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Detection of the Existence Rhodamine B in Chili Paste with Digital Image Processing

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ABSTRACT
The need for chili paste is increasing in line with the increasing variety of types and menus of dishes that use chili paste. To improve the colour of chili paste some traders use the textile dye Rhodamine B which causes significant health risks. The purpose of this study is to develop an image processing system that can detect the existence of Rhodamine B in chili paste quickly and practically using image processing and artificial neural networks (ANN). Image data retrieval using digital image acquisition techniques with the help of a webcam which is placed on the image capture toolbox and a computer. The number of samples used were 172 training data, 16 validation data, and 12 test data consisting of chili paste with the addition of various variations in the amount of Rhodamine B, namely 0 gram; 0.25 gram; 0.5 gram; 1 gram of Rhodamine B in 1 kg of chili paste. The data that has been extracted from the colour and texture features are then further processed and trained with an artificial neural network using the backpropagation method in order to detect the existence of Rhodamine B in chili paste properly. The resulting test system was then tested on 20 market samples taken from 4 different markets. The results of this study indicate that the parameters used to detect the existence of Rhodamine B in chili paste are parameters a, green, L, and b. The structure of the artificial neural network system consists of 4 input layers, 24 hidden layers, and 2 output layers. The GUI (Graphical User Interface) can detect the existence of Rhodamine B in chili paste with variations in the amount of Rhodamine B with the accuracy validation of the ANN system in detecting Rhodamine B in chili paste samples by 100% and testing the ANN system by 83%. Testing market samples with the ANN system gets an accuracy of 50%, the accuracy of the market samples is because the materials used are not controlled or heterogeneous.

Keywords: *Artificial Neural Network, Chili Paste, Digital Image Processing, Matlab, Rhodamine B.*

1. INTRODUCTION

Chili (*Capsicum annuu*m L.) is grown worldwide both as a spice and as a vegetable crop and world's second most important solanaceous vegetable after tomato. Chili is an important commercial crop of Bangladesh and grown for its green fruits as vegetable and in ripe dried fruits as spice and throughout the world because of its pungency and pleasant flavors [1]. The need for chili paste is increasing, it can be seen from the increase in chili production from 2016 to 2019 in Indonesia by 940 thousand tons. Total chili production in Indonesia in 2016 was 1.96 million tons and increased in 2017 by 2.35 million tons. There was a slight decrease in 2018 of 2.30 million tons and an estimated production plan for 2019 of 2.90 million tons.

Rhodamine B has been reported widely as present in various foods, including chili powder, preserved plums, sausage and sweets, presenting a significant health risk [2]. Rhodamine B was used as an artificial synthetic xanthene dye, which was initially widely used in textiles and plastic industries as a colorant [3]. Rhodamine B is a non-biodegradable organic substance with potential toxicity, mutagenicity, and carcinogenicity [4].

Image Processing has become essential feature for retrieving maximum information suitable for various professions like Remote Sensing, Medical Imaging, Non-destructive Evaluation, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Graphic arts and Printing Industry [5]. Pattern Recognition as a branch of computer vision focused on the process of

object identification through image transformation to get a better image quality and image interpretation. This process aims to extract information to make decisions based on images obtained from sensors [6]. Artificial neural network is considered as one of the modern mathematical-computational methods which are used to solve un-anticipated dynamic problems in developed behavioral systems during a time period. By learning to recognize patterns from data in which other computational and statistical method failed to solve them, artificial neural networks are able to solve the problems [7]. Backpropagation is a supervised learning algorithm and is usually used by perceptrons with many layers to change the weights connected to the neurons in the hidden layer. The backpropagation algorithm uses error output to change the value of the weights in the backward direction [8].

2. MATERIALS AND METHOD

2.1. Chili Preparation

The type of chili used is OR Twist 42. Chili used comes from farmers in the area of Dusun Kemiri, Purwobinangun Village, Pakem, Sleman, Yogyakarta, Indonesia. Fresh chili is then sorted and cleaned using running water to avoid contaminants and dirt after the harvesting process, after which the chili is dried by wiping the entire surface of the chili with a dry cloth.

