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PROCESS CAPABILITY ANALYSIS OF KATSUOBUSHI PRODUCTION AT PT. ABC

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ABSTRACT

Process capability in processing fishery products is a future challenge for the fish processing industry, one of it is katsuobushi. The capability process refers to how a company can produce according to specifications to make it effective and efficient. The absence of process capability in the company is the basis for stating an effective and efficient process. The aim of this study to improve the company's current condition and provide suggestions for process improvement and evaluation. Through assumptions, this study influences the results of Cp and Cpk, which are calculated by Minitab software version 21st as a method for measuring performance by identifying broad process tolerance production. In this study, the results for each data generated met data accuracy and standards. Still, at smoking 3rd and 4th stages, it was necessary to review specification values because of the value of Cpk < 1.00. As a result, after improving the standard by the six sigma concept, Cpk values are obtained > 1.00.

Keywords: Process Capability, Minitab software version 21st, Katsuobushi, *Cp*, *Cpk*

I. INTRODUCTION

One of the marine resources in Indonesia is skipjack tuna which has relatively high economic value for local consumption and export (Tumonda, Mewengkang, & Timbowo, 2017). In 2022 the value of tuna, cob and skipjack tuna production reached 865 million USD and will be increase 8,84% (KKP, 2023). One of skipjack tuna processing with a high export value is katsuobushi. In the processing of katsuobushi, smoking method is used, which aims to preserve fish and give it a distinctive aroma and taste (Tinuwo, et al., 2019). According to (Rieuwpassa, Tomasoa, Tanod, Ferre, & Karaeng, 2022) and (Puspita, 2020), katsuobushi is a type of processed fish product that has undergone a series of processes, such as boiling and multilevel smoking, so that the texture becomes as hard as wood and has a dark brown-black color. Katsuobushi contained nutrients including 9,26 % fat and 51,80% protein (Suliastini, Tamrin, & Isamu, 2017). (Karo, Sukirno, & Leksono, 2016) stated that katsuobushi is a processed product of marine fish that has undergone a series of processes so that the texture becomes problematic and has a blackish-brown color. The raw materials processing Katsuobushi are skipjack tuna (*Katsuwonus pelamis*).

Fish processing must pay attention to aspects of quality and productivity. Quality aspects can be seen from the products quality, and productivity aspects can be seen from the product yield (Waluyo *et al,* 2022). In processing productivity data in the form of yield, several tools are needed to process the data to produce conclusions. One of them is the statistical tools used to process numerical data. Many computer-based applications, including Minitab (Abatan, Olafadehan, Efeovbokhan, Oladokun, & Ayeni, 2023)**,** can process statistics. Minitab can detect capability from data generated by the production process. The features used in Minitab to determine process capability values ware *Cp* (Capability Potential) and *Cpk* (Capability Index) (Abatan, Olafadehan, Efeovbokhan, Oladokun, & Ayeni, 2023).

Utilization of statistical tools has yet to be widely used in PT. ABC, which is a katsuobushi processing company. So that in this study, we had to use a reference related to the application of statistical capability processes in the fishery processing industry. Previously nothing was found related to the history of similar research implemented in industrial fisheries that could be used as a reference. The reference used is an implementation in the food industry carried out by the food and beverage industry carried out by Rasib *et al*, in 2023. The reference is valid because same as the food industry.

Evaluating the process capability indices, several capacity indices have been proposed. *Cp* and *Cpk* are two of the most widely used indices in the process capability. These capability indices assess product's or service's current ability to meet the design specifications (Rasib *et al*, 2023). Process capability index is a straightforward and easy-to-understand measure of process capability. According to Yusof *et al*. (2019) 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 *Cp* will rise. However, Polhemus (2018) stated that *Cp* just considers how easily visible the figures measurements are. As a result, *Cp* is simpler to use but less useful. The *Cp* is easier compared to *Cpk* to make measurements for some process. Since it considers the mean and standard deviation in its measurement, *Cpk* is more commonly used than *Cp*. The difference between Cp and Cpk shows how much the process average deviates from the targeted specification (Udroiu & Braga, 2020). When the process is competent, the project performance controllers can be utilized to manage it, allowing standard approval efforts to be decreased or abolished entirely (Udroiu & Braga, 2020). The difference between *Cpk* and *Cp* closes as the process average reaches the target value and *Cpk* would never be larger than *Cp*. Here means that the generation of descriptive statistic views and histograms can be used to measure *Cp* and *Cpk* as shown in Figure. 1.

