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# Quality Control of Palm Oil Production (Crude Palm Oil) Using SPC Method

(Case Study at PT. BPG)

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***Abstract*—This research was conducted to analyze, knowing, and give an overview of the production process conducted by PT. BPG using Statistical Process Control (SPC) method. The research data is daily production data from January 2015 until December 2016. The results showed that the content of Free Fatty Acid and the level of dirt is still beyond the specified limits by National Standardization Agency (BSN) No. SNI-01-2901-2006. After analyzing using cause and effect diagram obtained source of problem from material factor, man, environment and method. In the Improve stage, a recommendation proposal is based on the analysis of the cause and effect diagram and the 5W+1H method with the aim of addressing the existing problems and reducing the level of disability that occurs. The proposals obtained are to provide additional standard criteria of fruit grading and provide training and refreshment for existing SOP-related laborers on the correct processing of fruit, in addition to the fruit shelter area made of cover so that the fruit is not exposed to direct sun and rain.**

***Keywords: SPC, 5W+1H, Crude Palm Oil***

## I. INTRODUCTION

The palm oil industry is a commodity that contributes the most to the Indonesian economy, this industry must be able to carry out its operational activities while maintaining environmental sustainability. Zero waste management is a concept that is being promoted in order to encourage industry actors in the country to run their businesses more responsibly.

Indonesia established the Indonesian Sustainable Palm Oil (ISPO) in 2011, which aims to improve the global competitiveness of Indonesian palm oil and regulates in tighter environmental regulations. All palm oil producers in Indonesia are encouraged to obtain ISPO certification, even though ISPO is not internationally recognized, its certification standards indicate the quality and safety of the products produced.

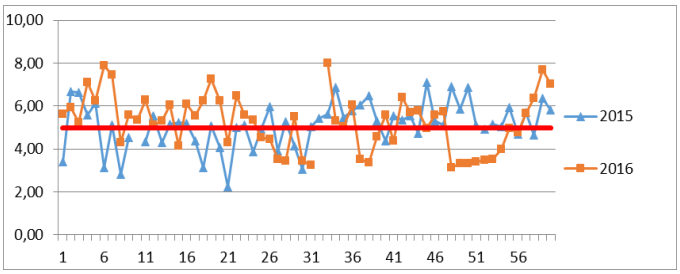
Quality control activities need to be carried out continuously by every business institution. Crude Palm Oil (CPO) products produced by PT. BPG referred to the CPO quality standards set by BSN (the national standardization agency). The government in implementing the program through BSN has set CPO quality standards contained in SNI-01-2901-2006, namely:

TABLE I. CPO QUALITY STANDARDS IN ACCORDANCE WITH INDONESIAN NATIONAL STANDARDS

| No | Characteristic | Information |
|---|---|---|
| 1 | Free Fatty Acid Level (FFA) | < 5.00 % |
| 2 | Moisture content (moist) | < 0.50 % |
| 3 | Levels of Dirt (dirt) | < 0.50 % |
| 4 | Iodine Numbers | 50-55g / 100g TBS |
| 5 | Color CPO (Crude Palm Oil) | Reddish Orange |

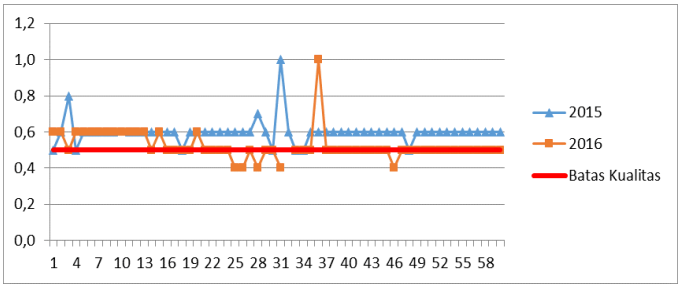
Source: National Standardization Agency

In producing CPO palm oil, the company determines quality specifications based on the provisions of the national standardization agency, but the realization of the quality of palm oil (CPO) of PT. BPG is still not in accordance with the provisions of the production quality standardization issued by the National Standardization Agency (BSN). The discrepancy could be seen in figure.




Source: Production Report PT. BPG 2015 & 2016

Fig. 1. Free Fatty Acid levels (FFA) 2015 and 2016.




Source: Production Report PT. BPG 2015 & 2016

Fig. 2. Levels of dirt 2015 and 2016.

