A COMPUTERIZED APPROACH TO STATISTICAL QUALITY CONTROL (A CASE STUDY OF GOLDEN GUINEAS BREWERIES, UMUAHIA)

BY

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CERTIFICATION

We, the undersigned certify that this project was carried out by MADUAKOLAM, C.N. of the Department of Mathematics & Computer Science, Federal University of Technology, Minna, Nigeria.

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DEDICATION

To my elder sister, Mrs Cecilia Nwakujurobi Uzoma

ACKNOWLEDGEMENT

I give thanks to God for making this academic pursuit successful. I acknowledge the efforts of all staff of the Department of Mathematics & Computer Science, Federal University of Technology, Minna. Special gratitude to my supervisor, Professor K.R. Adeboye for his intellectual contributions to the work.

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ABSTRACT

In industries, efforts are made to ensure that an operation is producing in conformity with the designed quality standard. It is easily observed that all piece of item that leave the production line are not exactly of the same quality and this may be due to random causes or non-random causes.

This work presents a computerized approach to statistical quality control. The software has been testrun on production data from Golden guiness breweries, Umuahia, Abia state and gave satisfactory output.

The software is recommended for use by any interested Quality Control Analyst.

TITLE OF CONTENTS

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

The quality of lots of manufactured items is a matter of considerable importance both to the producer and the consumer. Quality can be considered as one of the five components of efficiency, the others being speed, resource utilization, changeability (flexibility) and beauty. It finds its main formal application in industry with three main areas such as the quality of -:

i) goods and services received,

ii) work in progress, and

iii) finished goods for sale.

The producer of goods and services aims to produce that which will command armies of loyal buyers thereby enjoying a rapidly expanding market while the consumers on the other hand will examine the products to see if the expense is the goods attract a minimum expense of money and time saving in handling.

The quality control analyst ensures that the nature and performance of goods and services produced (or received) lie within predetermined limits. Hence, total quality control is an effective system for integrating the quality improvement efforts of the various groups in an organization so as to enable production and services at the most economical levels which allow for full customer's quantitative aspects of goods and services are compared with standards or specifications. Inspecting all items in the production line may be time consuming or at times may be destructive. Taking part of the production at regular intervals of time to test for the quality is usually preferred and this is known as "random sampling" in statistics.

Because of the recent widespread application of statistical packages in control process and also as a result of calculations which not only being laborious but take several hours to manipulate manually, researchers and statistical association established a prestigious committee to investigate the features of the various packages in order to solve such problems and to prevent statistical error from entering their design. Usage of computers and computer packages for solving or refining such problems of large magnitude, play an ever-increasing significant role. Thus, the quantitative oriented challenges and the application of statistical techniques towards the solution of such control problem found it rewarding in decision making in the face of uncertainty or imperfect sample information.

The test to be done on the product must be established and a sampling procedure decided upon. This is essential since it is usually not possible to test every unit of the product. After testing, the result must be reported in such a way that it will lead to action if need be; that is, if the result deviates so much from the mean value or the laid down standard for the production.

Statistical aspects of quality control can be divided into two broad areas namely -: acceptance sampling and process control.

Acceptance sampling refers to the testing of the sample of already exiting goods and decide wether to accept or reject the entire lot based on the sample tested, Chase and Aqulane (1985). Acceptance sampling can only be possible when goods are available. Then testing can be carried out. The application of acceptance sampling can not be put off especially in the purchasing and receiving situation. It occurs after the production and receiving of a "lot". Overall of the total production is determined by taking a sample of the lot. The lot is rejected if the proportion of bad items is more than the amount specified. However, the producer risks the rejection of a batch of goods if too little a sample is used. Process control is used to determine as soon as possible when the process is out of control. It involves testing a randomly sampled output from a process to determine wether the process is producing items within a specification. When the outputs tested exceed the specification limits, the production process is adjusted immediately. The procedure for process control is to establish an upper and lower limit for acceptability in which the output must always fall within, otherwise appropriate measures have to be taken.

Acceptance sampling is performed on completed goods while process control is performed on the process production line.

1.2 Scope and Limitations

The application of this work "Computerized Statistical Quality Control" is not limited to Golden Guiness brewery Umuahia, Abia State. The scope covers the production from 15th march 1995 through 21st march 1998. The software is for the Golden guiness brewery, Umuahia or any other company that may find it useful.

The analysis is done on weekly basis of three shifts a day. The data collected for this project shall be presented in a tabular form, notionally A, A, B,........H represent hourly.

1.3 Aims and Objectives

The aims and objectives are to:

determine wether the quality of the product conform to set standard identify any variation in the process and eliminate them evaluate the efficiency of the company and reliability up to date computerize the statistical quality control to sustain, improve and achieve quality of product

The objectives of quality control in the Golden guiness Nigeria PLc are to ensure that all the beer produced is of the required standard. However, the primary objective of the organization is profit making and this must be considered in all the activities. Other objectives are:

To increase the competitive advantages and increase sales as a result of high quality product.

To reduce or eliminate cost incurred because of customers dissatisfaction, as law requires the replacement of substandard goods.

CHAPTER TWO

METHODOLOGY

The data used for this project is secondary and it is collected from the Golden guiness breweries Umuhaia in Abia state. It is secondary because it is obtained from the official record that are kept for reference and it is restricted to the production of Golden guiness only.

The data collected has been organized and tabulated for easy understanding at a glance in the appendix.

2.1 Measure of Quality

Quality control is an all-embracing term. It was originally used to describe those analytical units of manufacturing organizations which assured the user of a product that its quality was up to a previously agreed standard. This was often a standard set by the individual manufacturer, with only very limited external guidance. Doubt about the reproducibility of the quality of beer formulations and the relevance of this to the in-use situation has been expressed in many ways that quality can be measured. It can be compared to an existing standard, It can be examined as to wether it is fit for use.

GRADE

Grading in quality is said to presume that scale has been created against which comparisons can be made. To most purity of colour of texture, taste, odour, reliability and range of operation. In this sense, quality is used to imply grade, Chase and Aqilano (1985).

FITNESS FOR USE

Fitness for use refers to the degree to which a product satisfies the user's satisfaction and generally depends on the three factors. The grade itself, the consistency of quality within that grade, and maintainability. A product should function for some specified time under specified condition, and repair service and replacement parts should be available unless the product is not expected to undergo repair, as in the case "throwaway" items like non-refillable filter or inexpensive radios.

CONSISTENCY

Product or service output is consistent and therefore predictable if a quality of the product/service remains the same for succeeding units.

2.2 <u>Statistical Basis of Quality Control</u>

Knowing what can go wrong during the generation of authentic samples, I am surprised that the analyst bothers to examine them; perhaps he would be much happier just developing methods of analysis, rather than actually having to use them foe real samples.

Statistical quality control in any analytical process usually include these two broad areas which are acceptance sampling and process control.

ACCEPTANCE SAMPLING

This refers to testing of the sample of already existing goods and decide wether to accept or reject the entire lot based on the sample tested.Chase and Aquilana (1985).

Acceptance sampling can only be possible when goods are available. Then testing can be carried out. The application of acceptance sampling can not be put off especially in the purchasing and the receiving situation taking samples of the goods or product that are ready to be distributed to consumers or market places, or item received from another company. Acceptance sampling is extended through a sampling plan.

Acceptance sampling, occurs after the production and receiving of a "lot" overall quality of the total production and is determined by taking a sample from the lot, the lot is rejected if there exist bad items more than the amount specified.

PROCESS CONTROL

This is used to determine as soon as possible when the process is out of control. It involves testing a random sample of output from a process in order to determine wether the process is producing item within a specification. When the output tested exceed the specification limits, the production process is adjusted.

Process control exists during the production process and not after.

Process control is used during the course of production process itself. The procedure for production process control is to establish upper and lower limits for acceptability. The output must all be within the upper and lower limits, if not, correction or appropriate adjustments are than made to allow all the output to fall within specification level. Chase and Aquilana (1985).

