



Research Article

Determination of Non Conformance to Standard of
Atlantis Bottled Water Products in Gombe

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ABSTRACT

Keywords:
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Product

This study aimed to assess the nonconformance to the standards of Atlantis bottled water products in Gombe, Nigeria. The objectives were to determine whether the defective proportion of bottled water at Atlantis is within the acceptable quality level (AQL), assess if the pH level meets the World Health Organization (WHO) standards, and evaluate how well the production process satisfies customer requirements. Various statistical quality control techniques were applied, and data on the proportion of defective bottled water products were collected. A normal approximation to a binomial function was used to evaluate if the proportion of defective products exceeded the AQL of 5%. Results, analyzed using P-charts for attribute data, indicated that the production process was in control, with all observed values falling within acceptable control limits. In addition, the pH levels of the bottled water conformed to the WHO standard range of 6.5-8.5 for drinking water. However, the process capability index ($C_p = 1.05$) revealed that the production process was not fully capable, indicating a need for improvement, as the ideal condition for capability is $C_p < 1$. The study recommends that training and awareness seminars be conducted for workers to help the firm achieve its quality goals. Future research could investigate other quality indicators, such as water salinity and chlorine levels, to enhance bottled water quality.

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INTRODUCTION

The Nigerian market is being flooded with a lot of sub-standard products. This implies that, there is still ongoing problem of quality control in Nigeria especially in the manufacturing sector. It has long been an accepted fact that quality holds the key to competitiveness in the global market irrespective of the size of the company. In this regard, competitiveness means possessing the capability to make the right goods and services of the right quality, at the right price and at the right time. Quality is a term that carries important meaning to both producers and consumers. According to Gbadeyan and Adeoti (2015). Quality is the conformance to requirements and those requirements must be defined in measurable and clearly stated terms. It includes the products overall durability, reliability, precision, ease of operation, repair and other valued attributes. The quality of the company product or service determines its position in the market. This is because customers desire to get the best value for their money. The quality of product or service can only be defined by the customer (Deaming, 2010). This means that for a production firm to be satisfied with the quality of its goods or services, its customers must be satisfied with it. Quality is the major goal organization seek to achieve but often time, this goal is not achieved due to some challenges. As a result of these problems of quality control especially in the manufacturing sector of Nigeria, this study took a cursory look at the statistical quality control in the bottled water production Company in Nigeria, a case study of Atlantis table Water. So far Atlantis table Water is the best bottled water company in Gombe, the source of water is borehole water. It is located off Mile 3 Bypass, near Gombe State House of Assembly complex Gombe, Gombe State. It was established in June, 2015, with a wide range distribution across the Northeastern States of Nigeria.

Quality is difficult to define, since it means different things to different people. On general definition it means "degree of excellence". In order to understand clearly what quality is all about, it is necessary to put the views of some authors. According to Anyanmu (2013). Quality is seen as all of the features and characteristics of a product or service that contributes to the satisfaction of customer needs. Those needs involve price safety;

maintain ability, reliability and usability. Ile (2011), Quality of a product is defined by a set of specifications governing functional performance, composition strength, shape, dimension, workmanship color and finish.

Nnamani & Fabosso (2013) researched on the statistical quality control of manufactured products (case study of packaging at lifespan at pharmaceutical limited). The research work investigated the level of quality control in Lifespan Pharmaceuticals Limited, makers of lifespan Table Water. The study involved the inspection of some randomly selected finished products on daily basis. The data on the number of defectives were collected two times per day. The physical observations from the company were analyzed using statistical tools such as descriptive statistics and control chart for attributes.

Uche & Ogele (2013); examined the effect of total quality Management on industrial Performance in Nigeria. Longitudinal design was employed which spanned the period of 1996 to 2008. The data were analyzed using ordinary Least Square Method of Multiple regression to determine the effect of the predictor variables on the dependent variable. It was concluded that total quality management substantially enhanced industrial performance in the brewery sector of the Nigerian Economy.

Keiko & Ricardo (2013) contributed on the application Of Statistical Quality Control tools to Monitor Ethanol Process Production. They deliberated on characterization of the ethanol production process and the implementation of control charts and process capability analysis. They therefore concluded that the study demonstrated that the principles of statistical quality control could be widely applied in ethanol production process. The quality tools allowed the diagnosis of which variables should be controlled to improve the alcoholic fermentation efficiency.

Marire and Sydney (2014) examined the problems of quality control in manufacturing firms. The various techniques of quality control that are used to assess the effectiveness of their applications. The research was undertaken to examine the problems of quality control in manufacturing firms, the various techniques of quality control used to assess the effectiveness and efficiency of their applications. The method of statistical analysis

used includes table and percentage while chi-square was used to test hypothesis formulated. There are quite a number of problems militating against control practice in bottled water production in Nigeria. A careful study, analysis and diagnoses will be performed in order to trace the problems, diagnose them, and prevent their re-occurrence. Some of the problems traced are Cost of Application, Lack of product conformity with the required standard and manufacturing firm attitude. The aim of this paper is to determine the nonconformance to standard of Atlantis bottled water products in Gombe and the objectives of the paper are to employ the different techniques of quality control in bottled water production, to determine whether the proportion defective found in the bottled water production at Atlantis table Water is not more than the acceptance quality level, to check whether the PH-level of bottled water produced at Atlantis table Water do conform to World Health Organization Standard for drinking water, to analyze whether the production of bottled water at Atlantis table Water is under Statistical control in a short term scope and to determine how well process output meets customer requirements. The study will be of great significance to Atlantis bottle water, researcher, regulatory authorities and the general public. Also the study will expose the pros and cons of the industry practices towards quality control, thereby serving as a signal for taking precautionary and necessary measures towards achieving the desired quality goals. Statistical quality control which includes statistical process control, Acceptance Sampling and control charts methods will be used in this research to ascertain the non-conformance to standard of bottle water in Gombe.