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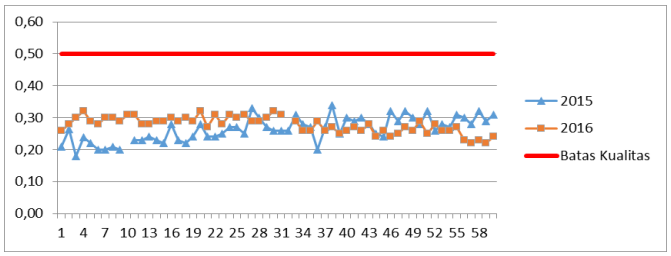



Source: Production Report PT. BPG 2015 & 2016

Fig. 3. Percentage of water content moist 2015 and 2016.

Based on the scatter diagram data shows the high percentage of product defects in the production of PT. BPG which is in the parameters of free fatty acid (Free Fatty Acid) FFA and Dirt content. The high percentage of defects in the last 2 years has come to the attention of PT. BPG, and the management are committed to make improvements to improve the quality of these products through reducing the number of reject products produced by first finding out the factors that cause the low quality of products produced

The purpose of this study: Knowing the source of the problem that is the cause of product defects. Knowing and providing recommendations for improvement of problems that occur, with the hope that the company can make continuous improvement in improving the quality of CPO produced by PT. BPG is in accordance with SNI standards set by BSN. And know the control process that can be recommended in achieving SNI.

## II. Theoretical Review

### A. Quality

Juran defines quality as fitness for purpose, which is based on the definition of quality as meeting requirements or conformity to needs [1]. While Feigenbaum refers to quality as an overall composite of characteristics of products and services in marketing, engineering, manufacturing, and maintenance where the products and services used can meet consumer expectations [1]. Quality is the overall features and characteristics of the product or service that is able to satisfy the needs that are visible or vague [2]. Quality is goods or services that meet customer specifications or requirements [3]. Whereas in ISO 9000, quality is the ability of a unified product, system or process characteristic to meet the stated or implied customer or related party requirements.

### B. Product Quality

According to Montgomery, the dimensions of good product quality consist of [4]:

- Performance, which is related to the functional aspects of an item and is a major characteristic that customers consider in buying the product. This dimension answers the question 'will the product fulfill the desired task?'
- Additional features or features, namely secondary or complementary characteristics, related to product choices and their development. This dimension explains what the product can do.
- Reliability (Reliability), which is less likely to experience damage or failure to use. In other words the success of the function in use at certain time periods and under certain conditions. This dimension discusses how often the product fails.
- Conformance to Specification (Conformance to Specification), i.e. the extent to which design and operating characteristics meet predetermined standards. This dimension answers the question ‘is the product made exactly as the designer wishes?’
- Durability, which is related to how long the product can continue to be used. This dimension answers the question 'how long does the product last?'
- Service ability, including speed, competence, comfort, easy to repair, satisfying complaint handling. This dimension explains the ease in repairing product damage.
- Aesthetics, a characteristic that is subjective, namely the attractiveness of the product to the five senses and the reflection of individual preferences. This dimension answers the question 'What does the product look like?'
- Fit and finish, subjective nature, is related to the customer's feelings about the existence of the product as a quality product. This dimension discusses the reputation of the company making the product or the product produced.

### C. Statistical Process Control

Quality control of statistical processes is a problem solving technique that is used as a monitor, controller, analyzer, manager, and improve the process using statistical methods. The philosophy on the concept of statistical process quality control or better known as statistical process control is the output in the process or service can be put into statistical control through management tools and design actions [5].

### D. Seven Tools

The seven tools are simple statistical tools used for problem solving. Kaoru Ishikawa has stated that these 7 tools can be used to solve 95 percent of all problems. These tools have become the foundation of the amazing rise of Japanese industry after the second world war [6].

### E. Control Map

Control chart is a line chart by listing the maximum and minimum limits which are control limits. This chart shows changes in data from time to time but does not indicate the cause of the deviation, although the existence of the deviation is seen in the control chart. Control chart can be used for data type size (length, volume, weight), type of count (number of rejections, number of defects, amount of damage) [7].

### F. Control Map X and R

Basically every control map has a central line (central line) denoted by CL and a pair of control limits, one control limit placed above the center line as the Upper Control Limits

(UCL), and another below the center line as Lower Control Limits (LCL) [8].

