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A Statistical Analysis of the Standard of Federal University Wukari's Bakery, Taraba State

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Abstract- People shy away from inferior goods and for this reason, most people prefer foreign goods to home-made goods thereby rendering some industries in Nigeria redundant. Due to the problem of producing less quality bread, some of the companies are not in existence especially bread making companies. This problem of collapses of some companies prompted us into carrying out this research work so as to assess if the bread made by Federal University Wukari is of high standard and void of consumers' complaints. The following Statistical methods; Chi Square, analysis of variance and quality control charts were used to assess the quality of the bread produced at Federal University Wukari. Data on two major components; sugar content and butter content used in making bread were collected from the company's production process Register for four (4) consecutive times in a day. The data spanned a period of thirty five (35) days at an interval of seven (7) days per month, from december2015 to April 2016. The results from the chi square and analysis of variance indicated that sugar and butter content used in the production of federal University Wukari's bread is statistically in-control. Also, with the use of mean chart and range chart, the results indicated that sugar content used in the production is statistically in-control but that of the butter content is not statistically in control as indicated in the control charts.

Keywords- Quality Control, Components, production, Content, Deviation

I. INTRODUCTION

Perfection has been a thing of interest in the minds of all that is involved in any productive activities. Right from the time when man earned his living through agricultural activities, man places much of his concern on the standard of input/output. With this, one can then say that the act of monitoring particular results to find if they comply with the quality standard can be traced back from the time of creation. This means that quality control started right from the time of creation. Duncan (1959) defined quality as the degree of excellence, perfection and control means to administer, manage, direct or regulate to achieve excellence.[1]. B.P Mahesh and Prashuswamy (2010) stated that quality has become one of the most important decision factors in the selection among the competing products and services. In broad sense, quality is defined as the characteristics or a property consisting of several defined technique and aesthetics, hence subjective functions are reliable as expected over a long period of time. This implies that low quality comes to set in whenever a variation in the characteristic of a product, technique and in the machine over a period of time [6]. Today, the application of quality control has advanced in industrial inspection and research. The activities of professional engagement all aimed at ensuring quality input for quality output. It is found worldwide that today, industries, government, non-governmental agencies do operate control unit charged with the responsibility of ensuring qualitative output and the responsibility of detecting less quality products from the whole lots of products during and after production. In order to detect serious deviation from the state of statistical quality control when or if possible before they occur. This can be done through the use of control charts. A control chart is simply defined as a chart that has three horizontal lines, a central line to indicate desired standard level or level of process, an upper control limit and lower control limit used as decision criterion. When a collected data is plotted using the control chart, any point that fall above the upper control limit or below the lower control limit, makes the process not to be in control. The use of control charts help in determining whether there is variation or problem in the production process. Quality control charts help in testing hypothesis related to the quality of the manufactured products to decide whether the desired standard is met or not. .Quality may be defined as that characteristic which renders a product or service as having a "fitness for purpose or use" [1-13].

Quality of product can be defined as some properties of a product such as length of a bolt, the weight of fruit juice or potency of a drug. S.O. Eguda (2006)[2]. The aim of this study is to enable the bakery of Federal University, Wukari to always put their bread production in check so as to produce bread that will be of high standard.

This paper is organized as follows, Section I contains the introduction. Section II contains the related work, Section III contains the Methodology, Section IV contains the Results and Discussion, Section V contains Conclusion, Section VI contains Recommend
ations

II. RELATED WORK

Indigenous companies are faced with the problem of lost of customers who have shifted their demand to only foreign made goods to the detriment of the local companies. This prompted this research so as to find out if there are ways through which the local companies can survive this great lost. To be able to do that, we have the following objectives;

i. To check whether the company (Federal University Wukari, bread bakery) products conform to the National Agency for Food and Drug Administration and Control (NAFDAC) requirement.
ii. To identify the possible causes of deviation from the standard and suggest the corrective measures

Many Scholars have carried out research works on quality control but to the best of our knowledge, no one has done work on quality control of Federal University Wukari's bread. For instance; Hammer and Chanpy, (1993), stated that quality is defined in terms of fitness of purpose. In their views, quality is a continuous process based on proper management. Hammer in his argument draw out the following points for ensuring quality product. These include;

1. Quality is achieved through a continuous improvement, thus it is always improving and never accepted.
2. Quality is managed through prevention and detection [4].