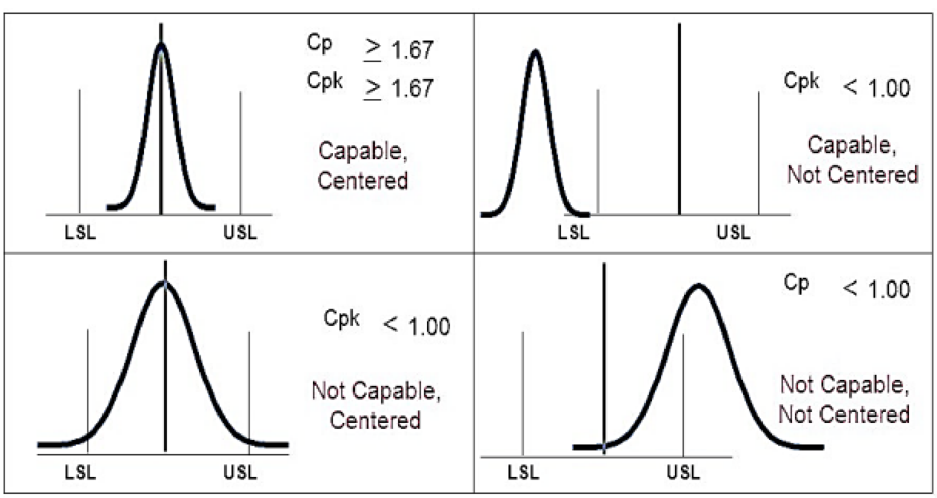

Figure 1. Relationship between *Cp* and *Cpk*

Minitab program is statistical software used to facilitate the process of interpreting data, from data entry to forecasting the data it self. This program can be used as a data processing medium that provides commands in data entry, data manipulation, graphing, numerical analysis, and statistical analysis (Abatan, Olafadehan, Efeovbokhan, Oladokun, & Ayeni, 2023). The advantage of the Minitab program compared to other programs in forecasting is that it can provide a more precise and thorough picture in analyzing data because it goes through several stages so that the model we get is perfect. The estimated value is hoped to be closer to reality (Abatan, Olafadehan, Efeovbokhan, Oladokun, & Ayeni, 2023). The Minitab menu that will be used is the capability process which can see how much accuracy the data (*Cp*) obtained is compared to the standards the company sets (*Cpk*) (Pratama & Susanti, 2018). Based on the Six Sigma concept, the value of a process is considered capable if it has a minimum *Cp* and *Cpk* value of more than 1.00 (Pratama & Susanti, 2018).

II. RESEARCH METHODS

2.1 Time and Place of Research

14 Februari - 23 April 2022 and PT. ABC Bitung, Bitung, Sulawesi Utara

2.2 Materials and Tools

Materials: Production Data PT. ABC

Tools: Mini Tab version 21st for Windows and Microsoft Excel 2019

2.3 Research Methods

The material used is the yield production data for each stage of the production process taken directly (primary data). The data collection process is carried out through interviews/direct conversation interviews with parties concerned with the production process and data during the production process.

2.4 The data confidentiality agreement obtained from the company becomes a consideration with the company so that the name is disguised in this publication. The data can be used for scientific research. This research seeks to answer problems related to processes that companies feel are unstable and cannot use statistics, so they work with educational institutions. During the research, the data obtained was in the form of manual data in the form of a log book which must be interpreted into digital data to make it easy to process. The company can provide it with digital data by capability operators using a personal computer, and they welcome any process changing for improvement.

III. RESULTS AND DISCUSSION

3.1 Production Flow Process

The production process of katsuobushi is carried out by receiving raw materials skipjack tuna at a temperature of < 5 ºC, and then sorting them according to the established criteria. The fish is washed and boiled at 95 ºC for 65 minutes, and the bones are removed. The fish is cooled to room temperature, dried, and arranged on a smoking rack according to standards. The fish were smoked four times for 12 hours each at 70 - 80 ºC two times and 5x24 hours at 40 - 50 ºC two times using smoke and cooling at each stage of the process. The product is subjected to metal detection to avoid any metal as contaminant (Berhimpon, *et al.*, 2019) and weighed according to specifications. The product is packaged for storage before being exported to the destination country. The smoking is intended to increase the penetration of chemical components of smoke, especially phenolic compounds (Puspita, 2020). (K, Dali, & Harmain, 2020) found that protein content increased in each stage of smoking. Stage 1 smoked skipjack fish has a protein of 22.37%, then changed to 40.21% at stage 2 and to 58.07% at the final stage. The fat content also increased, from 20.26% at stage 1 to 27.62% at the final stage.

