Global Journals LaTeX JournalKaleidoscope™

Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

Investigating the Quality Performance of Production of Some Selected Drinks using Hotelling T-square and Control Chart

Akomolafe A.[1], Olawale A.O.[2], Jennifer . J.[3] and Oladimeji O.A.,[4]

[1] Federal University of Technology

Received: 10 November 2020 Accepted: 3 December 2020 Published: 15 December 2020

Abstract

Consumers make complaint about the state of home-made goods, in fact many claim that foreign goods are of high quality compared to home-made goods. We discovered that many of our indigenous industries are no more in existence and so this brought the desire to carry out this research work so as to find out whether products from our indigenous brewery industry fall within the lay-down acceptable standard that is devoid of the consumers? complaint

---

Index terms— control charts, cumulative sum technique charts, hotellings t-square, fill height,

Introduction n many manufacturing firms where there exists mass production, measurement made on each product is subject to error due to variation from one item to the other. Since there must be variations, it becomes important to study and determine when any observed variation is significant or not. This is the reason why the Federal Government of Nigeria came up with legislations to protect the buyers from buying inferior goods. Increase in consumer buying behaviou towards some selected drinks will directly affect the production of such drinks in our breweries industry. Quality control relies partly upon patronage and some other reliable factors, in beer production process, the measurement of attributes such as fill height and level of co 2 is of paramount important and that is the reason why quality control is evolving in developing systems to ensure standard products or services as well as meeting or exceeding customer's requirements. Walter Shewhart introduced the concept of statistical quality control thereby controlling quality of mass produced goods. Shewhart believed that variation always exists in manufactured products and that the variation can be studied, monitored and controlled using Statistics. Walter Shew hart explained the theories about using statistical quality control charts to improve quality and productivity in which case he developed fourte en points agenda for companies to improve quality and productivity, reduce costs and compete effectively in the world market.

1 II.

2 Literature Review

Reeves and Bednar (1994) define quality as excellence, value, conformance to specifications, and meeting or exceeding customers' expectation. The term "fitness for use" defined by ??uran (1974) is also included in the quality definition presented by ??eeves and Bednar (1994). Thus, the customer perspective with respect to quality is the master key that should be understood while determining any term for quality or definition of quality. Deming, W.E ??1986). worked on Quality and Productivity Improvement using acceptance sampling method, and he was able to obtain increase in quality and simultaneous reduction in the cost of reducing waste, re write staff attrition and litigation while increasing customer's loyalty. Farhat, B. A. and Al-Darrab, I. (1998). Total quality management is now established and widely used management process. One of its associated features is the application of statistical quality control techniques. A quality product or service is one that meets the customer's needs and provides the value that they want and expect. They are also of the opinion that quality management is a formal approach to management in which the overriding priority of the organization is to deliver a quality product or service and to work towards excellence and continuous improvement in everything it does.

Quality can be viewed from the perspectives of design and product in which case; design quality is the different grades or levels of performance, reliability, I serviceability and function that are the results of deliberate engineering and management decision. On the other hand, product quality is the conformance of the product with specifications or expectations of the user in terms of fitness for use and cost. They are also of the opinion that control charts are closely related with statistical test of hypothesis. The control chart is a test of hypothesis that the process is in a state of statistical control. Shres tha and Chalidabhongse (2006) explained over their survey on 300 employees working in 60 Thai companies to what extent job satisfaction is affected by the existing performance appraisal system used by these companies. They concluded that since the performance appraisal system is part of the company's running processes, employees would show lower performance level if the appraisal system is not satisfactorily controlled.

Cooper (2008) have emphasized on the impact of TQM practices on job satisfactions. The main aim of their research was to examine the relationship between people-related TQM practices and job satisfaction of service employees. The study triggers the question whether a TQM has an effect on employees' satisfaction. Pitterman (2000)'s findings on Telecordia technologies showed that customer satisfaction figures had gone up from 60% in 1992 to 95% at the time of implementing ISO 9001 quality system. Also, there was a 63% reduction noted in test cost efficiency since 1993 that 98% of major software released by Telcordia between 1995 and 1998 were delivered in time, even though the number of releases had tripled during the four year time.

Takala et al. **??**2006) have gone even further to seeking customer satisfaction by improving and ensuring that customer satisfaction survey is supposed to be well designed and validated in order to be an effective measurement tool for its intended purpose. In their research paper, the purpose was to verify the reliability of customer satisfaction survey in context to three aspects of service; quality, delivery and responsiveness. They concluded that there was a need to work on the flexibility of the customer satisfaction survey to ensure the reliability in the qualitative analysis of the supply chain. Sitko-Lutek et al. (2010) examined the customer complaint handling process with respect to the information quality, thereby suggesting possible areas of improvements in the process. Their research method involved reviewing documents, complaint handling procedures and interviews through a social network analysis (SNA) model. The software used for SNA was UCI net and the results suggested that process engineering leadership played a vital and responsive role in disseminating quality assurance information in identifying potential areas of process improvements, thereby enhance and improve the company's profit and customers satisfaction.

3 III.

4 Methodology

A control chart is a graphical representation that shows whether a sample data falls within a normal range of variation. It used to know if a process is in statistical quality control or not. It is also a graphical representation of mathematical model used to monitor a process in order to detect changes in parameter of that process. It displays the quality characteristics that has been measured or computed from a sample against the sample number or time. They are simple to construct and to interpret as they employ a center line (denoted as CNL) and two major control limits; an upper control limit (denoted as UCL) and a lower control limit (denoted as LCL). The center line represents the average performance of the process when it is in a state of statistical control-that is, when only common cause variation exists. The upper and lower control limits are horizontal lines situated above and below the center line. These control limits are established so that when the process is in control, almost all plots will be between the upper and lower limits. In practice, -If all observed plot points are between the LCL and UCL and if no unusual pattern of points exists, we have no evidence that assignable causes exist and we assume that the process is in statistical control. In this case, only common causes of the process variation exist, and no action to remove assignable causes is taken on the process. If we were to take such action, we would be unnecessarily tempering with the process.

