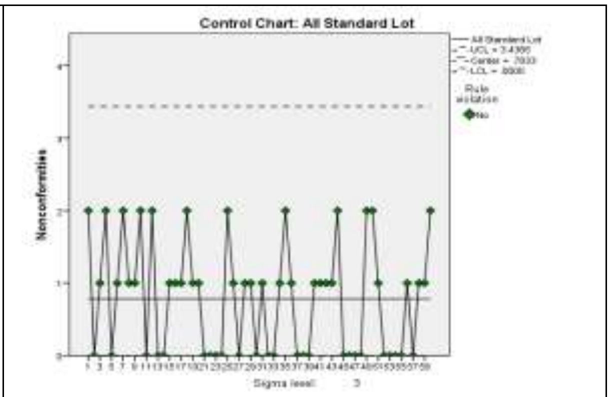


Figure 4.20 Attribute Control Chart (C Chart) – All Standard Lots

6.2. Individual Control Charts (All Lots Standard Vs Production)

In figure 4.21 attribute control chart for production lots has shown that at centerline average defects observed in all production lots at each test. Moreover, as shown in figure 4.22 the results of the standard sample were found under the acceptable limits after the replacement of the gum base in the recipe of the center filled bubble gum.

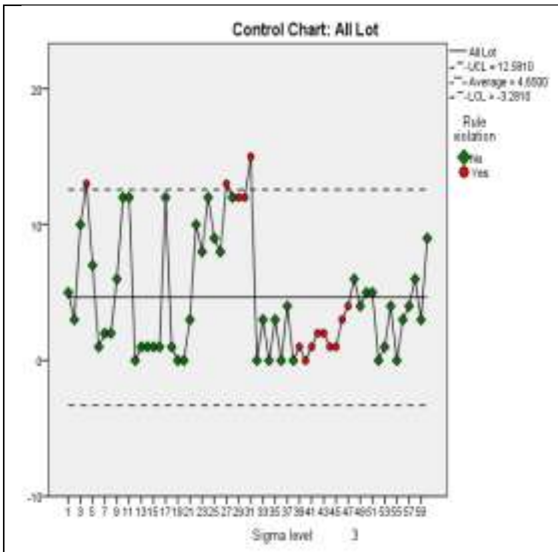


Figure 4.21 Individual Control Charts (For All Production Lots)

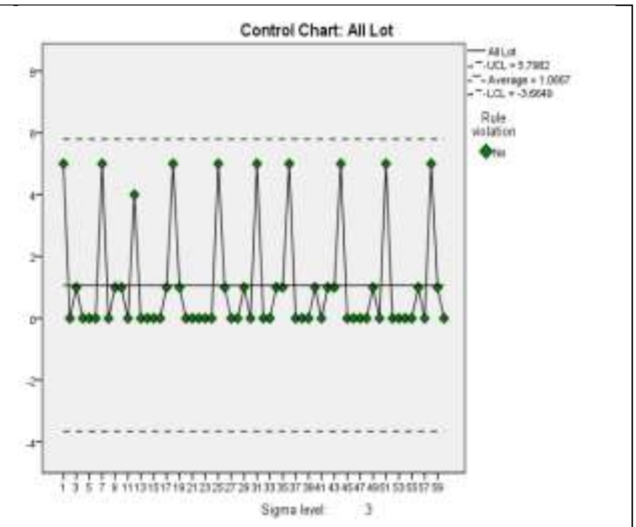


Figure 4.22 Individual Control Charts (For All Standard Lots)

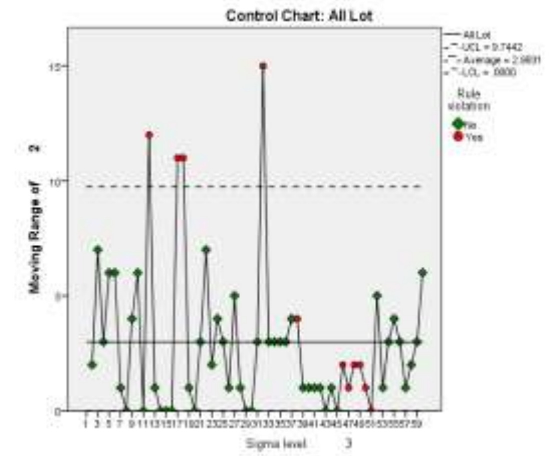


Figure 4.23 Individual Control Charts – Moving Range (For All Production Lots)

