Jurnal Pendidikan Sains Indonesia
(Indonesian Journal of Science Education)
https://jurnal.usk.ac.id/JPSI/index

13(2), p.336-347 (2025)
e-ISSN: 2615-840X p-ISSN: 2338-4379
https://dx.doi.org/10.24815/jpsi.v13i2.42861

Simple Practical Design of Making Purple Cabbage Indicator Paper as Acid-Base Indicator in Chemistry Learning

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Article History:
Received date: December 6 2025
Received in revised from: March 26 2025
Accepted date: April 11 2025
Available online: April 14 2025

Citation:
Salutri, G., Muna, L.N., & Pusfitasari, D.V. 2025. Simple practical design of making purple cabbage indicator paper as acid-base indicator in chemistry learning. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 13(2):336-347.

Abstract. The curriculum is the basis for implementing the learning activity method, and the practicum method can be one way to achieve learning outcomes. The acid-base practicum learning method in chemistry learning uses indicators to identify acid-base compounds. The indicator that can be used is the use of natural materials with purple cabbage. Purple cabbage has a distinctive color, namely purple, which is caused by the presence of a color pigment, namely anthocyanin. This study is a qualitative descriptive study with data collection techniques of triangulation data (literature study, observation, and experiment). This study aims to optimize the manufacture of indicator paper from purple cabbage, and to analyze the feasibility of its application experiment through curriculum analysis and learning outcomes. The methods used are maceration, anthocyanin test, indicator paper success test, indicator paper stability and durability test and analysis of learning outcomes. The results obtained are that purple cabbage indicator paper can be used to identify acids and bases effectively, especially strong acid and strong base compounds and can be used in chemistry learning to achieve learning outcomes. The stability and durability test of purple cabbage indicator paper can be used for 15 days of storage at room temperature.
Keywords: Lab, indicator paper, purple cabbage, chemistry, education.

Introduction

The curriculum has an important role in regulating national education because it is the basis for all educational policies implemented by the government and school management (Gunawan, 2017). In the transitional changes of the 2013 curriculum (K-13) to an independent curriculum which brings changes in the implementation of learning activities, the independent curriculum provides a lot of freedom and flexibility which encourages character development and soft skills, with a focus on project-based learning sa (Sari et al., 2022; Martatiyana et al., 2023). In chemistry, skills are further enhanced through experimental methods in practice.

Chemistry is a field of science that is based on experiments to find answers to questions about what, why, and how natural phenomena occur, especially those related to the dynamics, composition, structure, transformation, and energy of substances that require critical thinking and expertise (Rositasari et al., 2014; Cooper & Stowe, 2018). One of the chemical materials, namely acids and bases, is an important and contextual material. Students' understanding is very necessary in the learning process. Students can explain or describe something in more depth using their own language. After carrying out the activity, they can be considered to have understood it (Tambunan, 2016). Based on the results of research at SMA Negeri 12 Kupang, the implementation of practical work using acid-base indicators can provide solutions to problems that arise in classroom learning and provide skills in conducting experiments (Komisia et al., 2022).

In acid-base material practicums, the use of indicators is very necessary, such as litmus paper, universal indicator, phenolphthalein, methyl red, and bromothymol blue (N. Utami, 2022). The synthetic indicators have weaknesses, namely high availability and production costs, and their use causes chemical pollution. In the implementation of practical work in schools, practical work is not often carried out due to limited materials to carry out the practical work, therefore it is necessary to use simple, easily obtained, and economical tools and materials in terms of cost so that learning can run well. With such massive use, alternative natural indicators are very helpful because the materials already exist in nature and only need to be processed simply (Riniati et al., 2019; Okoduwa et al., 2015). The use of materials in making natural indicators has been widely carried out, by using natural indicators from natural materials, the continuity of the learning process can be maintained without depending on industrial chemicals (Mitarlis et al., 2018). The potential of plants as acid-base indicators is due to the anthocyanin content which comes from the red-purple pigment in plants (Dayanti et al., 2020). Purple cabbage is a plant that contains anthocyanins, the extract of which produces a purple color and changes in acidic conditions to red, neutral purple and alkaline green (Ghareaghajlou et al., 2021). The research (Gustriani et al., 2016b), purple cabbage can be used as a natural indicator in strong acid and strong base titrations.

Anthocyanins are a group of red to blue pigments that are widely distributed in plants (Khoo et al., 2017; Wallace & Giusti, 2015). This appearance indicates the presence of natural dyes. Natural dyes can be used as indicators because they can change color in acidic and basic conditions, although sometimes the color change is less clear or almost similar to a certain pH change (Dayanti et al., 2020). This happens because the color change is influenced by the stability of anthocyanins. Factors that affect the stability of anthocyanins are pH conditions, light, temperature, and solvent conditions during extraction (Ifadah et al., 2022; Enaru et al., 2021). Purple cabbage contains anthocyanin substances in the pH range of purple cabbage, namely pH 6.5-7.50 (purple-blue), pH 10.50-12.00 (green-blueish green) and pH 12.00-13.00 (blueish green-yellow)(Gustriani et al., 2016a).