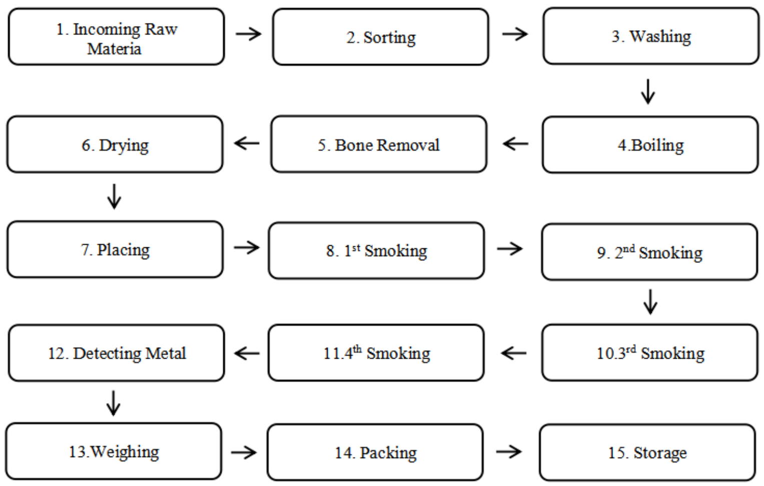

Figure 2. Katsuobushi production flow process

3.2 Standard Yield of Katsuobushi Processing

Yield is the value of comparison of the final product with the initial raw materials expressed in percent (Choo, Azlan, & Khoo, 2018). The yield of katsuobushi processing depends on the size and weight per fish used as raw material, handling during processing, and processing skills. The yield of fish processing can be calculated by comparing the final product with the initial raw materials starting from the receipt of raw materials to the packaging process by (final weight ÷ initial weight) × 100%. Yields for skipjack tuna to be processed into katsuobushi have different yields based on the weight scale of skipjack tuna (Purnomo and Selasa, 2022). The higher weight of processed skipjack tuna, the higher yield, but the higher raw material price. Ideally, the weight of skipjack used will be optimal in the 1.88 - 3.00 kg per fish range.

Table 1. Standar of yield katsuobushi processing

Weight of skipjack tuna (Kg)	Yield of katsuobushi processing
> 3.35	19.20%
2.63-3.00	18.50%
1.88-2.25	17.20%
1.50-2.00	16.20%

3.3 Yield Each Step Processing

Based on the results of observational data for one month (17 Februari - 17 March 2023) of the production process at PT. ABC, it was obtained that with an initial amount of raw material receipt of 101.31 Kg, a yield of 22.51% was obtained with a weight of 22.80 Kg. This result is relatively high because the skipjack tuna used is 1.88 - 3.00 Kg in size, which is 17.20 -18.50% by the standard. High yield value is due to the production team of PT. ABC, in detail oversees of the production process. It is necessary to determine the yield standard for each stage of the process in order to determine whether it is in accordance with the results or not (Rimantho & Athiyah, 2019).

Table 2. Calculation of yield katsuobushi in one month production

Step	Wight (Kg)	Yield
Raw Material Receiving	101.31	100.00%
Boiling	79.08	78.06%
Bone Removal	55.85	55.13%
Drying	44.67	44.09%
1st Smoking	36.00	35.53%
2nd Smoking	29.39	29.01%
3rd Smoking	25.29	24.96%
4th Smoking	22.80	22.51%

3.4 Process Capability Each Step Processing

Based on the katsuobushi production process, monitoring each stage of process capability starts in the boiling process until 4th smoking. The Data processing using Minitab version 21st with a capability six-pack menu to calculate data of *Cp* and *Cpk*. We take the data for each stage determines each stage related to process capability. Process Capability data at the boiling stage found that the *Cp* and *Cpk* values were > 1.00 with *Cp* 1.22 and *Cpk* 1.10, so the process was capable of the results obtained with the specifications set by the company. The standard set by the company for fish weight ranges from 8.00 kg - 11.00 kg in one production process. Boiling process capability ahead on the initial weight of the product to be carried out in the heating process, this boiling will produce a soft and uniform product in its water absorption (Tinuwo, et al., 2019), which causes the uniformity of the data obtained.

