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Potential Analysis of Boat Lily Leaf Extract (*Rhoeo spathaceae* (Sw.) Stearn) as an Alternative Indicator in Acid-Base Titration of Acid-Base Learning

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Abstract: The acid-base titration experiments at Senior High Schools typically use phenolphthalein and methyl orange indicators, which are relatively expensive and harmful to the environment. One of the plants containing anthocyanin pigments is boat lily (*Rhoeo spathaceae* (Sw.) Stearn) leaves. The research aims to determine the potential analysis of boat lily leaf extract as an alternative indicator used in chemistry learning in titration acid-base learning. The type of research used in this study is descriptive qualitative. Based on the research and discussion results, the pedagogical aspects carried out by chemistry teachers obtained results that using boat lily leaf extract indicators in acid-base titration in the acid-base chapter is appropriate and meets pedagogical terms to be applied by chemistry teachers. A review of chemistry teachers, laboratory employees, and students obtained results that the use of boat lily leaf extract indicators in acid-base titration in the acid-base chapter can be approved because it meets the aspects of ease to be applied in learning, understanding, and attractive to students, and ease of being provided in the laboratory. Based on the feasibility analysis of potential experiments, boat lily leaf extract is feasible based on financial aspects and shelf life resilience.

Keywords: acid-base; anthocyanins; boat lily; natural indicators

Introduction

The change in the curriculum from KTSP to the 2013 curriculum affects learning in schools (Setiawati, 2022). Chemistry learning in the 2013 curriculum explains that students are not only required to learn the concepts and principles of science verbally and memorized but also through a series of direct experiences, such as the experimental process (Ismawati, 2017).

In the 2013 Curriculum revised 2020, acid-base and titration chapter is one of the chapters taught in class XI of Senior High School. The fundamental competencies contained in acid-base and titration chapters include basic competence 4.10 in the form of analyzing the pH change route of several indicators extracted from natural chapters through experiments and basic competence 4.13 in the form of concluding the results of the analysis of acid-base titration experimental data (Hafsah, 2019). Based on these essential competencies, it can be stated that students should not only be introduced to theoretical concepts about acid-base and titration but also direct experience through experimental activities that aim to hone students' science process skills so that learning is more meaningful and demand-driven (Sibuea, 2020).

Constraints in implementing chemical experiments include limited time in carrying out experiments, the use of relatively expensive chemicals, and chemical experiments that tend to use hazardous chemicals that require a laboratory (Subagia et al., 2019). This is an obstacle for schools that do not have adequate laboratories. Therefore, it is necessary to have experiments that use simple tools and chapters that are

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readily available in the surrounding environment and, of course, economical in terms of cost so that meaningful learning can be achieved (Fitri, Purwoko, Arian, & Anwar, 2021).

Based on the results of interviews with five teachers and laboratory workers of a high school in Bogor City said that in acid-base learning, there are usually experiments in the form of titration using indicators of phenolphthalein and methyl orange (Mundriyastutik et al., 2021). Using such synthesis indicators is still relatively expensive (Riniati, Sularasa, & Febrianto, 2019) and harmful to the environment and health (Fitri & Fikroh, 2021). Therefore, it is necessary to conduct studies on natural chapters that can potentially be used as natural indicators to replace these synthetic indicators.

Research on using natural constituents in the form of plants as a natural indicator has been widely carried out. The potential of a plant can be used as an indicator of acid-base due to the anthocyanin content derived from the red-purple color pigment in a plant (Yusuf et al., 2021)

The color stability of anthocyanins is affected by pH. Anthocyanins are water-soluble pigments naturally found in various plants (Riniati et al., 2020). Dragon fruit peel extract can use as an indicator of acids and bases with pink to yellow discoloration (Gao et al., 2022; Pramitasari et al., 2022). Small bungur extract can also use as an acid-base indicator paper with a yellow discoloration in acid and dark green in base (Pulukadang, 2022). Solok sambang extract can give purple to yellow color in the pH range of 11-12 (Sopiah et al., 2018). In addition, rosella petal extract can use as an indicator of an acid base (Yazid & Munir, 2018).

One of the plants that contain anthocyanin pigments is the leaves of the boat lily (*Rhoeo spathaceae* (Sw.) Stearn) (Mahmud & Ihwan, 2018). The leaves of the boat lily are identical to the purple color on the lower surface of the leaves. This plant is useful as an antioxidant, anticancer, and anti-inflammatory. The community uses an ornamental plant and dye that gives a striking color (Ilahi & Sumardiasih, 2020). The stable phytochemical content of anthocyanins makes this plant suitable for use as a natural dye, while the phytochemical content of flavonoids has a good effect on health (Marpaung, 2020).

