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Application of Statistical Quality Control in Monitoring the Production, Packaging and Marketing Process of Sachet Water

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Authors' contributions

This work was carried out in collaboration among all authors. Author TGI designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SK and AIA managed the analyses of the study. Author IBE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Statistical process control is a technique employed to enhance the quality and productivity of processes and the distribution or marketing of its products. Sachet water is a product that has become popular and is being used as a replacement for lack of potable water. It is an alternative that is readily available, affordable but with questions about its purity, production and marketing processes. The objective of this study is to apply statistical control charts in monitoring the production, packaging and distribution or marketing processes of sachet water in Nigeria. This paper employed statistical quality control approach to monitor process stability in a Table Water manufacturing company. Quality control tools such as p-chart, u-chart, X-bar and R charts as well as process capability chart were use to observed field data obtained from the sachet water manufacturing company on important processes of sachet water production and marketing for 30 working days. This was done to check if the processes were in control or out of control and to verify

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the capability of the marketing process of the product meeting preset specifications. With this, the statistical control charts suitable for the processes were constructed using package "qcc" in R software version 3.6.1. The results from p-chart and u-chart showed that the production and packaging process of the product is not in control and hence the need for further investigations and corrective measures to prevent variability in the process and thus allowing improvement in the quality of the product. Also, the results from X-bar and R charts showed that the marking process was in statistical process control in respects of the product sales recorded by the four independent marketers, with no assignable cause of variation. It also revealed that, the product marketing process has low capability of successfully attending the preset specification limits in respect of the product sales and hence generating low profit for the company.

Keywords: Statistical process control; control charts; sachet water, production; sales; defective; capability analysis.

1. INTRODUCTION

1.1 Statistical Process Control

Generally, statistical process control (SPC) has been used in production, service and commercial industries, for instance, in the automobile industry [1] and in the commercial industry [2]. The interest of using SPC led to studies such as that of Koretsky, in the USA, which developed Applied Chemical Process Statistics, in which it analyzed the variation of Processes applying the Statistical Control of Processes and Design of Experiments and introduced as an elective course the Statistics of Chemical Processes. On the other hand, [3] in Australia developed the application of multivariable Statistical Control in chemical processes to monitor process performance and, fault detection and diagnosis. In Africa, [4] studied the integration of Statistical Process Control with engineering process control (EPC). For validation, the proposed approach was applied to the data collected from an industrial batch alkyd polymerization reactor. Through this case study application, the company's process engineers can now use a valuable decision-making tool when the production process is affected by disturbances that affect product and process quality, productivity and the competitiveness.

The use of SPC has yielded more benefits and this study will be a contribution to the industry through its strategy of quality improvement and competitiveness and in the academic sector it will be a contribution in the training of new process engineering professionals. It will also benefit the all sectors and industries to make them more competitive.

1.1.1 Theoretical framework

1.1.1.1 Theoretical basis

The theoretical basis focuses on the theoretical foundations of Statistical Process Control and on the unit operations of industrial processes. Statistics in the industry seeks to implement the probabilistic and statistical procedures of analysis and interpretation of data from a set of elements called industrial statistics, which helps to make decisions in the control of all the processes. The management and interpretation of data in industrial processes is generally done by using the measures of central tendency and for the decision making process in management, statistical tools for process control especially control charts are used with appropriate rules and statistical methods.

1.1.1.2 Variability in industrial processes

According to Carro R, Gonzales Gómez DA, [5], there are no two similar products or services because the production processes involve many causes of variation even when they are performed as planned. Differences in the state of products give rise to an important task in quality control that consists in determining the range of natural random variation in the process. For instance, the bottle of a soda called Cola Lux should contain an average of 16 ounces of liquid, but it is found that its volume when leaving the process varies between 15.8 and 16.2 ounces. If this is the case, the production process should be controlled to ensure that the filling volume remains within this range. If production were outside this range, such as bottles with an average content of 15.6 ounces, then it means that there is a problem in the process because the variation is greater than the natural random variation.

1.1.1.3 Types of variation

According to Shewhart WA, [6] of Bell Telephone Laboratories who developed the new variation management paradigm, basing his concept on the idea that a quality characteristic has one of two types of variation causes which are: Common causes (the natural variation that exists within any process therefore the causes that are always part of the process and affect all those who work in it) and special or assignable causes (the variation that is due to something out of the ordinary, it is not part of the process, or does not affect everyone, but they are attributable to specific circumstances). These types of causes are monitored and rectified so that they do not occur subsequently and can be identified easily because they are not always active in the process [7].

Note that there will always be variations in the state products such as length, diameter, thickness, weight, volume, density, etc., due to the variability that occurs in machines, tools, raw materials, and human operators. The presence of this unavoidable change and the interchangeability result in specifying limits for the variation of any quality characteristic, which are the specifications required by the customer. This acceptable variation is called tolerance.

The estimation of the natural tolerance limits of a process is an important problem with many significant practical implications. If the values of the measurements in the data exceed the tolerance limits, an extremely high percentage of production will be out of the specifications, which will result in a high loss [8].

1.1.1.4 Types of control charts

According to Shewhart WA [6], there are three horizontal parallel lines in a control chart: a centre line, an upper control limit above it and a lower control limit below it. The centre line (CL) on a control chart is where points are expected to cluster in the absence of an assignable cause. The centre line is usually set at average, the median, the mode or the target value of the points being plotted. The Upper Control Limit (UCL) line and the Lower Control Limit (LCL) defined a region improving the process, which reduces product where most observations are expected to fall. The upper and lower control limits refer to as statistical control limits or Statistical Process Control limits reflect the natural variability of the process and are constructed in such a way that when the process is in control most of the points will fall inside the control limits in random fashion. If a point on the control charts falls above the upper limits or below the lower control limits the process is said to be out of control, and assignable causes need to be investigated for timely removal.

