Improving the Productivity of Palm Oil Processing Plant using Total Quality Control

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ABSTRACT
The research aimed at improving the productivity of palm oil processing plant using total quality control. The data were collected weekly basis from SIAT company limited and analysis using the necessary statistical tools such as mean, standard deviation and range. MATLAB programming software was used in accomplishing the analysis, it was observed that the process capability of the company product was highest on the 10th month with a value of 7.11, followed by 4th month with a value of 7.04 and the least on the 5th month with a value of 5.32. The month 1, 3, 4 and 5 had positive values in their lower control limits. A model was used to determine the reliability of the production machines, it was observed that the best model to boost the reliability of the product was model 1 with yield production rate percentage of 70% and was considered more reliable than model 2 with 60%, model 3 with 50%, model with 40% and model 5 with 30%. It was considered that the total control tool to determine the rate of component A, R_A, rate of component B R_B, rate of component C R_C and the rate product p, R_P, with the highest maximum productivity of 0.687954713 approximately 0.7 and when converted to percentage is 70% productivity compared to other models such as model 1,2,3, and 4. It was further considered the functional parameters against year in months, monthly mean, monthly standard deviation and monthly range. The reliability model was simulated, there was positive agreement with manual calculations and simulation results. It was recommended that the 2A, 4B and 1C model arrangement be utilized for palm oil processing company and other related companies.

Keywords: *Productivity, Palm oil, Improvement, Total Quality Control*

1. INTRODUCTION:

Palm oil industry are set up to meet commercialization because of the growing demand and its economic importance. Local farmers around the communities were producing palm oil but in small quantities and not for export. The palm oil industry has large plantation area comprising about 5.600 hectares of land, with about production rate of 983.000 tons of palm oil (Raheem, *et al.*, (2016)). The increase in productivity indicate how well the resources are managed in the production, which leads to increase in the output (Chukwulozie *et al.*, 2018). Dalota (2013) on increasing productivity by total quality management and constraint management reported that the total quality management concept and its implementation is the critical need for the survival of industries. Taher and Alam (2014) conducted research on improving quality and productivity in manufacturing process by using quality control chart and statistical process controls including sampling and six sigma. Muzaffer *et al.* (2016) researched on the effects of Six Sigma Approach on Business Performance: A Study of White Goods (home appliances) Sector in Turkey reported that Increasing global competition in the world economy forces firms to sharpen their functionality and processes in order to gain competitive advantages.

Snezana (2014) research work on the implementation of total quality management in order to improve production performance and enhancing the level of customer satisfaction explained that doing business in a competitive and dynamic environment requires companies to continually improve and enhance their business performance and capabilities. Chiebus and Wojciechowska (2016) carried out research on Issues on Production Process Reliability Assessment- Review. The palm oil processing company are faced with major challenges like equipment, machine and plant used after a period of time gradually deteriorates in performance due to wear, tear and stress, it is important that this equipment be adequately monitored and maintain to prevent imminent failures and breakdowns as well as avoid downtimes.

This research aimed at improving the productivity of palm oil processing plant using total quantity control. The record of SIAT Company for four years was taken to determine the effective and defective products to obtain the variation in quality of palm fruit produced from 2016 to 2019, using the following steps: Obtain a quantity of palm fruit for analysis, Obtain the number of defective palm fruit, Group into sample size (n), Obtain the number of samples, Determine process capability, Utilized control charts for test, Carry out reliability, determine average range of sample and apply a total quality control tool to improve productivity of the company.

2. MATERIALS AND METHODS:

The materials used in the research work include: Palm fruits, Siat company chart and Human and equipment moving machine. The data was collected from the daily records of SIAT Company Nigeria Limited from January to December for a period of four years (2016 to 2019). Statistical methods were used to determine the mean, standard deviation and range which assisted in testing the models, While MATLAB programming software was used in accomplishing the analysis.

Statistical Models

The process capability model was used to test for process variation or quality standard of palm oil produced by SIAT Company Nigeria Limited.

Process capability $\delta_0 = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \bar{X})^2}{n-1}}$ (1)

where Xi = measure of quality of ith unit

n = sample size

Reading was taken at regular intervals (sample size n $\leq$ 12) and preferable n<6 to be made of the average range ($\bar{w}$) of the sample to estimate the process capability.

Equation (2) was used to obtained the processing capability

$$\delta_0 = \frac{\bar{w}}{dn} \quad (2)$$

where $\bar{w}$ = average range of samples.

d_n = Hartley's conversion constant, which is given in statistical table for different sample size (Murdoch, 1974).

If the large sample size required (usually $25 \leq n \leq 250$) to enable a reliable estimate to be obtained for the process. The process capability δ_0 is measured as the average fraction defective obtained over the samples.

$$P_o = \sum_{i=1}^{m} \frac{nPi}{mn} \quad (3)$$

where Pi = fraction defective.

n = sample size.

m = number of samples

Po = Average fraction defective

Control Charts

The sample mean is where the $x_1, x_2, x_3 \ldots . x_n$ are measurements and n is the number of measurements in the sample.

$$\overline{X} = \frac{x_1 + x_2 + x_3 + \ldots x_n}{n} \quad (4)$$

The estimate of the process mean is

$$\overline{\overline{X}} = \frac{\overline{X}_1 + \overline{X}_2 + \cdots \overline{X}_n}{n} \quad (5)$$

where

n = number of samples

$\overline{\overline{X}}$ = gives the reference axis of the control chart.

