The Use of Telang Flower Extract (*Clitoria ternatea L.*) as a Natural Universal pH Indicator coupled with Digital Image Colorimetry

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ABSTRACT

The acid base indicators commonly used by scientists are mostly synthetic indicators that are harmful for the environment. Moreover, chemists need various chemicals to detect broad pH ranges for acid and base samples solution. The aim of this research was to create a natural universal pH indicator from telang flower (Clitoria ternatea L.) extract coupled with the digital image detection. The universal pH indicator is very important in education chemistry that broadly used for titration and other class room chemical experiments. This process of making a natural universal pH indicator integrated with digital images meets green chemistry criteria that use environmentally friendly materials and technology. The results show that color absorption data at pH 1-2 are purple, pH 3-5 are violet, pH 6-10 are blue, pH 11-12 are green and pH 13-14 are yellow. RGB intensity digital image data shows the intensity of the red color increases in the pH range 6-11, while the intensity of the green and blue colors tends to be stable. The proposed method was validated using a UV-Vis spectrophotometer and conventional pH meter that give the comparable results.

Keywords: *Acids and Bases, Indicators, Digital Images Colorimetry, Telang Flower, Green Chemistry.*

INTRODUCTION

To determine acidic, basic or neutral properties, you can use an indicator that gives a characteristic color change (Karo, 2020). Commonly used acid base indicators include synthetic indicators such as phenolphthalein, methyl red, methyl orange and bromthymol blue, universal indicators and those most commonly used are litmus paper and pH meters. Synthetic indicators are dangerous chemicals, which can pollute the environment, water and soil, and endanger health. Apart from that, acid base indicators such as universal indicators, litmus paper and pH meters are relatively expensive (Rusiani & Lazulva, 2017).

Besides these indicators, natural indicators can also be used. Natural indicators can be obtained by using natural materials in the surrounding environment. Natural indicators are indicators made using plant extracts, such as flowers, tubers, fruit peels, or colored leaves (Andarias, 2018). In this way, natural indicators are indicators that are friendly to the environment (Green Chemistry) (Agustina et al., 2022).

Much research has been carried out regarding the use of natural materials as natural indicators. Plants containing anthocyanins can be used as alternative natural indicators (Yuliantini & Rahmawati, 2019). Anthocyanins are water-soluble secondary metabolites, have many benefits and can be found in various types of plants (Idrus et al., 2023). Anthocyanins tend to dissolve in polar solvents due to the presence of aromatic groups and glycosyl residues (Angriani, 2019). Anthocyanin dyes are influenced by the structure of the anthocyanin and the degree of acidity (pH), so this pigment can be used as a pH indicator. One of the plants that contains anthocyanin compounds is the telang flower (*Clitoria ternatea* L.) (Suryana, 2021).

Butterfly pea flowers are blue or purple flowers that belong to the Fabaceae family (Kosai et al., 2015). The telang flower is a plant that usually propagates in forests and home gardens. The appearance of the telang flower can reach 6 meters in height, the twigs are smooth, and the type of compound leaves. This flower can be cultivated by planting the seeds (Purwaniati et al., 2020). Butterfly flower (*Clitoria ternatea* L.) is one of the many natural ingredients that is often used in the daily lives of Indonesian people, both as a plant to decorate fences, drink ingredients, environmentally friendly natural food coloring and even as traditional medicine (Marpaung, 2020).

The natural indicators developed so far are still limited to indicators to differentiate acids and bases. Likewise, color matching on universal indicator paper still allows for less clear color changes. In line with this, innovation in pH measurement using natural, environmentally friendly materials at affordable prices is needed. One way that can be used is by using digital images.

In a general sense, an image is a picture. In a more specific sense, an image is a visual depiction of an object or several objects. The digital image method is part of the multimedia component which has a very important role in obtaining/searching for visual information (Munir, 2012). The digital image method is a combination of digital photography and colorimetry. Digital images consist of three types of images, namely monochrome images (black and white), grayscale images (gray) and true color images (colored images). Each image pixel or color image consists of three color elements known as RGB (Red, Green, and Blue) (Abdullah, 2022). RGB data from a sample which is an extension of data from a color system, which is interpreted as the reflection of light from an object and has a value range of 0 to 225 units (Bustomi & Dzulfikar, 2014). The data collection on digital images is then processed using a computer with the imageJ application. The main function of image processing is to improve image quality so that it looks better and clearer (Jumadi et al., 2021).

