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Development and Assessment of Kamote Leaf Extract as Potential Localized pH Paper

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Abstract. Many studies have investigated that natural plant extracts could be used as natural indicators, which are alternatives to commercial pH indicators used in acid-base lessons. However, no study has yet delved into developing and assessing purple sweet potato (Ipomoea batatas L.), locally called kamot,e as a potential material for creating localized pH paper (LpP). Therefore, this study was conducted to develop a pH paper for kamote leaf extract (KLEpP) and compare it with commercial pH paper and kamote leaf extract (KLE) to assess its potential as an LpP. The research is experimental and comparative. It focused on determining how KLEpP compares with commercial pH paper and kamote leaf extract (KLE). Additionally, the study analyzed the purple sweet potato extract for potential anthocyanin content using Fourier Transform Infrared (FTIR) Spectroscopy. Results indicated that the color of KLEpP shifts from light green to pink when immersed in a pH three standard. Further color changes were observed at pH 13 and 14, transitioning from light green to yellow-greenish and yellowish, respectively. While the color changes of KLEpP closely resemble those of KLE, the latter exhibited a wider spectrum of color changes. Notably, PSPLE demonstrated consistent color changes from pH 1 to 5, with a stronger pink at pH 3. The FTIR analysis revealed peaks indicative of various functional groups (hydroxyl groups, aldehyde group, aromatic group, hydrocarbon group, ester group bond, and C-O bond), signifying the presence of anthocyanins. The findings suggested that KLEpP has the potential to be an LpP and a practical alternative to commercial pH paper for teaching acid-base concepts. Furthermore, it could be employed to determine the pH of household materials.

Keywords: Acid-base indicator; Localized pH paper; Natural indicator; pH paper, Sweet potato.

1.0 Introduction

The significance of science and scientific advancement cannot be overstated in our modern world. As a result, science education is crucial in cultivating individuals who possess a comprehensive understanding of science and are equipped with vital 21st-century skills such as problem-solving (Kalogiannakis et al., 2021) and scientific inquiry. To help foster scientific knowledge, the availability of essential supplies is crucial for advancing scientific research and education. However, the world is currently facing difficulties in providing high-quality science education as some students find science difficult to learn (Degorio, 2023), which is evident in the significant decline in students' interest in pursuing careers in science (Dela Fuente, 2019). The decline may be attributed to the insufficient infrastructure and the lack of teaching and learning materials that causes science students anxiety (Fia et al., 2022).

This global issue is also a problem in the Philippines, particularly in areas with limited resources. Students face significant challenges due to a lack of laboratory supplies, such as pH paper (Estipular & Roleda, 2018; Noroña, 2021). This scarcity poses significant challenges to educational institutions and can hinder the quality and progress of education. It can impede scientific inquiry, experimentation, and educational activities, ultimately leading to a decline in students' performance in science. This is evident from the drop in the Philippines' ranking in science proficiency in the Programme for International Student Assessment (PISA, 2022), with Filipino students consistently ranking among the lowest worldwide (Acido & Caballes, 2024). To address this problem, the Department of Education integrated into the K to 12 Curriculum 2016 Guide in Science the usage of local and indigenous materials, which are more affordable and easier to obtain (Abugri et al., 2012). Especially in teaching acid-base lessons for grade seven students, teachers are encouraged to use natural indicators as supplements for expensive pH meters, pH paper, and synthetic pH indicators (Kapilraj et al., 2019), which are toxic (Jabeen et al., 2022).

Many studies have investigated natural indicators obtained from different plants as alternatives to commercial pH indicators, including red cabbage (Pakolpakçıl et al., 2018), purple sweet potato (Laila, 2019; Sohany et al., 2021; Farida et al., 2024), butterfly pea (Wiyantoko & Astuti, 2020), turmeric, rose, beetroot (Jabeen et al., 2022), guinea corn (Abugri et al., 2012), and bougainvillea (Killedar et al., 2017; Kapilraj et al., 2019). Also, Only Syahirah et al. (2018) and Jabeen et al. (2022) have produced pH paper strips using turmeric, rose, beetroot, red cabbage, and butterfly pea. However, no study is currently on developing and assessing kamote leaf extract as a potential material for creating localized pH paper (LpP). LpP presents a cost-effective, locally sourced, easily manufactured tool—like kamote, a common crop and a staple in the Philippines—that can be customized for various pH range requirements, making it a suitable resource for laboratories with limited means. Therefore, this study was conducted to develop a pH paper using sweet potato (Ipomoea batatas L.) leaf extract, locally known as "kamote" (KLEpP), and compare it with commercial pH paper and kamote leaf extract (KLE)to assess its potential as a LpP.

