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Research Article

Quality Assessment of Processed Milk Products in Bangladesh in the framework of Six Sigma Analysis

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Abstract

The processed milk products analysed observations were collected from different laboratory of Institute of Food Science and Technology (IFST), BCSIR, Dhaka over the year from 2007 to 2012 by Single Stage Cluster Sampling method. Data were non-participant observation of organization included in the study. Archival research included hard-copy issues of reports of analytical documents. The Figure 1 to 7 shows that processed milk products parameters of the different period are in process out of control in the analysis of sixpack process capability. Also the results showed that we are dealing with a normally distributed and stable process that all of the parameters ware not follows a Normal distribution as well as symmetric distribution.

Keywords: Sixpack Process Capability; Single Stage Cluster Sampling; Milk products; Normal distribution; Symmetric distribution.

Introduction

Average milk consumption in Bangladesh is the lowest compared to neighbouring countries. Its cost is the highest in the region due to low yield and high production cost, making it almost impossible for the majority people to have the nutritious food item. In Bangladesh, per capita daily calorie intake through milk is only 24 kilocalories, while in Sri Lanka it is 57, 82 in Nepal, 104 in India and 265 in Pakistan, according to statistical yearbook of Food and Agriculture Organisation (FAO). Nutritionists say milk is an ideal food that easily provides large amounts of calcium and protein to the body but inadequate intake of milk is causing calcium deficiency and bone-related diseases like rickets.They said nutrients of milk can be had from other food items but people are usually not conscious enough to get the nutrients from other sources. In the wake of the recent controversy over toxic melamine in milk, health and dairy experts said the best way to meet the milk demand is to expand dairy production at farm and household levels. According to FAO, average annual milk production in Bangladesh is 2,264,000 tonnes and only 13 kg of milk is available for every person annually. Low production results in the import of bulk amount of powdered milk. Bangladesh spent about Tk 1,500 crore to import 42,583.46 tonnes of powdered milk during the last fiscal year, said Tureen Afroze of United Nations Industrial Development Organisation (UNIDO). On an average, a Bangladeshi cow produces around 200kg of milk a year, which is 30 percent lower than an Indian cow's production figures. This low milk yield is mainly caused by poor livestock feed and low milk production of the common breeds of cattle in Bangladesh," says a study of International Farm Choose Network (IFCN) on milk production in Bangladesh. According to dairy industry insiders, each kilogramme of milk on an average sells between Tk 40 and Tk 45 but in India it is around Tk 22. A litre of pasteurized milk is sold at around Tk 47 in Bangladesh. Milk prices at farms of Bangladesh are about 40 to 50 percent higher than those of Indian and New Zealand farms, the IFCN study said."First of all, we have low productivity of milk and then the prices are too high. Therefore, milk consumption by majority people of the country is almost impossible," said Prof M Nazmul Hasan of Institute of Food and Nutrition Science at Dhaka University. Citing a survey at Chokoria in Cox's Bazar, he said the survey found that nine percent of the children in

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that area suffered from rickets. "Calcium deficiency is being seen a lot in recent times. More and more people are suffering from bone-related diseases, Nazmul told The Daily Star. He suggested that the government should take strong steps to encourage dairy production at farm and household levels to meet the local demand because milk is an ideal food. Mohammad Ali, general manager of Brac Dairy and Food Project, told The Daily Star that shortage of fodder and low productivity of cattle are the two major factors that hold the dairy sector back. The dairy farms are mainly located in northern Bangladesh," he said, adding that the government could provide incentives like loan arrangements for farmers to rear cows at household level. Besides, cooperatives could be formed at village level to develop milk marketing system and ensure that the dairy farmers get due price of milk, he said, adding, "Dairy farms could reduce our unemployment problem." The government should come forward and help set up infrastructure for milk preservation, Mohammad Ali added [1].