Often the limit is set by standard values base on what a process is expected to accomplish. In this case, the centre line, x, and the standard deviation δ are given.

$$\text{Control limits} = x \pm 3\delta\sqrt{n} \quad (6)$$

The range R for each sample is the difference between the highest and the lowest measurement in the samples. The mean range is then.

$$\bar{R} = \frac{R_1 + R_2 + \cdots + R_n}{n} \quad (7)$$

Where R is the maximum difference in the measurement for each sample.

The standard deviation of the sample mean is estimated from the mean range by applying a factor (A). This factor is based on the sample size n; this factor is obtained from statistical table Murdoch, (1974). The product of A and R establishes the three standard deviation boundaries around the centre lines as

$$\text{Upper control limit} = \overline{\overline{X}} + A\overline{R} \quad (8)$$

$$\text{Centre line} = \overline{\overline{X}} \quad (9)$$

$$\text{Lower control limit} = \overline{\overline{X}} - A\overline{R} \quad (10)$$

When more than one component is provided to serve the same purpose. In model 1, component A has 1 redundant, B has 3 redundant and the redundant ones fail, the product will still function provided component C is functional. In model 2, component A has 1 redundant, B, 2 redundant. In model 3, component A has zero redundant, B has 2 redundant. In model 4, component A has zero redundant, B has I redundant and finally in model 5, A and B have zero redundant.

$$R_p = R_A R_B R_C \quad (11)$$

$$RA = 1\ (1 - RA)^n \quad (12)$$

$$R_B = 1 - (1 - R_B)^n \quad (13)$$

$RC = \exp(1_C - C)$ (14)

$R_p =$ rate of production

$R_A =$ rate of component A

$R_B =$ rate of component B

$R_C =$ rate of component C

Where n is the number of units in the considering component such as A, B, and C. in model 1 the value of n from A is 2, B is 4 C=1.

Model 2, the value of n from A is 2, B is 3 and C is 1 model 3, the value of n in unit A is 1, B is 3 and C is 1 model 4, the value of n in unit A is 1, B is 2 and C is 1. Finally, in model 5 the value of n is equal in all the components meaning A=1, B=1 and C=1

3. RESULTS AND DISCUSSION:

The result in Figure1, shows the graphical relationship of the mean months against process capability from 2016 to 2019. It was observed that the process capability was highest at month 10 with the value of process capability of 7.11, followed by month 4 with process capability of 7.04, and least in month 5 with the process capability of 5.32. This was as a result of little or none presence of defective materials in the product during production. The result was in agreement as shown in the literature by Taher and Alams, (2014).

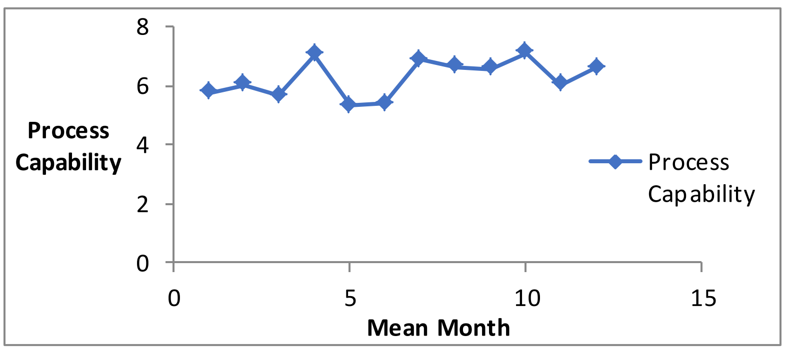

Figure 1: Graph of Mean Month against Process Capability from 2016 to 2019

The result in Figure 2 depicted the relationship between number of samples against number rejected in month 1. It implies that the Upper Control Limit was 125.75, Control Limit was 73.81 and Lower Control Limit was 21.87, it was observed that Point 13 with value of 35, Point 14 with value of 34, Point 15 with value of 39 and point 16 with value of 31, were below the control limit and improve production process. It indicates that points 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 do not improve the production process. But the best Production process was point 16 with value of 31. This result is in agreement with Raheem, *et al.*, (2016).