-If we observe one or more plot points outside the control limits, then we have evidence that the process is out of control due to one or more assignable causes. Here we must take action on the process to remove those assignable causes. **??**1956, **??**959, **??**985), **??**rosier (1988), **??**awkins (1991 **??**awkins (, 1993b)), **??**owry et al. (1992), Lowry and Montgomery (1995), Pignatiello and Runger (1990), Tracy, Young, and **??**ason (1992), **??**ontgomery and **??**adsworth (1972), and **??**lt (1985). This subject is particularly important today, as automatic inspection procedures make it relatively easy to measure many parameters on each unit of product manufactured. control of two or more related quality characteristics is necessary. The process is considered to be in control only if the sample means x 1 and x 2 fall within their respective control limits. Monitoring these two quality characteristics independently can be very misleading. So it is best we use the HotellingT 2 control chart.

5 b) The Multivariate Normal Distribution

In univariate statistical quality control, we generally use the Normal distribution to describe the behaviour of a continuous quality characteristic. The Univariate Normal probability density function isf(x)=1/(?2??^2) e^(-1/2 ?((x-?)/?)?^2) -?<x < ? ?**(1)**

The mean of the normal distribution is ? and the variance is ?2. Note that (apart from the minus sign) the term in the exponent of the normal distribution can be written as follows:(x-?) (?^2)^(-1) (x-?**(2)**

This quantity measures the squared standardized distance from x to the mean, where by the term "standardized" we mean that the distance is expressed in standard deviation units. This same approach can be used in the multivariate normal distribution case. Suppose that we have p variables, given by x1, x2, . . . ,xp. Arrange these variables in a pcomponent vector x? = [x1, x2, . . . ,xp]. Let ?1 = [?, ?2, . . . , ?p] be the vector of the means of the x's, and let the variances and covariances of the random variables in x be contained in a p * p covariance matrix ?

The main diagonal elements of ?are the variances of the x's and the off-diagonal elements are the covariances. Now the squared standardized (generalized) distance from x to ?is(?? ? ??) ? ? ?1 (?? ? ??)**(3)**

The multivariate normal density function is obtained simply by replacing the standardized distance in equation (.2) by the multivariate generalized distance in equation (3) and changing the constant term to a more general form that makes the area under the probability density function unity regardless of the value of p. Therefore, the multivariate normal probability density function isð ??"ð ??"(??) = 1 (2??) ?? /2 |?| 1/2 ?? ? 1 2 (??? ??) ? ? ?1 (??? ??) (4) where ?? < ?? ?? < ?, j = 1, 2, . . . , p.

A multivariate normal distribution for p = 2 variables (called a bivariate normal).ð ??"ð ??"(??) = 1 2??|?| 1/2 ?? ? 1 2 (??? ??) ? ? ?1 (??? ??) ...**(5)**

6 c) The Sample Mean Vector and Covariance Matrix

Suppose that we have a random sample from a multivariate normal distribution-say, where the I th sample vector contains observations on each of the p variables xi 1 , xi 2 , . . . , xi p . Then the sample mean vector is??? ?? = 1 ?? ? ?? ???? ?? ??=1 {?? = 1,2, ? , ??}**(6)**

and the sample variance is?? ?? 2 = 1 ?? ? 1 ???? ???? ? ??? ?? ? 2 ?? ??=1 {?? = 1,2, ? , ??} = ??} (7)

and the sample covariance is The HotellingT 2 chart is the analog of the Shewhartx chart. Multivariate control charts work well when the number of process variables is not too largesay, 10 or fewer. As the number of variables grows, however, traditional multivariate control charts lose efficiency with regard to shift detection. A multivariate approach should be used to monitor process stability with more than one important characteristic. This approach can account for correlations between characteristics and will control the overall probability of falsely signaling a special cause of variation when one is not present. The most common multivariate chart is the T 2 chart. There are many situations in which the simultaneous monitoring or control of two or more?? ?? ??? = 1 ?? ? 1 ?(?? ?????? ? ??? ????) (?? ????? ? ??? ???) ? ?? = 1,2, . . . , ?? ?? ? ?(**8**)) d) Hotelling T 2 Control Chart

It is the most familiar multivariate processmonitoring and control procedure. HotellingT 2 control chart is for monitoring the mean vector of the process. It is a direct analog of the univariate Shewhart chart. There are two versions of the HotellingT 2 charts which are Sub grouped data and Individual observations.

7 e) Subgrouped Data

Suppose that p quality characteristics x 1 , x 2 , ...,x p are jointly distributed according to the multivariate normal distribution (see equation 3.6.4). Let µ 1 , µ 2 , ...,µ p be the mean values of the quality characteristics and let ? jk 's represent the variance-covariance values of the pcharacteristics. In practice, it is usually necessary to estimate ? and µ from the preliminary samples of size n, taken when the process is assumed to be in control. Suppose that m such samples are available. the sample means and variances are calculated from each sample as usual; that is,??? ???? = 1 ?? ? ?? ?????? ?? ??=1 ? ?? = 1,2, . . . , ?? ?? = 1,2, . . . , ??(**9**)?? ???? 2 = 1 ?? ? 1 ???? ?????? ? ??? ???? ? 2 ?? ??=1 ? ?? = 1,2, . . . , ?? ?? = 1,2, . . . , ??**(10)**

where ?? ?????? is the I th observation on the j th quality characteristics in the kth sample. The covariance between quality characteristic j and quality characteristic h in the k th sample is?? ?? ??? = 1 ?? ? 1 ?(?? ?????? ? ??? ????) (?? ????? ? ??? ???) ? ?? = 1,2, . . . , ?? ?? ? ?**(11)**