The Six Sigma Methodology is a customer focused continuous improvement strategy that minimizes defects and variation towards an achievement of defects per million opportunities in product design, production, and administrative process [2]. Six Sigma is a strategy of continuous improvement of the organization to find and eliminate the causes of the errors, defects and delays in business organization processes [3]. The design of experiments is one of the most important tools inserted in DMAIC (define, measure, analyse, improve and control) methodology. This tool searches problems solutions in a coordinated way and the improvement of processes and people involved in the same activities always defined by the project manager [4,5]. The six sigma DMAIC method was critically compared with insights from scientific theories in the field of problem solving [6,7]. It was used to examine multiple measures of experience and their relationship to the performance of work teams[8], the impact of adopting Six Sigma on corporate performance [9], and also in manufacturing execution systems (MESs) [10], in information security risk management (ISRM) [11] and in a knowledge management system [12].

The overall objective of the study is to model economic aspects of food production and analysis systems, understanding physiochemical analysis report and concern stakeholder awareness for food products. Specifically the study will pursue the following objectives: (i) to describe the physiochemical analysis of data characteristics of food products; (ii) establish the determinants of food decision to accept in food products distinguishing between the fully-accepted food and unaccepted; (iii) elicit producer risk preferences and empirically analyze producer sources of risk and risk management strategies; (iv) explore consumer or stakeholder awareness, perceptions and attitudes regarding food products; and (v) identify the factors that affect the consumer‘s preference and consumption of food products. The outcome of which will help make policy recommendations that have an implication on technology adoption, increase smallholders capacity to bear risk and enable government and other role players have a clear understanding of consumers’ food purchase decisions.

Materials and methods

Selection of the Six Sigma Tools

There are many quality and problem solving tools from which to choose. The seven basic quality tools were selected because there are the most commonly known, promoted, and used of the quality tools [13]. These seven tools [14–17] are;

Cause and effect diagram: A schematic tool that resembles a fishbone that lists causes and sub-causes as they relate to a concern, also known as fishbone diagram or Ishikawa diagram.

Check sheet: A form used to collect, organize, and categorize data so it can be easily used for further analysis.

Histogram: A graphic display of the number of times a value occurs.

Pareto diagram: A bar chart that organizes the data from largest to smallest to direct attention on the important items (usually the biggest contributors).

Process flow diagram: A graphical illustration of the actual process.

Scatter diagram: A graphical tool that plots one characteristic against another to understand the relationship between the two.

SPC control chart: A graph of time-ordered data that predicts how a process should behave.

The other tools selected for the matrix are the quality and organizational tools from the Six Sigma operation [14,15,17–21]. Alphabetically, these tools are;

Box plot: A graphical display fo data in a box format that displays the median and variation of the data.

Capability analysis: A calculation used establish the proportion of the operating window taken up by the natural variation of the process.

Control plan: A written description of the systems for controlling parts and processes.

Cost benefit analysis: A summary analysis that weighs the cost of improvement to the customer against the cost of the change to the process.

DOE: A systematic set of experiments that permit the evaluation of the effect of one or more factors on the response.

Failure mode and effects analysis (FMEA): A structured approach to identify the way the product or process can fail and eliminate or reduce the risk of failure to protect the customer.

Hypothesis testing: Data driven tests that answer the question: "Is there a real difference between A and B?" using relatively small sample sizes to answer questions about the population.

Process flow diagram: A graphical illustration of the actual process.

Thought process map: A graphical representation of the logical sequence in which the Black Belt will solve the problem using Six Sigma methodology.

Trend/run chart: A graphical display of data over time to understand what the process is doing based on the pattern of the data [22].

Data

The food sample analysed observations from different food products (Table 1) as Fortified Milk 32 data collected by Single Stage Cluster Sampling method from Institute of Food Science and Technology (IFST), BCSIR, Dhaka over the year from 2007 to 2012 [23]. Data collection methods were non-participant observation of organization included in the study. Archival research included hard-copy issues of reports of analytical documents.

Table 1. Milk products list that are included in analysis

Sl. No.	Name of milk powder	Sl. No.	Name of milk powder
1.	Sagar Skimmed Milk.	8.	UHT milk.
2.	Rajat Skimmed Milk.	9.	Cow head Full Cream Milk.
3.	Madhusudon Skimmed Milk.	10.	Milk Chocolate.
4.	Amul Spray Infant Milk.	11.	UHT Milk Low Fat.
5.	Skim Milk Powder.	12.	Aarong Pasteurized Milk.
6.	Dried Skimmed Milk (DSM).	13.	Therapeutic Milk.
7.	Milk Powder.	14.	Fressh sweetened condensed filled milk.