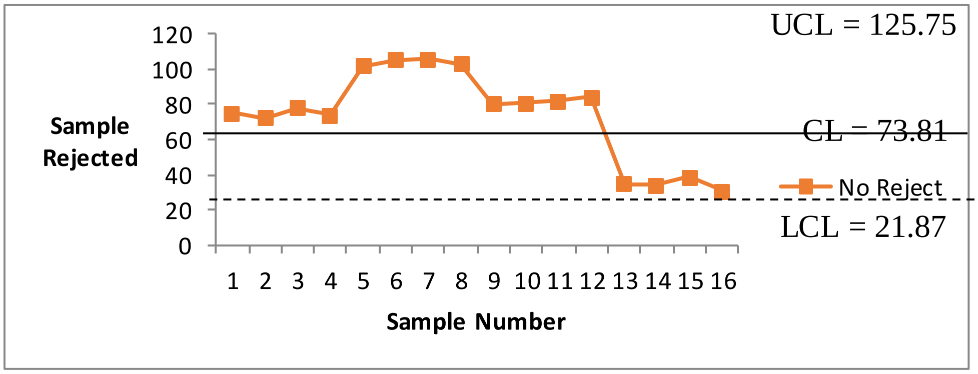

Figure 2 Graph of Number of Sample against Number Rejected in Month 1

The result on the reliability of the production machine in Figure 3, shows the Relationship Between Numbers of Sample against Number Rejected in Month 2. It implies that the Upper Control Limit was 111.94, Control Limit was 84.38 and Lower Control Limit was -3.18, It was observed that , Point 1 with value of 50, Point 3 with value of 25, Point 4 with value of 45, point 5 with value of 49, Point 7 with value of 27, point 8 with value of 40, Point 9 with value of 52, Point 11 with value of 24, Point 12 with value of 46 Point 13 with value of 45, Point 15 with value of 25 and Point 16 with value of 44 were below the control and improve production process. It indicates that points 2, 6, 10, 14, with values 100, 101, 98, 96, respectively, do not improve the production process. But the best Production process was point 11 with value of 25. The Lower Control Limit cannot be negative; the negative value may be attributed to so many lower values.

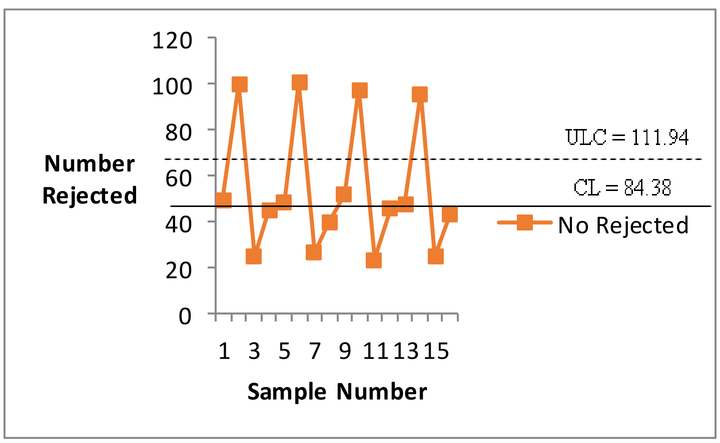

Figure 3 Graph of Number of Sample against Number Rejected in Month 2

The result in Figure 4. Highlighted the Relationship Between Numbers of Sample against Number Rejected in Month 3. It implies that the Lower Control Limit was 13.62, Upper Control Limit was 76.06 and Lower Control Limit was 0.44, It was observed that, Point 1 with value of 37, Point 4 with value of 15, Point 6 with value of 76, point 8 with value of 14, Point 9 with value of 34, point 12 with value of 12, Point 13 with value of 32, Point 16 with value of 13, were below the control and improve production process. It indicates that points 2, 3, 6, 7, 10, 11, 14, 15 with values 78, 63, 76, 60, 74, 62, 71 and 65 respectively, do not improve the production process. But the best Production process was point 12 with value of 12.

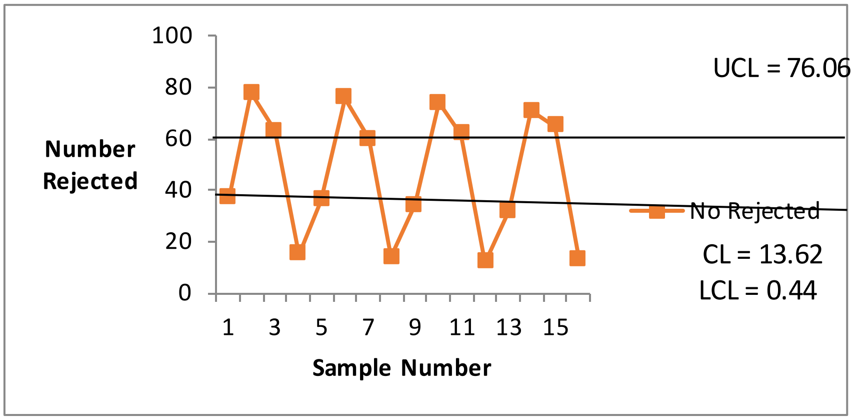

Figure 4: Graph of Number of Sample against Number Rejected in Month 3

The result in Figure 5. Illustrates the relationship between rate of production against types of model from 2016 - 2019. It was observed that the Model 1 is the best model with the yield of 70% rate of production as depicted in the diagram above.