Research on the use of natural materials in the form of plants as natural indicators has been widely carried out, one of which is the use of purple cabbage (Hidayah & Fikroh, 2023). The form of the indicator produced is usually in the form of a solution, whereas the production of natural indicators in the form of pH paper and powder can be used relatively longer compared to natural indicators in the form of a solution (Marwati, 2012). Acid-base indicator paper is one of the results of the development of acid-base learning media, so that it can help teachers in presenting teaching materials with the practical method (Octaviani et al., 2023).

This research is different from previous research which only used purple cabbage extract (Muhammad et al., 2018) in the form of indicator solution without knowing the analysis of indicators in paper form and analysis in chemistry learning to achieve learning outcomes. Based on previous research, it is necessary to conduct research that optimizes the manufacture of paper indicators and analyzes the feasibility of application experiments through curriculum analysis and learning outcomes.

Based on previous research, it is necessary to conduct research that optimizes the manufacture of paper indicators and analyzes the feasibility of application experiments through curriculum analysis and learning outcomes. This research will be conducted on the manufacture of indicator paper from purple cabbage, analyzing the color changes of purple cabbage indicator paper in acidic and basic solutions, the stability and durability of the use of indicator paper in acidic and basic solutions and analyzing the feasibility of its application experiments through curriculum analysis and learning objectives.

Methods

Descriptive qualitative research is the type of research used in this study. The sampling technique used is purposive sampling. This study was conducted to utilize purple cabbage as an alternative indicator to replace synthetic indicators. This technique is used because purple cabbage samples are selected based on the desired quality or certain properties, namely good types of purple cabbage will produce indicators with good anthocyanin content. The technique used in data collection through data triangulation (Sugiyono, 2015), namely with several collection techniques, namely literature studies, observations and experiments (Abdussamad & Sik, 2021). Data collection was carried out using several collection techniques, namely literature studies in the process of collecting, analyzing, and integrating information from various sources related to learning outcomes according to the curriculum, observations were made in the analysis of making purple cabbage indicator paper as an acid-base indicator and analysis of learning outcomes in the curriculum. In this study, indicator paper will be made from purple cabbage and qualitative testing will be carried out to analyze the color change of purple cabbage indicator paper in acid-base solutions and the stability or durability of the use of indicator paper in acid-base solutions in chemistry learning.

The stages of the practical activities begin with the extraction of purple cabbage by maceration. Purple cabbage is weighed as much as 750 grams then thinly sliced and dried using an oven at a temperature of 55°C. After obtaining the dried purple cabbage, it is then blended and sieved to produce 25 grams. Maceration with 96% ethanol for 48 hours with a ratio of 1:4(w/w) or the dried purple cabbage is completely submerged, then filtered using filter paper and the extraction results can be used (Ernawati & Rahayu, 2016; Tena & Asuero, 2022).

The extraction results have been obtained, an anthocyanin test was carried out. The extract was heated with 2M HCl then heated at a temperature of 100°C for 5 minutes. The characteristics of anthocyanin are that the red color will not fade. The extract was added with 2M NaOH solution drop by drop until the result changed from red to bluish green and faded slowly (Gustriani et al., 2016b).

Making indicator paper using whatman paper 41, the paper is cut into pieces according to the desired size, for example 1 x 4 cm, then the paper pieces are soaked in the extract with a soaking time of 3 hours. After soaking, the indicator paper is dried (air-dried) (Qoirunnisa & Asngad, 2018). Purple cabbage indicator paper is tested with acid-base solutions and at various pH solutions. Testing the success of the indicator paper using strong acid solutions (HCl 1N), weak acid (CH_3COOH 1N), strong base (NaOH 1N) and weak base (NH_4OH 1N) (Ernawati & Rahayu, 2016) and tested using pH 1 – 13 solution (Qoirunnisa & Asngad, 2018). Measurement of the stability and durability of purple cabbage indicator paper was carried out using a strong acid solution (HCl 1N, weak acid (CH_3COOH 1N), strong base (NaOH 1N) and weak base (NH_4OH) periodically every 5 days until the 20th day (Dayanti et al., 2020).

In the analysis of the identification of purple cabbage indicator paper as an acid-base indicator used in chemistry learning on learning objectives. The method used is indicator analysis and learning objective analysis with literature study on acid-base material. The goal is to analyze learning in accordance with learning objectives in schools.

