International Journal of Modern Computation, Information and Communication Technology, 2018;1(3):69-82.
ISSN: 2581-5954
http://ijmcict.gjpublications.com

Research Article

Quality Assessment of High Energy Biscuits (HEB) Products in Bangladesh in the framework of Process Capability Analysis

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Abstract

The Fortified High Energy Biscuits analysed data collected from Institute of Food Science and Technology (IFST), BCSIR, Dhaka by Single Stage Cluster Sampling method over the year from 2007 to 2012. The process capability analysis as a means of decision making in manufacturing company was aimed, to investigate whether the production process is in control, to investigate whether the specification limit of the company is properly centred, to examine the process capability of the company and to state if the process is capable or not. Also the analysis of process capability was used. It was discovered that the specification limit of the company is not properly centred i.e. off centred. It is recommended that in order to achieve continuous improvement of the process, the company should always attempt to redefined the voice of the process to watch and them to surpass the expectation of the customers. Also, the institutional specification limit should be redefined to be properly centred and to meet customer requirement.

Keywords: Process capability analysis; Specification limit; Voice of the process; Properly centred; Single Stage Cluster Sampling.

Introduction

High Energy Biscuits (HEB) are biscuits (small baked bread or cakes) that are supplemented with a premix of vitamins and minerals. This ready to eat food participates to the covering of urgent needs in the acute phase of an emergency situation during which population is not able to cook due to a lack of access to basic facilities (clean water, cooking equipment, etc.). Their use is also extended to a complement food ration (use as snacks) to provide vitamins and minerals in regions/population where diet is subjected to nutritional deficiencies. HEB can be used also to prevent micronutrients deficiency of young children and school age children [1, 2].

Complete lists of mills and food processing factories can easily be found at the divisional level (contacting the local Chambers of Commerce, for example) or by contacting the professional organizations or trade-unions. The lists here are the suppliers short listed by WFP [3].

HEB must be manufactured from fresh and good quality, free from foreign materials, substances hazardous to health, excessive moisture, insect damage and fungal contamination and must comply with all relevant national food laws and standards [4].

Requirements for the main ingredients are, wheat flour must conform to Codex STAN 152 [5], sugar must conform to Codex STAN 212-1999 [6], shortening must be prepared from oil that conform to Codex STAN 210-1999, must be free from trans fatty acids and must contain only antioxidants that comply with Codex and relevant regulations [7] and skimmed milk powder must conform to Codex STAN 207-1999. It must be accompanied by a 'melamine-free' certificate [8]. Maximum level aflatoxin M1:<0.5 mcg/kg milk (recommended methods

Received: 13.07.2018; Received after Revision: 31.08.2018; Accepted: 31.08.2018; Published: 04.09.2018

ISO 14501/IDF 171:2007 [9] or ISO 14674/IDF 190:2005 [4, 10].

Key achievements in 2010 are school feeding program for poverty prone areas in Bangladesh, provided school feeding to 1,170,719 preprimary and primary school children (51 percent girls) in 9,965 schools, each child received an average of 182 feeding days during the year, amounting to 8,191mt of high energy biscuits, established 375 school gardens to demonstrate good homestead gardening practices and to deliver food and nutrition security messages, and increased female representation in school management committees from 18 percent in 2009 to 37 percent in 2010 [11].

Process Capability Analysis (PCA) involves statistical techniques, which are useful throughout the product cycle. Generally, PCA is used in development activities prior to manufacturing process, in quantification of process variability, in analysis of this variability relative to specifications and in elimination or reduction of the process variability [12]. As a fundamental technique in any production, quality and process improvement efforts, PCA is used to improve processes, products or services to achieve higher levels of customer satisfaction. PCA has become widely adopted as the measure of performance to evaluate the ability of a process to satisfy customer requirements in terms of specification limits [13, 14]. PCA is often used to estimate the process capability. The estimate of process capability can be in the form of a distribution that has parameters of shape, center (mean) and spread (standard deviation). In this case, PCA can be performed without regard to specifications of the quality characteristic. Here, process capability can be expressed as a percentage outside of specifications [12].

The science of process capability analysis, first introduced by Juran began as a Choose of the process output distribution with the product tolerances [15]. Frequency histograms, log plots and control charts were used to compare process data to product tolerances. Process capability indices were born out of the need for an index that could relate information from the various plots into a single value. Pearn, Kotz and Johnson discussed the distributional properties of the three basic indices, C_p, C_{pk} and C_{pm} and their estimators. A new index C_{pmk} was proposed, which was more sensitive to the departure of the process mean from the target value and thus able to distinguish between off-target and on-target processes [16]. To evaluate quality of industrially processed packed food products such as fortified high energy biscuit in Bangladesh by measuring several parameters i.e. protein, fat, iron, sugar, SPC, coliform etc. for compliance of the WFP standard in the framework of Process Capability Analysis (PCA).

Research Methodology

Process Capability Indices

In the literature, process capability indices (PCIs) are also called process capability ratios (PCRs). PCIs are used as tools for characterizing the process quality. In order to measure the process capability numerically, PCIs have been developed. PCIs use process specifications as well as process variability, in this regard, the use of PCIs is important as they are statistical indicators of the process capability. PCIs are also defined as the quantitative indicators that compare the behavior of process or product characteristic to the specifications. In other words, PCIs are used to determine how well the process performs with respect to specifications and they express the ability of the process to meet these specifications, as a unique value quantitatively. There are several statistics that can be used to measure the capability of a process. Frequently used measures of performance are the PCIs, which relate the natural tolerance limits of a process to the specification limits [13]. In practice, Cp, Cpk (Cpl, Cpu), Cpm are some of the widely used PCIs. In next sections, process capability indices: Cp, Cpk (Cpl, Cpu), Cpm, Cpmk will be explained [14].

Process Capability index, Cp: In the literature, Cp index is also called process potential index, or process capability ratio, or inherent capability index, and two-sided PCI for two-sided specifications, that is, process is having both lower and upper specification limits. Cp is frequently used in industrial environment in order to express process capability in a simple quantitative way. When the parameters are known, that is, in that case, when process standard deviation σ is known, PCI Cp is computed as follows:

$$Cp = \frac{USL - LSL}{6\sigma}$$

where LSL and USL are lower and upper specification limits, respectively. The percentage of the speciation band used up by the process can be calculated in the following way:

$$P = \left(\frac{1}{Cp}\right) * 100$$

In practice, it is often impossible to know parameters. Generally, it is suitable to use sample standard deviation s to estimate process standard deviation σ. Thus, when the parameters are unknown, that is, in that case, when process standard deviation σ is unknown, by replacing sample standard deviation s to estimate process standard deviation σ, the formula used for estimating Cp is given below:

$$\hat{Cp} = \frac{USL - LSL}{6s}$$

where LSL and USL are lower and upper specification limits, respectively.

A Cp value less than 1 indicates that the process variation exceeds the specifications and a significant number of defects are made. A Cp value equal to 1 indicates that the process is exactly meeting the specifications. At least 3% defects would be made. However, if the process is not centered on the target value (off-center), more defects are expected to be made. A Cp value greater than 1 indicates that the process variation is less than the specifications. However, if the process is not centered on the target value (off-center), more defects are expected to be made. A Cp value greater than 1.67 indicates that the process is highly capable.