Acceptance sampling is performed on completed goods while process control is performed on the process in production.

2.3 Control Chart Procedure

No quantitative estimate should be quoted without a guide being given to its precision and accuracy. Precision refers to the scatter of data around its mean. The accuracy refers to the relation between the experimental mean and the true value. People say that it is better to be roughly accurate than precisely wrong. The question arises as to the best methods for assessing precision and accuracy.

A control chart, in its rudimentary form is simply a graphical tool for conducting periodic significant test, right at the scene of the production process, as an aid to maintaining acceptable standard. Some specified variation in quality from piece to piece is usually accepted as a compromise between the high cost (and perhaps unattainability) of perfection and the consequences of marketing a product of uncontrolled quality.

When the probability distribution assumed to describe piece to piece variation remains constant as the production proceeds, the process is said to be in control. A process that "goes out of control" because of assignable causes may be investigated and corrected. In an industrial environment there is continuing effort to bring a process into acceptable control and then monitor its behaviour.

The basis of a control chart procedure is a sequence of samples from the production line, taken at regular intervals. The sample size is usually small on the order of 2 to 10, partly because of expediency and partly because of the presumption that the process is not changing much during the production of that small sample.

The control limits for the mean are

$UCL_x = X + A_2R$ = upper control limit

$LCL_x = X - A_2R$ = lower control limit

$CL = X$ = central line

Where

R is the mean of sample ranges

X is the mean of sample means

A_2 is tabulated and dependent on the sample size

CHAPTER THREE

LITERATURE REVIEW

Various statistical methods are used in business and industry. This chapter takes up "statistical quality" control which is important and is demonstrated to be of great value in the area of production. This involves ramifications of the basic ideas of testing hypothesis.

The quality of lots of manufactured items is a matter of considerable importance both to the producer and the consumer. Quality can be determined by a 100 percent inspection, but this is often too expensive and not necessarily perfect.Moreover, it may be destructive in some instances. It is common practice to inspect only the items in a sample from the lot and to judge the whole lot on the basis of the sample quality. Quality may be measured by some numerical characteristic, or it may be defined by whether individual items are "good" or "defective" hence quality is the key to success and this is why Chase/Aquilano in their book "production and operations management" 1989 fifth edition argued that since all sections of human institutions such as individual Companies,Hospital, School and a host of others engage in the provision of products or services to human beings.

Still on quality control, Isaac N Gibra in his book probability and statistical inference for scientists and engineers patience-Hall, Inc Englewood N.J. He stated in piece of item that leave the production line are not exactly of the same quality. To him, these observed variations in quality are due to two types of causes. These are:

1. Random causes or chance causes.
2. Non- Random causes.

He said when a process is operating under chance or random cause of variations in quality, it is said that the process is under statistical control or simply under control.

But when it is operating under non-random cause of variation, we say that there is assignable cause of variation.

Assignable causes of variation are those causes responsible for the major variation in quality. These causes must be identified and removed for effective and economic functions of the process, some of these causes of variation are as follows:

i. The use of sub-standard raw materials.
ii. carelessness/Negligence of the operator.
iii. Catastrophic or major breakdown in machine.
iv. fatigue.
v. Unskilled operator.

Still on this topic Dennis R Lillirap and John A Cosins on their book Food and beverage service (1991) ELBS. To them, in any production process, some variations in quality are unavoidable, variations can be divided into two:

1. Random variation.

2. Assignable variation.

In their book, both argued that random variations are the variations that result from the interraction of a combination of a very complex random variable that produce slight differences in the product characteristics, individually, these variables produce slight changes in products dimension and it is impossible or uneconomical to identify or eliminate these causes. For instance, slight changes in temperature, pressure, friction, metal hardness and similar other factors interact randomly to produce slight variations in products quality. Random variations to them tend to be predictable statistically.

They also went further to say that assignable variations are variations in quality of a machine that can be identified and hence differences among machines, adjustment of a machine by an operator,. a change in the character of the input raw material mistake by workmen or sometimes workers fatigue may bring about marked variations. They concluded by saying that assignable variations are unpredictable statistically.

Going further to the book of Chase and Aquilano production and operations management fifth edition (1989) Irwin, said that the concepts of statistical quality control can be viewed from two points.

I) Statistical Process control

ii) Quality assurance

Statistical process control, which is mainly the control charts is the use of statistical technique to test a random sample of output from a process to ensure that the process is producing items within a specific range. When the tested output exceeds that range, it is a signal to adjust the production process to force the output back to the acceptance range. If exact design production and measurement were possible, no variation in the measurement. The fact is that neither measured nor manufactured product can be performed without variations and the important problem to solve in any experimental inquiry is distinguishing between inherent and removable variation.

Quality assurance, since the customer is the "final inspector" of quality, quality assurance includes all the activities that are performed to ensure that the product preforms to the customers satisfaction. These activities include

i) Reliability engineering - to ensure that the design will have an adequate expected useful life.

ii) Value engineering - to ensure that the product will perform the necessary function at minimum cost.

iii) Evaluation of Usability - to see that the product will be convenient and safe in the hands of the users.

iv) Service assurance - to see that the customer is that adequately trained to use and maintain the product and that service parts and manuals are made available.

3.1 **Hint on Beer Processing**

Beer Is on alcoholic beverage found in all bars and areas dispensing alcoholic beverages either in their own right or to accompany a meal.

Beer is product of yeast fermentation of cereal water extract flavoured with the female flower of the hop plant. The major ingredients are water and germinated barley.

The species of barley commonly used for brewing are HOP, Malt, Yeast and Sorghum.

HOPs - These are specially grown for brewing and the part of the hop that is used is the flower, which contains an oil that gives beer its flavour.

MALT - The best cereal for use in the production of beer is barley. This cereal goes through a process which converts it to what is termed malt.

SORGHUM - Specially grounded and refined. Sorghum are used to aid the fermentation and the production of alcohol and it adds sweetness too.

YEAST - Yeast is a living thing and is added to the beer at a set time to cause fermentation. Yeast plus sugar produces alcohol and gives off a gas called carbon dioxide.

$$C_6H_{12}O_6(aq) \quad -> \quad 2C_2\,H_5OH(aq) + 2CO_3(g)$$

During fermentation the yeast multiplies and this new yeast is collected and used for future brews.

Explanation -:

Ethyl alcohol can be made by fermentation of sugars or grains. The reaction is carried out in solution in the absence of air and in the presence of certain enzymes, which are natural catalysts, secreted by various yeasts; for glucose a simple sugar, the reaction would be.

3.2 Control Chart for Mean

Standard practices have developed over the years, practices that can be used as a starting point, with modification then made as experience in a particular situation suggests. In the united states, the standard control suggests. In the United States, the standard control lines are set at the mean+ 3standard deviations, referring to moments of the test statistic being used. In Great Britain, standard practice is set to set warning limits at + 1.96 standard deviations, and rejection limits at +3.09 standard deviations from the mean (corresponding to = .05 and = .002 respectively, for each point if the test statistic is normal).

Control charts are also used to check control of a process for which standards have not yet been set. " In control" would simply mean, in such contexts, that the population is not changing. Again small samples are taken from the process periodically.

Several values of X and R are entered on the charts for a number of samples before the control lines and control limits are determined. A decision as to wether or not there is control will be made after the control lines are in place.

The centre line for the X-chart should be at u=E(X), but since u is unknown, the mean X of the sample means is used to estimate u. The control limits should be at u+3o/n, but since o is not known, R/a_n is used in its place, where R is the mean of the ranges of the samples on hand and a_n can be read from table of values attached.