*1) Equation for graph R*

$$\bar{R} = \frac{\sum_{i=1}^{g} Ri}{g} \quad (1)$$

$$\text{Upper Control Limit (UCL)} = D4 * \bar{R} \quad (2)$$

$$\text{Lower Control Limit (LCL)} = D3 * \bar{R} \quad (3)$$

*2) Equation for graphs X*

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}_i}{g} \quad (4)$$

$$\text{Upper Control Limit (UCL)} = \bar{\bar{x}} + A_2 R \quad (5)$$

$$\text{Lower Control Limit (LCL)} = \bar{\bar{x}} - A_2 R \quad (6)$$

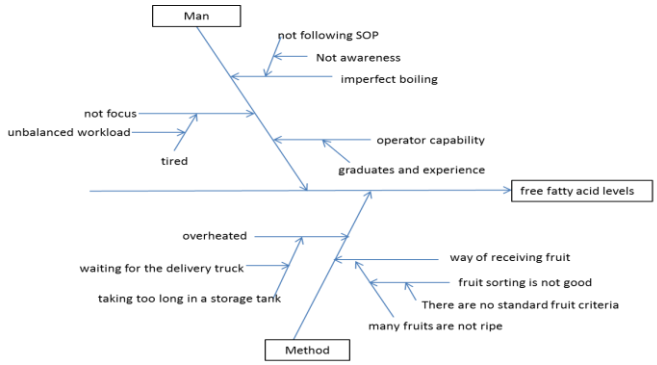
## III. METHOD

This research was conducted using descriptive analytical methods and semi-experimental methods, namely solving by describing and interpreting objects according to what they are as well as obtaining a comparison and analysis of results before and after the application of Total Quality Management with Statistical Process Control methods.

The study was conducted on the finished product or the processed oil palm fruit at PT. BPG is crude palm oil (CPO) during 2015 to the end of 2016. Analysis of Cause and Effect diagram and 5W1H to unravel the roots or sources of problems.

## IV. RESULTS AND DISCUSSION

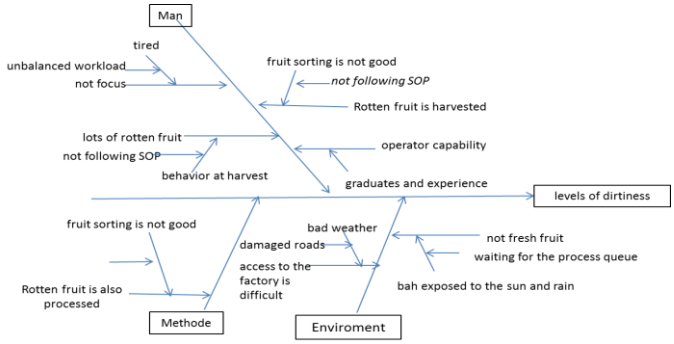
Preliminary research explains that during January 2015 to December 2016, production results have not reached the SNI target because there are still many samples that are outside the standard. After being traced, a high amount of reject is found in the parameters of free fatty acid levels and the levels of impurities contained in the Figure 4.




Source: PT. BPG (2017)

Fig. 4. Cause and effect diagram of free fatty acid levels.

Reject high fatty acid levels caused by several factors, namely: 1) Human Factors, there are at the stew station (sterilizer) operator involvement due to lack of awareness during the boiling process so it is not in accordance with the standard operating procedure (SOP). In addition, due to workload that is not appropriate, resulting in the operator unfocused and exhausted. The final cause of human factors is that competence and experience are deemed insufficient. 2). Factor Method; In the method factor, there are two causes of high defect in the acidity of CPO products, namely, because there are no good standard fruit criteria at the time of receipt of fruit and too long to wait for the delivery truck.




Source: PT. BPG (2017)

Fig. 5. Cause and effect diagram of soil levels.

Reject high levels of impurities in CPO products caused by several factors, namely: 1) Human Factors; there are 4 factors that cause high levels of dirt to reject, namely unbalanced workload, not following SOPs and graduates from plant operators. 2). Factor Method; there is no good standard of fruit criteria at the time of receiving the fruit so that there are many rotten fruits. Checking the arrival of material by the operator is not based on the appropriate standard fruit criteria because there is no company standard. 3). Environmental Factors; the fruit waits for too long so that the fruit is not fresh or even rotten. Poor infrastructure becomes an obstacle when shipping fruit to the factory so that it causes rotten fruit because it is late in processing.

