

PROCESS CAPABILITY STUDY FOR IMPROVEMENT OF PRODUCT RELIABILITY AT FOOD AND BEVERAGE INDUSTRY

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Abstract

Despite the numerous challenges faced by competitors in the same sectors, particularly in the Food and Beverage (F&B) industries, manufacturing has improved its performance. Process capability refers to a process ability to produce a product or service that meets the customer's specifications. The issue is that the manufactured items are delivered to customers that not meeting their expectations. The purpose of this study is to develop an understanding of a product reliability through process capability study factors that occur during the industrial production and how they can be applied by converting the manual activities to automated activities. Through assumption, this study influenced the outcome of the C_p and C_{pk} which calculated by Minitab software as a method for measuring the quality performance through identifying the production's process wide tolerances. In this study, the C_p 's results are 0.86, when the C_p 's results is less than 1.0, then the process is incapable. Therefore, it is necessary to think for action to be taken. Based on the C_p 's results, it is helpful for level of managers, and any companies to use C_p 's results as a guideline in order to increase their product's reliability through appropriate improvement while reducing process tolerances. Finally, water volume can be monitored and take an action for improvement based on C_p 's results.

Keywords: Production, process capability, product reliability.

1. Introduction

In today's competitive manufacturing environment, the challenge is to produce excellent products at the lowest possible cost. Quality management is part of the process that can be observed and discussed with the product. When planning the quality aspects of operations, nothing is more important than ensuring that the procedure can meet the specific process capability [1]. The process capability is critical for mechanical directors to grasp [2].

The process capability (C_p) measures a process ability to produce parts within the specified parameters consistently. Several methods can be calculated by focusing on the product range and the standard deviation or sigma value. C_p and C_{pk} measurements use sample, variance, or deviation mean within the appropriate categories. P_p and P_{pk} measurements use standard deviation or coefficient of variation based on the population results [3]. The C_p and C_{pk} indices are used to test a sample of a process ability to meet the customer's needs.

Many product requirements will be based on the process capability. Therefore, by knowing the product reliability helps to improve production processes in the Food & Beverage (F&B) industry. Reliability is the ability of a device or component to operate under specified conditions over time. The efficiency is genetically related to reliability [4].

Process capability is the consistency of a process output from predetermined values. In most cases, high reliability is desired, especially when the output quality is critical. It is possible to improve process efficiency by monitoring past output and changing certain factors.

Process capability indices assess an in-control process adherence to a set of specifications. Process Capability Studies determine a process capability in a controlled setting. Therefore, it is essential to understand the specification required for the volume of water. In this study, the water volume is inconsistent in the F&B industry. The research looks at how effective a method is under ideal conditions. A processing capacity assessment helps evaluate the process short-term reliability and capability.

The issue in the F&B industry is the quality of manufactured products delivered to customers, resulting in unsatisfactory products or services. Most organisations believe in development without even considering a strategy. The consistency or accuracy of test results is measured by the Process capability. Process capability indices are used in production to meet the product's requirements, increasing product reliability in the F&B industry. A process capability inspection assesses the method ability to meet the specifications. Unfortunately, there is no study regarding reliability of water volume by using process capability indices at F&B industry. As a result, this method would help to improve the product's reliability in the F&B industry.

First, this paper describes some theoretical aspects of process capability studies that must be considered in order to receive reliable results. Then the adherence to these theoretical aspects is described that regularly use process capability studies. Since it has been found that, indeed, there is a gap between theory and practice, some possible explanations are given as to why this is. This is done by carefully describing the barriers that usually arise when implementing and using process

capability studies. Finally, some suggestions are given for improvement in order how to act based on process capability studies results.

2. Understanding of Capacity Study

Today's engineers must test products in the manufacturing industry to see if they can deliver the same results or otherwise, they end up delivering faulty product to consumers. Process capabilities appear to have a distinct impact on production costs in each F&B industry sector. The process capability refers to the uniformity of a study or measuring test in F&B industry. Hassing [5] identified the intrinsic statistical variability of a characteristic mixture of instruments, materials, procedures and requires collaboration to make a quantitative development.

Quality has become one of the most important market decision factors when comparing goods and processes [2]. As a result, the method is vital to maintaining production efficiency. It is a measurable attribute of an operation represented as a process capability index. This study examines the product reliability in the food and beverage industry.

2.1. Reliability of product

Reliability of a product must perform satisfactorily for a specified period. According to Mcleod [6], reliability refers to a studies or tests consistency. Regardless, quality refers to a product's initial effectiveness, whereas reliability refers to its long-term performance. A product that performs better initially may not necessarily perform well later. In this case, the product is deemed untrustworthy [7]. As a result, manufacturers must produce reliable products of high quality at all times.

Various industrial and manufacturing contexts use the term "reliability." Generally, reliability is used when achieving consistent results [8]. Defined limits, for example, are reliable manufacturing processes. A car, or any other product, is reliable if it consistently performs and meets the expectations. The reliability of financial and other data depends on compiled and prepared information [9].