Result and Discussion

Experimental Design for Making Purple Cabbage Indicator Paper

In the process of making purple cabbage simplicia, it is carried out at a temperature of 55°C because the anthocyanin substance affects the temperature, where if the temperature is high it will change the stability of the anthocyanin substance (Laswatin, 2020). After the purple cabbage is dry, it is then mashed by blending and sifting because it aims to expand the surface and help break down the cell walls and membranes, thus facilitating the extraction process to the maximum, because the compounds that dissolve in the solvent will be more if the solvent is more easily spread throughout the sample, particle size affects the amount of compound extracted. Extraction is carried out by maceration because it is easy, namely by soaking the simplicia in a container containing the solvent at room temperature and protected from light and does not need to be heated so as not to damage or decompose natural materials and to attract substances and chemical components contained in the simplicia by using 96% ethanol solvent because the higher the concentration, the better the solvent will be in taking the anthocyanin substances in purple cabbage and are polar, universal and easy to obtain (Gustriani et al., 2016b; Fernando et al., 2023; Galvão et al., 2020). The amount of sample and solvent for maceration is 1:4(w/w). The purpose of using a solvent with 96% ethanol is to dissolve more secondary metabolite compounds in purple cabbage (Astuti, 2018). The maceration process was carried out for 48 hours to maximize the anthocyanin extraction process. Filtering the extract using filter paper to separate the dregs (residue) from the filtrate (extract) which will be used as an indicator.

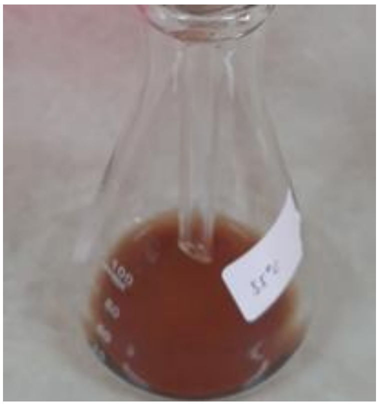


Figure 1. Purple Cabbage Extract

The anthocyanin test was carried out as proof that purple cabbage contains anthocyanin by using HCl compounds to identify acidic compounds and NaOH compounds to identify basic compounds, and can be used as a natural indicator. This proves that purple cabbage contains anthocyanin, if in an acidic environment it will be red and if in an alkaline environment it will be blue to green (Anu et al., 2022). Factors that affect the color of anthocyanins are changes in pH, when HCl is added, the color changes to red, indicating a positive result that anthocyanins in acidic conditions have dominant methoxy groups, causing the color to become red and relatively more stable, then when NaOH is added, the color changes from bright red to a fading bluish green, indicating a positive result that anthocyanins in lower conditions become dark in color due to the presence of dominant hydroxyl groups, causing the color to tend to be relatively unstable (Richart et al., 2023). That at pH 1-2 anthocyanin is predominantly in the form of red flavylium cations, at pH < 6 it changes into carbinol and some into blue quinoidal so that it is purple, at pH 6.5-9 it is predominantly blue cubinoidal, at pH > 9 chalcone is yellow-green (Susanti et al., 2019).

(a) (b)

Figure 2. (a) Identification of Acid Compounds, (b) Identificaion of Base Compounds

Making indicator paper using Whatman 41 paper as the paper material in making indicator paper because the thickness of the paper is thicker than ordinary filter paper, is able to absorb extracts well, is not easily torn, and is denser (Puspitasari et al., 2022). The soaking process for 3 hours so that the extract absorption process runs well. Dry purple paper is obtained because of the anthocyanin from purple cabbage.

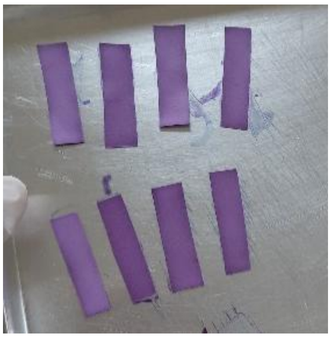


Figure 3. Purple Cabbage Indicator Paper

Indicator paper is tested with acid and base solutions to distinguish acid and base properties from the color changes that occur and tested with pH 1-13 solutions. Testing using pH solutions to determine the acid or base levels on indicator paper with the color changes that occur. In weak acid solutions, the color changes to red or pink. In strong base solutions, the color that occurs changes from green to blue to green (Qoirunnisa & Asngad, 2018).

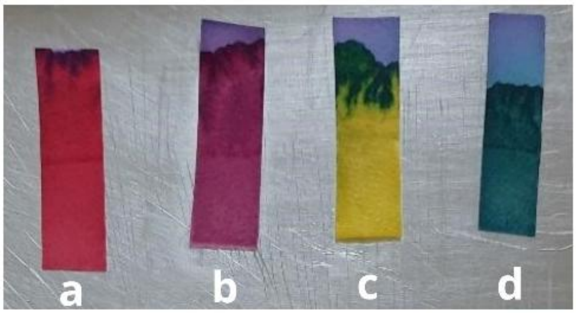


Figure 4. Testing with solution (a) strong acid (HCl 1N), (b) weak acid (CH_3COOH 1N), (c) strong base (NaOH 1N), and (d) weak acid (NH_4OH 1N).

Testing with concentrated acid solutions, weak acids, concentrated bases, weak bases produces a drastic color change in concentrated acids from purple to red while in weak acids from purple to light purple which proves that anthocyanins on purple cabbage indicator paper are more accurate in strong acids, similarly in strong bases there is a color change from purple to yellow while in weak bases from purple to dark blue, this also proves that anthocyanins on purple cabbage indicator paper are accurate in strong bases (Gustriani et al., 2016a).

