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Analysis of Practical Design for Making Natural Indicator Paper from *Ruellia simplex* as Teaching Material for Acid-Base Material

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Abstract. Experiments are an essential part of chemistry. Synthetic indicator is generally used in acid-base practice. Using synthetic indicators can cause waste that is dangerous for the environment and is relatively expensive. *Ruellia simplex*s are one of the plants that contain high levels of anthocyanin compounds, which have the potential to be an alternative in making natural acid-base indicators. This research aims to determine the curriculum and learning outcomes of acid-base material, the potential of *Ruellia simplex* paper as a substitute for synthetic indicators, and the feasibility of paper as a design for chemical experiments in SMA/MA. This research uses descriptive qualitative methods, which include literature studies, interviews, observations, and experiments. The *Ruellia simplex* indicator is produced by extraction using the maceration method using 96% ethanol solvent. The research results show that paper from *Ruellia simplex* extract can be used as a natural acid-base indicator by producing a pink color change in acidic and a green color in essential. Based on the natural indicator paper analysis, the *Ruellia simplex* can be used as an alternative indicator in practicum design in schools.
Keywords: Simple practice, *Ruellia simplex*, natural acid-base indicator paper, synthesis indicators

Introduction

The change in curriculum from the 2013 curriculum to the independent curriculum will significantly impact the learning system and process in schools (Angraini, 2019). This curriculum change aims to achieve higher quality education and to adapt it to student needs and current developments. The independent curriculum aims to create enjoyable education for students and teachers so that this curriculum emphasizes aspects of student skills, student participation in the teaching and learning process, and the development of student character by the values of the Indonesian nation (Ainia, 2020). Students are encouraged to be more active in each learning material, and teachers must be more creative when carrying out the teaching and learning process. Learning chemistry in the independent curriculum involves learning science concepts and principles verbally and through direct experience such as experiments (Aulia & Andromeda, 2019). Learning chemistry tends to result in students experiencing a lack of understanding of chemical concepts (Zuhroti et al., 2018). This is the basis for learning chemistry, which should be taught theoretically and experimentally (Wiratma, 2014).

The experimental method is an effective strategy for increasing students' understanding of the learning process. Based on the learning achievements in phase F, students can use the acid-base concept in everyday life; in other words, students are not only introduced to the theoretical concept of acids and bases but also through direct experience, which aims to hone students' science skills so that the learning process is more pleasant (Sibuea, 2020). However, implementing students' process skills through experimental activities has several obstacles. According to Priyanto et al. (2021), many chemistry practicums use tools and chemicals which are relatively expensive, and not all schools have complete practicum equipment; chemistry experiments tend to use dangerous chemicals (Damayanti et al., 2019) as well as the limitations that educators have regarding the potential of local resources in the surrounding environment (Hasniarridha, 2020). Therefore, it is necessary to carry out experimental activities by utilizing tools and materials that are simple, easy to obtain, and economical in terms of costs so that learning can run well.

Based on the results of interviews with chemistry teachers in Klaten district in June 2023, it was stated that in acid-base material, there are usually experimental activities using synthetic indicators such as PP and BTB. The teacher stated that there was an obstacle when carrying out experimental activities, namely the use of relatively expensive chemicals, and it was rare to find shops selling indicators in the Klaten area itself. The results of interviews with teachers at a public high school in Semarang also stated that in the acid-base practicum, synthetic indicators were carried out, such as phenolphthalein (PP), methyl orange (MO), and bromothymol blue (BTB) (Susatyo & Damanik, 2021). The use of this indicator is a synthetic indicator that is sold on the market at a relatively high price and can cause chemical pollution, limited availability, and high production costs (Khofifah, 2021). Therefore, another alternative is needed by conducting experiments using natural materials that are easy to find in everyday life and are environmentally friendly as a substitute for synthetic indicators (Arif, 2020).

Much research has been carried out regarding using natural materials as natural indicators. The novelty of this research is that people have yet to research the natural materials used. Apart from that, the raw materials used have yet to be appropriately utilized even though these flowers are widely distributed in the surrounding environment.Using natural materials is an alternative to replace synthetic indicators in acid-base learning. Natural ingredients containing anthocyanins have been studied as potential for making natural indicators. Anthocyanins are water-soluble pigments naturally found in various plants that provide color to flowers, fruit, and plant leaves (Wibawa & Tirta, 2021). Anthocyanin color pigments from various plants are widely used in the food and medicine industries because their colors are attractive and safe for health (Andarias, 2018). Anthocyanin dyes are influenced by the structure of the anthocyanin and the degree of acidity (pH) (Aprilia, 2020). In addition, anthocyanins tend to dissolve in polar solvents because of aromatic ring groups (Oktiana et al., 2021).

