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STATISTICAL QUALITY CONTROL ON WEIGHT OF EMPTY LIPTON TEA CARTON AT NAMPAK CARTON NIGERIA LIMITED

Oladimeji Olanrewaju Adedipupo[1*], Lasisi Taiwo Abideen[2], Babalola Olutola Olayemi[3], Oyeniyi Ramoni Olawale Abiodun[4], and Adesina Oluwaseun Ayobami[2]

[1]Department of Statistics, Federal Polytechnic, Ile-Oluji, Ondo State, Nigeria

[2]Department of Statistics, Ladoke Akintola University of Technology, Ogbomosho Oyo State, Nigeria

[3]Department of Mathematics and Statistics, Osun State College of Technology, Esa-Oke, Osun State, Nigeria

[4]Department of Mechanical Engineering, Osun State College of Technology, Esa-Oke, Osun State, Nigeria

*Corresponding Author: adedipupo.oladimeji@gmail.com

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ABSTRACT: *Quality control process assures that the product being developed is of the required quality which includes inspection, deliverable peer reviews and software testing process. Quality control helps any company that manufactures a product or provides a service to improve customer satisfaction by consistently delivering quality products or services, reducing wastage of resources and increasing efficiency and profits for the company. This research work deals with the statistical quality control on the weight of empty Lipton tea at Nampak carton Nigeria Limited Oyo State, within six working days (Monday - Saturday). The data used in this research is secondary data, it was collected from the Nampak database and the method of data analysis used in the research is a control chart and test of randomness, in order to monitor the process and effectiveness of the data. After using various tools like an x-bar chart, R-chart, and Test of randomness, it was discovered that the weight of the product is within control limit both at the upper and lower control limit.*

KEYWORDS: Specification Limit, Inspection, Process Control, Process Variability, Tolerance Limit, Natural Tolerance.

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INTRODUCTION

Modern statistical quality control may be thought to have begun in the USA in the 1920s, where, in the Bell telephone company, a team had been set up to face the problem involved in producing large volumes of good quality equipment for the rapidly expanding telephone system.

In 1924, Waiter Shewhart designed the first control chart and gave a rationale for its use in-process monitoring and control. The idea of the control chart is 'proactive', in the sense that it is intended to monitor and process signals when they go 'out of control' and thereby ensure quality products. Shewhart [20] developed his ideas on economic quality control considerably. These ideas were to have considerable influence in later developments although, at the time, they appeared to have little, Instead, another approach also statistically based, dominated in the shorter term.

The next major development took place in post-war Japan, in 1950, W.E. Deming, at the invitation of Japanese engineers, began to spread his ideas, particularly concerning the importance of statistical thinking in manufacturing problem-solving. Deming's approach was influenced considerably by the earlier work of Shewhart.

By the seventies, Japan had become a major world economic force, In the 1980" and 1990s, western industry, in an attempt to catch up with the Japanese competition, started to re-import from Japan the ideas of statistical thinking and quality management first exported by Deming, Juran and others, as well as ideas which had been developed by the Japanese themselves in the period since world war II. In particular, the approach to industrial experimental developed by Taguchi has had a major impact on the practice of statistical quality control and improvement in the last 10years.

Nowadays, there is a plethora of theories, systems and methodologies, along with gurus to promote them. These include advocates of simple statistical process control, quality control zero defects, zero inventory, quality management system, world-class manufacturing, continuous quality improvement, total quality management, re-engineering and others. When carefully analyzed, there is a considerable amount in common between the various gurus, although some of them go to considerable lengths to distance themselves from each other.

The main aim of this paper is to review the role of statistical methods and thinking in quality. The principle ideas and approaches are set out in the next two sections, first, those associated with statistical process control and then those involving experimentation. These should not be viewed in isolation from their organization and management context, which is dealt with in Section 4. Finally, some broad conclusions about the present state and future development of the statistical approach to quality are presented. One of the techniques that are used to monitor manufacturing processes and provide feedback is statistical process control. The feedback is used to maintain and improve the capability of the process and to ensure product conformance. SPC is used to control the process by signalling when adjustments may be necessary; some techniques associated with SPC include frequency histograms and control charts.