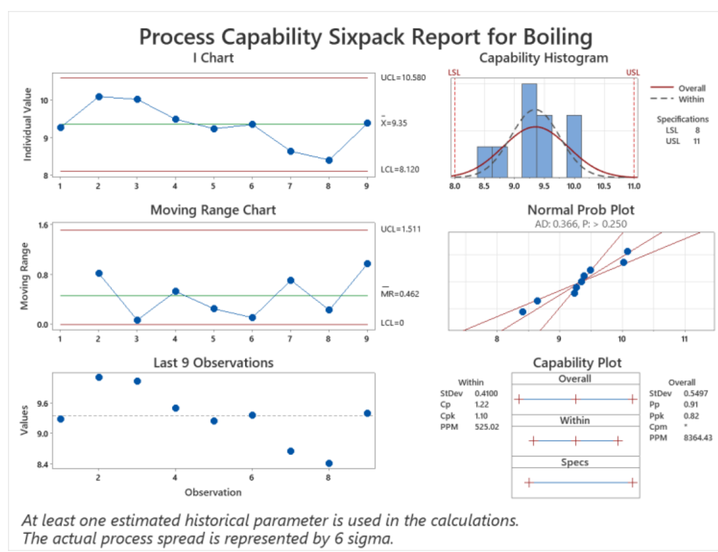

Figure 3. *Capability process* Minitab boiling step

After the boiling process, then the production process continues with the process of removing the bones, cutting off the head and removing the entrails of the fish.

The result is a significant reduction in fish weight because from the previous minimum weight of 8.00 kg to 1.80 kg per basket. The results of processing the capability process obtained data that the *Cp* and *Cpk* values are the same, namely 1.12, this indicates that the specification setting is correct compared to the process capability (Sunarti, 2023). *Cp* is equal to *Cpk* occur when the standards set by the company for bone removal weight are the same as their process capabilities (Rasib, et al., 2023).

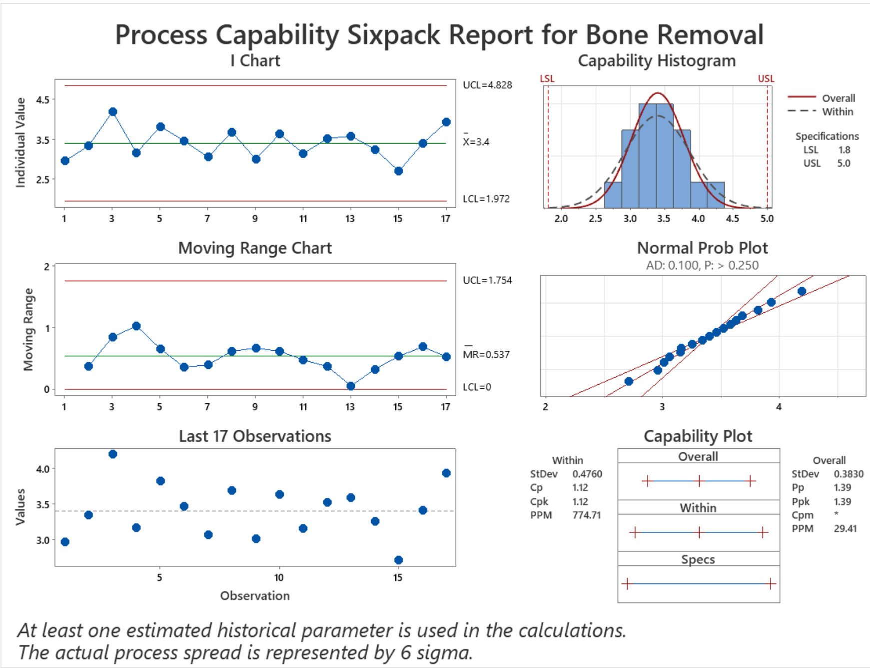

Figure 4. *Capability process* Minitab bone removal step

The fish that has had its bone removed is then subjected to the drying process. Theoretical drying will reduce the weight of the fish according to its equilibrium water content (Tinuwo, et al., 2019). In processing data to see the process capability, the results show that *Cp* and *Cpk* values exceed 1.00; for Cp, it is worth 1.52, which proves that the data is quite capable and Cpk is 1.41; this proves that the placement of the specifications that have been determined at this stage is correct. Fish drying can be considered uniform in all baskets because water reduction in all fish occurs almost evenly and under almost the same conditions (Tinuwo, et al., 2019). This drying process can be declared capable from the data and specifications.