### A. Map X and R Free Fatty Acid Levels

*1) Calculation of full Xbar control chart of Free Fatty Acid (FFA)*

X mean $\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}_i}{g}$

$= \frac{122.37}{24}$

$= 5.1\ \%$

R mean $\bar{R} = \frac{\sum_{i=1}^{g} R_i}{g}$

$= \frac{57.11}{24}$

$= 2.38\ \%$

UCL $= \bar{\bar{x}} + A_2 \cdot \bar{R}$

= 5.10 + 0.577 x 2.38

= 6.47 %

LCL $= \bar{\bar{x}} - A_2 \cdot \bar{R}$

= 5.1 - 0.577 x 2.38

= 3.72 %

*2) Calculation of control map of R Free Fatty Acid Levels (FFA)*

UCL $= D_4 \cdot \bar{R}$

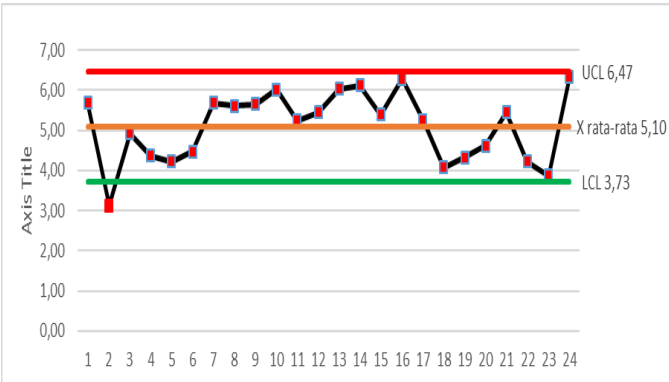
= 2.114 x 2.38

= 5.03%

LCL $= D_3 \cdot \bar{R}$

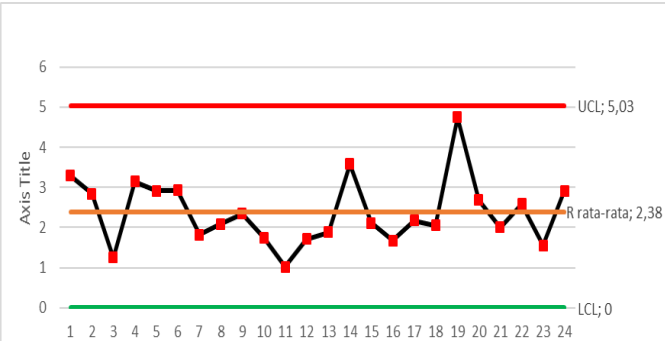
= 0 x 2.38

= 0%




\Source: PT. BPG 2017

Fig. 6. Full X bar Free Fatty Acid map.




Source: PT. BPG 2017

Fig. 7. Full R Fat Free Acid Control map.

Based on the Xbar control chart, there is 1 sample that is outside the LCL limit, namely the second data with a value of 3.13%, but this means that it is very good based on the SNI standard maximum FFA content <5.00%. However, many samples are above the average X value of 5.1%, namely in the data 1, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 21, and 24, this means that the quality of CPO PT. BPG is still not good.

Whereas for the control chart R like there is no data that is out of control and does not exceed 5.00%.

*B. Map X and R Moisture Content*

*1) Calculation of X bar control charts of dirt levels*

X mean $\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}_i}{g}$

$= \frac{13.26}{24}$

= 0.55 %

R mean $\bar{R} = \frac{\sum_{i=1}^{g} R_i}{g}$

$= \frac{2.4}{24}$

= 0.1 %

UCL $= \bar{\bar{x}} + A_2 \cdot \bar{R}$

= 0.55 + 0.577 x 0.1

= 0.60 %

LCL $= \bar{\bar{x}} - A_2 \cdot \bar{R}$

= 0.55 – 0.577 x 0.1

= 0.49 %

*2) Calculation of control chart of R soil level (Dirt)*

UCL $= D_4 \cdot \bar{R}$

= 2.114 x 0.1

= 0.21 %

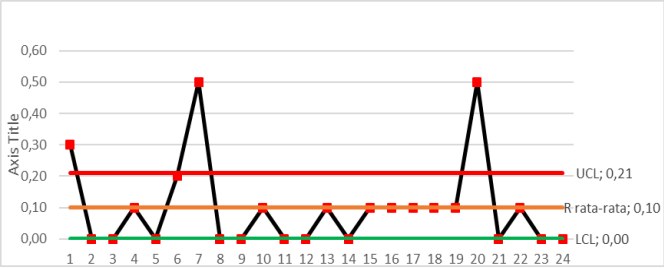
LCL $= D_3 \cdot \bar{R}$

= 0 x 0.1

= 0 %


Source: PT. BPG 2017

Fig. 8. Xbar control map of dirt levels.




source: PT. BPG 2017

Fig. 9. Control map R levels of dirt.

