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Monitoring the Quantity and Period of Milk Production by a Sindhi Cow using Statistical Quality Control Charts

Abirami .K

PG Student, Kongunadu Arts and Science College, Department of Mathematics, Coimbatore-641029, India
192ma007[at]kongunaducollege.ac.in

Abstract: ***In this paper, the Statistical Quality Control (SQC) charts are prepared to monitor the quantity and time period of milk production by a Sindhi breed cow for a 30-day period. The values obtained are tested against the planned values for analyzing the stability of production. The control charts are prepared to observe whether the production is statistically under control. The stable production results in good health of the cow.***

Keywords: Statistical Quality Control, SQC, Milk production, Sindhi cow

1. Introduction

An exciting area of applied mathematics called Operations Research combines mathematics, statistics, computer science, physics, engineering, economics, and social sciences to solve real-world business problems. Numerous companies in industry require Operations Research professionals to apply mathematical techniques to a wide range of challenging questions. Operations Research can be defined as the science of decision-making. It has been successful in providing a systematic and scientific approach to all kinds of government, military, manufacturing, and service operations. Operations Research is a splendid area for graduates of mathematics to use their knowledge and skills in creative ways to solve complex problems and have an impact on critical decisions.The process of operations research can be broadly broken down into the following steps:

1) Identifying a problem that needs to be solved.
2) Constructing a model around the problem that resembles the real world and variables.
3) Using the model to derive solutions to the problem.
4) Testing each solution on the model and analyzing its success.
5) Implementing the solution to the actual problem.

2. Statistical Quality Control (SQC)

Statistical quality control refers to the use of statistical methods in the monitoring and maintaining of the quality of products and services. Statistical Quality Control (SQC) is the term used to describe the set of statistical tools used by quality professionals. SQC is used to analyze the quality problems and solve them. Statistical quality control gives the good amount of data to obtain reliable results. The Science of statistics handles this data in order to draw certain conclusions. Its techniques find extensive applications in quality control, production planning and control, business charts, linear programming etc. Statistical quality control is a system for measuring and checking or inspecting a phenomenon. It suggests when to inspect, how often to inspect and how much to inspect, Control ascertains quality characteristics of an item, compares the same with prescribed quality standards and separates defective item from non-defective ones.

The benefits of Statistical Quality Control are:

1) It provides a means of detecting error at inspection.
2) It leads to more uniform quality of production.
3) It improves the relationship with the customer.
4) It reduces inspection costs.
5) It reduces the number of rejects and saves the cost of material.
6) It points out the bottlenecks and trouble spots.
7) It provides a basis for attainable specifications and means of determining the capability of the manufacturing process.
8) It promotes the understanding and appreciation of quality control.

Statistical Quality Control (SQC) is the term used to describe the set of statistical tools used by quality professionals. SQC is used to analyze the quality problems and solve them. Statistical quality control refers to the use of statistical methods in the monitoring and maintaining of the quality of products and services. All the tools of SQC are helpful in evaluating the quality of services. Some of the tools in SQC are, Descriptive Statistics, Statistical Process Control (SPC) and Acceptance Sampling.

3. Advantages and Disadvantages of SQC

3.1 Advantages

- It gives an early warning of defects. It provides a means of detecting errors at inception.
- Statistical Quality Control avoids the need for and costs of cent per cent inspection by pointing out trouble spots.
- SQC helps to maintain customer relations by ensuring uniformly high quality.
- Provides a basis for attainable specifications.
- It serves as a means of determining, the capability of the manufacturing process.

3.2 Disadvantages

- It cannot be indiscriminately applied as a solution to all quality demands.
- Implementation of statistical quality control is a costly endeavour.
- A false sense of security is created in absence of general awareness.
- Since only an information service is provided, the managers' responsibility cannot be reduced.

4. Control Charts

A control chart is an important statistical tool used for the study and control of repetitive processes. This was introduced by W. A. Shewhart based on the fact that variability does exist in all repetitive processes. Control limits are defined within which variations are acceptable and beyond which they are unacceptable. Control charts are a means of graphing variation patterns from process or product characteristics so that corrective action may be taken if required. When a process is in statistical control, a control chart will display known patterns of variation. When the control chart points deviate from these known patterns, the process is considered to be out of control.A control chart consists of,

- A control or central line (CL) that indicates desired control level of the process.
- An upper control limit (UCL) that indicates the upper tolerance limit.
- A lower control limit (LCL) that indicates the lower tolerance limit.

A process is said to be 'in control' if it produces items whose attributes fall within the acceptable range and it is said to be 'out of control' if it produces items whose attributes are beyond the acceptable range.