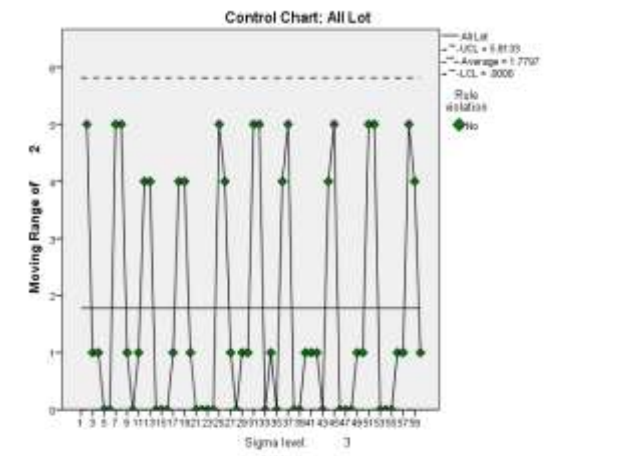


Figure 4.24 Individual Control Charts – Moving Range (For All Standard Lots)

6.3. Individual Control Charts (Standard Vs Production for each Lot) Control charts for each lot number with respect to defects on individual and moving range scale are shown from figure 4.25 and figure 4.43 respectively.

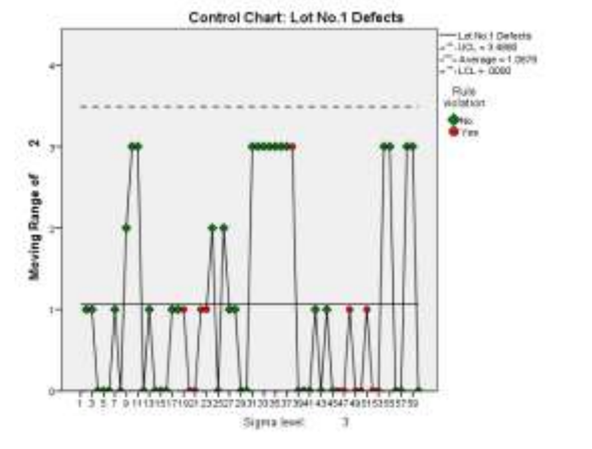


Figure 4.25 Individual Control Charts (Production Lot1)

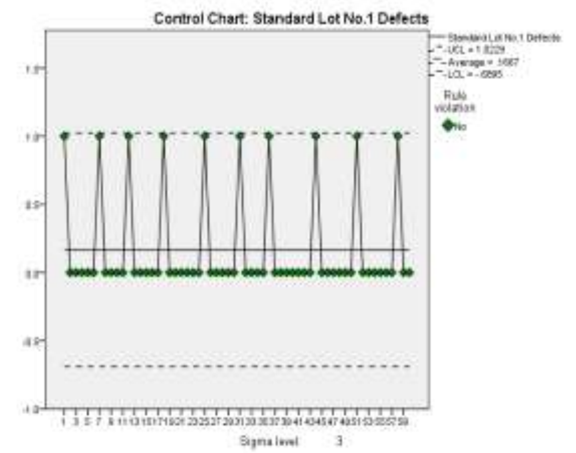


Figure 4.26 Individual Control Charts (Standard Lot 1)

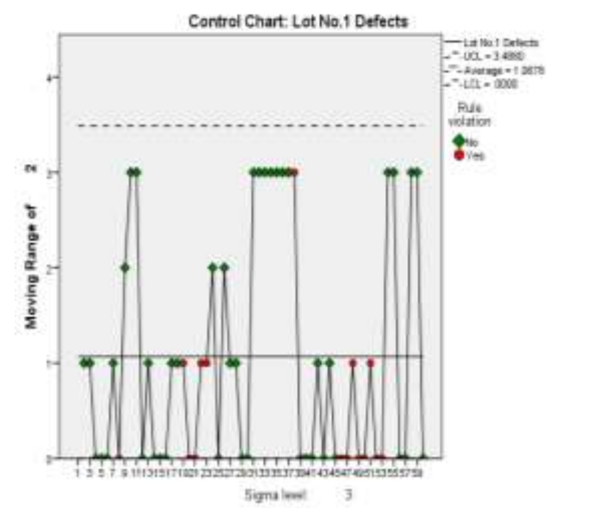


Figure 4.27 Individual Control Charts (Production Lot1)