One plant that contains quite a large amount of anthocyanin compounds is the *Ruellia simplex* (Sari et al., 2022). *Ruellia simplex* is a plant from the *Acanthacea* family that grows in many places, such as bushes, rice fields, and roadsides (Putri et al., 2022). *Ruellia simplex* are 5 to 5.5 cm long and blue-purple (Mitarlis et al., 2018). The flower's color shows a malvidin-type anthocyanin pigment, which is available in relatively large quantities in the flower (Wati & Wakhidah, 2023). The bioactive compounds contained in *Ruellia simplex*s are alkaloids, flavonoids, triterpenoids, steroids, and saponins (Handayani et al., 2020). The phytochemical content of this anthocyanin has good stability so that it can be applied as a natural dye (Saati, 2017). Anthocyanin compounds can be effectively obtained using solvent extraction methods (Agustin & Ismiyati, 2015). Methanol and

ethanol are quite effective solvents used for extraction in phytochemical tests (Zhang et al., 2018). Effective extraction of anthocyanin compounds can be carried out using ethanol solvent (Fitriyanti et al., 2022). The extraction method using maceration is often chosen because this method can prevent damage to the anthocyanin compound content in *Ruellia simplex*s (Anggraeni et al., 2018).



Figure 1. *Ruellia simplex*

Research results in Malik et al. (2023) show that *Ruellia simplex* extract can be used as an alternative coloring; in other words, it can be used as a natural indicator. Another study related to making natural indicator paper with different materials was carried out by Widiani (2019), namely telang flower. The result is a transparent color change, namely green at pH 11 - pH 14, blue at pH 5 - 10 solutions, and purple - pink at pH 1 - 4 solutions. Many studies have been carried out regarding manufacturing indicator paper from natural materials but with different materials. This research focuses on making natural acid-base indicator paper from natural materials of *Ruellia simplex*s with independent curriculum learning outcomes as alternative teaching materials for practicum design in schools.

Methods

The type of research used in this research is descriptive qualitative. Qualitative research describes and analyzes data based on phenomena that occur where the researcher is the critical instrument (Setiawan, 2018). This data collection technique is through data triangulation, meaning that data collection is carried out using several collection techniques, namely literature study, interviews, observation, and experimentation. The researcher collected several books related to the problem and research objectives in the data collection technique through literature study. Literature studies are used when analyzing the curriculum. Data collection through interviews is carried out when exploring the potential of paper as a substitute for synthetic indicators and a simple, practical alternative. Data collection through observation was carried out when analyzing the potential of *Ruellia simplex* paper as a substitute for synthetic indicators and a simple, suitable alternative. Experiments collected data to study the feasibility of making natural indicator paper from *Ruellia simplex*.

According to (Wijaya, 2018), the qualitative data analysis process includes data collection, reduction, presentation, and concluding. The data collection stage is obtained from primary data sources, documented as written or audio recordings. The data reduction stage is carried out by strictly selecting data, summaries, or short descriptions and grouping them into broader patterns. The data presentation stage is narrative text in the

form of field notes, tables, and charts. The conclusion drawing set is the final stage in analyzing the data so that the data is more detailed. This research stage includes curriculum analysis and learning outcomes in acid-base material, experimental design, and analysis of the feasibility of paper as a substitute for synthetic indicators.

Curriculum Analysis and Learning Achievements on Acid-Base Material.

The method used for curriculum analysis and learning outcomes is a literature study of acid and base material. The literature study was carried out using the independent curriculum script. This aims to analyze the content of independence in learning in schools. The essential things in the text are then matched with the chemistry learning regarding acids and bases.

Experimental Design

Sample Preparation of *Ruellia simplex*s

The *Ruellia simplex* picked during the day are weighed as much as 20 grams and then cut into small pieces using scissors. The flower pieces are then ground until smooth.

Extraction

Extraction is carried out using the maceration method. The solvent used is 96% ethanol. The crushed *Ruellia simplex*s are then put into a maceration container, and 400 mL of solvent is added. Solvent ratio 1:20. The mixture was macerated for five days with occasional stirring. Next, the mixture is filtered to obtain the filtrate and then concentrated with a hair dryer.

Manufacturer of Indicator Paper

In this research, the Whatman Grade 91 paper was used. Each piece of paper was cut to a size of 5 cm x 1 cm, and then the paper was soaked in the extract that had been made previously. The paper was soaked for three days. The paper is dried by air-drying so that indicator paper is obtained from the *Ruellia simplex*.

Test Indicator Paper at Various pH

The indicator paper is tested with a pH 1-14 solution. The acid solution uses hydrochloric acid (HCl) pH 1, and the base solution uses sodium hydroxide (NaOH) pH 14. These solutions are then diluted to obtain an acid pH of 1-6 and a base pH of 8-14. Next, each pH solution is dipped in indicator paper that has been soaked and dried. Observe the color changes that form in the test solution and record them. Also observed were changes in paper and paper resistance.