8 ?? ??=1

The statistics ??? ???? , ?? ???? 2 and ?? ?? ??? are then averaged over all m samples to obtain??? ?? = 1 ?? ? ??? ?? ? ? ? ? ? (3.6.12) ?? ?? =1 ??? ?? 2 = 1 ?? ? ?? ???? 2 (**12**) ?? ??=1

and??? ?? ? = 1 ?? ? ?? ?? ??? (13) ?? ?? =1

The ??? ? ?? ? are the elements of the vector ?? ?, and the p x p average of sample covariance matrices S is formed as?? = ? ??? 1 2 ? ??? 1?? ? ? ? ??? ??1 ? ??? ?? 2 ? (**15**)

To use the T 2 Control Chart, we will use the test statistics;?? 2 = ??(??? ? ???) ? ?? ?1 (??? ? ???)

Control chart. This is a directionally invariant control chart; that is, its ability to detect a shift in the mean vector only depends on the magnitude of the shift, and not in its direction. There are two distinct phases of control chart usage. PHASE I is the use of the charts for establishing control; that is, testing whether the process is in control when the m preliminary subgroups are drawn. The control limit for T 2 control chart are given by?????? = ??(?? ? 1)(?? ? 1) ???? ? ?? ? ?? + 1 ?? ?,??,???? ??? ???+1 ?????? ?????? = 0 (**17**)

Phase II is the use of the chart for monitoring future production, sample size of at least n= 200 is needed. The control limits are as follows: f) Individual Observation Here, multivariate control charts with subgroup size, n = 1 is of interest. Suppose that m samples, each of size n = 1, are available and that p is the number of quality characteristics observed in each sample. Let ?? ? and S be the sample mean vector and covariance matrix, respectively, of these observations. The Hotelling T 2 statistic in equation becomes?????? = ??(?? + 1)(?? ? 1) ???? ? ?? ? ?? + 1 ?? ?,?? 2 = (?? ? ???) ? ?? ?1 (?? ? ??? (19)

The phase II control limits for this statistic are?????? = ??(?? + 1)(?? ? 1) ?? 2 ? ???? ?? ?,??,????? ?????? ?????? = 0 (**20**)

When the number of preliminary samples m is large, say m > 100, most practitioners use an approximate control limit, either?????? = ??(?? ? 1) ?? ? ?? ?? ?,??,????? (21) ?????? = ?? ?,?? 2(**22**)

However, for m> 100, equation (**??**1) is a reasonable approximation.

For phase i, the limits are based on a beta distribution,?????? = (?? ? 1) 2 ?? ?? ?, ?? 2 , ?? ????1 2 ?????? ?????? =0 (**23**)

Where ?? ?,??/2,(?? ????1)/2 is the upper ? percentage point of a beta distribution with parameters p/2 and (m-p-1)/2. Approximations to the phase I limit based on the F and chi-square distributions are likely to be inaccurate. Basically, the focus will be on the Sub grouped data because it suits the type of data that was collected.

9 Control Chart for Monitoring Variability

Monitoring multivariate process are in two levels, which are to monitor the process mean vector m and to monitor process variability. Process variability is summarized by the p x p covariance matrix ?. The main diagonal elements of this matrix are the variances of the individual process variables, and the off-diagonal elements are the covariances. We can use the approach based on the sample generalized variance, |S|. This statistic, which is the determinant of the sample covariance matrix, is a widely used measure of multivariate dispersion. Another method would be to use the mean and variance of |S|, that is, E(|S|) and V(|S|), and the property that most of the probability distribution of |S| is contained in the interval

10 ??(|S|) ± 3?(??(|S|)).

It can be shown that??(|??|) = ?? 1 |?| ?????? ??(|??|) = ?? 2 |?| 2 (24)

where?? 1 = 1 (?? ? 1) ?? ?(?? ? ??) ?? ??=1 (25)

and?? 2 = 1 (?? ? 1) 2?? ?(?? ? ??) ?? ??=1 ??(?? ? ?? + 2) ?? ?? = 1 ? ?(?? ? ??) ?? ?? =1 ? (26)

Therefore, the parameters of the control charts for |S| would be Investigating the Quality Performance of Production of Some Selected Drinks using Hotelling T-square and Control Chart) g)?????? = |?| ??? 1 + 3?? 2 1 2 ? ???? = ?? 1 |?| ?????? = |?|(?? 1 + 3?? 2 1/2)(27)**13**

The lower control limit in equation (**??**7) is replaced with zero if the calculated value is less than zero. In practice, ? usually will be estimated by a sample covariance matrix S, based on the analysis of preliminary samples. If this is the case, we should replace |?| in equation (**??**7 In this study, two measurement quality characteristics are being analyzed using Multivariate statistical quality control.

Fill height: It measures the level of liquid in a bottle of drink. The products under study are STAR, MALTINA and GOLDBERG from Nigerian Breweries plc. The standard is always at 60cl. Co 2 level: It measures the level of co 2 in each bottle. The target for corking a bottle of STAR is between (0.52-0.54%wt/wt), that of MALTINA is (0.59-0.61%wt/wt) and GOLDBERG is (0.62-0.64%wt/wt) where %wt/wt means weight per weight.

Data Presentation: The data used for this analysis is shown in the appendix 'A to appendix F.

11 IV.

12 Data Analysis and Results

In this chapter, the Hotelling T 2 control chart is used for the analysis of fill height and level of co 2 measurements of Star, Maltina and Goldberg using R.