Process Capability index, Cpk: In the literature, for one-sided specifications, Cpk is defined as one-sided PCI for specification limit nearest to the process mean. When the parameters are known, that is, in that case, when process mean μ and process standard deviation σ are known, PCI Cpk is computed as follows:

$$Cpk = \frac{1}{3\sigma}\min(USL - \mu, \mu - LSL) = \min(Cpu, Cpl)$$

Where LSL and USL are lower and upper specification limits, respectively. In practice, it is often impossible to know parameters. Generally, it is suitable to use sample mean x to estimate process mean μ and sample standard deviation s to estimate process standard deviation σ. When the parameters are unknown, that is, in that case, when process mean μ and process standard deviation σ are unknown, by replacing sample mean x and sample standard deviation s to estimate process mean μ and process standard deviation σ, respectively, the formula used for estimating Cpk is given below:

$$\hat{Cpk} = \frac{1}{3s}\min(USL - \bar{x}, \bar{x} - LSL) = \min(Cpu, Cpl)$$

Where, LSL and USL are lower and upper specification limits, respectively.

Cp as the measurement of the potential capability in the process is defined by Montgomery in 2009 [12]. As a matter of fact, Cp does not consider where the process mean is located relative to the specification limits. Cp only measures the spread of the specifications relative to the six sigma spread in the process. Cp does not deal with the case of a process with mean μ that is not centered between the specification limits. On the other hand, he defined Cpk as the measurement of the actual capability in the process. Cpk takes process centering into account. In other words, Cpk deals with the case of a process with mean μ that is not centered between the specification limits. The magnitude of Cpk relative to Cp is the direct measure of how off-center the process is operating. [12] Examined several cases, which can explain the relationship between Cp and Cpk, are given below:

- If Cp=Cpk, the process is centered at the midpoint of the specification limits.
- If Cpk<Cp, the process if off-centered. This can be accepted as lower capability than the case that the process is centered. The reason is that it is not operating at the midpoint of the interval between the specification limits.
- If Cpk=0, the process mean is exactly equal to one of the specification limits.
- If Cpk<0, the process mean lies outside the specification limits, that is for μ>USL or μ<LSL, Cpk<0.
- If Cpk<-1, the entire process lies outside the specification limits. It should be noted that some authors define Cpk to be nonnegative so that values less than zero are defined as zero.
- 1<Cpk<1.33 means that the process is barely capable. Automotive industry uses Cpk=1.33 as a benchmark in accessing the capability of a process [17].

Process Capability index, Cpm: In the literature, Cpm is referred to as Taguchi index. Simply, Cpm is defined as the ability of the process to be clustered around the target or nominal value, which is the measurement that meets to exact desired value for the quality characteristic. Actually, Cpm was developed because Cpk is observed to be inadequate measure of process centering although Cpk was developed to deal with the case of a process with mean μ that is not centered between the specification limits wheras Cp is inadequate in process centering. As a matter of fact, when μ is in the interval of the specification limits, LSL and USL, Cpk depends inversely on process standard deviation σ and becomes large as process standard deviation σ gets closer to zero. Keeping these features in mind, it is possible to say that Cpk is not convenient as a measure of centering. This means a large value of Cpk does not actually give any information about the location of the mean in the interval of the specification limits, LSL and USL. In that case, process capability index Cpm, which is a better indicator of process centering, would be much more convenient [12]. Consequently, the PCI Cpm is intended to account for variability from the process mean and deviation from the target value T and Cpm is shown to be useful in process centering. When the parameters are known, that is, in that case, parameters of process mean μ and process standard deviation σ are known, PCI Cpm is computed as follows:

$$Cpm = \frac{USL - LSL}{6\tau}$$

Where τ is the square root of expected squared deviation from target T. The target value T, which is the measurement that meets to exact desired value for the quality characteristic, is known to be the midpoint of the specification interval. Target T is evaluated as follows:

$$T = \frac{1}{2}(LSL + USL)$$

The formula for process variation around desired process target is given below:

$$\tau^2 = E[(x-T)^2] = E[(x-\mu)^2] + (\mu - T)^2 = \sigma^2 + (\mu - T)^2$$

Computation of Cpm can also be performed with the following way:

$$Cpm = \frac{USL - LSL}{6\sqrt{\sigma^2 + (\mu - T)^2}} = \frac{Cp}{\sqrt{1 + \left(\frac{\mu - T}{\sigma}\right)^2}}$$

Cpm approaches zero asymtotically as $|\mu - T| \rightarrow \infty$. When the parameters are unknown, that is, in that case, when process mean μ and process standard deviation σ are unknown, by replacing sample mean $\bar{x}$ and sample standard deviation s to estimate process mean μ and process standard deviation σ, respectively, the formulas used for estimating PCI Cpm is given below:

$$\hat{Cpm} = \frac{\hat{Cp}}{\sqrt{1 + V^2}}$$

Where; $V = \frac{\bar{x} - T}{s}$.

Process Capability index, Cpkm: The motivation of Cpkm is increased sensitivity to departures of the process mean μ from the desired target value T. Cpkm is known as a third generation PCI, since it is derived from the second generation PCIs Cpk and Cpm, in the same way that the PCIs, Cpk and Cpm are derived from the first generation PCI Cp. Computation of Cpkm is as follows:

$$Cpkm = \frac{Cpk}{\sqrt{1 + \left(\frac{\mu - T}{\sigma}\right)^2}}$$

At the end of this section, it has to be emphasized that PCIs can measure expected future performance. Industrial use of PCIs concentrates on evaluating and interpreting the point estimates of the desired quantities of PCIs, which are utilized to measure the ability of a process to meet the specification limits. It must be noted that point estimates of PCIs are simply point estimates and they are subject to statistical fluctuation. In other words, since point estimates of PCIs are subject to variability, alternatively, researchers recommend practitioners to use confidence intervals for estimating PCIs. There is a recent focus on hypothesis testing and confidence intervals on PCIs that are used as the basis for establishing the process capability [13]. For details about hypothesis testing and confidence intervals on PCIs, interested readers are referred to [12, 14].

Choices between, PCIs: In the review paper of [19], Cp is ascribed to Juran, Cpk to Kane, and Cpm for the most part to Hsiang and Taguchi. Kotz and Johnson emphasized that it is necessary to distinguish the features of PCIs and the features of their estimators. Apart from this, the relationship between these PCIs are defined as; "Cp ≥ Cpk and Cp ≥ Cpm". Also, researchers

realize that Cpk and Cpm coincide with Cp when $\mu=T$ and decrease as μ moves away from target T, wheras $Cpk<0$ for $\mu<LSL$ or $\mu>USL$.

Highlighted that both Cp and Cpk are related to expected proportion of nonconforming items or defects. In other words, Cp and Cpk are related to marginal expected value of ppm (parts per million). On the other hand, Cpm does not arise from examining the number of nonconforming product in the process. Therefore, Cpm is unreliable if the expected proportion of nonconforming is regarded as the most important feature. Unlike the other PCIs, Cpm is not distributionally sensitive [20].

In industrial practice, it should be noticed that the motivation of Cp, Cpl, Cpu, Cpk are the most extensively used PCIs, while Cpm is seldomly being used. According to [21], Cpk seems to have the greatest degree of acceptability among the PCIs. It is important to emphasize that Cpk is not suitable for product features with asymmetric tolerances. Even all the assumptions are satisfied, a higher Cpk does not represent a higher level of quality for customers. On the other hand, Cpm is related to Taguchi quadratic loss function because Cpm is defined as the ability of the process to be clustered around the target. Furthermore, Cp, Cpl, Cpu, Cpk are interpreted as the measure of nonconforming. Any change in the magnitude of these indices, under the constraint of holding customer requirements constant, is due to changes in the distance between the specification limits and the process mean. Cpk does not in itself say anything about distance between μ and T and it only measures the process yield [14], [20].

Assumptions

There are two critical assumptions to consider when performing process capability analyses with continuous data, namely:

1. The process is in statistical control.
2. The distribution of the process considered is Normal.

If these assumptions are not met, the resulting statistics may be highly unreliable. One finds in practice that, typically, one or both of these assumptions are disregarded [22].

Data

The food products analysed observations from different laboratory of Institute of Food Science and Technology (IFST), BCSIR, Dhaka as Fortified High Energy Biscuits 310 data were collected by Single Stage Cluster Sampling method over the year from 2007 to 2012 [23].