Checking control with current data. limits are

$UCL = X + A_2R$

$CL = X$

$LCL = X - A_2R$

Where

$$X = \frac{\sum X}{n};\ R = \frac{\sum R}{n}$$

3.3 Control Chart for the Range

The distribution of the range R is known when the population is normal. In this case, contants a_n and b_n are defined by

$$a_n \equiv E(\frac{R}{\sigma});b_n \equiv \sqrt{Var\frac{R}{\sigma}}$$

and given in tables I and II at the back cover of the project for various sample sizes. The expected value $a_n o$ is often taken as the centre line at an R-Chart, even if the population is not exactly normal. And since $o_R = b_n o$, the control limits are placed at $a_n o + 3b_n o$ while the centre line should be at $a_n o$: this is estimated by R.

Cecking control with current data

R - chart

$UCL_R = D_4R \qquad (D_4 = 1 + 3b_n/a_n)$

$CL_R = R$

$LCL_R = D_3R \qquad (D_3 = Max(0, 1-3b_n/a_n)$

D_3 and D_4 values for selected samples can be read from Grant and Leaven worh computed Statistical quality control table.

The R- chart is a useful device for detecting changes in the variability of quality and is got by plotting the range of each sample against the sub-groups as a control chart using the above formula.

3.4 Control Chart for Proportion (P-chart)

Articles may be classified as either defective or good, and the quality of a lot is measured by the proportion p of defectives in the lot. Small p means high quality, and one might arbitrarily set a standard of the form $p < p^*$ for a lot to be acceptable.

A sample is assumed to be drawn from the lot at random, without replacement. A lot is to be accepted or rejected on the basis of the fraction or proportion defective in the sample. A rule for doing this is essentially a test of the hypothesis that the lot is acceptable, although it is not necessary, in defining a rule, to specify a precise range of population proportion (such as $p < p^*$) as constituting H_o, (Null hypothesis). The obvious type of decision rule to use is one of the form: "Accept the lot if the number of defective in the sample is less than or equal to c, where c is a specific constant that defines the rule.

$p = d/n$ or $d = np$

where d is defective item in the sample and n is the sample size(number).

$$p = \frac{\textit{Total number of defective} \in k \textit{ samples}}{\textit{Total number of units} \in k \textit{ samples}}$$

$p = d/n$

$$\sigma_p = \sqrt{\frac{p(1-p)}{n}}$$

Checking control with current data, control limits for p-chart are

$UCL = P + 3\sigma_p$

$CL = P$

$LCL = P - 3\sigma_p$

Evaluating the efficiency of the company and reliability up to date.

For instance, Nigerian Bottling Company produces its product to an acceptable quality level of 2% defective and is willing to run a risk of 5%. The sales regional distributor considers the product of 5% or more defective (LTPD) unacceptable and wants to make sure that they will not accept such poor quality product if more than 10% out of 10,000 of the product delivered to the distributor are defective.

CHAPTER FOUR

SYSTEM DESIGN

4.1 Input Description

i) The program starts by requesting the user to input 1 if interested in control for variables or 2 for control for attributes

ii) The program then requests for sample size which should lie between 3 - 10

iii) Program requests for number of samples to be analyzed.

iv) Program requests user to enter 1 if interested in control to specific means and standard deviation or 2 for homogeneity.

v) If response to iv is 1, program requests for population mean and standard deviation.

vi) requests for sample values to be entered.

vii) requests the user to enter Y if interested in further analysis - control for attributes or n otherwise. Program would have skipped steps (iii)-(vi) if response to (i) is 2.

viii) if response to (vii) has y, it requests the user to enter 1 for control for proportion or two for number of counts.

ix) if response to viii) is 1, requests the user to enter 1 for control to specific proportion or 2 otherwise.

x) it requests for number of samples to be analyzed.

xii) request for sample defective in each sample.

xiii) if response to viii) is 1, it requests user to enter value for the specific proportion.

xiv) it requests the user to enter y if interested in c-chart or n otherwise.

xv) if response to xiv) in y, it requests that 1 be entered for control for specific count or 2 for homogeneity.

xvi) requests for the number of units to be inspected.

xvii) requests for the number of defects per unit

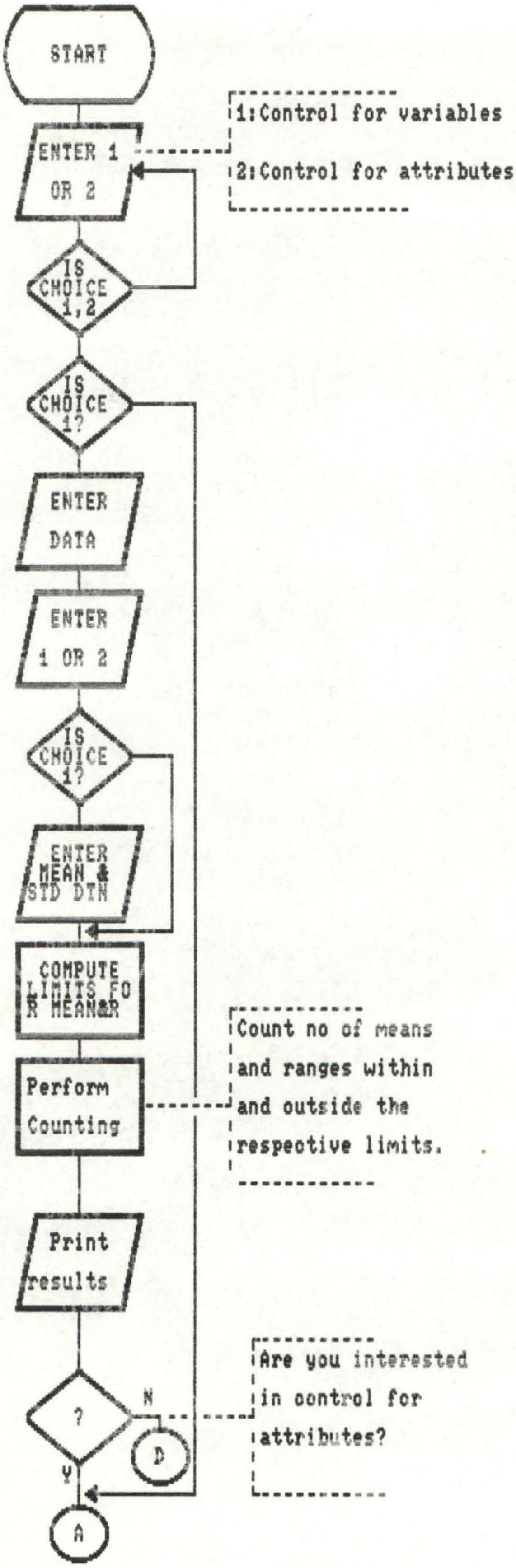
xviii) requests for the value of the specific count if response to xv is 2.

