International Journal of Management and Business Applied

Vol.1, No.1, (2022)
e-ISSN: 2827-9840

Exponential Weight Moving Average (EWMA) Control Chart for Quality Control of Crude Palm Oil Product

Wetri Febrina[1], Widya Fitriana[2]
[1]Industrial Engineering Departement, Sekolah Tinggi Teknologi Dumai, Riau, Indonesia
[,2,] Agribusiness Departement, Universitas Andalas, Padang, Indonesia
Email: wetri.febrina@gmail.com, [2]widyafitriana66@gmail.com,

doi.org/10.54099/ijmba.v1i1.93

ARTICLE INFO

Research Paper

Article history:
Received: February 28, 2022
Revised: March 15, 2022
Accepted: March 30, 2022

Keywords: Control Chart, Product Quality, EWMA, Crude Palm Oil.

ABSTRACT

Purpose – This paper seeks to to compare the EMWA control chart with the Shewart control chart in analizing the quality of a product. The product used was crude palm oil (CPO) with a case study data from PT X laboratories, a palm oil processing company in Dumai, Riau..
Methodology/approach – The commonly used control chart - the Shewhart control chart, does not show the real situation in the company. The Exponential Moving Weight Average (EMWA) control map is used as an alternative control map to detect small average shifts. In measurement of quality of Crude Palm Oil Product, such as Free Fatty Acid content and level of Colour, where the sampling points are the same, or the samples used are the same, but are collected at different times, this situation could happen. As a result, predictions based on control charts are sometimes not in accordance with real conditions.
Findings – We compared the performance of EWMA Control Chart with basic Shewart Control Chart and found that EWMA Control Chart give best performance and much shorter of out of control data.
Novelty/value – EWMA gives a better result than basic control chart for small average shift data. Keywords Control Chart, Product Quality, EWMA, Crude Palm Oil.

INTRODUCTION

The control chart is widely used statistical quality control (SQC) or Statistical Processes Control (SPC) tools to find assignable cause of variation and detects any changes of process. This tools include control chart, check sheets, Pareto diagrams, histograms, cause and effect diagrams, defect contentration diagrams and scatters diagrams (Khaliq et al., 2016). Generally, Shewart Control Chart for Variable, like X-R and X-S are most frequently used. But in some case, the Shewart control chart can not give good results, especially when data have small average shift. Alternative control chart is needed, like Exponential Weight Moving Average (EWMA), Double Exponential Weight Moving Average (DEWMA), Cumulative Sum (CUSUM) and others. (Iskamto et al., 2020; Patel & Divecha, 2011), (Hamsah, La., Purnamasari, Ika., Satriya, 2019), (Saleh et al., 2015), (Solahuddin, 2015).
A control chart base on exponential weight moving average (EWMA) was first describe by Roberts in 1959(Tang et al., 2019). Whereas the Shewart chart takes only the immediate control into consideration for statistical testing, the EWMA chart uses the previous values also (Hamsah, La., Purnamasari, Ika., Satriya, 2019).

$$Zj = \lambda xj + (1\text{-}\boldsymbol{\lambda})Z_{j-1} \qquad (1)$$

With thefirst value z_{j-1} in this sum generally being set to the mean of former observation. This smoothing process means that the contribution of a value to the test statistic decays exponentially by time or by the number of the next observation, with the speed of decay being adjustable by the weighting factor. (chem..)

$$CL = \mu o = X \frac{\sum_{j=1}^{m} Xj}{m} \qquad (2)$$

$$\text{UCL} = \mu_0 + 3\sigma\sqrt{(\frac{\lambda}{(2-\lambda)}[1-(1-\lambda)^{2j}]} \qquad (3)$$

$$\text{LCL} = \mu_0 - 3\sigma\sqrt{(\frac{\lambda}{(2-\lambda)}[1-(1-\lambda)^{2j}]} \qquad (4)$$

withZ_j=moving averageEWMAat sample-*j*

l=weighting parameter

w=subgrouporrun length

x_j=mean at sample-j

CL = Centre LineEWMA

UCL=UpperControlLimit

LCL=LowerControl Limit

μ_0=*X*total average of production sample

$$\sigma = \frac{MR}{d_2} \qquad (5)$$

If j>w, the equation will be :

$$\text{UCL} = \mu_0 + 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}} \qquad (6)$$

$$\text{LCL} = \mu_0 - 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}} \qquad (7)$$