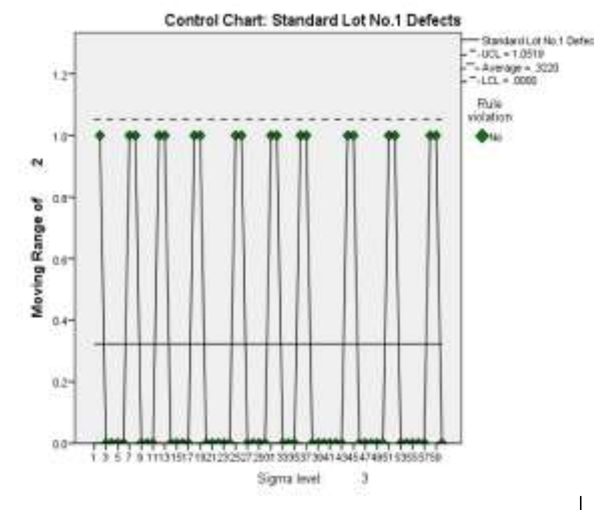


Figure 4.28 Individual Control Charts (Standard Lot 1)

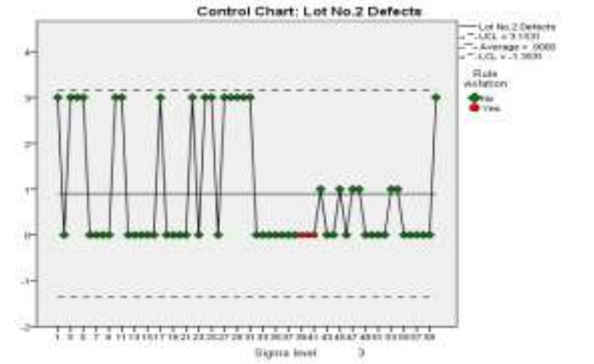


Figure 4.29 Individual Control Charts (Production Lot2)

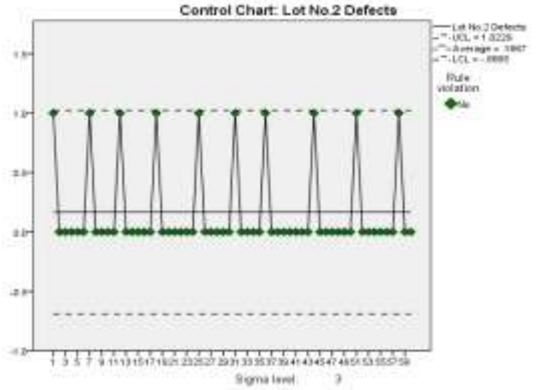


Figure 4.30 Individual Control Charts (Standard Lot 2)

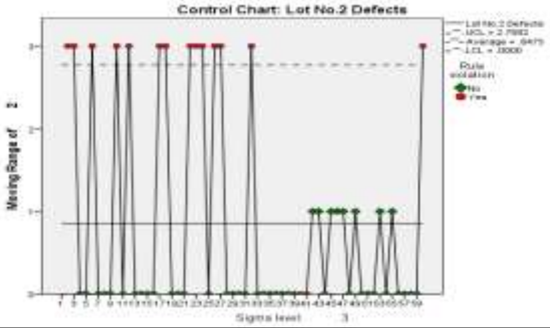


Figure 4.31 Individual Control Charts (Production Lot2)

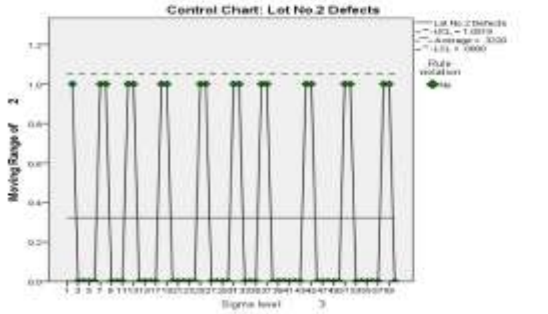


Figure 4.32 Individual Control Charts (Standard Lot 2)