MATERIALS AND METHOD

Source of Data

Simple random sampling method was adopted, which is the purest of sampling probability in the sense that each member of the population has a known zero probability of being selected. Secondary Data was used, it is done by recording observation during production for a space of two weeks, consecutively on daily basis, and each day 20 samples were taken, each containing 2000 bottles. Data on the average value of PH level of the bottle water produced for five consecutive years has been collected on monthly basis, so as to check

conformity with the World Health Organization standard for drinking water.

Formulation, Formulae and procedures for P and np – Chart

The statistical process control, which is a statistical approval that is used for assisting operators, supervising and managers, plays a crucial role in managing quality and eliminating special causes of variability in a process. This control varies depending on the type of data being presented, whether it is attribute data or variable data. The attribute data refers to data that is categorical in nature and can be counted, such as the number of defects in a product. On the other hand, variable data refers to data that is continuous and can be measured, such as the weight or length of a product. By understanding the type of data being analyzed, operators, supervising and managers are able to effectively utilize statistical process control to identify and address any issues or deviations in the process, ultimately leading to improved quality and reduced variability. The quality of numerous products is contingent upon a plethora of characteristics that elude quantification as variables, such as the count of articles conforming or not conforming, or perhaps being appraised solely as either present or absent, acceptable or not acceptable, defective or non-defective, satisfactory or non-satisfactory. In order to analyze attribute data, various tools can be employed, including but not limited to the P-chart and the np-chart. These tools provide invaluable insights into the performance and adherence of attributes within a given product, enabling organizations to make informed decisions and implement appropriate measures for improvement. By utilizing such statistical methods, companies can ensure the delivery of high-quality products that satisfy customer expectations and contribute to overall market success.

The tools used for the control of quality in this work are the P-chart and the np-chart. These tools are appropriate of control the quality when the variables are attributing in Nature. The P-chart is designed to control the percentage or proportion of defective samples while np-chart is designed to control the number of defectives rather than the proportion defective.

Steps in constructing the np-chart

$$P(X = x) = \binom{n}{x} p^x (1 - p)^{n-x} \dots\dots\dots(1)$$

$$E(x) = np = \bar{x}, \text{ Var}(x) = np(1 - p) \text{ or } npq \text{ where } q = (1 - p)$$

where x is the number of defectives

To Compute the average number defective we have;

$$\text{Central Limit (CL)} \Rightarrow CL = np \dots\dots\dots(2)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = np + \sqrt[3]{n(1 - p)} \dots\dots\dots(3)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = np - \sqrt[3]{n(1 - p)} \dots\dots\dots(4)$$

Steps in Constructing P-Chart

If x is a proportion defective, then

$$E(x) = p = \bar{x}, \text{ Var}(x) = \frac{p(1 - p)}{n} \text{ or } \frac{pq}{n} \text{ where } q = (1 - p)$$

Compute the average fraction defective p by dividing the number of defectives by the total number of units inspected as follows;

$$\text{Central Limit (CL)} \Rightarrow CL = \bar{P} = \frac{\sum_{i=1}^n x}{n} \dots\dots\dots(5)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = \bar{P} + \sqrt[3]{\frac{p(1 - p)}{n}} \dots\dots\dots(6)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = \bar{P} - \sqrt[3]{\frac{p(1 - p)}{n}} \dots\dots\dots(7)$$

Data of variable in nature were analyzed in chapter four of this research work, suitable tools has been introduced to analyze the data, which is the \bar{X} and \bar{R} chart.

\bar{X} and \bar{R} Chart

It applies when analyzing data of variable in nature when $n \leq 10$ and if

$$X \square iid N(\mu_1, \sigma^2), \text{ then } \bar{X} \square N\left(\mu_1, \frac{\sigma^2}{n}\right) \text{ from normal distribution,}$$

$$E(\bar{x}) = \mu, \text{ Var}(\bar{x}) = \frac{\sigma^2}{n}$$

$$\text{Central Limit (CL)} \Rightarrow CL = \bar{\bar{X}} \dots\dots\dots(8)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = \bar{\bar{X}} + 3\sigma\bar{\bar{X}} \dots\dots\dots(9)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = \bar{\bar{X}} - 3\sigma\bar{\bar{X}} \dots\dots\dots(10)$$

An estimate of σ is $\sigma = \frac{\bar{R}}{d_2}$, where d_2 is a constant value from statistical quality control table. Hence;

$$\text{Central Limit (CL)} \Rightarrow CL = \bar{\bar{X}} \dots\dots\dots(11)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = \bar{\bar{X}} + 3\frac{\bar{R}}{d_2}\sqrt{n} \dots\dots\dots(12)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = \bar{\bar{X}} - 3\frac{\bar{R}}{d_2}\sqrt{n} \dots\dots\dots(13)$$