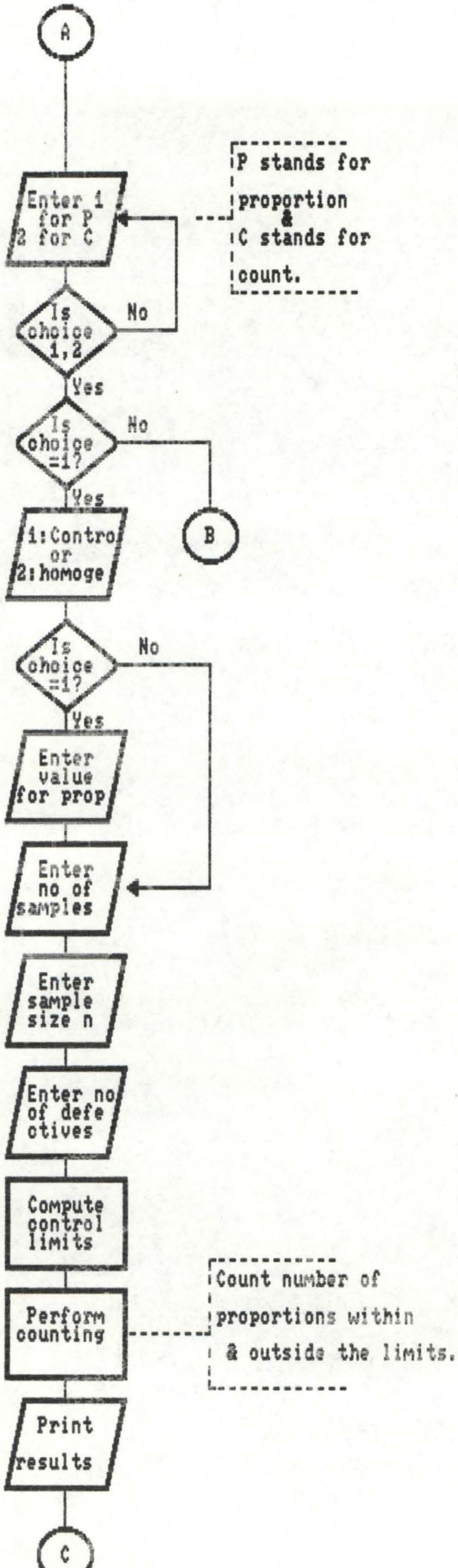
xiv) if response to)viii) is 2, steps (ix-xiv) would have been skipped.

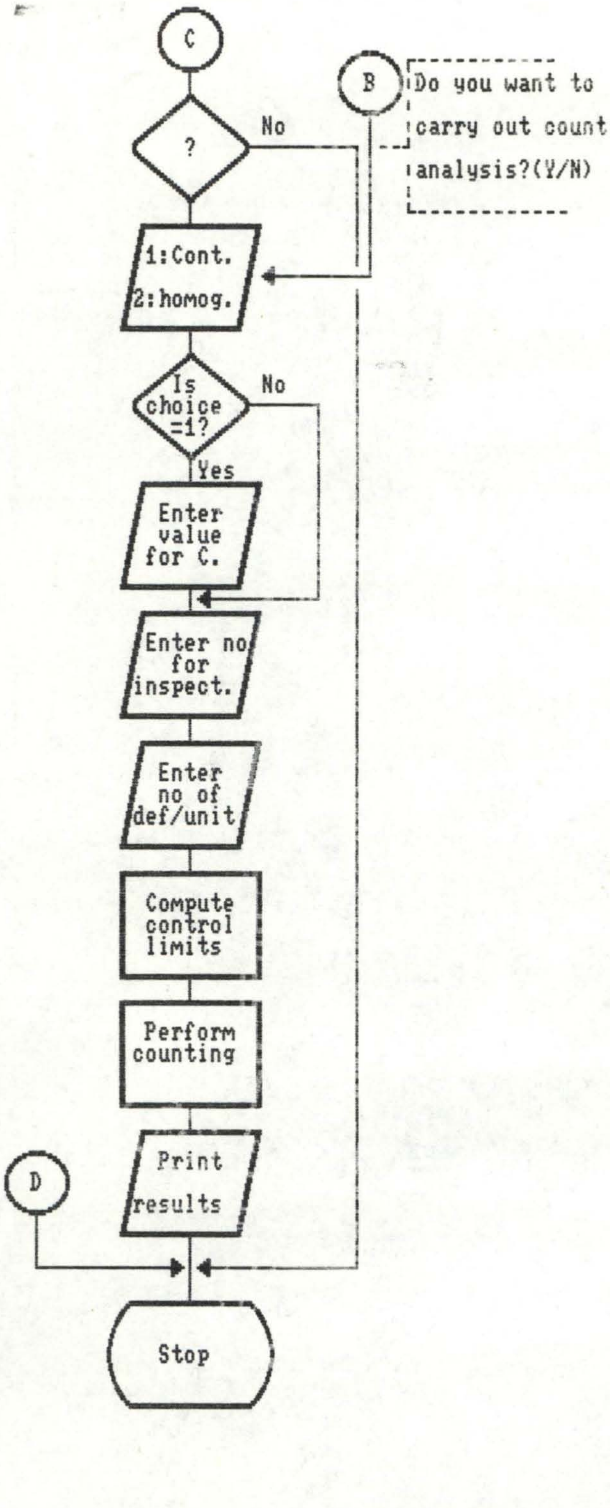
4.2 Algorithm

The flowchart shall be used in presenting the algorithm.

FLOWCHART


START
ENTER 1 OR 2
1:Control for variables
2:Control for attributes
IS CHOICE 1,2
IS CHOICE 1?
ENTER DATA
ENTER 1 OR 2
IS CHOICE 1?
ENTER MEAN & STD DTN
COMPUTE LIMITS FOR MEAN&R
Perform Counting
Count no of means and ranges within and outside the respective limits.
Print results
?
N
D
Y
A
Are you interested in control for attributes?


A
Enter 1 for P 2 for C
P stands for proportion & C stands for count.
Is choice 1,2
No
Yes
Is choice =1?
No
Yes
B
1:Contro or 2:homoge
Is choice =1?
No
Yes
Enter value for prop
Enter no of samples
Enter sample size n
Enter no of defe ctives
Compute control limits
Perform counting
Count number of proportions within & outside the limits.
Print results
C