Orhii Paul, (2010), spelt out a four-point safety standard that must be adhered to by bakers of bread and flour millers to ensure that consumers have access to only safe and well baked bread. The standards, according to National Agency for Food and Drug Administration and Control (NAFDAC) consist production of flour fortified with vitamin A and C and other 'safe enhancers in approved quantities to prevent bakers from adding dangerous chemicals like potassium, bromate as flour/bread improvers and compliance with set standards of good manufacturing practices (GMP) and hazard analysis critical control points (HACCP) guidelines and requirements [12].

S.O Eguda assert in his book, Statistical Method (2006), that it is a common occurrence that two apparently identical machine parts made under carefully controlled situations from the same batch of raw materials, can nevertheless be quite different in many aspects. He further explained that in any manufacturing process, however good, it is characterized by certain amount of variation which is of the same chance or random in nature. Variation in any process is due to common causes or special causes. The natural variations that exist in materials, machinery and people give rise to common causes of variation [2].

B.P Mahesh and Prashuswamy (2010), assert that variation is part and parcel of life. The concept of variation states that no two products will be perfectly identical even if extreme care is taken to make them identical in some aspect [6].

Eguda, (2006), defined chance variation as an inherent and unavoidable part of any process and it cannot be completely eliminated since it is due to natural causes. He stressed further that when the variability is present in production process and it confined to chance variation, the process is said to be in statistical control [2].

According to B.P Mahesh and M.S Prabhuswamy (2010), assignable cause of variation can be defined as Causes that can be identified and eliminated.[6].

Keith Zoeyer (1984) in his book "production management" states that quality control involves the monitoring and adjustment of parameters during the production process which is aimed at obtaining an end product that conforms to a given standard specification. He further argued that quality a quality control is synonymous with the control of parameters within specified limits.[5].

For the control to be effective, uniformity of testing leading to reproducibility of results is very essential.
Oakland, (1989), defined quality control as a system for comprising output with standards to achieve and maintain quality of production or services. Expanding, quality control is a branch of statistics which uses methods such as control charts and

acceptance sampling to determine from a given data whether or not a process is in a state of statistical control depending on already set quality requirements [9].

Ocheije, (2003), defined quality control as "an industrial or scientific techniques of improving industrial operation so as to monitor, control and maintain the quality standard of industrial products". [10].
C. E. Okorie and Adubisi Obinna (2016) defined quality control as a means of checking, determining and predicting the quality level of a product.[11].

III. METHODOLOGY

In this research work, we applied the following models, the chi-square (χ^2), one-way analysis of variance $(one - way\ anova)$, mean chart ($\bar{x} - chart$), range chart $(R - chart)$ and standard deviation chart ($S - chart$) to analyze the data collected.

MODEL ASSUMPTIONS:
Below are the model assumptions;

(i) The sampling distribution of the mean is normal.

(ii) All the observations X_{ij} are independent and $X_{ij} \approx N(\mu_{ij}, \delta_e^{\ 2})$,different effects are additive in nature and ε_{ij} are $i.i.d\ N(0, \delta_e^{\ 2})$

(iii) The sampling distributions of several means are homogeneous.

Chi-Square Test for Normality
The chi-square test is used to investigate the normality of the data on sugar content and butter content which determine the taste of the bread, and hence quality of the bread. It measures the closeness of the observed number (O_i) and occurrences of the expected number $(E_i); k = 1, \ldots, k.$ it can be shown that if (O_i) is the observed frequency for the i^{th} class interval and (E_i) is the corresponding expected frequency, and then the statistic is

$$x^2 = \sum_{k=o}^{n} \frac{O_i - E_i}{E_i} \quad [13] \tag{3.01}$$

Hypothesis:
H_0: Taste is normally distributed.
H_1: Taste is not normally distributed.