This research aims to create a natural universal pH indicator from butterfly pea flowers using digital image methods.

EXPERIMENTAL SECTION

Materials

Telang flowers (*Clitoria ternatea L.*) were taken from Unib's campus garden. Distilled water, universal indicator paper, HCl, NaOH and all other chemicals were bought from Merck.

Instrumentation

UV-Vis spectrophotometer, smartphone camera, mini studio, ImageJ application, microsoft excel application, cuvette, pH meter, test tube, analytical balance, beaker, Erlenmeyer, measuring cup, funnel, paper. filter, dropper, stirrer, thermometer, lumping and pestle.

Procedure

Making a natural universal pH indicator from natural ingredients of butterfly pea flowers begins with making butterfly pea flower extract using distilled water as a solvent at a temperature of 80 °C (Purwaniati et al., 2020).

The acid base solution used is made by dilution. The acid solution uses a hydrochloric acid (HCl) solution pH 1 and the basic solution uses a sodium hydroxide (NaOH) solution pH 14. These solutions are then diluted to obtain an acid solution pH 1-6 and a base solution pH 8-14. For solutions with a pH of 7, distilled water is used.

The acid base solution test using natural indicators of butterfly pea flowers was carried out by taking 5 ml of each acid base solution with various pH ranges and putting them into a test tube. Next, these solutions were dripped with 1 ml of butterfly pea flower indicator extract and the color change was observed.

Digital images were taken using a smartphone camera (Meileza et al., 2019). The digital image is then analyzed using an imageJ

application (Faiqoh, 2016). Processing RGB data via the ImageJ application is carried out in the following way:

a) Upload the sample image file to be analyzed to the ImageJ application
b) Crop the sample image to be analyzed using the crop feature available on the ImageJ application display
c) Select Image > duplicate
d) Select Plugins > analyze >RGB Measure
e) After selecting RGB Measure, the results will appear from the RGB data of the sample image being analyzed.

The digital image data is used as a natural universal pH indicator which will be used as an indicator to determine the pH of the solution that will be tested next.

RESULTS AND DISCUSSION

Observation results of color changes in Telang flower extract in acid-base solutions

The results of observations of color changes in telang flower extract with acid-base solutions are presented in table 1.

Table 1. Maximum wavelength absorption of Telang flower extract with the addition of an acid base solution

pH	Sampel	Maximum wavelength	Absorbance	Absorbed color	Complementary colors
1	HCl 0,1 M	542	0.4603	Green	Purple
2	HCl 0,01 M	550	0.41059	Green	Purple
3	HCl 0,001 M	572	0.38021	Yellow-Green	Violet
4	HCl 0,0001 M	572	0.41137	Yellow-Green	Violet
5	HCl 0,00001 M	572	0.50805	Yellow-Green	Violet
6	HCl 0,000001 M	616	0.53492	Red	Blue-Green
7	H_2O	620	0.55762	Red	Blue-Green
8	NaOH 0,000001 M	620	0.62785	Red	Blue-Green
9	NaOH 0,00001 M	626	0.64036	Red	Blue-Green
10	NaOH 0,0001 M	626	0.55047	Red	Blue-Green
11	NaOH 0,001 M	400	0.67913	Violet	Yellow-Green
12	NaOH 0,01 M	400	0.81275	Violet	Yellow-Green
13	NaOH 0,1 M	400	0.68581	Violet	Yellow-Green
14	NaOH 1 M	400	0.73081	Violet	Yellow-Green

Table 1 show that the blue butterfly pea flower extract changes color when added to an acidic or alkaline solution. At a low pH <2, most of the anthocyanins are found in the form of the red flavium cation (AH^+). Meanwhile, at a higher pH, the flavium cation changes to a quinoid base. The color changes from red to purple. At pH values between six and seven (close to neutral), the quinoid base (purple) is deprotonated to form a blue anionic quinoid base. The stability of anthocyanins slowly decreases as the Ph increase > 7. Isomerization into chalcone causes the anthocyanin color to become green to yellow (Hasanah et al., 2023).

Results of color absorption analysis of butterfly pea flower extract at the maximum wavelength

Color absorption testing using a UV-Vis spectrophotometer then obtained color absorption data based on the maximum wavelength of color absorption. At pH 1-2, with the complementary color purple, the color absorbed was green in the wavelength range of 500-560 nm. At pH 3-5, with the complementary color violet, the color absorbed was yellow-green in the wavelength range of 560-580 nm. At pH 6-10, with the complementary color blue-green, the color absorbed was blue in the wavelength range of 595-610 nm. At pH 11-14, with the complementary color yellow-green, the color absorbed was violet in the wavelength range of 400-435 nm.