Reliability is essential in industries such as engineering. Plants, processes, materials, and other aspects of the manufacturing process are all rigorously tested. Because reliability does not always imply perfection, Ippolito [10] stated that efforts are made to improve the dependability of various manufacturing functions. The dependability of such processes directly impacts the financial performance and product's dependability.

Reliability is imperative for both the manufacturer and the customer. Customers expect products to work well and last long when they buy them [11]. Industries that offer extended warranties are confident in their products' dependability. In most cases, the manufacturer covers the cost of repairs or replacements during the warranty period [12].

The conditions of use must also be considered when assessing a product's reliability. A products operating time and reliability may be reduced if improperly used or maintained.

2.1.1. Factor of reliability

The relative lack of error in an instrument is referred to as reliability. Furthermore, the properties of the underlying construct being tested, the test itself, the groups being evaluated, the testing context, and the object of evaluation all influence reliability.

Next, a product's intended function is defined as a product that would be designed for specific applications and is expected to perform those tasks. An electric hoist, for example, should be able to lift a load that exceeds the processes.

It is also included the validity of the product on the F&B industry. Besides, the term of reliability and validity have been used to examine the effectiveness of the findings. Terms used to describe the accuracy with which a methodology, approach, or measurement instrument information.

2.1.2. Comparison reliability and validity

Middleton [13] mentioned if a product receives a similar score on the same test given to them twice, the measure is considered accurate. It is important to keep in mind that reliability is an expectation rather than a measurement. On the other hand, validity refers to how accurately an analysis represents or evaluates the particular definition that a consumer is attempting to measure. Validity is focussed on achieving the intended measure, while reliability is concerned with the accuracy of the actual measurement technique or produces as shown in Fig. 1. Through this situation, industries can achieve reliability of product.

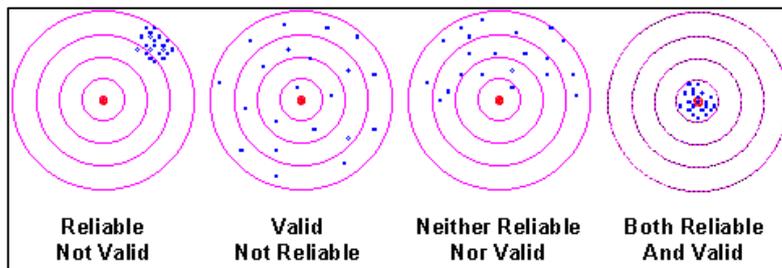


Fig. 1. The different between reliability and validity [26].

2.1.3. Achieving reliability

Four phases of production on process capability can achieve reliability. This increased emphasis on product reliability is taken from the Consumer Protection Act (Laws of Malaysia, 1999). Due to automation, when an automatic component fails, the products can often be operated manually. In terms of a system reliability, products with more parts have a higher chance of working.

Reliability is also determined by design, which should be as simple as possible. The lower the amount, the more reliable. Similar to a parallel component, a backup or redundant component increases the reliability.

DfR is used during a product design to improve the product reliability. Quality procedures can also reduce the product unreliability in the F&B industry. It can ensure that the F&B industry's specifications are appropriate for the job and determine which conditions result in the most reliable product.

2.2. Process capability study

The process capability is the maximum limit for how much a methodology can generate in a given time, which is much more receptive and responsive to improvement [9]. Pawar et al. [2] described a process capability as a critical concept for engineering coordinators to comprehend.

This process capability study would be necessary to ensure that perhaps the output and machine ability are beyond the established tolerances throughout the problem statement, as a higher probability of failure resulted in decreased production. Reduced demand costs, as indicated by Caulcutt [15], assist industries classified as Small and Medium Enterprises (SME) remain viable in the commercial centre on process capability analysis.

Process capability studies indicate if a process can produce almost any conforming commodity. Following a process capability analysis, an operation would be classified as competent or incompetent, as illustrated in Figs. 2 and 3. When one process becomes incapable of creating almost all conforming products, it also seems to be incompetent, therefore 100% of inspections should remain as a component of the production process. Besides, a long term action can be taken in order to avoid incapable condition of water volume such as timely check of parameter setting at filling machine.

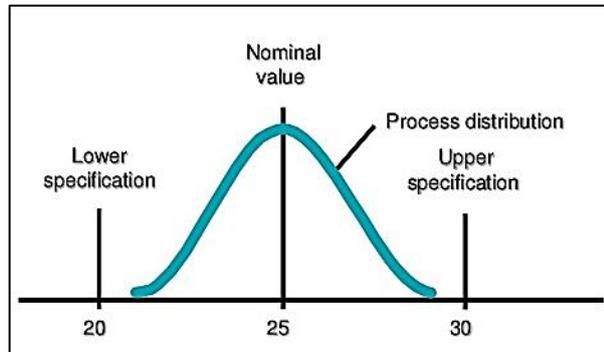


Fig. 2. Capable process [15].