Results and discussions

In this case, we want to assess the analysis of food products quality capability for different industries producing certain fortified high energy biscuits. The proximate analysis of the biscuits is of concern. The specification limits on the biscuits were given [24]. There has been a consistent problem with meeting the specification limits and the some process produces a high percentage of rejects.

The histogram of the data shows that proximate analysis of biscuits follow a normal distribution or approximately normal distribution. The variation from biscuit to biscuit 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 left box in Fig. 1 reports are the data including the lower specification limit and the upper specification limit. These values were provided by the Minitab statistical package program. The calculated values are the sample mean and the estimates of within standard deviations.

Fig. 1 shows the histogram of the data along with normal curves overlaid on the histogram. Normal curve of histogram is a solid line. Moisture of biscuit analysis report is exceeding the upper specification limit (USL) by this process. Note that the AD test exhibits a p-value greater than 0.05 (in this case, the p-value = 0.268 as shown in Fig. 1) and there are no serious deviations from linearity in the Normal probability plot. Therefore reasonably conclude that (i) the process is in statistical control and (ii) the data can be assumed to approximately follow a Normal distribution [22].

The necessary assumptions appear to have been fulfilled and investigate the capability of this process, as shown in Fig. 1. The potential or within process capability of the process is reported on the right hand side. Cpk =0.69 is less than 1.00. This means that the process is off centered.

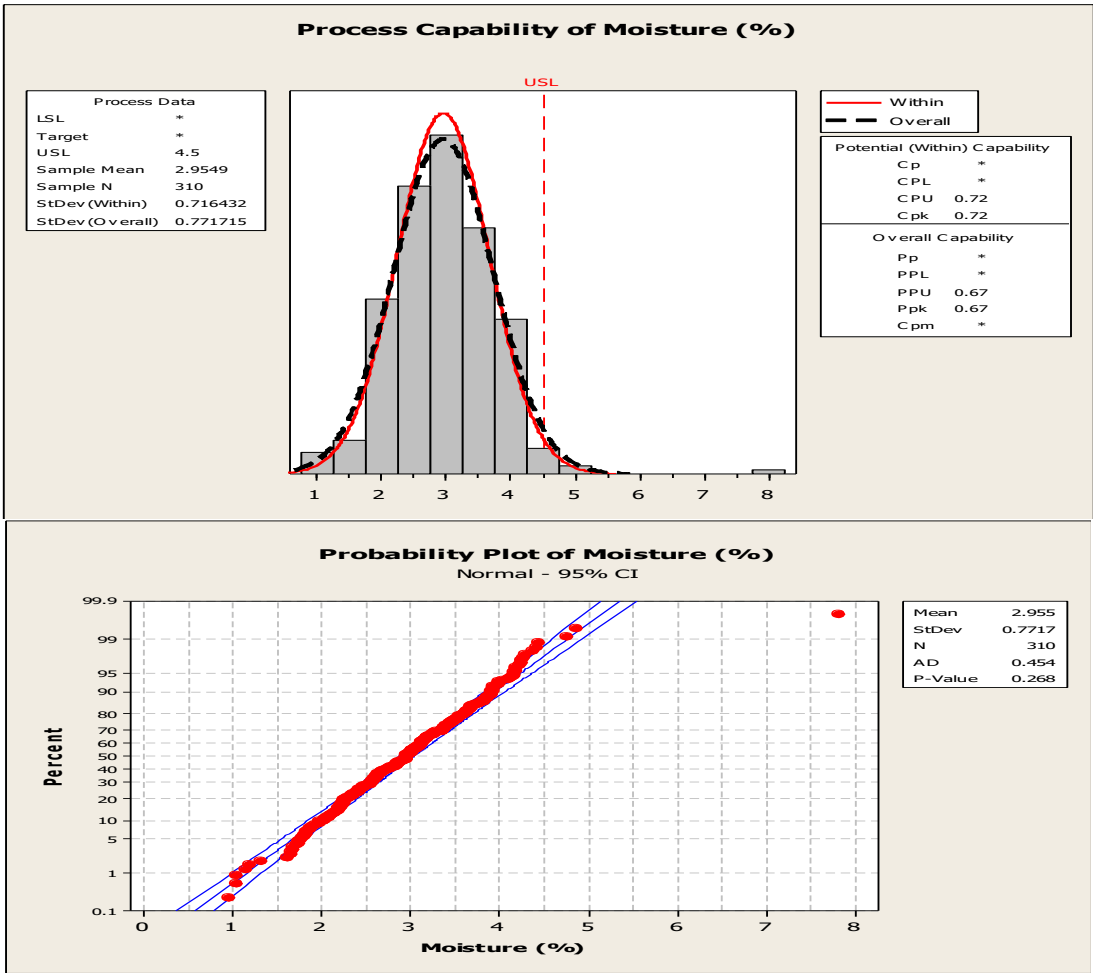

Fig. 1. Process capability report of moisture (%)

The left box in Fig. 2 reports the process data including the lower specification limit and the upper specification limit. The calculated values are the analysis sample mean and the estimates of within standard deviations. Fig. 2 shows the histogram of the data along with normal curves overlaid on the histogram. The products of biscuit of Protein analysis report by this process exceed the lower specification limit (LSL). A significant percentage of the Protein of biscuits is outside of Lower Specification Limit. 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 [25]. This is due to the fact that the p-value of test is 0.005, which is p-value less than 0.05 a frequently used level of significance for such a hypothesis test, as opposed to the more traditional 0.05 significance level. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =0.38 is less than 1 means that the process is off centered and not capable.

The left box in Fig. 3 reports the analysis data including the lower specification limit and the upper specification limit. The calculated values are the process sample mean and the estimates of within standard deviations. Fig. 3 shows the histogram of the data along with normal curves overlaid on the histogram. A normal curve with a solid line. The biscuit products of Fat analysis report by this process exceed the lower specification limit (LSL). A significant percentage of the Fat of biscuits is outside of Lower Specification Limit.

From the Normal probability plot in Fig. 3, that shows 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 [25]. This is due to the fact that the p-value of test is 0.005, which is p-value less than 0.05 a frequently used level of significance for such a hypothesis test, as opposed to the more traditional 0.05 significance level. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =-0.06 is less than 1 means that the process is off centered and capable.