Anthocyanins in the leaves of boat lily consist of cyanidin-3-galactose or peonidin-3-glucose (Husniati et al., 2020). Boat lily leaf extract can be obtained by extraction. The maceration method is a suitable extraction method for extracting the leaves of the boat lily. This aims to avoid damage to thermolabile compounds in the leaves of boat lily (Tiswara, 2021).

Figure 1. Boat Lily Leaves (*Rhoeo spathaceae* (Sw.) Stearn) (Carolina, 2017)

Boat lily leaves contain anthocyanin substances that give a red color at pH <6.3 and green color at pH >8.6 (Padmaningrum, 2011). Research conducted by Mahmud et al. (2019) concluded that boat lily leaves could be used as an indicator of the acid-base by extracting them so that a purple extract is obtained (Kadam, Salgar, Raul, & Patil, 2019). Discoloration of several concentrations of the solution used, namely, H_2SO_4 0.1 N (reddish orange), CH_3COOH 0.1 N (pink), NaOH (yellowish green), and $NaHCO_3$ (green) (Mahmud & Ihwan, 2018; Padmaningrum, 2011).

This research differs from earlier studies, which only used boat lily leaf extract and were restricted to testing procedures to identify the type of acid or base (Mahmud & Ihwan, 2018; Padmaningrum, 2011) and applied to litmus paper (Kadam et al., 2019) without knowing the potential analysis for application in Senior High School/Islamic Senior High School.

Based on prior research, it is necessary to carry out research that considers the possibility of using boat lily leaf extract as a replacement for synthesis indicators and evaluates the viability of application experiments in senior high school or Islamic senior high schools through curriculum analysis and indicators of achievement of acid and base chapter competencies. This research aims to create an alternative indicator in chemical analysis using boat lily leaf extract, which can reduce reliance on synthetic indicators, which are costly and difficult to obtain in schools. Furthermore, by proposing the practical application of this natural indicator, which can enrich students' understanding of acid and base concepts, this research has the potential to significantly improve chemistry education in Senior High School/Islamic Senior High School. The research will also assess the educational curriculum and competency achievement of acid and base chapters to improve learning effectiveness at the high school level. This study has significant depth by combining analytical, educational, and curriculum aspects, and it has the potential to make essential contributions to the ongoing development of chemistry science and education.

Method

The method used in this research is the descriptive qualitative research method. Qualitative research is to explain a phenomenon in depth by collecting data that is as deep as possible, which shows the importance of the depth and detail of the data under study. In qualitative research, the more in-depth, thorough, and triggered data obtained, it can also be interpreting that the better the quality of the research (Harahap, 2020). The research stages used refer to research by Fitri & Fikroh (2021), namely (1) curriculum identification and learning outcome indicators, (2) laboratory research to test experimental designs, and (3) feasibility analysis. However, in this study, modifications were made so that there were only two stages, namely (1) research in the laboratory to test the experimental design and (2) analysis of the potential of pineapple shell leaf extract as an alternative indicator of acid-base titration. In the second stage, (1) identification of curriculum and competency achievement indicators of acid-base chapter, (2) comparative analysis between synthetic indicators and pineapple leaf extract indicators as alternative indicators in acid-base titration, (3) feasibility analysis of the implementation of pineapple leaf extract indicators in acid and base titration practicum.

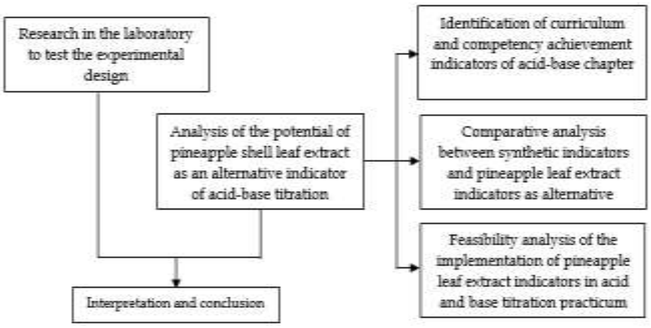

Figure 2. Research Flowchart

Laboratory Research as Experimental Design of the Potential of Boat Lily Leaf Extract as a Substitute for Synthetic Indicators

The research laboratory stage consists of stages, preparation of samples of boat lily leaves, extraction, determination of indicator discoloration at various pH, acid-base titration, and indicator shelf life endurance testing. Sample preparation of boat lily leaves. The leaves of the boat lily are cleaned and then dried. The boat lily's dried leaves blend and sifted to obtain an acceptable sample.

Extraction is carried out by the maceration method. The solvent used is 96% ethanol. The powder of the boat lily is weighed as much as 200 grams, then put in a beaker glass, and 2000 mL of 96% ethanol is added. The mixture is allowed to stand for three days. Furthermore, the mixture is filtered so that the filtrate is obtained. The filtrate is then concentrated with a rotary evaporator at a temperature 50°C. Determination of the color change of the indicator at various pH. A pH 1-14 is prepared, and each solution is put in test tubes of 5 mL. Next, drip three drops of boat lily leaf extract, and note the discoloration.