But $A_2 = \frac{3}{d_2} \sqrt{n}$. Then

$$\text{Central Limit (CL)} \Rightarrow CL = \bar{\bar{X}} \dots\dots\dots(14)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = \bar{\bar{X}} + A_2 \bar{R} \dots\dots\dots(15)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = \bar{\bar{X}} - A_2 \bar{R} \dots\dots\dots(16)$$

2..4 \bar{R} - Chart

For the corresponding \bar{R} -Chart, we have;

$$\text{Central Limit (CL)} \Rightarrow CL = \bar{R} \dots\dots\dots(17)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = \bar{R} + 3\sigma_{\bar{R}} \dots\dots\dots(18)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = \bar{R} - 3\sigma_{\bar{R}} \dots\dots\dots(19)$$

$$\text{But } \sigma_{\bar{R}} = d_3 \frac{\bar{R}}{d_2}$$

Then,

$$\text{Central Limit (CL)} \Rightarrow CL = \bar{R} \dots\dots\dots(20)$$

$$\text{Upper Control Limit (UCL)} \Rightarrow UCL = \bar{R} + 3d_3 \frac{\bar{R}}{d_2} = \bar{R} \left(1 + 3 \frac{d_3}{d_2} \right) = \bar{R} D_4 \dots\dots\dots(21)$$

$$\text{Lower Control Limit (LCL)} \Rightarrow LCL = \bar{R} - 3d_3 \frac{\bar{R}}{d_2} = \bar{R} \left(1 - 3 \frac{d_3}{d_2} \right) = \bar{R} D_3 \dots\dots\dots(22)$$

$$\text{where } D_4 = \left(1 + 3 \frac{d_3}{d_2} \right) \text{ and } D_3 = \left(1 - 3 \frac{d_3}{d_2} \right)$$

Capability

Capability index is a measure in a capability analysis that is used to check on the capability and characteristics of the process, denoted by C_p . It is defined to be ratio of tolerance to process capability. It is mathematically given as follows:

$$C_p = \frac{USL - LCL}{6\sigma} \dots\dots\dots(23)$$

Where

C_p is the Capability Index

USL – LCL is the tolerance, 6σ is the process capability.

$$\sigma = \frac{\bar{R}}{d_2} \text{ and } d_2 \text{ value is obtained from statistical quality control table.}$$

Acceptance Sampling

Acceptance sampling involves taking random samples of lots or batches of finished products and having inspectors measures them against pre-determined standard. The act of randomly sampling is deemed to be more cost-effective in comparison to conducting a thorough inspection of every individual item within the lot. Consequently, the quality of the selected sample is employed as a means to assess the

overall quality of each and every item contained within the aforementioned lot. Acceptance sampling is a major component of quality control. It is useful when the cost of testing the lots is high compared to the cost of passing a defective item, or when the test involved is a destruction one. It is compromise between a 100% inspection and no inspection at all.

Acceptance sampling is based on probability theory and mathematical statistic. The procedures of acceptance sampling are:

- i. Segregation of product into inspection lots
- ii. Selection of sample or samples for each lot
- iii. Inspection of each item in the sample or samples to determine their quality
- iv. Acceptance or rejection of each lot on the basis of inspection of the sample

Determination of Good Sampling Plan

A good sampling plan is characterized and determine by taking into consideration, the consumers and producer sides, where both of them has what and what to account for, consumer has specifications of products which he has in mind for his consumption while the producer has limits to which he can afford for his products.

The Model for the Plan

The probability model used in observing exactly defectives is an approximation to Binominal Distribution because it deals with the number of defectives observed per sample, which is given and defined as:

$$P(d \text{ defective}) = f(d) = \frac{n!}{d!(n-d)!} p^d (1-p)^{n-d} \dots\dots\dots(24)$$

The probability of acceptance “ P_a ” is the probability that d is less than or equal to c . Thus;

$$P_a = P(d \leq c) = \sum_{d=0}^c \left(\frac{n!}{d!(n-d)!} p^d (1-p)^{n-d} \right) \dots\dots\dots(25)$$

Test Statistic

The test statistic is the estimator used in the normal approximation to binomial distribution.

$$Z = \frac{\bar{P} - p}{\sqrt{\frac{pq}{n}}} \dots\dots\dots(25)$$

Software for the Analysis

The statistical package/software used for the analysis of this research article is R package. R is a language and environment for statistical computing and graphics. It is a GNU project which is similar to the S language and environment which was developed at Bell Laboratories (formerly AT&T, now Lucent Technologies) by John Chambers and

colleagues. R can be considered as a different implementation of S language.

Analysis

This phase provide an analysis, result and interpretation of the data obtained for Atlantis table water in Gombe. The results below will indicate whether they conform to world health organization standard or not.