Even tough the company has implemented quality standards, in fact sometimes defective products were still found. This defectives products was caused by variation in products quality parameters **(Handika, 2003)**. To explore the root cause of problems, it's usually used 5 M + 1 E analysis, i.e Man, Material, Methods, Measurement, Machine and Environment **(Rahmad et al., 2020)**, **(Tang et al., 2019)**, **(Febrina et al., 2019)**.

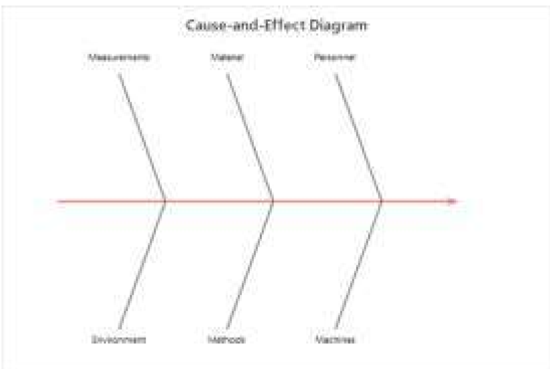

Figure 1. Cause and Effect Diagram

METHOD

The EWMA chart statistic is a weighted average measurements, giving heaviest weights to the most recent observations **(Saleh et al., 2015)**. This provide the charts with the advantage of being sensitives to the small and moderate size sustained shifts on process parameters.

The analysis stages on making Shewart and EWMA control chart are **Hamsah, La., Purnamasari, Ika., Satriya, 2019)**, :

1. Performs desctiptive statistical analysis
2. Calculating Xbar for subgroup and X for the whole data
3. Calculating R for subgroup and for the whole data
4. Calculating σ for subgroup and for the whole data
5. Calculating the value of Z using equation (1)
6. Calculation UCL and LCL of Shewart Control Chart (here Minitab Software have used)
7. Calculating CL, UCL and LCL of EWMA Control chart using equation (2)-(7)
8. Performs control chart X-R and X-S from Shewart Control Chart (here Minitab Software have used)
9. Performs control chart EWMA (here Minitab Software have used)
10. Compare the output of Shewart Control Chart and EWMA Control chart

RESULT AND DISCUSSION

Here we analyze of statistical quality control of data Free Fatty Acyd content from Crude Palm Oil refinery station. 8 samples was collected randomly everyday for 12 days.

Statistic descriptive of data show on table 1

Table 1. Descriptive Statistic Analysis

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
x1	12	0	0,05833	0,00194	0,00672	0,04900	0,05125	0,05950	0,06300	0,07000
x2	12	0	0,06058	0,00242	0,00839	0,04800	0,05250	0,06150	0,06825	0,07200
x3	12	0	0,06292	0,00221	0,00765	0,05200	0,05575	0,06350	0,06975	0,07300
x4	12	0	0,06183	0,00191	0,00662	0,04900	0,05650	0,06350	0,06750	0,07100
x5	12	0	0,06150	0,00229	0,00794	0,05200	0,05425	0,05900	0,07050	0,07400
x6	12	0	0,06167	0,00155	0,00537	0,05600	0,05700	0,06050	0,06700	0,07100
x7	12	0	0,06208	0,00212	0,00733	0,05200	0,05600	0,06050	0,06975	0,07400
x8	12	0	0,06350	0,00194	0,00671	0,05700	0,05800	0,06100	0,07150	0,07400
Xbar	12	0	0,06155	0,00186	0,00643	0,05412	0,05444	0,06112	0,06897	0,07013