Results and discussion

Application of control charts on milk

In order to verify whether quality of food products were under control condition or not we have adopted following control chart of milk for such purposes we have used several Shewhart Control Charts. In this subsection we present results and analysis that is application of control charts. We show the results and analysis by type of products and types of control chart.

Process Capability Analysis (Using Normal Distribution Curve)

In this case, we want to assess the process capability for different industries producing certain milk. The proximate analysis of the milk is of concern. There has been a consistent problem for meeting the specification limits and the some process produces a high percentage of rejects. The histogram of the data shows that proximate analysis of milk follow a normal distribution or approximately normal distribution. The variation from milk to milk can

be estimated using the within group standard deviation. Since the process is stable and the measurements are normally or approximately normality distributed, the normal distribution option of process capability analysis can be used.

The quality control and process capability analysis chart given as output is the chart of Moisture (%). These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the process is out of control limit in mean chart. The upper right box reports the process data including the upper specification limit. The calculated values are the process sample mean and the estimates of standard deviations.

From the Normal probability plot in Fig. 1, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value is 0.005, which is less than 0.05. Fig. 1 shows the histogram of the data along with normal curves overlaid on the histogram. Moisture of milk analysis report by this process exceed the Upper specification limit (USL). A significant percentage of the Moisture (%) of milk is outside of Upper Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =-0.37 is less than 1 means that the process is off centered and is not capable.

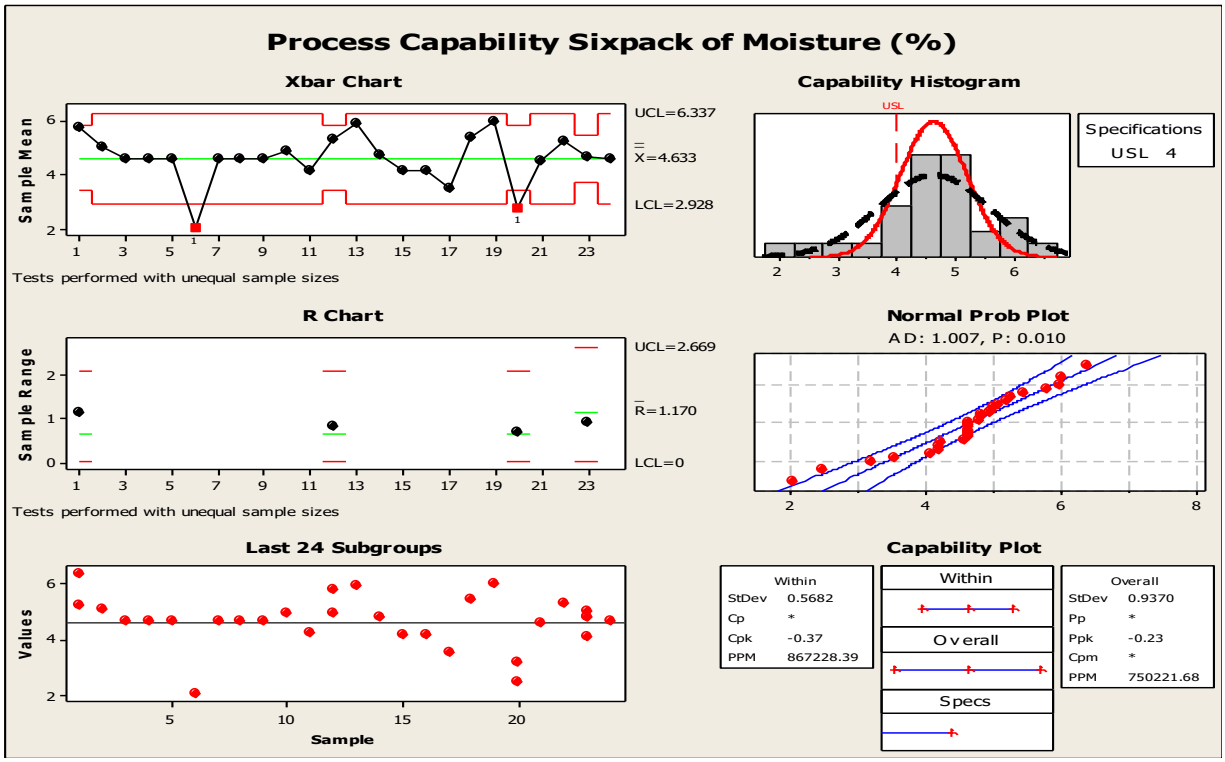

Fig. 1. Quality Control Charts and Process Capability Analysis for Moisture (%) of milk