Feasibility Analysis

Analysis of the feasibility of paper for *Ruellia simplex*s as a substitute for synthetic indicators was carried out using interviews, experiments, and literature studies, which covered several aspects, including financial or cost aspects, shelf life aspects, and human resource aspects.

Financial Aspects or Costs; The financial aspect includes the overall costs incurred to carry out experiments on making natural indicator paper for *Ruellia simplex*s.

Aspects of Shelf Life; This aspect is carried out to measure the ability of the indicator paper to be used.

Human Resource Aspects; This aspect was carried out by interviewing teachers regarding readiness to implement experiments on making natural indicator paper for *Ruellia simplex*s in schools.

Result and Discussion

Identification of Curriculum and Indicators of Achievement of Learning Goals

The SMA/MA chemistry curriculum was analyzed to determine learning outcomes and indicators of achievement of school learning objectives (Afifah & Yusmaita, 2019). The curriculum is the most essential part or component of education (Fujiawati, 2016). Curriculum analysis was carried out using the independent curriculum in class XI acids and bases material. The curriculum that has been analyzed then analyzes indicators of achievement of learning objectives. Analysis of indicators of achievement of learning objectives was obtained from the flow of learning objectives (ATP) of one of the schools in Klaten district in terms of learning outcomes so that several indicators of learning objectives were obtained. The relationship between experimental results and indicators of achievement of learning objectives, among others.

Table 1. The Relationship between experiment results and indicators of achievement of learning goals

No	Experimental Stage	Learning Materials
1.	Making *Ruellia simplex* extract	Discusses natural materials that can be used as indicators
2.	Making indicator paper from *Ruellia simplex*s	Design and conduct experiments to make acid-base indicators from natural materials
3.	Change in color of indicator paper at various pH	Identify the pH of a solution using several indicators

Experimental Design of *Ruellia simplex*s Paper

The experimental design for this acid-base indicator paper utilizes natural materials in the manufacturing process. The natural ingredients used are plant parts that contain anthocyanin compounds. The selection of natural materials with anthocyanin content has been studied to have a role in making indicators that have the characteristic of experiencing a color change at a certain pH so that they can be applied as natural acid-base indicators (Meganingtyas & Alauhdin, 2021). The *Ruellia simplex* is one natural ingredient with a reasonably high anthocyanin content in the flowers (Sari et al., 2022). Making *Ruellia simplex* extract is carried out using the maceration method. This method is relatively easy and does not damage the anthocyanin content in *Ruellia simplex*s because it does not go through a heating process (Dewatisari, 2020).

The maceration process is carried out using ethanol solvent, which is close to the polarity of flavonoid compounds (Salsabila & Fuadi, 2023). The anthocyanin content in *Ruellia simplex*s is a flavonoid, which will be attracted to and dissolve in an ethanol solution. Using ethanol solvent with a concentration of 96% aims to dissolve more secondary metabolite compounds in *Ruellia simplex*s (Dillak et al., 2019). This is supported by research on turmeric extract with 96% ethanol as a solvent, giving the best results with higher yields than 50% and 70% ethanol (Rezki et al., 2015). Apart from that, Qoirunnisa & Asngad (2018) made acid-base indicator paper by soaking the filter paper in 96% ethanol solvent because it has the same polarity as anthocyanin to dissolve anthocyanin in large quantities. The following is a picture of the structure of anthocyanin compounds.

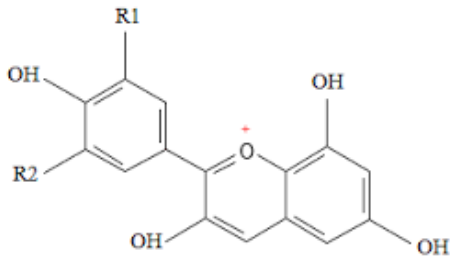


Figure 2. Structure of Anthocyanin Compounds

The maceration process was initially carried out with varying maceration times: one day, two days, three days, four days, and five days. The right maceration time will produce optimal extract yield results (Bankova et al., 2021). According to (Kemit et al., 2017), a short maceration time means that not all phytochemical compounds are dissolved, and if the extraction time is too long, the extracted phytochemical compounds will be damaged. After the maceration process, the *Ruellia simplex* extract is evaporated using a hair dryer for 1-2 hours. This hair dryer is an alternative to replacing the rotary evaporator for SMA/MA who do not have this tool.



Figure 3. *Ruellia simplex* Extract

The *Ruellia simplex* extract produced is a blackish purple. These results are by the research conducted by Mahmud et al. (2019). Extracting *Ruellia simplex*s produces a blackish-purple extract, which has the potential to be used as a natural dye. The ready *Ruellia simplex* extract is then used for the indicator paper soaking process. The indicator paper used in this research is a Whatman-type paper. This is in accordance with research conducted by Widiani (2019) whatman paper produces the best color changes, which is durable and cheap. The paper is soaked for three days, which has previously been cut to a size of 5 cm x 1 cm.