Based on the X-bar and R control charts, there is 1 sample that is outside the UCL limit of 0.61%, which is the 7th data, but most of the samples can be above the average X limit of 0.55%, i.e. in data 1, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, and 20. Shows the content of impurities in the CPO production of PT. BPG is still not good because it is outside the maximum limit of <0.5% set by BSN.

While the control chart R, there are 3 samples that are outside the UCL limit of 0.21%, namely the data 1, 7, and 20 and most are at an average R value of 0.1%.

With the implementation of quality control, the company can make the efficiency of the production process, especially in the palm oil CPO processing industry [8]. Success in controlling quality to maintain production sustainability in accordance with user expectations. In order to maintain product quality, quality control is carried out to reduce products that do not comply with the standards produced by the company. If the product produced by the company is not in accordance with the standards, it will require additional costs for repairs until the product cannot be marketed and eventually disposed of which causes harm to the company. So that with quality control it will help the company in cost efficiency [9].

### C. 5W+1H Method

Improvement is based on priority corrective actions at the root of the problem. The corrective action for each CPO oil production process is to use data derived from a cause and effect diagram developed using the 5W + 1H method made including:

- Improved free fatty acid levels (FFA)
- Improvement of dirt levels 5W + 1H method.

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- Improved free fatty acid levels (FFA)
- Improvement of dirt levels

TABLE II. CORRECTIVE ACTION MEASURES 5W + 1H FREE FATTY ACID LEVELS

| FACTOR | PROBLEM | WHAT | WHY | WHERE | WHEN | HOW |
|---|---|---|---|---|---|---|
| *Man* | Unbalanced workload | So that operators stay focused | To make operators not make mistakes in the production process | *All station* | While working | Balancing workload |
| | Graduates and experience | So that there are no operators who are not capable | So that every production process is handled by qualified human resources | *All station* | When hiring employees | Tightening the recruitment process |
| | employee Awareness | So that employees care about SOP | To keep work according to the rules | All divisions | When *meeting* | Provide refreshment related to SOP |
| *Method* | There are no standard fruit criteria | So that the fruit sorting activities go well | So that there is no raw fruit and ripe passing | *Loading ramp station* | When receiving fruit | Make standard criteria |
| | Waiting for the truck is too long | So that the CPO is not too long in the storage tank | So that the FFA level does not rise because it is too often heated | *Bulking station* | Every *meeting* | Coordinate with the production department and related parties |

Source: PT. BPG (2017)

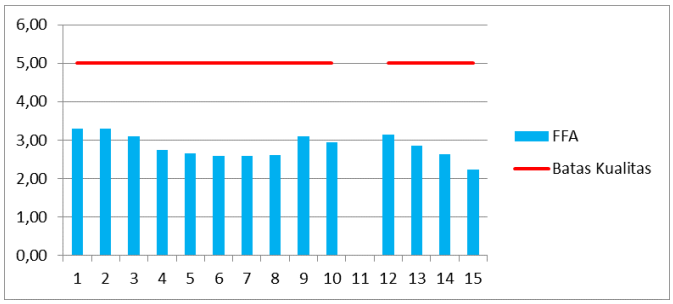
TABLE III. CORRECTIVE ACTIONS WITH THE 5W + 1H METHOD LEVELS OF DIRT

| FACTOR | PROBLEM | WHAT | WHY | WHERE | WHEN | HOW |
|---|---|---|---|---|---|---|
| *Man* | Unbalanced Workload | So that operators stay focused | To make operators not make mistakes in the production process | *All Station* | At work | Balancing Workload |
| | Not Following SOP | So that there are no operators who are not capable | So that every production process is handled by qualified human resources | *All Station* | While doing work | Provides punishment for operators who do not comply with SOP |
| | Graduates and Experience | So that employees care about SOP | To keep work according to the rules | *All Station* | During Employee Recruitment | Tightening the Recruitment Process |
| *Method* | There are no standard fruit criteria | So that the fruit sorting activities go well | So that there is no raw fruit and ripe passing | *Loading Ramp Station* | At the Reception of Fruit | Make a Criteria Standard |
| *Environment* | Damaged roads | So that the infrastructure is in good condition | So there is no delay in sending CPO | *Manajemen* | September 2017 | Propose road improvements |
| | Waiting for Process Queue | So that the fruit is not exposed to the sun and rain | Maintaining the quality of raw materials | *Loading Ramp Station* | September 2017 | Implement the FIFO Method |