Decision Rule: Testing at 5% level of significance, we reject the null hypothesis, H_0if the Chi-square calculated value is greater than Chi-square critical value $\chi^2{}_v$at v = k-m degrees of freedom.

One-way Analysis of variance (One-way ANOVA):
The analysis of variance is a powerful statistical tool for the test of significance in a situation where we have two or more variables to consider at a time. The basic purpose of the analysis of variance is to test the homogeneity of several means.
There are many scheme of classification of analysis of variance, for example one-way analysis of variance, two-way analysis of variance, three-way analysis of variance etc. For this work, we will be using the one-way analysis of variance which is a scheme of classification according to a single criterion to analyze the data.
Thus, the model of one-way analysis of variance is

$$X_{ij} = \mu + \alpha_i + \varepsilon_{ij} \qquad ;(i = 1,2,\ldots,k\,;\ j = 1,2,\ldots,n_i) \tag{3.02}$$

X_{ij} is the bread from the j^{th} sample.

μ_i is the fixed effect due to i^{th} sample.

α_i is the effect of the i^{th} sample.

ε_{ij} is the error effect due to chance.

X_i Mean of the i^{ih} class $= \frac{1}{n_i}\sum_{j=1}^{n_i} X_{ij} = \frac{T_i}{n_i}; i = 1,2,...,k.$ (3.03)

$$\overline{X} = Grand\,mean = \frac{Sum\,of\,\,all\,the\,sample\,observations}{Total\,number\,of\,\,observations}$$

$$= \frac{1}{n}\sum_{i=1}^{k}\,\,\sum_{j=1}^{n_i} X_{ij} - \frac{\sum_{i=1}^{k}\left[\sum_{j=1}^{n_i} X_{ij}\right]}{\sum_{i=1}^{k} n_i}$$

$$\Rightarrow \overline{X} = \frac{\sum_{i=1}^{k} n_i X_i}{\sum_{i-1}^{k} n_i} = \frac{n_1\overline{X}_1 + n_2\overline{X}_2 + ... + n_k\overline{X}_k}{n_1 + n_2 + ... + n_k}$$

(3.04)

The least square estimate of the parameters μ and α_i in the model is given by;

$$\hat{\mu} = \overline{X} = grand\,mean$$

$$\hat{\alpha}_i = \overline{X}_i - \overline{X};\ (i = 1,2,...,k)$$

(3.05)

Thus, the model (2.02) becomes:

$$X_{ij} = \overline{X} + (\overline{X}_i - \overline{X}) + (X_{ij} - \overline{X}_i)$$

$$\Rightarrow X_{ij} - \overline{X} = (\overline{X}_i - \overline{X}) + (X_{ij} - \overline{X}_i)$$

(3.06)

Squaring both sides of equation 2.09 and summing over all the n observations (over j from 1 to n_i and over i from 1 to k), yields:

$$\sum_{i=1}^{k}\,\sum_{j=1}^{n_j}(X_{ij} - \overline{X}_i)^2 = \sum_{i=1}^{k}\,\sum_{j=1}^{n_i}(\overline{X}_i - \overline{X})^2 + \sum_{i=1}^{k}\,\sum_{j=1}^{n_i}(X_{ij} - \overline{X}_i)^2$$

$$+ 2\left[\sum_{i}(\overline{X}_i - \overline{X})\left\{\sum_{j=1}^{n_i}(X_{ij} - \overline{X}_i)\right\}\right] \quad (3.07)$$

But $\sum_{j=1}^{n_i}(X_{ij} - \overline{X}_i) = 0$, because the algebraic sum of the deviations from mean is zero.

Therefore $\sum_{i=1}^{k}\,\sum_{j=1}^{n_j}(X_{ij} - \overline{X}_i)^2 = \sum_{i=1}^{k}\,\sum_{j=1}^{n_i}(\overline{X}_i - \overline{X})^2 + \sum_{i=1}^{k}\,\sum_{j=1}^{n_i}(X_{ij} - \overline{X}_i)^2$

Or $\sum_{i}\,\sum_{j}(X_{ij} - \overline{X})^2 = \sum_{i=1}^{k} n_i(\overline{X}_i - \overline{X})^2 + \sum_{i=1}^{k} n_i s_i^2$

(3.08)

Where $s_i^{\,2} = \frac{1}{n_i}\sum_{j=1}^{n_i}(X_{ij} - \overline{X}_i)^2$, is the sample variance for the i^{th} class.