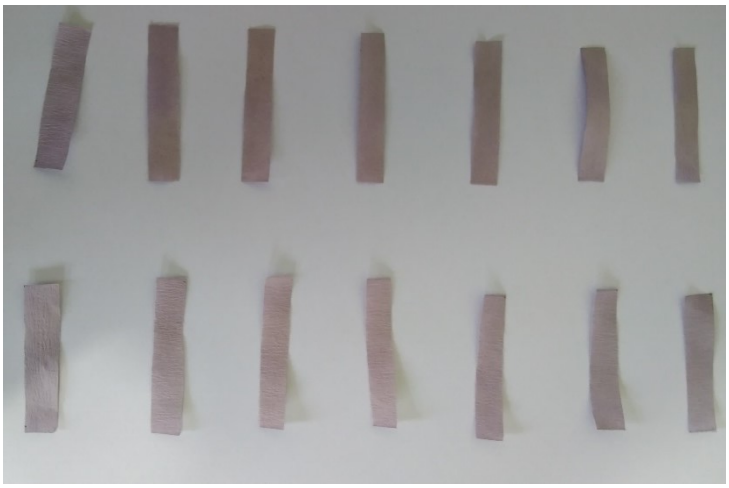


Figure 4. *Ruellia simplex* Indicator Paper

The *Ruellia simplex* indicator paper ready to be used was tested for color changes in acid and alkaline solutions. First, acid and base pH 1-14 solutions are made using the dilution technique. Acid solutions are made by diluting HCl solutions, and primary solutions are made by diluting NaOH solutions. The *Ruellia simplex* indicator paper was then dipped in an acid-base solution, and a different color change was produced at each pH. The following is a picture of the color change of indicator paper at various pH levels.

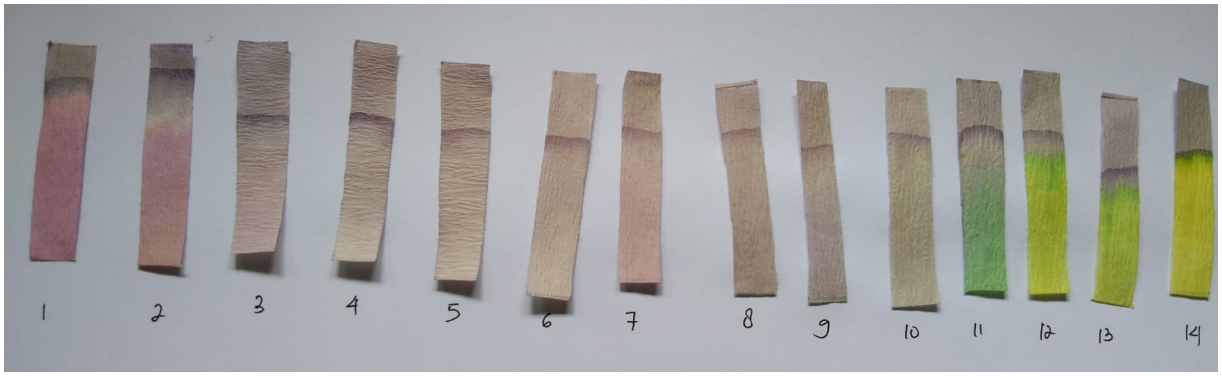
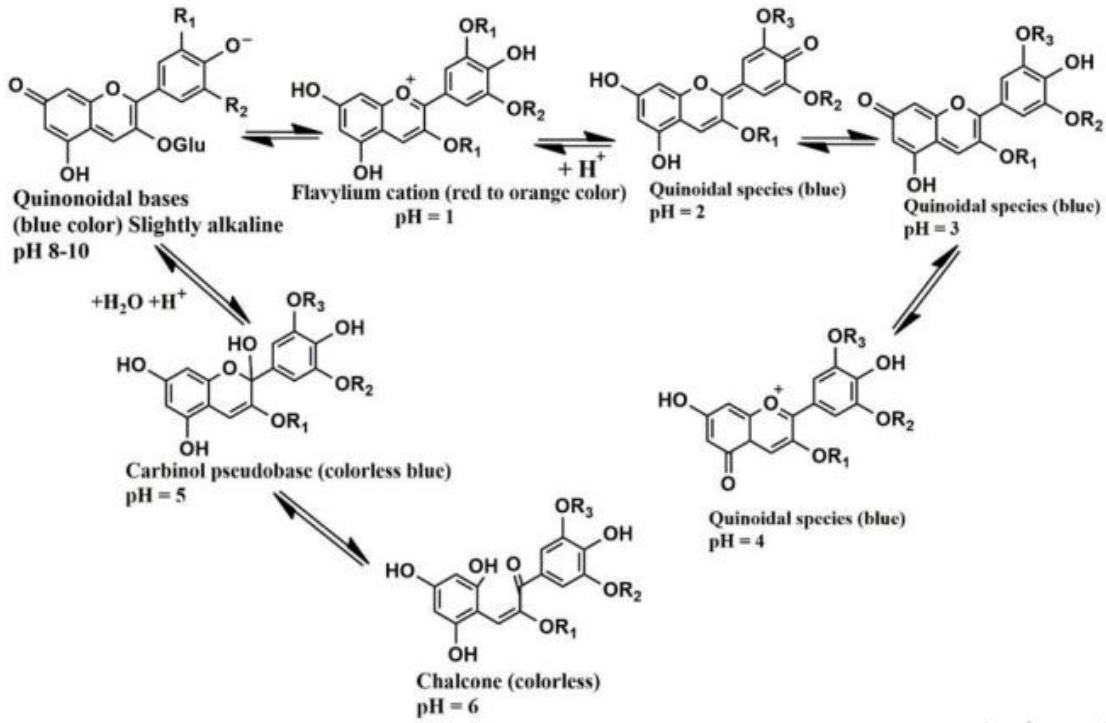