Two types of control charts are usually used. They are:

1) **Control charts for variables:** These charts are used to achieve and maintain an acceptable quality level for a process, whose output product can be subjected to quantitative measurement or dimensional check.
2) **Control charts for attributes:** These charts are used to achieve and maintain an acceptable quality level for a process whose output products are not subjected to dimensional or quantitative measurement but can be classified as good or bad or acceptable and non-acceptable.

5. Calculation of $\bar{x}$ and R Charts

1) Analyze the time period and quantity of milk production. In particular, we have taken a sample of 30-day period.
2) We have chosen Control chart for attributes, where we construct the $\bar{x}$ and R charts.
3) Calculate the Period Performance Index(PPI) and Quantity Performance Index(QPI) using the formula,

$$PPI = \frac{ACTUAL\ TIME\ (AT)}{SCHEDULED\ PERIOD\ (SP)}$$

$$QPI = \frac{ACTUAL\ QUANTITY\ (AQ)}{EXPECTED\ QUANTITY\ (EQ)}$$

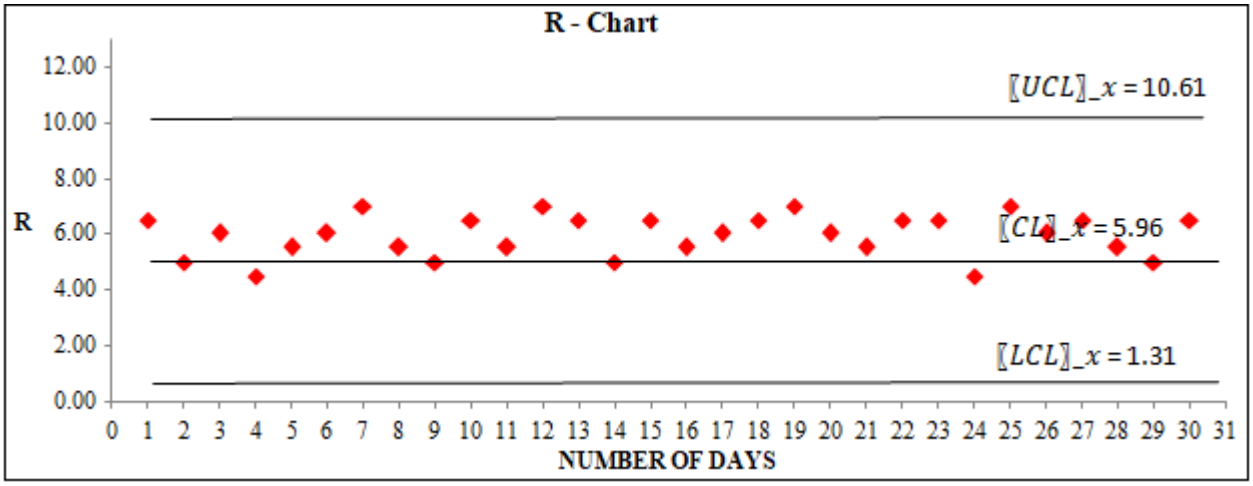
1) Calculate $\bar{R}$ and calculate CL_R, UCL_R and LCL_R.
   $CL_R = \bar{R}$
   $UCL_R = D_4\bar{R}$
   $LCL_R = D_3\bar{R}$
   (For n=10, D_3=0.22,D_4=1.78)
2) Calculate $\bar{\bar{x}}$ and calculate CL_x, UCL_x and LCL_x.
   $CL_x = \bar{\bar{x}}$
   $UCL_x = \bar{\bar{x}} + \frac{3\bar{R}}{d_2}$
   $LCL_x = \bar{\bar{x}} - \frac{3\bar{R}}{d_2}$
   (For n=10, d_2=3.08