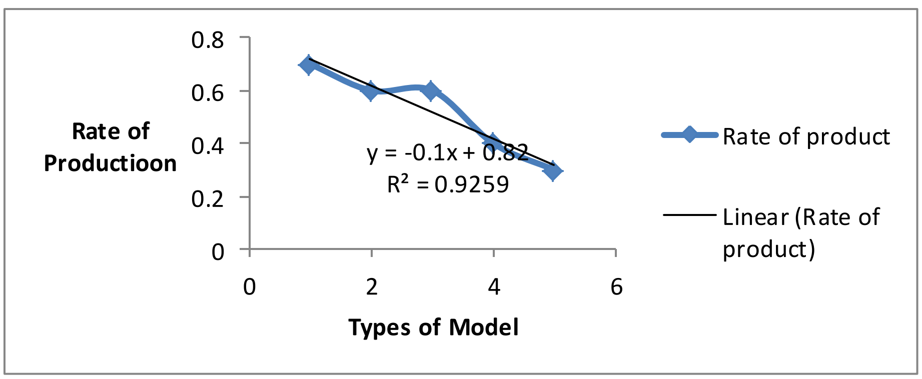

Figure 5: The Relationship between rate of Production against Types of Model

The result in Figure 6. illustrates the relationship between numbers of mean defectives against weeks for months 1, 2, and 3. It was observed that in 2016, week 1, was 54 defectives, week 2, was 93 defectives, week 3, was 56 defectives, Week 4 was 34 defectives. In 2017, week 1, was 69 defectives, week 2, was 94 defectives, week 3, was 56 defectives, Week 4 was 29 defectives. In 2018, week 1, was 46 defectives, week 2, was 93 defectives, week 3, was 56 defectives, Week 4 was 32 defectives. In 2019 week 1, was 50 defectives, week 2, was 90 defectives, week 3, was 58 defectives, Week 4 was 29 defectives. R^2 –value of 2016 was 0.2347, R^2 –value of 2017 was 0.5679, R^2 –value of 2018 was 0.1528, R^2 –value of 2019 was 0.2347. It increases exponentially, then, decreases with weeks. The increase and decrease may be attributed to fluctuation in the number of defectives and the reason why the trend remained similar may be as a result of closeness of number of defective at the various points and given time.

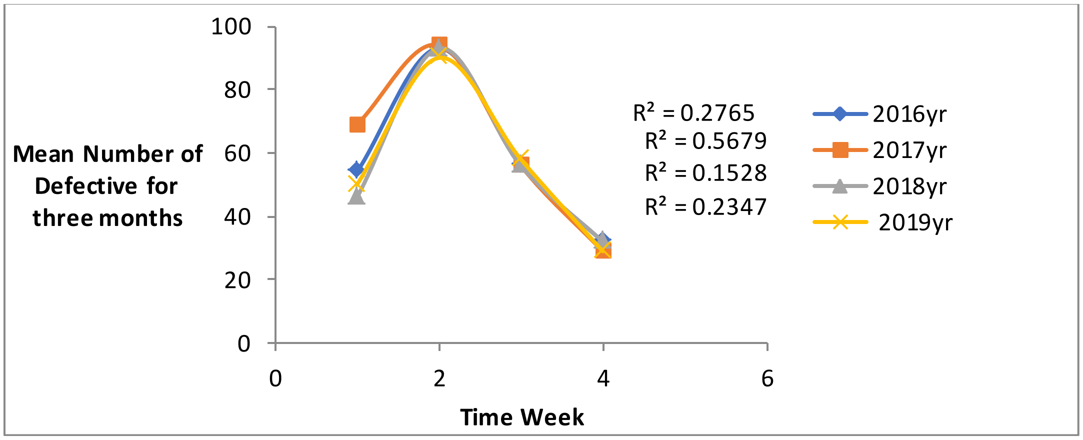

Figure 6: Graph of Number of Mean Defectives against Week for Months 1, 2and 3

The result in Figure 7. Illustrates the relationship between numbers of mean defectives against weeks for months 7, 8, and 9. It was observed that in 2016, week 1, was 57 defectives, week 2, was 109 defectives, week 3, was 30 defectives, Week 4 was 24 defectives. In 2017, week 1, was 57 defectives, week 2, was 102 defectives, week 3, was 28 defectives, Week 4 was 22 defectives. In 2018, week 1, was 57 defectives, week 2, was 106 defectives, week 3, was 29 defectives, Week 4 was 23 defectives. In 2019 week 1, was 57 defectives, week 2, was 109 defectives, week 3, was 25 defectives, Week 4 was 23 defectives. R^2 –value of 2016 was 0.3516, R^2 –value of 2017 was 0.4004, R^2 –value of 2018 was 0.3727, R^2 –value of 2019 was 0.3578. It increases exponentially, then, decreases with weeks. The increase and decrease may be attributed to fluctuation in the number of defectives and the reason why the trend remained similar may be as a result of closeness of number of defective at the various points and given time.