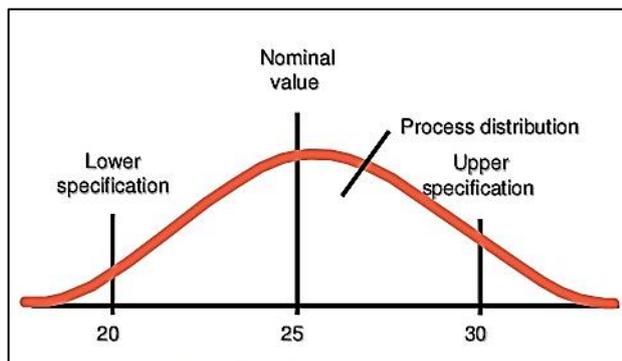


Fig. 3. No capable process [15].

2.2.1. Control limit and specification limit

There is a distinction between a method based on specifications and statistical control. There are two types of limits. First is control limit and second is specification limit. Control limits are calculated based on process's voice, while specification limits are calculated based on customer's voice. Process variance is captured in the production control chart's control limits. Control limits for each control chart are based on process data.

According to Podder et al. [16], the X-bar charts and individual measurements chart's limits can vary. To establish even when a technique is far out of range, Bottani et al. [14] suggested using the horizontal lines above and below the central axis. Any process control limit contains all the deviation from the predicted source [17].

The process capability compares an in-control procedure actual result to a specification limitation. According to Singh et al. [17], these constraints define the product's requirement. These products claim to meet expectations in the USL/LSL range. Any product that does not drop into the upper specification limit/lower specification limit (USL/LSL) range does not meet the product's needs.

2.2.2. Assessing process capability

It is difficult to assess process capabilities in terms of dependability. Some instructions require awareness and consumer should delay till the system recognises equilibration before taking any sample and calculating the standard deviation. The estimates of process capability generated using this technique will be informative as well as independently of processes means changeability between sampling intervals in this case.

2.3. Process capability indices

As identified by Singh et al. [17], there is not commonly acknowledged meaning for the word process capability. It is widely accepted that its primary goal is to decide how well a process produces production that meets the design requirements for a product or service.

To evaluate the process capability indices, several capacity indices have been proposed. C_p and C_{pk} are two of the most widely used indices in the F&B industry, whereas C_{pm} and C_{pmk} are more advanced indices. These capability indices assess a product's or service's current ability to meet the design specifications [18].

2.3.1. Standard deviation

A standard deviation seems to be a computation of such range among observations relative to respective means which highlights the fact because measurements to differ from the means contain different preferences. The standard deviation originally defined even as the square root of variances between both the observation and also the average. The average \pm standard deviations are also the two most commonly used measurements for defining a distribution as shown in Eq. (1):

$$\sigma = \sqrt{\frac{1}{N}(x_i - \bar{x})} \quad (1)$$

2.3.2. Capability index

Process capability index is a straightforward and easy-to-understand measure of process capability as shown in Eq. (2). According to Yusof et al. [19], the process index is a numerical representation of variance in comparison to the tolerance or specification. It means that if the distribution is less, the C_p will rise. However, Polhemus [20] stated that C_p just considers how easily visible the figures measurements are. As a result, C_p is simpler to use but less useful. The C_p is easier compared to C_{pk} to make measurements for some process.

$$C_p = \frac{USL - LSL}{6\sigma} \tag{2}$$

2.3.3. Capability ratio

It means that capability ratio is an index that measures the possibility of a process producing a defective product that is either at upper or lower specification as shown in Eq. (3). Similarly, Polhemus [20] one of the most common metrics for assessing process capability is C_{pk} . It's used to determine how the product fits within the product's requirements. The process capability ratio becomes a straightforward metric that illustrates as proximity processes are to fulfilling the specified limitations in contrast to its inherent variability [21].

$$C_p = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right) \tag{3}$$

A process capability ratio of at least 1.33 implies that perhaps the operation would satisfy the product's requirements. This value has a process yield of 99.99 percent and a sigma level of 4.0, indicating that nearly all measurements are within the product's requirements [20] as shown in Table 1.

Table 1. The sigma level for Capability Ratio, Cpk

Cpk	Sigma	Yield %
0.33	1.0	68.27
0.67	2.0	95.45
1.00	3.0	99.73
1.33	4.0	99.99
1.67	5.0	99.9999
2.00	6.0	99.9999998

2.3.4. Relationship Cp and Cpk

Since it considers the mean and standard deviation in its measurement, C_{pk} is more commonly used than C_p . The difference between C_p and C_{pk} shows how much the process average deviates from the targeted specification [22]. When the process is competent, the project performance controllers can be utilised to manage it, allowing standard approval efforts to be decreased or abolished entirely [23]. The difference between C_{pk} and C_p closes as the process average reaches the target value. Hsu and Shu [24] confirmed that C_{pk} is equal to C_p when the specification's average is equal to the target value. C_{pk} would never be larger than C_p . Here means that the generation of descriptive statistic views and histograms can be used to measure C_p and C_{pk} as shown in Fig. 4.