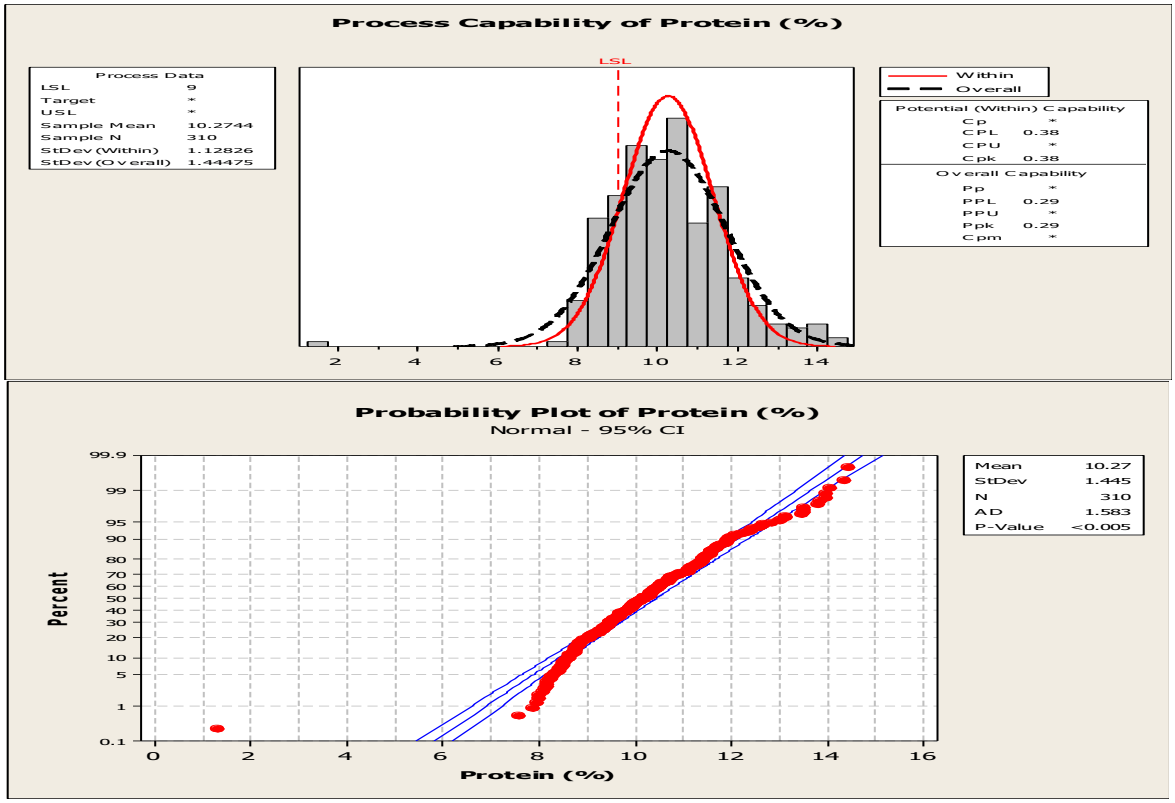

Fig. 2. Process capability report of protein (%)

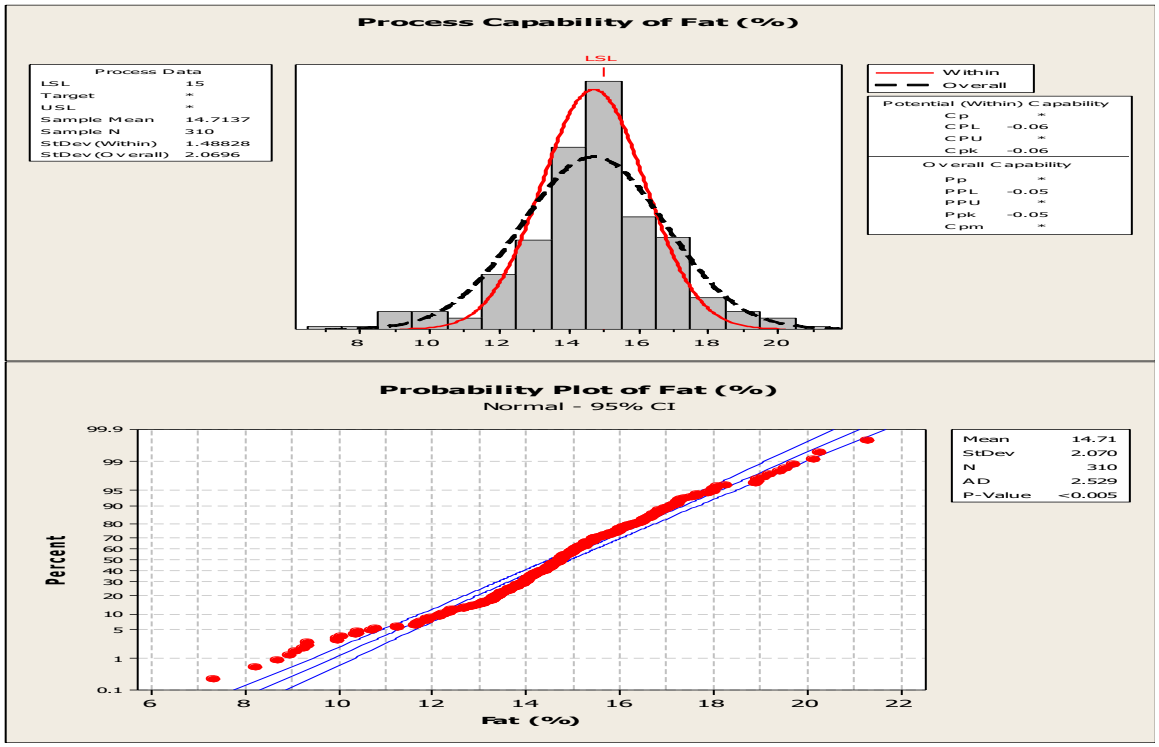

Fig. 3. Process capability report of fat (%)

The left box in Fig. 4 reports the data including the lower specification limit and the upper specification limit. The calculated values are the sample mean and the estimates of within standard deviations. The Fig. 4 shows the histogram of the data along with normal curves overlaid on the histogram. A normal curve is a solid line. The histogram and the normal curves can be used to check visually if the process data are normally distributed. To interpret the process capability, the normality assumption must hold. Total Carbohydrate of biscuit analysis report exceeds the lower and upper specification limit (LSL & USL) by this process. A significant percentage of the Total Carbohydrate of biscuit is outside of Lower and upper Specification

Limit. The AD test exhibits a p-value greater than 0.05 (in this case, the p-value = 0.156 as shown in Figure 4) and there is no serious deviations from linearity in the Normal probability plot. Therefore reasonably conclude that (i) the process is in statistical control and (ii) the data can be assumed to approximately follow a Normal distribution [22]. The necessary assumptions appear to have been fulfilled and investigate the capability of this process, as shown in Fig. 4. The potential or within process capability of the process is reported on the right hand side. The value of Cp=0.37 indicates that the process is not capable (Cp < 1). Also, Cpk =0.28 is less than Cp=0.37. This means that the process is off centered.

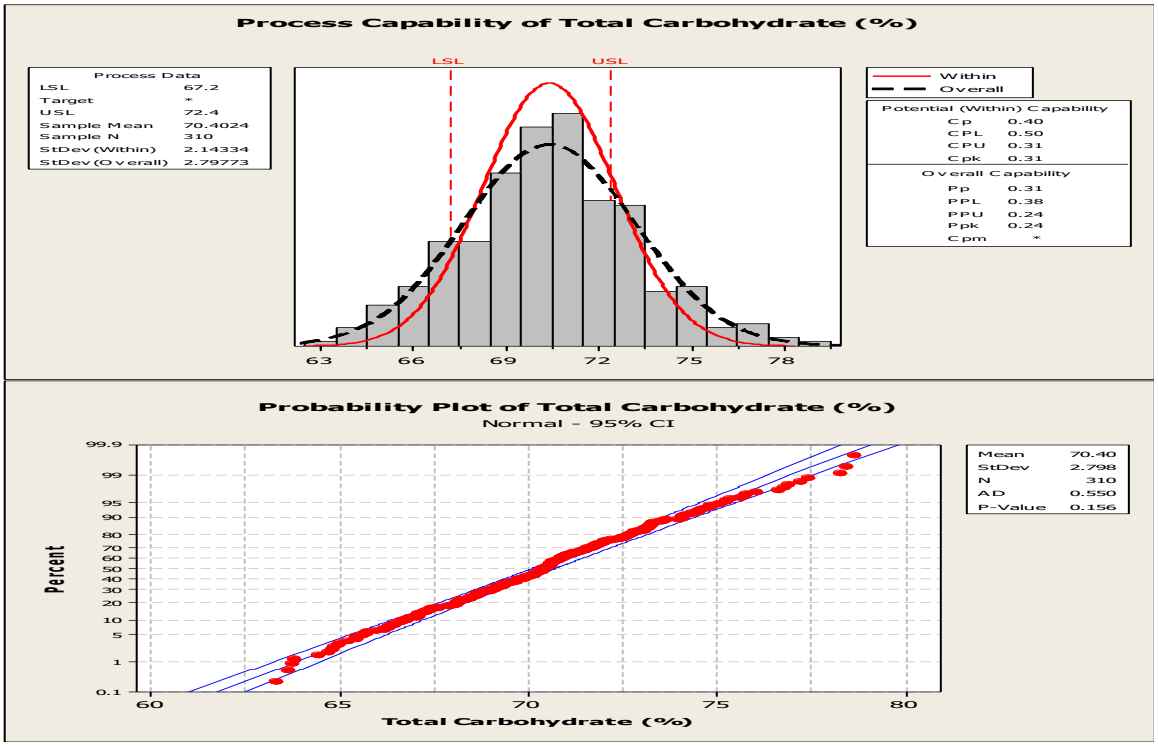

Fig. 4. Process capability report of total carbohydrate (%)