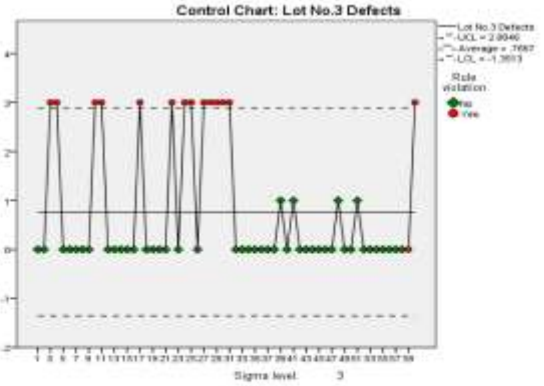


Figure 4.32 Individual Control Charts (Production Lot3)

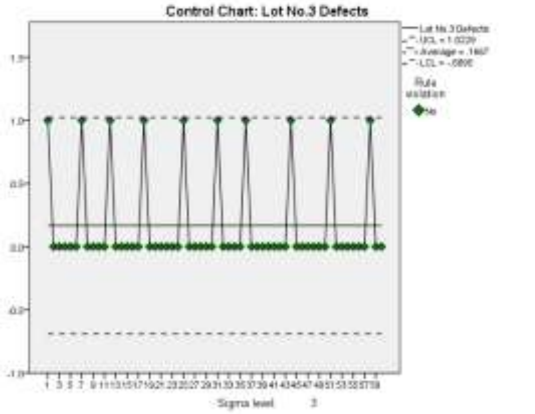


Figure 4.33 Individual Control Charts (Standard Lot 3)

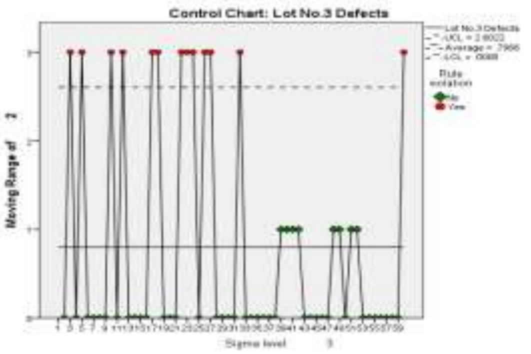


Figure 4.34 Individual Control Charts (Production Lot3)

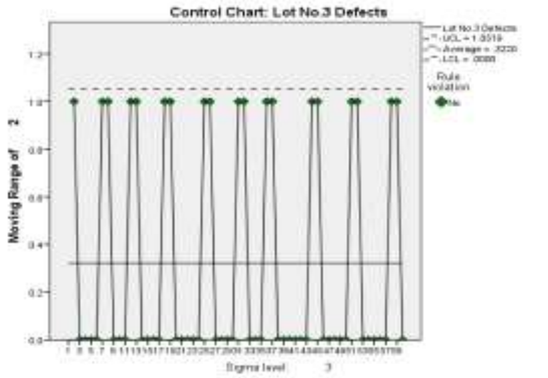


Figure 4.35 Individual Control Charts (Standard Lot 3)

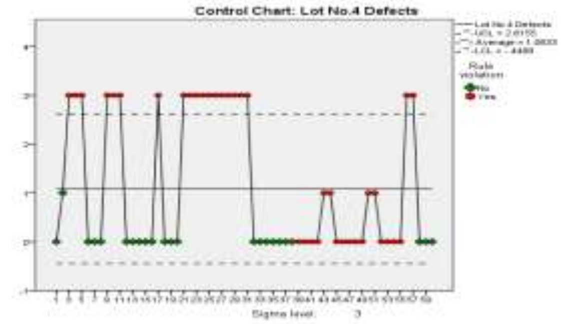


Figure 4.36 Individual Control Charts (Production Lot4)