After drying, the fish is arranged on a tray before being put into the smoking cupboard. The smoking consists of 4 stages, starting from the first and second stages, which are smoked for 12 hours at a temperature of 70 - 80 ºC. The third and fourth smoking was performed 5x24 hours at 40 - 50 ºC. The first smoking process removed the remaining water from the fish body. The first smoking will result in a significant weight reduction compared to the subsequent smoking stages. Regarding process capability, the data obtained is that *Cp* and *Cpk* reach a value of > 1.00. From a six sigma concept, it can be said that both the process and specifications set are capable (Rasib et al, 2023).

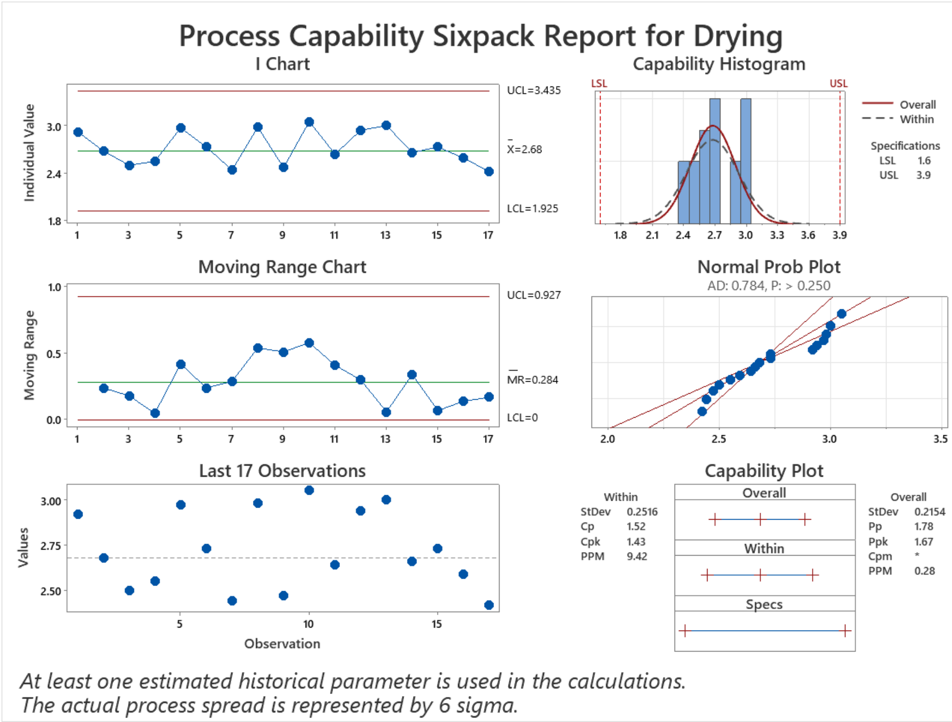

Figure 5. *Capability process* Minitab tahap pengeringan

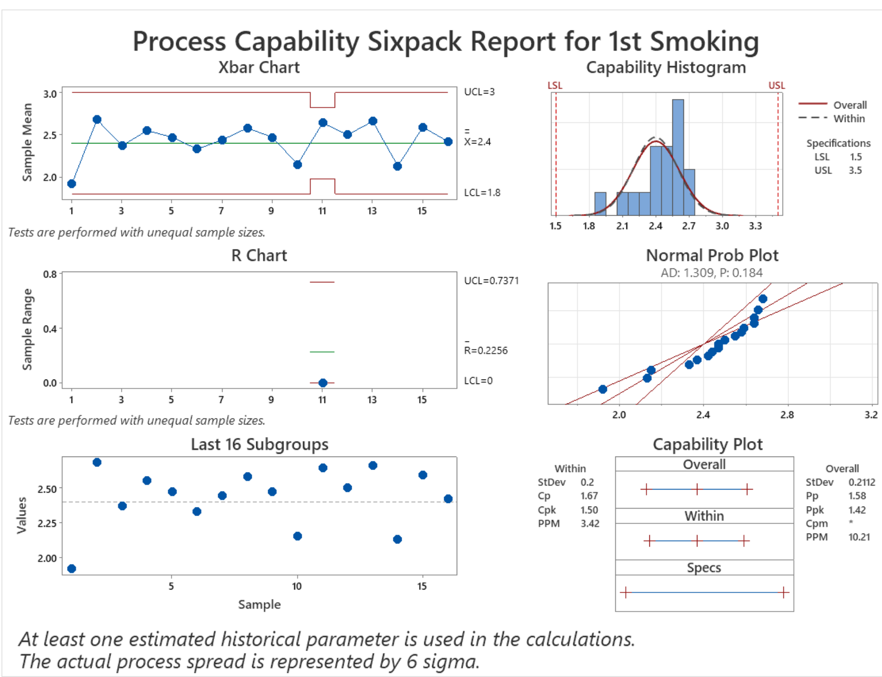

Figure 6. *Capability process* Minitab 1st smoking step

The second smoking step is continued after the first smoking. The function of second smoking is to decrease the water in fish so that it leaves only a little water in the fish, making it dry. At this second smoking stage, the water that will come out of the product has reached the optimal stage, and only a little