The color change that occurs is caused by anthocyanins being in an equilibrium form that depends on pH conditions (Virliantari et al., 2018). The form of anthocyanin balance can be seen in Figure 5.

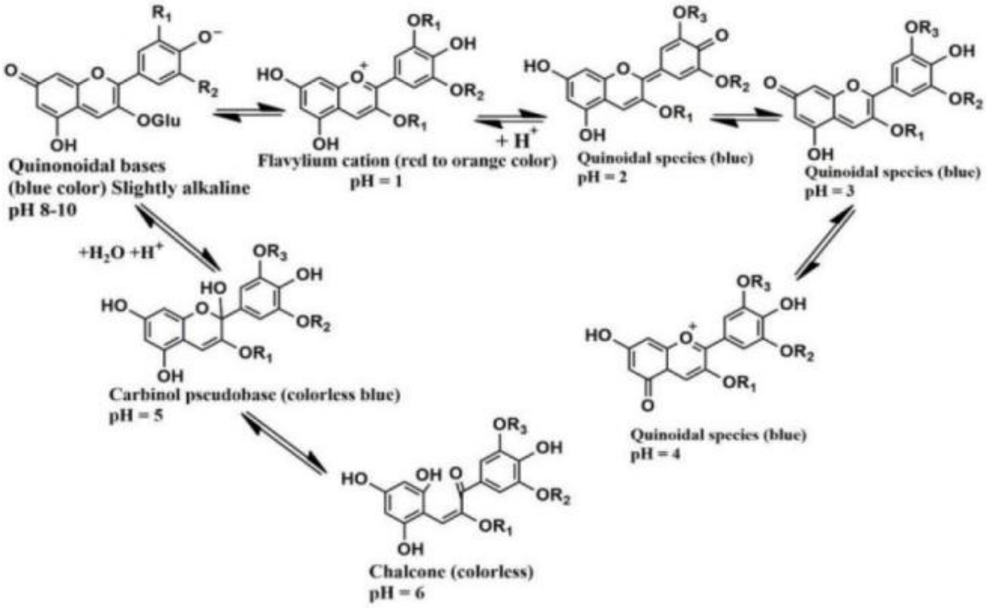


Figure 6. Anthocyanin Equilibrium at Various pH

Anthocyanin compounds in acidic conditions (pH<2) are dominated by flavium cations which are reddish orange in color, whereas in weakly acidic, neutral and basic conditions they will fade from flavium red to bluish greenish purple (Herfayati et al., 2020). The pH color change in anthocyanins is caused by changes in the anthocyanin structure from the quinonoid form to the carbinol form (Ifadah et al., 2022). Structural changes in the quinonoid form will result in a decrease in the blue color.

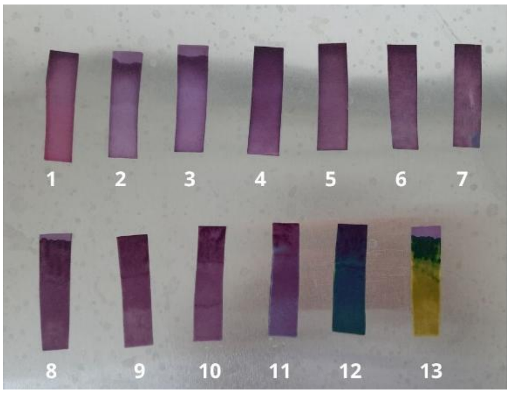


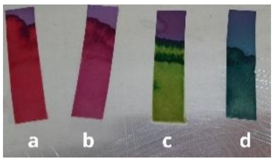
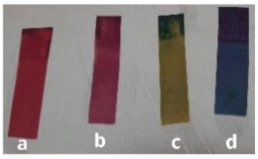
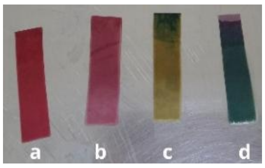
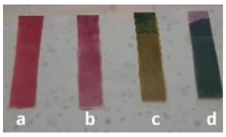
Figure 7. Changes in The Color of The Indicator Paper at Various pHs

Anthocyanins are hydrophilic which makes them easily soluble in water. In addition to being hydrophilic, anthocyanins can also dissolve in polar organic solvents such as ethanol, methanol, acetone, and chloroform (Taghavi et al., 2023). The stability of anthocyanins in water and neutral or basic polar solvents can be further enhanced by the addition of organic acids such as acetic acid, citric acid, or hydrochloric acid (Sipahli et al., 2017). The combination of polar solvents with the right organic acids to obtain very acidic pH conditions (pH 1-2) can further stabilize anthocyanins in the form of red flavium cations, whereas if the solvent is combined with a weak acid pH 3; red purple at pH 4; purple at pH 5-6; and blue purple at pH 7 (Pedro et al., 2016; Mahmudatussa'adah et al., 2014). The results of color changes from various pHs showed that in very acidic pH conditions (pH 1-2) it was red, and at pH 3 -11 it was purple and at pH 13 -14 it was blusarie to yellowish green. This was influenced by the maceration process with a drying process at a temperature of 55°C and the length of the paper soaking process in the extract. This color change occurs due to changes in the structure of the anthocyanin molecule due to the influence of pH.