The quality control and process capability chart given as output is the chart of Protein, %. These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the process is out of control. The upper right box reports the process data including the lower specification limit. The calculated values are the process sample mean and the estimates of standard deviations. From the Normal probability plot in Fig. 2, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value is 0.005, which is less than 0.05 a frequently used level of significance for such a hypothesis test. Fig. 2 shows the histogram of the data along with normal curves overlaid on the histogram. The products of milk of Protein, % analysis report by this process are exceeding the lower specification limit (USL). A significant percentage of the Protein, % of milk is outside of Lower Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =-0.52 is less than 1 means that the process is off centered and not capable.

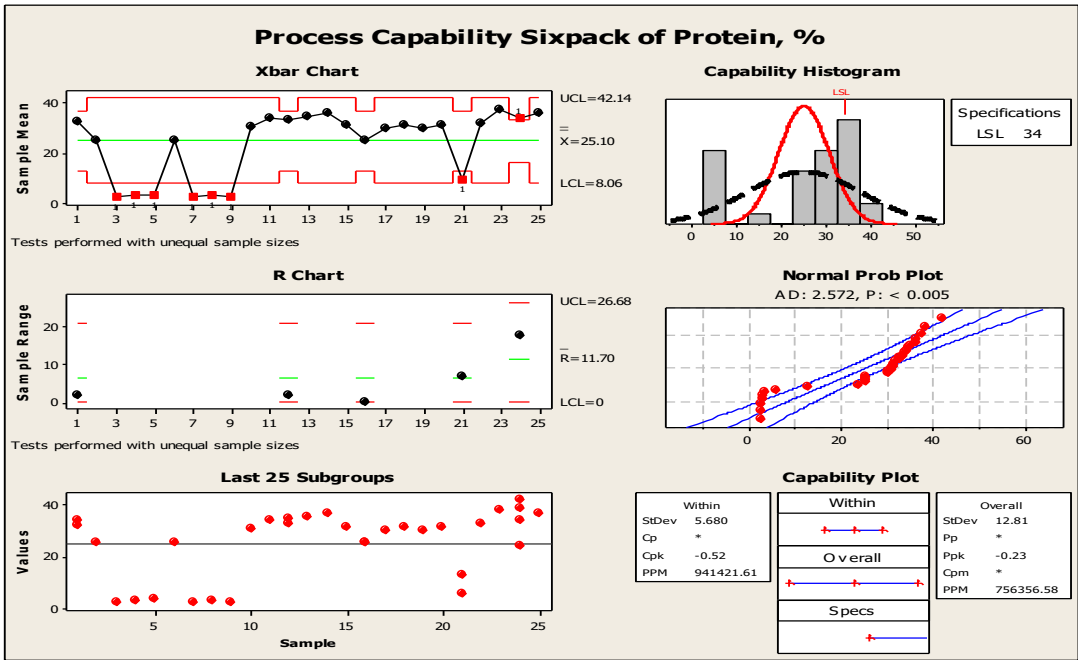

Fig. 2. Quality Control Charts and Process Capability Analysis for Protein, % of milk

The quality control and process capability chart given as output is the chart of Total Ash (on dry basis) %. These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the process is out of control. The upper right box reports the process data including the upper specification limit. The calculated values are the process sample mean and the estimates of standard deviations. From the Normal probability plot in Fig. 3, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value is 0.005, which is less than 0.05 a frequently used level of significance for such a hypothesis test.

Fig. 3 shows the histogram of the data along with normal curves overlaid on the histogram. The products of milk of Total Ash (on dry basis), % analysis report by this process are exceeding the Upper specification limit (USL). A significant percentage of the Total Ash (on dry basis), % of milk is outside of Upper Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =0.54 is less than 1 means that the process is off centered and not capable.