A control chart is a tool used to monitor the variation in a process and ensure that the process is in a state of control. This allows the operator to monitor the trends occurring in the process. The control chart reflects the specification limit, namely, the upper specification limit (USL)

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and the lower specification limit (LSL). In addition, it has upper and lower control limits that lie within the specification limits. The upper control limit (UCL) and lower control limit (LCL) are determined by evaluating the dispersion (variability) in the process. In a well-controlled process, this limit can be equal to $\mu \pm 3\sigma$ respectively, where σ is the process standard deviation and μ is the process mean. These statistical limits are normally called the 3 sigma control limits. In a normal (Gaussian) distribution 99.73% of the values measured lie in intervals of width 6σ. The benefits of using control charts in the manner suggested include the following: when a process is under control, there is no point in wasting time and other resources in discussing and investigating what is no more than inevitable chance deviations.

In particular, one should not make unnecessary adjustments to a process when the evidence, properly evaluated suggests a mere chance deviation from the target. On the other hand when a process does go out of control; it is wise to have a rational method of detecting this so that the situation can be corrected as soon as possible.

The aim of this research work is to determine the performance of the quality action during the process and the conformance of the weight of the empty Lipton tea carton to set a standard of 10.2kg.

The objectives of this research are to; Select a sample of some carton for measurement; Check the process by using the mean control chart X-bar chart and R-bar chart; Perform a Test of Randomness on the selected sample; Ensure guarantee in quality produced.

LITERATURE REVIEW

The need for quality as a fundamental component in the formulation of strategies for institutions to implement TQM is clearly outlined by Bilich & Neto[1] who state that quality, as a macro function of institutions, must be present in the day-to-day running of an institution, in aspects such as the establishment of policies, the decision process, selection of personnel, allocation of resources, the definition of priorities and service delivery to satisfy customer requirements. The two authors continue and state that the quality approach, as a strategic element, has brought to institutions a new manner of conceiving quality, as it engages the top decision-makers of the institution in the effort for better performance in service delivery. According to Djerdjour & Patel[6], quality is no longer an optional extra; it is an essential strategy to survive. TQM is, therefore, a solution for improving the quality of products and services. Before one can discuss the concept of TQM, one first needs to discuss, understand and analyze the concept of 'quality' itself. Dale[2] and Evans & Dean[12] state that quality, reliability, delivery and price build the reputation enjoyed by an institution. Quality is the most important of these competitive weapons and is an extremely difficult concept to define in a few words in order to agree on a consensus definition; a trait it shares with many phenomena in business and social sciences Hoyer & Hoyer[10]. Quality does not only refer to goods and services but includes quality of time, place, equipment and tools, processes, people, the environment and safety, information and measurement Dale[2]; Schonberger[18]. Quality is an ongoing process that has to be so persuasive throughout the institution that it becomes the philosophy and culture of the whole institution. All institutions and each department within the institution need to adopt the same strategy, to serve the

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customer with even better quality, lower cost, quicker response and greater flexibility Schonberger[18].

There appears to be no uniform understanding and definition of the meaning of the term quality and even well-known authors seem to have different perspectives on this issue. According to Reeves & Bednar[17], a search for the definition of quality has yielded inconsistent results. The two researchers emphasize that regardless of the time period or context in which quality is examined, the concept has had multiple and often muddled definitions and has been used to describe a wide variety of phenomena. The strategies and tools for assuring quality may have changed, but the basic customer expectations have been fairly constant for a long time Hoyer & Hoyer[10]. Although many definitions of quality exist, it is prudent to create a deeper insight into the definitions of researchers such as the quality gurus, Deming, Crosby, Feigenbaum, Ishikawa and Juran. These gurus claim that their definitions, prescriptions, conclusions and recommendations work equally well for producing products and delivering services. From the various definitions of quality indicated by these gurus in literature, there seem to be two levels in the concept of quality, Hoyer & Hoyer[10], namely:

1. By producing products or delivering services whose measurable characteristics satisfy a fixed set of specifications.
2. Products and services that satisfy customer expectations for their use or consumption.

In short, level one quality means conformance to specifications and level two means satisfying the customer. Evans & Dean[12] note that quality is much more than that stated at level one, namely conformance to specifications. They identify eight attributes for category one, namely: (1) performance, (2) features, (3) reliability, (4) conformance, (5) durability, (6) serviceability, (7) aesthetics, and (8) perceived quality.