In testing the stability and resistance of the purple cabbage indicator. Purple cabbage indicator paper is generally stable in acidic and basic solutions. However, its durability can be affected by several factors, such as solution concentration, contact time, and temperature. Storage of indicator paper is carried out at room temperature in a tight place. Stability measurements use the same solution concentration, namely 1M in strong acid (HCl), weak acid (CH_3COOH), strong base (NaOH), and weak base (NH_4OH) solutions. Resistance measurements are measured from the storage time with the color changes that occur.

Day 5 to 10 there was no difference in color change from stability testing using acid and base solutions, on day 15 there was a color change in durability, namely a change in color from dark purple to light purple, and on day 20 there was a difference in stability constipation using acid and base solutions compared to day 5, and in durability the purple color became paler or light purple. From the difference in days, it was found that the stability and durability of the purple cabbage indicator paper can be used for a storage period of 15 days with normal storage, because during the 20-day storage period there was a color change that occurred differently from day 5, namely the color faded. Because the solvent used in the manufacture of volatile indicator paper and purple cabbage extract is easily oxidized (Utami et al., 2020; Putri & Haryati, 2018).

Table 1. The results of the stability test and endurance of the purple cabbage indicator

Day	5	10	15	20
Stability in acid and base solutions				
Stability of changes that occur on indicator paper	The colors are clearly different, (a) bright red, (b) pink, (c) yellow green, (d) dark blue.	The colors are clearly different, (a) bright red, (b) pink, (c) yellow green, (d) dark blue.	The colors are still clearly visible, (a) bright red, (b) pink, (c) yellow green, (d) dark blue.	The colors have faded, (a) pink, (b) purple, (c) yellow green, (d) blue
Durability during storage at room temperature				
Durability of changes that occur on indicator paper	The indicator is solid purple	The indicator is solid purple	The indicator is pale purple	Purple gray indicator

In the stability test results, the letter description is given to distinguish the solution used on the purple cabbage indicator paper, namely the solution (a) strong acid (HCl), (b) weak acid (CH_3COOH), (c) strong base (NaOH), and (d) Weak base (NH_4OH).

Factors that are important indicators of acid-base storage are storage containers, sunlight, and room temperature (Muhammad et al., 2018); Enaru et al., 2021). The storage container used is a regular, transparent and closed storage container. This is in accordance with research conducted by (Kwartiningsih et al., 2016), which states that increasing temperature and light intensity during storage can reduce the levels of anthocyanins and antioxidants in rosella flower petal extract. Because storage at room temperature and exposure to indoor light makes anthocyanins excited through electron transfer which can affect pigments against phytochemical decomposition. That anthocyanins are unstable, so that purple cabbage indicator paper with anthocyanins for conditions is still stable on the 15th day, for the following days it can still be used but its use is not as optimal as the first 15 days of use.

Identifications Purple Cabbage Indicator Paper in Chemistry Learning

Curriculum analysis is done by studying literature on acid-base material, with the aim of finding out the learning objectives for the material. Learning objectives are needed to support the success of a curriculum, the relationship between the results of experiments that have been carried out with the achievement of learning competencies (Nurmalasari, 2022), namely.

Table 2. Relationship between Experimental Design Results and Learning Objectives

No.	Experimental Design	Learning Objectives
1	Extract and paper indicator manufacturing	Determining natural materials to use as indicators
2	Colour change at various pH	Identifying pH with multiple Indicators (synthetic and natural)

Learning objectives are used to measure students' concrete competencies in chemistry learning through practical activities (Ahmad & Aliyatul, 2023). The results of the experimental design for making purple cabbage indicator paper can be used as an indicator for chemistry learning (Muthiasari & Muna, 2023). Its use can be done in making extracts and indicator paper as a simple practicum design for chemistry learning practices in schools. The results of the indicator paper can be used as teaching materials about color changes at various pH, by identifying pH with several indicators (Wulan, 2024).

Conclusion

Extraction of purple cabbage by maceration method is one of the effective ways to obtain anthocyanin. Anthocyanin in purple cabbage extract can be used as a natural acid and base indicator. Purple cabbage indicator paper can be made by utilizing it to identify acids and bases effectively, especially strong acid and strong base compounds. The stability and resistance test of the purple cabbage indicator can be used for 15 days of storage at room temperature. Based on the results of the research that has been done and the discussion, purple cabbage indicator paper can be used as a substitute for synthetic indicators in chemistry learning that is in accordance with the learning objectives in practical activities.

References

Abdussamad, H.Z., & Sik, M.S. 2021. *Metode penelitian kualitatif*. CV. Syakir Media Press.