Figure 5. Change in Color of Indicator Paper in Various pH

The results of various pH paper tests with the *Ruellia simplex* indicator give a color change from purple to pink at pH 1-pH 3, a color change from purple to green to yellow at pH 11-pH 14, while the solution at pH 7 produces a pink color. This proves that the anthocyanin of *Ruellia simplex*s is red in acidic conditions, whereas in alkaline conditions, it is yellowish-green. The results of this research are the research that has been carried out Fatihah & Zidny (2023), that *Ruellia simplex* extract in acidic areas (pH < 3) gives a pink to red color, while in alkaline areas (pH > 10) it will turn yellowish green. The color change occurs because the nature of anthocyanins is sensitive to pH. Anthocyanin in acidic conditions will be in the form of a pink flavilium cation, whereas in alkaline conditions, the anthocyanin will be in the form of a quinonoidal base which is green in color (Riswanto &

Aminah, 2020). The following is a picture of changes in the structure of anthocyanins based on the pH value.



Activate Winc

Figure 6. Changes in the Structure and Color of Anthocyanins Based on the pH (Evangeline et al., 2020)

Different color changes at various pH values prove that *Ruellia simplex* extract can be used as an alternative raw material to replace synthetic acid-base indicators. The following is a table of color changes on indicator paper from *Ruellia simplex* extract.

Table 2. Change in Color of Indicator Paper in Various pH

No	pH	Initial Color	Final Color
1.	1	Purple	Pink
2.	2	Purple	Pink
3.	3	Purple	Pink
4.	4	Purple	Violet
5.	5	Purple	Violet
6.	6	Purple	Violet
7.	7	Purple	Pink
8.	8	Purple	Violet
9.	9	Purple	Violet
10.	10	Purple	Violet
11.	11	Purple	Green
12.	12	Purple	Yellowish Green
13.	13	Purple	Yellow
14.	14	Purple	Yellow

Feasibility Analysis of *Ruellia simplex* Paper

The feasibility of *Ruellia simplex* indicator paper was analyzed through 3 aspects: financial aspects or costs, shelf life, and human resources. Based on the calculation results, the costs incurred as an accumulation of costs used in making *Ruellia simplex* indicator paper are IDR 128,500 for 200 mL of *Ruellia simplex* indicator. The cost of purchasing 200 mL of the synthetic indicator is IDR 235,000, so the efficiency ratio for using telang indicators can be calculated as 45.32%. Therefore, based on financial aspects, the cost of making *Ruellia simplex* indicator paper is relatively more economical when compared to the cost of purchasing synthetic indicators.

Storage of *Ruellia simplex* indicator paper is carried out indoors and stored at room temperature. Anthocyanins are heat-sensitive, so sunlight and room temperature are essential for storage (Achyadi, 2019). When exposed to sunlight, anthocyanin substances will be easily degraded (Cai et al., 2022). Anthocyanin substances that experience degradation will decrease in quality and can no longer be used. The following is a picture of the durability test of *Ruellia simplex* indicator paper.



Figure 7. Paper Durability Test

Based on the results of storing indicator paper, it can be concluded that the storage time for paper can only last up to 2 months. After over two months, the indicator paper has started molding and turning brownish.

The human resource aspect is reviewed based on the teacher's readiness and ability to carry out the experimental design of the *Ruellia simplex* indicator paper. The laboratory is one of the school facilities that plays a vital role in learning, especially chemistry learning (Emda, 2017). This is because the laboratory is a place where students conduct experiments. Based on the results of interviews with teachers at several high schools/MAs, it was found that the experiment of making *Ruellia simplex* indicator paper could be carried out as an alternative experiment in schools. This is because the tools used are not too complex, the manufacturing materials are not too dangerous, and the way of working is simple. The price is cheaper than synthetic indicators, even though the storage time is limited. Apart from that, with a simple work method, making *Ruellia simplex* indicator paper can be done outside the laboratory.