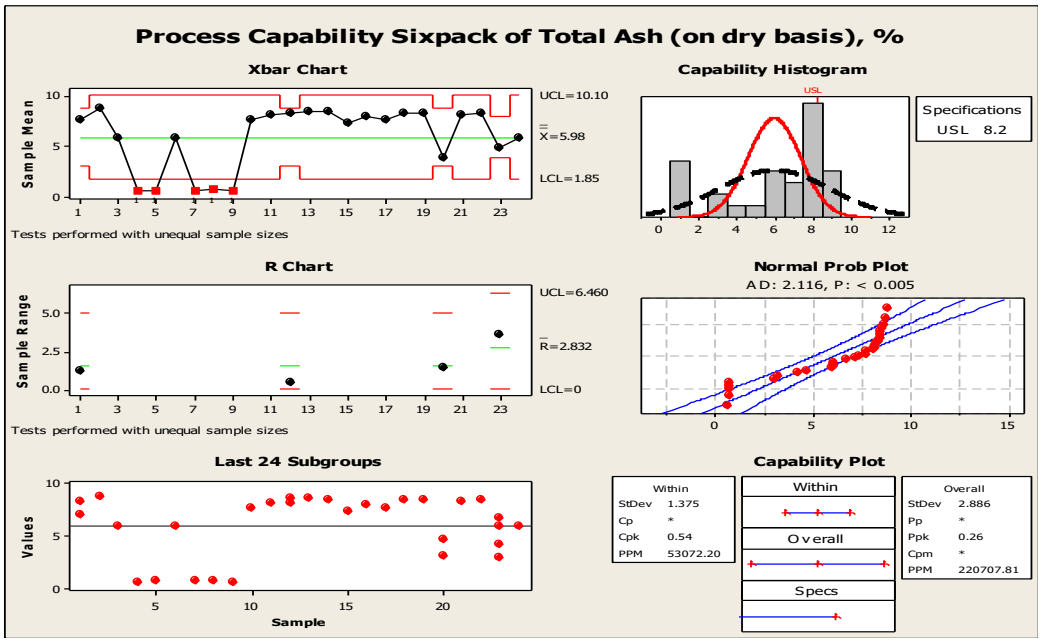

Fig. 1. Quality Control Charts and Process Capability Analysis for Total Ash (on dry basis), % of milk

The quality control chart given as output is the chart of Tritratable Acidity (as lactic acid), %. These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the process is out of control. The upper right box reports the process data including the upper specification limit. The calculated values are the process sample mean and the estimates of within standard deviations. From the Normal probability plot in Fig. 4, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value is 0.005, which is less than 0.05 a frequently used level of significance for such a hypothesis test. Fig. 4 shows the histogram of the data along with normal curves overlaid on the histogram. The products of milk of Tritratable Acidity (as lactic acid) analysis report by this process exceed the Upper specification limit (USL). A significant percentage of the Tritratable Acidity (as lactic acid) (%) of milk is outside of Upper Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =0.81 is less than 1 means that the process is off centered and is not capable.