Titration of the strong acid-strong base with indicators of boat lily leaves and PP indicators is done by a solution of 0.1 N hydrochloric acids as much as 5 mL and put in Erlenmeyer. The solution is then dripped with three drops of boat lily leaf extract and titrated with a 0.1 N sodium hydroxide solution until a discoloration occurs. The titration volume is recorded. Titration is carried out with three repetitions. After that, titration is also carried out with the PP indicator as a comparison. The titration volume obtained was compared between the boat lily leaf extract and the PP indicator.

Titration of weak acid-strong base with indicators of boat lily leaves and PP indicators is done by a 4% acetic acid solution is taken as much as 5 mL and put in Erlenmeyer. The solution is then dripped with three drops of boat lily leaf extract and then titrated with a 0.1 N sodium hydroxide solution until discoloration occurs. The titration volume is recorded. Titration is carried out with three repetitions. After that, titration was also carried out with the PP indicator, and the results were compared.

Titration of the strong acid-weak base with indicators of boat lily leaves and MO indicators is done by a solution of sodium bicarbonate 0.1 N is taken as much as 5 mL and put in Erlenmeyer. The solution is then dripped with three drops of boat lily leaf extract and titrated with a 0.1 N hydrochloric acid solution until discoloration occurs. The titration volume is recorded. Titration is carried out with three repetitions. After that, titration is also carried out with the MO indicator as a comparison.

Titration of the weak acid-weak base with indicators of boat lily leaves and PP indicators is done by a 4% acetic acid solution is taken as much as 1 mL and put in Erlenmeyer. The solution was then dripped with three drops of boat lily leaf extract and titrated with a solution of ammonium hydroxide 0.1 N until a discoloration occurred. The titration volume is recorded. Titration is carried out with three repetitions. After that, titration is also carried out with the PP indicator as a comparison.

Indicator shelf life endurance testing is carried out with variations in place and temperature. Storage is carried out on clear containers and dark bottles at room and cool temperatures.

Analysis of Potential Boat Lily Leaf Extract as an Alternative Indicator of Acid-Base Titration in Acid-Base Learning

Identification of Curriculum and Indicators of Achievement of Acid-Base Competencies and Base

The method used for curriculum analysis and learning outcomes is study literature of acid and base chapter. Literature studies conducted using manuscripts curriculum 2013 revised 2020. It aims to analyze the content of the curriculum 2013 revised 2020 on learning in schools. Important things contained in later manuscripts matched with learning the chemistry of acid and base chapter.

Comparative Analysis between Commercial Synthesis Indicators and Boat Lily Leaf Extract Indicators as an Alternative Indicator in Acid-Base Titration

To determine the comparison of quality with commercial indicators (phenolphthalein and methyl orange) analyzed from the clarity of the titration endpoint, financial or cost aspects, and aspects of durability or shelf life.

Feasibility analysis of Implementation Indicators Boat Lily Leaf Extract in the Acid and Base Titration Practicum

The potential of application in Acid-Base learning in Senior High School / Islamic senior High Schools can be seen from two observations through interviews and filling out questionnaires. The first observation was an analysis of the questionnaire results and interviews of five chemistry teachers on conformity based on pedagogical aspects. The second observation was an analysis of the results of a questionnaire and interviews with five chemistry teachers, laboratory workers, and students regarding whether or not it can be implemented in applying the acid-base titration practicum using boat lily leaf extract indicators.

Result and Discussion

Experimental Design of the Potential of Boat Lily Leaf Extract as a Substitute for Synthetic Indicators

The boat lily leaf extract is carried out by the maceration method because this extraction method is easy and can avoid damage to anthocyanin compounds in boat lily leaves.Boat lily leaf powder is soaked in a 96% ethanol solution for three days with occasional stirring. The shape of the leaves of the boat lily is converted into powder aimed at enlarging the surface area so that the anthocyanin substances contained in it are increasingly dissolved in solvents. The particle size of the extracted chapter is more petite (Paristiowati et al., 2019). The molecular structure is more straightforward, it will cause the porosity or pores of the chapter to be larger, and the solvent will be distributed more easily into the extracted chapter so that more solutes will dissolve in the solvent.

The extraction process begins with maceration using ethanol solvent Sapiun et al. (2020), which has a polarity close to the polarity of flavonoid compounds (Belwal et al., 2018). The anthocyanin compounds in the leaves of boat lily are a type of flavonoid, so they will be attracted and soluble in ethanol solutions. Derivatives of flavonoid compounds that affect the color of the leaves of boat lily are anthocyanin compounds. The degree of acidity (pH) significantly affects the color of anthocyanins (Wu, Yang, & Chiang, 2018). Anthocyanin compounds will give a red-purple color to the acidic pH and green color to the alkaline pH (Priyadarshi et al., 2021).