Crosby's definition of quality is "conformance to requirements", which is a level one formulation. Crosby's essential points in his definition of quality are (1) it is necessary to define quality, (2) one must know what the requirements are and be able to translate these requirements into measurable product or service. Deming's perspective of quality is based on a level two definition and he defines quality as "multidimensional to produce a product and/or deliver a service that meets the customer's expectations to ensure customer satisfaction." Through this definition, he equates to high quality and customer satisfaction. His essential arguments are (1) that quality must be defined in terms of customer satisfaction, (2) quality is multidimensional where it is impossible to define the quality of a product or service in terms of a single characteristic or agent, and (3) there are different degrees of quality because quality is essentially equated with customer's satisfaction.

Feigenbaum's definition of quality is a level two definition and he defines quality as "The total composite product and service characteristics of marketing, engineering, manufacturing and maintenance through which the product and service in use will meet the expectations of the customer." Feigenbaum's essential points are (1) that quality must be defined in terms of customer satisfaction, (2) quality is multidimensional and must be defined comprehensively, and (3) as customers have changing needs and expectations, quality is dynamic. In this regard, Feigenbaum writes, "A crucial quality role of top management is to recognize this

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evolution in the customer's definition of quality at different stages of product growth" Feigenbaum[8].

Ishikawa's definition of quality is a level two definition, namely: "We engage in quality control in order to manufacture products with the quality which can satisfy the requirements of consumers." Ishikawa makes it clear that high quality is essential to satisfy the ever-changing consumer expectations. Ishikawa's essential points are: (1) that quality is equivalent to consumer satisfaction; (2) quality must be defined comprehensively; (3) consumers' needs and requirements change continuously; therefore, the definition of quality is ever-changing, and (4) the price of a product or service is an important part of its quality Ishikawa[11]. Juran's definition of quality is a simultaneous attempt to be a level one and level two definition. He defines quality based on multiple meanings, namely: (1) "Quality consists of those product features which meet the needs of customers and thereby provide product satisfaction," (2) "Quality consists of freedom from deficiencies." Juran's essential points are (1) a practical definition of quality is probably not possible, (2) quality is apparently associated with customers' requirements, and fitness suggests conformance to measurable product characteristics.

A common definition of quality, however, is needed to prevent confusion among staff and helps to resolve any arguments, which may arise from time to time within and between departments in an institution. Based on the above-mentioned analysis of quality definitions by different authors, the following definition of quality was developed for the purpose of this research.

"Quality is the degree to added ***value*** to products and/or service delivery ***as perceived by all the stakeholders*** through ***conformance to specifications*** and the degree to added ***excellence*** to products and/or service delivery through a ***motivated workforce***, to ***meeting customer satisfaction***."The definition provided places conformance to specifications as the starting point with customer satisfaction at the centre of the institution's purpose and focus.

Defining quality in these terms emphasizes two important aspects. Firstly, it reminds managers of their institution's purpose ("conformance to specifications" as the top priority) and secondly, of the methods to follow in order to achieve customer satisfaction. As no definition of quality is best in every situation, managers and researchers must examine the strengths and weaknesses of each definition before adopting a definition to guide their work. By explicitly identifying the quality definition managers are using, and recognizing its strengths and weaknesses, managers are better able to move institutions toward the achievement of quality, and researchers can make progress toward assessing the impact of quality on institutional performance and other variables of interest.

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METHODOLOGY

There are seven quality tools named by Ishikawa[11]. These tools, are often called magnificent seven that are applied in this research work which is:

1) Check sheet
2) Pareto Chart
3) Histogram
4) Scatter Diagram
5) Process flow chart
6) Cause and effect Diagram or Fishbone Diagram
7) Control Chart

The control chart is perhaps the most widely used of the "seven basic quality control tools" it is the key tools in statistical process control because it displays to monitor and control processes within the specified control limit.

A control chart is a statistical tool principally used for the study and to control repetitive processes; a control chart can also be defined as a graph used to regulate the quantitative characteristics of an article from a production line. The main tool for process control is the control chart, there are different types of control charts, depending on different ways of assessing the quality of the products. Many characteristics are measurable, such as the length of a screw, the tensile strength of a yarn, the resistance of the wire, the life of an electric bulb etc. such variables are continuous, for controlling such quality, two types of charts are plotted alone for the mean of the measurement, X chart and another for the range of the measurement R chart.

Statistical Tools

The following statistical tools will be used to analyse the data and conclude appropriately based on the results obtained.