C
B
Do you want to
carry out count
analysis?(Y/N)
?
No
1:Cont.
2:homog.
Is
choice
=1?
No
Yes
Enter
value
for C.
Enter no
for
inspect.
Enter
no of
def/unit
Compute
control
limits
Perform
counting
Print
results
D
Stop

```
CLS
REM PROGRAM ON STATISTICAL QUALITY CONTROL BY MADUAKOLAM CHRISTIAN
REM REG. NO PGD/MCS/97/255
1   INPUT "Enter 1 for control for variables or 2 for attributes"; ch
 IF ch <> 1 AND ch <> 2 THEN GOTO 1
  IF ch = 2 THEN 50
DIM a1(10), a2(10), d1(10), d2(10), d3(10), d4(10)
a1(3) = 1.732: a1(4) = 1.5: a1(5) = 1.342: a1(6) = 1.225: a1(7) = 1.134
 a1(8) = 1.061: a1(9) = 1: a1(10) = .949
a2(3) = 1.023: a2(4) = .729: a2(5) = .577: a2(6) = .483: a2(7) = .419
a2(8) = .373: a2(9) = .337: a2(10) = .308
d1(3) = 0: d1(4) = 0: d1(5) = 0: d1(6) = 0: d1(7) = .205
d1(8) = .387: d1(9) = .546: d1(10) = .687
d2(3) = 4.358: d2(4) = 4.698: d2(5) = 4.918: d2(6) = 5.078: d2(7) = 5.203
d2(8) = 5.307: d2(9) = 5.394: d2(10) = 5.469
FOR i = 3 TO 6
  d3(i) = 0
NEXT i
d3(7) = .076: d3(8) = .136: d3(9) = .184: d3(10) = .233
d4(3) = 2.574: d4(4) = 2.282: d4(5) = 2.114: d4(6) = 2.004
d4(7) = 1.924: d4(8) = 1.864: d4(9) = 1.816: d4(10) = 1.777
10 INPUT "enter btw 3-10 for sample size                  ", n
 IF n < 3 OR n > 10 THEN
    PRINT
   PRINT "sample size supplied is out of range"
   PRINT
   GOTO 10
 END IF
11    INPUT "enter no of samples                                 ", s
   IF s < 1 THEN
    PRINT
    PRINT "no of samples can not be less than 1"
    PRINT
    GOTO 11
   END IF
20 INPUT "enter 1 for control to specific mean & dev. or 2 for homogenity ",
choice
   IF choice <> 1 AND choice <> 2 THEN 20
   IF choice = 1 THEN
   INPUT "enter value for popn mean                          ", miu
21      INPUT "enter value for popn std deviation                  ", dev
     IF dev < 0 THEN
       PRINT
       PRINT "standard deviation can not be negative"
       PRINT
       GOTO 21
      END IF
   END IF
   DIM x(s, n), mean(s), range(s), locatx$(s), locatr$(s)
  FOR i = 1 TO s
   PRINT "enter values for sample"; i
     FOR J = 1 TO n
      INPUT x(i, J)
     NEXT J
  NEXT i: CLS
REM computation of mean  for each sample
FOR i = 1 TO s
  sumr(i) = 0
  FOR J = 1 TO n
    sumr(i) = sumr(i) + x(i, J)
    NEXT J
mean(i) = sumr(i) / n
NEXT i
REM   computation of range
FOR i = 1 TO s
```

```
    PRINT i, range(i), locatr$(i)
  NEXT i: PRINT
  PRINT "ucl for r-chart ="; uclr
  PRINT "lcl for r-chart ="; lclr
  PRINT "no of ranges outside the control limits ="; kr
  PRINT "no of ranges inside the control limits ="; s - kr
    IF kr = 0 THEN
    PRINT "r-chart suggests that the process is in control"
      ELSE
    PRINT "r-chart suggests that the process is out of control"
    END IF: PRINT : PRINT
25   INPUT "Are you interested in control for attributes (y/n)?"; ch$
   IF ch$ <> "y" AND ch$ <> "n" THEN
     PRINT
     PRINT "enter y for YES or n for NO"
     PRINT
     GOTO 25
   END IF
   IF ch$ = "y" THEN
     CLS : GOTO 50
       ELSE
     END
   END IF
50 INPUT "Enter 1 for control for prop. or 2 for no of counts"; ch
   IF ch <> 1 AND ch <> 2 THEN 50
   IF ch = 1 THEN 70 ELSE 100
70 INPUT "Enter 1 for control to specific prop. or 2 for homogenity"; ch
  IF ch <> 1 AND ch <> 2 THEN 70
72   INPUT "Enter value for no of samples"; ns
   IF ns < 1 THEN
    PRINT
    PRINT "no of samples can not be negative"
    PRINT
    GOTO 72
   END IF
  DIM d(ns)
73  INPUT "Enter value for sample size"; n
 IF n < 1 THEN
  PRINT
  PRINT "sample size can not be negative"
  PRINT
  GOTO 73
 END IF
 FOR i = 1 TO ns
74     PRINT "Enter value for no of defectives in sample"; i
   INPUT d(i)
  IF d(i) > n OR d(i) < 0 THEN
   PRINT
   PRINT "invalid figure,larger than sample size or less than 0"
   PRINT
   GOTO 74
  END IF
 NEXT i: CLS
 IF ch = 1 THEN
71  INPUT "Enter value for specific proportion"; p
   IF p >= 1 OR p < 0 THEN
   PRINT
   PRINT "invalid figure ,proportion should lie withing 0 & 1"
   PRINT
   GOTO 71
   END IF
   w = 3 * SQR(p * (1 - p) / n)
   uclp = p + w
   lclp = p - w
     ELSE
```

```
    sum = 0
    FOR i = 1 TO ns
      sum = sum + d(i)
    NEXT i
    pb = sum / (ns * n)
   w = 3 * SQR(pb * (1 - pb) / n)
   uclp = pb + w
   lclp = pb - w
 END IF
IF lclp < 0 THEN lclp = 0
REM Identification of locations
  kp = 0
  FOR i = 1 TO ns
    IF d(i) / n < lclp OR d(i) / n > uclp THEN
     kp = kp + 1
     locatp$(i) = "outside"
       ELSE
       locatp$(i) = "inside"
    END IF
   NEXT i: CLS
REM  Printing of results
 PRINT "Sample no", "Proportion", "location"
 PRINT
 FOR i = 1 TO ns
   PRINT i, d(i) / n, locatp$(i)
 NEXT i: PRINT
 PRINT "ucl for P-chart ="; uclp
 PRINT "lcl for P-chart ="; lclp
 PRINT "no of prop. outside the limits ="; kp
 PRINT "no of prop. inside the limits ="; ns - kp
   IF kp = 0 THEN
     PRINT "P-chart suggests that the processs is in control"
              ELSE
     PRINT "P-chart suggests that the process is not in control"
   END IF: PRINT : PRINT
99  INPUT "Do you wish to perform control chart for C-chart (y/n)?"; ch$
      IF ch$ <> "y" AND ch$ <> "n" THEN
         PRINT
         PRINT "enter y for YES or n for NO"
         PRINT
        GOTO 99
      END IF
      IF ch$ = "y" THEN 100 ELSE END
100 INPUT "Enter 1 for control to specific c or 2 for homogenity"; ch
   IF ch <> 1 AND ch <> 2 THEN 100
101  INPUT "Enter value for no of units to be inspected "; ns
     IF ns < 1 THEN
      PRINT
      PRINT "no of units to be inspected can not be negative"
      PRINT
      GOTO 101
     END IF
     DIM df(ns)
  FOR i = 1 TO ns
104       PRINT "Enter no of defects on sample "; i
       INPUT df(i)
       IF df(i) < 0 THEN
         PRINT
         PRINT "no of defects can not be negative"
         PRINT
         GOTO 104
         END IF
     NEXT i: CLS
     IF ch = 1 THEN
102       INPUT "Enter value of specified c"; c
```

```
    big(i) = 0: small(i) = x(i, 1)
  NEXT i
  FOR i = 1 TO s
    FOR J = 1 TO n
      IF x(i, J) > big(i) THEN big(i) = x(i, J)
      IF x(i, J) < small(i) THEN small(i) = x(i, J)
    NEXT J
    range(i) = big(i) - small(i)
  NEXT i
REM computation of control ,limits
    IF choice = 1 THEN
       c1 = 3 * dev / SQR(n)
       uclx = miu + c1
       lclx = miu - c1
       uclr = d2(n) * dev
       lclr = d1(n) * dev
          ELSE
       tmean = 0: trange = 0
         FOR i = 1 TO s
           tmean = tmean + mean(i)
           trange = trange + range(i)
         NEXT i
           mmean = tmean / s
           rbar = trange / s
           c1 = a2(n) * rbar
           uclx = mmean + c1
           lclx = mmean - c1
           uclr = d4(n) * rbar
           lclr = d3(n) * rbar
     END IF
 REM identification of locations
   kx = 0: kr = 0
    FOR i = 1 TO s
      IF mean(i) < lclx OR mean(i) > uclx THEN
        kx = kx + 1
         locatx$(i) = "outside"
          ELSE
         locatx$(i) = "inside"
       END IF
       IF range(i) < lclr OR range(i) > uclr THEN
         kr = kr + 1
         locatr$(i) = "outside"
           ELSE
           locatr$(i) = "inside"
       END IF
   NEXT i: CLS
REM printing of results
  PRINT TAB(10); "SUMMARY OF RESULTS"
  PRINT TAB(10); "******************": PRINT
  PRINT "sample no", "mean", "location"
  FOR i = 1 TO s
    PRINT i, mean(i), locatx$(i)
  NEXT i: PRINT
  PRINT "ucl for mean chart ="; uclx
  PRINT "lcl for mean chart ="; lclx
  PRINT "no of means outside the control limts ="; kx
  PRINT "no of means inside the control limits ="; s - kx
   IF kx = 0 THEN
     PRINT "mean chart suggests that the process is in control"
       ELSE
     PRINT "mean chart suggests that the process is not in control"
   END IF
     PRINT : PRINT
  PRINT "sample no", "range", "location"
    FOR i = 1 TO s
```

```
        IF c < 1 THEN
          PRINT
          PRINT "no of counts can not be less than 1"
         PRINT
         GOTO 102
        END IF
        uclc = c + 3 * SQR(c)
        lclc = c - 3 * SQR(c)
            ELSE
            sum = 0
         FOR i = 1 TO ns
           sum = sum + df(i)
         NEXT i
         cbar = sum / ns
         uclc = cbar + 3 * SQR(cbar)
         lclc = cbar - 3 * SQR(cbar)
      END IF
     IF lclc < 0 THEN lclc = 0
      PRINT
REM Identification of locations
     kc = 0
     FOR i = 1 TO ns
       IF df(i) < lclc OR df(i) > uclc THEN
         kc = kc + 1
         locatc$(i) = "outside"
           ELSE
         locatc$(i) = "inside"
       END IF
     NEXT i
REM Printing of results
  PRINT TAB(4); "Sample no", TAB(17); "no of defects/unit", TAB(43); "location"
  PRINT
  FOR i = 1 TO ns
    PRINT TAB(7); i, TAB(22); df(i), TAB(44); locatc$(i)
  NEXT i: PRINT
  PRINT "uclc for C-chart ="; uclc
  PRINT "lclc for C-chart ="; lclc
  PRINT "no of defects outside the limits ="; kc
  PRINT "no of defects inside the limits ="; ns - kc
  IF kc = 0 THEN
    PRINT "C-chart suggests that the process is in control"
        ELSE
    PRINT "C-chart suggests that the process is not in control"
  END IF
```