## V. Implementation Results

From the results of CPO production quality testing of PT. BPG in October, November and December 2017 can be seen in the following figure 10 and figure 11.

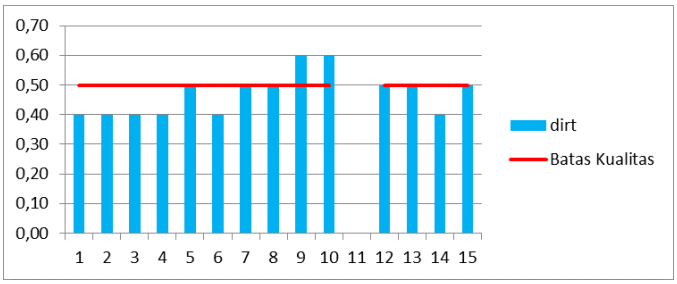
### *A. Free Fatty Acid Levels*




Source: Production Report PT. BPG (2017)

Fig. 10. Free Fatty Acid Levels (FFA) October, November, December 2017.

### *B. Dirtiness Levels*




Source: Production Report PT. BPG (2017)

Fig. 11. Levels of dirtines October, November, December 2017.

### *C. Comparison of Implementation Results*

Based on the analysis of the discussion and implementation of the improvement recommendations, the average comparison of the levels of CPO quality characteristics is summarized in Table 4.

TABLE IV. Comparison of the Value of Fatty Acid Levels and Levels of Defilement before and after the Implementation of the 5W1H Application

| Caracteristic | Value (%) | | | Information |
|---|---|---|---|---|
| | *Before* | *After* | *Different* | |
| Free Fatty Acid Levels | 5.18 | 2.84 | 2.34 | according to SNI |
| Levels of Defilement | 0.56 | 0.47 | 0.09 | according to SNI |

Source: Production Report PT. BPG (2018)

Based on Table 4 shows the average content of free fatty acids in the CPO production of PT. BPG decreased by 2.34% or to 2.84% from the previous 5.18%, while the level of dirtiness also decreased by 0.09% or to 0.47% from the previous 0.56%.

In this research a gradual completion strategy is needed, so that the potential nonconformities in CPO production can be controlled properly. The strategies that can be done from the results of this study are:

- Conduct periodic training for plant operators and harvest workers on the importance of working according to existing SOP guidelines.
- Strict supervision on all production lines to ensure there are no employees working without referring to existing SOP.
- Implement the system and proposed improvements that have been recommended so that the production process can run well.

In principle, the company can minimize product damage by focusing on management's attention on the process worksheet that has a high level of product damage, especially those that are already approaching the level of damage as depicted on the Histogram chart [10].

Likewise, in the study of Alfikri and Hariastuti, that improvements made to waste unnecessary inventories that affect the quality of palm oil production is to determine the amount of use of raw materials during the lead time and added use during certain periods as safety stock and to produce and ship products with on time [11]. The changes made to the quality of palm oil are periodically inspecting the temperature, pressure of the vacuum dryer.

## VI. Conclusion and Recommendations

The causes of defects in the CPO production process from human factors are unbalanced workloads, factory operator awareness, operator experience and not following the SOP. As for the method factor, namely the absence of good standard fruit criteria and waiting for the transport trucks that are too long. The last cause of disability is environmental factors which include damaged road access and fruit waiting for the process queue.

Improvement efforts with the 5W1H method on human factors, namely by managing employee workload, tightening the recruitment process, giving punishment to employees who do not follow SOPs and providing refreshments related to existing SOPs.

Improvement efforts on the method factor is to create standard criteria for good palm fruit and coordinate with related parties regarding the delivery of CPO to all customers.

While the improvement efforts for environmental factors are by improving roads and infrastructure at certain points.

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