Conclusion

Based on the results of the research and discussion, it can be concluded that the results of identifying learning outcomes, learning objectives, and indicators of achievement of learning objectives show a link between the acid-base material and the experimental design of *Ruellia simplex* indicator paper as a natural indicator to replace synthetic indicators. The analysis results show that the experimental design for making *Ruellia simplex* indicator paper as a natural indicator is by the characteristics of experiments in SMA/MA. *Ruellia simplex* indicator paper can be used as a substitute for PP and BTB synthetic indicators. In addition, based on the feasibility analysis, the potential for the *Ruellia simplex* indicator paper experiment is feasible based on financial aspects or costs, shelf life, and human resources.

References

Achyadi, N.S. 2019. Pengaruh bahan pengekstrak terhadap karakteristik ekstrak senyawa fungsional dari kulit buah naga merah (*Hylocereus polyrhizus*). *Pasundan Food Technology Journal (PFTJ)*, 6(1):23-30. https://doi.org/10.23969/pftj.v6i1.1505.

Afifah, S. & Yusmaita, E. 2019. Perancangan assesmen literasi kimia pada materi termokimia kelas XI SMA/MA. *Edukimia*, 1(3):79–83. https://doi.org/10.24036/ekj.v1.i3.a60.

Agustin, D. & Ismiyati, I. 2015. Pengaruh konsentrasi pelarut pada proses ekstraksi antosianin dari bunga kembang sepatu. *Jurnal Konversi*, 4(2):9-16. https://doi.org/10.24853/konversi.4.2.9-16.

Ainia, D.K. 2020. Merdeka belajar dalam pandangan ki hadjar dewantara dan relevansinya bagi pengembanagan pendidikan karakter. *Jurnal Filsafat Indonesia*, 3(3):95-101. https://doi.org/10.23887/jfi.v3i3.24525.

Andarias, S.H. 2018. Potensi organ tumbuhan sebagai indikator asam basa. *Sang Pencerah: Jurnal Ilmiah Universitas Muhammadiyah Buton*, 4(2):64-69. https://doi.org/10.35326/pencerah.v4i2.299.

Anggraeni, V.J., Ramdanawati, L., & Ayuantika, W. 2018. Penetapan kadar antosianin total beras merah (*Oryza nivara*). *Jurnal Kartika Kimia*, 1(1):11-16. https://doi.org/10.26874/jkk.v1i1.11.

Angraini, N. 2019. Pengaruh kebijakan perubahan kurikulum terhadap pembelajaran sekolah. INA-Rxiv. https://doi.org/10.31227/osf.io/aq2g7.

Aprilia, A.Y. 2020. Ekstrak etanol kulit buah rambutan (*Nephelium lappaceum*) sebagai indikator alami titrasi asam basa. *Journal of Pharmacopolium*, 2(3):143-148. https://doi.org/10.36465/jop.v2i3.531.

Arif, K. 2020. Pengembangan penuntun praktikum kimia berbasis green chemistry untuk semester ganjil kelas XII IPA SMA. *Semesta: Journal of Science Education and Teaching*, 3(1):59-64.

Aulia, A. & Andromeda, A. 2019. Pengembangan e-modul berbasis inkuiri terbimbing terintegrasi multirepresentasi dan virtual laboratory pada materi larutan elektrolit dan nonelektrolit untuk kelas X SMA/MA. *Edukimia Journal*, 1(1):94-102. https://doi.org/10.24036/ekj.v1.i1.a34.

Bankova, V., Trusheva, B., & Popova, M. 2021. Propolis extraction methods: A review. *Journal of Apicultural Research*, 60(5):734–743. https://doi.org/10.1080/00218839.2021.1901426.
.

Cai, D., Li, X., Chen, J., Jiang, X., Ma, X., Sun, J., Tian, L., Vidyarthi, S.K., Xu, J., Pan, Z., & Bai, W. 2022. A comprehensive review on innovative and advanced stabilization approaches of anthocyanin by modifying structure and controlling environmental factors. *Food Chemistry*, 366:130611. https://doi.org/10.1016/j.foodchem.2021.130611.

Damayanti, N.K.A., Maryam, S., & Subagia, I.W. 2019. Analisis pelaksanaan praktikum kimia. *Jurnal Pendidikan Kimia Undiksha*, 3(2):52-60. https://doi.org/10.23887/jjpk.v3i2.21141.

Dewatisari, W.F. 2020. Perbandingan pelarut kloroform dan etanol terhadap rendemen ekstrak daun lidah mertua (*Sansevieria trifasciata* Prain) menggunakan metode maserasi. *Prosiding Seminar Nasional Biologi*, 6(1):127-132. https://doi.org/10.24252/psb.v6i1.15638.