4.3 Program Description

Segment 1: Line 1 is the beginning of the program and it requests the user to enter 1 for control for variables or 2 for attributes. If any number besides 1 and 2 is entered, it returns control to line 1. If choice is 2, program transfers control to line 50 which begins analysis for attributes. If 1 is entered, program requests for sample size. If the sample size supplied is less than 3 or greater than 10, the user is prompted to re-enter the sample. The program requests for number of samples and requests for re-entering if figure supplied is less than 1.

Segment 2: Line 20 requests user to enter 1 for control to specific mean and standard deviation or 2 for homogeneity. If neither 1 nor 2 is entered, control is returned to line 20. If response is 1, line 21 requests for population mean and standard deviation, control is returned to line 21. Program then requests for sample values in the following order: sample 1, sample 2, sample 3,....... sample n where n was specified as the number of samples.

Program computes the mean and the range of each sample. Control limits for mean and range are then computed.

Segment 3: On the basis of the computed limits, location of each mean in respect of wether it lies inside the control limits or outside. The number of means inside is counted. So also is the number of means outside.

Same is done for the range

Segment 4: Results of the control for variables are printed.

Segment 5: Program requests user to enter y if interested in control for attributes on n if not. If response is y, control is transferred to line 50 otherwise the process is terminated. It requests for 1 to be entered or control to specific proportion or 2 for homogeneity. Line 72 requests for number of samples and if a negative number is entered, control is returned to line 72. Line requests for sample size and control is returned to line 72 if a negative number is entered.

Line 74 requests for number of defective in each sample and does not accept any negative number or any number less than sample size supplied in line 72. Line 71 requests for specific proportion and control is transferred to line 71 if figure supplied does not lie within 0 - 1.

Segment 6: Control limits for proportion are computed.

Segment 7: Location of each proportion is identified and counts of proportion inside and outside the limits is taken. Results are then printed.

Segment 8: Line 99 requests user to enter y if control for counts is desired or if n if not. If input is neither y nor n, control is returned to line 99.

Segment 9: If response to line 99 is y, line 100 requests user to enter 1 for control to specific number of defects/unit or 2 for homogeneity. If response is neither 1 nor 2, control is returned to 100. Line 101 requests for number of units to be inspected and returns control to lie 101 if negative number is supplied. Line 104 requests for number of defects on each sample and does not accept any negative number. Line 102 requests for specified number of counts/unit if response in line 100 is 1.

Segment 10: Control limits for number of defects/unit are computed. Location of each number of count is found and counts of those inside and outside the control limits are taken.

Segment 11: Results of control for number of defects per unit are printed.

CHAPTER FIVE

SYSTEM IMPLEMENTATION

By system implementation, we mean placing the system into operation. On placing the software into operation, expected output and interpretation of results obtained are discussed.

5.1 Output Expected

Quality may be measured by some numerical characteristics or defined by wether individual items are good or defective hence we have variables and attributes.

Quality measured by variable or variables are either categorical or numerical., In discussing the case in which it is given by a single numerical variable - a dimension or weight, the charts usually applied are X-chart and R-chart.

In X-chart, we usually consider the following

i) Mean of each sample - in controlling quality to determine mean, it is assumed that past experience provides parameter values for the distributions of control-chart constants and the sample values.

ii) Location of mean, that is wether the mean lies within the control limits of X-chart.

Also in R-chart, we consider the following

i) A count of the printed means within and outside the limit

ii) Statement on wether the process is in control or not.

normal.

ATTRIBUTES - The quality of production is measured by the proportion "p" of defective in the lot. This is usually referred to as sampling inspection by attributes. The charts for attributes are p-chart and the c-charts.

P-chart shows if the proportion of defective in each sample lies within the upper and the lower limits or if it is outside the limits and are counted. Also statements are made on wether the process is in control or not based on the result.

C-chart on the other hand shows the number of defects per unit of production. It enables us to locate and count the number of defects within and outside the control limits.

Anyone using these control charts would soon see that they contain more information than just wether or not the statistic goes outside the control limit. Even the eye can pick-up variations in time that will point to process changes.

Too many points above a centre line for instance or a sequence of several points steadily rising on the chart wold alert one to the possibility that some thing is going on.

Control chart constants for both kinds of charts presented here are given together with the program in chapter iv and the photo-copy is before the back page cover of this project.

If this process is found to be in control using these charts and if the levels of means and variability are acceptable the control line that has been established can be used for checking the process as it proceeds further.

5.2 Output Interpretation

Having applied some statistical techniques, the analysis enabled us to interpret the result with respect to our data.

The statistical techniques that are used are -:

i) The control chart for means called X-chart

ii) The control chart for range called R-chart

iii) The control chart for proportion called P-chart

iv) The count chart called C-chart

These control charts enable us to find out wether the process maintains statistical stability or not by the way of one monitoring variables.

X-chart is used to monitor the means of samples drawn from the population. It is used in conjunction with R-chart which monitors the variation within samples drawn from a population.

Interpreting the output of the four elements of this project, that is HOP, MALT, SUGAR, SORGHUM and YEAST, we have -:

X-chart for HOP -:

When we inputted the formula for control chart together with figures and constants such as

$UCL_x = X + A_2R$

$CL = X$

$LCL_x = X - A_x R$

Which have been defined earlier on while the constants are attached at the last page before the cover.

We observed that the process maintained statistical stability since all the samples fall within the control limit other, the process wold have been said to be out of control.

R-chart for HOP

This is the variability of quality. The output of the computation shows that the process maintains statistical stability since all the observed sample ranges fall within the control limits otherwise the process would indicate out of range

R-chart and X-chart for MALT

Just like the HOP, analysis of all the samples shows that all samples fall within the limits both mean and range charts are said to be in control.

X-chart and R-chart for SUGAR SORGHUM

The mean has one out of the limits. This is as a result of machine breakdown. R-chart suggests control.

X-chart and R-chart for YEAST

The result for the mean shows that the process is in control since all the computed results lie within the limits. Also the range proves that the process is in control since all the figures lie within the limits. P-chart suggests control.

5.3 **Conclusion**

This project has been concerned with computerized statistical quality control in Golden guinea breweries Nigeria Plc located at Olokoro Umuahia in Abia state.

Emphasis has been on the production process to get a quality product. By all observation, it is obviously clear that the assignable causes of variation which could be one or more of -:

i) the use of sub-standard raw material

ii)Breakdown in machine

iii) adjustment of a machine by an operator

iv) Unskilled operation or negligence of the operator

v) Differences among machine whose assignable causes are unpredictable statistically have been eliminated from the process and that all points inputted on the control chart remain within the control limits which indicate that the process is in a state of control.