The flavonoids contained in the boat lily leaves have been studied from the aquadest extract of boat lily leaves using LC-MS, Uv-Vis, MS, and NMR spectrophotometers. As a result, it was found that there was a malvidin content (Ishak & Adriana, 2022). The following is a picture of the structure of anthocyanin compounds.

Figure 3. Chemical Structure of Anthocyanins (Khoo et al., 2017)

The use of ethanol solvent with a concentration of 96% aims to dissolve more secondary metabolite compounds in the leaves of the boat lily. This treatment is supported by research on purple cabbage extract with a 96% ethanol solvent providing more yield when compared to ethanol 70, 80, and 90% (Senja et al., 2014). In addition, Paristiowati et al. (2019) also used 96% ethanol in the extraction process of rosella and rose flowers which produced extracts with more excellent anthocyanin content. Maceration is carried out at room temperature and in dark places in the storage process because the stability of anthocyanins is affected by high temperature and light, which can cause damage to anthocyanin substances (Astuti, 2018; Wiyantoko & Astuti, 2020).

Tabel 1. R1 and R2 Substituents for Each Type of Anthocyanins

Anthocyanins	R1	R2
Cyanidin (Cv)	OH	H
Delphinidin (Dp)	OH	OH
Malvidin (Mv)	OCH3	OCH3
Pelargonidin (Pg)	H	H
Petunidin (Pt)	OH	OCH3
Peonidin (Pn)	OCH3	H

The maceration process is carried out for three days. The right maceration time will result in an optimal yield of the extract. The short maceration time results in phytochemical compounds not being optimally extracted, while extraction for too long will damage the phytochemical compounds (Momchev et al., 2020; Utami et al., 2009). After the maceration is complete, the boat lily leaf extract is concentrated using a rotary evaporator at a temperature of 50^{o}C, So that a concentrated extract of 8.9634 grams from dry simplisia of 257.1086 grams was obtained. Based on observations by Fitri & Fikroh (2021), not all senior high schools/Islamic Senior High Schools have rotary evaporators, so alternative tools are needed. An alternative that can be done is to carry out the evaporation process using a hair dryer for ±1 hour. Using a hair dryer is an alternative to a rotary evaporator (Fitri & Fikroh, 2021).

Figure 4. Boat Lily Leaf Extract

Boat lily leaf extract produced from boat lily. Extracting the leaves of boat lily produces a reddish-purple extract that can be used as a dye in artificial rice development (Husniati et al., 2020)—yield extract obtained by 3.48%. Then, the extract was dissolved with 96% ethanol and obtained the concentration of ethanol by 10% because the extract obtained formed a thick paste. Indicators of boat lily leaf ready for use are then tested for discoloration in acid and alkaline solutions.

First, an acid-base solution of pH 1-14 is prepared by dilution technique. The acid solution is prepared by diluting the HCl solution, and the alkaline solution is prepared by diluting the NaOH solution. The acid-base solution is then dripped with the boat lily leaf indicator, and a different color change is produced in each pH of the solution. Here is a picture of the change in color of the solution in various pH.

Table 2. Discoloration of Boat Lily Leaf Extract Indicator in Any Variation of pH 1-14

Solutions	pH	Initial Color	Final Color
1	1	Colorless	Red
2	2	Colorless	Red-Orange
3	3	Colorless	Red Purplish
4	4	Colorless	Red Purplish
5	5	Colorless	Light Purple
6	6	Colorless	Light Purple
7	7	Colorless	Amethyst Purple
8	8	Colorless	Aubergine
9	9	Colorless	Aubergine
10	10	Colorless	Aubergine
11	11	Colorless	Rangoon Green
12	12	Colorless	Dark Jungle Green
13	13	Colorless	Heavy Metal Green
14	14	Colorless	Himalaya

The test results of various pH solutions with the boat lily indicator at pH 1 produce a red to bluish-purple color at pH 7, while at pH 8, it produces a dark purple to yellowish-green color at pH 14. This proves that the anthocyanin substance of boat lily leaves in the acidic condition is reddish-orange, while in the alkaline condition, it will be yellowish-green. The results of this study follow the research that has been carried out by (Mahmud & Ihwan, 2018) that there is a greenish-green color change when NaOH is added to the ethanol extract of boat lily leaves and is red when added HCl or H_2SO_4 0.1 M. Discoloration occurs due to the nature of anthocyanins that are sensitive to pH. Research by Padmaningrum (2011) also reported that boat lily leaf extract showed an orange-red color under acidic conditions and green in alkaline conditions. Anthocyanins in alkaline conditions will be quinonoidal green, while in acidic conditions will be in the form of red flavilium cations (Herfayati, Pandia, & Nasution, 2020).