Dillak, H.I., Kristiani, E.B.E., & Kasmiyati, S. 2019. Secondary metabolites and antioxidant activity of ethanolic extract of faloak (*Sterculia quadrifida*). *Biosaintifika: Journal of Biology & Biology Education*, 11(3):296-303. https://doi.org/10.15294/biosaintifika.v11i3.20736.

Emda, A. 2017. Laboratorium sebagai sarana pembelajaran kimia dalam meningkatkan pengetahuan dan ketrampilan kerja ilmiah. *Lantanida Journal*, 5(1):83-92. https://doi.org/10.22373/lj.v5i1.2061.

Evangeline, I., Barithazar, N., & Emmanuel, G. 2020. Biosynthesis of anthocyanins and their applications as food additives. *Journal of Academia and Industrial Research (JAIR)*, 9(1):10-20.

Fatihah, W. & Zidny, R. 2023. Production and characterization of natural acid-base indicator of kendi belang and kendi bukacu for school chemistry experiment. *EduChemia (Jurnal Kimia dan Pendidikan)*, 8(1):22-39. https://doi.org/10.30870/educhemia.v8i1.16541.

Fitriyanti, R., Emmawati, E., & Yuliantini, A. 2022. Review jurnal efektifitas ekstraksi antosianin dengan berbagai macam pelarut. *Jurnal Health Sains*, 3(7):812-818. https://doi.org/10.46799/jhs.v3i7.527.

Fujiawati, F.S. 2016. Pemahaman konsep kurikulum dan pembelajaran dengan peta konsep bagi mahasiswa pendidikan seni. *JPKS (Jurnal Pendidikan dan Kajian Seni)*, 1(1):16-28. https://doi.org/10.30870/jpks.v1i1.849.

Handayani, S.N., Purwanti, A., Windasari, W., & Ardian, M.N. 2020. Uji fitokimia dan aktivitas antibakteri ekstrak etanol daun kencana ungu (*Ruellia tuberosa* L.). *Walisongo Journal of Chemistry*, 3(2):66-70. https://doi.org/10.21580/wjc.v3i2.6119.

Hasniarridha, N. 2020. Analisis desain eksperimen laju reaksi kimia berbasis keragaman sumber daya alam tropis Indonesia bagi pembelajaran kimia kontekstual. *Thesis,* UIn Sunan Kalijaga Yogyakarta.

Kemit, N., Widarta, I.W.R., & Nocianitri, K.A. 2017. Pengaruh jenis pelarut dan waktu maserasi terhadap kandungan senyawa flavonoid dan aktivitas antioksidan ekstrak daun alpukat (*Persea americana* Mill). *Jurnal Ilmu Teknologi Pangan,* 5(2):130-141.

Khofifah, A.N. 2021. Pengembangan buku petunjuk praktikum kimia ramah buta warna untuk materi asam-basa. *Journal of Tropical Chemistry Research and Education*, 3(1):18-27. https://doi.org/10.14421/jtcre.2021.31-03.

Mahmud, N.R.A., Ihwan, I., & Jannah, N. 2019. Inventarisasi tanaman berpotensi sebagai indikator asam-basa alami di Kota Kupang. *Prosiding Seminar Nasional Biologi dan Pembelajarannya*, 19(1):491-496. https://doi.org/10.35580/bionature.v19i1.7306.

Malik, N., Nasruddin, Suriana, Harlis, W.O., & Abdullah, S. 2023. Sosialisasi pemanfaatan ekstrak bunga kencana ungu (*ruellia tuberosa* l) sebagai pewarna alami preparat squash akar bawang merah (*Allium cepat* L) pada mahasiswa Jurusan Biologi Fakultas MIPA Universitas Halu Oleo: Bahasa Indonesia. *Jurnal Pengembangan Inovasi dan Pembangunan Masyarakat*, 1(1):19-27.

Meganingtyas, W. & Alauhdin, M. 2021. Ekstraksi antosianin dari kulit buah naga (*Hylocereus costaricensis*) dan pemanfaatannya sebagai indikator alami titrasi asam-basa. *Agritech*, 41(3):278-284. https://doi.org/10.22146/agritech.52197.

Mitarlis, M., Azizah, U., & Yonatha, B. 2018. Pemanfaatan indikator alam dalam mewujudkan pembelajaran kimia berwawasan green chemistry. *JPPIPA (Jurnal Penelitian Pendidikan IPA)*, 3(1):1-7. https://doi.org/10.26740/jppipa.v3n1.p1-7.

Oktiana, A., Yanuarto, T., & Densi, S.S. 2021. Formulasi dan evaluasi minuman herbal sirup sari bunga telang (*Clitoria ternatea L.*). *Thesis,* Stikes Al-Fatah Bengkulu.

Priyanto, S., Nurhadi, M., & Usman. 2021. Pengembangan indikator universal alami dan perangkat pembelajaran kimia pada materi larutan asam-basa. *Neo-Jer: North Borneo Journal of Educational Research*, 1(2):13-19.