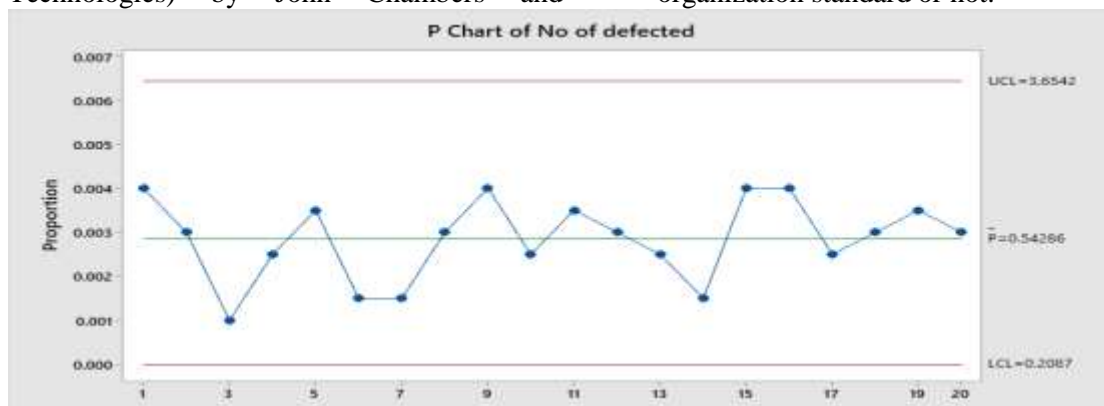


Figure 1: Control Chart for Monday production
 Number of groups = 20, Center = 0.54286, LCL = 0.2087, UCL = 3.6542, StdDev = 1.838 Number beyond limits = 0 and Number violating runs = 0. From figure 1 we can see that all the points in the

chart are within the range of control limits. Hence, conclude that the proportion of number of defectives is under statistical quality control.

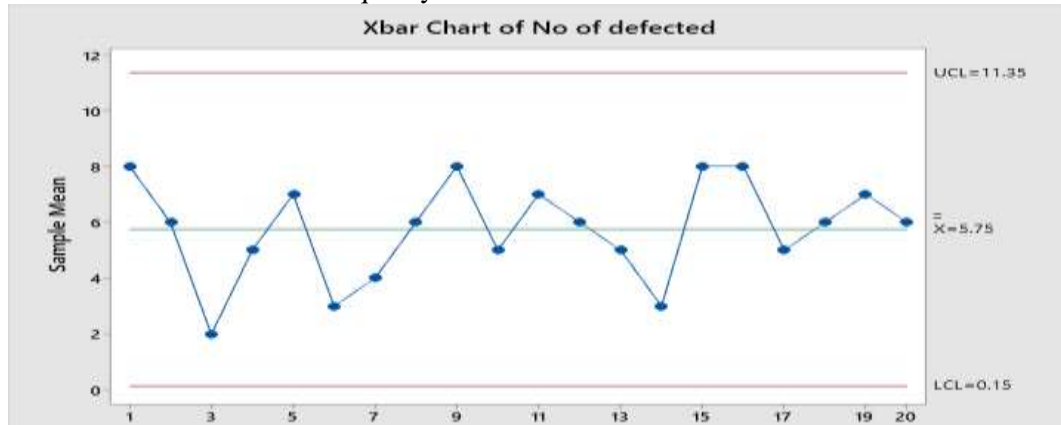


Figure 2: Show the X- bar chart for Monday production

Number of groups = 20, UCL = 11.35, Center = 5.75, LCL = 0.15, StdDev = 1.838
 Number beyond limits = 0, Number violating runs = 0. Figure 2 vividly justify the fact that

Atlantis Bottle Water do conform to world Health organization standard. Hence, the water is adequately purified and safety as no value violates the control limits.

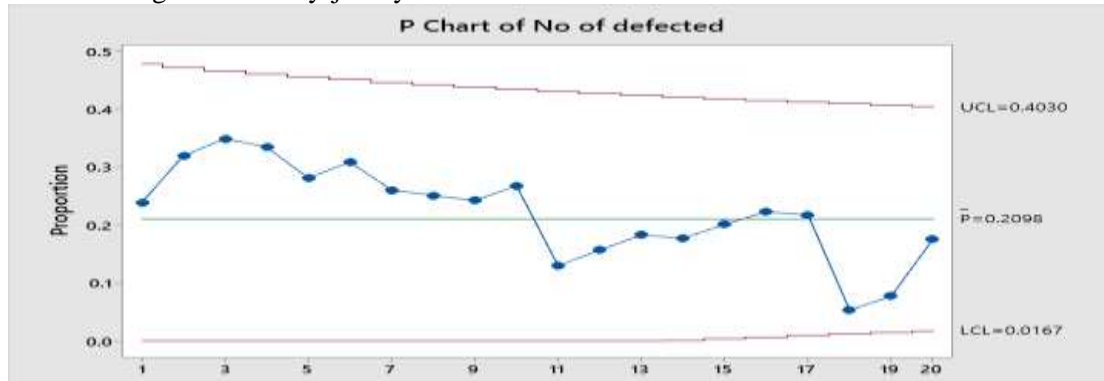


Figure 3: Control Chart for Tuesday production

Number of groups = 20, Center = 0.2098, LCL = 0.0167, UCL = 0.4030, StdDev = 1.759
 Number beyond limits = 0, Number violating runs = 0. From figure 3 we can see that all the

points in the chart are within the range of control limits. Hence, conclude that the proportion of number of defectives is under statistical quality control.