As presented at table 1.1 we found that total average of 8 samples that collected in 12 days were 0,0615. Maximum FFA value happened at day 2nd andrd. Minimum FFA value had found at day 10th

Using Shewart Control Chart for Variable, we used X-R chart and X-S chart as shown in figure 1 and figure 2 below

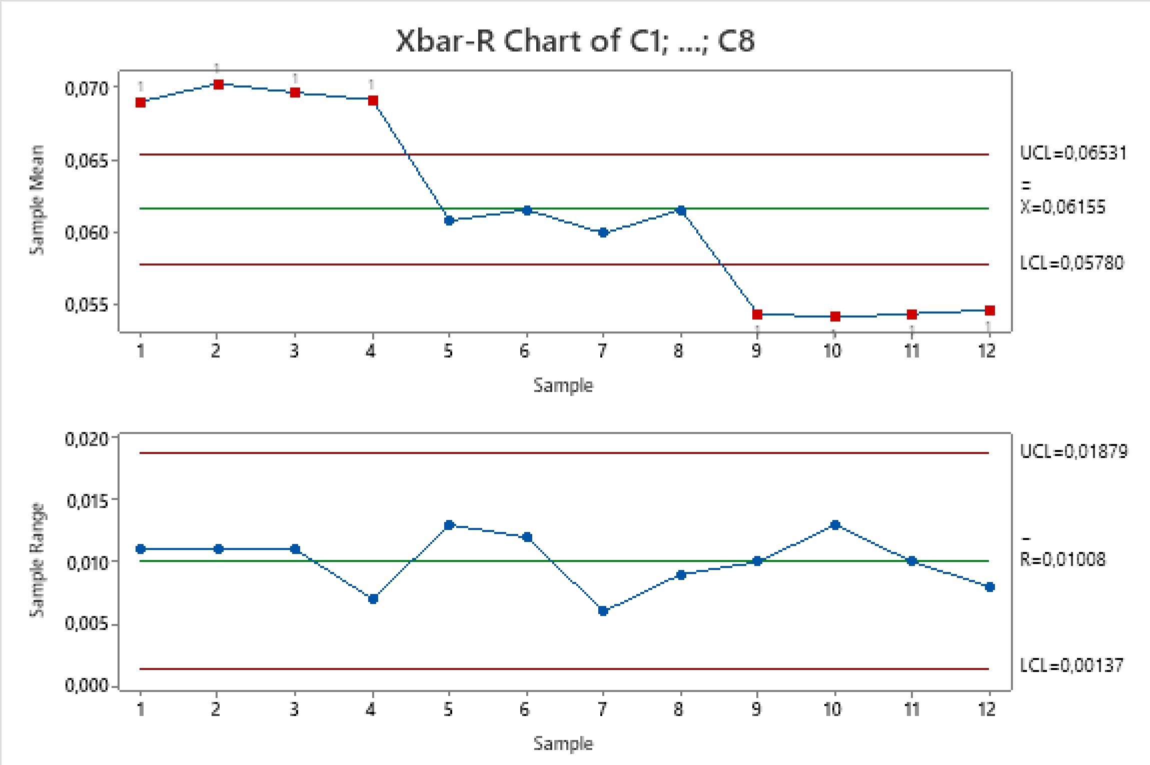

Figure 2. Shewart X-R Control Chart