water will come out at the next stage. Based on the capability process, the data obtained is that *Cp* and *Cpk* reach a value of more than 1.00. Both the process and specifications set are capable of a six sigma concept (Rasib et al, 2023).

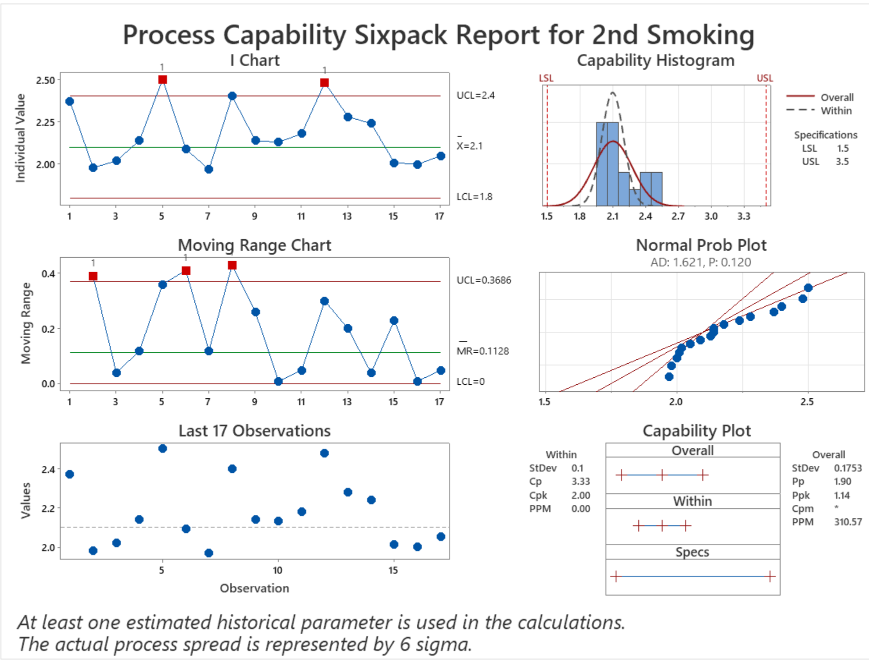

Figure 7. *Capability process* Minitab 2nd smoking step

The third and fourth smoking processes are carried out to make the katsuobushi taste drier and tastier. It will be tastier because the water content will be minimal, and the protein denaturation reaction in fish. This stage plays an important role related to the aroma and taste produced. The longer the drying process, the more dry and tasty the product, but the longer the time, the more energy it will take. The results of process capability on the parameters *Cp* and *Cpk* for the third and fourth smoking processes are obtained; *Cp* is capable because it gets a value of more than 1.00, while *Cpk* is < 1.00, means that the process of determining the specifications is not correct, this is evidenced by the histogram capability for the peak being on the left side of the graph, which means that the specifications need to be adjusted (Rasib et al, 2023).