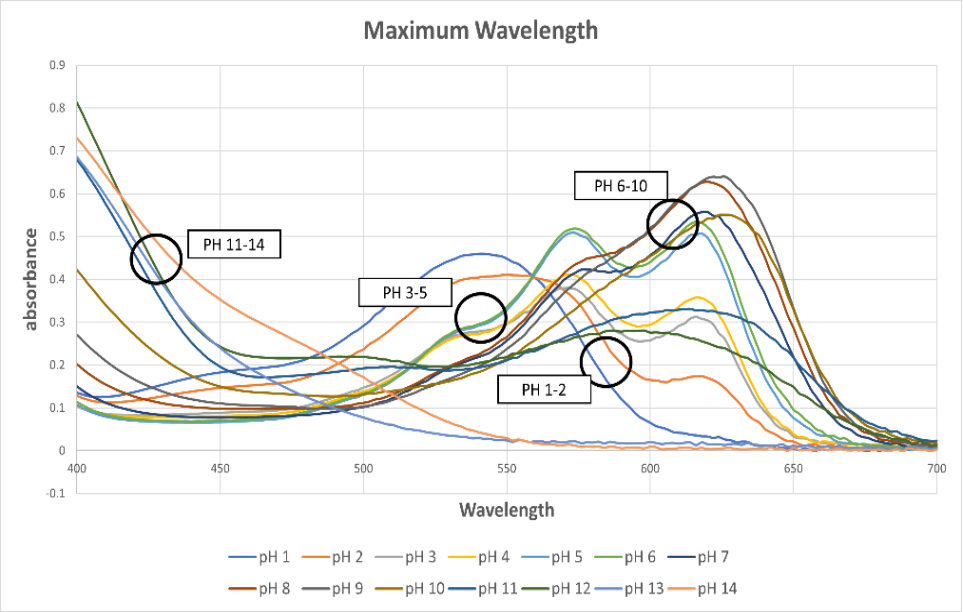

Figure 1. Graph of the maximum wavelength of color absorption of telang flower extract

The graph shows the proximity of the maximum wavelength region at several pH levels. This means that the pH range has the same color. At pH 1-2 it is purple, at pH 3-5 it is violet, at pH 6-9 it is blue, at pH 10-14 it is green to yellow.

Results of Digital Image Analysis of pH Indicators for Natural Materials of Telang Flower (Clitoria ternatea L.)

The next process is to take a digital image of the acid-base solution test results using natural indicators of butterfly pea flowers and analyze the RGB color intensity for each color change. The digital image analysis process is carried out by taking pictures of the solution in a mini studio using a smartphone camera. The following is the image obtained:

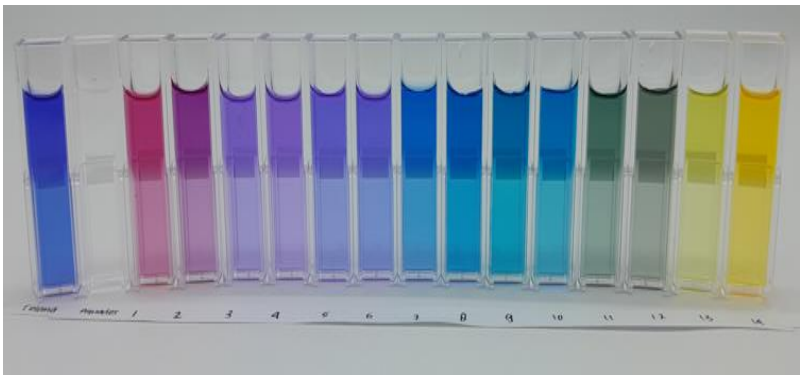

Figure 2. Changes in the extra color of telang flowers with the addition of an acid-base solution

The image that has been taken is cropped to a size of 0.5 × 0.5 cm, then the RGB value is searched using the imageJ application. The image obtained is then used as a natural universal pH indicator. The following is a picture of a natural universal pH indicator from telang flowers.