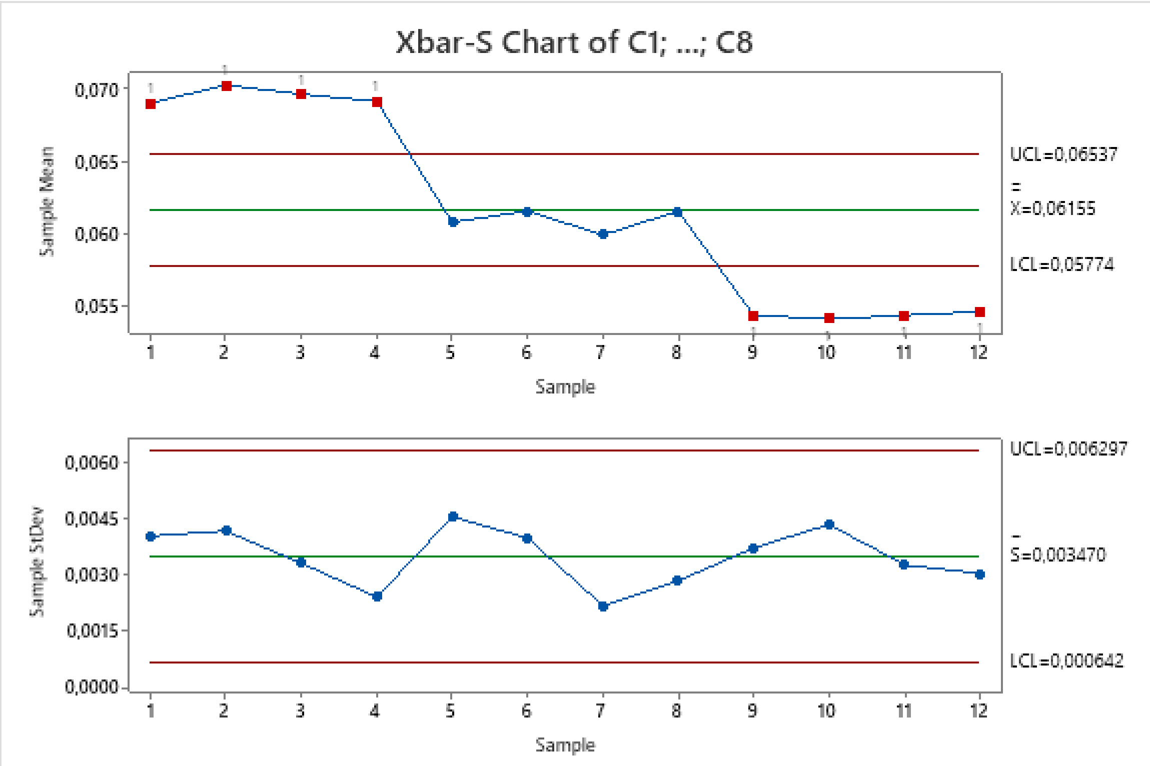

Figure 3. Shewart X-S Control Chart

Adjust moving average at EWMA Control Chart

As result, we got that all data were in control. But thats not meet standard quality, where the company required FFA minimum 5% in value.

So we need to check whether the product had capable or not with using capability index. The result showed on Figure 4 below.