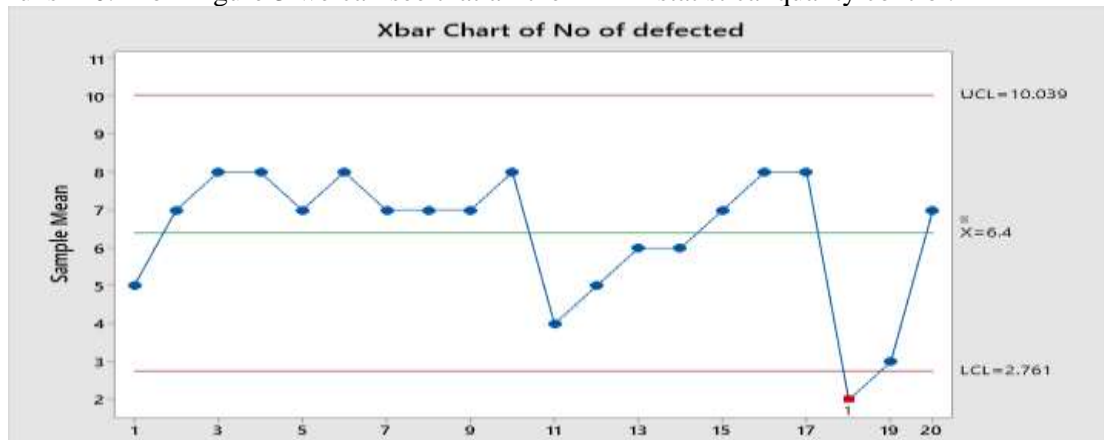


Figure 4: Show the X- bar chart for Tuesday production

Number of groups = 20, UCL = 10.039, Center = 6.400, LCL = 2.761, StdDev = 1.759
 Number beyond limits = 1, Number violating runs = 1. Figure 4 explain that Atlantis Bottle Water do conform

to world Health organization standard as only one run that is beyond the lower control limit which need the company to improve the quality of production. Hence, the water is under control.

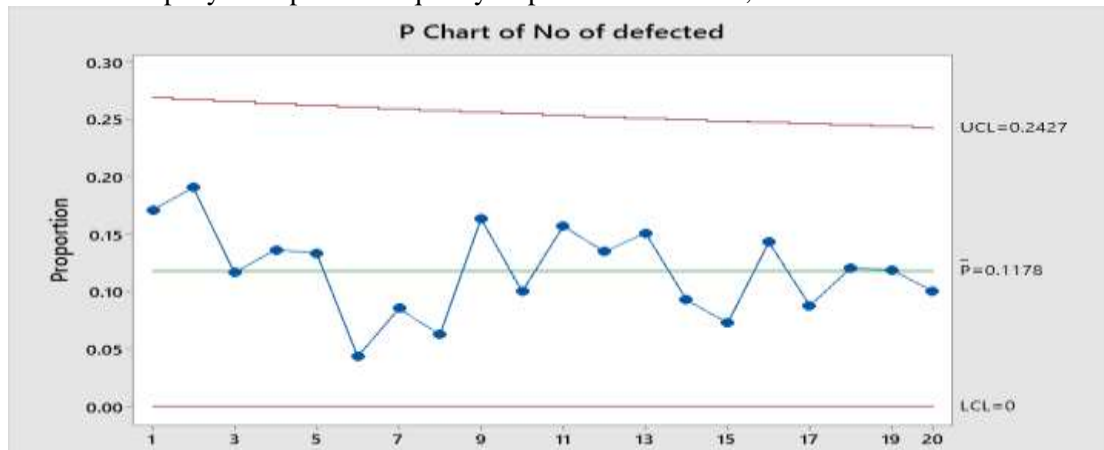


Figure 5: Control Chart for Wednesday production

Number of groups = 20, Center = 0.1178, LCL = 0.00, UCL = 0.2427, StdDev = 1.791 Number beyond limits = 0, Number violating runs = 0. Figure 5 indicates that all the points in the chart are within the range of control limits. Hence, conclude that the proportion of number of defectives is under statistical quality control.

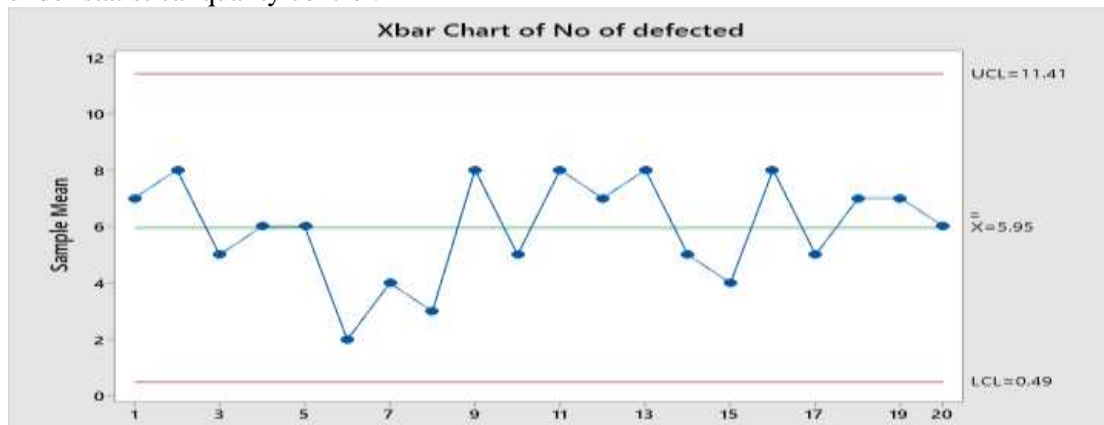


Figure 6: Show the X- bar chart for Wednesday production

Number of groups = 20, UCL = 11.41, Center = 5.95, LCL = 0.49, StdDev = 1.791 Number beyond limits = 0, Number violating runs = 0. Figure 6 shows that Atlantis Bottle Water does conform to world Health organization standard. Hence, the water is adequately under control as no value violates the control limits.

