P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 7; Issue 10; October 2024; Page No. 556-559

Received: 01-08-2024
Accepted: 02-09-2024

Indexed Journal
Peer Reviewed Journal

Analysis of milk production in Chhattisgarh through statistical technique

Aman Ekka[1], Chandan Nagar[1], Mujahida Sayyed[2] and Aparna Sharma[3]

[1]Department of Mathematics and Statistics, JNKVV, Jabalpur, Madhya Pradesh, India

[2]Department of Mathematics and Statistics, JNKVV, College of Agriculture, Ganjbasoda, Madhya Pradesh, India

[3]Department of Food Science, JNKVV, College of Agriculture, Ganjbasoda, Madhya Pradesh, India

DOI: https://doi.org/10.33545/26180723.2024.v7.i10h.1287

Corresponding Author: Chandan Nagar

Abstract

The dairy industry faces increasing pressure to optimize production processes due to global competition, especially from countries with lower production costs. At the same time, consumer expectations and regulatory standards for product quality continue to rise. In response, Statistical Process Control (SPC) has emerged as a critical methodology for monitoring and improving production efficiency while maintaining product quality. This study focuses on the application of SPC in dairy production within Chhattisgarh, India, with the aim of enhancing process stability and control. The research investigates milk production trends, identifies key factors affecting the production process, and evaluates the use of control charts for tracking variability and maintaining consistent quality. By analyzing the production data, the study seeks to establish stable, under-control conditions that ensure smooth operations and minimize deviations from quality standards. The insights gained will provide dairy producers in Chhattisgarh with actionable strategies for optimizing their production processes using SPC, ultimately contributing to improved operational efficiency and product quality in the competitive dairy market.

Keywords: SQC, production, quality, process control, product control, mean chart, range chart

1. Introduction

A control chart (CC) is a graphical tool used to assess whether a production process is operating within its specified limits. It visually displays the extent to which a process adheres to or deviates from the desired specifications. The effectiveness of a control chart lies in its ability to detect variations quickly, enabling timely corrective actions. Control charts are typically categorized into two types based on the nature of the data being analyzed: variable control charts and attribute control charts (ACCs).Variable control charts are used when the quality characteristic of interest is measurable on a continuous scale. For instance, attributes like the weight of a product or the dimensions of a container would be analyzed using variable control charts. In contrast, attribute control charts (ACCs) are employed in scenarios where products are classified into discrete categories, such as "good" or "defective." ACCs are especially advantageous because they streamline the analysis process, reducing both time and cost by only focusing on whether units meet the quality criteria or not, without needing detailed measurements.

Numerous studies have explored the application of attribute control charts in various industries. For example, Wu et al. (2006) developed an np control chart with curtailment, enhancing its efficiency while ensuring that false alarm rates remain within acceptable limits. Similarly, the research conducted by Sayyed and Sayyed (2012) [12] examined how Statistical Quality Control (SQC) methodologies contribute to maintaining consistent quality in both manufacturing and service sectors. According to Montgomery (2009) [10], Statistical Process Control (SPC) is grounded in Shewhart's theory of process variability. SPC is a powerful toolset designed to achieve process stability and improve capability by identifying and controlling sources of variation. By using SPC, organizations can effectively minimize deviations caused by specific factors, ensuring that the process remains stable and operates within the desired control limits. This proactive approach not only enhances product quality but also ensures the long-term sustainability of the production process.

The effectiveness of the proposed control charting structure is evaluated by calculating the out-of-control (OC) average time to signal (ATS) in steady-state mode, which is a key performance measure. Aslam et al. (2015) [5] introduced an np control chart that utilized multiple dependent state (MDS) sampling. Aldosari (2017) [2] presented a more advanced attribute control chart (ACC) using multiple-dependent state repetitive sampling (MDSRS), which proved to be more effective at detecting smaller shifts in the production process than previous ACC designs. Balamural and Aslam (2019) [6] developed a variable batch-size ACC designed to monitor non-conforming items in production, further expanding the utility of control charts in quality management. Research in this area continued, and Al-Marshadi (2021) [3] explored the concept of time-truncated life tests (TTLT) to enhance process monitoring. Aslam et al. (2022) [4] further advanced the field by presenting an np attribute control chart based on MDSRS, specifically designed to monitor product lifetimes using TTLT. Abirami (2020) [1] monitored the milk production process of a Sindhi cow using Statistical Quality Control (SQC) and concluded that the production process over a 12-hour period, including the quantity produced, was stable and under control. Taye et al. (2021) [15] used time series analysis on secondary data to predict cow milk production trends, offering insights into future dairy industry performance based on historical data. In a different area of study, Singh and Banerjie (2020) [14] applied linear programming techniques to minimize the costs associated with feeding dairy cows, while also proposing a development plan that includes certain constraints on livestock enterprises to optimize their sustainability and profitability. Chakravorty (2018) [8] focused on the current valuation of the livestock market in India and examined the broader economic impact of the livestock business sector on the country's economy. Their study provides key insights into how livestock contributes to both local and national markets. Similarly, Chauhan (2012) [9] investigated livestock management in rural areas, particularly in the Navasari district of South Gujarat. He found that women play a crucial role in advancing animal husbandry practices in rural communities, demonstrating how gender can influence agricultural productivity in these areas. In related research, Sayyed and Singh (2013) [13] explored mixed sampling plans for the Markoff model under conditions of inspection error. Obadara and Alaka (2013) defined quality as "fitness for purpose" in their research, emphasizing that a product must meet its intended use to be deemed of high quality.