Total variation $=$(Variation between Classes) $+$ (Variation within Classes)

Total variation $=$(Variation due to treatments) $+$ (Variation due to error)

$(S_T)^2 = \sum_i \sum_j (X_{ij} - X)^2$ This is the total sum of squares (TSS).

$$s_i^{\,2} = \sum_{i=1}^{k}\sum_{j=1}^{n_j}(X_{ij} - \overline{X}_i)^2 = \sum_{i=1}^{k} n_i(\overline{X}_i - \overline{X}) \qquad (3.09)$$

Between classes sum of squares or treatment sum of squares.

$$s_e^{\,2} = \sum_i \sum_j (X_{ij} - \overline{X}_i)^2 = \sum_{i=1}^{k} n_i s_i^{\,2} \qquad (3.10)$$

The equation above is called 'within classes' S.S. or sum of squares due to error (SSE).

Thus, from the equation we have:

Total S.S = Between classes S.S. + Within classes S.S.

Or Total S.S = Treatment S.S + Error S.S.

Degree of freedom for various sums of squares

The degree of freedom associated with any sum of square is equal to the total number of observations whose squares are summed minus the number of linear constraints satisfied by these observations.

The degree of freedom $(d.f)$ *for mean Total* $S.S. = n - 1$

The degree of freedom $(d.f.)$ *forBetween Classes* $S.S.$ *or* '*Treatments* $S.S.' = k - 1$

The degree of freedom $(d.f.)$ *for* '*Within Classes* $S.S.$'*or* $S.S.E = n - k$

It may be noted that:

$n - 1 = (k - 1) + (n - k)$

i.e. $d.f.$ *for Total* $S.S. = (d.f.$ *of Treatment* $S.S.) + (d.f.$ *for Error* $S.S.)$

Hence the d. f for the various sums of squares are additive.

Mean Sums of Squares (M.S.S.).

The sum of squares divided by its degrees of freedom gives the corresponding variance or the mean sum of squares (MSS).

$$\frac{S.S.\ due\ \ to\ \ treatment}{d.f.} = \frac{S_t^{\,2}}{k-1} = s_t^{\,2} \qquad \textbf{(3.11)}$$

This is the MSS due to treatments.

$$\frac{S.S.\ due\ \ to\ \ error}{d.f.} = \frac{S_e^{\,2}}{n-k} = s_e^{\,2} \qquad \textbf{(3.12)}$$

This is the MSS due to error.

Hypothesis:

$H_0 = \mu_1 = \mu_2 = ... = \mu_k = \mu$

$H_1 =$ At least two of the means $\mu_1, \mu_2, ..., \mu_k$ are different.

Test Statistic:

$$F = \frac{MSS\ \ due\ \ to\ \ treatments}{MSS\ \ due\ \ to\ \ error} = \frac{Between\ \ classes\ \ MSS}{Within\ \ classes\ \ MSS} = \frac{s_t^{\,2}}{s_e^{\,2}} \qquad \textbf{(3.13)}$$

F follows $F-$distribution within $(v_1 = k-1, v_2 = n-k)\, d.f.$, testing at 5% level of significance.

Decision rule:
Reject H_0 if the computed value of F is greater than the critical (tabulated) value of F for $(k-1, n-k)$ at $\alpha = 0.05$ degree of freedom.

Control Charts:
Control charts may be defined as; A chronological (hour by hour, day by day) graphical comparison of actual product quality characteristics with limits reflecting the ability to produce as shown by past experience on the product characteristics (Feigenbarm, 1961, page 250). However, a control chart can simply be said to be a graphical tool for conducting periodic significance tests as an aid to maintain acceptable standards of quality. The control chart can therefore be said to be a tool used primarily for analyzing data either discrete or continuous, which are generated over a time period. The control charts have limits shown as horizontal lines. These are the upper warning limits or the upper control limits and the lower control limits or the lower warning limits.