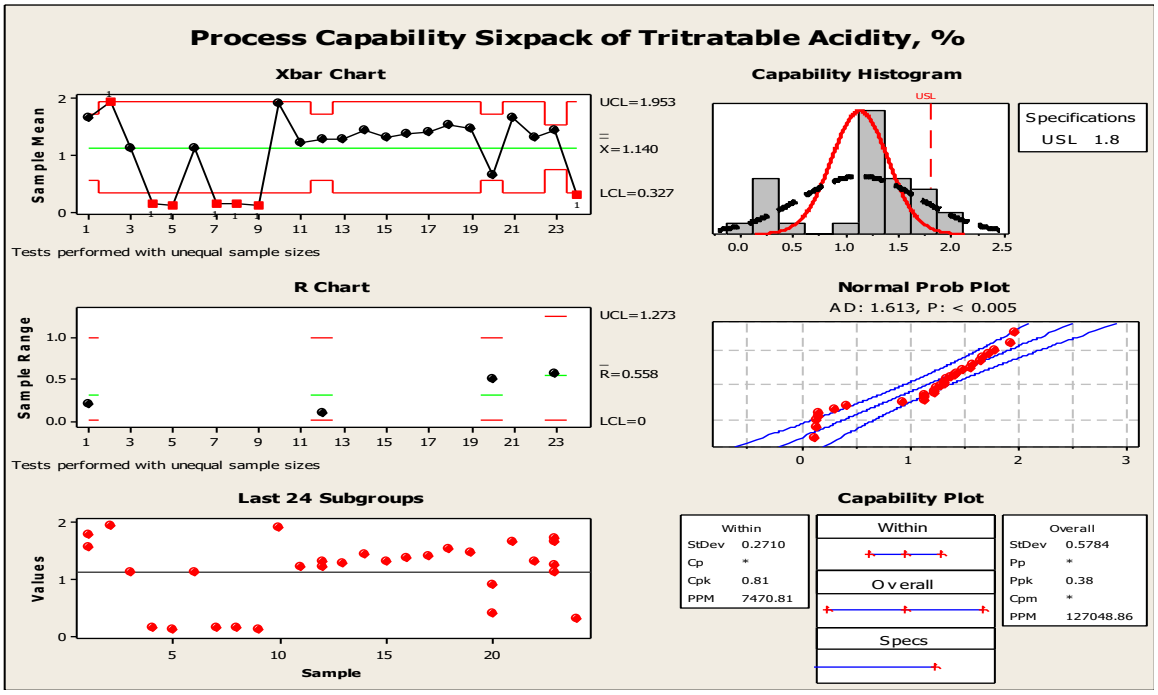

Fig. 4. Quality Control Charts and Process Capability Analysis for Tritratable Acidity (as lactic acid), % of milk

The quality control chart given as output is the chart of Solubility (%). These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the process is out of control. The upper right box reports the process data including the upper specification limit. The calculated values are the process sample mean and the estimates of standard deviations. From the Normal probability plot in Fig. 5, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value is 0.005, which is less than 0.05 a frequently used level of significance for such a hypothesis test. Fig. 5 shows the histogram of the data along with normal curves overlaid on the histogram. The products of milk of Solubility analysis report by this process exceed the Lower specification limit (LSL). A significant percentage of the Solubility (%) of milk is outside of Lower Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =-0.88 is less than 1 means that the process is off centered and is not capable.

The quality control chart given as output is the chart of Total Milk Solid, %. These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the

process is out of control. The upper right box reports the process data including the lower specification limit. The calculated values are the process sample mean and the estimates of within standard deviations.