5.4 **Recommendations**

In view of the analysis in chapters ii,iii and iv, we feel it is safe to make the following recommendations

1) The company should as a matter of fact always seek the opinion or ideas of their customer so as to know where to improve and if need be for any necessary adjustment.

2) The Golden guinea company, Umuahia should keep on

meeting customers satisfaction and as well targeting at making profit on their products without altering the quality of their products.

4) There must be a training program organized for the workers on the need for quality improvements on weekly basis which will give rise to high production and huge sales.

5) There must be regular publication of quality policy say bi-monthly or quarterly.

6) There must be a constant review of quality management system to ensure progress and conducive environment for production.

For any company whose aim is to make a better product or to improve more on the quality and attain a specified standard, the above recommendations if properly adhered to, will ensure production of high quality product.

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Table I: **The Strength of HOPs**

Shift/ S/NO	A	B	C	D	E	F	G	H
1	76.25	75.80	75.00	74.80	80.55	77.75	80.50	71.30
2	80.00	76.75	77.15	75.00	74.80	78.75	78.25	75.30
3	76.75	76.25	77.35	77.75	97.05	78.95	80.00	75.00
4	80.50	77.25	76.65	78.60	76.25	76.75	74.90	76.00
5	70.00	73.50	71.50	77.50	78.00	77.00	77.50	77.00
6	75.00	78.00	78.75	76.50	77.00	76.25	76.75	71.25
7	76.25	75.00	78.75	76.75	78.00	72.00	74.75	70.25
8	74.80	80.50	77.75	80.50	74.80	75.00	75.80	76.25
9	75.50	78.25	78.75	79.80	75.00	77.25	76.75	80.00
10	75.00	80.00	74.85	77.05	77.75	77.47	76.25	76.25
11	80.50	76.00	74.90	76.75	76.25	78.60	76.65	77.25
12	71.25	78.50	76.75	77.00	76.25	76.50	78.00	75.00
13	74.50	70.00	71.50	77.50	77.00	76.25	76.75	77.00
14	75.00	76.25	70.25	74.25	72.00	78.00	76.75	78.25
15	81.00	76.00	80.50	74.85	78.75	72.00	75.00	76.85
16	77.85	80.10	75.60	72.20	71.80	76.15	75.00	80.00
17	70.00	75.00	80.00	81.25	82.25	77.25	77.75	75.00
18	75.00	75.30	71.00	78.75	80.15	80.10	80.00	75.00
19	80.50	77.25	76.65	78.60	76.25	76.75	74.90	76.00
20	75.00	80.10	74.85	77.05	77.75	77.35	76.75	80.00
21	80.00	76.75	77.25	75.05	74.80	78.75	78.25	75.00

Table II: **The Strength of Malt**

Shift/ S/NO	A	B	C	D	E	F	G	H
1	69.75	69.48	69.00	74.88	75.30	76.65	75.30	74.88
2	75.00	76.05	76.35	75.00	74.88	77.25	76.95	75.30
3	76.05	75.75	76.41	76.65	76.23	77.91	78.06	73.30
4	69.30	76.35	75.99	77.16	76.05	74.94	77.94	75.06
5	75.00	76.80	77.10	75.90	76.20	75.75	76.05	72.75
6	72.00	74.10	72.90	75.90	76.80	76.20	76.50	76.20
7	75.75	75.0	77.25	76.05	76.80	73.20	74.85	72.15
8	74.88	69.30	76.65	78.30	74.88	75.00	75.48	75.75
9	75.36	76.95	77.19	74.88	75.00	76.35	76.05	75.00
10	75.00	75.00	74.91	76.23	76.65	76.41	75.75	76.05
11	75.30	75.60	74.94	70.05	75.75	77.16	75.99	76.35
12	72.75	77.10	75.05	76.20	75.75	75.90	76.80	75.00
13	71.10	72.00	70.50	71.95	76.50	76.20	76.20	75.00
14	75.00	75.75	72.15	74.85	73.20	76.80	70.80	70.20
15	69.60	75.60	69.30	74.91	72.25	73.20	75.00	76.05
16	76.50	69.21	75.00	73.32	73.08	75.69	75.00	76.05
17	72.00	75.00	69.00	69.75	70.35	76.35	76.65	75.00
18	75.00	75.18	72.60	77.25	75.09	69.06	69.00	75.00
19	69.30	76.35	75.99	77.16	75.75	76.05	74.94	75.60
20	75.00	69.00	74.91	76.23	76.65	76.41	76.05	69.00
21	69.00	76.05	76.35	75.00	74.88	77.25	75.30	77.25

Table III: **The Strength of Sugar sorghum**

Shift/ S/NO	A	B	C	D	E	F	G	H
1	75.00	69.00	74.91	76.25	76.66	76.41	76.45	69.00
2	75.00	75.18	72.60	77.25	75.09	69.06	69.00	75.00
3	72.72	77.10	76.05	76.20	75.75	75.90	76.80	75.00
4	75.00	75.75	72.15	74.85	73.20	76.80	70.80	70.00
5	69.30	76.35	75.99	77.16	75.75	76.05	74.94	75.60
6	75.36	76.95	77.16	74.94	75.75	75.35	76.05	75.00
7	74.88	69.30	76.23	74.91	76.35	75.60	75.48	75.75
8	75.35	75.99	76.75	70.35	76.05	76.95	75.60	73.30
9	75.00	75.00	69.70	76.80	77.35	75.00	76.95	76.65
10	69.00	72.00	76.70	80.10	74.90	72.75	75.00	76.65
11	77.10	75.75	76.75	80.50	72.25	74.85	72.75	76.20
12	75.00	80.00	76.25	80.00	75.00	78.60	74.85	77.75
13	77.25	76.65	77.75	78.00	74.75	81.25	78.60	76.75
14	75.00	75.00	78.25	78.25	78.75	72.25	81.25	70.00
15	78.75	75.50	70.25	78.00	74.75	76.75	72.25	79.80
16	76.25	78.75	75.05	78.00	78.75	80.00	76.75	72.00
17	77.25	74.80	77.50	77.00	71.50	78.00	80.00	75.50
18	70.00	77.00	73.50	77.50	77.00	71.50	78.00	75.50
19	74.85	75.00	77.75	80.00	77.05	76.75	77.47	76.25
20	71.00	80.10	80.15	75.00	75.00	80.00	75.30	78.75
21	64.20	69.21	63.00	71.90	63.60	69.90	63.00	71.40

Table IV: **The Strength of Yeast**

Shift/ S/NO	A	B	C	D	E	F	G	H
1	63.00	73.80	87.00	91.00	78.60	84.00	60.00	90.00
2	72.00	78.00	87.00	75.60	84.00	76.20	78.00	84.00
3	66.00	68.70	80.00	67.32	88.40	78.00	84.60	90.00
4	60.00	63.00	60.90	75.00	73.80	84.00	78.00	72.00
5	72.00	78.00	82.20	69.00	88.80	84.00	66.00	60.00
6	82.20	81.60	75.00	68.70	73.80	82.50	88.50	90.00
7	76.80	84.00	82.80	70.50	84.00	74.10	84.00	80.10
8	84.00	81.90	86.70	90.00	78.00	88.50	80.10	72.00
9	63.00	67.20	68.10	69.00	71.10	79.80	88.20	72.00
10	60.00	81.00	84.00	87.90	71.70	87.00	88.00	89.10
11	76.80	79.80	80.40	74.70	81.00	66.60	66.60	75.48
12	66.00	75.00	82.50	84.00	88.50	84.00	86.00	74.10
13	90.00	88.50	60.00	82.50	74.10	70.80	70.74	76.56
14	67.50	64.50	73.80	82.50	72.00	81.60	80.10	76.32
15	88.50	89.10	90.00	70.50	78.00	74.50	74.10	84.96
16	69.60	76.20	82.80	86.10	84.00	84.90	84.90	78.36
17	76.50	89.10	85.50	87.90	78.00	86.50	86.70	84.84
18	84.00	74.10	84.00	66.00	88.50	69.30	70.20	79.38
19	79.80	80.84	81.10	74.70	81.00	66.60	75.48	76.80
20	61.50	63.60	86.10	70.50	82.50	84.00	84.00	68.70
21	90.00	78.00	88.50	81.70	76.50	84.00	84.00	80.16