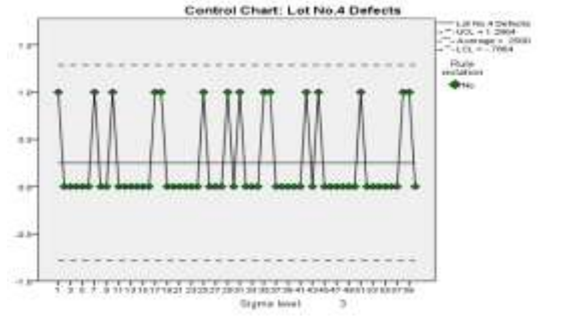


Figure 4.37 Individual Control Charts (Standard Lot 4)

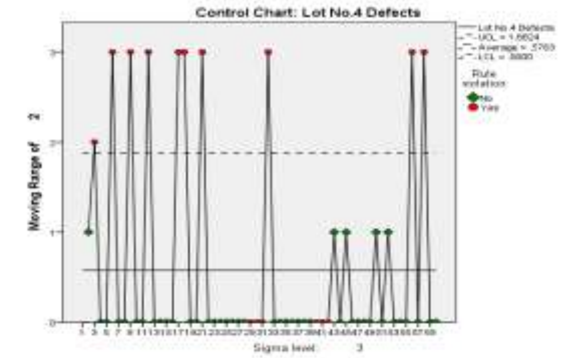


Figure 4.38 Individual Control Charts (Production Lot4)

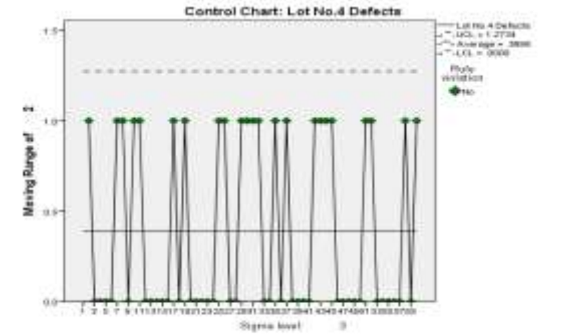


Figure 4.39 Individual Control Charts (Standard Lot 4)

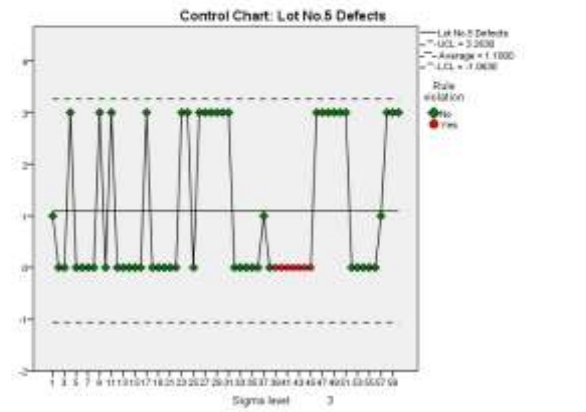


Figure 4.40 Individual Control Charts (Production Lot5)

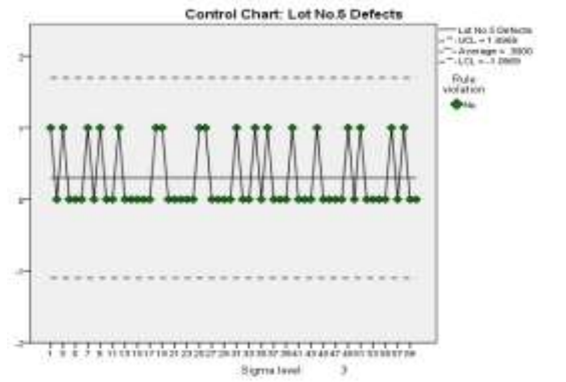


Figure 4.41 Individual Control Charts (Standard Lot 5)