Table 1: Values of $\bar{x}$ and R Charts

Sample (n=10)	AT	SP	PPI= (AT/SP)	AQ	EQ	QPI= (AQ/EQ)	$\bar{x}$	R
1	10	12	0.83	6.5	7	0.93	9.96	6.51
2	8	12	0.67	5	7	0.71	8.04	4.97
3	9	12	0.75	6	7	0.86	9.00	6.02
4	11	12	0.92	4.5	7	0.64	11.04	4.48
5	13	12	1.08	5.5	7	0.79	12.96	5.53
6	11	12	0.92	6	7	0.86	11.04	6.02
7	9	12	0.75	7	7	1.00	9.00	7.00
8	10	12	0.83	5.5	7	0.79	9.96	5.53
9	10	12	0.83	5	7	0.71	9.96	4.97
10	11	12	0.92	6.5	7	0.93	11.04	6.51
11	11	12	0.92	5.5	7	0.79	11.04	5.53
12	12	12	1.00	7	7	1.00	12.00	7.00
13	9	12	0.75	6.5	7	0.93	9.00	6.51
14	10	12	0.83	5	7	0.71	9.96	4.97
15	12	12	1.00	6.5	7	0.93	12.00	6.51
16	11	12	0.92	5.5	7	0.79	11.04	5.53
17	13	12	1.08	6	7	0.86	12.96	6.02
18	10	12	0.83	6.5	7	0.93	9.96	6.51
19	9	12	0.75	7	7	1.00	9.00	7.00
20	9	12	0.75	6	7	0.86	9.00	6.02
21	7	12	0.58	5.5	7	0.79	6.96	5.53
22	12	12	1.00	6.5	7	0.93	12.00	6.51
23	10	12	0.83	6.5	7	0.93	9.96	6.51
24	11	12	0.92	4.5	7	0.64	11.04	4.48
25	11	12	0.92	7	7	1.00	11.04	7.00
26	12	12	1.00	6	7	0.86	12.00	6.02
27	10	12	0.83	6.5	7	0.93	9.96	6.51
28	12	12	1.00	5.5	7	0.79	12.00	5.53
29	8	12	0.67	5	7	0.71	8.04	4.97
30	10	12	0.83	6.5	7	0.93	9.96	6.51

5.1 Calculation of R-Chart

$CL_R = \bar{R} = 5.96$
$UCL_R = 10.61$
$LCL_R = 1.31$



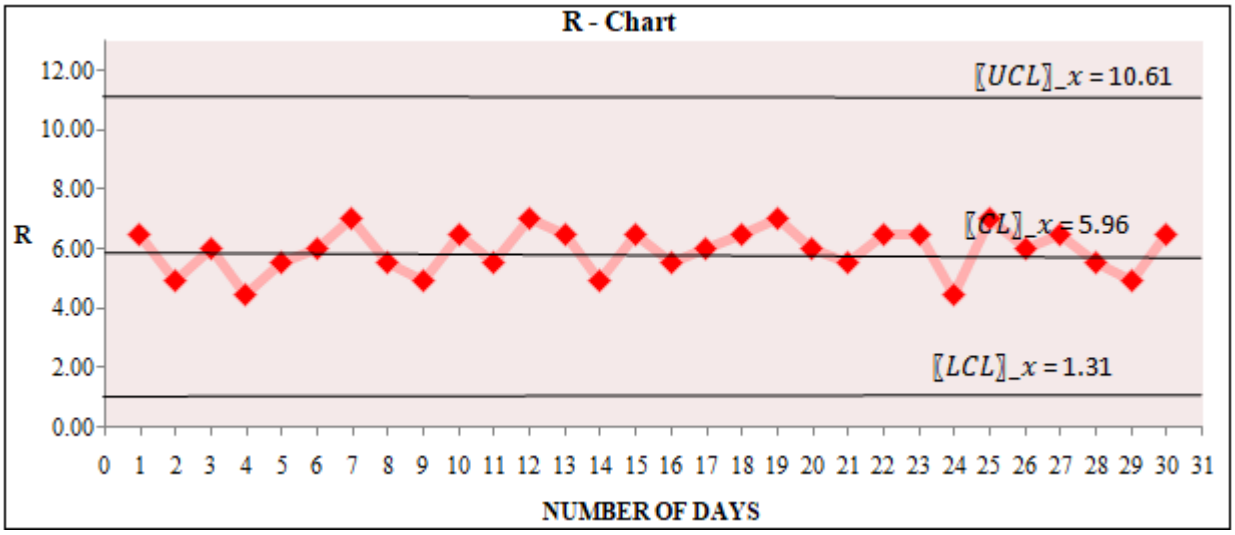
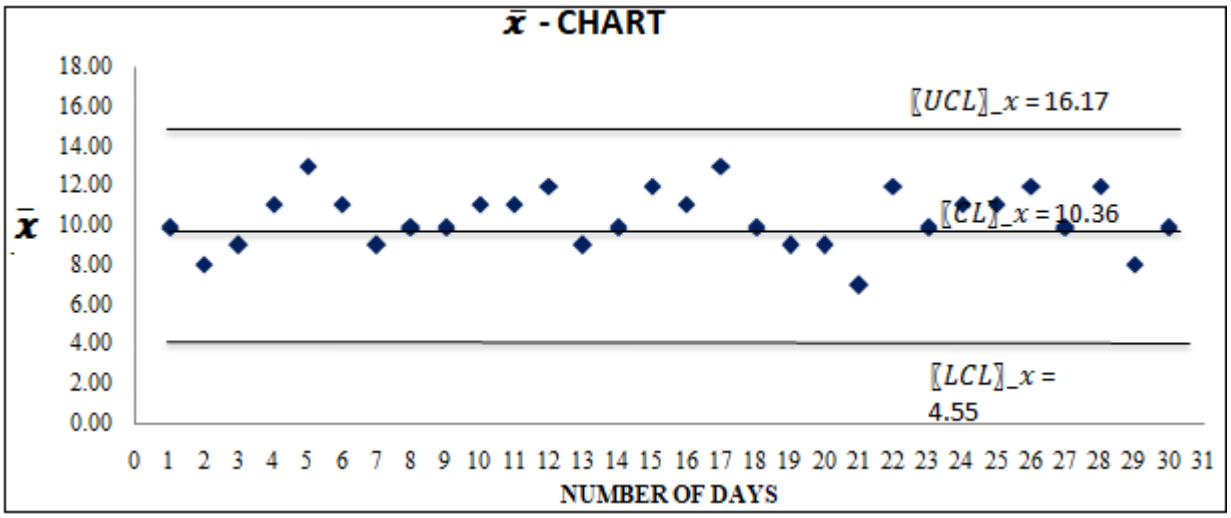