Anthocyanin compounds in acidic conditions (pH<2) are dominated by flavylium cations which are orange-red while weak, neutral, and alkaline acidic conditions will fade red flavylium to purple-blue-green (Kurniawati & Alauhdin, 2020; Wati & Hasby, 2021). The change in pH color in anthocyanins is caused by a change in the structure of anthocyanins from a quinonoidal form to a carbinol form (Ifadah, Wiratara, & Afgani, 2022). A change in structure to a quinonoidal shape will lead to a decrease in the blue color (Raji et al., 2022; Wiyantoko & Astuti, 2020). Here is a picture of changes in the structure of anthocyanins based on the pH value.

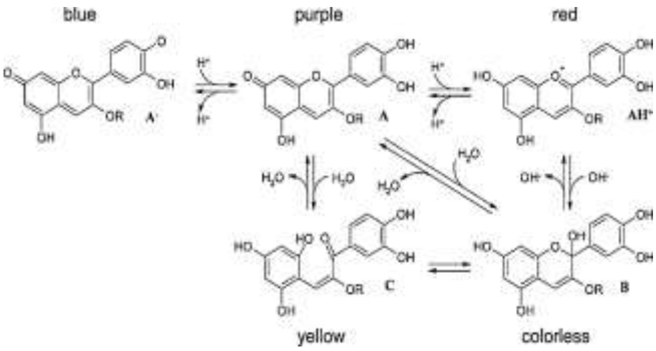

Figure 5. Anthocyanin Equilibrium Form

Indicators of boat lily leaves are further tested by acid-base titration. This acid-base titration is carried out to determine whether boat lily leaf extract can substitute synthesis indicators currently used in phenolphthalein and methyl orange. Synthetic indicators are used as a comparison.

Titration is carried out with four types: strong acid-strong base titration, weak acid-strong base titration, strong acid-weak base titration, and weak acid-weak base acid titration. Each titration is carried out three times to validate the results. The titration results include the following:

Table 3. Difference in Average Titration Volume Synthesis Indicator and Boat Lily Leaf Extract Indicator

Titration Type	Indicators	Volume (mL)	N	Q%
Strong acid-strong base	PP	5.467	0.1037	0.60%
	Boat Lily	5.500	0.1031	
Weak acid-strong base	PP	39.530	0.0910	0.159%
	Boat Lily	39.467	0.0911	
Strong acid-weak base	MO	5.300	0.1034	0.62%
	Boat Lily	5.267	0.1041	
Weak acid-weak base	PP	34.667	0.1038	0.19%
	Boat Lily	34.733	0.1036	

Table 4. Color Change End point Titration Synthesis Indicator

Titration Type	Synthesis Indicator	
	Initial Color	Titration Endpoint
Strong acid-strong base (PP)	Colorless	Faded Pink
Weak acid-strong base (PP)	Colorless	Pink
Strong acid-weak base (MO)	Tumeric Yellow	Red-Orange
Weak acid-weak base (PP)	Colorless	Pink

Table 5. Color Change End point Titration Boat Lily Indicator

Titration Type	Boat Lily Indicator	
	Initial Color	Titration Endpoint
Strong acid-strong base (Boat Lily Indicator)	Pomelo	Faded Violet
Weak acid-strong base (Boat Lily Indicator)	Pomelo	Faded Violet
Strong acid-weak base (Boat Lily Indicator)	Heavy Metal Green	Red Purplish
Weak acid-weak base (Boat Lily Indicator)	Red Purplish	Greenish slightly

At first, the pH solution is colorless. Then when dripping the indicator of the boat lily leaf, the acidic solution will turn pomelo-red, while the alkaline solution will be green. In a strong acid-strong base titration, the discoloration is pomelo-red to faded violet. In the weak acid-strong base titration, the discoloration that occurs is pomelo red-light purple-bluish purple-faded violet. At titration of strong acid-weak base, the solution changes color from green-blue-greenish-dark purple-purple-red purplish. The discoloration that occurs during titration of the weak acid-weak base is red purplish-light purple-bluish-bluish-greenish slightly. Based on the titration results, when using the pineapple leaf indicator, the endpoint of the titration is reached when the solution changes color to green or purple. Purple when the atmosphere is sour-neutral and green when the atmosphere is alkaline. However, if one of the solutions uses a weak solution, it will go through several colors first.

Indicators of boat lily leaf extract are similar to the indicators of phenolphthalein. The discoloration that occurs in the extract of boat lily leaves is caused by the presence of anthocyanin compounds whose structure contains flavilium cations (Ajay et al., 2023) in charge of forming anhydrobas when there is a change in pH (Rahmadhia et al., 2023).