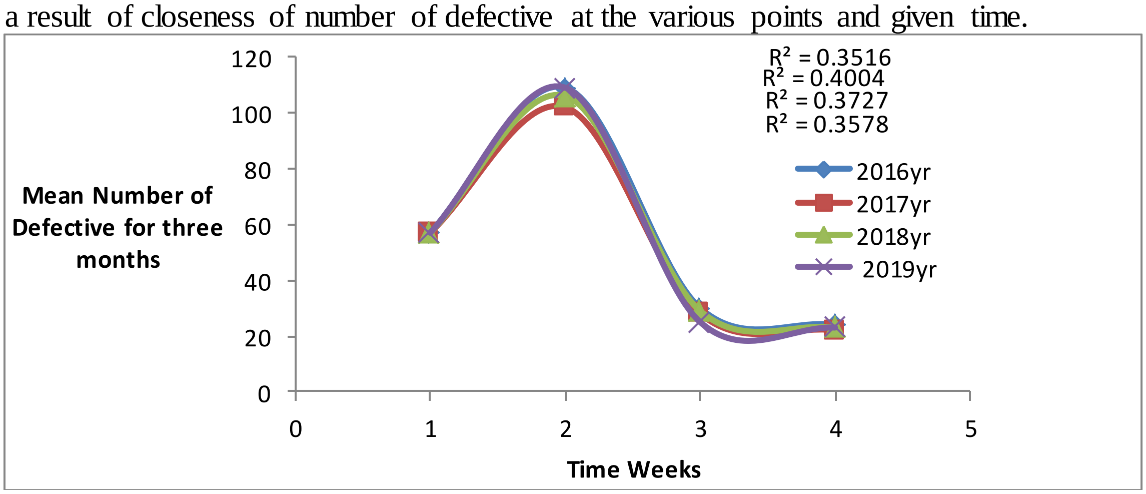

Figure 7: Graph of Number of Mean Defectives against Week for Months 1, 2and 3

The result in Figure 8. Shows the relationship between mean months and time. It was observed that mean month 1, has the value of 73 in 2016, 73 in 2017, 76.25 in 2018 and 73 in 2019. Mean month 2, has the value 55.00 in 2016, 54.25 in 2017, 55.00 in 2018 and 53.25 in 2019, in mean month 3, with the value of 48.25 in 2016, 46.50 in 2017, 45.50 in 2018 and finally 45.25 in 2019. The line of month 1 decreased and then increased with time, month 2 increased and then decrease with time, month 3 increased later decreased with time. Mean month 1 is highest, followed by mean month 2 and least in mean month 3.

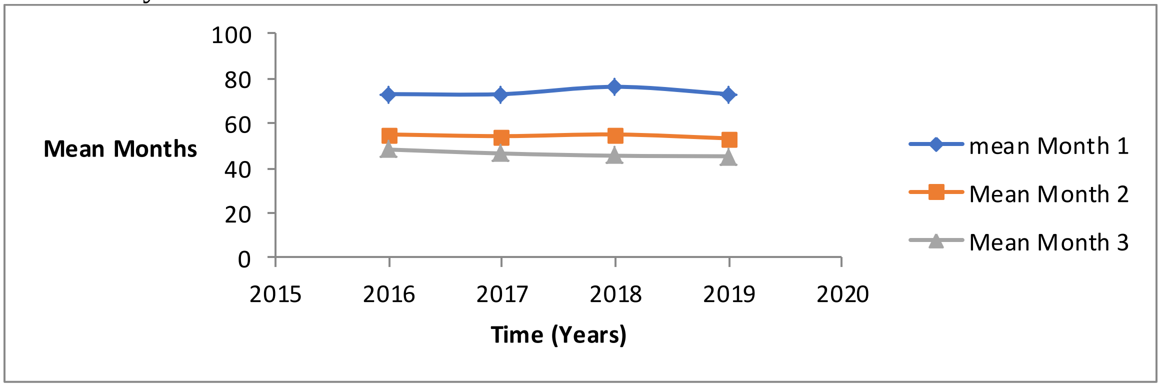

Figure 8: Graph of Comparison of Mean Months, 1, 2 and 3 against Time

The result in Figure 9. Shows the relationship between standard deviation months and time. It was observed that standard deviation month 1, has the value of 24.18 in 2016, 25.54 in 2017, 24.02 in 2018 and 26.39 in 2019. S.D month 2, has the value 27.61 in 2016, 28.13 in 2017, 26.93 in 2018 and 26.17 in 2019, in S.D month 3, with the value of 24.16 in 2016, 23.55 in 2017, 24.18 in 2018 and finally 23.82 in 2019. In month 1, there were standard deviation fluctuation in time with its peak value of 26.39 in 2019. Month 2 increased and then decreased and with time, month 3 decreased, later increased and then decreased with time. Month 2 is highest, followed by mean month 1 and least in mean month 3.

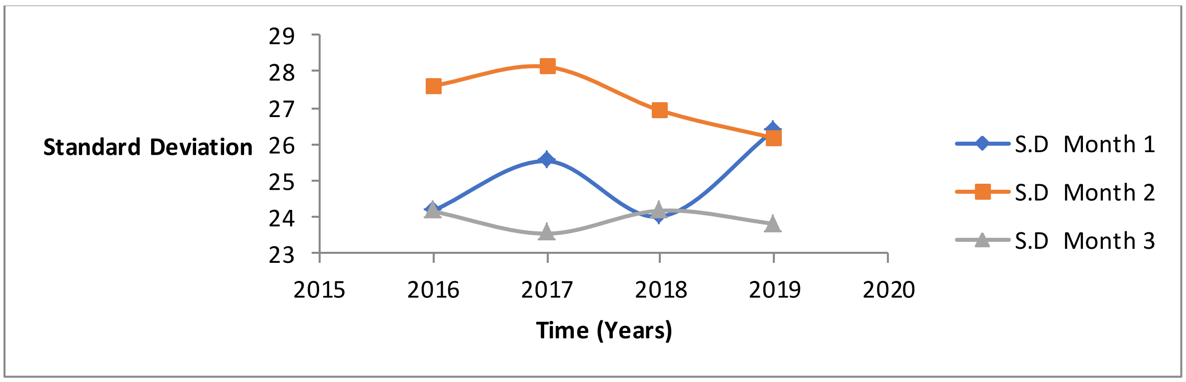

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Figure 9: Graph of Comparison of S.D Months, 1, 2, and 3 against Time

The result in Figure 10. Shows the relationship between the standard deviation against time (month) from 2016 to 2019. It was observed that the highest value was at month 10 with the value of standard deviation of 37.93, followed by month 4 with standard deviation value of 37.22, and least in month 5 with the standard deviation value of 21.20. This was as a result of little or none presence of defective materials in the product during production.