Furthermore, various studies have demonstrated that the active compound anthocyanin, an organic compound that exhibits colors ranging from pink, red, and violet to blue (Laila, 2019; Alappat et al., 2020) and is found in a wide range of fruits, vegetables, flowers, and cereal grains (Wrolstad, 2004), is the primary factor behind the color changes in these natural indicators due to its sensitivity to pH (Tuslinah et al., 2021). Thus, the study also examined the presence of anthocyanin in the extract of purple sweet potato leaves using Fourier Transform Infrared Spectroscopy (FTIR) to assess if anthocyanin was the active compound that caused a color change in KLEpP.

2.0 Methodology

2.1 Research Design

The research design is experimental because it used the standard pH from pH 1-14 and utilized commercial pH paper as a control. The study is also comparative because the KLEpP was compared to the KLE to determine the color change difference. Furthermore, the purple sweet potato leaf extract was also analyzed for the potential presence of anthocyanin using FTIR Spectroscopy (PerkinElmer Spectrum IR).

Development of KLEpP

The sweet potatoes were purchased from the local vegetable market. They were washed, then 25.00g of sweet potato leaves were weighed and transferred to a mortar and pestle. Next, 10.00mL of 90% ethanol solution was added, and the mixture was slowly pestled. The resulting extract was used to soak a piece of prepared paper (bond paper cut into the desired size) and was then dried in a preheated oven at 80°C. Moreover, the remaining kamote leaf extract was centrifuged for 10 minutes at 1940 rpm and was analyzed using FTIR Spectroscopy for the potential presence of anthocyanin.

Extraction of Leaf Extract for KLE

Kamote leaves were washed and extracted using boiled distilled water at a weight-per-volume ratio of 2:1 for 5 minutes.

2.2 Research Analysis Procedure

The constructed KLEpP and KLE were subjected to pH evaluation by dipping the prepared KLEpPs in the different (pH 1-14) standards. Fourteen (14) KLEpP strips were prepared for each pH standard, while five drops of pH standards were dropped into the different test tubes with 2.00mL of prepared KLE for each test tube. Fourteen (14) test tubes were prepared; at the same time, 14 strips of control (commercialized pH paper) were also dipped in the standards. Also, the kamote leaf extract (used in constructing the KLEpP) was analyzed for the potential presence of anthocyanin using FTIR Spectroscopy.

2.3 Ethical Considerations

The study ensured that the kamote leaves bought in the public market were harvested sustainably without damaging the ecosystem or endangering the species. Proper plant waste disposal after the experiment was observed to minimize environmental impact. The chemicals used in the test were properly stored or disposed of according to local regulations and guidelines. Above all, the research did not involve any animals, ensuring that animal welfare concerns were not a factor.

3.0 Results and Discussion

3.1 Evaluation of Color Changes on the Sweet Potato Extract pH Paper

The KLEpP was evaluated using pH standards to determine the exact pH at which color change occurs. Moreover, it was compared to the commercialized pH paper and KLE. When dipped in the pH 3 standard, the color of KLEpP changed from light green to pinkish. Color changes also occurred in pH 13 (from light green to yellow-greenish) and 14 (from light green to yellowish color).

Table 1. Standard solution with pH range of 1-14 and the different color changes of different indicators

Samples pH	Commercialized pH Paper	KLE	KLEpP
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

The resulting color changes on KLEpP were almost identical to those on KLE. However, a wide range of color changes occur on the KLE compared to the KLEpP. However, it must be noted that the KLE produced the same color change from pH 1 to pH 5, except for pH 3, where there was a stronger pinkish color. These color changes were almost the same as the color changes that occurred in the findings of Sohany et al. (2021) on the commercial purple sweet potato root crop anthocyanin (CA) when subjected to different pH (pH 1 to 14). However, there were color changes that did not match, which may have resulted from the different parts of the plant being used, especially since the current study only used the leaf part of the plant. The contrast of colors in the findings further corroborated the results of Kapilraj et al. (2019) that eco-friendly natural indicators showed clear color changes between acids and bases.

These findings on the color change of KLE and KLEpP strongly supported the findings of Abugri et al. (2012), Sanchez et al. (2021), and Jabeen et al. (2022) that using natural acid-base indicators and natural pH-paper indicators could be used in laboratory experiments and may solve the problems of laboratory material unavailability for teachers as they are easy to extract, cheap, and non-toxic, and may enhance student learning. The results were also in line with the findings of Sai-Ut et al. (2021) that using natural indicators showed a wide range of color changes that indicated the pH of a substance and that the color change may be caused by hydrolysis of anthocyanin due to changes in the environmental condition, like the change in the degree of acidity or pH (Wiyantoko & Astuti, 2020). Therefore, the KLE and KLEpP may help the Philippines' problem of the lack of laboratory supplies (Orbe et al., 2018), especially for acid-base experiments. These findings also proved that KLEpP is a potential LpP and a potential alternative for commercialized pH paper.

3.2 Assessment of the Presence of Anthocyanin from the Sweat Potato Extract

The FTIR analysis results indicate that purple sweet potato leaf extract displays seven spectrum peaks between the wavelengths of 876.98cm-1 and 3305.28cm-1.