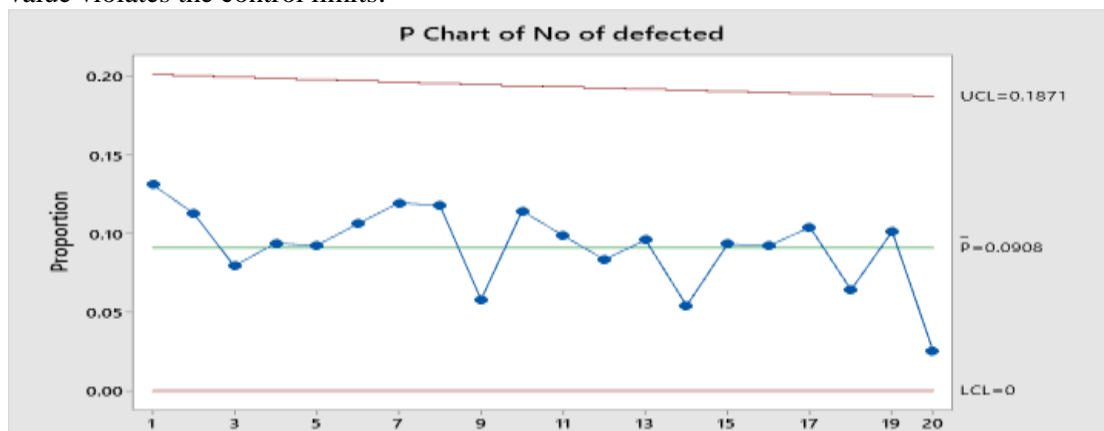


Figure 7: Control Chart for Thursday production

Number of groups = 20, Center = 0.0908, LCL = 0.00, UCL = 0.1871, StdDev = 1.667 Number beyond limits = 0, Number violating runs = 0. Figure 7 indicates that all the points in the chart are

within the range of control limits. Hence, conclude that the proportion of number of defectives is under statistical quality control.



Figure 8: Show the X- bar chart for Thursday production
 Number of groups = 20, UCL = 11.44, Center = 6.40, LCL = 1.36, StdDev = 1.944 Number beyond limits = 0, Number violating runs = 0. Figure 8 further ascertain that Atlantis Bottle Water do conform to world Health organization standard. Hence, the water is adequately under control as no value violates the control limits.



Figure 9: Control Chart for Friday production
 Number of groups = 20, Center = 0.0652, LCL = 0.00, UCL = 0.1393, StdDev = 1.667 Number beyond limits = 0, Number violating runs = 0. Figure 9 indicates that all the points in the chart are within the range of control limits. Hence, conclude that the proportion of number of defectives is under statistical quality control.

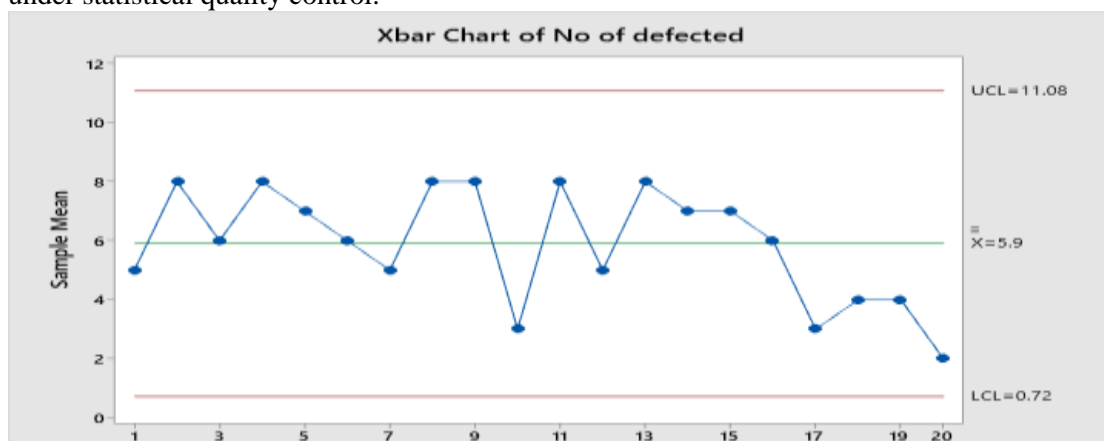


Figure 10: Show the X- bar chart for Friday production
 Number of groups = 20, UCL = 11.08, Center = 5.90, LCL = 0.72, StdDev = 1.944, Number beyond limits = 0, Number violating runs = 0. Figure 10 shows that Atlantis Bottle Water does conform to world Health organization standard. Hence, the water is adequately under control as no value violates the control limits.