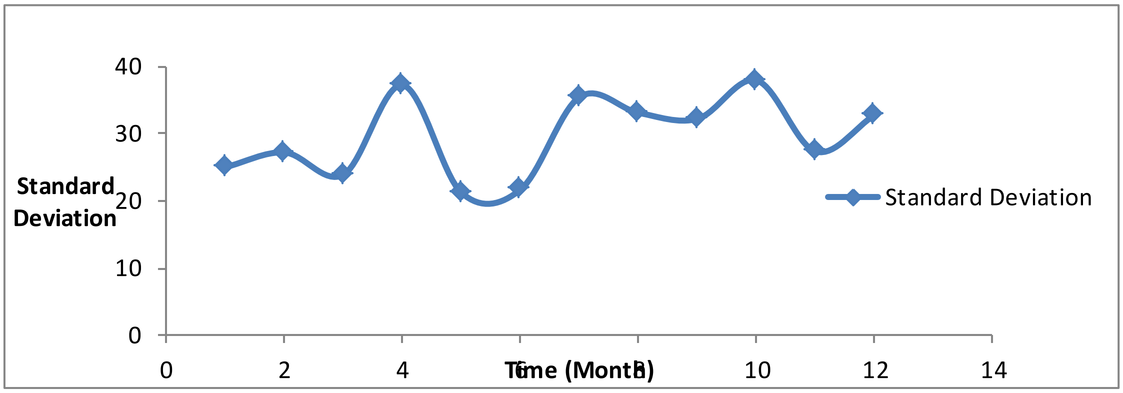

Figure 10: The Relationship between the Standard Deviation against Time (Month)

It was observed that the Range was highest at month 10 with the value of range of 94.25, followed by month 4 with range value of 83.25, and least in month 5 with the range value of 49.50. This was as a result of little or none presence of defective materials in the product during production as shown in Figure 11.

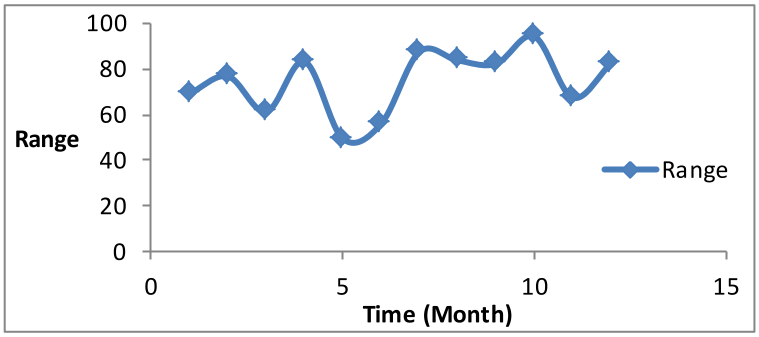

Figure 11: The relationship between the Range against Time (month) from 2016 to 2019.

The result in Figure 12. shows the relationship between functional parameters and time. It was observed that in 2016, mean was 73 in 2017, the mean was 73 in 2018 the mean was76.25, in 2019 it was 73. The S.D was 24.18, in 2016, S.D was 25.54 in 2017, S.D was 24.02 in 2018, and S.D was 26.39 in 2019, in 2016, range was 67 in 2017, range was 71 in 2018 range was 67 and finally in 2019 range was 72. The line of mean increased and decreased with time, Standard deviation increased, decreased and then increased with time. While range increased, decreased and then increased with time. The mean was highest, followed by range and least in standard deviation.

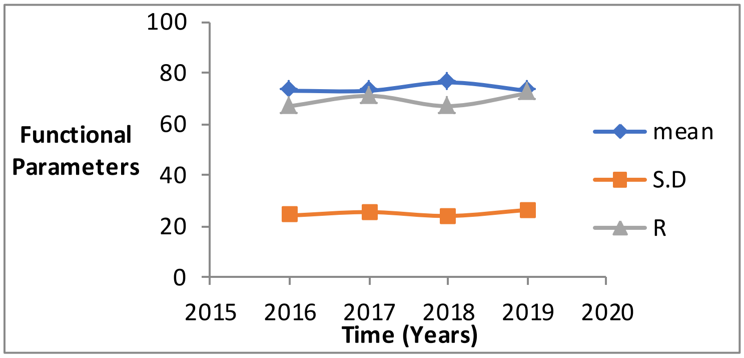

Figure 12: Graph of Functional Parameters against Time in Month 1

The result in Figure 13. shows the relationship between functional parameters and time. It was observed that in 2016, mean was 55 in 2017, the mean was 54.25 in 2018 the mean was 55, in 2019 it was 53.25. The S.D was 27.61, in 2016, S.D was 28.13 in 2017, S.D was 26.93 in 2018, S.D was26.17 and in 2019, the range was 75 in 2017, range was 74 in 2018 range was 74 and finally in 2019 range was 84. The line of mean decreased and increased with time, Standard deviation, decreased and with time. While range increased, decreased and then increased with time. The range was highest, followed by mean and least in standard deviation.