Figure 1: R-Chart

5.2 Calculation of $\overline{x}$-Chart

$CL_x = \bar{\bar{x}} = 10.36$
$UCL_x = 16.17$
$LCL_x = 4.55$



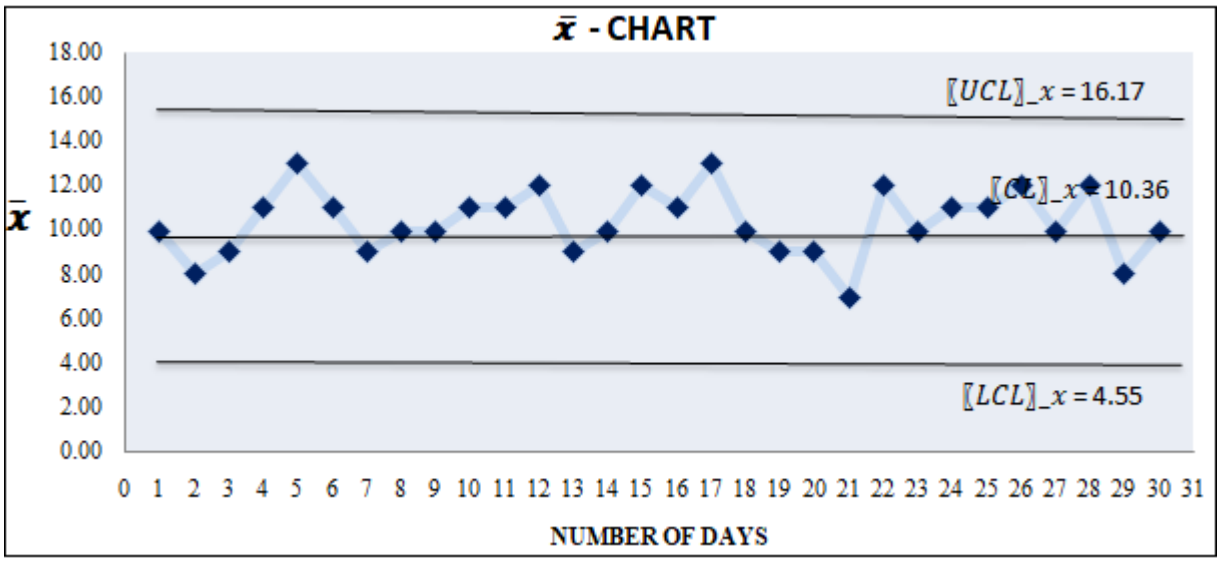


Figure 2: $\bar{x}$-Chart

6. Conclusion

From the study, it is concluded that the process of milk production for a time period of 12 hours with a quantity of 7 liters is stable and under control. Hence, the health of the cow is good. Once, if the process is out of control then there is a problem in the health of the cow. This method is not only useful to monitor the stable production of milk by a cow but also to analyze its health. Using this method, the owner can easily identify if there is any health related problems in the cow. Thus operations research is always helpful in maintaining the situation both optimally and statistically.

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Author Profile

Abirami K received the B.Sc. degree in Mathematics in addition with PG Diploma in Operations Research in the year 2019 and 2020 respectively and currently perusing M.Sc. degree in Mathematics.
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