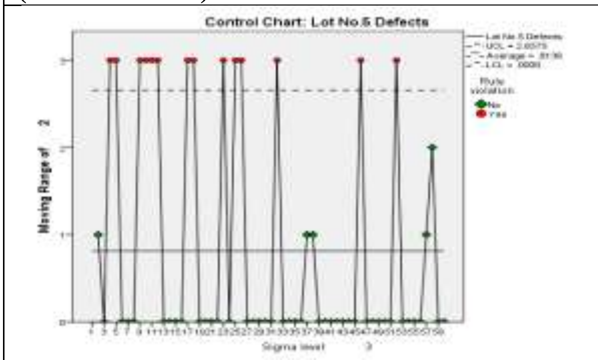


Figure 4.42 Individual Control Charts (Production Lot5)

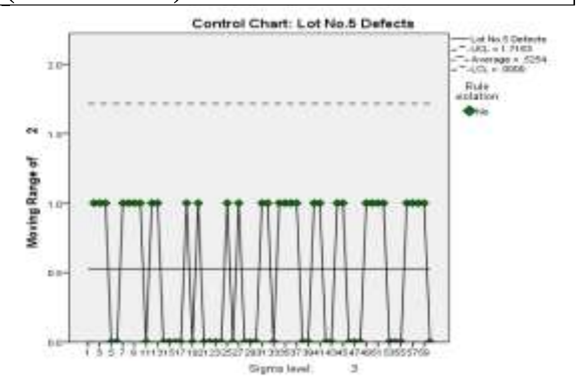


Figure 4.43 Individual Control Charts (Standard Lot 5)

VII. Scatter Diagram

Scatter diagram plotted as figure 4.44 for production lots and figure 4.45 for standard lots shows that there are 60 numbers of pieces were inspected after oven testing and horizontal axis demonstrating total number of defects appeared in each test of respective lot.

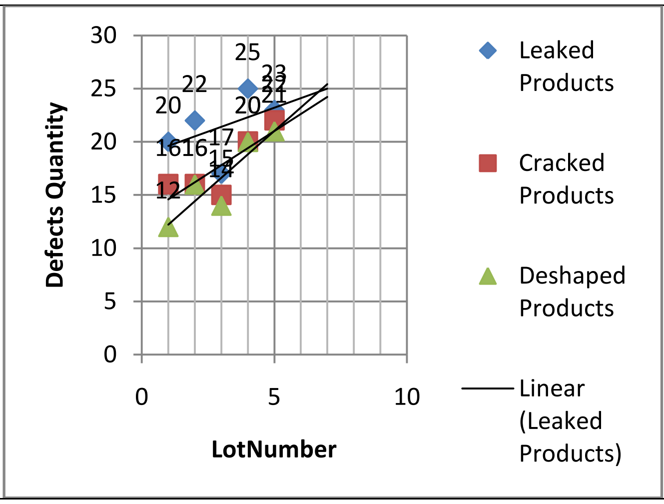


Figure 4.44 Scatter Diagram of Production Lots

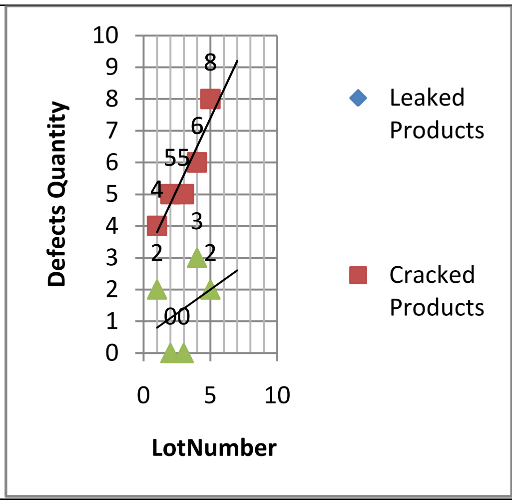


Figure 4.45 Scatter Diagram of Standard Lots

VIII. Findings And Conclusion

1. Summary

Although quality of confectionery food items are considered important for customer satisfaction but its significance is increased during production process. Customer perceptions are generally based on made up products and definitely products prior to final packing are thoroughly checked by quality control department whereas, during production even small quantity of probable defects decrease the efficiency of the manufacturing plant because due to defects like leakage material of the products spread and splashed in the machines which required additional cleanliness, work force and time. Recently, production units are more quality conscious as new theories like zero defects, six sigma and process lean sigma are known for defects free quality products and in confectionery food items mainly depend upon quality of raw material. It has been assumed that raw materials of the confectionery product can impose significant variation to the process, however often due to low quantity of defects these types of variations are overlooked while this marginal variation has significant impact on plant efficiency. In this perspective, seven quality control tools has been used to interpret defective and non-defective products cumulatively. Design of this study appropriately and meticulously analyzed the data collected from oven test for the evaluation of each production and standard product lots separately and aggregately.