When the process is in control one point should be above the upper warning limit. Two successive points outside the warning limits are usually taken to be good evidence that assignable causes of variation are present. For the purpose of this study, the mean or X-chart and the range or R-chart are used.

Mean Chart ($\bar{x} - chart$):
This is a control chart that monitors the changes in the mean of a process (samples drawn from a population). It shows variations in the average of samples. The mean ($\bar{x}$) is obtained by summing up elements in each x_i and dividing by the number of the total samples (n).

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots + x_n}{n} \qquad (3.14)$$

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{m} \qquad (3.15)$$

$Where\ i = 1, \ldots, 35; n = 4\ and\ m = 35.$

The upper, central and lower sigma limits for mean deviation chart respectively, are;

$$UCL = \bar{\bar{x}} + 3\bar{R}/d_2\sqrt{n} \qquad \textbf{(3.16)}$$

$$CL = \bar{\bar{x}} \qquad \textbf{(3.17)}$$

$$LCL = \bar{\bar{x}} - 3R/d_2\sqrt{n} \qquad \textbf{(3.18)}$$

Substituting A_2 for $3\bar{R}/d_2\sqrt{n}$.

We have respectively the 3-sigma limits for mean chart as;

$$UCL = \bar{\bar{x}} + A_2\bar{R} \qquad \textbf{(3.19)}$$

$$CL = \bar{\bar{x}} \qquad \textbf{(3.20)}$$

$$LCL = \bar{\bar{x}} - A_2\bar{R} \qquad \textbf{(3.21)}$$

Where,

$\bar{x}$ is the mean of the individual days.

$\bar{R}$ is the range of the individual days.

A_2 is the constant which depends on the size from the table.

$\bar{\bar{x}}$ is the grand mean.

Range Chart ($R-chart$):
The range chart (R-chart) is obtained by subtracting the smallest value in each row from the largest value.
First, the range for each sub-group sample is computed. In this case the process (subtracting the smallest value in each row from the largest) will be repeated for the thirty five (35) days.

The mean range $(\bar{R})$ is obtained by summing up the ranges of the sub-groups and dividing by the total number of sub-groups. That is

$$R = \frac{R_1 + R_2 + R_3 + ... + R_n}{n} \quad (3.22)$$

Where, $n =$ Number of sub-groups.

$$\bar{R} = \frac{\sum R_i}{m} \quad (3.23)$$

Where, $i = 1, 2, 3, ..., m;$ and m=35

For R-chart, the three (3) different control limits are;

$$UCL = \bar{R} + 3\delta R \quad (3.24)$$

$$CL = \bar{R} \quad (3.25)$$

$$LCL = \bar{R} - 3\delta R \quad (3.26)$$

Hence,

$$UCL = D_4\bar{R} \quad (3.27)$$

$$CL = \bar{R} \quad (3.28)$$

$$LCL = D_3\bar{R} \quad (3.29)$$

Where,
$\bar{R}$ is the average of the ranges.
D_3 and D_4 are constants read from the table

IV. RESULTS AND DISCUSSION

Table.1: Testing for normality in the Sugar content in the bread, using the Chi Square test.

N	DF	Chi-Sq	P-Value
5241.79	139	0.0018600	1.000

In testing for normality in the Sugar content, the chi square calculated yields $0.001860 \cong 0.002$, to three decimal places. The value from the chi square table $= 19.281$. This shows that the distribution of Sugar is normal in the Bread production.

Table.2: Testing for the variation from the means, using the Analysis of variance

ANOVA

SUGAR CONTENTS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	3	.000	.154	.927
Within Groups	.069	136	.001		
Total	.070	139			

The F value from the Analysis of variance computed with SPSS$= 0.155$, while the value from the F distribution table 2.912. This means that calculated value is less than the value from the table, we therefore accept the null hypothesis.