2.1.1. Uniformity of Chili Colour Data

The measurement of the color of curly chilies aims to ensure that the chilies used have a uniform and homogeneous color when harvested because if the color that is read during the measurement has a significant difference with Chromameter, testing the data using Shapiro-Wilk Test and T Test. For the Shapiro-Wilk test, the L* color value of the color chroma mater measurement in general research alpha is 5% or (0.05). While the value of Sig. using shapiro-wilk for the first harvesting data sample of 0.485 and the second harvesting variable of 0.873 so that the interpretation is the value of Sig. > research alpha (0.05) then the data is normally distributed. Shapiro-wilk test a* color values for the first and second harvests were 0.554 and 0.695 so that both were normally distributed. Finally, the b* value for the Shapiro-Wilk test is 0.684 and 0.083 so that both are normally distributed.

In the Shapiro-Wilk test, all data are normally distributed so that it can continue to the next stage, namely the T-test. In the T-test of the Chromameter data L*, a*, b* the value of Sig. (2-tailed) which are generated sequentially are 0.295; 0.232; 0.135. The value of Sig. (2 tailed) > research alpha (0.05) then in this study the color value of fresh curly chilies when harvested did not have a significant difference so that the data were uniform and homogeneous.

2.1.2. Milling Process.

Chili milling is done in the Colombo Market with a milling tool owned by the seller of chili paste and seasoning, namely a matrix machine, pmj-8 type, with a cap of 60 kg/hour, speed of 710 rpm, and electricity needs of 1.1 KW.

2.2. Sample Preparation and Mixing (Chili paste, Rhodamine B, and Salt)

Laboratory samples require as much as 1 kg of chili for each variation made so that a total requires 8 kg of chili. The variation is without salt (0 gram) and using 100 grams of salt, because the majority of

Table 1. Variation, notation, and number of samples.

No.	Sample variation	Sample notation	Number of samples
1	0 gram Rhodamine B / 0 gram salt + 1 kg chili paste	0R0G	25
2	0.25 gram Rhodamine B / 0 gram salt + 1 kg chili paste	0.25R0G	25
3	0.5 gram Rhodamine B / 0 gram salt + 1 kg chili paste	0.5R0G	25
4	1 gram Rhodamine B / 0 gram salt + 1 kg chili paste	1R0G	25
5	0 gram Rhodamine B / 100 gram salt + 1 kg chili paste	0R100G	25
6	0.25 gram Rhodamine B / 100 gram salt + 1 kg chili paste	0.25R100G	25
7	0.5 gram Rhodamine B / 100 gram salt + 1 kg chili paste	0.5R100G	25
8	1 gram Rhodamine B / 100 gram salt + 1 kg chili paste	1R100G	25
Total			**200**

sellers of chili pastes use salt in a ratio of 1:10 to the total weight of chili used. For variations of the addition of Rhodamine B, namely 0 gram; 0.25 gram; 0.5 gram; and 1 gram of Rhodamine B, can be seen in table 1.

The chili paste sample is then placed in a container made of aluminum because it has a lot of water content so that the sample remains in place and it is easy to take an image, can be seen in figure 1.

Figure 1. Sample picture.

2.3. Market Sample Preparation

The markets selected in this study were randomly selected from 4 different markets located in the city of Yogyakarta. The markets and codes used for the market sample are as follows: Code P = Colombo market; Code Q = Condong Catur market; Code R = Godean market; Code S = Demangan market.

2.4. Image Acquisition and Image Processing

The photo was captured using Logitech C270 camera manually and connected to the computer. The image extracted colour and texture features using the MATLAB application, can be seen in figure 2.

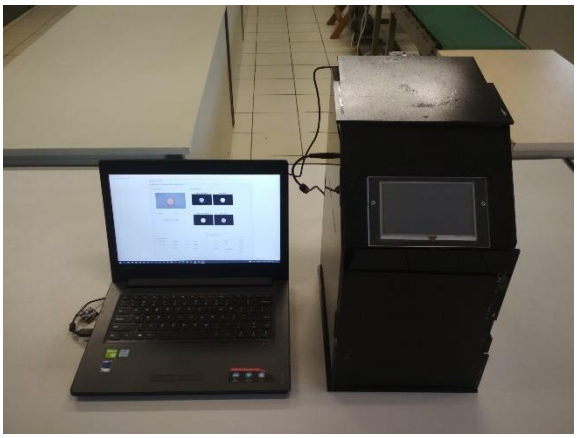

Figure 2. Image capture box.