Shewhart WA, [6] introduced a deductive approach for applying control charts which is based on the type of data (attributes or variables) and the algorithm is presented in Fig. 1 as shown below. This method involves providing answers to the following questions:

- If the data are attributes, there are two questions: Are the data countable? Is the sample size constant or does it varies? What is the defective fraction or the number of defects?
- If the data is variable, the question is: were the data collected in sub groups? If so: is the sub group> 8 or ≤ 8? Does each sampling report several data from several elements or are they individual data?

These questions are asked and answered using the following algorithm in Fig. 1.

Control charts are divided into: Charts for attribute control: p, np, c and u; and Charts for variable control: XmR, XbarR, ImR, XmR trend, XbarS, among others.

p chart: It is used to evaluate the defected fraction. Defective items can be counted and the sample size is not constant. According to Douglas CM [9] and [10], the functional defective products (defects) in a sample or a day can be estimated by:

$$p_i = \frac{d_i}{n_i} \quad (1)$$

where p_i =fractional defective products in a sample or day, d_i = the number of defective products in a sample or day, n_i = the number of defective products produced in a sample or day as

$$\overline{p} = \frac{Total\ defective\ bags\ or\ products}{Total\ n\ umberof\ bags\ or\ packs\ produced} \quad (2)$$

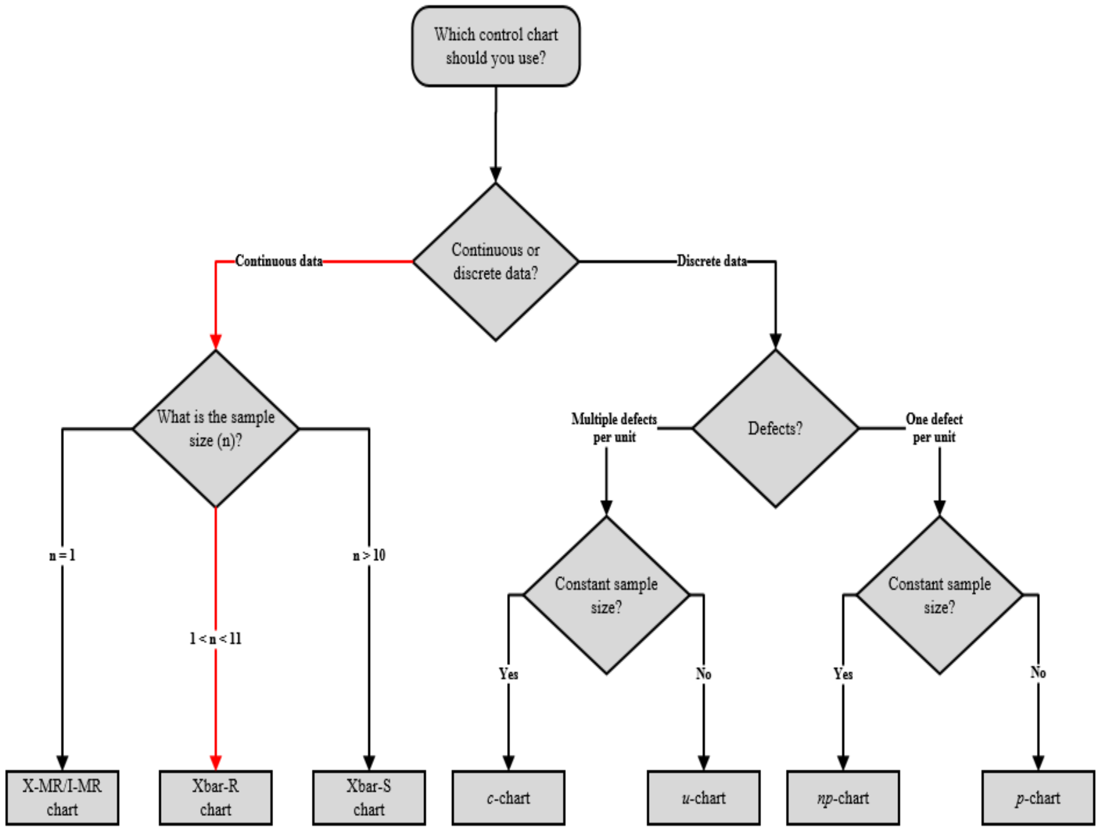

Fig. 1. Algorithm to select the type of control chart

Total lot = sum of individual sample size, $n = \sum_{i=1}^{i=m} n_i$, Total defective bags or packs, $d = \sum_{i=1}^{i=m} d_i$ Average defective,

$$\overline{p} = \sum_{i=1}^{i=m} d_i \div \sum_{i=1}^{i=m} n_i \quad (3)$$

Once $\overline{p}$ is determined the control limits can be calculated [9] from $\eta_p = \sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$ as:

Upper control limit (UCL) = $\overline{p} + z_p \eta_p$, Centre line (CL) = $\overline{p}$ and Lower control limit (LCL) = $\overline{p} - z_p \eta_p$.

where $\overline{p}$ is the fraction defective, η_p is the standard deviation, n is the sample size and z_p is the number of standard deviation for a specific confidence level. Typical z_p =3 (3–signal is 99.73% confidence level) [9].

np chart: It is used to evaluate the defective fraction when it is easy to count the number of defective elements and the sample size is always the same [11]. The equations to build the charts are:

CL = $\overline{np} = \frac{\sum np_i}{\sum n_i}$, UCL = $\overline{np} + 3\sqrt{\frac{\overline{np}\left(1-\overline{np}\right)}{n}}$

and LCL = $\overline{np} - 3\sqrt{\frac{\overline{np}\left(1-\overline{np}\right)}{n}}$

where CL stands for Centre line, UCL stands for Upper control limit, LCL stands for the Lower control limit, n is the sample size and $\overline{np}$ is average of defective elements.

c Chart: It is used when a small number of defects can be counted in a large opportunity area, or in an article or product, and when the sample size is constant [11]. The equations to build the graphs are:

CL $=\bar{c}=\frac{\sum c_i}{n}$, UCL $=\bar{c}+3\sqrt{\bar{c}}$ and LCL = $\bar{c}-3\sqrt{\bar{c}}$

where CL stands for Centre line, UCL stands for Upper control limit, LCL stands for the Lower control limit, n is the sample size and $\bar{c}$ is average of defective elements.

u chart: It is used when you can count the defects in an item or product, and the sample size varies [11]. The equations to build the graph are:

CL $=\bar{u}=\frac{\sum u_i}{\sum n_i}$, UCL $=\bar{u}+3\sqrt{\frac{\bar{u}}{n_i}}$ and LCL $=\bar{u}-3\sqrt{\frac{\bar{u}}{n_i}}$

where CL stands for Centre line, UCL stands for Upper control limit, LCL stands for the Lower control limit, n is the sample size and $\bar{u}$ is average of defective elements.

1.1.2 X-bar and R control charts

Following [12], the X-bar and R-Control Charts is one of the Statistical Process Control (SPC) methods used for monitoring and improving a company's quality and productivity. X-bar chart is used to monitor the average value of a process over time. For each subgroup, the x-bar value is plotted. The upper and lower control limits define the range of inherent variation in the subgroup means when the process is in control. R-Chart on the other hand is a control chart that is used to monitor process variation when the variable of interest is a quantitative measure [12]. These charts give deviations from desired limits within the quality process and, in effect, allow the company to make necessary adjustments to improve quality [12].

According to [12], the following steps are used for constructing X-bar and R-charts.

i. Collection and entering of the data into sub-group

ii. Determination of the Average $\bar{X}$ of each subgroup;

$$\bar{X}=\frac{X_1+X_2+X_3+\ldots+X_n}{n} \quad (4)$$

iii. Calculate the grand mean $\bar{\bar{X}}$ of the sub-group's average. The grand mean of the subgroup's average becomes the centerline for the upper plot.

$$\bar{\bar{X}}=\frac{\bar{X}_1+\bar{X}_2+\bar{X}_3+\ldots+\bar{X}_n}{n} \quad (5)$$

iv. Determine the Range R of each sub-group by subtracting lowest value from the highest value in the sub-group. Range = Highest-Lowest i.e.

$$R=X_{\max}-X_{\min} \quad (6)$$

v. Calculate average of subgroup Ranges, $\bar{R}$

$$\bar{R}=\frac{R_1+R_2+R_3+\ldots+R_n}{k} \quad (7)$$

vi. Determine the Upper Control Limit UCL and Lower Control Limit LCL for sub-group averages. For X-bar chart:

$$UCL_{\bar{X}}=\bar{\bar{X}}+A_3\bar{s} \quad (8)$$

$$LCL_{\bar{X}}=\bar{\bar{X}}-A_3\bar{s} \quad (9)$$

1.1.3 For R chart we have:

$$UCL_{\bar{R}}=D_4\bar{R} \quad (10)$$

$$LCL_{\bar{R}}=D_3\bar{R} \quad (11)$$

1.2 Process Capability Analysis

Process capability is a measure that estimates ability of a production process to meet preset specifications. It is determined by using the process capability index cpk which is computed as the ratio of the specification width to the width of the process variability [13].

$$C_p=\frac{Specification-Width}{\Pr ocess-Width}=\frac{USL-LSL}{6\sigma within} \quad (12)$$

where:

USL = upper specification limit
LSL = lower specification limit
$\sigma within$ = standard deviation of the samples that fall within the specification limits

However, to address a possible lack of centering of the process over the specification range, the process capability of each half of the normal distribution is computed and the minimum of the two is used. That is;

$$C_{pk} = \min\left\{CPU, CPL\right\} \quad (13)$$

where:

$$CPU = \frac{USL - \bar{\bar{X}}}{3\sigma within} \text{ and } CPL = \frac{\bar{\bar{X}} - LSL}{3\sigma within}$$

CPL is a capability index defined as the ratio of the interval formed by the process mean and LSL and one-sided spread of the potential process. CPU is a capability index defined as the ratio of the interval formed by the process mean and USL and one-sided spread of the potential process.

Hence,

$$C_{pk} = \min\left\{\frac{USL - \bar{\bar{X}}}{3\sigma within}, \frac{\bar{\bar{X}} - LSL}{3\sigma within}\right\} \quad (14)$$

Generally, if

$C_{pk} = 1$: The process variability just meets specification.
$C_{pk} \leq 1$: The process variability is outside the range of specification and not capable of producing within specification.
$C_{pk} \geq 1$: The process variability is tighter than specification and exceeds minimal capability.