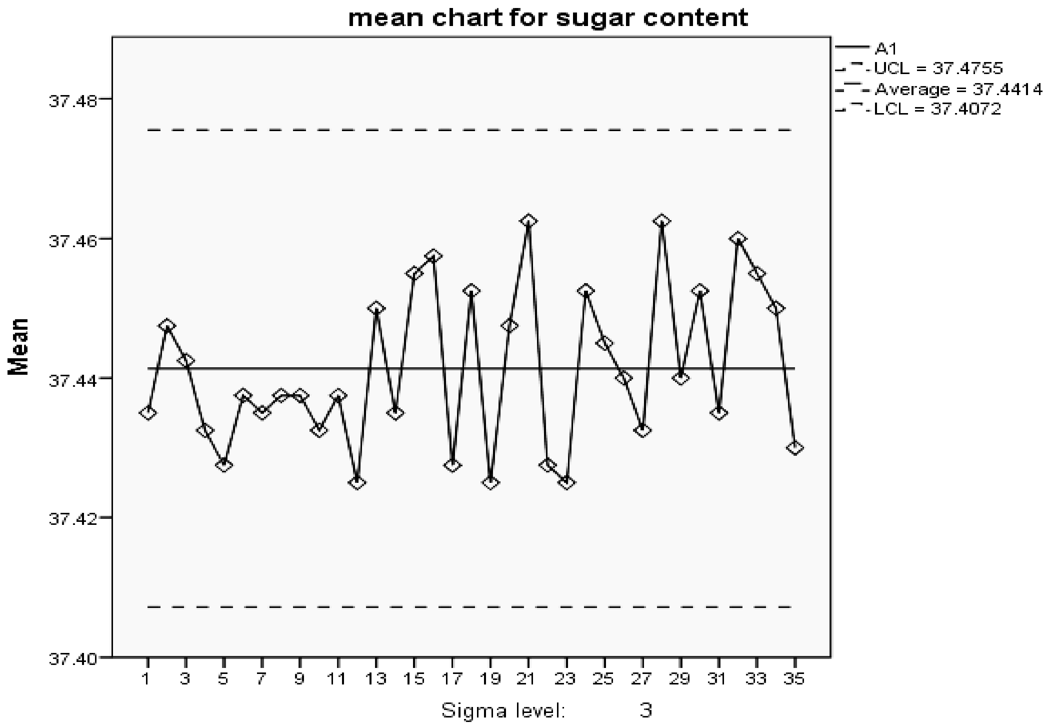

Figure.1: The Mean chart

This shows that there is no variation because there is no point that moves to the upper control limit or the lower control limit.

