Quality Prediction of Refined Bleached Deodorized Palm Oil (RBDPO) Using Partial Least Square Regression Technique

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Abstract

Out of specification in the production of Refined Bleached Deodorized Palm Oil (RBDPO) will cause recycling in palm oil refining process as well as zero production during that period. Hence, the ability to predict the output quality variables so that appropriate adjustment can be made in the process beforehand is very useful in minimizing the production cost and time consumption. In this study, Multivariate Statistical Process Control (MSPC) is used to develop a prediction tool in order to predict the output quality variables before the process even began and eventually reduce the utility cost as compared to traditional method of using tacit knowledge which is not very practical. Knowing product quality in advance, adjustment can be made at the specific unit operation and also to identify in which standard the quality variables belongs to, be it Palm Oil Refiners Association Malaysia (PORAM) standard, China or Vietnam. The MSPC method used in this study is Partial Least Squares Regression (PLS) which capable in finding the relationships between the process and quality variables of the palm oil refining process assuming that the data are linear. In simulation, data used are obtained from Lahad Datu Edible Oil Sdn. Bhd. (LDEO) with percentage of fatty acid (FFA), moisture content, and iodine value as both the process and quality variable which undergone pre-screening and pre-processing of data. This study also considers a constant sampling time to ensure the randomness of the data as well as the residence time in determining the relationships of the quality variables corresponded to the actual process variables. Simulation results obtained from developed correlation coefficient are evaluated and compared using Mean Squared Error (MSE). MSE results shows that PLS method is capable in predicting the output quality variables.

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Keywords: palm oil; quality prediction tool; partial least square regression

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1. Introduction

Statistical process control concepts and methods have become very important in the manufacturing and process industries. Their objective is to improve the processes and product quality by studying the relations between the dependent and independent variables of the process [3].

PLS regression is a recent technique that generalizes and combines features from principal component analysis and multiple regression. Its goal is to predict or analyze a set of dependent variables from a set of independent variables or predictors. Many applications of PLS regression have appeared over the years for prediction and estimation in the manufacturing industry including chemical, pharmaceutical, and semiconductor processes [1][2].

The recycle process of out-spec RBDPO in the refinery plant is required when product specification are not met. The recycle process not only resulted in profit loss due to no production with estimated of nearly RM 10,000 per month to ensure the product quality meets the customer standard. Theoretically, if a statistical model is created to predict the quality of the end product before the process starts, the possibility of recycle process requirement can be reduced or removed as recycle process is an insignificant process and an extra expenditure for the company. Their objective is to improve the processes and product quality by studying the relations between the process (input) and quality (output) variables of the process [3]. Multivariate statistical process control (MSPC) was used to predict the RBDPO quality. There are three major standard quality of RBDPO which are PORAM, CHINA and VIETNAM as shown in Table 1.

<table>
<thead>
<tr>
<th>Properties</th>
<th>CPO</th>
<th>RBDPO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CHINA</td>
</tr>
<tr>
<td>Free Fatty Acid, FFA (%)</td>
<td>≤5</td>
<td>≤0.07</td>
</tr>
<tr>
<td>Moisture, MOIST (%)</td>
<td>≤0.25</td>
<td>≤0.10</td>
</tr>
<tr>
<td>Iodine Value, IV (Wijs)</td>
<td>50-55</td>
<td>50-55</td>
</tr>
</tbody>
</table>

2. Methodology

2.1. Data Collection and Preparation

A total of 148 data with 4 hours(h) time interval were collected from Lahad Datu Edible Oil Company and prepared as training data set. Standardization of data is done to ensure all the variables have a uniform range of scale and proceeded with box-plotting in which to find the best sample size from the whole set of data. From the boxplot, the normality and skewness of the data was checked based on the central limit theorem. Best sample size data was used for autocorrelation plot to determine process optimum sampling time. Data sorting is conducted according to the optimum sampling time. The sorted data were used to determine the optimum process resident time using staggered cross-correlation plot [7].

Nomenclature

CPO  Crude palm oil
FFA  Free fatty acid
IV   Iodine value
MOIST Moisture Content
PLS  Partial Least Square
RBDPO Refine bleached deodorized palm oil
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