The equipment in it are: Camera, this camera is used to take an image of an object (image acquisition). Background is used as the sample object background. Cover box is used as a protective tool as well as a barrier to the entry of outside light into the system. LED lights as a lighting source in the image capture box, can be seen in figure 3. The laptop functions as an energy resource for the tools in the box and is used to run Matlab and IBM SPSS applications. MATLAB is not only exploited in computations but also in the process of teaching and learning. In the MATLAB environment, there are applications that can be created to improve learning [9].

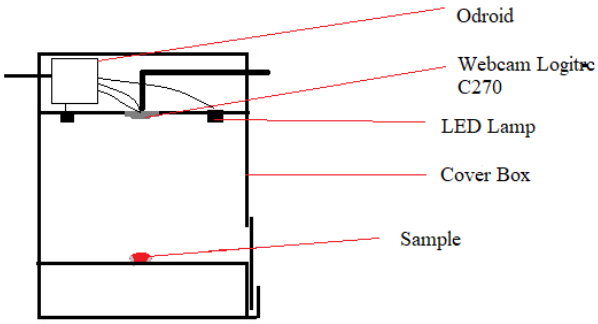

Figure 3. Inside the image capture box.

Image retrieval is divided into two parts, namely without the addition of salt and with the addition of salt. Each sample number is 172 samples in image processing with a comparison of 22 samples without the addition of Rhodamine B or 0 gram of Rhodamine B per one kilogram of chili, 22 samples with the addition of 0.25 gram of Rhodamine B per one kilogram of chili, 22 samples with the addition of 0.50 gram of Rhodamine B per one kilogram of chili, and 22 samples with the addition of 1 gram of Rhodamine B per one kilogram of chili, while if using salt, each variation amounted to 21 samples. 16 samples for ANN validation, and 12 samples for final ANN testing. The last is market sample testing using 20 market samples from four different markets which will be compared with thin layer chromatography testing at the Yogyakarta Special Region Health Office.

2.5. Classification using ANN

The information extracted at the ANN stage is the value of color features (red, green, blue, hue, saturation, value, L, a, b) and texture feature values (contrast, correlation, energy, entropy, homogeneity). To simplify the processing by the

user, a GUI is made to display the results of image processing, can be seen in figure 4.

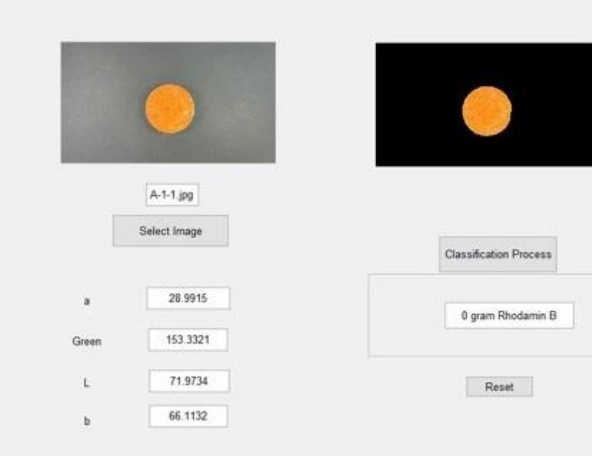

Figure 4. GUI (Graphical User Interface) ANN.

3. RESULT AND DISCUSSION

3.1. Wet Base Water Content Measurement

Wet base water content measurement in the sample was carried out so that there was uniformity of data when the chili was harvested so that the chili used was relatively uniform chili.

Table 2. Wet base water content measurement.