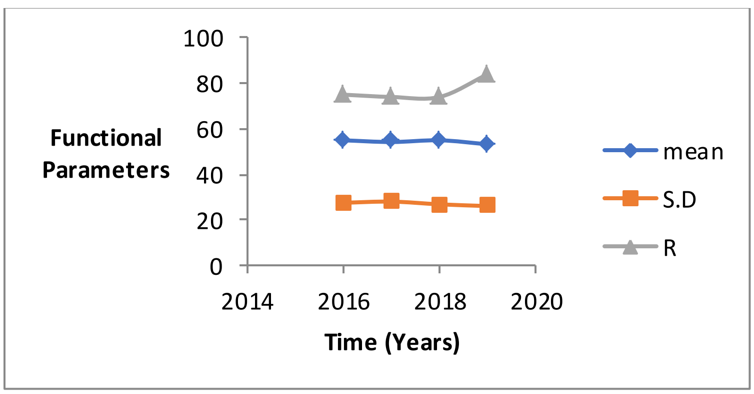

Figure 13: Graph of Functional Parameters against Time in Month 2

Figure 14. Shows the relationship between functional parameters and time. It was observed that in 2016, mean was 48.25 in 2017, the mean was 46.5 in 2018 the mean was 45.5, in 2019 it was 45.25. The S.D was 24.16, in 2016, S.D was 23.55 in 2017, S.D was 24.18 in 2018, and S.D was 23.82 in 2019, the range was 63 in 2017, range was 62 in 2018 range was 62 and finally in 2019 range was 58. The line of mean increased with time, Standard deviation, increased and decreased and with time. While range increased, and decreased with time. The range was highest, followed by mean and least in standard deviation.

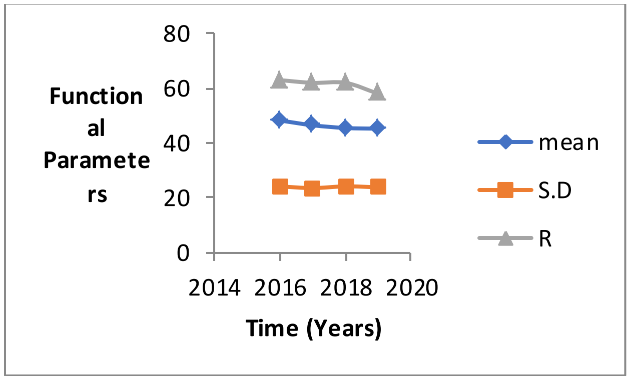

Figure 14: Graph of Functional Parameters against Time in Month 3

Figure 15: Illustrates the relationship between rate of production against types of model from 2016 - 2019. It was observed that the Model type 1 is the best model with the yield of 70% rate of production as depicted in the diagram above.

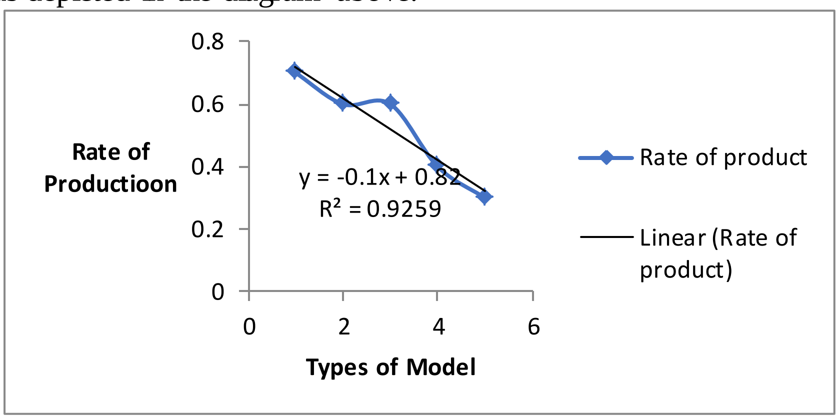

Figure 15: The Relationship between Rates of Production against Types of Model

The result in Figure 16. Illustrates the relationship between number of samples against number rejected in Month 4. It implies that the Upper Control Limit was 84.125, Control Limit was 47.00 and Lower Control Limit was 9.875, It was observed that , Point 3 with value of 30, Point 4 with value of 26, Point 7 with value of 29, point 8 with value of 24, Point 9 with value of 27, point 11 with value of 27, Point 13 with value of 67, Point 15 with value of 31, and Point 16 with the value of 23 were below the control limit. It indicates that points 1, 2, 5, 6, 9, 10, 13, 14 with values 61, 75, 60, 72, 63, 70, 67 and 74 respectively, do not improve the production process. It shows that the best production process was point 16 with value of 23.