The left box in Fig. 5 reports the process data including the lower specification limit and the upper specification limit. These values were provided by minitab program. The calculated values are the sample mean and the estimates of standard deviations. The Fig. 5 shows the histogram of the data along with normal curves overlaid on the histogram. A normal curve is a solid line. The histogram and the normal curves can be used to check visually if the process data are normally distributed. To interpret the process capability, the normality assumption must hold. Sugar % of biscuit exceeds the lower and upper specification limit (LSL & USL). A significant percentage of the sugar of biscuits is outside of Upper and Lower Specification Limit. From the Normal probability plot in Fig. 5, the Normality test shows that 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 [25]. 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, as opposed to the 0.05 significance level. The potential or within process capability of the process is reported on the right hand side. The value of Cp=0.78 indicates that the process is not capable (Cp < 1). Also, Cpk =0.62 is less than Cp=0.78. This means that the process is off centered.

The upper left box in Fig. 6 reports the process data including the lower specification limit, target and the upper specification limit. These values were provided by the Minitab Statistical program. The calculated values are the process sample mean and the estimates of within standard deviations. Fig. 6 shows the histogram of the data along with normal curves overlaid on the histogram. A normal curve is a solid line. The histogram and the normal curves can be used to check visually if the process data are normally distributed. To interpret the process capability, the normality assumption must hold. Vitamin A of biscuits by this process exceeds the lower specification limit (LSL). A significant

percentage of the Vitamin A of biscuits is outside lower specification limit.

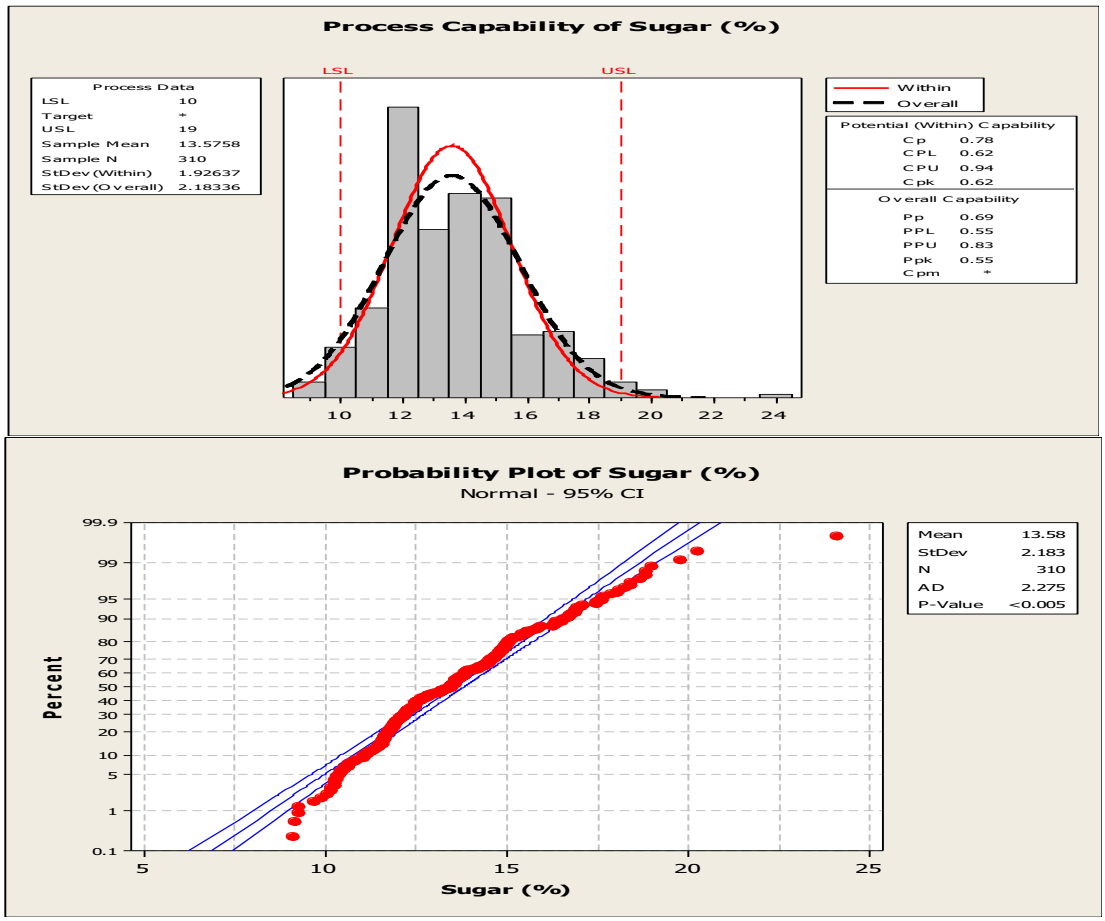

Fig. 5. Process capability report of sugar (%)

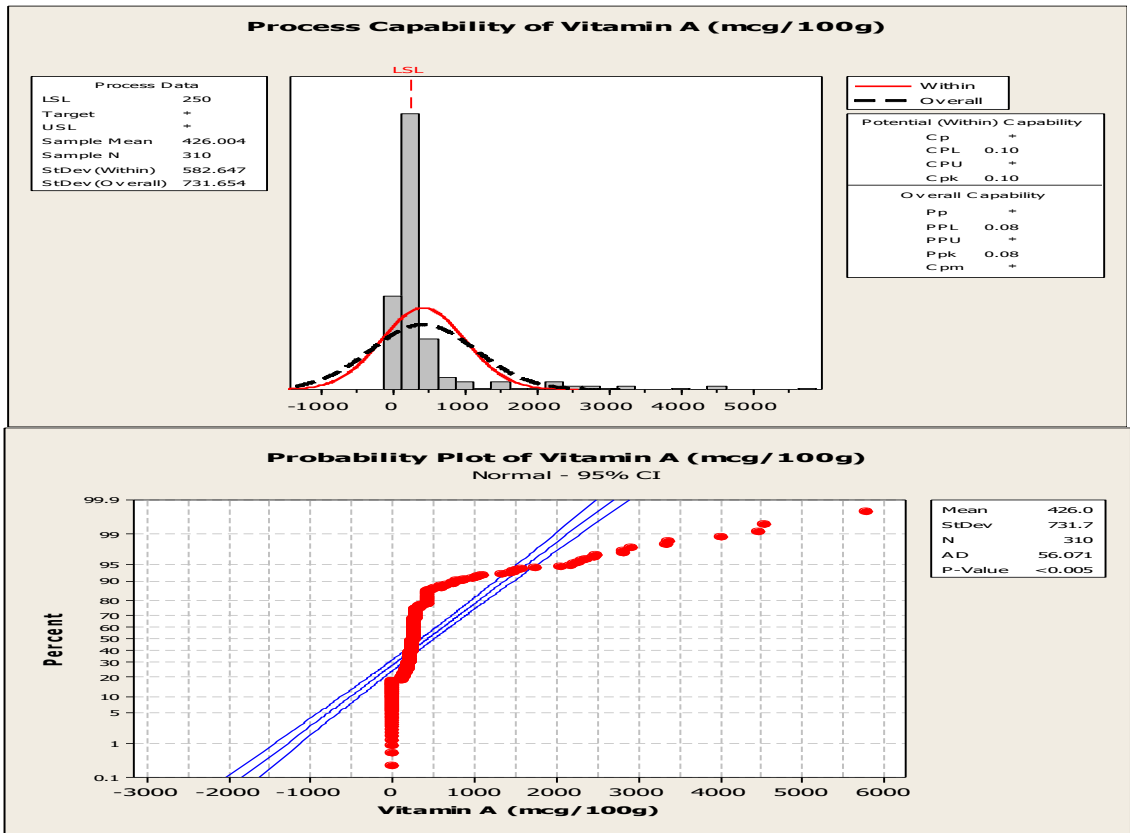

Fig. 6. Process capability report of vitamin a (mcg/100g)

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 [25]. 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, as opposed to the 0.05 significance level. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =0.10 is less than 1 means that the process is off centered and not capable.