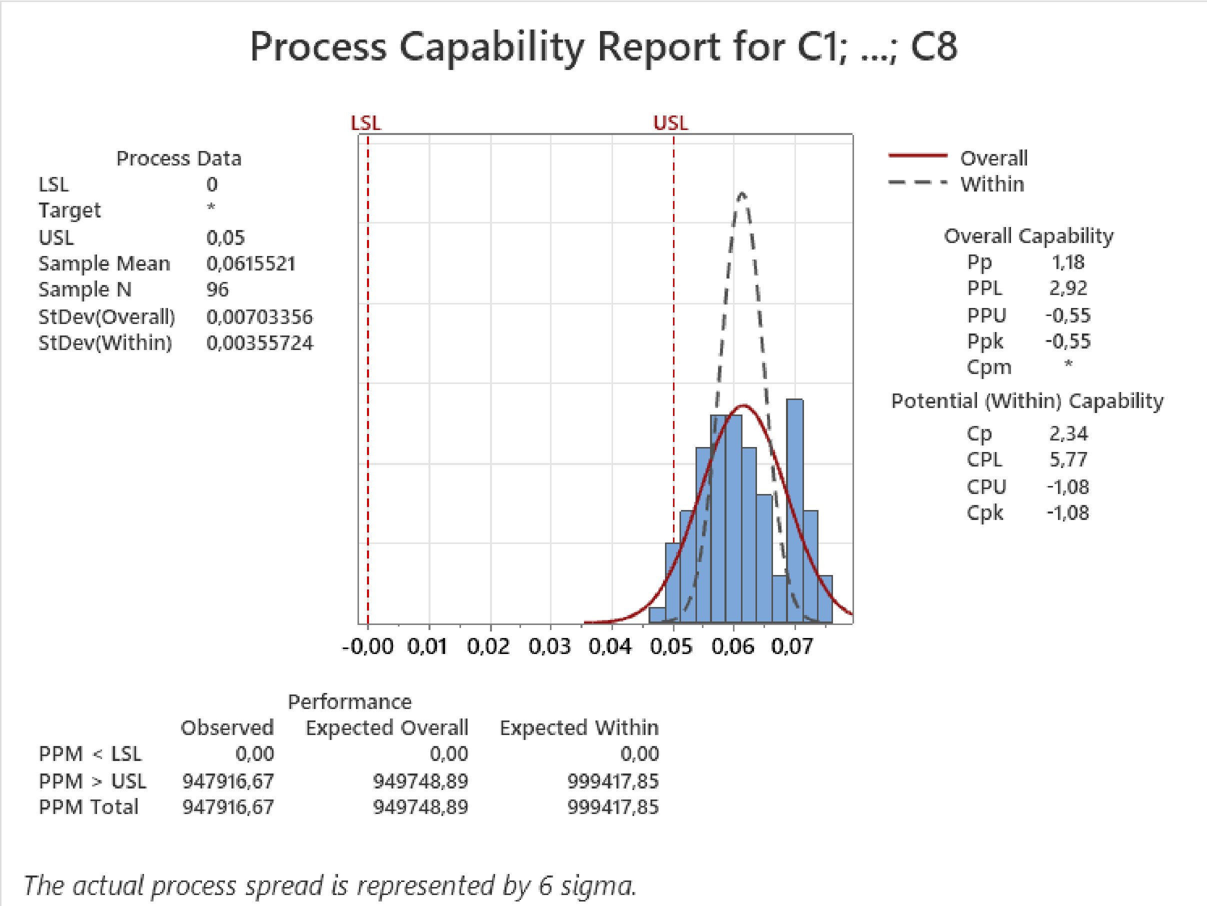

Figure 4. Process Capability

Have found that the result is the process wasn't capable. To get real condititon on product processing, we calculate moving average of the product.

$$\lambda = \frac{2}{w+1} = 0,222$$

The value of Z were calculate using equation (1) and tabulated on table below :

Table 2. Z Value

Day	Z	Day	Z
1	0,063	7	0,063
2	0,065	8	0,063
3	0,066	9	0,061
4	0,066	10	0,060
5	0,065	11	0,058
6	0,064	12	0,058

The next step were calculating UCL and LCL of EWMA Control, show below :

$Cl = \mu_o = X = 0{,}0615$
For $j<w$

$$UCL = \mu0 + 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}[(1-(1-\lambda)^{2j}}$$

$$LCL = \mu0 - 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}[(1-(1-\lambda)^{2j}}$$

While for j>w

$$UCL = \mu0 + 3\sigma\sqrt{\frac{\lambda}{(2-\lambda\ )}}$$

$$LCL = \mu0 - 3\sigma\sqrt{\frac{\lambda}{(2-\lambda\ )}}$$

Tabel 3. Value of UCL and LCL of EWMA Control Chart

Days	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
UCL	0,0620	0,0622	0,0622	0,0623	0,0623	0,0623	0,0623	0,0623	0,0623	0,0623	0,0623	0,0623
LCL	0,0611	0,0609	0,0609	0,0608	0,0608	0,0608	0,0608	0,0608	0,0608	0,0608	0,0608	0,0608