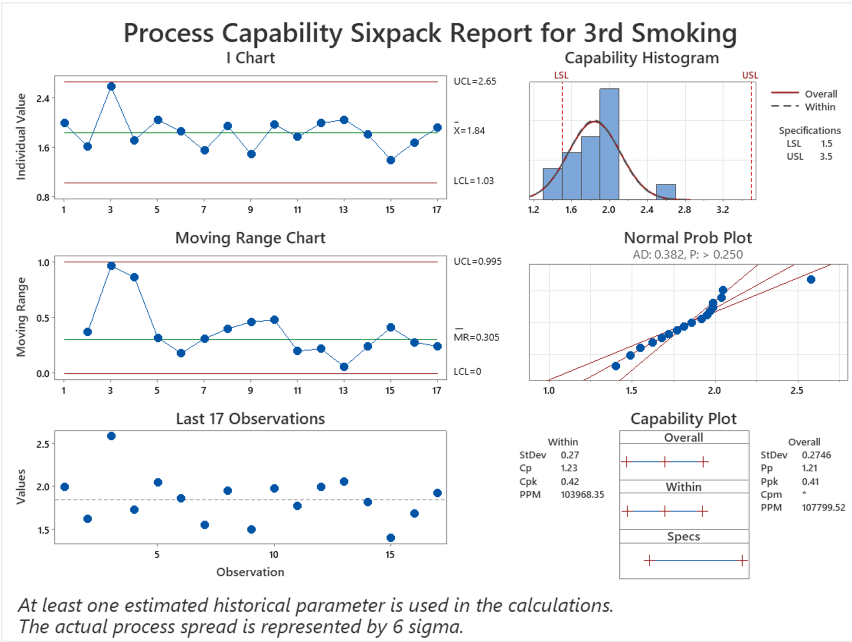

Figure 8. *Capability process* Minitab 3rd smoking step

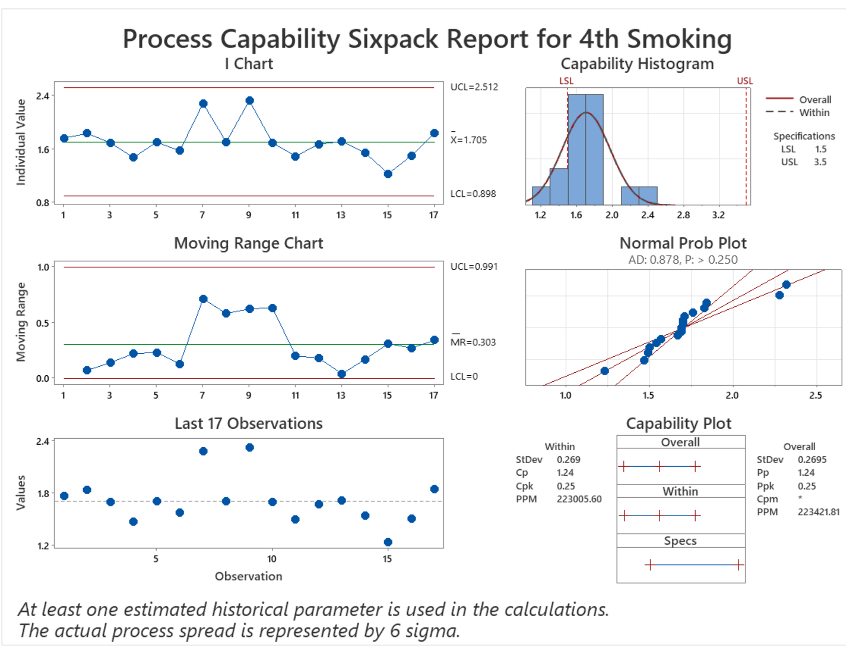

Figure 9. *Capability process* Minitab 4th smoking step

3.5 Improving Specification

Improvements were made on the third and fourth smoking, where the *Cp* results were found to be > 1.00; this indicated that the process was stable and capable, but looking at the *Cpk* data, which was < 1.00, it can be seen that the common capability histogram value exceeds the specifications that have been set (Rasib et al, 2023). This result exists because the company sets specifications for the third and fourth smoking stages, the same as the first and second. It is not correct condition because the amount of water will continue to decrease with smoking, so specifications need to be changed as smoking occurs. In six sigma specification determination of capable data, minimum = median - standard deviation and maximal = median + standard deviation (Rasib et al, 2023). The concept of 3 times the standard deviation shows that a capable process has a deviation ratio of 3 times the standard deviation (Yusof, 2019). Improvements to the standard with 3 times standar deviation concept showed promising results in the third and fourth smoking. The *Cpk* value obtained reached > 1.00, and this standard change was said to be successful.