13 Analysis on the Fill Height Measurement and co 2 Level of Star

The fill height of STAR refers to the height of the liquid content in a bottle of a STAR. And the co 2 level refers to the level of co 2 in each bottle of STAR. There can be cases of low fill, high fill and normal fill. The normal or standard fill height of STAR of the company is 60cl. And the standard co 2 level of STAR is between (0.52-0.54%wt/wt). The tables below display analysis carried out using R on various readings on fill height and co 2 level that was observed at different times. Table1.0 shows the Variances and Covariances of the fill height and level of CO 2 of STAR and also the Hotelling T 2 and Variability of each of the 20 samples. The Grand mean, Variance-Covariance Matrix (s) for the control limit used in the Variability plot, and the control Limits for the Hotelling T 2 and Variability plot are represented in the table(s) below.

14 Grand Mean

15 h) Interpretation of Star Chart

From the Variability plot above, most of the sample variances are on or close to the lower control limit (LCL) while they are very far from the upper control limit, which means that the variability (the variances of the observation from the mean) is in control. Thus, the Hotelling T 2 can be plotted to see if the process is actually in control. From the Hotelling T 2 plotted above also, it can be seen that all the plot point fall within the UCL and LCL, which means that it can be concluded that the fill height and level of Co 2 of STAR is under control. The R code was used for the analysis of STAR.

16 Analysis on the Fill Height Measurement and co 2 Level of Maltina.

The fill height of MALTINA refers to the height of the liquid content in a bottle of a MALTINA. And the co 2 level refers to the level of co 2 in each bottle of MALTINA. There can be cases of low fill, high fill and normal fill. The normal or standard fill height of MALTINA of the company is 60cl. And the standard co 2 level of MALTINA is between (0.59-0.61%wt/wt). The tables below display analysis carried out using R on various readings on fill height and co 2 level that was observed at different times. Table2 shows the Variances and Covariances of the fill height and level of Co 2 of MALTINA and also the Hotelling T 2 and Variability of each of the 20 samples. The Grand mean, Variance-Covariance Matrix (s) for the control limit used in the Variability plot, and the control Limits for the Hotelling T 2 and Variability plot are represented in the table(s) below. From the Hotelling T 2 plotted above, it can be seen that all the plot point fall within the UCL and LCL, which means that the fill height and level of co 2 of MALTINA is under control.

17 Grand Mean

18 Variance-Covariance Matrix (S) for the control limit used in the variability plot

19 Analysis on the Fill Height Measurement and Co 2 Level oif Goldberg

The fill height of GOLDBERG refers to the height of the liquid content in a bottle of a GOLDBERG. And the co 2 level refers to the level of co 2 in each bottle of GOLDBERG. There can be cases of low fill, high fill and normal fill. The normal or standard fill height of GOLDBERG of the company is 60cl. And the standard level of co 2 GOLDBERG is between (0.62-0.64%wt/wt). The tables below display analysis carried out using R on various readings on fill height and co 2 level that was observed at different times. From the Hotelling T2 plotted above also, it shows that all the plot point fall within the UCL and LCL, which means that the fill height and level of Co of GOLDBERG is under control.

Based on the results obtained from the analysis so far for all the drinks considered, none of the characteristics examined and analyzed fall within the control which invariably means we do not have sufficient evidence to reject the null hypothesis hence we Accept the null hypothesis for both the fill height and the level of Co2.

V.

20 Conclusion

The results obtained from the method used show that the components for the production of the beer under consideration(fill height and level of Co2) shows that the variability of the three products are in control, and this information helped in proceeding to check if the two quality characteristics are in control, also, using the Hotelling T2 control chart of Sub grouped data, the values were all within the lower and upper control limit for the three products, which helps to affirm the fact that the quality characteristics of STAR, MALTINA AND GOLDBERG are in control. This shows that the Quality Control Unit of the Company should not relent in carrying out their test on the products, all these will help the company to maintain the required standard and survive competition with other likely products from other company. [1]

[1]© 2020 Global Journals

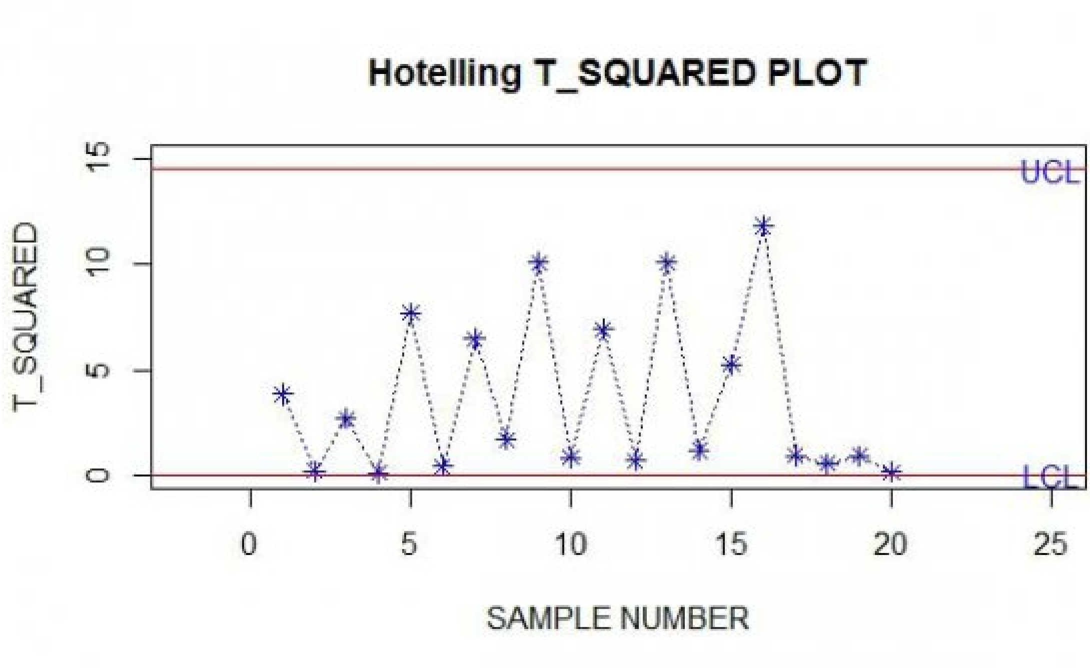


Figure 1:

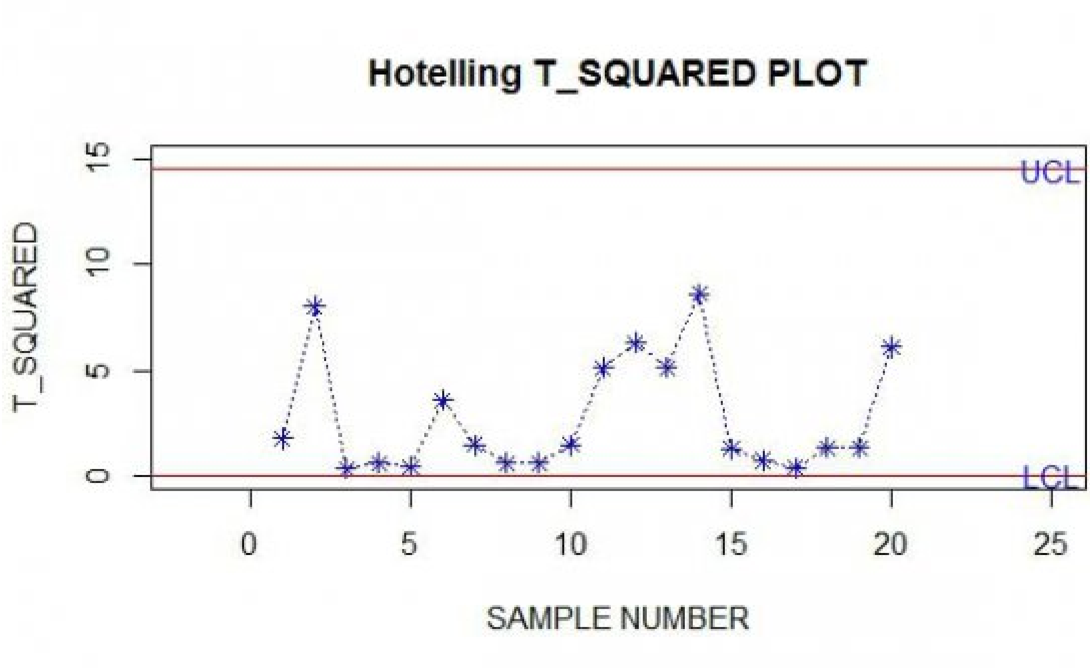


Figure 2:

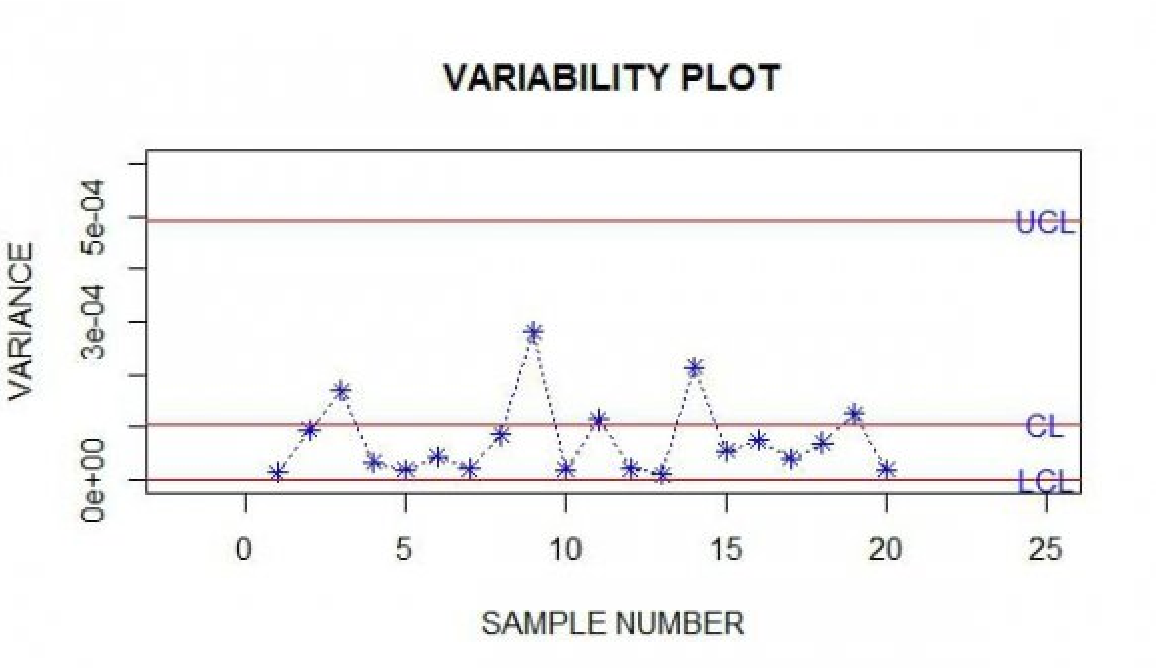
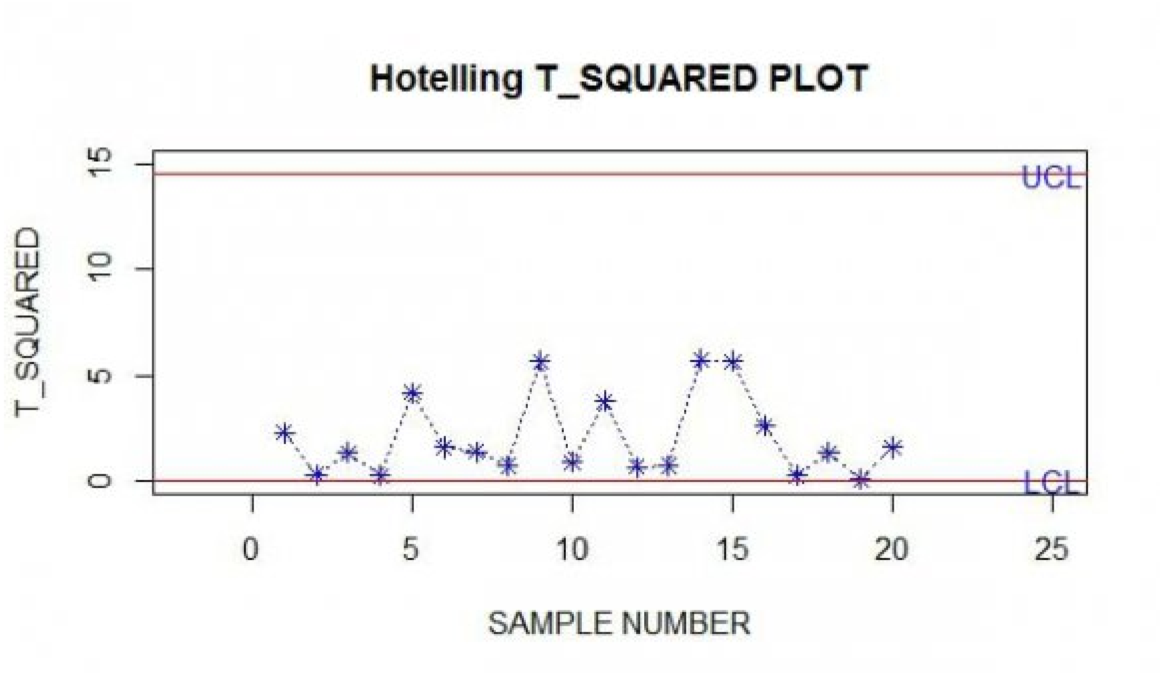