The percentage of samples that have measurements less or greater than the preset lower or upper specification limit are determined respectively as thus:

$$\% < LSL = \left\{1 - \left(\frac{\bar{\bar{X}} - LSL}{3\sigma within}\right)\right\} \times 100\% \quad (15)$$

$$\% > USL = \left\{1 - \left(\frac{USL - \bar{\bar{X}}}{3\sigma within}\right)\right\} \times 100\% \quad (16)$$

1.2.1 Overall capability analysis indices

The capability analysis indices considered thus far estimates the performance of the samples that are within the specification limits. However, in order to estimate the performance of all the samples, overall capability indices are defined. P_p, PPL, PPU and P_{pk} are overall capability indices respectively defined in the same manner as in C_p, CPL, CPU and C_{pk}, but with a little difference in their computation. Within standard deviation is used while computing C_p, CPL, CPU and C_{pk}, whereas overall standard deviation is used while computing P_p, PPL, PPU and P_{pk}. Overall standard deviation is defined as the standard deviation of all the samples considered over the twenty days (which is equal to eighty at four samples per day over a period of twenty days). C_{pm} is a capability index that is the ratio of the specification spread (USL - LSL) to the square root of the mean squared deviation from the target. Hence, the higher the value of C_{pm}, the better the process.

1.3 Sachet Water

Pure water is an odourless and tasteless liquid. It has a bluish tint, which may be detected, however, only in layers of considerable pressure. Accessibility and availability of fresh clean water is a key to sustainable development and an essential element in health, food production and poverty reduction [14]. However an estimated 1.2 billion people around the world lack access to safe water and close to 2.5 billion are not provided with adequate sanitation (Third World Water Forum on Water, 2003). The standard industrialized world model for delivery of safe drinking water and sanitation technology is however, not affordable in much of the developing world. Thus, given the renewed global commitments towards the Millennium Development Goals (MDG) marked for 2015, the importance and contribution of locally sourced low cost alternative drinking water schemes to sustainable access in rural and semi-urban settings of developing nations cannot be over emphasized [15].

Statutorily, portable water supply in Nigeria had been by the Government Owned Public Water Utilities (GPWU) in the past. The GPWUs provided their supply from conventional water treatments plants that uses water from impounded reservoirs, flowing perennial streams, lakes and deep boreholes. As the country population grows and industries increase, the supply of water by the GPWUs becomes inadequate in quality and quantity. This led to the emergence of some Privately Owned Water Enterprises (POWE) that operated side by side with the GPWUs within the water sector [16].

One of the most popular POWE in Nigeria is the sachet water sold in polythene sachet otherwise called 'Pure Water'. The POWEs mainly collect their water as the end product of initially treated water supplied by the GPWUs and do little treatment such as the removal of the suspended solids to make the GPWUs water more potable. They also do some minor treatment on water from natural springs, open wells and deep boreholes. Some also collect water directly from the GPWUs kiosks and later resells them at a higher price [16].

The production, marketing and consumption of sachet water have increased tremendously. There are now several brands of these type of packaged water marketed in Nigeria and other developing nations ([17] and [18]). This so called Pure Water in sachets is readily available, easy to serve and the price is affordable and finds patronage from the middle class and members of low socio-economic classes, but there are concerns about its production, purity, packaging and distribution.

Water packaging industries are the most common industries located in cities, towns and even villages in Nigeria. These industries are great employers of unskilled or semi-skill worker in Nigeria in addition to providing Nigerian people with clean and safe drinking water. The quality of water supplied by these industries to their consumers is carefully monitored and maintained by the National Agency for Food and Drug Administration and Control (NAFDAC) by examining and certifying through quality water analysis, regular fumigations of factory and its environment, medical tests of factory workers, uses of correct water packaging polythene materials e.g low density polythene.

Water packaging industries consist of water supply from boreholes or public pipe borne water. Water is the main source of raw material, usually stored in overhead storage tank. The water filtration section is made of particles/sediment filtration, reverse osmosis membrane filtration systems or cartridge fillers (of varying microns) and ultra-violet water sterilizer system. Water sachet production section is where the water is sealed in sachets using automatic liquid (water) packaging/sealing machine. Packaging storage sections is where sealed water sachets (containing 50cl of water) are packed in plastic bags. Each plastic bag contains twenty sachet and they are stored for sale.

2. PROBLEMATIC REALITY

Today, business competitiveness is the primary tool of large companies to be first in the market for goods and services. Medium and small businesses are not alien to it. The industrial sector, mainly the transformation companies such as chemical industries are increasingly concerned about being competitive and for this they have two basic tools that are quality and productivity. These can be molded to the needs of the market, but they depend on the quality of the industrial processes that are the ones that make the quality of the products, and the productivity that defines the cost.

In Nigeria today, there are few companies that handle their industrial transformation processes in the best way and this affects the quality of products or processes that lose competitiveness compared to similar products or processes that come from foreign companies that use better technologies and apply better tools for the control of its processes. A science with optimal results in the management of product quality or production processes is the Statistical Process Control, which in most cases has been applied only to the quality of the products, however, knowing that the quality of the products depends on the production process, so it is obvious to think that the statistical process control system can be applied to industrial processes through the control of the variables and according to the characteristics of the products.

A major sachet water production defect is water leakage from the sachets. The water leakages or defects are caused by (i) incorrect use of machines sealing temperatures, its under-set or over-set temperatures causes poor sealed sachets and burnt sealed sachets respectively that later result to water leakage (ii) electric power supply fluctuation causing varying set temperature (iii) variation of thickness of supplied polythene during manufacturing, requiring varying sealing temperatures to properly seal the plastic sachets (iv) damaged or pierced supplied caused by plastic roll during transportation or manufacturing or (v) dist or sticky Teflon surfaces used for sealing sachets can result to leakage or product defects.

These are some of the problems that have motivated this research of real life application type focused on the statistical control of packaging and marketing processes applied in Nigerian company in the water industry.

This research work aimed at ensuring that the production and marketing process of sachet water is monitored to reduce variability and maintain the process target. To determine when the process needs adjustment and when it does not. To establish process stability and detect process changes so that corrective action can be taken and finally, to improve quality and productivity by improving the process, which reduces product inspection, scrap and rework at the end of the line.