$\underline{X}$ - Chart

$\underline{X}$ - Chart is used to detect changes in the process mean, but it does so, by monitoring the variation in the mean sample that has been drawn from the process. The $\underline{X}$ - bar chart is more sensitive than the individual chart for detecting changes in the process mean. This chart makes it possible to determine whether a process has gone out of control because the variation has changed or because the mean has changed.

The following rules must be calculated before the chart is constructed.

- The mean of each sample $X_1, X_2 \ldots X_n$ must be obtained. i.e. $\underline{X} = \sum x / n$
- The mean of the sample mean must be obtained i.e.

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Where k is the number of samples of size n from which the chart is to be constructed.

- The mean of the range R (i.e. $\overline{R}$) must be found i.e. $\overline{R} = \sum R / n$. The control limit

UCL = $\underline{X} + A_2\overline{R}$

LCL = $\underline{X} - A_2\overline{R}$

A_2value is obtained from statistical table

R – Chart

R-chart is used to detect changes in process variation, to show the variability or dispersion of the quality produced by a given process. It is advisable to construct R-chart first to find out whether the variable is out of control or under control.

Procedure

- The range of each sample (R) i.e. upper value minus lower value, must be obtained.
- The mean of the sample ranges (R) must also be obtained to give the centre line i.e. $\overline{R} = \sum Ri / n$
- Obtain the upper control limit (UCL) = $D_4\overline{R}$
- Obtain the lower control limit (LCL) = $D_3\overline{R}$

Where D_3 and D_4 are obtained from the statistical quality constant.

Test of Randomness

Random selection is mostly used in the whole process of quality control. There is a need to do a test on the randomness of the random selection itself using runs. The run test can be used to check whether there might be a trend in data so that it is possible to adjust a machine setting or some other process variable before any damage occurs.

Formula

.

$$z_r = \frac{\mu - \mu_r}{\sigma_r}$$

$$\mu_r = \frac{2n_1n_2}{n_1n_2} + 1$$

$$\sigma_r = \frac{\sqrt{2n_1n_2(2n_1n_2 - n_1 - n_2)}}{(n_1 + n_2)^2(n_1+n_2-1)}$$

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DATA AND ANALYSIS

Data

carton weight = 1.1kg

number of empty Lipton carton inside = 300pics

total weight = 10.2kg

Table 1. Samples Data

SAMPLES NO	DAY	MORNING 7am:2pm	AFTERNOON 2pm:9pm	NIGHT 9pm:7am
1	MONDAY	10.2, 10.0, 10.1,	10.2, 10.2, 10.1	10.2,10.3,10.4
2		9.7,10.7,10.5,	10.3,10.2,10.3	10.7,10.5,10.1
3		10.1, 10.2, 10.1	10.0,10.2,10.6	10.6,9.8,9.9
4	TUESDAY	10.2, 10.1, 10.2,	10.2,10.4,10.2	10.6,10.2,10.1
5		9.9, 10.2, 10.1	10.3,10.4,10.5	10.1,10.3,10.4
6		10.1, 10.1, 10.0	10.3,10.5,10.6	10.2,10.1,10.3
7	WEDNESDAY	10.5, 10.6, 10.3,	10.3,10.2,10.4	10.0,10.2,10.3
8		10.3, 10.4, 10.2	10.5,10.4,10.2	10.3,10.6,10.5
9		10.5,10.6, 10.2	10.1,10.4,10.5	10.4,10.2,10.5
10	THURSDAY	10.6, 10.5, 10.3,	10.2,10.2,10.5	10.4,10.1,10.6
11		10.3, 10.2, 10.2,	10.1,10.0,10.5	10.1,10.5,10.1
12		10.2, 10.3, 10.1	10.2,10.4,10.4	10.2,10.4,10.3
13	FRIDAY	10.5, 10.2, 10.7,	10.1,10.2,10.3	9.9,10.5,10.1
14		10.8, 10.7, 10.0,	10.2,10.3,10.4	10.4,10.1,9.9
15		9.9, 10.1, 10.2	10.4,10.4,10.1	10.1,10.10.1
16	SATURDAY	10.5, 10.4, 10.2,	10.3,10.2,10.3	10.3,10.2,10.3
17		10.1, 10.2, 10.3,	10.2,10.2,10.1	10.3,10.2,10.6
18		10.2, 10.1, 10.3	10.1,10.2,9.9	10.5,10.2,10.2