Putri, H.Z. 2022. Struktur sel kristal pada 7 spesies suku acanthaceae sebagai penunjang praktikumanatomi tumbuhan. *Thesis,* UIN Ar-Raniry.

Qoirunnisa, M.A. & Asngad, A. 2018. Uji kertas indikator asam basa dari ekstrak bunga pacar air dengan variasi suhu pengeringan dan jenis pelarut. *Prosiding Seminar Nasional Pendidikan Biologi dan Saintek ke-3.*

Rezki, R.S., Anggoro, D., & Mz, S. 2015. Ekstraksi multi tahap kurkumin dari kunyit (*curcuma domestica valet*) menggunakan pelarut etanol. *Jurnal Teknik Kimia USU*, 4(3):29-34. https://doi.org/10.32734/jtk.v4i3.1478.

Riswanto, B. & Aminah, S. 2020. Utilization of kalpataru flower extract (*Hura crepitans Linn*) as an alternative acid base indicator. *Jurnal Akademika Kimia*, 9(3):148–157. https://doi.org/10.22487/j24775185.2020.v9.i3.pp148-157.

Saati, E.A. 2017. Pigmen Antosianin: Identifikasi dan Manfaatnya Bagi Industri Makanan dan Farmasi. *Research Report*.

Salsabila, A.F. & Fuadi, A.M. 2023. Pengaruh waktu maserasi dan konsentrasi pelarut etanol terhadap rendemen dan aktivitas antioksidan kayu secang. *Jurnal Teknik Indonesia*, 2(2):87–100. https://doi.org/10.58860/jti.v2i2.16.

Sari, A.N., Tazkiya, A., & Mafira, Y. 2022. Ekstrak air bunga kencana ungu (*Ruellia simplex*) sebagai pewarnaan alternatif preparat sediaan apusan darah tepi (SADT). *Prosiding Seminar Nasional Biotik*, 9(2):195-199. https://doi.org/10.3126/pbio.v9i1.11662.

Setiawan, A.A. & Johan. 2018. *Metodologi penelitian kualitatif*. CV Jejak (Jejak Publisher).

Sibuea, G. V. 2020. Pengembangan Penuntun Praktikum Kimia SMA Kelas Xi Berbasis Inkuiri Terbimbing Terhadap Sikap Ilmiah dan Keterampilan Proses Sains. *Thesis,* Unimed.

Susatyo, E.B. & Damanik, Y.F. 2021. Pengembangan e-laboratory instruction model guided inquiry berbasis blended learning pada materi titrasi asam basa. *Jurnal Inovasi Pendidikan Kimia*, 15(1):2754-2763. https://doi.org/10.15294/jipk.v15i1.26265.

Wati, S.S. & Wakhidah, A.Z. 2023. Kencana ungu (*Ruellia tuberosa* L.): botani, fitokimia dan pemanfaatannya di Indonesia. *Indobiosains*, 5(1):33–42. https://doi.org/10.31851/indobiosains.v5i1.9742.

Wibawa, I.P.A.H. & Tirta, I.G. 2021. Aktivitas antioksidan ekstrak methanol jahe merah (*Zingiber officinale Var. Rubrum theilade*), bayam hias merah (*Iresine herbstii* Hook) dan Azolla merah (*Azolla pinnata* R. Br.). *Jurnal Widya Biologi*, 12(2):77-80. https://doi.org/10.32795/widyabiologi.v12i02.2140.

Widiani, N.N.A. 2019. Kerinlang (inovasi kertas indikator asam basa dari bunga telang). *Jurnal Analis Medika Biosains (JAMBS)*, 2(2):161-170. https://doi.org/10.32807/jambs.v2i2.44.

Wijaya, H. 2018. Analisis Data Kualitatif Model Spradley (Etnografi).

Wiratma, I.G.L. 2014. Pengelolaan laboratorium kimia pada SMA Negeri di Kota Singaraja: (acuan pengembangan model panduan pengelolaan laboratorium kimia berbasis kearifan lokal tri sakti). *JPI (Jurnal Pendidikan Indonesia)*, 3(2):425-436. https://doi.org/10.23887/jpi-undiksha.v3i2.4459.

Zhang, Q.-W., Lin, L.-G., & Ye, W.-C. 2018. Techniques for extraction and isolation of natural products: A comprehensive review. *Chinese Medicine*, 13(1):1-26. https://doi.org/10.1186/s13020-018-0177-x.

Zuhroti, B., Marfu'ah, S., & Ibnu, M.S. 2018. Identifikasi pemahaman konsep tingkat representasi makroskopik, mikrokopik dan simbolik siswa pada materi asam-basa. *J-PEK (Jurnal Pembelajaran Kimia)*, 3(2):44-49. https://doi.org/10.17977/um026 v3i22018p044