The mean end point of the titration is then calculated as percent difference (%Q) to determine whether there is a significant difference between the synthesis indicators (PP and MO) and the boat lily leaf extract indicators. Based on the test results, it was obtained that there was no difference too far between the synthesis indicators (PP and MO) and the indicators of mussel pineapple leaf extract, which can be seen from the percent difference in succession for a strong acid-strong base, weak acid-strong base, and weak acid-weak base titration is 0.60%, 0.159%, 0.623%, and 0.19%. The difference in titration volume is not too significant when using boat lily leaf indicators, and synthetic indicators make boat lily leaf indicators can be used as an alternative to synthetic indicators in acid-base titration.

Analysis of Potential Boat Lily Leaf Extract as an Alternative Indicator of Acid-Base Titration in Acid-Base Learning

Identification of Curriculum and Indicators of Achievement of Acid-Base Competencies and Base

Analysis of the Senior High School /Islamic Senior High School chemistry curriculum is carried out to determine the competencies and indicators of competency achievement contained in schools. The curriculum is one of the important components of education. Curriculum analysis was carried out using the 2013 revised 2020 curriculum on acid and base chapter of class XI. After the curriculum is analyzed then analyze the indicators of competency achievement. The analysis of competency achievement indicators was obtained from the Senior High School/Islamic Senior High School/Package C syllabus published by the Ministry of Education and Culture on the official website of the www.guruberbagi.kemendikbud.go.id seen from the competency standards and basic competencies so that several learning indicators were obtained. The relationship between the results of the experiment and the indicators of competency achievement include.

Table 6. Linkage of Experimental Results with Competency Achievement Indicators

Stages of the Experiment	Learning Chapters
Making boat lily leaf extract	Determines the natural ingredients that can be used as indicators
Discoloration at various pH's	Identifying pH with multiple indicators
Acid-Base Titration	Analyze data on the results of various types of acid-base titration

Comparative Analysis between Commercial Synthesis Indicators and Boat Lily Leaf Extract Indicators as an Alternative Indicator in Acid-Base Titration

Comparative analysis between commercial synthesis indicators and boat lily leaf extract indicators is carried out through two aspects, financial aspects and shelf life resilience.

Based on the calculation results, the costs incurred as accumulated costs used in making the boat lily indicator without the cost of acid-base titration experiments are Rp. 52,000 for 100 mL of boat lily indicator 10%. The purchase cost of 250 mL of synthesis indicator is Rp. 400,000, so the efficiency ratio of using the boat lily indicator can be calculated at 87.00%. Therefore, based on the financial aspect, the cost of making the boat lily indicator is relatively more economical when compared to the purchase cost of the synthesis indicator.

Table 7. Testing the shelf life of boat lily leaf extract indicators

Treatments	Date	Observation
Transparent bottle at room temperature	Nov 11, 2022	Indicator is deep purplish-red
	Dec 13, 2022	Indicator is deep purplish-red
	Jan 12, 2023	Dark green spots appear
	Feb 11, 2023	Thickening indicator
Amberrglass bottle at room temperature	Nov 11, 2022	Indicator is deep purplish-red
	Dec 13, 2022	Indicator is deep purplish-red
	Jan 12, 2023	Indicator is deep purplish-red
	Feb 11, 2023	Indicator is deep purplish-red
Amberrglass bottle at refrigerator (4oC)	Nov 11, 2022	Indicator is deep purplish-red
	Dec 13, 2022	Indicator is deep purplish-red
	Jan 12, 2023	Indicator is deep purplish-red
	Feb 11, 2023	Indicator is deep purplish-red

One of the crucial factors in the storage of indicators is the storage container, sunlight, and room temperature. Anthocyanin substances have the property of being sensitive to heat (Hematian et al., 2023; Oancea, 2021; Tena & Asuero, 2022) and sunlight (Li et al., 2023). Based on research method conducted by Fitri & Fikroh (2021) Testing the shelf life of boat lily leaf extract indicators extract against three storage treatments, namely transparent bottle at room temperature, amberglass bottle at room temperature, and amberglass bottle at refrigerator temperature 4^{o}C. The best shelf life result is treating amberglass bottle at refrigerator temperature 4^{o}C with durability for 3 months. This follows the research carried out by Kwartiningsih et al. (2016), which states that an increase in temperature and light intensity during storage can reduce anthocyanin levels and antioxidants of rosella petal extract (Kwartiningsih, Prastika, & Triana, 2016). The increase in light intensity has a more substantial effect when compared to an increase in temperature in reducing anthocyanin levels (Amperawati et al., 2020).