Figure 3:



1

Figure 4: ControlFigure 1 :

1

	Means		Variance and Covariances			Control Chart Statistics	
Sample Number k	Fill Height (?? ? 1k)	Level of CO 2 (?? ? 2k)	S 2 1k	S 2 2k	S 12k	Hotelling T 2 k	|S k |
1	60.0	0.518	1.5	0.00037	0.0200	3.8339370	0.00015500
2	59.6	0.530	1.3	0.00035	0.0100	0.1962245	0.00035500
3	59.8	0.520	0.7	0.00005	0.0000	2.6772350	0.00003500
4	60.0	0.530	1.0	0.00010	0.0025	0.1181133	0.00009375
5	59.8	0.546	2.2	0.00013	0.0015	7.7073474	0.00028375
6	60.0	0.526	1.0	0.00013	-0.0025	0.4357597	0.00012375
7	59.4	0.516	1.3	0.00008	-0.0005	6.4532623	0.00010375
8	60.0	0.522	1.5	0.00007	0.0075	1.6743676	0.00004875
9	60.0	0.548	2.5	0.00012	0.0000	10.0856025	0.00030000
10	59.4	0.528	0.3	0.00017	-0.0065	0.8187689	0.00000875
11	60.0	0.514	1.0	0.00013	-0.0025	6.9144678	0.00012375
12	59.6	0.534	0.8	0.00003	-0.0030	0.6801556	0.00001500
13	60.0	0.548	1.5	0.00017	0.0000	10.0856025	0.00025500
14	59.8	0.536	2.7	0.00053	-0.0285	1.1678815	0.00061875
15	60.0	0.516	1.0	0.00023	-0.0125	5.2590822	0.00007375
16	59.6	0.550	0.3	0.00005	-0.0025	11.8254949	0.00000875
17	60.0	0.524	2.5	0.00003	0.0025	0.9399435	0.00006875
18	59.8	0.534	1.7	0.00008	-0.0015	0.5507094	0.00013375
19	59.8	0.524	0.7	0.00013	0.0035	0.9184544	0.00007875
20	60.0	0.528	1.5	0.00057	-0.0225	0.1618163	0.00034875
Averages	59.83	0.5296	1.5	0.00057	-0.0225		

Figure 5: Table 1 :

2

Means		Variances and Covariances				Control Chart Statistics	
Sample Number k	Fill Height (?? ? 1k)	Level of CO 2 (?? ? 2k)	S 2 1k	S 2 2k	S 12k	Hotelling T 2 k	|S
1	60.0	0.596	1.0	0.00003	0.0025	1.7606748	0.0
2	59.6	0.590	1.3	0.00010	0.0100	8.0208486	0.0
3	59.8	0.598	1.2	0.00007	0.0070	0.3296529	0.0
4	60.0	0.598	0.5	0.00017	0.0075	0.6161894	0.0
5	59.6	0.598	1.3	0.00002	-0.0010	0.4235547	0.0
6	60.0	0.594	0.5	0.00003	0.0025	3.5875338	0.0
7	59.4	0.602	1.3	0.00002	-0.0035	1.4622119	0.0

Figure 6: Table 2 :