No.	Sample variation	Wet base water content
1	Laboratory sample (0 gram salt)	79%
2	Laboratory sample (100 gram salt)	73%
3	Market sample P	77%
4	Market sample Q	69%
5	Market sample R	75%
6	Market sample S	73%

From the measurement of water content in the sample, can be seen in table 2. The average value of the water content contained is that the sample without salt contains an average water content of 79%, the sample uses 100 gram of salt per 1 kg of chili the average water content is 73%. The market sample moisture content data is the average value of water content in the Colombo Market sample of 77%, Condong Catur Market 69%, Godean Market 75%, and Godean Market 73%. The maximum limit of wet base moisture content (wb) of chili paste is 83%. All of the sample were under 83% so all of the data would be used.

3.2. Determination of ANN Parameters

In this study, parameters with a strong and very strong relationship level or the value of the relationship are more than 0.60. The reason is that the selected parameters have a strong relationship so that the designed system can easily and precisely classify between variations of the existence or absence of Rhodamine b levels in the sample.

Table 3. Determining the parameters used.

No.	Parameter	Description		
		R.	Sig.	Interpretation
1	a	0.840	0.000	Used
2	Green	-0.824	0.000	Used
3	L	-0.813	0.000	Used
4	b	-0.645	0.000	Used
5	Homogenity	-0.592	0.000	Not used
6	Correlation	-0.523	0.000	Not used
7	Energy	-0.394	0.000	Not used
8	Entrophy	0.338	0.000	Not used
9	H	-0.299	0.000	Not used
10	Blue	0.292	0.000	Not used
11	Red	0.289	0.001	Not used
12	Contrast	0.203	0.017	Not used
13	V	-0.186	0.028	Not used
14	S	-0.026	0.756	Not used

The parameters used in this study are 4, can be seen in table 3. Namely: parameter a with a coefficient of 0.840. Green's parameter with a coefficient of -0.824. Parameter L with a coefficient of -0.813. The last parameter is b with a coefficient of -0.645. Because the four parameters exceed ±0.60 then parameter b is strongly related and parameters a, green, and L are very strongly related to the results to be displayed.

3.3. Structure and Training of ANN

The ANN architecture was comprised of 3 layers, namely the input layer, the hidden layer, and the output layer. As for the hidden layer, it was determined by trial and error to get the number of neurons with the lowest Mean Square Error (MSE) value. Trial and error were also used to determine training algorithms, transfer function, and a number of iterations. The output layer has 2 layers because it uses binary output and produces 4 classifications, can be seen in table 4. The smallest MSE search results get the following attributes. Training: Trainrp; Input layer: 4; Hidden layer: 24; Output layer: 2; Transfer function: Logsig-logsig; Iterations (Epoch): 5000.

Table 4. ANN Output Target.

No.	Output Target	Binary output
1	0 gram Rhodamine B / 1 kg chili paste	0 0
2	0.25 gram Rhodamine B / 1 kg chili paste	0 1
3	0.5 gram Rhodamine B / 1 kg chili paste	1 0
4	1 gram Rhodamine B / 1 kg chili paste	1 1

The smallest MSE result obtained is 0.0289, with 5000 iterations, with a time of 7 seconds, and a gradient value of 0.256. The values of these attributes will be used for validation and testing, can be seen in figure 5.

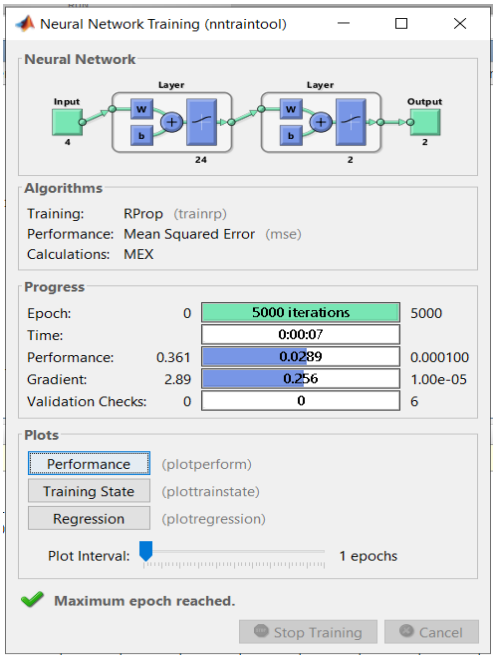

Figure 5. Training result ANN.