The ability of light to make anthocyanins excited through electron transfer can affect pigments to photochemical decomposition (Attoe & Von Elbe, 1981; Cai et al., 2022; Fennema, 1996; Fitri & Fikroh, 2021). Based on literature studies, shelf life can be concluded that anthocyanins are unstable, so the indicators of boat lily with anthocyanin content should be stored in dark places and cold temperatures.

Feasibility analysis of Implementation Indicators Boat Lily Leaf Extract in the Acid and Base Titration Practicum

The potential of Application in Acid-Base learning in Senior High School / Islamic senior High Schools can be seen from two observations through interviews and filling out questionnaires. The first observation was an analysis of the questionnaire results and interviews of five chemistry teachers on conformity based on pedagogical aspects. The second observation was an analysis of the results of a questionnaire and interviews with five chemistry teachers, laboratory workers, and students regarding whether or not it can be implemented in applying the acid-base titration practicum using boat lily leaf extract indicators. Based on teachers' pedagogical abilities, this experimental design can support ten aspects of teacher pedagogical competence as stated in the Regulation of the Minister of National Education No. 16 of 2007 concerning academic qualification standards and teacher competencies.

To test the suitability of the experiment in making indicators of boat lily leaves to pedagogic aspects. The results of the analysis of ten indicators of the teacher's pedagogical competence are as follows, 1) experiments can assess the characteristics of students, especially moral and intellectual aspects, 2) Experiments can be used as one of the creative, not dull, and educational learning because they learn about not only the theory but also the practice, 3) this experiment is used to develop the curriculum, 4) Experiments in the laboratory will form active learning, and learning objectives can be achieved as a whole. 5) experiments will teach learners to utilize technology, 6) the existence of this experiment can be used to actualize the potential of learners, 7) experiments can create compelling, empathetic, and polite communication, 8) experiments can be used as an questionnaire and evaluation of processes and results learning, 9) evaluation of learning through experiments can be done with pretest, posttest, or process questionnaire exams during the experiment, and 10) reflecting after experimental activities to find out the shortcomings when learning is continuous.

The goal of the pedagogic aspect analysis is to ascertain whether using the boat lily leaf indicator in the acid-base titration can be applied in the learning of acid-base chapter chemistry from a pedagogical point of view to be implemented by chemistry teachers. The first competency a teacher must possess and master is pedagogic competence, which refers to the teacher's capacity to oversee students' academic progress. If the use of the boat lily indicator has met pedagogic aspects that follow the pedagogic competence of the teacher and is realized, the use of the boat lily leaf indicator can be applied in learning.

Based on the interviews of the five chemistry teachers, the results were obtained that using the boat lily leaf indicator in the acid-base titration can be applied in the learning of acid-base chapter chemistry. A questionnaire containing ten indicators on pedagogic aspects given to five chemistry teachers obtained results:

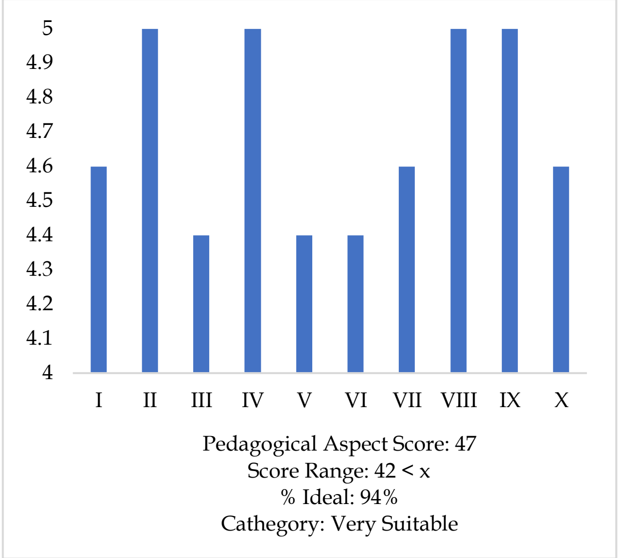

Figure 6. Graph of Questionnaire Results on the Suitability of Pedagogic Aspects According to Chemistry Teachers

The average score obtained on the pedagogical aspect based on the chemistry teacher's questionnaire is 47, with an ideal maximum score of 50. The ideal percentage is 94% with the Very Suitable (VS) category. Based on the data from the questionnaire of pedagogical aspects, the experiment of making indicators of boat lily leaves has received excellent suitability. This value shows that the pedagogic aspects contained in the experiment follow the Regulation of the Minister of National Education No. 16 of 2007 so that it can be applied in the learning of acid-base titration in class.