The upper left box in Fig.7 reports the process data including the lower specification limit, target and the upper specification limit. The calculated values are the process sample mean and the estimates of within standard deviations. Fig. 7 shows the histogram of the data along with normal curves overlaid on the histogram. A normal curve is a solid line. The histogram and the normal curves can be used to check visually if the process data are normally distributed. To interpret the process capability, the normality assumption must hold. Iron of biscuit products by this process exceed the lower specification limit (LSL). A significant percentage of the Iron of biscuits is outside of lower and upper specification limit.

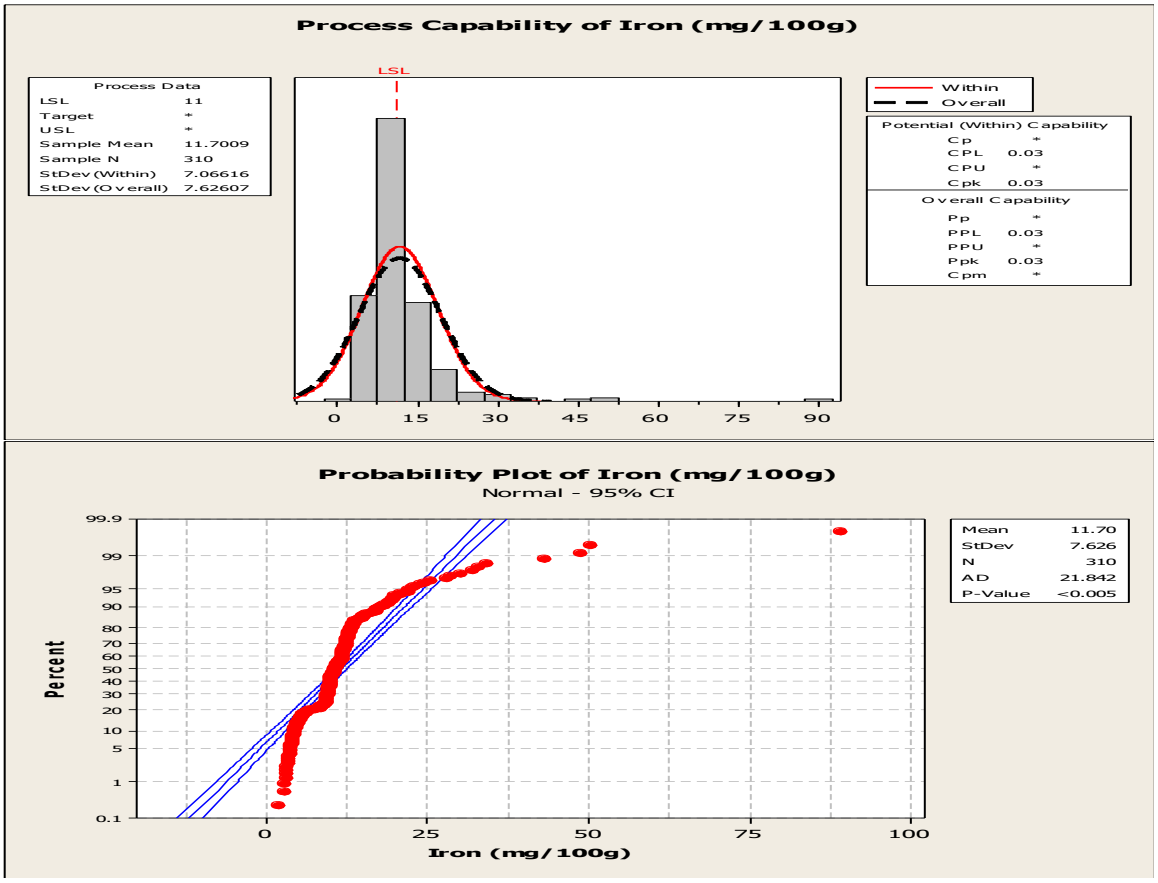

Fig. 7. Process capability report of iron (mg/100g)

From the Normal probability plot in Fig. 7, the Normality test shows that 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 [25]. 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, as opposed to the 0.05 significance level. The potential or within process capability of the process is reported on the right hand side. The value of Cpk =-0.03 is less than 1 means that the process is off centered and not capable.

The Fig. 8 shows the histogram and Probability Plot of the data along with normal curves overlaid on the histogram. The histogram and the Probability Plot can be used to check visually if the process data are normally and symmetrically distributed. From the Fig. 8, shows that data was not follow a Normal distribution as well as symmetric distribution.

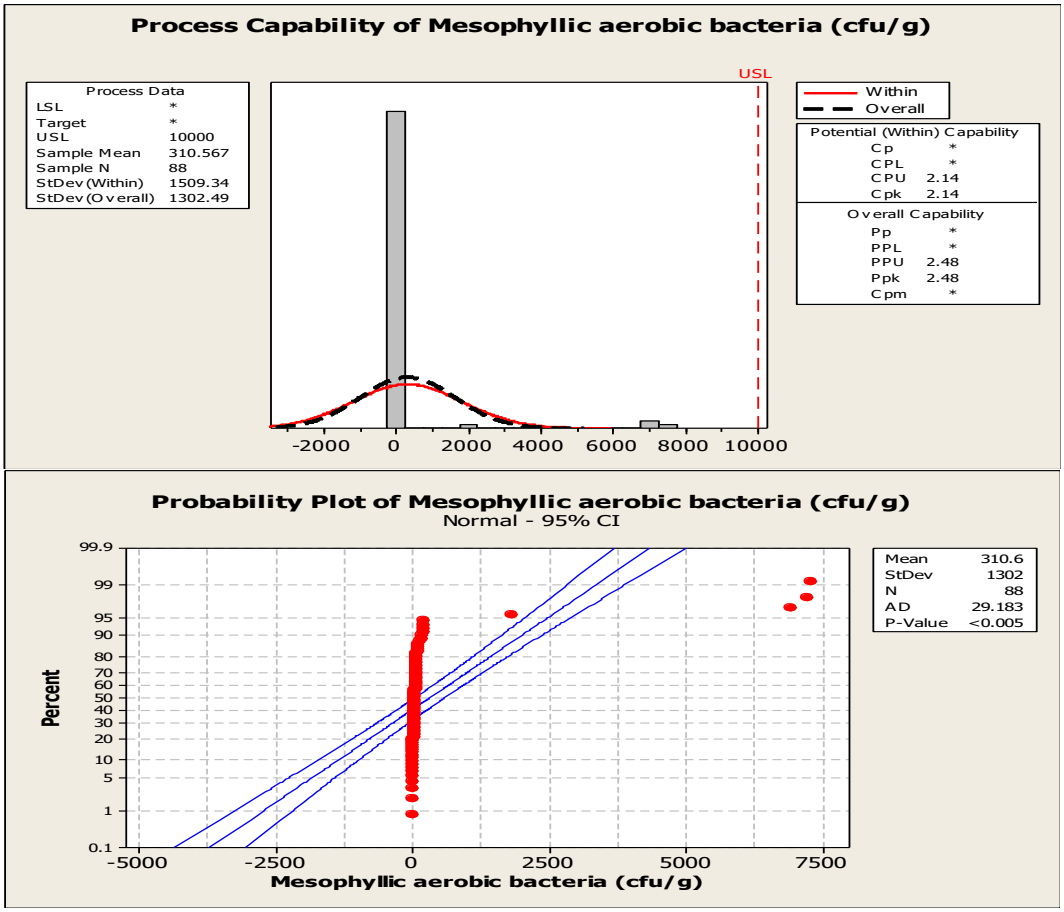

Fig. 8. Process capability report of mesophyllic aerobic bacteria (cfu/g)