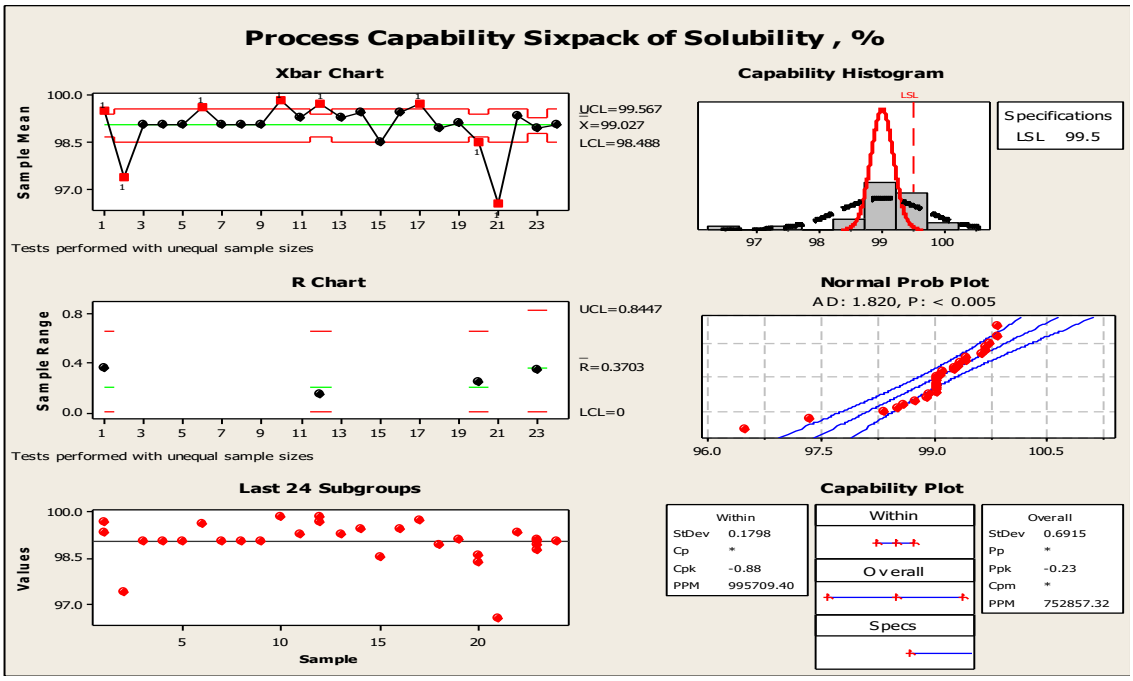

Fig. 5. Quality Control Charts and Process Capability Analysis for Solubility, % of milk

From the Normal probability plot in Fig. 6, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value is 0.005, which is less than 0.05 a frequently used level of significance for such a hypothesis test. Fig. 6 shows the histogram of the data along with normal curves overlaid on the histogram. The products of Milk of Total Milk Solid analysis report by this process is not exceed the Lower specification limit (LSL). An insignificant percentage of the Total Milk Solid (%) of Milk is outside of Lower Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =16.88 is greater than 1 means that the process is centered and capable.

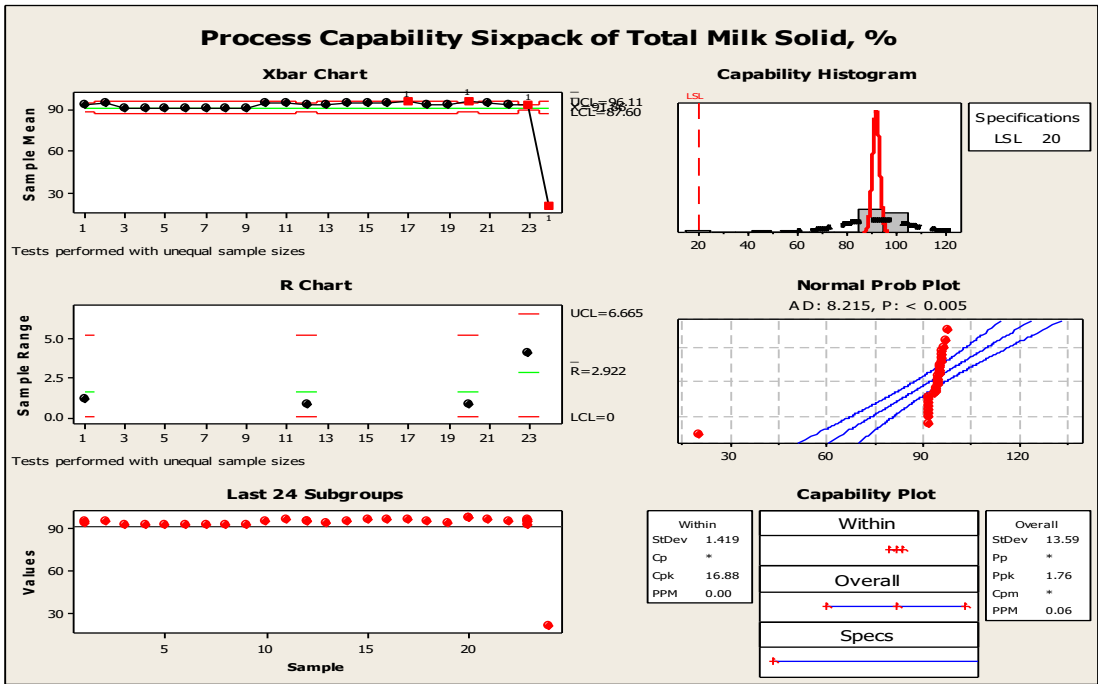

Fig. 6. Quality Control Charts and Process Capability Analysis for Total Milk Solid, % of Milk.