3

	Means		Variances and Covariances			Control Chart Statistics	
Sample Number k	Fill Height (?? ? 1k)	Level of CO 2 (?? ? 2k)	S 2 1k	S 2 2k	S 12k	Hotelling T 2 k	|S k |
1	60.0	0.642	1.0	0.00007	0.0075000	2.28910604	0.00001375
2	59.6	0.636	1.3	0.00008	0.0030000	0.28786007	0.00009500
3	59.8	0.630	0.7	0.00025	-0.0025000	1.31283293	0.00016875
4	60.0	0.634	0.5	0.00008	0.0025000	0.25264057	0.00003375
5	59.6	0.626	0.3	0.00013	-0.0045000	4.15963167	0.00001875
6	60.0	0.630	1.0	0.00010	-0.0075000	1.58110868	0.00004375
7	59.4	0.638	0.8	0.00007	0.0060000	1.37548756	0.00002000
8	60.0	0.632	0.5	0.00037	0.0010000	0.72131622	0.00008500
9	60.0	0.646	3.5	0.00008	0.0000000	5.65403962	0.00028000
10	59.4	0.634	1.3	0.00003	-0.0045000	0.88317403	0.00001875
11	60.0	0.644	1.5	0.00008	-0.0025000	3.77601443	0.00011375
12	59.6	0.632	0.3	0.00007	0.0010000	0.66321829	0.00002000
13	60.0	0.632	0.5	0.00002	0.0000000	0.72131622	0.00001000
14	59.8	0.646	2.7	0.00008	0.0015000	5.72751642	0.00021375
15	60.0	0.646	1.0	0.00008	0.0050000	5.65403962	0.00005500
16	59.6	0.628	1.3	0.00007	0.0040000	2.60304373	0.00007500
17	60.0	0.634	0.5	0.00008	0.0000000	0.25264057	0.00004000
18	59.8	0.630	0.7	0.00010	-1.1 x 10 -22	1.31283293	0.00007000
19	59.8	0.634	0.7	0.00018	0.0010000	0.06980296	0.00012500
20	60.0	0.630	0.5	0.00005	0.00250000	1.58110868	0.00001875

Figure 7: Table 3 :

3

Investigating the Quality Performance of Production of Some Selected Drinks using Hotelling T-square and Control Chart

Grand Mean Variance-Covariance Matrix (S) for the control limit used in the variability plot Fill Height Lev

Level of CO_2		0.0011250	0.0001035
Control Limits for the Hotelling T^2 and Variability plot			
	LCL	CL	UCL
Hotelling T^2	0	-	14.52384
Variability	0	0.0001053	0.000492

© 2020 Global Journals

Figure 8: Table 3

B

3	9:00am	59	60	60	61	59
4	10:00am	60	61	61	59	59
5	11:00am	60	59	60	58	62
6	12 noon	61	59	60	59	61
7	1:00pm	60	59	59	58	61
8	2:00pm	62	60	59	60	59
9	3:00pm	58	62	60	59	61
10	4:00pm	60	59	59	60	59
11	5:00pm	61	59	61	60	59
12	6:00pm	60	59	59	61	59
13	7:00pm	58	60	60	61	61
14	8:00pm	57	60	61	61	60
15	9:00pm	59	61	59	60	61
16	10:00pm	60	59	60	60	59
17	11:00pm	58	60	62	59	61
18	12:00am	59	60	59	62	59
19	1:00am	59	60	59	60	61
20	2:00am	60	60	59	59	62
Sample No	Time	A	B	C	D	E
1	7:00am	0.52	0.51	0.50	0.55	0.51
2	8:00am	0.55	0.50	0.54	0.53	0.53
3	9:00am	0.53	0.52	0.52	0.52	0.51
4	10:00am	0.54	0.54	0.52	0.52	0.53
5	11:00am	0.53	0.56	0.55	0.54	0.55
6	12noon	0.51	0.52	0.54	0.53	0.53
7	1:00pm	0.52	0.51	0.53	0.51	0.51
8	2:00pm	0.53	0.52	0.52	0.53	0.51
9	3:00pm	0.54	0.54	0.54	0.56	0.56
10	4:00pm	0.52	0.54	0.53	0.51	0.54
11	5:00pm	0.51	0.53	0.51	0.52	0.50
12	6:00pm	0.53	0.54	0.54	0.53	0.53
13	7:00pm	0.55	0.56	0.53	0.54	0.56
14	8:00pm	0.56	0.55	0.53	0.50	0.54
15	9:00pm	0.54	0.51	0.52	0.51	0.50
16	10:00pm	0.55	0.56	0.55	0.54	0.55
17	11:00pm	0.52	0.52	0.53	0.53	0.52
18	12:00am	0.54	0.54	0.52	0.53	0.54
19	1:00am	0.52	0.51	0.52	0.54	0.53
20	2:00am	0.51	0.54	0.53	0.56	0.50

[Note: Note: A, B, C, D, and E are the numbers of observations for each samples respectively.]

Figure 9: Table B :

D

Sample No.	Time	A	B	C	D	E
1	7:00am	0.60	0.60	0.59	0.60	0.59
2	8:00am	0.58	0.58	0.59	0.60	0.60
3	9:00am	0.59	0.60	0.60	0.61	0.59
4	10:00am	0.59	0.61	0.61	0.60	0.58
5	11:00am	0.60	0.60	0.60	0.60	0.59
6	12noon	0.59	0.59	0.59	0.60	0.60
7	1:00pm	0.60	0.60	0.61	0.60	0.60
8	2:00pm	0.60	0.61	0.60	0.59	0.59
9	3:00p m	0.59	0.61	0.60	0.59	0.60
10	4:00pm	0.60	0.60	0.60	0.60	0.61
11	5:00pm	0.62	0.61	0.61	0.60	0.60
12	6:00pm	0.61	0.61	0.61	0.60	0.61
13	7:00pm	0.61	0.62	0.60	0.61	0.60
14	8:00pm	0.62	0.60	0.60	0.61	0.62
15	9:00pm	0.60	0.61	0.60	0.61	0.60
16	10:00pm	0.61	0.59	0.60	0.61	0.60
17	11:00pm	0.60	0.60	0.60	0.60	0.61
18	12:00am	0.60	0.61	0.59	0.59	0.59
19	1:00am	0.59	0.60	0.58	0.60	0.61