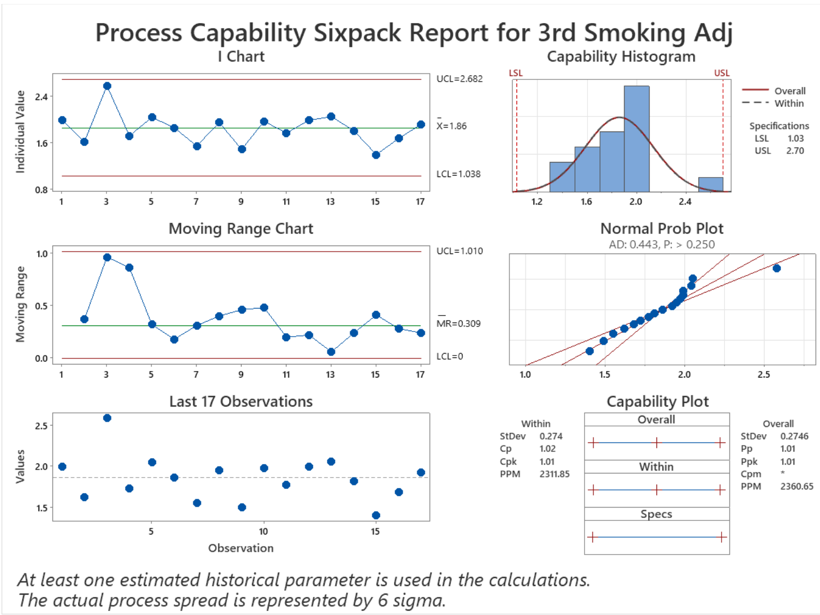

Figure 10. *Capability process* Minitab 3rd smoking step after adjustment

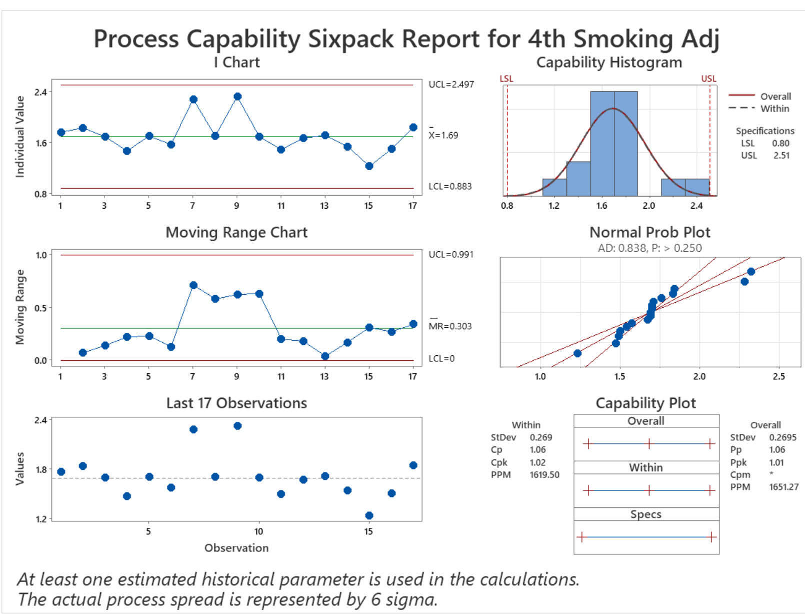

Figure 11. *Capability process* Minitab 3rd smoking step after adjustment

IV. CONCLUSION

PT. ABC has carried out yield mapping, which includes several processes, flows, and calculations, starting with boiling, bone removal, drying, and smoking. The final weight of the product obtained from sampling 101.31 kg of raw materials is 101.31 kg, with a yield value of 22.5%. The results of this yield are more than the standards obtained in previous studies. The data for each stage of the process is then validated through the *Cp* and *Cpk* capability processes, where at the third and fourth smoking stages, it is necessary to review the data specification because the value of *Cpk* < 1.00. Improvement made a new standard by the six-sigma concept with mean + or - 3 times standard deviation to make a good specification from data capable. Based on the new standard, the third and fourth smoking value of Cpk is > 1.00, which means the new specification is good.

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