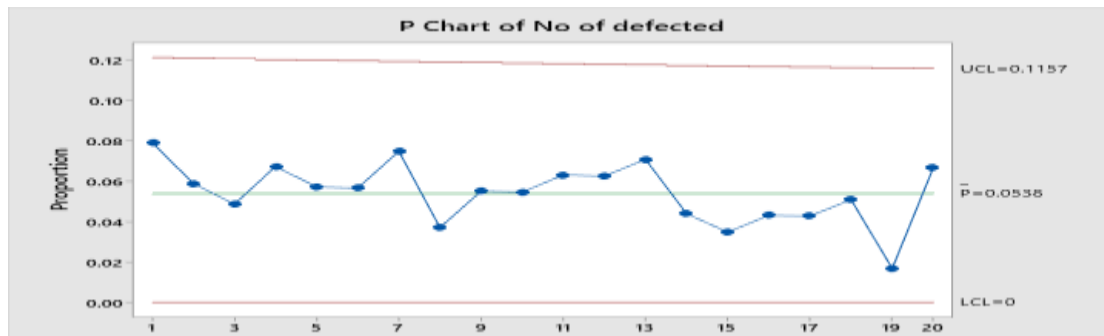


Figure 11: Control Chart for Saturday production
 Number of groups = 20, Center = 0.0538, LCL = 0.00, UCL = 0.1157, StdDev = 1.572 Number beyond limits = 0, Number violating runs = 0. Figure 11 indicates that all the points in the chart are within the range of control limits. Hence, conclude that the proportion of number of defectives is under statistical quality control.



Figure 12: Show the X- bar chart for Saturday production

Number of groups = 20, UCL = 10.43, Center = 5.95, LCL = 1.47, StdDev = 1.572
 Number beyond limits = 0, Number violating runs = 0. Figure 12 shows that Atlantis Bottle Water does conform to world Health organization standard. Hence, the water is adequately under control as no value violates the control limits.

Interpretation of P-Charts

One of the objectives of this research has been achieved so far in the sense that the available data has been statistically analyzed, chart were plotted and concluded that only one of the chart above critically has unusual pattern while

the rest pattern point felt within the interval between the upper and lower control limit. Hence the production of water at Atlantis Bottle water is under statistical control in short term scope. Based on the information obtained from the charts above it is evidence that Atlantis bottle water do stick to standard in their production.

Analysis of Acceptance Sampling Plan

Table 1 below shows the results of sampling plan for the data collected using acceptance sampling for bottled water produced by Atlantis Bottle water

Table 1: Acceptance Sampling Data

Sampling parameter	Value
Lot Size, N	120
Sample Size, N	2000
Acceptance Number	3
AQL	0.045
Producer Risk (X)	0.040
Consumer Risk (B)	0.17
Probability Model	Binomial Distrubution
Observed Defective	11

Hypothesis: $H_0: \bar{P} = 0.045$ Vs $H_1: P > 0.040$

Test Statistics

The normal approximation to Binomial estimator is used in the analysis, from equation 25

$$Z = \frac{\bar{P} - p}{\sqrt{\frac{\bar{P}q}{n}}} = \frac{0.046 - 0.040}{\sqrt{\frac{(0.046 \times 0.040)}{120}}} = \frac{0.005}{\sqrt{0.000358}} = \frac{0.005}{0.0146} = 0.2643$$

Decision Rule

Reject H_0 if $Z_{cal} > Z_{tab}$ otherwise, do not reject H_0

Standard normal table $Z_{0.05} = 1.462$ (one tailed)

Below are the computation using R statistical software:

```
>xbar = 0.045          #sampe mean
> mu = 0.040          # Hypothesized deviation
> sigma = 2.076# Population standard Deviation
>n = 200              # Sample Size
>z = (xbar - mu0)/(sigma/sqrt (n))
>z # Test Statistic
[1] 0.02425096
```

The critical value at 0.05 level of significance is also computed using R

```
>alpha = 0.05
>z.alpha = qnorm (1-alpha)
>z.alpha          # critical value
[1] 1.644854
[2] Since  $Z_{cal} = 0.2643 < Z_{tab} = 1.462$ , we therefore accept  $H_0$ 
```

Interpretation of the Result

Since $Z_{cal} = 0.2643 < Z_{tab} = 1.46$, we do not have enough evidence to reject H_0 , we therefore accept H_0 at 5% level of significance and conclude that the proportion of defective found in bottled water production at Atlantis Bottle water is not more than the acceptance quality level, thus, in statistical control. This implies that the defectives in the lot are less than or equal to 5%, which tally with the company's historical control. Hence, we

conclude that the production of bottled water at Atlantis Bottle water is under statistical control.

Analysis on PH Level

Table 2 shows the total mean and ranges of pH level of water obtained over the span of five years of bottled water production. On the table, we let the variables to the subgroup values of data obtained over the years 2017, 2018, 2019, 2020 and 2021 from Atlantis Bottle water

Table 2: Record of pH level of water produced

	2017	2018	2019	2020	2021	TOTAL	MEAN	RANGE
JANUARY	6.6	6.8	7.9	6.6	7.7	35.6	7.1	1.3
FEBRUARY	8.7	7.0	7.8	6.8	7.8	38.1	7.6	1.9
MARCH	7.0	7.5	8.0	8.2	6.6	37.3	7.5	1.6
APRIL	7.3	6.8	8.4	8.4	8.3	39.2	7.8	1.6
MAY	7.0	6.7	6.8	8.0	8.1	36.6	7.3	1.4
JUNE	7.1	8.3	6.7	7.0	8.0	37.1	7.4	1.6
JULY	6.8	8.2	6.9	7.1	7.7	36.7	7.3	1.4
AUGUST	8.2	7.9	7.7	7.5	6.7	38.0	7.6	1.5
SEPTEMBER	8.4	7.5	6.6	7.5	7.6	37.6	7.5	1.8
OCTORBER	7.5	8.0	8.4	7.5	8.4	39.8	8.0	0.9
NOVEMBER	6.9	6.8	8.1	6.8	6.8	35.4	7.1	1.3
DECEMBER	8.1	6.9	6.7	7.1	7.1	35.9	7.2	1.4