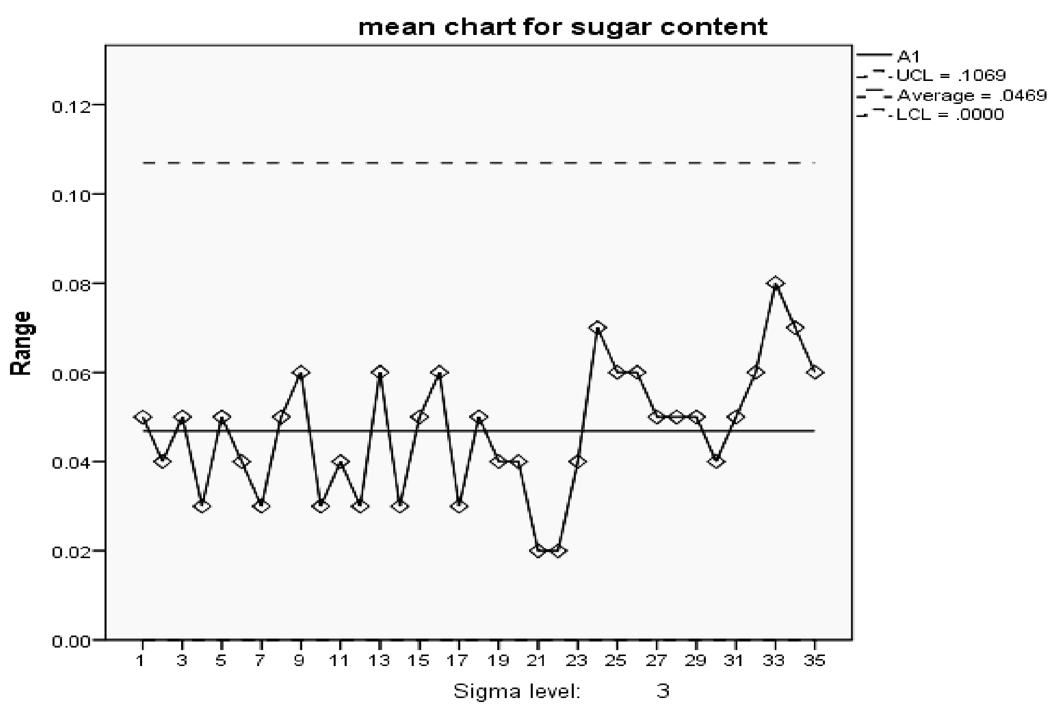

Figure.2: The Range Chart

The Range Chart indicates that the production is in control.

Table.3: Testing for normality in the Butter content in the Bread

Chi-Square Goodness-of-Fit Test for Observed Counts in Variable: BUTTER CONTENT

N	DF	Chi-Sq	P-Value
2589.99	139	0.0013135	1.000

The Chi Square value as calculated with Minitab 16$= 0.0013135 \cong 0.001$, to three decimal places. The value from the Chi distribution table $= 19.281$. This also shows that the taste is normally distributed.

Table 4.4: Testing the variation by using the Analysis of Variance

ANOVA

BUTTER CONTENT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.328	4	.082	.063	.993
Within Groups	174.672	135	1.294		
Total	175.000	139			

The ANOVA table generated by the SPSS indicated that the F value 0.063, while the value from the F distribution yields 2.912. This then shows that there is no variation in the mean of the content.