The Fig. 9 shows the histogram and Probability Plot of the data along with normal curves overlaid on the histogram. The histogram and the Probability Plot can be used to check visually if the process data are normally distributed. Fig. 9 shows that data was not follow a Normal distribution as well as symmetric distribution.

The Fig. 10 shows the histogram and Probability Plot of the data along with normal curves overlaid on the histogram. The histogram and the Probability Plot can be used to check visually if the process data are normally distributed. Fig. 10, shows that data was not follow a Normal distribution.

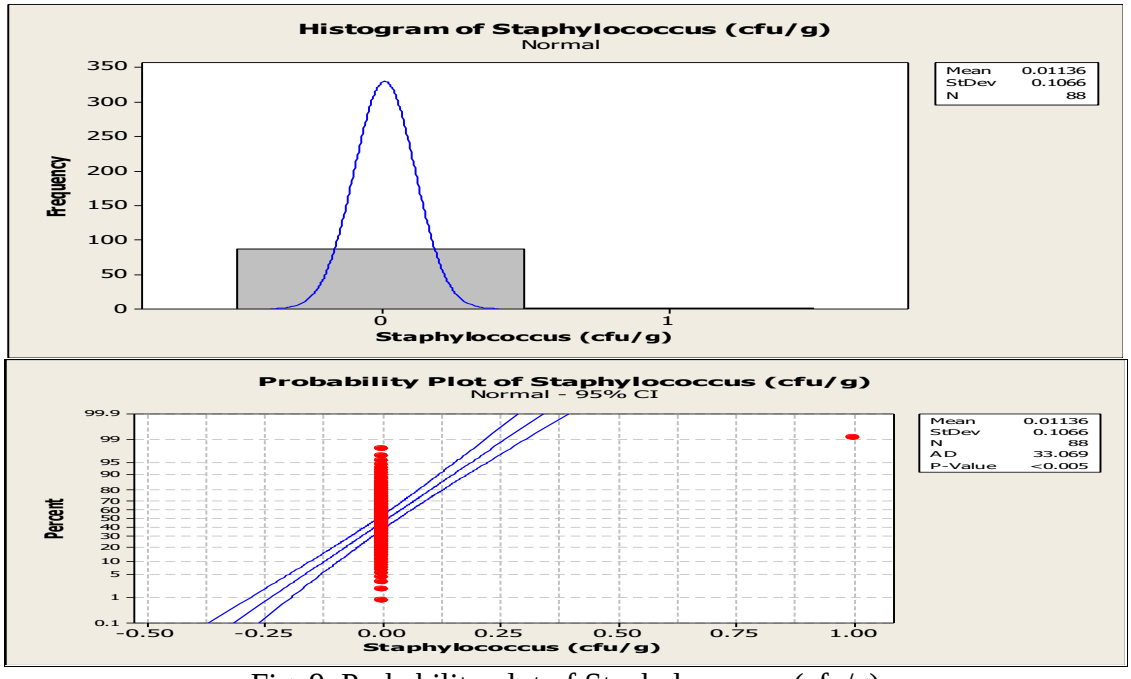

Fig. 9. Probability plot of Staphylococcus (cfu/g)

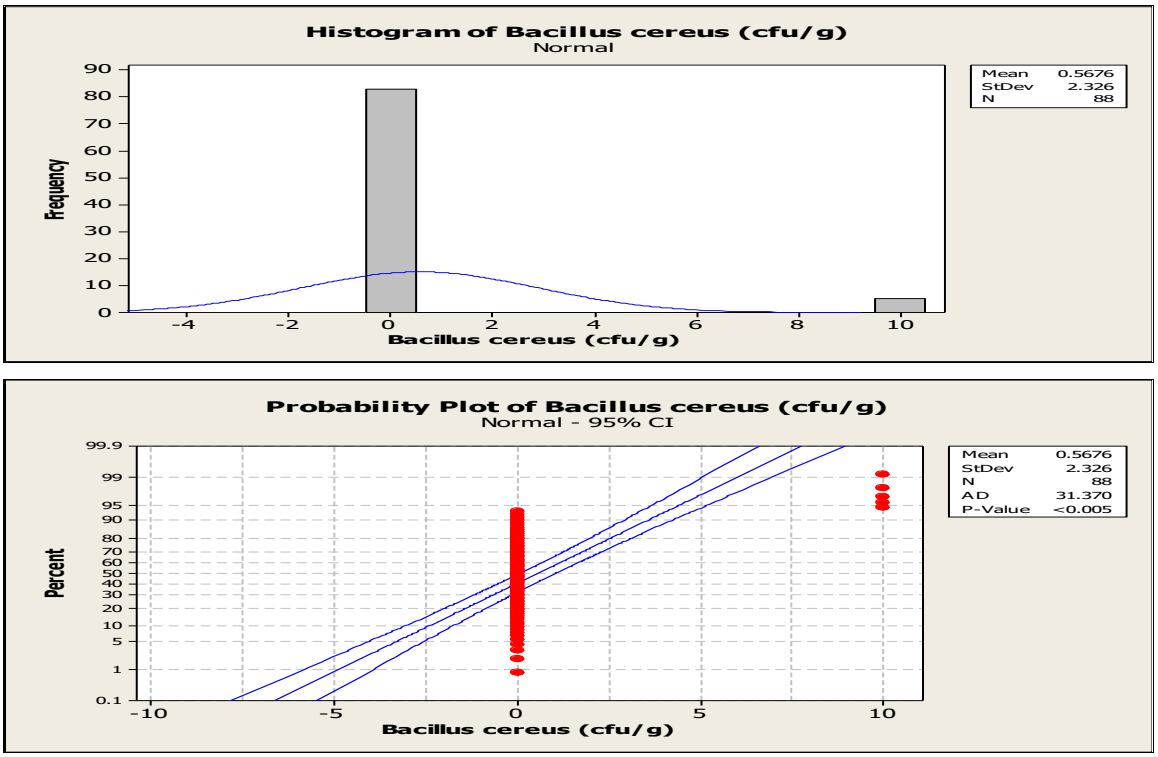

Fig. 10. Probability plot of *Bacillus cereus* (cfu/g)

The Fig. 11 shows the histogram and Probability Plot of the data along with normal curves overlaid on the histogram. The histogram and the Probability Plot can be used to check visually if the process data are normally and symmetrically distributed. From the Fig. 11, shows that data was not follow a Normal distribution.

The Fig. 12 shows the histogram and Probability Plot of the data along with normal curves overlaid on the histogram. The histogram and the Probability Plot can be used to check visually if the process data are normally distributed. From the Fig. 12, shows that data was not follow a Normal distribution.