Data Analysis

$$\underline{R} = \frac{\Sigma \quad R_i}{n} = \frac{0.4+1.0+0.8+0.5+0.6+0.6+0.6+0.4+0.5+0.5+0.5+0.4+0.3+0.8+0.9+0.5+0.3+0.5+0.6}{18} = \frac{10.2}{18} = 0.567$$

The center line is positioned at $\underline{R}$ = 0.567, to determine the control limits, we substitute the D_3 and D_4 value from statistical quality control table where n = 9

Upper Control Limit = D_4R

= 1.816(0.567)

UCL = 1.089

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Lower Control Limit = D_3R

= 0.184(0.567)

LCL = 0.10

Therefore:

CL = 0.567

UCL = 1.028

We now calculate UCL for the X-bar chart whether it meet the specification

$$i.e. UCL = \bar{\bar{X}} + A_2R$$

$$LCL = \underline{X} - A_2R$$

To obtain $\bar{\bar{X}}$ which is mean of the sample mean:

$$\bar{\bar{X}} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n}$$

$$= \frac{10.1 + 10.3 + 10.2 + 10.2 + 9.2 + 10.3 + 10.4 + 10.4 + 10.4 + 10.1}{18}$$

$$\bar{\bar{X}} = \frac{183.6}{18} = 10.2$$

The centre line of the chart is positioned at $\bar{\bar{X}}$ = 10.2

We need to constant A2 from the statistical quality control table.

$$UCL = \bar{\bar{X}} + A_2R$$

$$UCL = 10.2 + 0.337(0.56)$$

$$= 10.2 + 0.19$$

$$= 10.4$$

$$LCL = \bar{\bar{X}} - A_2R$$

$$= 10.2 - 0.337(0.567)$$

$$= 10.2 - 0.1919$$

$$= 10.0$$

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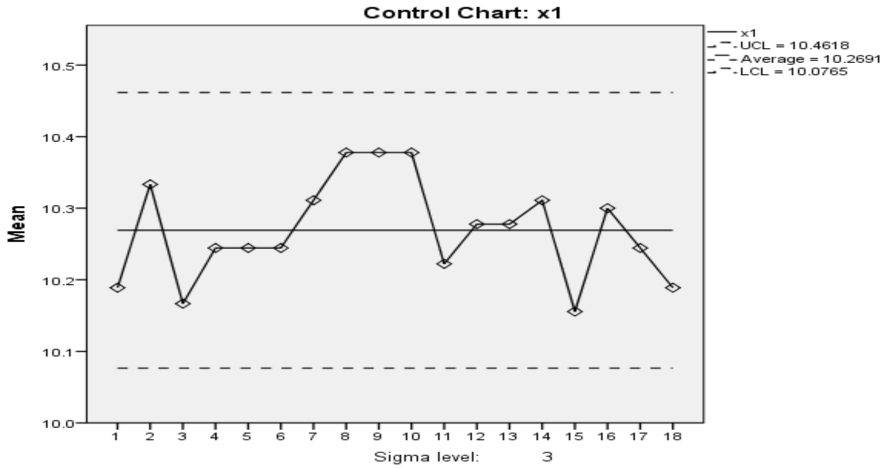

Figure 1. $\underline{X}$- BAR CHART

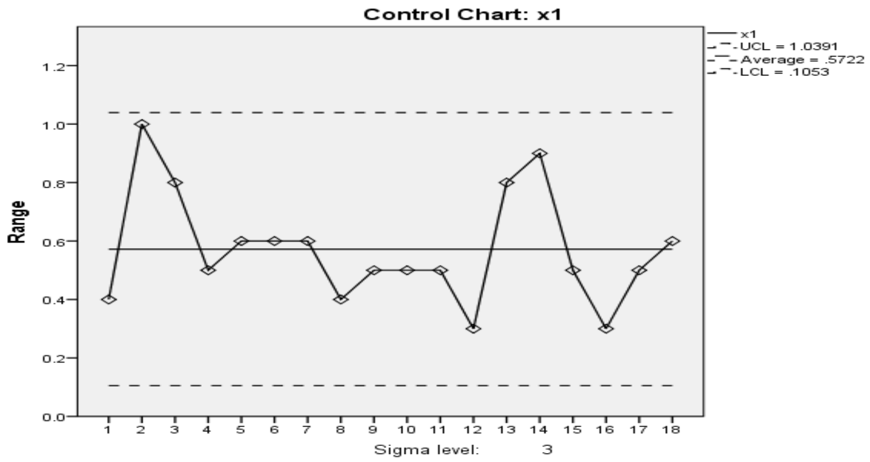

Figure 2. $\underline{R}$ - CHART

Test of Randomness

The following hypothesis is set in order to know if H_o value is at random

H_o: Arrangement of sample value is random

H_1: H_o is false

Level of significance = 0.01

Decision rule: Reject H_o if $Z > 2.33$ the table value

Where Z is obtained using the above formula

Median = 10.2

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The arrangement of value below and above 10.2 is as follows