3. MATERIALS AND METHODS

This research took place in Kaduna state, Nigeria. The data was collected from Wellcare Table Water Company Nigeria Limited., Kilometer 13, Along Government Secondary School Jagindi-Tasha, Kaduna state, Nigeria. Daily production data comprising of useful output products, defectives and sales were collected and recorded for 30 days of production and marketing.

Related data needed for the monitoring process of sachet water were obtained directly from Wellcare table Water Company. The data include: i) Number of bags of water produced for each day, ii) Number of defective bags from the production, and iii) Number of bags of sachet water sales by different marketers. Each of the above-mentioned data was analyzed with “qcc” package using R statistical software. If the X-bar chart indicates that the marketing process is stable, we then proceed to R-chart to further confirm the process stability. If both conditions for stability were met, then the next step was to check if the sales were within the predefined specifications/limits. It is not only enough to confirm the stability of the marketing process but there is also need to find out if the processes were within the specified limit. Process Capability analysis was employed to check if the products are within the preset limits.

4. RESULTS AND DISCUSSION

The field data collected for this research contains the number of bags of sachet water produced per day and the number of defectives from the daily productions as well as the number of bags marketed by four independent distributors or sellers of the company which were presented in Table 1 and Table 2 respectively in the appendix.

Using equations (1 to 3) from section 1.1 and “qcc” package in R software, the information from Table 1 was used to construct p-chart and u-chart in Fig. 2 and Fig. 3 respectively as given below.

Also, making use of equations (4) to (11) from section 1.1 and “qcc” package in R software, the data from Table 2 in the appendix was used to construct x-bar chart and R-chart in Fig. 4 and Fig. 5 respectively as given below.

Similarly, considering equations (12) to (16) from section 1.2 and using Minitab (version 16) software, the data from Table 2 in the appendix was used to construct a process capability chart in Figs. 6 and 7 as given below.

The control chart of Fig. 2 and Fig. 3 represent a total of 30 days investigated fractional defectives with a confidence level of 99.73% (i.e 3 sigma or standard deviations). The plot indicates that the production processes of sachet water for twelve (12) days are found to be out of control. This statistically means that the production and packaging processes for the sachet water are unstable. It indicates that there is an assignable cause of variation in the production and packaging processes. Hence, there is a high chance of unexpected level of process variation which could be as a result of poor power supply, inexperienced workers and faulty working machines. Furthermore, it is interesting to note that the process being out of statistical control signifies a very high level of naturally occurring variations in the processes. Hence, investigations and corrective actions are required to check and remove the assignable cause or causes responsible for this unwanted behavior. It is also good to note that the control limits (LCL and UCL) are not given in straight lines (as shown in Figs. 2 and 3), this is as a result of the fact that the samples sizes are not the same (as shown in Table 1 in the appendix).