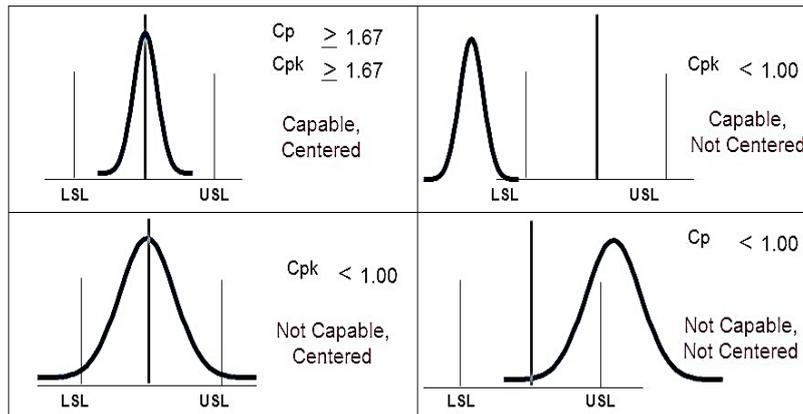


Fig. 4. The relationship C_p and C_{pk} .

According to Yusof et al. [19], if C_p is 1.0 or more, the operation is possible to produce a product that fulfils its specifications. The C_p value doesn't accommodate for process centring. But when the process is centred, on the other hand, C_p is equalled to C_{pk} as shown in Fig. 4. Then, if C_p is greater than or equal to 1.0 and C_{pk} is 1.00 or greater, it indicating that the process in F&B industry meets the products' expectations. Tools of process capability.

Process capacity research aims to measure whether or not an operation can satisfy the specified restrictions. By using the tools of process capability, it can make measurements for a production process's inherent precision. Antonucci et al. [25] highlighted that usually since accurate estimates upon this process during operating environment are not feasible, the system can be monitored implicitly through estimating product uniformity.

2.3.5. Statistical process control

SPC (Statistical Process Control) is a statistical method for managing and controlling a food and beverage industry procedure or a service [18]. SPC is a statistical method for reducing a process variance. Improving quality involves reducing variation. Remember that SPC keeps control charts to show if a procedure is out of statistical control [15]. But it doesn't tell the user what is wrong with the process (or operator). Therefore, SPC charts are widely used in the process improvement in food and beverage industries.

2.3.6. X-bar and S- chart

Experimenting with the process mean and standard deviation over-time is expected. The S chart provides a better understanding of the spread of subgroup data than the range chart. This is because of the subgroup standard deviation, whereas R charts plot the subgroup range defined by [5]. The X bar-S chart should also be used when the subgroup size is 10. For example, [9] showed how to use X Bar-S control charts when the sampling procedure is consistent and normally distributed

As stated previously, reliability is critical in the food and beverage industry. Reliability is the measurement method of accuracy and precision [26]. Reliability is the lack of error in an instrument. In this case, process capability is required to

configure which process is capable. Deleryd [27] defined process capability as a process ability to produce a product. The ability to meet design specifications is also assessed by capability indices [15]. Standard deviation, capability index, and process capability ratio may be used to determine a product's current ability. Statistical methods are used to make the system more efficient. This capability process will thus improve the product reliability.

3. Methodology

The aim of methodology in this study is to explain the method use in order to achieve objectives. Initially, the design of studies is a research strategy for determining the study details. It ensures the qualitative and quantitative research objectives are met. A process flowchart is created to clarify the workflow based on the analysis. The phase flowchart improves the function by providing a guideline for completing the study steps. As a result, well-organised processes and procedures will ensure smooth research. Preliminary data collection from industry is required before performing the analysis. Next, data is collected by observation, interview, and recording. The data will be analysed using Cp / Cpk after collection.

3.1. Design of studies

The design of studies is a method of research design that is used to determine the specifics of a study. For instance, qualitative and quantitative analyses were used to describe and classify the method. Qualitative analysis is an interview to obtain other people's perspectives, a literature review based on what they find and collect data to know what the process are used for.

On the other hand, quantitative analysis is concerned with collecting quantifiable data, statistical methods, and other observable data. Figure 5 demonstrates the design of studies that resolve the goals by using a suitable method.

Research Approach	Process	Method	Source	Size	Research Objective
1. Qualitative Research	Identification	Literature Study	Journal Type: Reliability, Process Capability, Cp Cpk etc	30 Journals	1
	Verification	Interview Initial Data Collection	1. Manufacturing System 2. Process Capability	Food Industry	2
2. Quantitative Research	Propose	Case Study Data Collection	1. Monthly Quality Record 2. Process Time 3. Maintenance Record 4. Monthly Production Record	Min: 3 Month	3

Fig. 5. Design of studies.

3.2. Process flow of methodology

The detailed process flow of methodology is shown below in Fig. 6.