Figure 10: Table D :

F

Year 2020
22
Volume XX Issue X Version I
( ) B
Global Journal of Management and Business Research

Sample	Time 7:00am	A	0.65	B	0.64	C	0.64	D	0.65	E	0.63
No 1	8:00am	0.63	0.61	0.63	0.63	0.64	0.65	0.65	0.62	0.63	0.64
2 3 4	9:00am	0.64	0.63	0.64	0.62	0.64	0.61	0.63	0.64	0.62	0.63
5 6 7	10:00am	0.62	0.63	0.64	0.65	0.64	0.64	0.63	0.63	0.62	0.64
8 9	11:00am	0.64	0.65	0.66	0.66	0.62	0.64	0.63	0.64	0.61	0.64
10 11	12noon	0.64	0.64	0.64	0.63	0.63	0.65	0.63	0.65	0.63	0.65
12 13	1:00pm	0.62	0.63	0.64	0.63	0.63	0.63	0.64	0.63	0.63	0.64
14	2:00pm 3:00pm 4:00pm 5:00pm 6:00pm 7:00pm 8:00pm	0.64		0.66		0.64		0.64		0.65	
15	9:00pm	0.64		0.66		0.64		0.65		0.64	
16	10:00pm	0.63		0.62		0.62		0.63		0.64	
17	11:00pm	0.64		0.64		0.64		0.62		0.63	
18	12:00am	0.62		0.64		0.64		0.62		0.63	
19	1:00am	0.62		0.64		0.65		0.62		0.64	
20	2:00am	0.62		0.63		0.63		0.63		0.64	

© 2020 Global Journals

Figure 11: Table F :

.1 Appendix

[James and Benneyan David Birn ()] , C James , Benneyan & David Birn . *Methods in Infection Control and Hospital Epidemiology. Hospital Epidemiology* 1998. 19 (3) p. .

[Ohta et al. ()] 'An economic model for X and R chart with time-varying parameters'. H Ohta , A Kimura , M A Rahim . *Quality and Reliability Engineering-International* 2002. 18 p. .

[Mason and Jiju ()] *An essential ingredient for improving service and manufacturing quality*, B Mason , A J Jiju . 2007. p. . (Statistical process control)

[Shenawy and Baker ()] 'Analysis of the Effect of TQM on competitive Advantage'. E Shenawy , T Baker . *International Journal of Quality and Reliability management* 2007. p. .

[Askegaard and brunsø ()] 'Food-related life styles in Singapore: Preliminary testing of a Western European research instrument in Southeast Asia'. S Askegaard , K &brunsø . *Journal of Euro marketing* 1999. 7 p. .

[Carter and Price ()] *Integrated Materials Management; Therm. and E. 2ndEdn. Handbook Series*, R J Carter , P M Price . 1995. McGraw-Hill Inc. p. 648. (Dervirsiotis KN. Operations Management; International Student Edn)

[Bech-Larsen and Grunert (1998)] *Integrating the theory of planned behaviour with means-end chain theory -A study of possible improvements in predictive ability*, T Bech-Larsen , K G Grunert . 1998. May. Stockholm. (27th EMAC Conference)

[Edn] *Irwin Series in Quantitative Analysis for Business*, Edn . p. 164.

[Rahim and Costa ()] 'Joint economic design of X and R charts under Weibull shock model'. M A Rahim , A F B Costa . *International Journal of Production . Research* 2000. 28 p. .

[Mahosh and Prabhuswany ()] 'Process Variability Reduction Through Statistica Process Control for Quality Improvement'. B P Mahosh , M S Prabhuswany . *Int. J. Quality Rese* 2010. 4 (3) p. .

[Chaser and Aquilano ()] *Production and Operations Management A life cycle approach 5th*, R B Chaser , N J Aquilano . 1989.

[Peter ()] *Production Control for Supervisors; 1st Edn. Collins, London and Glasgow*, King-Scott Peter . 1971. p. 95.

[Houchi ()] 'Statistical Quality Control of High Resolution Winds of Different Radios ode Types for Chmatology Analysis'. Karim Houchi . *Journal of Atmospheric and Oceanic Technology* 2015. 2015. (10) p. 32.

[Camergo et al. ()] 'Statistical quality control. A case study research'. Maria Emilia Camergo , Walter Paesnitz Filho , Angela Isabel Dos , Santos Bulius , Jose Maurcio Carre Maciel . *4th IEEE International Conference Mayer Raymond R1975*, 2008. 2008. 2008. McGraw-Hill book Company Inc. p. 347. (Mittag HJ and Rinne H1993)

[Eze ()] 'Statistics and quantitative methods for construction and business managers'. J I Eze . *The Nigerian institute of Building*, 2005.

[Andersen ()] *The evolution of credence goods: A transaction approach to product specification and quality control*, E S Andersen . 1994. (MAPP working paper no 21)

[Acebrón and Dopico ()] 'The importance of intrinsic and extrinsic cues to expected and experienced quality: An empirical application for beef'. L B Acebrón , D C Dopico . *Food Quality and Preference* 2000. 11 p. .

[Ajzen and Fishbein ()] *Understanding attitudes and predicting social behavior*, I Ajzen , M Fishbein . 1980. Englewood Cliffs, NJ: Prentice-Hall. (1st ed)

[Baadsgaard et al. ()] *Undersøgelseafmulighederne for eksportafø kologiskemael keproduktertil Nordtyskland*, A Baadsgaard , K G Grunert , S C Grunert , H Skytte . 1994. (MAPP project paper)