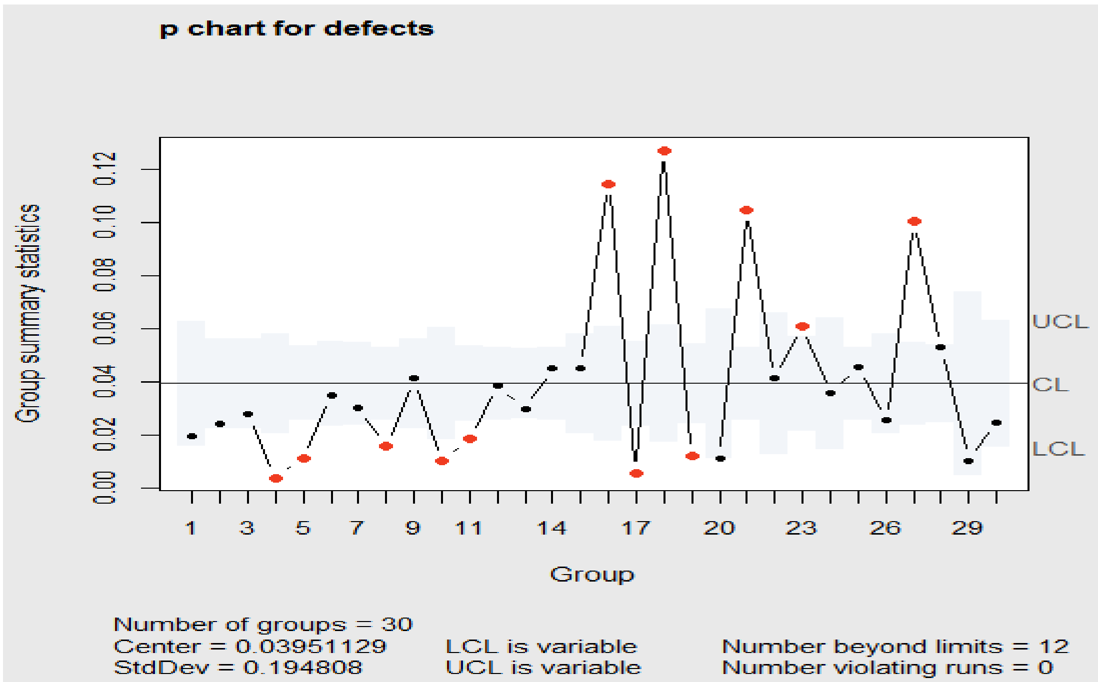

Fig. 2. p-chart for the number of defectives bags produced in 30 Days

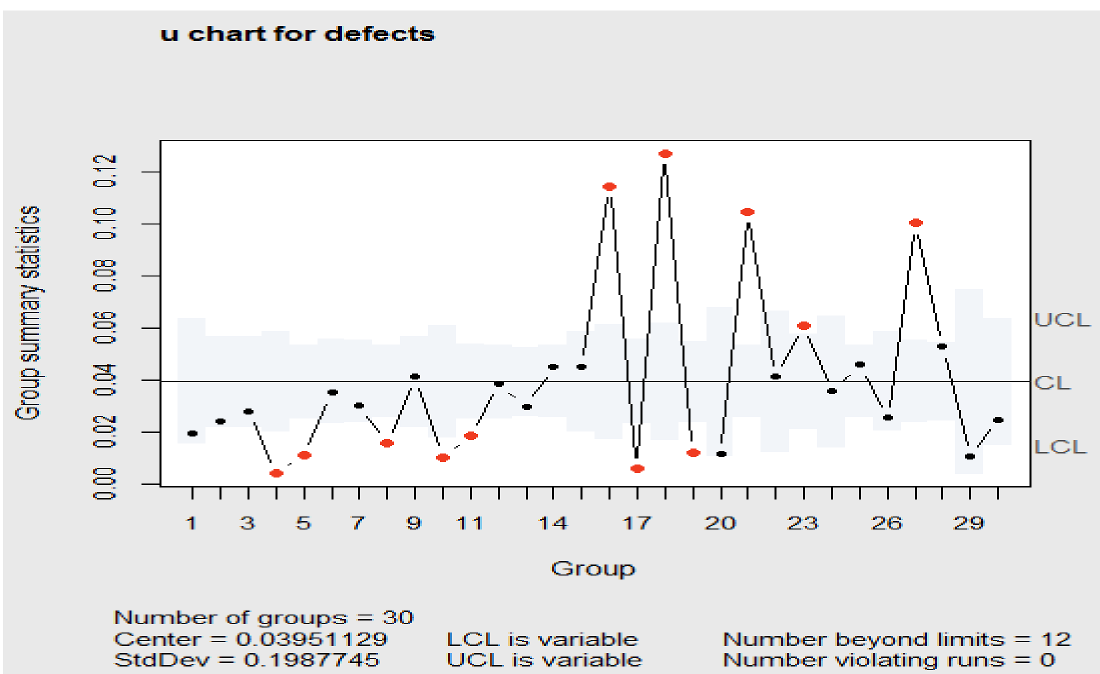

Fig. 3. u-chart for the number of defectives bags produced in 30 Days

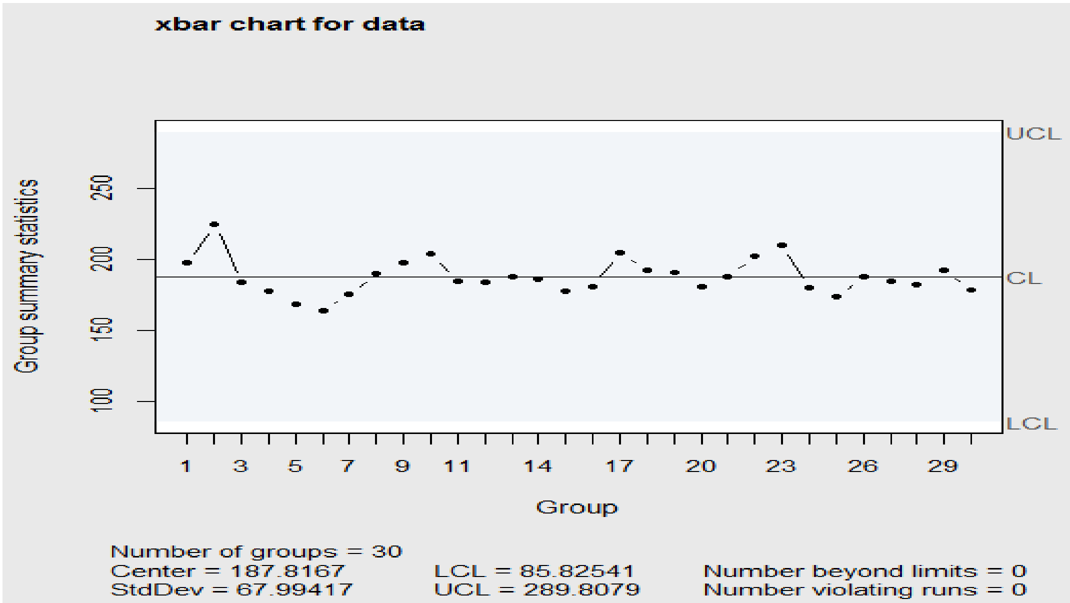

Fig. 4. X-bar chart for the sales of sachet water in 30 days by four marketers

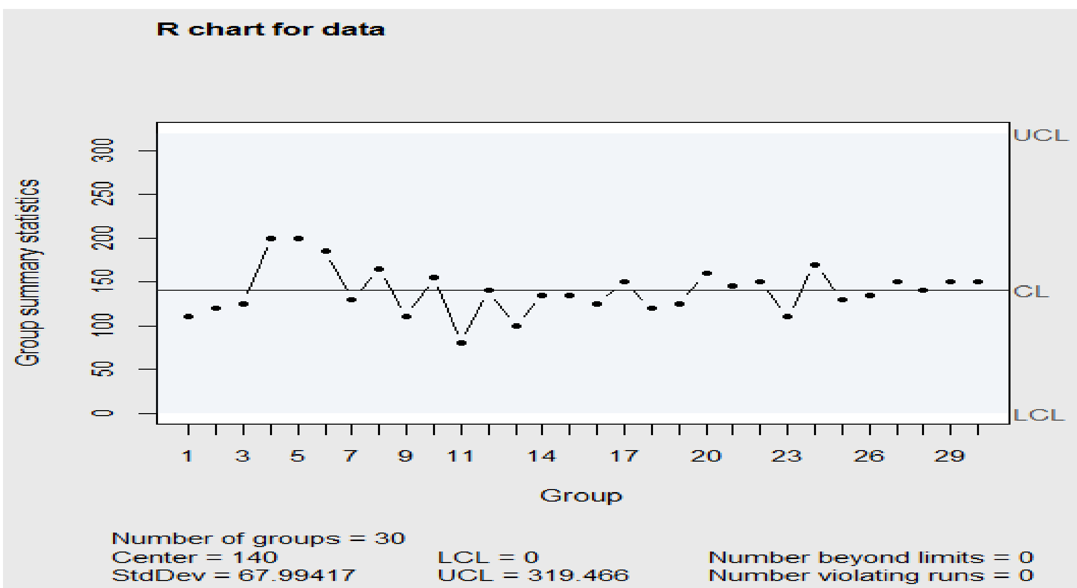

Fig. 5. R-Chart for the sales of sachet water in 30 days by four marketers

Figs. 4 and 5 show the X-bar and R charts of the product sales by four different marketers in 30 working days. It could be observed from the charts that all the 30 days' averages and ranges fall within the lower and upper control limits (which are respectively three-sigma below and above the mean with 99.73% level of confidence). Therefore, it can be noted that there is a 99.73% probability that the marketing process by the four independent sellers of the product (sachet water) obtained from the control processes fall within the control limits, with only 0.27% outside a 3-sigma control limits. This shows that the sachet water marketing process by the four marketers is stable for all the 30 days. It also shows that there is no assignable cause of variation in the marketing processes despite the differences in the individual distributors or sellers. This also indicates that there is a very low chance of unwanted level of process variation.