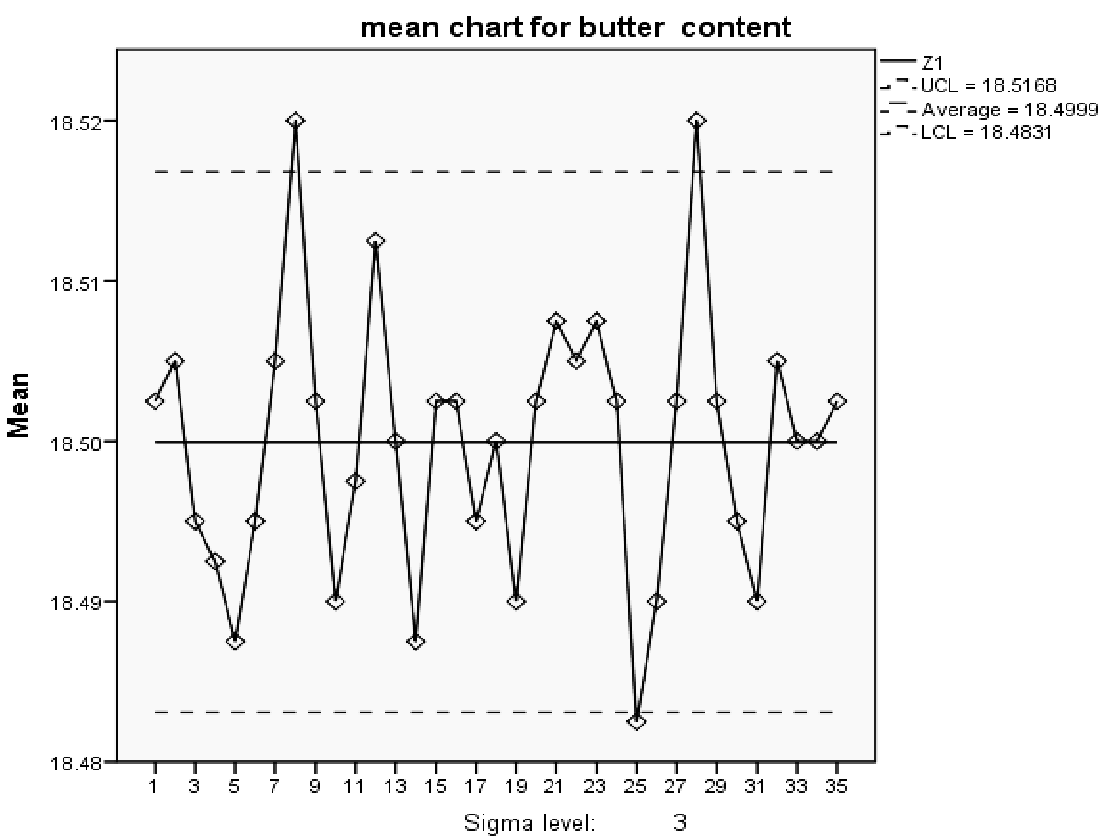

Figure.3: The Mean Chart

The mean chart shows variation in the mean. From the chart, three (3) points fall above the upper and the lower control limit. Here, it shows that butter is out of control.

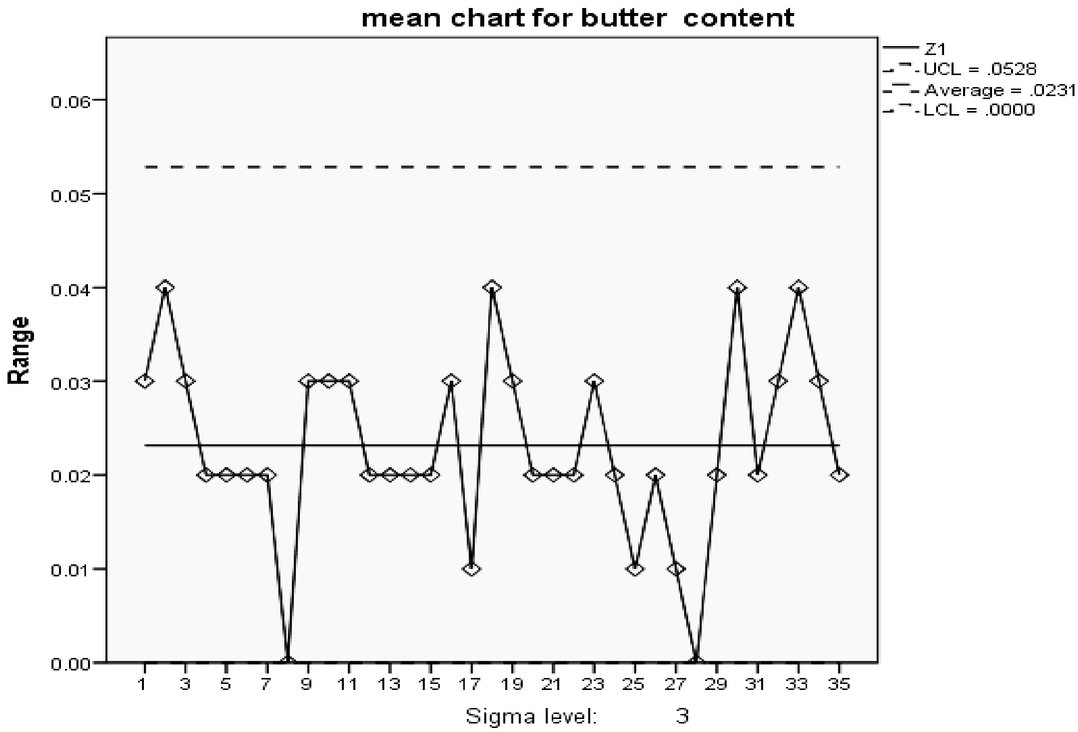

Figure.4: The Range Chart

The Range Chart shows that butter is out of control. This is because two (2) points fall to the signal level.

V. CONCLUSION

It is an established fact that in any manufacturing process, however good is characterized by a certain amount of variability which is of the same chance or random in nature. This variation brings about different taste in the products produced by the same producers at different times in the production process.

From our findings in Federal University bakery, we discovered that sugar as one of the components for bread production is in control but butter is not in control. For a component to be out of control, it means that the entire production needs to be checked.

VI. RECOMMENDATION

The company needs to employ the services of a quality control expert who will always put the products under check to avoid production of low quality goods.

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