The table below shows the number of beer sampled for inspection to judge wether the process is meeting the desired quality level using number of defective beer for 21 days

S/NO	Beer Inspected (n)	No. of defective	Fractions of defective
1	440	16	0.036
2	440	15	0.034
3	440	15	0.035
4	440	14	0.032
5	440	18	0.041
6	440	17	0.038
7	440	19	0.043
8	440	22	0.050
9	440	14	0.032
10	440	18	0.041
11	440	17	0.038
12	440	17	0.038
13	440	19	0.043
14	440	20	0.045
15	440	18	0.041
16	440	14	0.032
17	440	16	0.036
18	440	15	0.034
19	440	19	0.043
20	440	16	0.036
21	440	18	0.041
	9240	357	

Sample no	Proportion	location
1	3.636364E-02	inside
2	3.409091E-02	inside
3	3.409091E-02	inside
4	3.181818E-02	inside
5	4.090909E-02	inside
6	3.863636E-02	inside
7	4.318182E-02	inside
8	.05	inside
9	3.181818E-02	inside
10	4.090909E-02	inside
11	3.863636E-02	inside
12	3.863636E-02	inside
13	4.318182E-02	inside
14	4.545455E-02	inside
15	4.090909E-02	inside
16	3.181818E-02	inside
17	3.636364E-02	inside
18	3.409091E-02	inside
19	4.318182E-02	inside
20	3.636364E-02	inside
21	4.090909E-02	inside
22	4.772727E-02	inside
23	3.181818E-02	inside
24	3.636364E-02	inside
25	3.863636E-02	inside

ucl for P-chart = 6.620003E-02
lcl for P-chart = .0110727
no of prop. outside the limits = 0
no of prop. inside the limits = 25
P-chart suggests that the processs is in control

SUMMARY OF RESULTS (1)
****

sample no	mean	location
1	76.49375	inside
2	76.9625	inside
3	77.3875	inside
4	77.1125	inside
5	75.25	inside
6	76.1875	inside
7	75.21875	inside
8	76.925	inside
9	77.6625	inside
10	76.80251	inside
11	77.1125	inside
12	76.15625	inside
13	75.0625	inside
14	75.09375	inside
15	76.86874	inside
16	76.08749	inside
17	77.3125	inside
18	76.9125	inside
19	77.1125	inside
20	77.35625	inside
21	77.04375	inside

ucl for mean chart = 79.20952
lcl for mean chart = 73.94489
no of means outside the control limts = 0
no of means inside the control limits = 21
mean chart suggests that the process is in control

sample no	range	location
1	9.25	inside
2	5.199997	inside
3	5	inside
4	5.599998	inside
5	8	inside
6	7.5	inside
7	8.5	inside
8	5.699997	inside
9	5	inside
10	5.349998	inside
11	5.599998	inside
12	7.25	inside
13	7.5	inside
14	8	inside
15	9	inside
16	8.299995	inside
17	12.25	inside
18	9.150002	inside
19	5.599998	inside
20	5.25	inside
21	5.199997	inside

ucl for r-chart = 13.15451
lcl for r-chart = .9597715
no of ranges outside the control limits = 0
no of ranges inside the control limits = 21
r-chart suggests that the process is in control

SUMMARY OF RESULTS (11)

****

sample no	mean	location
1	73.15501	inside
2	75.8475	inside
3	76.3625	inside
4	75.41624	inside
5	75.695	inside
6	75.075	inside
7	75.13125	inside
8	75.03	inside
9	75.84875	inside
10	75.75	inside
11	75.1425	inside
12	75.69375	inside
13	73.68	inside
14	73.59375	inside
15	73.23875	inside
16	74.21875	inside
17	73.0125	inside
18	73.5225	inside
19	75.14249	inside
20	74.15625	inside
21	75.135	inside

ucl for mean chart = 77.04628
lcl for mean chart = 72.463
no of means outside the control limts = 0
no of means inside the control limits = 21
mean chart suggests that the process is in control

sample no	range	location
1	7.650002	inside
2	2.370003	inside
3	5.299995	inside
4	8.639999	inside
5	4.349998	inside
6	4.800003	inside
7	5.099998	inside
8	9	inside
9	2.310005	inside
10	1.739998	inside
11	7.110001	inside
12	4.349998	inside
13	6	inside
14	6.600006	inside
15	6.75	inside
16	7.290001	inside
17	7.650002	inside
18	8.25	inside
19	7.860001	inside
20	7.650002	inside
21	8.25	inside

ucl for r-chart = 11.45206
lcl for r-chart = .8355582
no of ranges outside the control limits = 0
no of ranges inside the control limits = 21
r-chart suggests that the process is in control

SUMMARY OF RESULTS (iii)
****

sample no	mean	location
1	74.15875	inside
2	73.5225	inside
3	75.69	inside
4	73.56875	inside
5	75.14249	inside
6	75.945	inside
7	74.8125	inside
8	75.0425	inside
9	75.30625	inside
10	74.6375	inside
11	75.76875	inside
12	77.18125	inside
13	77.625	inside
14	76.09375	inside
15	75.75625	inside
16	76.94375	inside
17	76.44375	inside
18	75	inside
19	76.89	inside
20	76.9125	inside
21	67.02625	outside

ucl for mean chart = 78.0184
lcl for mean chart = 72.40706
no of means outside the control limts = 1
no of means inside the control limits = 20
mean chart suggests that the process is not in control

sample no	range	location
1	7.650002	inside
2	8.25	inside
3	4.379997	inside
4	6.800003	inside
5	7.860001	inside
6	2.220001	inside
7	7.049995	inside
8	6.599998	inside
9	7.650002	inside
10	11.1	inside
11	8.25	inside
12	5.150002	inside
13	6.5	inside
14	11.25	inside
15	9.550003	inside
16	8	inside
17	8.5	inside
18	8	inside
19	5.150002	inside
20	9.150002	inside
21	8.900002	inside

ucl for r-chart = 14.02083
lcl for r-chart = 1.022979
no of ranges outside the control limits = 0
no of ranges inside the control limits = 21
r-chart suggests that the process is in control

SUMMARY OF RESULTS (iv)

****

sample no	mean	location
1	78.425	inside
2	79.35	inside
3	77.87749	inside
4	70.8375	inside
5	75	inside
6	80.2875	inside
7	79.46249	inside
8	82.64999	inside
9	72.3	inside
10	81.08749	inside
11	75.1725	inside
12	80.0125	inside
13	76.65	inside
14	74.79	inside
15	81.2075	inside
16	80.8575	inside
17	84.38	inside
18	76.93501	inside
19	77.04	inside
20	75.1125	inside
21	82.8575	inside

ucl for mean chart = 85.99301
lcl for mean chart = 70.41582
no of means outside the control limits = 0
no of means inside the control limits = 21
mean chart suggests that the process is in control

sample no	range	location
1	31	inside
2	15	inside
3	24	inside
4	24	inside
5	28.8	inside
6	21.3	inside
7	13.5	inside
8	18	inside
9	25.2	inside
10	29.1	inside
11	14.4	inside
12	22.5	inside
13	30	inside
14	18	inside
15	19.5	inside
16	16.5	inside
17	12.6	inside
18	22.5	inside
19	14.5	inside
20	24.6	inside
21	13.5	inside

ucl for r-chart = 38.9221
lcl for r-chart = 2.83981
no of ranges outside the control limits = 0
no of ranges inside the control limits = 21
r-chart suggests that the process is in control