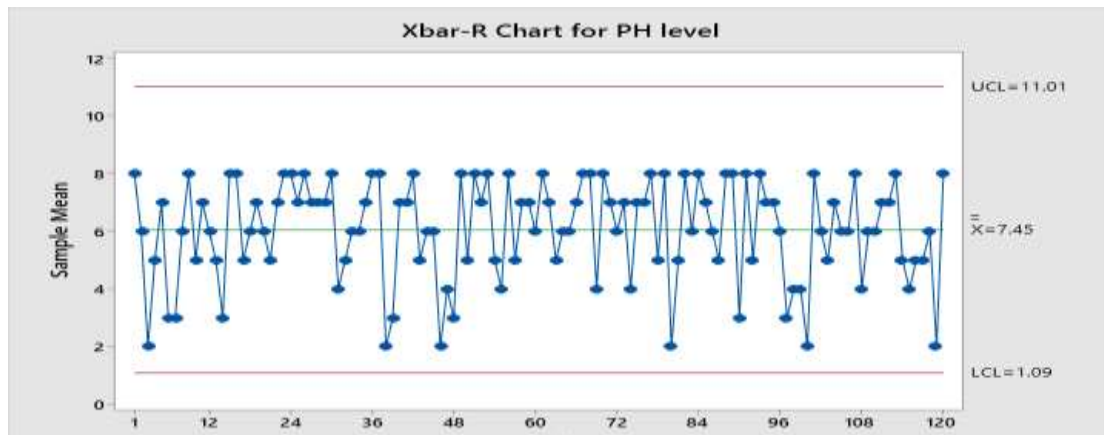


Figure 13: X and R-Chart PH level of bottled water produced

Number of groups = 120, UCL = 11.01, Center = 7.45, LCL = 1.09, StdDev = 1.748
 Number beyond limits = 0, Number violating runs = 0. Figure 13 indicates that the PH level of Atlantis bottle water is under statistical quality control as for the period under study as no value is outside the range of PH level given by World Health Organization (6.5 – 8.5). Thus, the company should maintain the

standard for consumption and satisfactory of the costumers.

Capability Analysis

In computation of capability analysis, we need the values of R which is the mean of ranges and d2 which is the value obtained from a table if it is computed manually, rather statistical software had been used



Figure 14: Process Capability Report for PH Level

Inter-operation of Process Capability

From the figure above, the value of $C_p = 1.05$ indicates that the process is not capable since C_p^D is less than 1 ($C_p < 1$). Also $C_{pk} = 0.81$ less than $C_p = 1.05$ means that the process is off centered. Higher value of C_{pk} indicate that the process is meeting the target with minimum process variation, while lower value ($C_p < 1$) is an indication that an improvement in the process is warranted.

3.6 Discussion of the Results

The result obtained in all the analysis are enough to say whether the production of bottled water at Atlantis Bottle Water is in control or otherwise. We can deduce the implication of the result from the analysis of acceptance sampling plan; which shows that

the defectives in the lot are less than or equal to 5%, which therefore implies that the production is strictly under statistical control. The data obtained for number of detectives per 1000 bottles for two consecutive week’s shows that the production is in statistical control in a short term scope.

Moreover, the result on the analysis of PH-level emphasized to us more that the production of bottled water in the company for the past five consecutive years, 2017, 2018, 2019, 2020 and 2021 all are in accordance with the World Health Organization (WHO) standard for drinking water, which states that the PH level of standard drinking water is within the range of 6.5 and 8.5, hence the

production of bottled water at Atlantis Bottle Water is under statistical control.

The analysis on Capability index indicated that the process is not capable as the desired condition for capability was not at hand ($C_p > 1$). It is therefore a signal that an improvement in the process is warranted and must be considered for the process output to meet customer requirements.

The tables in the previous chapter displayed the data collected on respective days, the figures below are P-Charts, for the respective reproduction days. It displays the patterns of observed defectives in the production per lot sample selected. The charts are plotted using R statistical package.

CONCLUSION

The research was aimed at applying statistical quality control techniques to the available data provided by the company. The physical and chemical quality properties of bottled water were successfully analyzed, thus, the proportion of defectives was found to be less than the acceptance quality level which makes the production to be in a smooth line of control. Also, the chemical property which is the PH level was observed in five years' record, and the analysis showed that the PH level of water produced at Atlantis Bottle Water is under Statistical Quality Control. Moreover, the capability analysis showed that the process was off centered, which means that the process output did not meet customer requirements. Hence, a considerable improvement in the process would be required. This research is very vital in any country, states, local or any area where people lives in order to monitor the safety of consumable products at the same time very vital to health.

RECOMMENDATIONS

Based on the results obtained the company should implement a dependable data storage system with expert in statistical quality control, organize awareness program within the company's department highlighting the significance of quality control in manufacturing firms. Promote the use of acceptance sampling to enhance consumer

trust and confidence in product quality and adhere strictly to the standard set by regulatory bodies such as NAFDAC, SON, NSDWQ, WHO among others for their products.

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