3.4. Validation of ANN

Based on the selected attributes, laboratory samples were validated and the results were, can be seen in table 5.

$$\text{Validation accuracy } (\%) = \frac{16}{16} \times 100\% = 100\%$$

The validation of the results of the ANN training is worth 100% so that it is considered successful and represents the values of the training.

Table 5. Validation Laboratory Sample Set.

No.	Code	Target		Result		Description
1	A-1	0	0	0	0	True
2	A-2	0	0	0	0	True
3	E-1	0	0	0	0	True
4	E-2	0	0	0	0	True
5	B-1	0	1	0	1	True
6	B-2	0	1	0	1	True
7	F-1	0	1	0	1	True
8	F-2	0	1	0	1	True
9	C-1	1	0	1	0	True
10	C-2	1	0	1	0	True
11	G-1	1	0	1	0	True
12	G-2	1	0	1	0	True
13	D-1	1	1	1	1	True
14	D-2	1	1	1	1	True
15	H-1	1	1	1	1	True
16	H-2	1	1	1	1	True

3.5. Laboratory Sample Test

After the ANN validation is carried out, ANN testing will be carried out with 12 laboratory samples that have been made for test samples, can be seen in table 6.

Table 6. Testing Laboratory sample set.

No.	Code	Target		Result		Description
1	A-3	0	0	0	0	True
2	E-3	0	0	0	0	True
3	E-4	0	0	0	0	True
4	B-3	0	1	0	1	True
5	F-3	0	1	0	1	True
6	F-4	0	1	0	1	True
7	C-3	1	0	0	0	False
8	G-3	1	0	0	0	False
9	G-4	1	0	1	0	True
10	D-3	1	1	1	1	True
11	H-3	1	1	1	1	True
12	H-4	1	1	1	1	True

The percentage of the final test classification with artificial neural networks was 83%, this value was high enough.

3.6. Market Sample Test

3.6.1. Thin Layer Chromatography Test Results for Comparison.

Prior to testing with artificial neural networks, 20 samples were first tested at the Testing and Calibration Laboratory, Health Laboratory and

Calibration Center of the Yogyakarta Special Region of Health. This test uses the thin layer chromatography method. From four markets and the 20 samples used, all of them did not contain Rhodamine B so that the four markets did not use the addition of Rhodamine B dye into the chili paste products sold. These results will be used for comparison against the results of the classification on the ANN architecture that has been made.

3.6.2. Market Sample Testing with ANN.

After obtaining the results of comparison with the thin layer chromatograph method, then with the same market sample, testing was carried out with the ANN system that had been produced, can be seen in table 7.

Table 7. Testing market sample.

No.	Code	Target		Result		Description
1	P1	0	0	0	0	True
2	P2	0	0	0	0	True
3	P3	0	0	0	0	True
4	P4	0	0	0	0	True
5	P5	0	0	0	0	True
6	Q1	0	0	1	0	False
7	Q2	0	0	1	0	False
8	Q3	0	0	1	0	False
9	Q4	0	0	1	0	False
10	Q5	0	0	1	0	False
11	R1	0	0	0	1	False
12	R2	0	0	0	1	False
13	R3	0	0	0	1	False
14	R4	0	0	0	1	False
15	R5	0	0	0	1	False
16	S1	0	0	0	0	True
17	S2	0	0	0	0	True
18	S3	0	0	0	0	True
19	S4	0	0	0	0	True
20	S5	0	0	0	0	True

The results of testing using the ANN system that has been made in this study, the percentage of test classification with artificial neural networks is 50%. The market sample test accuracy is obtained by 50%. The accuracy in this study resulted in this value because the market sample was not controlled for the materials used.

4. CONCLUSION

The artificial neural network structure generated from this study uses 4 parameters, namely a, green, L, and b as input layers, 24 hidden layers, and 2 output layers with binary numbers for 4 sample variations, namely 0; 0.25; 0.5; 1 gram of Rhodamine B in 1 kg of chili paste. The accuracy of the ANN system validation in detecting Rhodamine B in chili paste samples was 100% and the ANN system testing was 83%.

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