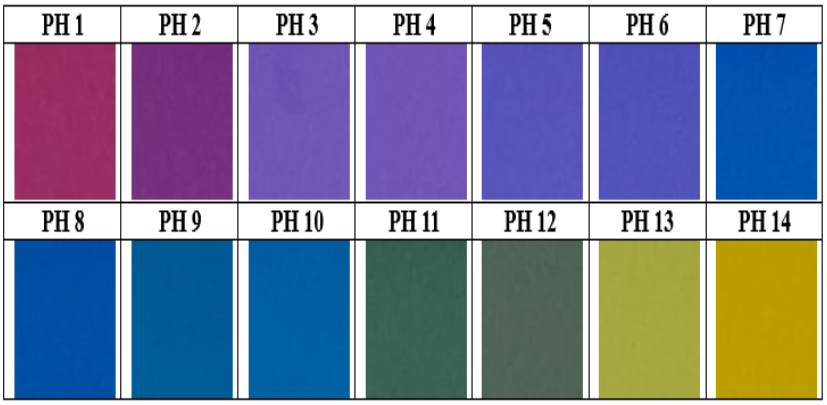

Figure 3. Natural universal pH indicator for telang flowers

From the image above, look for the absorbance intensity value of each color Red, Green, Blue (RGB) using the following equation:

$$A = Log\ \frac{I0}{It} \quad \ldots.(1)$$

Where Io is the blank color component value and It is the standard color component value. The color component values of the RGB color intensity of telang flower extract in acid-base solutions are shown in table 2 below:

Table 2. Color component values and RGB color intensity of telang flower extract

pH	Mark			Intensity		
	Red	Green	Blue	Red	Green	Blue
Blank	174.238	176.207	175.223	0.000	0.000	0.000
1	151.960	45.190	98.920	0.059	0.591	0.248
2	118.103	47.261	125.062	0.169	0.572	0.146
3	110.324	86.336	180.505	0.198	0.310	-0.013
4	112.278	85.278	180.278	0.191	0.315	-0.012
5	87.103	84.361	185.425	0.301	0.320	-0.025
6	80.106	82.311	184.037	0.337	0.331	-0.021
7	1.930	83.290	174.456	1.956	0.325	0.002
8	0.974	78.937	164.084	2.253	0.349	0.029
9	0.434	90.622	149.304	2.604	0.289	0.070
10	0.530	95.649	161.561	2.517	0.265	0.035
11	56.453	96.465	85.499	0.489	0.262	0.312
12	79.847	99.336	87.357	0.339	0.249	0.302
13	165.485	166.534	64.190	0.022	0.025	0.436
14	186.171	157.690	0.372	-0.029	0.048	2.673

Based on the RGB color intensity, it can be seen that the intensity of the red color increases in the pH range 6-11. Meanwhile, the intensity of Green and Blue tends to be stable.

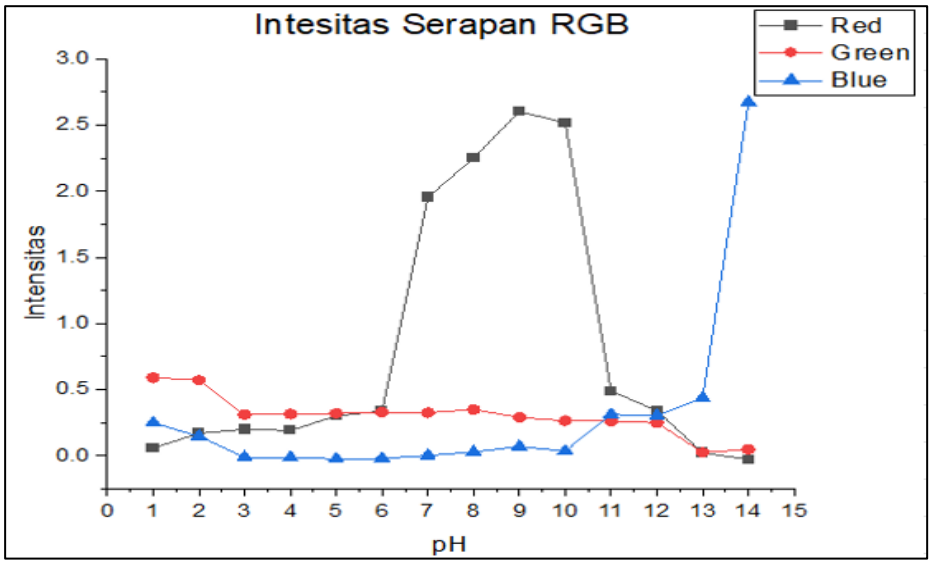

Figure 4. Intensity of extra RGB color absorption of telang flowers in acid-base solutions

Test Results of the natural universal pH indicator of Telang Flower (Clitoria ternatea L.) in Solutions in the Surrounding Area.