2. Findings And Conclusions From Literature Review

It has already been mentioned that in the confectionery industry no previous research was available regarding the relationship of the variation in raw material quality on productivity on the basis of evaluation through seven quality control tools. However, literature on the use of 7QC tool has been available therefore for effective statistical analysis has been accomplished by using guidelines provided in different books, websites and research articles. Important characteristics of 7QC tools find out from literature review are concluded as under:

3. Finding And Conclusions From Descriptive Analysis

- Practically check sheet has been evaluated during study and found that necessary aspects i.e. the area of operation, date, product name and shift and these all parameters are considered as basic information. Clearance of the production floor has been found satisfactory and all products cartons, pouch rolls, display boxes and wrapper rolls from previous batch/product were removed and segregation of packaging material with proper labeling has been completed prior to start new batch of production. Moreover, all parameters regarding health and safety purposes included waste removal, floor/bins/doors/drains cleanliness. Staff uniform cleanliness and adoption of safety standards by the staff like hair cover, safety shoes, gloves and mask etc. Similarly, cleanliness of process equipment for productivity enhancement, separate stacking of rework material, validity of material, availability of personal protection (PPs), proper labeling, maintenance of environmental temperature for processing etc. has been checked and found satisfactory fulfilled.

- Flow of complete manufacturing process of center filled bubble gum start from the receipt and storage of raw material and subsequently raw material then gum base softening procedure will be applied for next process of sugar and glucose mixing process. Then addition of necessary ingredients took place and again addition of remaining sugar in this mixture will be put-up. Then this batch will be hold to lower its temperature and further processed on extruder, through mechanical extrusion device then after rope forming and filling it will be passed through the die for shaping and finally passed through the cooling tunnel for the solidification of the product. Then the center filled bubble gum will be sorted according to sorting or grading predefined criteria and these sorted products carefully wrapped in food grade wrapper. Finally, wrapped products packed in boxes with different quantities as per the company standards.
- Following results have been extracted from the histogram analysis for each lot of the center filled bubble gum production and standard samples.

➢ Descriptive statistics has been analyzed for lot-1 describing that total 60 pieces were analyzed that 33.3% were leaked products, 26.7% were cracked products and 20% were de-shaped products.
➢ Descriptive statistics has been analyzed for lot-2 describing that total 60 pieces were analyzed that 36.7% were leaked products, 26.7% were cracked products and 26.7% were de-shaped products.
➢ Descriptive statistics has been analyzed for lot-3 describing that total 60 pieces were analyzed that 28.3% were leaked products while 25% were cracked products and 23.3% were de-shaped products.
➢ Descriptive statistics has been analyzed for lot-4 that 41.7% were leaked products while 33.3% were cracked products and 33.3% were de-shaped products.
➢ Descriptive statistics has been analyzed for lot-5 describing that total 60 pieces were analyzed 38.3% were leaked products while 36.7% were cracked products and 35% were de-shaped products.
➢ Descriptive statistics has been analyzed for lot-5 describing that total 60 pieces were analyzed that 38.3% were leaked products while 36.7% were cracked products and 35% were de-shaped products.
➢ Comparative results after the replacement of the gum base shows that all standard lots have only 28 leaked pieces which is 9.3% of the total whereas in the production samples 107 leaked pieces which is 35.7% of the totals pieces from all five production lots.
➢ Comparative results after the replacement of the gum base shows that all standard lots have only 28 cracked pieces which is 9.3% of the total whereas in the production samples 89 cracked pieces which is 29.7% of the totals pieces from all five production lots.
➢ Comparative results after the replacement of the gum base shows that all standard lots have only 07 de-shaped pieces which is 2.3% of the total whereas in the production samples 83 de-shaped pieces which is 27.7% of the totals pieces from all five production lots.
➢ From histograms of production and standard lots respectively we can easily conclude that the histogram of the production lots found negatively skewed whereas the histogram of the standard lots is positively skewed which clearly shows that after the replacement of the gum base in center filled bubble gum recipe the leakage, cracking and de-shaping problems are controlled.