The results of a questionnaire and interviews with five chemistry teachers, laboratory workers, and students regarding whether or not it can be implemented in applying the acid-base titration practicum using boat lily leaf extract indicators. The laboratory is one of the school facilities that play an essential role in learning, especially chemistry. This is because the laboratory is a place for students to access. The aspects reviewed are ease of understanding and engaging in learning, ease of being provided in the laboratory, and ease of application in learning. A review of ease of understanding and engagement in learning is tested on learners. Ease of understanding by learners and the ability to attract interest in learning are indispensable to improve the quality of learning and absorption of knowledge. Based on the results of interviews and questionnaires, it is proven that using boat lily leaf indicators in acid-base titration in acid-base learning can be approved by students because it meets the aspects of ease of understanding and interest.

A review of the ease of being provided in the laboratory is tested on laboratory workers. Convenience to be provided by laboratory workers is needed to meet the needs in implementing acid-base titration practicum. Easy-to-find raw materials, a non-difficult, cheap manufacturing process, and a clear endpoint have become a plus for using boat lily leaf indicators in acid-base titration practicums.

Based on the results of interviews and questionnaires, it was proven that the use of boat lily leaf indicators in acid-base titration in acid-base learning could be approved by laboratory workers because it meets the aspects of ease of provision. A review of the ease of application in learning is tested on chemistry teachers. In addition to conformity to pedagogic aspects, chemistry teachers' ease of application in learning is needed to meet learning achievement indicators in acid-base titration practicum.

Based on the results of interviews and questionnaires, it is proven that the use of boat lily leaf indicators in acid-base titration in acid-base learning can be approved by chemistry teachers. Because it is simple to make and cheap, it can increase students' interest in learning based on information from student interviews. It has met learning achievement indicators at the time of curriculum analysis, in addition to meeting pedagogical requirements. The results of questionnaires with five chemistry teachers, laboratory workers, and students regarding the ability and interest in applying acid-base titration practicum using the Boat Lily leaf extract indicator obtained the following results:

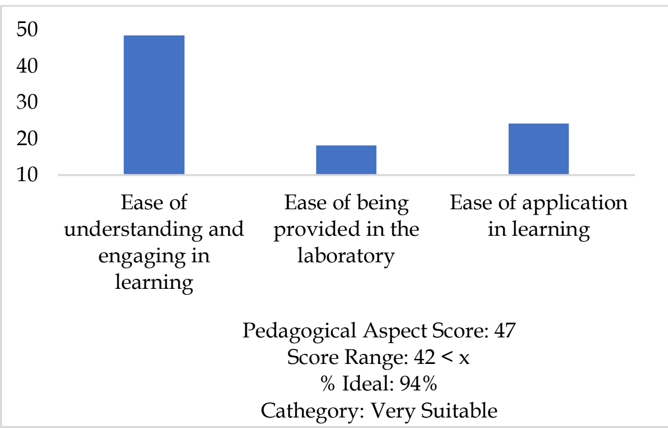

Figure 7. Graph of Questionnaire Results Regarding Whether or Not it Can be Implemented

The average score obtained on the human resources aspect is 91, with an ideal maximum score of 95. The ideal percentage is 96% with the Strongly Agree (SA) category. Based on the data from the interviewing five chemistry teachers, laboratory workers, and students. The use of boat lily leaf extract indicators in acid-base titration practicum has received strongly agree. The results of this study explained that the use of boat lily leaf extract indicators in acid-base titration could be carried out as an alternative experiment in schools in acid-base learning. This is because the tools used are simple enough, the material of manufacture is not too dangerous, and the way it works is simple. The price is also lower than the price of synthetic indicators, with a long enough shelf life at refrigerator temperature. In addition, with a simple way of working, the manufacture of telling indicators can be done outside the laboratory.

Conclusion

Based on the results of the research and discussion, the boat lily leaf extract indicator can be used as an alternative to the synthesis indicator in the acid-base titration practicum. This is supported based on the results of lab experiments where natural indicators can distinguish acid-base pH and titration endpoint results. In terms of pedagogical aspects, based on the results of the questionnaire on chemistry teachers, an ideal of 94% was obtained, which is very suitable, and based on the results of interviews and questionnaire regarding whether or not it can be implemented in applying the acid-base titration practicum, an ideal of 96% was obtained with the results of teachers, laboratory workers, and learners strongly agreeing with the use of boat lily leaf extract indicators in acid-base titration practicum. So, The boat lily leaf indicator can substitute for phenolphthalein and methyl orange indicators. In addition, based on the feasibility analysis of potential experiments, boat lily leaf extract is feasible based on financial aspects and shelf life resilience.

Author Contribution

Muhamad Aditya Hidayah was heavily involved in organizing the research activities, gathering and analyzing the data, and writing the initial draught of the paper. The entire research process, from developing the proposal to processing the data and writing the article, was supervised and directed by Retno Aliyatul Fikroh.

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Conflicts of Interest

The authors further affirm that there were no conflicts of interest in the research until this article was written. They further state that the research findings, which were appropriately reported, were not affected by any external factors or personal interests.

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