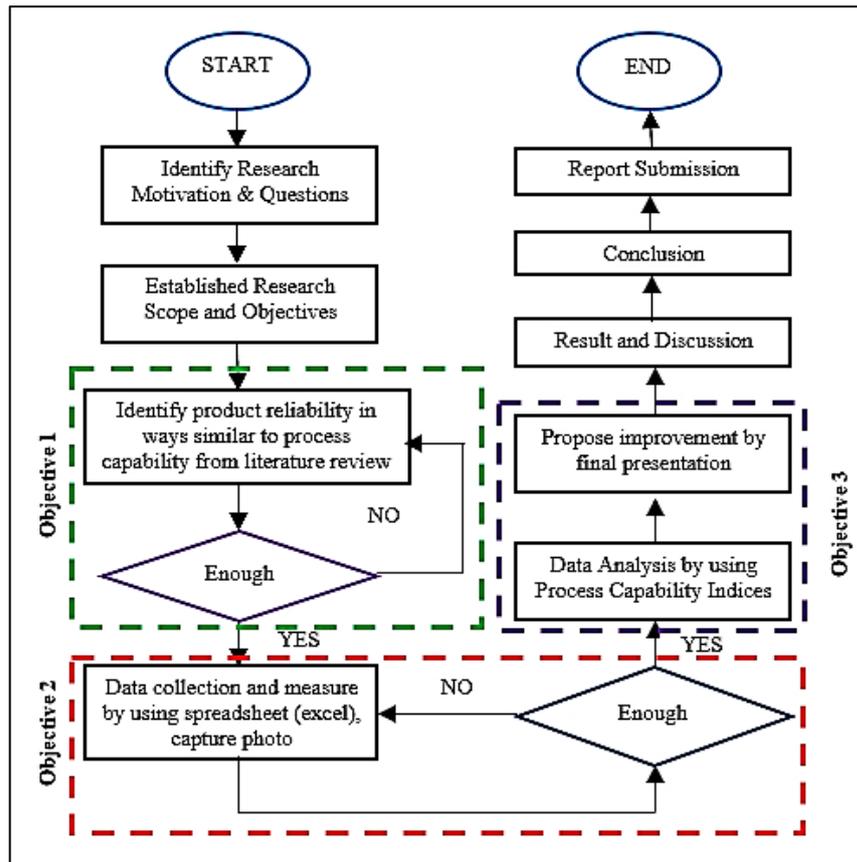


Fig. 6. Process flow of methodology.

The literature review might be valuable in offering information or indications over where the researcher intends to go for a certain topic to be explored that related to objective 1. C_p / C_{pk} charts demonstrate the process capacity to satisfy criteria beyond elemental quality control.

The process of transforming something in order to make it better is known as a proposal for improvement. It was also known as management's modification or change work in order to get more profitability and revenue for the organisational performance.

A Cause-and-Effect diagram shows the visual representation of the relationship between an effect and the possible causes of a problem. This tool is preferable to ascertain the root cause of the problem before proposing a solution or making any other improvement.

4. Results and Discussion

More precisely, this section will elaborate on the project's problem definition using the Define, Measure, Analysis, Improve and Control (DMAIC) method. Additionally, once the problem has been defined, the chapter will continue with the data collection from the factory itself. Then, data will be analysed to make recommendations of how the company can improve and control its productivity.

4.1. Define of study

4.1.1. Process flow of production

The flowchart depicts the process of entering the industry from the beginning of the product to the finish of the procedure. The flowchart of a soybean process at the F&B industry is shown in Fig. 7.

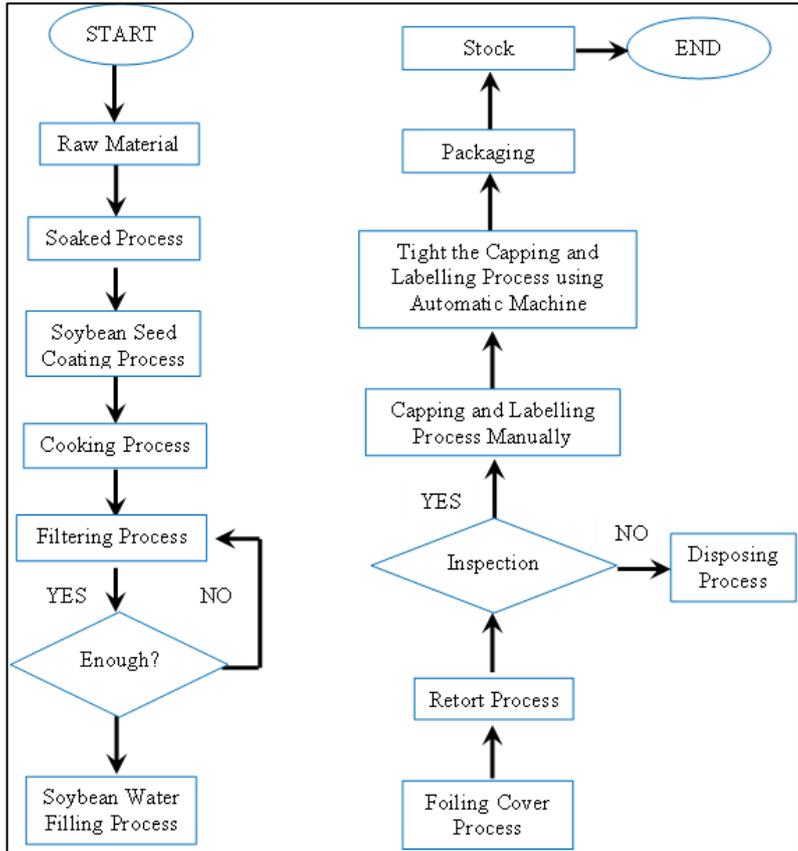


Fig. 7. Process flow chart of soybean drink production

4.1.2. Facility layout

The process plans for the manufacture of soybean drinks in F&B industry is shown in Fig. 8.