The quality control chart given as output is the chart of Standard Plate Count, cfu/g. These charts, which are pretty much self-explanatory, clearly shows the date wise sample point along with the (UCL and LCL) control limits. It is clear that the process is out of control. The upper right box reports the process data including the upper specification limit. The calculated values are the process sample mean and the estimates of within standard deviations. From the Normal probability plot in Fig. 7, the Normality test shows that reject the null hypothesis, H_0: data follow a Normal distribution vs. H_1: data do not follow a Normal distribution, at the 0.05 significance level. This is due to the fact that the p-value test is 0.005, which is p-value less than 0.05 a frequently used level of significance for such a hypothesis test. Fig. 7 shows the histogram of the data along with normal curves overlaid on the histogram. The products of Milk of Standard Plate Count analysis report by this process is not exceed the Upper specification limit (USL). An insignificant percentage of the Standard Plate Count, cfu/g of Milk is outside of Upper Specification Limit. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =14.08 is greater than 1 means that the process is centered and capable [24].

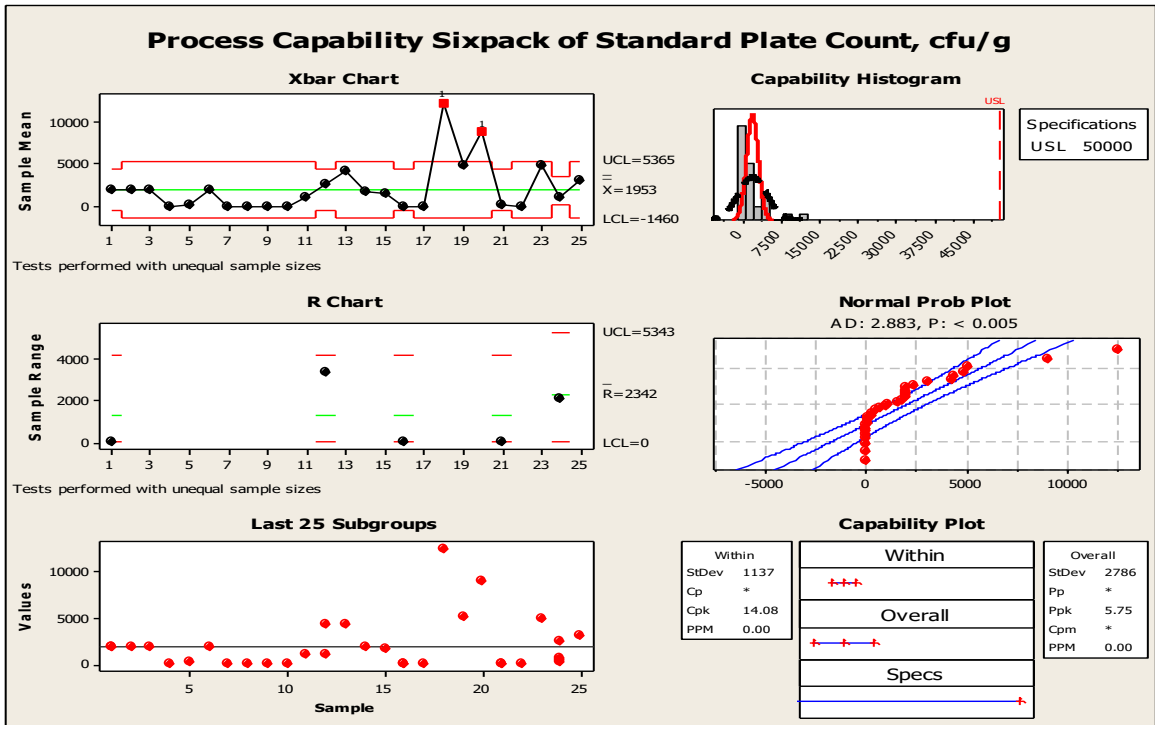

Fig. 7. Quality Control Charts and Process Capability Analysis for Standard Plate Count, cfu/g of Milk

The Figure 1 to 7 shows that Milk parameters of the different period are in the process out of control. Also the results showed that we are dealing with a normally distributed and stable process that all of the parameters ware not follows a Normal distribution as well as symmetric distribution.

Conclusions

Statistical methods, in particular designed and monitored control charts, enable graphical visualising measurements of processes. They also describe stability and repeatability of those processes. Using the statistical quality control (SQC) in food products allows for measuring, researching, estimating and controlling a few parameters of the product. A Choose of results with requirements, in order to state, whether with reference to each of these properties the unanimity was also possible. The statistical quality control of the process for the organization means preventing occurrence of defects, for minimizing to the systematic identification and analysis of key-processes and the direct control.

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Conflicts of interest

Authors declare no conflict of interest.

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