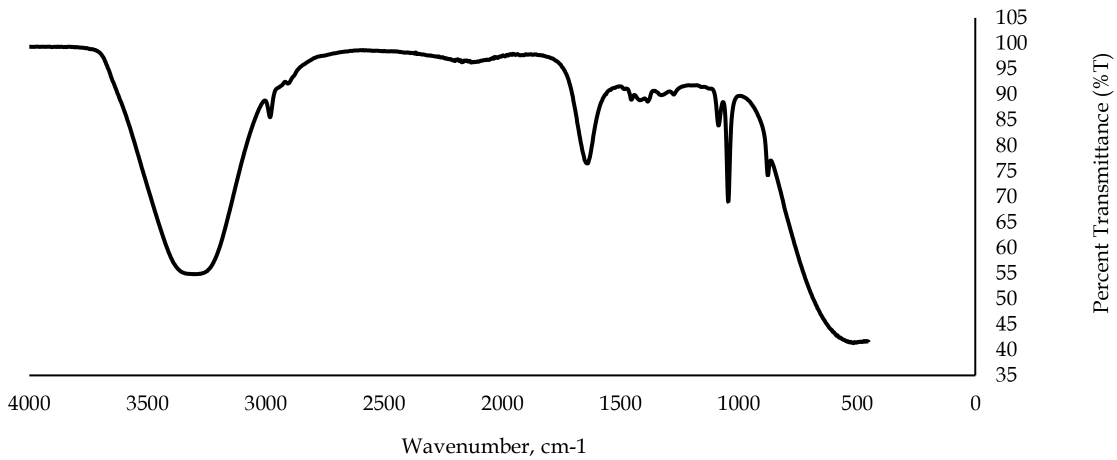

Figure 1. FT-IR transmittance result from the kamote leaf extract

Based on Figure 1, the kamote leaf extract has peaks at 3305.28 cm-1, which indicates the presence of hydroxyl groups (-OH). It also has an aldehyde group (2981.96 cm-1), aromatic group (1638.8 cm-1), Hydrocarbon group (1385.27 cm-1, 876.98 cm-1), ester group or C=O bond (1085.51 cm-1), and C-O bond (1044.29 cm-1), respectively. These results are shown in Table 2.

Table 2. Noticeable peaks produced from the FT-IR Transmittance result.

Peak	Wavenumber, cm-1	Percent Transmittance (%T)	Functional Group
1	3305.28	54.81	Hydroxyl (C-OH)
2	2981.96	85.54	Aldehyde
3	1638.80	76.50	Aromatic
4	1385.27	88.61	Hydrocarbon (C-H)
5	1085.51	83.90	C=O, Ester, C-OH
6	1044.29	68.93	C-O
7	876.98	74.11	Hydrocarbon C-H

This result is an indicator that the kamote leaf extract contains anthocyanins, which are organic compounds that have color varieties from red, violet, and blue (Laila, 2019) and may change color due to its instability to pH changes (Tuslinah et al., 2021). These results were in line with the FT-IR findings of Farida et al. (2024) and Sohany et al. (2021), which concluded that purple sweet potato contained anthocyanin and further specified that there are

14 types of anthocyanins in the purple sweet potato. Similarly, the functional group found in the current FT-IR results coincides with the FTIR findings of Swer et al. (2018) on the extracts of Prunus nepalensis L., which showed the presence of O-H, aromatic rings, and esters and that these were the characteristics of anthocyanin. This further indicates that the Purple sweat potato leaf extract has the characteristics of anthocyanin. This may also prove that the color change in the different pH ranges, both in the KLEpP and the KLE, was caused by anthocyanin.

Moreover, natural anthocyanins have poor color stability and are vulnerable to degradation from environmental factors (Maylinda, 2019), which was also observed in the KLE. However, the shelf-life of KLEpP was more than 30 days. Nevertheless, it must be noted that further analysis must be done on the accuracy of KLEpP's shelf life.

4.0 Conclusion

The findings of this study showed the potential of KLEpP as an LpP, which teachers in the Department of Education and private basic education institutions could use as an alternative for commercialized pH paper for their acid-base lessons. It is then suggested that further research must be done on using the KLEpP in determining pH in different available household materials, which can be useful for teachers in making acid-base activities. Moreover, the findings affirmed the presence of anthocyanin in purple sweet potato leaves, which may help future researchers who look for natural indicators and anthocyanins for their studies.

5.0 Contributions of Authors

The authors declare that they all contributed equally to this study and have reviewed and approved the final paper. Specifically, Mr. Christopher Bernard S. Benong and Mrs. Shery-Ann T. Benong formulated the research framework, methodology, and data collection, ensuring the study's objectives were clearly defined and attainable. Mr. Jesson B. Belen was involved in formulating and assessing the experimentation and data collection.

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7.0 Conflict of Interests

All authors declared that they have no conflicts of interest as far as this study is concerned.

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