4.2. Measurement of data

Quality Data

The following 30 days with 10 samples of water volume details are presented in *Appendix A*. Fig. 9 shows the example method to measure a water volume and stock of soybean in F&B industry. Jagadesh and Babu [28] stated that, process capability analysis requires the estimation of process standard deviation. Besides, the process standard deviation data should be carried out at least 50 observations of data [28].

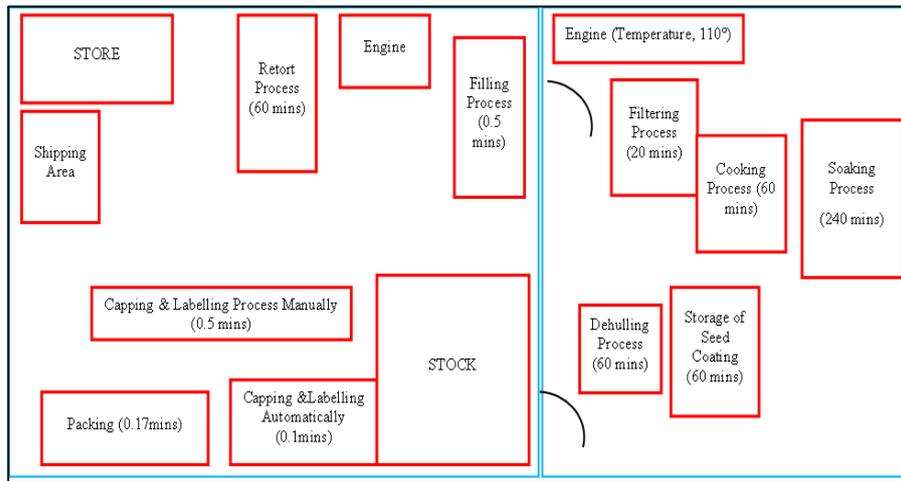


Fig. 8. Process flow chart of soybean drink production.



Fig. 9. Example of weigh soybean after seal capping.

4.3. Data analysis

Data analysis in the qualitative approach is the process of evaluating data using logical tools or statistical processes that are used consistently. The data analysis will discuss in detail the difficulties that have been highlighted and will identify some potential sources of the problem. Data analysis is carried out in the integrated graph analysis, Ishikawa diagram, and why-why analysis.

4.3.1. Minitab

Figure 10 shows the Minitab Xbar-S charts. Again, the USL and LSL were all within the specified range. This indicates that the red diamond's subgroups processes are outside their control limits and is called the point of failure. According to Kalpande and Toke [29], Minitab's analysis capable to evaluate the collected data was correct and supported confidence in decision-making.

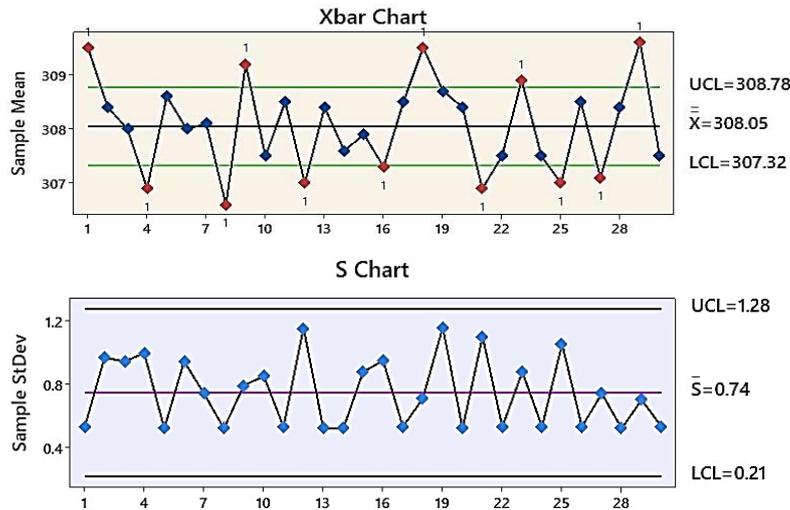


Fig. 10. Xbar -S chart graph.

By using C_p calculations by Minitab, it was discovered that the process now produces incapable water volume. The C_{pk} value is nearly identical to C_p , indicating that the process meets the specification. So, if C_p is less than 1.0 ($C_p < 1.0$), then the process is incapable. The S chart shows that the process has irregular variations in C_p and C_{pk} as shown in Fig. 11.