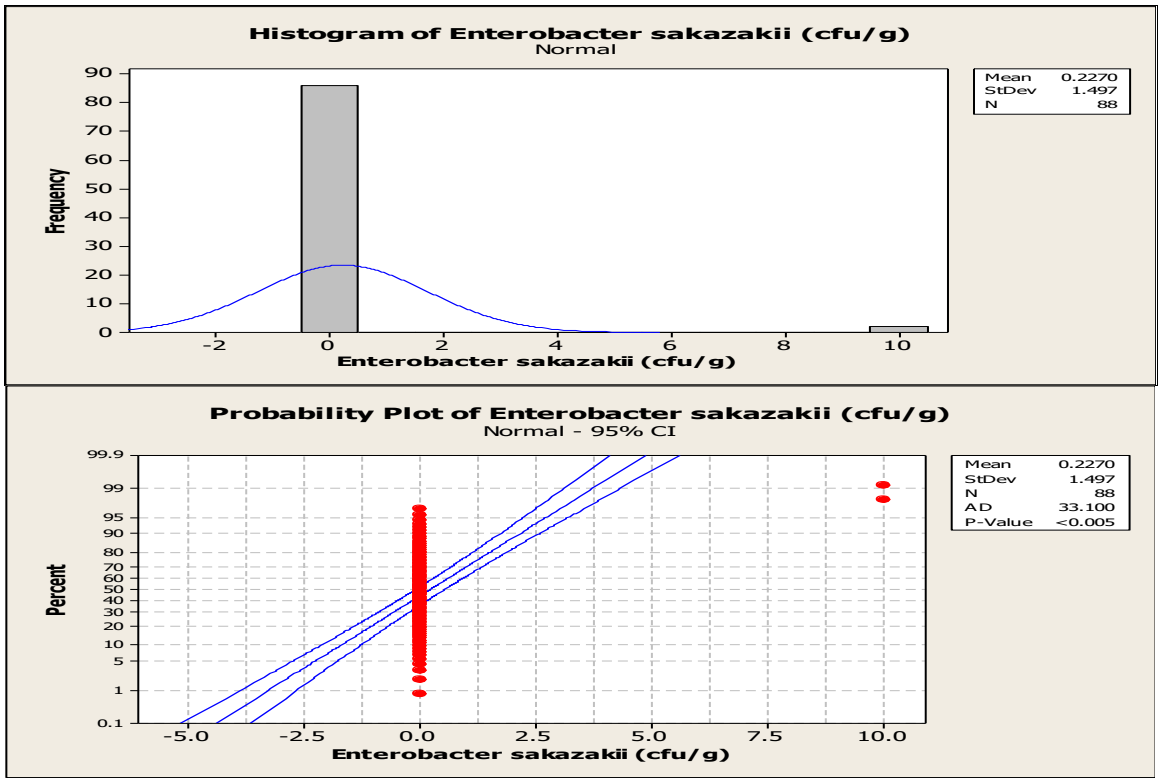

Fig. 11. Probability plot of *Enterobacter sakazakii* (cfu/g)

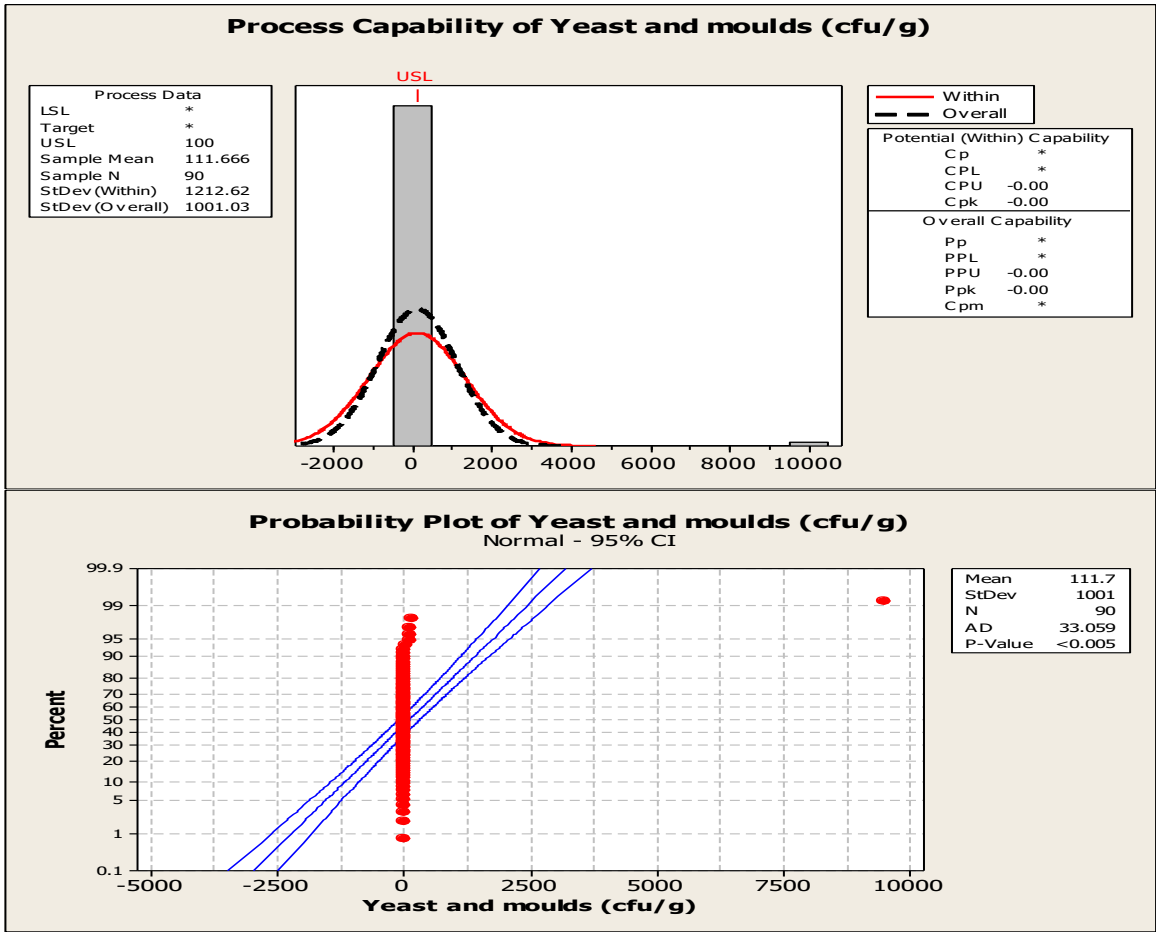

Fig. 12. Process capability analysis of yeast and moulds (cfu/g)

In conclusion, the results showed that we are dealing with a normally distributed and stable process that most of the parameters ware not follows a Normal distribution as well as symmetric distribution.

Conclusions

The results of process capability study of the given food analysis results reveals that, graphical presentations of parameters approaches very nearer to the magnitude of the analytical values and hence graphical approach could be treated as equivalent to analytical method. Graphical approach can be used to study the variability of foods analysis data. It is one of the tools to convey the results through which it is easy to make inference on the quality of data. The approach helps a stakeholder of the food to make the assessment about the analyzed parameters. Thus, it also helps to process management and identifies opportunities for improvement quality and operational performance [26]. The estimation of process capability is one of the basic tasks of the statistical process control (SPC). The values of Cp, Cpk indices are very precise information on a process potential relating to the client's expectations. Correct determination of Cp, Cpk indices values requires identification of a distribution size, at least as a general settlement whether it is a normal distribution or not. If it is a normal distribution, for the estimation of Cp,Cpk this can use a simple classic approach that isbased on the rule of three standard deviations. If it is not a normal distribution, the application of a classic approach leadsto wrong results [27].

Acknowledgement

I would like to thank Authority of BCSIR for gives an opportunity to use of analytical service data and Ministry of Science and Technology to allocate research fund.

Conflicts of interest

Authors declare no conflict of interest.

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