The natural universal pH indicator for telang flowers is used to measure acid-base solutions in the surrounding environment. The following results were obtained:

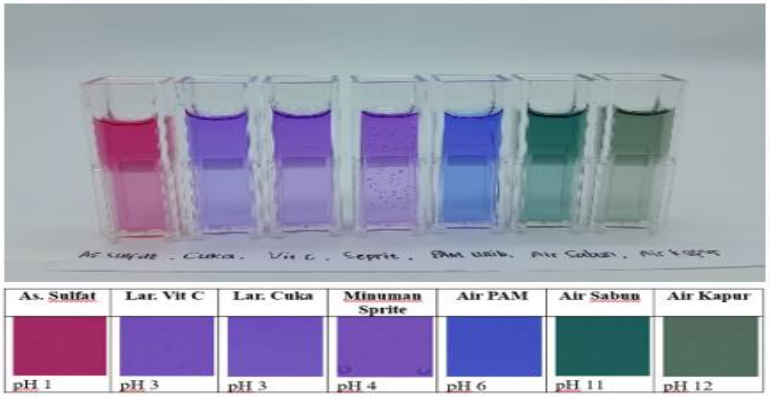

Figure 5. pH of acid-base solutions in the environment

Measurements show that the natural universal pH indicator of telang flowers can be used to measure acid-base solutions in the surrounding environment. With the results, the sulfuric acid solution has a pH of 1, the vitamin C and vinegar solution has a pH of 3, the sprite drink has a pH of 4, PDAM water has a pH of 6, soapy water has a pH of 11 and lime water has a pH of 12. This measurement is compared with a comparative pH measuring instrument in the form of a universal indicator. from Merck and a digital pH meter with the following results.

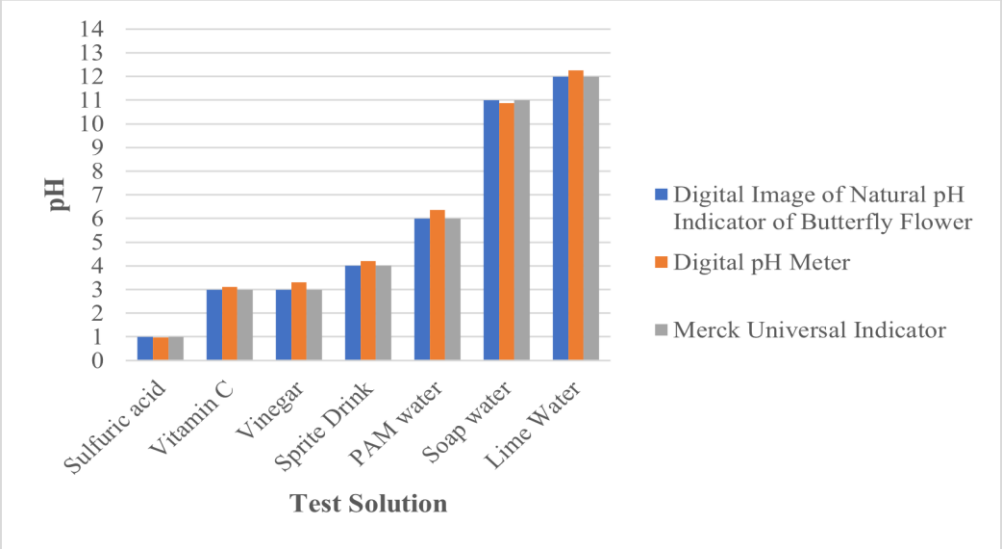

Figure 6. Measurement of real sample solutions using digital images of the natural universal pH indicator of telang flowers compared to measurements using a digital pH meter and a universal indicator from Merck. There are no sigfinificant differences between the developed methods with references.

The results obtained are a digital image of a natural universal pH indicator that is made to measure pH values with the same or comparable results as a comparative pH measuring instrument in the form of a universal indicator from Merck and a digital pH meter.

CONCLUSION

The process of making a natural universal pH indicator from natural ingredients of telang flowers (*Clitoria ternatea L.)* which is integrated with digital images to measure the pH of several substances in the environment meets green chemistry criteria and uses environmentally friendly technology. Based on data analysis, it can be concluded that the digital image of telang flower extract can be used as a natural universal pH indicator with a color trajectory, namely at pH 1-2 purple, pH 3-5 violet, pH 6-10 blue, pH 11-12 green and pH 13 -14 yellow.

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