Ahmad, A. & Aliyatul, F.R. 2023. Practicum design for making bioplastics from uli banana peel (*Musa paradisiaca* S.) to grow the character of the pancasila student profile in polymer chapter. *Jurnal Pendidikan Kimia*, 15(3):198–207. https://doi.org/10.24114/jpkim.v15i3.48864

Anu, M.Y., Leba, M.A.U., & Hayon, V.H.B. 2022. Pembuatan kertas indikator dari ekstrak daun bayam merah (*Amaranthus tricolor L*) sebagai indikator asam basa alami dalam praktikum kimia. *Seminar Nasional Kimia Dan Pendidikan Kimia*, 1(1):230–240.

Astuti, B. 2018. Ekstrak (*Clitoria ternatea* L.) sebagai indikator pengujian titrasi asam basa. *Jurnal Analisa Kimia*, 1(1):22–32. https://doi.org/10.20885/ijca.vol3.iss1.art4

Cooper, M.M. & Stowe, R.L. 2018. Chemistry education research—from personal empiricism to evidence, theory, and informed practice. *Chemical Reviews*, 118(12):6053–6087. https://doi.org/10.1021/acs.chemrev.8b00020

Dayanti, N., Saputri, S.V., Arit, A., Muharini, R., & Masriani, M. 2020. Natural dyes characterization of local plants as acid-base indicator. *EduChemia (Jurnal Kimia Dan Pendidikan)*, 5(1):72–86. https://doi.org/10.30870/educhemia.v5i1.7512

Enaru, B., Drețcanu, G., Pop, T.D., Stănilă, A., & Diaconeasa, Z. 2021. Anthocyanins: factors affecting their stability and degradation. *Antioxidants*, 10(12):1–24. https://doi.org/10.3390/antiox10121967

Ernawati, D. & Rahayu, T. 2016. Pengaruh jenis pelarut dalam ekstraksi kulit buah manggis (*Garcinia mangostana*) sebagai kertas indikator asam basa. *Seminar Nasional Pendidikan Biologi dan Saintek I1*, 405–410.

Fernando, A., Rahmadhani, A.W., & Susanti,E. 2023. Pengaruh proses pengeringan terhadap kadar total fenolik dan flavonoid ekstrak metanol kubis ungu (*Brassica oleraceae* L.). *Jurnal Penelitian dan Pengkajian Ilmiah Eksakta*, 2(1):102–109. https://doi.org/10.47233/jppie.v2i1.796

Galvão, A.C., Souza, P.P., Robazza, W.S., & França, C.A.L. 2020. Capacity of solutions involving organic acids in the extraction of the anthocyanins present in jabuticaba skins (*Myrciaria cauliflora*) and red cabbage leaves (*Brassica oleracea*). *Journal of Food Science and Technology*, 57(110):3995–4002. https://doi.org/10.1007/s13197-020-04430-5

Ghareaghajlou, N., Hallaj-Nezhadi, S., & Ghasempour, Z. 2021. Red cabbage anthocyanins: Stability, extraction, biological activities and applications in food systems. *Food Chemistry*, 365(1):1–13. https://doi.org/10.1016/j.foodchem.2021.130482

Gunawan, I. 2017. Instructional management in indonesia: a case study. *Journal of Arts, Science & Commerce*, 8(1):99–107. https://doi.org/10.18843/rwjasc/v8i1/12

Gustriani, N., Novitriani, K., & Mardiana, U. 2016. Penentuan trayek pH ekstrak kubis ungu (B*rassica oleracea* L.) sebagai indikator asam basa dengan variasi konsentrasi pelarut etanol. *Jurnal Kesehatan Bakti Tunas Husada: Jurnal Ilmu-Ilmu Keperawatan, Analis Kesehatan Dan Farmasi*, 16(1):94–100. https://doi.org/10.36465/jkbth.v16i1.171

Gustriani, N., Novitriani, K., & Mardiana, U. 2016. Penentuan trayek pH ekstrak kubis ungu (*Brassica oleracea* L.) sebagai indikator asam basa dengan variasi konsentrasi pelarut etanol. *Jurnal Kesehatan Bakti Tunas Husada: Jurnal Ilmu-Ilmu Keperawatan, Analis Kesehatan Dan Farmasi*, 16(1):94–100. https://doi.org/10.36465/jkbth.v16i1.171

Herfayati, P., Pandia, S., & Nasution, H. 2020. Karakteristik antosianin dari kulit buah nipah (*Nypa frutican*) sebagai pewarna alami dengan metode soxhletasi. *Jurnal Teknik Kimia USU*, 9(1):26–33. https://doi.org/10.32734/jtk.v9i1.2831

Hidayah, M.A. & Fikroh, R.A. 2023. Potential analysis of boat lily leaf extract (*Rhoeo spathaceae* (Sw.*) stearn*) as an alternative indicator in acid-base titration of acid-base learning. *Jurnal Penelitian Pendidikan IPA*, 9(9):7491–7502. https://doi.org/10.29303/jppipa.v9i9.3306