The present study aimed to explore the causes and effects of milk quality and production challenges within the dairy industry, with particular focus on how Statistical Process Control (SPC) tools can be employed to enhance process performance and improve overall product quality. By identifying and addressing sources of variability and defects, SPC can lead to more consistent outcomes, helping the dairy sector to meet both consumer expectations and regulatory standards.

2. Materials and Methods

The study area is Chhattisgarh. For making detailed study 10 years data of milk production collected. The study based on secondary sources of data. The data sources are-

1. Basic Animal Husbandry Statistics, DAHD&F, GoI.
2. Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, GoI.
3. Chhattisgarh State Co-operative Dairy Federation.

3. Research methodology

SQC refers to a collection of statistical tools employed by the quality assurance department to monitor, analyze, and control the quality characteristics of a process or product. These tools are used to ensure that the process remains within predetermined limits and to identify any deviations that may require corrective actions. A control chart is a graphical representation that displays the variation in a quality characteristic over time or across sample numbers. It is used to monitor process stability and consists of the following elements:

- **Centre Line (CL):** The center line represents the mean or target value of the process.
- **Upper Control Limit (UCL):** The UCL indicates the upper boundary of acceptable variation. Values above this limit suggest that the process may be out of control due to assignable causes.
- **Lower Control Limit (LCL):** The LCL represents the lower boundary of acceptable variation. Values below this limit also suggest that the process may be out of control, potentially due to assignable causes.

The control limits are typically set at three standard deviations (3σ) from the process mean. If data points fall beyond the UCL or LCL, the process is considered out of control, indicating the presence of assignable causes. These causes need to be identified and addressed to return the process to a stable state.

3.1 $\bar{X}$ and R Charts (Mean and Range Charts): The $\bar{X}$ and R charts are used to monitor both the central tendency and variability of a process over time. They are particularly useful for identifying trends, shifts, or changes in the process. These charts consist of the following:

- **$\bar{X}$ Chart (Mean Chart):** The $\bar{X}$ chart is used to monitor the average of a characteristic measured on a continuous scale, such as thickness or size. It helps detect shifts or trends in the process mean over time.
- **R Chart (Range Chart):** The R chart is used to monitor the variability within samples, reflecting the dispersion or range. It is valuable in detecting changes in the process variation. Changes observed in the $\bar{X}$ chart are often related to factors such as machine settings or process adjustments, whereas changes in the R chart may be caused by variations in raw materials or operator performance. These charts are particularly useful for small and consistent sample sizes and are often used in manual calculations of control limits.

Each point on the $\bar{X}$ chart represents the average value of a subgroup, while the center line represents the process mean or the weighted mean of subgroup averages. Control limits on these charts help determine whether the process is in control or if there are assignable causes of variation. The use of $\bar{X}$ and R charts is essential for monitoring and controlling process variability, enabling organizations to identify and address factors that may affect product quality and consistency. They are essential components of a robust quality management system.

Control limits for $\bar{X}$ Charts ($\bar{X}$ and SD are given)

$$UCL_{\bar{X}} = \bar{\bar{X}} + \frac{3\sigma}{\sqrt{n}},\ CL_{\bar{X}} = \bar{\bar{X}} \text{ and } LCL_{\bar{X}} = \bar{\bar{X}} - \frac{3\sigma}{\sqrt{n}}$$

Control limits for $\bar{X}$ Charts ($\bar{X}$ and SD are not given)

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2\,\bar{R},\ CL_{\bar{X}} = \bar{\bar{X}} \text{ and } LCL_{\bar{X}} = \bar{\bar{X}} - A_2\,\bar{R}$$

A_2 is found in constants for various values of n.