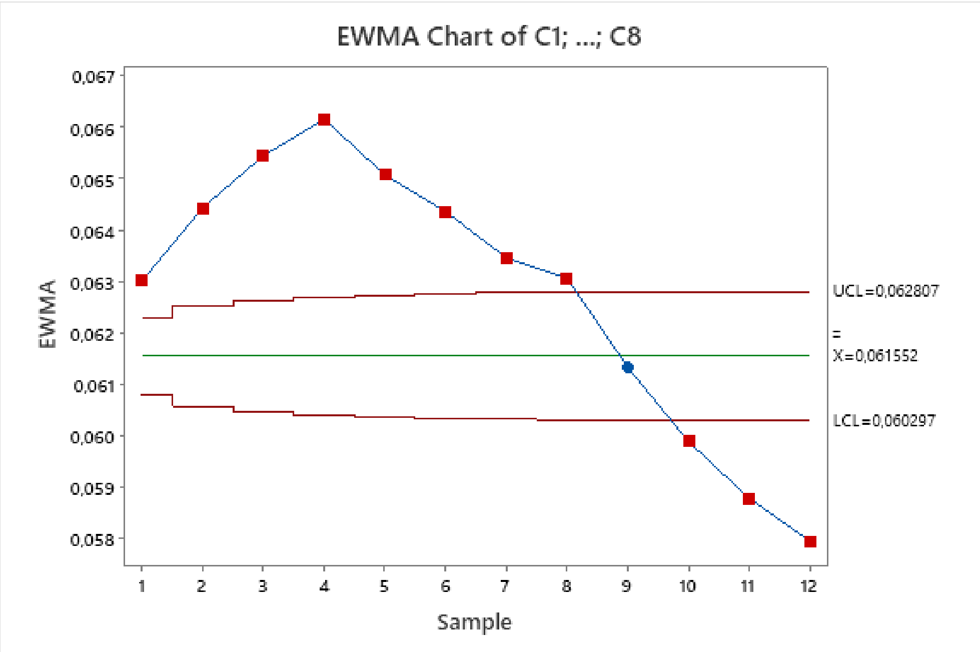

Figure 5. EWMA Control Chart

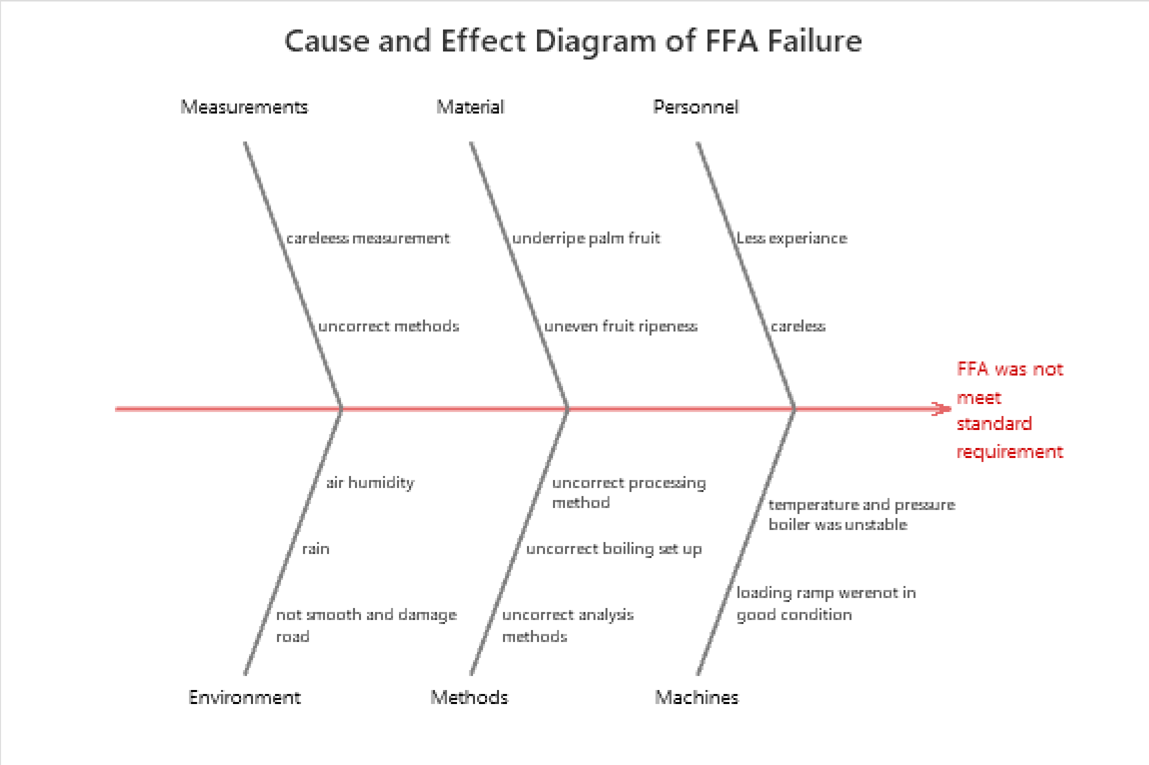

Figure 6. Cause and Effect Diagram

Using EWMA chart, the real condition on the process more eligible, so we can do the next step to find the root of the quality problem and way to solve it.

CONCLUSION

A simple control chart for monitoring quality product frequently can not display actual process conditions, so alternative control chartlike EWMA can be an option, espescially for data with small shifts. In this paper, we propose that EWMA control chart can give better result than X-R Shewart control chart and X-S Shewart control chart on measurement and analysis quality of crude palm oil product.

REFERENCES

Febrina, W., Yusrizal, & Abrar, A. (2019). Minimization of palm oil losses on sterilization process by optimization boiling pressure and boiling time. *Journal of Physics: Conference Series*, *1339*(1). https://doi.org/10.1088/1742-6596/1339/1/012089

Hamsah, La., Purnamasari, Ika., Satriya, M. A. (2019). Penerapan peta kendali exponentially weighted moving average (EWMA) dan peta kendali double exponentially weighted moving average (DEWMA) dalam pengendalian kualitas produk mie pada. *P*, 222–230.

Handika, R. (2003). *Pengendalian Kualitas Six Sigma dengan EWMA*. Undip.

Iskamto, D., Ghazali, P. L., & Aftanorhan, A. (2020). Exploratory Factor Analysis (EFA) To Measure Entrepreneur Satisfaction. *The International Conference on Industrial Engineering and Operations Management*, 9.