Ifadah, R.A., Wiratara, P.R.W., & Afgani, C.A. 2022. Ulasan Ilmiah : antosianin dan manfaatnya untuk kesehatan. *Jurnal Teknologi Pengolahan Pertanian*, 3(2):11–21. https://doi.org/10.35308/jtpp.v3i2.4450

Khoo, H.E., Azlan, A., Tang, S.T., & Lim, S.M. 2017. Anthocyanidins and anthocyanins: colored pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food & Nutrition Research*, 61(1):1–21. https://doi.org/10.1080/16546628.2017.1361779

Komisia, F., Leba, M.A.U., & Tukan, M.B. 2022. Pelatihan praktikum kimia berbasis lingkungan untuk meningkatkan keterampilan proses sains siswa kelas XI MIPA SMA Negeri 12 Kupang. *Abdimas Galuh*, 4(1):453–462. https://doi.org/10.25157/ag.v4i1.7189

Kwartiningsih, E., Prastika, A., & Triana, D.L. 2016. Ekstraksi dan uji stabilitas antosianin dari kulit buah naga super merah (*Hylocereus costaricensis*). *Seminar Nasional Teknik Kimia" Kejuangan"*, 6. https://doi.org/10.37631/agrotech.v3i1.170

Laswatin, D.T. 2020. Pengaruh waktu pemanasan terhadap aktivitas anti oksidan dan daya terima selai buah naga merah (*Hylocereus polyrhizus*). *Agrotech : Jurnal Ilmiah Teknologi Pertanian*, 3(1):1–7. https://doi.org/10.37631/agrotech.v3i1.170

Mahmudatussa'adah, A., Fardiaz, D., Andarwulan, N., & Kusnandar, F. 2014. Karakteristik warna dan aktivitas antioksidan antosianin ubi jalar ungu. *Jurnal Teknologi Dan Industri Pangan*, 25(2):176-184. https://doi.org/10.6066/jtip.2014.25.2.176

Martatiyana, D.R., Derlis, A., Aviarizki, H.W., Jurdil, R.R., Andayani, T., & Hidayat, O.S. 2023. Analisis komparasi implementasi kurikulum merdeka dan kurikulum 2013. *Muallimuna: Jurnal Madrasah Ibtidaiyah*, 9(1):96–109. https://doi.org/10.31602/muallimuna.v9i1.11600

Marwati, S. 2012. Ekstraksi dan preparasi zat warna alami sebagai indikator titrasi asam basa. *Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA*.

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

Muhammad, Y., Sri, I., & Nur Fitriani, U.A. 2018. Karakterisasi antosianin kubis merah sebagai indikator pada kemasan cerdas. *Jurnal Galung Tropika*, 7(1):46–55. https://doi.org/10.31850/jgt.v7i1.298

Muthiasari, D. & Muna, L. 2023. Pengembangan video praktikum sederhana berbasis discovery learning materi stoikiomeri untuk meningkatkan keterampilan siswa kelas X. *Journal of Tropical Chemistry Research and Education*, 5(1):1–6. https://doi.org/10.14421/jtcre.2023.51-01

Nurmalasari, D. 2022. *Merdeka mengajar kimia: perspektif, desain, dan praktik pembelajaran*. Inspirasi Pustaka Media.

Octaviani, V.N., Syahputra, L.A., Sapfitri, S.I.N., Khadiningsih, S., Solfarina, S., & Rohimat, S. 2023. Pelatihan pembuatan kertas indikator asam basa dari bahan alam untuk siswa SMA. *Jurnal Informasi Pengabdian Masyarakat*, 1(4):121–127. https://doi.org/10.47861/jipm-nalanda.v1i4.554

Okoduwa, S.I.R., Mbora, L.O., Adu, M.E., & Adeyi, A.A. 2015. Comparative analysis of the properties of acid-base indicator of rose (*Rosa setigera*), allamanda (*Allamanda cathartica*), and hibiscus (*Hibiscus rosa-sinensis*) flowers. *Biochemistry Research International*, 2015(1):1–6. https://doi.org/10.1155/2015/381721

Pedro, A.C., Granato,D., & Rosso,N.D. 2016. Extraction of anthocyanins and polyphenols from black rice (*Oryza sativa L.*) by modeling and assessing their reversibility and stability. *Food Chemistry*, 191(1):12–20. https://doi.org/10.1016/j.foodchem.2015.02.045

Puspitasari, D.J., Sosidi, H., & Prismawiryanti, P. 2022. Pembuatan kertas pH dari bahan alam (bunga) sebagai alternatif pengganti indikator sintetis di MGMP kimia kabupaten Donggala. *Jurnal Abdinus: Jurnal Pengabdian Nusantara*, 6(3):611–618. https://doi.org/10.29407/ja.v6i3.16896

Putri, A.S. & Haryati, S. 2018. Kandungan antioksidan pada kubis merah (*Brassica oleracea* L.) dan aplikasinya pada pembuatan kerupuk. *Metana : Media Komunikasi Rekayasa Proses dan Teknologi Tepat Guna*, 14(1):1–6. https://doi.org/10.14710/metana.v14i1.19162

Qoirunnisa, M.A. & Asngad, A. 2018. Uji kertas indikator asam basa dari ekstrak bunga pacar air dengan variasi suhu pengeringan dan jenis pelarut. *Prosiding SNPBS (Seminar Nasional Pendidikan Biologi dan Saintek)*, 80–85.