The R chart complements the $\bar{X}$ chart by focusing on process dispersion rather than central tendency. Changes in the R chart can reveal important insights into issues such as operator errors, machine wear, or variations in raw materials. By identifying unusual patterns in range values, the R chart enables process managers to take corrective action, ensuring that variability remains within acceptable limits and that the process continues to produce consistent, high-quality output.

Control limits for R chart (when SD is given)

$UCL_R = \overline{R} + 3\sigma R$, $CL_R = \overline{R}$ and $LCL_R = \overline{R} - 3\sigma R$

Control limits for R chart (when SD is not given)

$UCL_R = D_4 \overline{R}$, $CL_R = \overline{R}$ and $LCL_R = D3\overline{R}$

The D_3 constant is a function of d_2, d_3, and n. The D_4 constant is a function of d_2, d_3, and n.

4. Results and Discussion

The graphical data clearly demonstrates that the process remains in control across the entire dataset. Milk production over the 12-month period consistently falls within the upper and lower control limits, signifying stability in output. With no discernible patterns or systematic behaviour each data point lies securely within the control bounds we conclude that the process is self-regulating and remains under consistent control. This observation confirms that the trial control limits are well-suited for ongoing and future production monitoring.

This type of control chart is straightforward to construct, especially when historical sample data is available, even if exact process parameters are unknown. By utilizing existing data, the chart effectively oversees the production process, ensuring that variability stays within acceptable limits. As such, it proves to be a valuable tool for maintaining control in processes where parameters may not be precisely defined but consistency is essential over time.

Table 1: Year wise mean production and range of the production Chhattisgarh (In million tonne)

Year	Mean	Range
2011-12	5210	3121
2012-13	5392.58	2011.35
2013-14	4209.16	1099.34
2014-15	5153.33	2534.87
2015-16	4370	2876
2016-17	4430.83	2579.53
2017-18	5117.33	1623.03
2018-19	5193.41	1643.72
2019-20	5389.16	1432.17
2020-21	5420.83	1934.65
	49886.67	

(Source- Chhattisgarh Co-operative Dairy Federation)

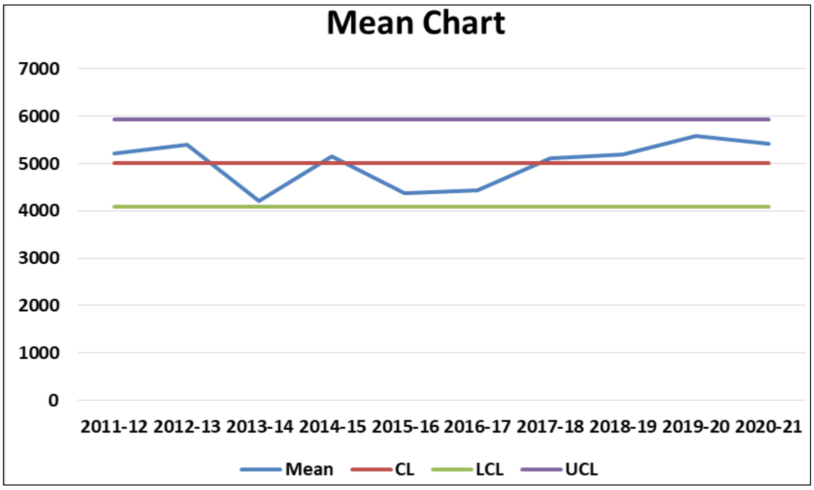

Fig 1: Mean chart for the milk production in Chhattisgarh
(Source- Chhattisgarh Co-operative Dairy Federation)

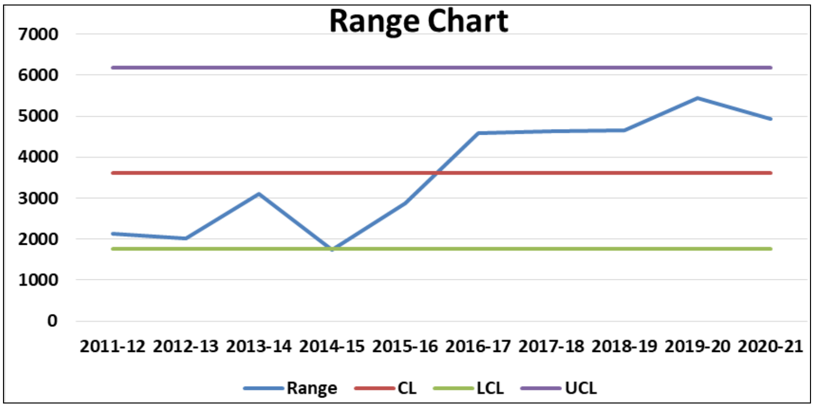

Fig 2: Range chart for the milk production in Chhattisgarh
(Source- Chhattisgarh Co-operative Dairy Federation)