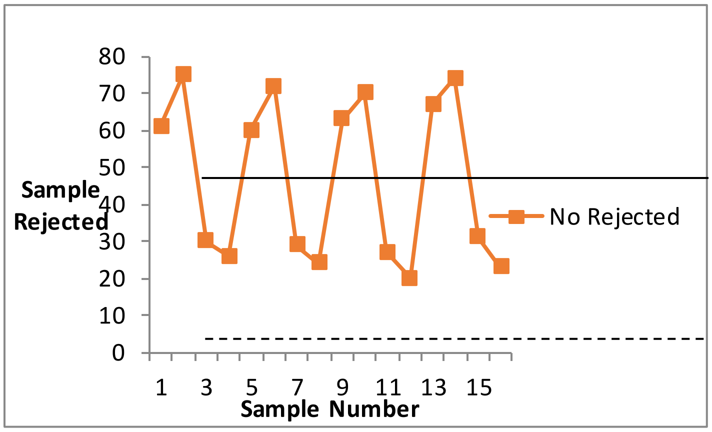

Figure 16: Graph of Number of Samples against Number Rejected of Month 4

The result in Figure 17, depicted the relationship between numbers of samples against number rejected in Month 5. It implies that the Upper Control Limit was 78.38, Control Limit was 36.38 and Lower Control Limit was -23.03, It was observed that , Point 1 with value of 36, Point 3 with value of 15, Point 4 with value of 18, point 5 with value of 30, Point 7 with value of 16, point 8 with value of 17, Point 9 with value of 32, Point 11 with value of 14, Point 12 with value of 19 Point 13 with value of 35, Point 15 with value of 13 and Point 16 with value of 19 were below the control and improve production process. It indicates that points 2, 6, 10, 14, with values 103, 100, 102, 104, respectively, do not improve the production process. But the best Production process was point 15 with value of 13. The Lower Control Limit cannot be negative; the negative value may be attributed to so many lower values.

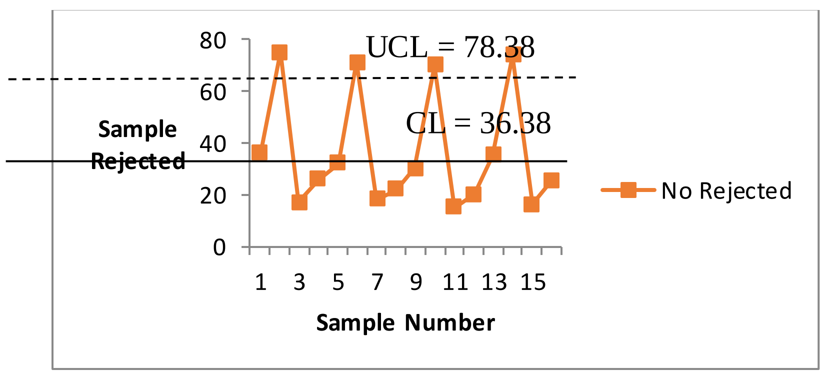

Figure 17: Graph of Number of Samples against Number Rejected of Month 5

Figure 18. Illustrated the relationship between number of sample against number rejected in Month 10. It implies that the Upper Control Limit was 122.44, Control Limit was 60.75 and Lower Control Limit was -0.94, It was observed that , Point 3 with value of 23, Point 4 with value of 27, Point 7 with value of 21, Point 8 with value of 26, point 11 with value of 22, Point 12 with value of 24, Point 15 with value of 24 Point 16 with value of 20, were below the control and improve production process. It indicates that points 1,2, 5, 6, 9, 10, 13, 14, with values 65, 119, 60, 101,63, 115, 64, and 118 respectively, do not improve the production process. But, the best Production process was point 16 with value of 20. For the fact that the

lower control limit cannot be negative, the negative values observed may be atributed to the higher numbers of lower values.

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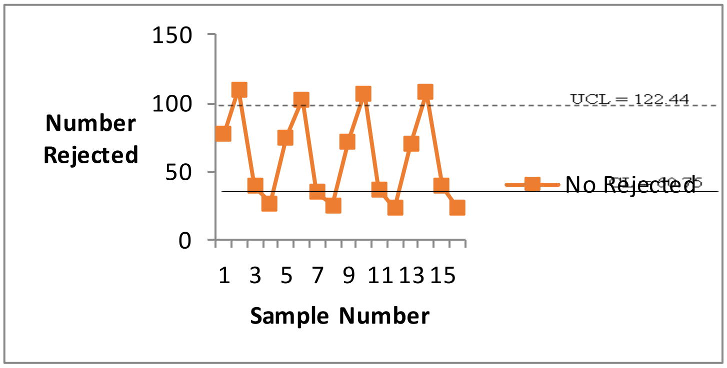

Figure 18: Graph of Number of Samples against Rejected Samples of Month 10

4. CONCLUSION:

In conclusion, improving the productivity of palm oil processing plant using total quality control, was achieved using statistical methods, the reliability analysis carried out depicted the optimal type 1 model (model type 1) for the reliability of the products with 70% yield production rate, while those of models 2, 3 and 4 were 60%, 50% and 30% respectively. The result indicates that model 1 is the most reliable.

5. ACKNOWLEDGEMENTS:

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