- Pareto chart for cumulative results of each production lot data has been prepared and categorized defects from both standard and production lots summarized. Results of Pareto diagram provided visual illustration of defects where leakage of center filled bubble gum dominantly appeared on the left with highest frequencies in each lot; whereas from cumulative Pareto chart we found that crack products are second largest defect appear in the production lots. Moreover, in standard lots it has been observed that all three defects also appeared with less frequency but leaked and crack has same occurrence whereas minor pieces shows de-shaping problems. Overall results of Pareto chart identifying leakage, cracking and de-shaping problems comprises 82% in production samples and after replacement of gum base problem rest of 18% belongs to standard samples. Although the Pareto charts are used to evaluate the vital few to control the defect but in this case the Pareto chart used to compare the results of the production and standard samples shows that the leakages, cracking and de-shaping have no relationship with each other but these defects were minimized in the standard samples after the replacement of gum base in the recipe of the center filled bubble gum. Hence, it is concluded that incompetent quality of gum base results leakage, cracking and de-shaping in the production samples.
- In order to effect of product variation and causes relationship following information collected:-

➢ Competency of workmanship evaluated and operator’s capabilities has been observed satisfactory without problem for the past year.
➢ Oven test method for testing the material is also evaluated against standardized international methodology practicing globally and found satisfactory.

- Environmental conditions have been observed during production to understand possible effect but all records of room temperature and humidity conditions found according to the requirements. So it was not a potential cause.
- All the ingredients used in the center filled bubble gum recipe received from the approved supplier and no change found in the ingredients but only new gum base used in the production samples and after that problems of leakages, cracking and de-shaping were observed.
- The team analyzed that the filling device speed, extruder temperature and forming die efficiency and cooling tunnel temperature and humidity of the machine and other parameters were working as per the required standards.

- Following important observations has been illustrated in control charts:-
  - In attribute control chart has shown that on C chart that 19 points violating the control rules for all production lots and regularized after changing gum base as shown in standardized control charts
  - It has been found that 14 points and 11 points violating the control rules individual control chart and moving average control charts in all production lots which is also regularizing after changing gum base.
  - Control charts for lot number one defects on individual and moving range scale are 01 points and 15 points violating the control rules respectively.
  - Control charts for lot number two defects on individual and moving range scale are 03 points and 16 points violating the control rules respectively.
  - Control charts for lot number three defects on individual and moving range scale are 15 points and 13 points violating the control rules respectively.
  - Control charts for lot number four defects on individual and moving range scale are 37 points and 16 points violating the control rules respectively.
  - Control charts for lot number five defects on individual and moving range scale are 07 points and 14 points violating the control rules respectively.
  - From the individual control charts and moving average charts of all the production and standard lots we can easily conclude that after replacement of the gum base production process became under control and no violation of control chart rules observed.
  - Scatter diagram plotted as individual testing results are representing that there is significant variations have been found in testing material cumulatively from all lots. The comparison of the production and standard product samples after the replacement of gum base in the center filled bubble gum recipe shows that there is a significant relationship between the raw material quality and defects.

4. **Finding and Conclusions From Inferential Statistics** In the light of nonparametric hypothesis test results null hypothesis retained and alternative hypothesis is rejected. Chi-square test was also used for the identification of relationship and it is concluded that there is a significant relationship of the variation in the raw materials quality on productivity
5. **Recommendations** Raw material quality not only improves the productivity but also significantly reduced variability. Team had identified the root cause initially with the help of fish bone diagram and also analyzed by other quality control tools and decided to replace the gum base in the recipe of the center filled bubble gum in order to avoid the future problems. Productivity can be greatly reduced by the incompetent quality of the raw material and this can be analyzed systematically with the help of Seven QC tools. The study uncovers that quality tools has important place in data collecting, analyzing, visualizing and making sound base for data founded decision making and if the organizations need to improve their processes to continually achieve customer satisfaction and, to do that in an effective and efficient way, should use 7QC quality tools.

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