Prediction of Dried Durian Moisture Content Using Artificial Neural Networks

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Abstract. Moisture content has a crucial issue in post-harvest processing since it plays main role to estimate a quality of dried product. However, estimating the moisture content is difficult since it shows mathematically nonlinear systems and complex physical processes. We investigate the prediction of moisture content of dried product by using Artificial Neural Networks (ANN). Our sample is a Bengkulu’s local durian that is dried using a microwave oven. Our results show that ANN can predict the moisture content by performing with R\(^2\) value is 98.47\%. Moreover, the RMSE values is 3.97\% and MSE values is 0.16\%. Our results indicate that ANN model have high capability for predicting moisture content and it is potentially applied in post-harvest product, especially in drying product quality control.

1. Introduction

Durian (Durio zibethinus, Murr.) is horticultural product that consumed not only as a fresh but also as a processed product. This tropical fruit that grown widely in Southeast Asia causes many oversupply after harvest since it grows only in certain season [1]. To overcome the problem, various processed durian product with drying process have been developed [2].

Drying is the most important treatment in post-harvest [2]. This treatment is adopted worldwide to reduce the spoilage and increase the shelf life or storage durability of agricultural product [3]. Drying is a well-known method to preserve fruits and vegetables [2]. The drying is a process of the removal of water (moisture) from hygroscopic materials at low to medium moisture content, normally less than 30\% wet basis. When the moisture content of the agricultural products is high, the process of removal of moisture is referred to as dehydration [3].

Nowadays, microwave drying is a relatively inexpensive method and has attracted many researchers attention. In a microwave drier, electromagnetic energy is directly converted to kinetic energy of water molecules and heat is produced within the product [2]. As microwaves can penetrate deep into food material, the entire food product is heated up quickly from the inside to the outside. The way microwave oven drying takes less time make it popular drying methods, especially for fruits. The agrophysics study has investigated potato drying by using microwave oven [4]. The same study also investigates the moisture content of dried tomato under microwave oven [5]. Even durian is dried using microwave oven and produces high quality durian chips [1].

Several models have been developed to determine moisture content of drying product like mathematical modelling using Maxwell equation along with mass and heat transfer equation [1]. Although that kind of modelling could describe the temperature distribution and moisture content during
drying, this approach is referred to the accurate prediction of physical properties of used parameters. The prediction using mathematical model approach is a very complex problem since the physical properties of parameters change during drying process [5]. On the other hand, modelling using physical dynamics is solving the complex problem. However, it results the double non-linear differential equation with partial derivation that make this approach take more time to solve the problem [11].

Apparently, artificial neural network (ANN) is an advanced computational method to handle complex systems between physical properties of foods and drying process [5]. A well-trained ANN has function as predictive model for a specific application, which is a data-processing system inspired by biological neural system [3]. In drying process, ANN is a reliable tool to determine temperature distribution and moisture content [2]. The studies of predicting moisture content by using ANN has been evaluated [3][7] for potato [4], freeze dried strawberry [6], microwave oven dried green pear [8], apple [7], and tomato [5]. The application of ANN for drying using microwave oven has been used widely.

Durian as popular consumed fruit in Indonesia has been developed as processed product under microwave oven drying [1]. Moisture content as quality parameter of microwave oven dried durian product has been investigated conventionally [1]-[7]. In this study, we use ANN to predict the moisture content of microwave oven dried durian.

2. Methods

The meats of Durian was excluded from the seed and then squeezed to be a puree. Then, we sliced durian purees using 1.5 cm thickness and 3.5 cm diameter tube. Furthermore, we dried the durian puree slices using microwave oven with four power levels which are medium low, medium, medium high, and high. For each drying condition, we dried the durian puree slices for 2 minutes. Then, we measured the mass of durian using digital weight to determine the moisture content of the dried durian. Moreover, the moisture content was calculated using equation as follows [6]:

\[
MC = \frac{M_i - M_d}{M_d}
\]

MC is moisture content, \(M_i\) is initial mass before drying, and \(M_d\) is the mass after drying. Other drying parameters measured are sample temperature, sample diameter, and sample thickness. The temperature was measured using mercury thermometer and both sample diameter and thickness were measured using Vernier calipers. All of drying parameters were measured for each 2 minutes until the moisture content of the durian approach 0 %.

At the following step, we designed the networks with backpropagation algorithm. First, we collected moisture content and drying parameters data from the experiment. They were divided into training data and testing data. Then, we determined the number of neuron for the hidden layer which is 10 neurons (see Fig. 1). All the process of creating the artificial neural networks uses MATLAB.
3. Results and Discussion
Figure 2 shows the transformation of the moisture content of durian slices during microwave oven drying. As can be seen, the moisture content tended to decrease during drying time. The drying with high power level took less time than those with lower power level. Durian purees required 200 seconds to dry with 800 watt. At the same time, they require 2000 seconds to dry with 575 watt. However, the appearance of dried durian under medium low power lever of microwave oven is more likely better than those under high power level. They are not burnt and they have better texture and color (see Fig. 3).
FIGURE 2. The moisture content of durian with various power levels of microwave oven: (a) 575 watt, (b) 600 watt, (c) 700 watt, and (d) 800 watt
FIGURE 3. The dried durian slice puree with various microwave power level: (a) 575 watt, (b) 600 watt, (c) 700 watt, and (d) 800 watt

The aim of constructed ANN is to determine the moisture content of dried durian using microwave oven. We use the Neural Network Tool Box with the certain code in Command Window to solve the problem. In this study, predicting and estimating problems are solved by Fitting App. The neural network in fitting app is a two-layer feed-forward network with sigmoid hidden neurons and linear output neurons. The training of neural network uses Lavenberg-Marquardst backpropagation algorithm.

| TABLE 1. The Statistical Test |
|-------------------------------|
| **R2** | **RMSE** | **MSE** |
| 98.47 % | 3.97 % | 0.16 % |
We test the prediction result by using R², RMSE, and MSE between experiment data and the ANN’s result. The values are 0.98, 0.04, and 0.002 respectively (See Table 1). Table 1 also suggests that ANN’s result has a good agreement with the experiment data and the lower values of MSE and RMSE show that the ANN prediction model has a good performance. Figure 4 shows that ANN’s result successfully has a good fit with the experiment data. Particularly, ANN model is adequate to predict moisture content as drying product quality control.

4. Conclusion

We have introduced a method to predict moisture content by using ANN. The results indicate that the developed model is successfully predicting the moisture content of durian which is dried using microwave oven. Analysis of prediction data shows a good agreement between the ANN’s result and the experimental data. The ANN’s performance is good in predicting moisture content of durian during microwave oven drying process.

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