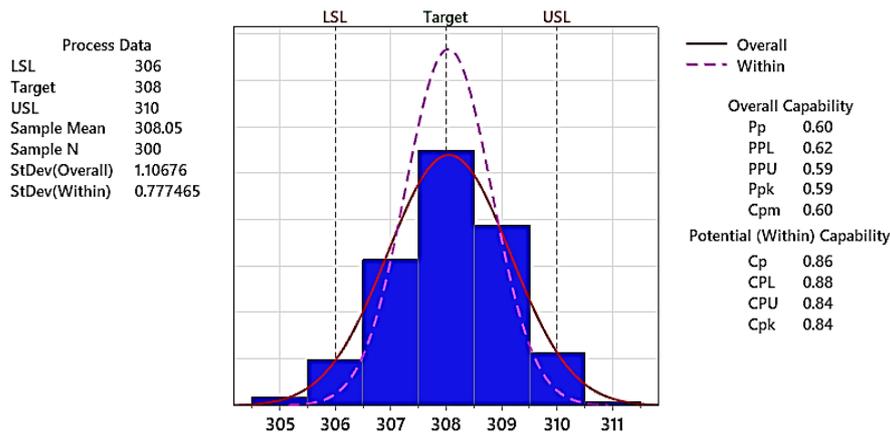


Fig. 11. Target of specification limit on capability histogram.

4.3.2. Ishikawa diagram

According to the Ishikawa diagram as shown in Fig. 12, the majority of the aspects or issues affecting product reliability in production are primarily caused by the Method, Man and Machine factors. Material factor has the lowest percentage, meaning it has the lowest effect of the 4M factors.

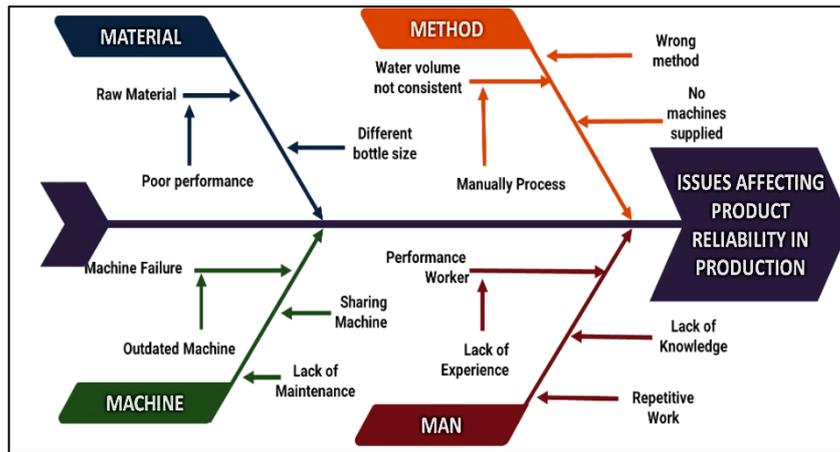


Fig. 12. Ishikawa diagram for issue affecting product reliability.

4.3.3. Why-why analysis

The why-why analysis in Table 2 is performed to determine the causes and underlying cause of an issue in the workplace. The why-why analysis is a method of analysing and determining the fundamental reasons for a problem. It will discover genuine reasons and prevent failures from recurring.

Table 2. Why-why Analysis with root cause.

Main Factor	Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Root Cause
Method	Water volume is inconsistent	Manually reduces the quantity of water on the soy bottle	Have no specific machine to reduce water	No machine supplied	No investment	No financial support	Not enough investment on automatic machine
				Improper systematic format	Not supporting tools for approach improvement	Lack of knowledge	Poor instruction & job description
Man	Poor Performance Worker	Less manpower	Worker not interested on department	No proper planning	No knowledge	No training	No training cost provided
			No proper worker's working division	Repetitive work	Workers become bored & fatigued	-	Lack of motivation
Machine	Sharing Machine for each product	Soybean Machine Failure	Outdated machine	Lack of investment on new machine	No financial support	No person in charge	Poor monitoring
			Improper handling machine	Lack of knowledge about machine	Lack of experience	Lack of training	Inadequate experience

4.4. Improvement proposal

The process improvement strategy is the vision, goals, and set of steps that will allow an organization process to attain a sustainable competitive advantage by addressing the inefficiencies, waste, asset condition, and culture within the process and its industry leaders. Based on this statement, several improvements were made to improve the product reliability of soybean production in the F&B industry. Table 3 shows the proposal for improvement based on the root causes identification.

Table 3 The root cause and proposed action.

	Root Cause	Propose Action
Method	Not enough cost to investment in automation.	Find a lower cost way to invest and rebalance regularly on automation.
Man	Poor Instruction & job description	Make an appropriate work instruction.
	No training cost provided.	Provides a specific training that related to position or responsibility.
	No creativity on work.	Provides a clean and fragrant environment and large space.
Machine	Inadequate maintenance.	Provides an appropriate schedule for maintenance.
	Inadequate experience.	Use free online resources.

4.5. Controlling the improvement

To the best of research knowledge, the industry method of control is the application of the DMAIC principle in the final section of the research. The purpose of DMAIC is to make sure that the proposed improvements to the manufacturing process are carried out consistently and sustainably.