Richart, J.E., Salempa, P., & Faika, S. 2023. Analisis kadar antosianin pada daun miana (*Lamiaceae*). *Jurnal Chemica*, 24(1):40–52. https://doi.org/10.35580/chemica.v24i1.44328

Riniati, R., Sularasa, A., & Febrianto, A.D. 2019. Ekstraksi kembang sepatu (*Hibiscus rosa-sinensis* L.) menggunakan pelarut metanol dengan metode sokletasi untuk indikator titrasi asam basa. *Indonesian Journal of Chemical Analysis (IJCA)*, 2(1):34–40. https://doi.org/10.20885/ijca.vol2.iss1.art5

Rositasari, D., Saridewi, N., & Agung, S. 2014. Pengembangan tes diagnostik two-tier untuk mendeteksi miskonsepsi siswa SMA pada topik asam-basa. *Edusains*, 6(2):169–176. https://doi.org/10.15408/es.v6i2.1148

Sari, F.I., Sunedar, D., & Anshori, D. 2022. Analisa perbedaan kurikulum 2013 dan kurikulum merdeka. *Jurnal Pendidikan dan Konseling*, 5(1):146–151. https://doi.org/10.31004/jpdk.v5i1.10843

Sipahli, S., Mohanlall, V., & Mellem, J.J. 2017. Stability and degradation kinetics of crude anthocyanin extracts from *H. sabdariffa*. *Food Science and Technology*, 37(2):209–

215. https://doi.org/10.1590/1678-457X.14216

Sugiyono, P. 2015. Metode penelitian kombinasi (mixed methods). Bandung: Alfabeta.

Susanti, R.E.E., Nurjanah, A., Safitri, R.E., & A'yun, Q. 2019. Pemanfaatan ekstrak kubis ungu (*Brassica oleraceae*) sebagai indikator warna pada analisis hidrokuinon. *Akta Kimia Indonesia*, 4(2):95–106. https://doi.org/10.12962/j25493736.v4i2.5134

Taghavi, T., Patel, H., & Rafie, R. 2023. Extraction solvents affect anthocyanin yield, color, and profile of strawberries. *Plants*, 12(9):1–15. https://doi.org/10.3390/plants 12091833

Tambunan, N. 2016. Pengaruh strategi pembelajaran dan minat belajar terhadap kemampuan berpikir kreatif matematis siswa. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 6(3):207–219. https://doi.org/10.30998/formatif.v6i3.993

Tena, N., & Asuero, A.G. 2022. Up-to-date analysis of the extraction methods for anthocyanins: principles of the techniques, optimization, technical progress, and industrial application. *Antioxidants*, 11(2):1–40. https://doi.org/10.3390/antiox 11020286

Utami, N. 2022. Improving the students' comprehension on acid natural indicator through discovery learning. *Tamansiswa International Journal in Education and Science (TIJES)*, 3(2):63–73. https://doi.org/10.30738/tijes.v3i2.12250

Utami, N.F., Sutanto, S., Nurdayanty, S.M., & Suhendar, U. 2020. Pengaruh berbagai metode ekstraksi pada penentuan kadar flavonoid ekstrak etanol daun iler (*Plectranthus scutellarioides*). *Fitofarmaka: Jurnal Ilmiah Farmasi*, 10(1):76–83. https://doi.org/10.33751/jf.v10i1.2069

Virliantari, D.A., Maharani, A., Lestari, U., & Ismiyati. 2018. Pembuatan indikator alami asam-basa dari ekstrak kulit bawang merah (*Allium ascalonicum* L.). *Semnastek*, 1–6. https://doi.org/10.30738/tijes.v3i2.12250

Wallace, T.C., & Giusti, M.M. 2015. Anthocyanins. *advances in nutrition*, 6(5):620–622. https://doi.org/10.3945/an.115.009233

Wulan, W. 2024. Analisis capaian pembelajaran kurikulum merdeka pada materi asam basa. *Tsaqofah : Jurnal Penelitian Guru Indonesia*, 4(1):58–65. https://doi.org/10. 58578/tsaqofah.v4i1.2129

Yulia, S.R., Issusilaningtyas, E., Kharis, N.A., & Prawita, S.E. 2014. The comparison of extraction method and solvent variation on yield and antioxidant activity of (*Brassica oleracea* L. *var. Capitata frubra)* extract. *Traditional Medicine Journal*, 19(1):43–48. https://doi.org/10.22146/tradmedj.8090