b,b,b,b,b,b,b,a,a,b,a,a,a,b,a,a,a,b,b,b,b,b,b,a,a,b,b,b,b,b

b,a,b,a,b,b,b,b,b,a,a,a,b,a,a,b,b,b,a,a,a,b,b,a,a,a,a,a,a,b,a,

b,b,a,a,a,b,a,a,b,a,a,a,a,a,b,b,a,a,a,b,a,a,a,a,b,b,a,a,b,a,a,b

b,b,b,a,b,a,b,b,a,b,b,a,a,b,a,a,a,b,a,b,b,a,b,a,a,b,b,a,a,b,b,

b,b,b,a,a,b,b,b,b,a,a,b,a,b,a,a,b,a,b,b,a,b,b,b,a,b,a,b,b,a,b,b

b,a,b,b

$n_1 = 75, \qquad n_2 = 87 \quad R = 77$

$$\mu_r = \frac{2n_1n_2}{n_1n_2} + 1$$

$$= \frac{2(75)(87)}{75(87)} + 1$$

$$= 81.5$$

$$\sigma_r = \sqrt{\frac{2n_1n_2(2n_1n_2 - n_1 - n_2)}{(n_1 + n_2)^2(n_1+n_2-1)}}$$

$$\sigma_r = \sqrt{\frac{2(75)(87)(2(75)(87) - (75) - (87)}{(87 + 75)^2(87+75-1)}}$$

$$= 6.3031$$

$$z_r = \frac{\mu - \mu_r}{\sigma_r}$$

$$= \frac{77 - 82}{6.30}$$

$$= -0.7936$$

$$/ z / = 0.7936$$

Decision : Since $Z_{cal} < Z_{tab}$, we accept the H_o and conclude that the arrangement of sample value is random

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SUMMARY

The analysis carried out on the weight of empty Lipton tea Nampak carton Nigeria limited gives us the opportunity of having an insight into the application of the control chart. The control chart was used to check the quality of their product (Lipton carton) and detect the weight of the product after our analysis of the sample collected showed that the product is under control.

CONCLUSION

From the finding, the analysis in chapter four shows that the weight of the empty (Lipton carton) is under control. On the graph plotted for the mean chart and R chart, it can show that no point falls outside. It means that the Lipton Carton weight is under statistical quality control and also it reveals that the data are randomly selected during the process.

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APPENDIX

STATISTICAL QUALITY CONTROL CONSTANT

No. of observation in subgroup, n	A2	D2	D3		D4
1					
2	1.880	1.128	0.853	0.000	3.267
3	1.023	1.693	0.888	0.000	2.574
4	0.729	2.059	0.880	0.000	2.572
5	0.577	2.326	0.880	0.000	2.282
6	0.483	2.534	0.843	0.000	2.0040
7	0.419	2.074	0.833	0.076	1.924
8	0.373	2.847	0.820	0.136	1.864
9	0.337	2.970	0.808	0.184	1.816
10	0.308	2.078	0.797	0.223	1.777
11	0.285	3.173	0.787	0.256	1.744
12	0.266	3.253	0.770	0.283	1.717
13	0.249	3.336	0.7762	0.307	1.693
14	0.235	3.407	0.775	0.328	1.672
15	0.223	3.472	0.749	0.347	1.653
16	0.212	3.532	0.743	0.363	1.637
17	0.203	3.588	0.738	0.378	1.622
18	0.194	3.640	0.738	0.931	1.608
19	0.187	3.689	0.733	0.403	1.597
20	0.180	3.735	0.729	0.415	1.585
21	0.173	3.778	0.724	0.425	1.575
22	0.167	3.819	0.720	0.434	1.560
23	0.162	3.858	0.716	0.443	1.557
24	0.517	3.895	0.712	0.451	1.548
25	0.153	3.931	0.709	0.459	1.541

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