Khaliq, Q. U. A., Riaz, M., & Ahmad, S. (2016). On designing a new Tukey-EWMA control chart for process monitoring. *International Journal of Advanced Manufacturing Technology*, *82*(1–4), 1–23. https://doi.org/10.1007/s00170-015-7289-6

Patel, A. K., & Divecha, J. (2011). Modified exponentially weighted moving average (EWMA) control chart for an analytical process data. *Journal of Chemical Engineering and Materials Science*, *2*(1), 12–20. https://doi.org/10.5897/JCEMS.9000014

Rahmad, J. A., Febrina, W., & Yusrizal, Y. (2020). Analisis Pengendalian Kualitas Refined Bleached Deodorized Palm Oil Dan Refined Bleached Deodorized Palm Olein Di PT. Adhitya Seraya Korita Dumai. *Jurnal Unitek*, *13*(1), 1–14. https://doi.org/10.52072/unitek.v13i1.150

Saleh, N. A., Mahmoud, M. A., Jones-Farmer, L. A., Zwetsloot, I., & Woodall, W. H. (2015). Another look at the EWMA control chart with estimated parameters. *Journal of Quality Technology*, *47*(4), 363–382. https://doi.org/10.1080/00224065.2015.11918140

Solahuddin, A. (2015). *Grafik Pengendali EWMA dan CUSUM untuk Trend Exponensial AR 1*. UIN Sunan Gunung Djati Bandung.

Tang, A., Sun, J., Hu, X., & Castagliola, P. (2019). A new nonparametric adaptive EWMA control chart with exact run length properties. *Computers and Industrial Engineering*, *130*, 404–419. https://doi.org/10.1016/j.cie.2019.02.045