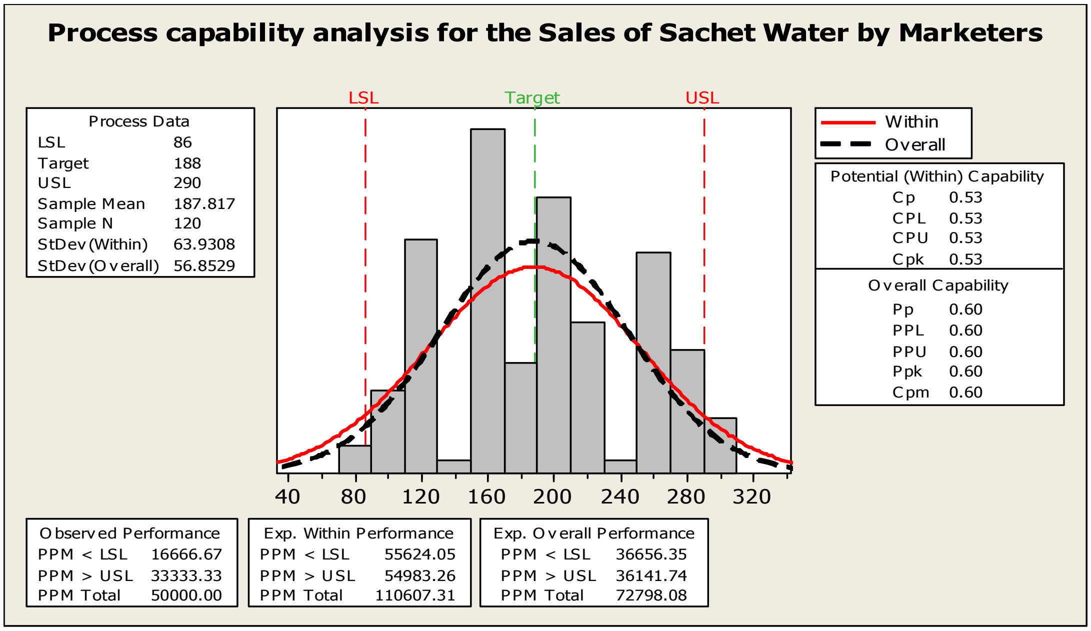

Fig. 6. Process capability analysis for the sales of sachet water by marketers

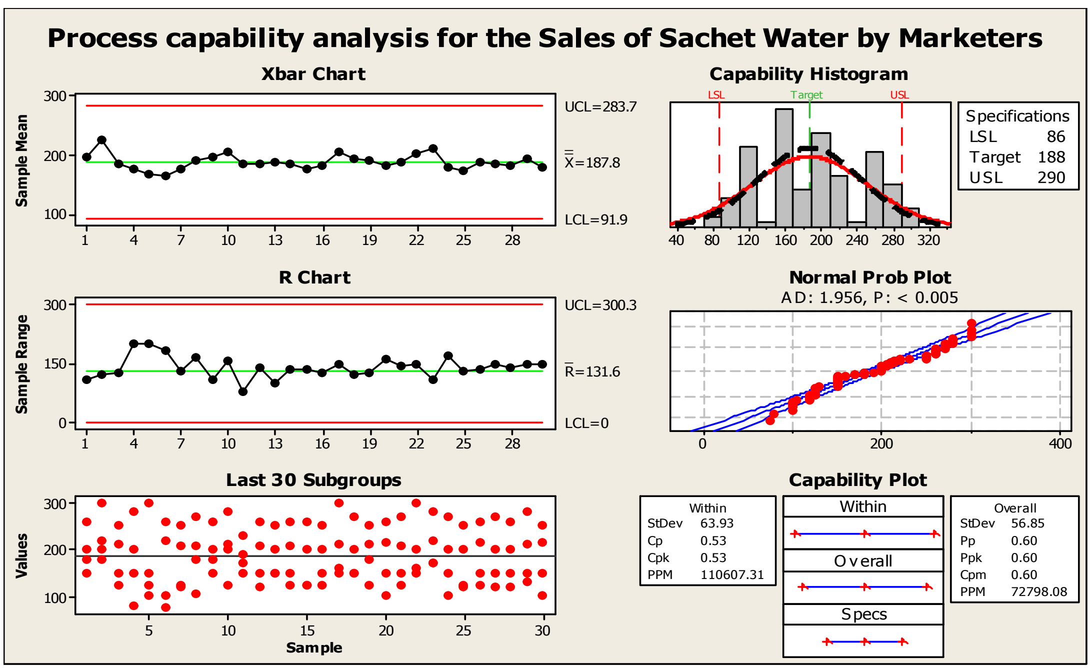

Fig. 7. Process capability analysis for the sales of sachet water by marketers

Figs. 6 and 7 show the process capability analyses of the marketing process. From both Figures, it can be observed that there are low process capability indices in respect of the marketing process of the product. All the capability indices are less than unity (<1), meaning that the marketing process of the product (sachet water) has a very low capability of meeting the preset specification limits in respect of the product sales. Also, in both figures the normal distribution curve is not centered based on the preset specification because its capability index is less than one. Though, it has earlier been established that there are no assignable variations in the process, yet, the fact that the capability index is less than one may result in a substantial percentage of the sales not within the preset specification limits in respect of independent sellers or marketers of the product.

Confirming that a process is stable is not enough; rather, it is expedient to check if variables are within the pre-set limits/specifications. This was the reason for performing Process capability analysis on the data obtained from the company. Since all the Overall Capability indicators Pp, PPL, PPU, Ppk and Cpm as well as the Potential Capability (within) indicators CP, CPL, CPU and CPK are less than one, that implies that the process is not capable of giving a very good market value of the product within the pre-set limits.

5. CONCLUSION

The p-chart in Fig. 2 and the u-chart in Fig. 3 show that the process is out of control and there is a presence of assignable causes of variations in which efforts must be made by the company manager or quality control officer to know the causes of variation and deal with it appropriately.

The statistical quality control X-bar and R charts have been successfully applied to the distribution or marketing process of Nigeria Sachet Water Industry Limited with respects to Sales of the product by independent sellers or distributors. The X-bar and R charts constructed revealed that the data obtained on the Sales are uniformly distributed and that the data are all within the control limits with 0.27% of the points outside the 3-sigma control limits, which is equivalent to a 99.73% level of confidence. Consequently, this shows that there is no assignable cause of variation in the marketing processes, which means that the marketing process is stable despite individual differences. Hence, there is a very low chance of unprecedented level of process variation, with normal inherent level of variation as the only common source of variation which may arise as a result of inadequate working condition. However, if a system falls within the control limits, it does not guarantee that the preset specification limits will be met. Hence, the process capability analysis was carried out to check its ability of meeting the preset specification limits in respects of the individual marketing process. Therefore, in respect of the product sales process by independent marketers, the capability analysis revealed low values for all the capability indices, which corresponds to low capability of the marketing process in successfully meeting the preset specification limits for the product sales.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table 1. Number of bags of sachet water produced/ackaged and defectives

Work Days	Number of Bags produced	Number of Defectives	Proportion of Defectives
1	609	12	0.019704
2	1159	28	0.024159
3	1181	33	0.027942
4	962	4	0.004158
5	1758	20	0.011377
6	1332	47	0.035285
7	1417	43	0.030346
8	1822	29	0.015917
9	1159	48	0.041415
10	766	8	0.010444
11	1713	32	0.018681
12	1783	69	0.038699
13	2000	60	0.03
14	1813	82	0.045229
15	947	43	0.045407
16	723	83	0.114799
17	1341	8	0.005966
18	699	89	0.127325
19	1468	18	0.012262
20	432	5	0.011574
21	1809	190	0.10503
22	483	20	0.041408
23	1048	64	0.061069
24	558	20	0.035842

Work Days	Number of Bags produced	Number of Defectives	Proportion of Defectives
25	1827	84	0.045977
26	976	25	0.025615
27	1434	144	0.100418
28	1584	84	0.05303
29	283	3	0.010601
30	600	15	0.025

Table 2. Bags of Sachet Water Distributed or marketed by 4 workers

Work Days	Sales in Bags by independent workers				Mean	Range
	A	B	C	D		
1	120	260	180	150	197.5	110
2	220	300	200	180	225	120
3	210	250	150	125	183.75	125
4	200	280	150	80	177.5	200
5	150	300	125	100	168.75	200
6	220	260	100	75	163.75	185
7	206	250	125	120	175.25	130
8	206	270	180	105	190.25	165
9	200	260	150	180	197.5	110
10	210	280	125	200	203.75	155
11	190	230	170	150	185	80
12	206	260	150	120	184	140
13	200	250	150	150	187.5	100
14	209	260	125	150	186	135
15	200	260	125	125	177.5	135
16	200	250	150	125	181.25	125
17	210	300	160	150	205	150
18	200	270	150	150	192.5	120
19	210	250	180	125	191.25	125
20	215	260	150	100	181.25	160
21	206	270	125	150	187.75	145
22	200	300	150	160	202.5	150
23	220	280	170	170	210	110
24	200	270	100	150	180	170
25	200	250	125	120	173.75	130
26	215	260	125	150	187.5	135
27	200	270	150	120	185	150
28	200	260	120	150	182.5	140
29	210	280	150	130	192.5	150
30	215	250	100	150	178.75	150
					$\bar{\bar{X}}$ =187.8167	$\bar{\bar{R}}$ =140

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