Firstly, a preventive maintenance plan can be cost saving to the company because it will help employers and employees to focus on preventing the machine failure rather than reacting in case of emergencies. A better maintenance schedule can ensure that all machine is inspected at the appropriate frequency to control the mechanical failure that requires maintenance.

Next, a checklist of elements that the industry must verify, check, or inspect. The checklist can be used in various fields, from construction to healthcare, but in this case, the checklist is used to monitor the process performance. A process performance checklist assists in identifying performance actions on the machine to keep it in perfect working condition and improve the product's reliability in production. Lastly, arrange a "Time for Workers to Check the Water Level". This method is to control or check the volume of water effectively. The ideal way to conduct an inspection is to weigh water bottles using a kitchen-used beverage weighing scale.

Additionally, this tool serves as a visual representation of the path leading to the root cause of any problems that occur in industries. Additionally, this tool is highly effective because it can aid in generating ideas about the root cause of a problem and then present the details in a structure resembling a fishbone.

In conclusion, the process capability is the maximum number of processes created in a given time. It should be implemented effectively and includes the items that most businesses can afford. While examining this aspect of the company, it is necessary to develop it for future projects. Capability studies help to determine the company's production capacity within tolerance limits and technical standards.

Capability analysis can be used on machines and production periods alike. The situation is similar to the first objective, which is to identify the product's reliability.

The process too encourages to use C_p / C_{pk} indices to determine the upper and lower specification limits required to resolve issues in the F&B industry. Determining the C_p / C_{pk} method's reliability is the second goal. During production, capability studies reveal the system changes and new features. This is used to test the system's tolerance limits. As a result, irregularities and defects in average process dimensions are possible to be detected.

Finally, creating the C_p / C_{pk} indices had improved the manufacturing process reliability. Process capabilities can also identify, and correct issues based on documentation, research, and data analysis. Moreover, using the Process capabilities could improve and determine the reliability of the current production system's products.

5. Conclusion

In conclusion, the process capability is the maximum number of processes created in a given time. It should be implemented effectively and includes the items that most businesses can afford. While examining this aspect of the company, it is necessary to develop it for future projects. Capability studies help to determine the company's production capacity within tolerance limits and technical standards. Capability analysis can be used on machines and production periods alike. The situation is like the first objective, which is to identify the product's reliability.

In this study, define of study is to determine the scope of study. Therefore, the process flowchart and the layout are important source in order to identify the specific of study's area.

Then, measure the data is essential in order to collect data from appropriate area in production which related to the water volume level including the value of the identified factors.

In analysis stage, Study data are collected to determine the factors that significantly affect to the water volume. The Minitab's software had been used to calculate the C_p and C_{pk} . In order to identify the root causes, the Ishikawa Diagram had been studied based on significant factors such as Main, Method, Machine and Material. Then, the Why-why Analysis had been used in order to confirm the actual root causes.

Appropriate action had proposed based on the identified root causes. The action is considered as an improvement shall be taken by the organization. Anyway, it is dependent to the criticalness to the respective organization.

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Finally, creating the C_p / C_{pk} indices had improved the manufacturing process reliability. Process capabilities can also identify, and correct issues based on

documentation, research, and data analysis. Moreover, using the Process capabilities could improve and determine the reliability of the current production system's products. The organisation should use the C_p / C_{pk} approach to resolve the situation.

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Appendix A

Data collection for Cp, Cpk and for Xbar-S chart.

Subgroup (SG)	Sample (n)									
	1	2	3	4	5	6	7	8	9	10
1	309	310	309	309	310	310	309	310	309	310
2	309	310	309	309	308	308	308	309	307	307
3	307	309	307	309	307	309	307	308	308	309
4	306	307	307	305	306	308	307	307	308	308
5	308	309	308	309	309	308	308	309	309	309
6	309	309	309	307	308	307	308	307	307	309
7	307	308	309	308	307	309	308	309	308	308
8	307	306	307	307	307	306	307	306	307	306
9	310	308	309	310	310	309	309	308	309	310
10	308	308	308	308	307	308	306	308	306	308
11	308	309	309	308	309	308	308	309	308	309
12	308	308	305	306	306	308	308	307	308	306
13	309	308	308	309	308	308	309	309	308	308
14	308	307	308	307	307	308	308	307	308	308
15	308	308	307	307	309	307	307	308	309	309
16	307	309	307	307	307	306	306	308	308	308
17	308	308	309	308	308	309	309	309	308	309
18	309	309	311	309	310	309	310	309	310	309
19	310	307	309	309	310	307	310	309	308	308
20	308	309	309	308	308	309	308	308	309	308
21	306	305	306	308	307	308	308	307	306	308
22	308	307	308	307	308	307	308	307	308	307
23	308	310	308	310	310	309	308	308	309	309
24	307	308	308	308	307	308	307	307	308	307
25	307	307	306	308	305	308	306	308	308	307
26	309	308	308	308	308	309	309	309	308	309
27	308	307	308	306	307	307	307	307	306	308
28	308	309	308	308	309	309	308	309	308	308
29	309	309	310	309	309	309	311	310	310	310
30	307	308	308	307	308	308	308	307	307	307