	CL	UCL	LCL
Mean	4988.66	5543.42	4433.90
Range	2085.56	3578.83	592.30

Based on the analysis of 120 subgroups, the graphical representation for the state of Chhattisgarh illustrates the sample means, the center line representing the process mean, and the established control limits. The data indicates that the process is effectively in control. The accompanying chart shows the ranges for each subgroup, along with the corresponding center line and control limits. The R chart further confirms that variation within the process remains stable and under control. There are no signals indicating that the process is out of control, nor is there a significant proportion of points plotted above the center line. This suggests that the process has not undergone any shifts, reinforcing the conclusion that the current operational parameters are stable and that quality control measures are effectively maintaining consistency in milk production.

5. Conclusion

The study highlights the significant role of Statistical Process Control (SPC) tools in enhancing process performance within the dairy industry by effectively reducing variability in end products. By implementing SPC methods, companies can systematically monitor their production processes, which enables the early identification and rectification of quality issues. This proactive approach leads to improvements in both product quality and overall productivity, ultimately benefiting the organization.

The research identified several critical factors affecting milk quality throughout the production process, including contamination during raw milk collection, instances of adulteration, hygiene issues, and challenges with packaging materials. Additionally, human factors such as insufficient training and work ethics, along with environmental uncertainties like power fluctuations and machine maintenance issues, were found to adversely impact milk quality. Addressing these factors is essential for the industry to improve operational efficiency, reduce waste, and maintain consistent quality standards.

By focusing on these improvements, the dairy industry can better meet consumer expectations and comply with regulatory requirements, both of which are crucial for sustaining competitiveness in a challenging market. Overall, integrating SPC tools not only supports quality assurance but also positions dairy companies for long-term success and resilience.

6. References

1. Abirami K. Monitoring the quantity and period of milk production by a Sindhi cow using statistical quality control charts. Int J Sci Res (IJSR); c2020;ISSN: 2319-7064.
2. Aldosari MS, Aslam M, Jun C-H. A new attribute control chart using multiple dependent state repetitive sampling. IEEE Access. 2017;5:6192-6197.
3. Al-Marshadi AH, Shafqat A, Aslam M, Alharbey A. Performance of a new time-truncated control chart for Weibull distribution under uncertainty. Int J Comput Intell Syst. 2021;14:1256-1262.
4. Aslam M, Balamurali S, Jeyadurga P, Raza MA. Monitoring number of non-conforming items based on multiple dependent state repetitive sampling under truncated life tests. Commun Stat-Theor Methods. 2022;51:5806-5825.
5. Aslam M, Nazir A, Jun C-H. A new attribute control chart using multiple dependent state sampling. Trans Inst Meas Control. 2015;37:569-576.
6. Balamurali S, Aslam M. Variable batch-size attribute control chart. J Stat Manag Syst. 2019;22:1037-1048.
7. Capucho TO, Parré JL. Milk production in Paraná: a study considering the spatial effects. Informe GEPEC J. 2012;16(1):112-127.
8. Chakravorty D. Livestock marketing in India: A case study. New Horizon Int J Manag Res. 2018;1(1):1-10.
9. Chauhan NM. Contribution of the tribal women in livestock management. Agric Res Train Inst; c2012.
10. Montgomery DC. Introduction to Statistical Quality Control. 6th ed. New York, NY: John Wiley & Sons; c2005, 2007, 2009, 2012.
11. Obadare OE, Alaka AA. Accreditation and quality assurance in Nigerian universities. J Educ Pract. 2013;4(8):3-6. ISSN: 2222-1735.
12. Sayyed M, Sayyed SA. The role of Six Sigma in quality control. J Ultra Eng. 2012;1(2):173-176.
13. Sayyed M, Singh JR. Mixed sampling plans for Markov model under inspection error. J Reliab Stat Stud. 2013;6(1):47-58.
14. Singh JP, Banerjie J. Optimum farming plans for marginal farmers with restriction on livestock enterprises using linear programming problem. Int J Agric Stat Sci. 2020;16(2):791-731.
15. Taye BA, Alene AA, Nega AK, Yirsaw BG. Time series analysis of cow milk production at Andassa dairy farm, West Gojam Zone, Amhara Region, Ethiopia. Model Earth Syst Environ. 2021;7(1):181-189.
16. Wu Z, Luo H, Zhang X. Optimal np control chart with curtailment. Eur J Oper Res. 2006;174:1723-1741.