



Phytochemical screening of Balinese grape (*Vitis vinifera* L. var. Alphonso Lavallee) peel extract: Resources local plant-based lessons in biology

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Article Information	Abstract
Keyword: Balinese grape peel extract; Phytochemical screening; Biology lesson Kata Kunci: Ekstrak kulit anggur Bali; Skrining fitokimia: Pelajaran biologi History: Received : 07/04/2025 Revised : 24/05/2025 Accepted : 03/06/2025 Published : 14/06/2025	The utilization of local natural resources for contextual and practical-based learning is an innovative approach in biology education. This study aimed to conduct a phytochemical screening of Balinese grape (<i>Vitis vinifera</i> L. var. Alphonso Lavallee) peel extract and integrate the findings into plant-based biology lessons. A mixed-method approach with a one-group pretest-posttest design was applied. Phytochemical tests identified the presence of flavonoids, phenols, alkaloids, tannins, and terpenoids. The integration of results into laboratory-based lessons led to an increase in students' average scores from 66.70 to 78.48, as well as improvement in laboratory skills, cultural awareness, and appreciation of local biodiversity. These findings demonstrate that Balinese grape peel extract is a valuable educational tool for enhancing understanding of secondary metabolites and promoting scientific literacy. The future impact of this research includes the potential for in vitro and in vivo studies to assess the extract's biological activity, and the implementation of local plant-based learning models that support sustainable education and preservation of indigenous knowledge. Abstrak. Pemanfaatan sumber daya alam lokal untuk pembelajaran kontekstual berbasis praktikum merupakan pendekatan inovatif dalam pendidikan biologi. Penelitian ini bertujuan untuk melakukan skrining fitokimia kulit anggur Bali (<i>Vitis vinifera</i> L. var. Alphonso Lavallee) serta mengintegrasikan hasilnya ke dalam pembelajaran berbasis sumber daya tumbuhan lokal. Penelitian ini menggunakan metode campuran dengan desain pra-eksperimen one-group pretest-posttest. Skrining fitokimia dilakukan terhadap senyawa flavonoid, fenol, alkaloid, tanin, dan terpenoid melalui uji pereaksi spesifik. Hasil skrining menunjukkan adanya kelima senyawa aktif tersebut. Integrasi hasil ke dalam pembelajaran laboratorium meningkatkan nilai rerata siswa dari 66,70 menjadi 78,48, serta memperkuat keterampilan laboratorium, kesadaran budaya, dan apresiasi terhadap biodiversitas lokal. Temuan ini menunjukkan bahwa penggunaan ekstrak kulit anggur Bali dapat meningkatkan literasi sains dan pemahaman peserta didik terhadap metabolit sekunder. Dampak jangka panjang dari penelitian ini mencakup potensi pengembangan studi in vitro dan in vivo untuk mengeksplorasi aktivitas biologis ekstrak serta penerapan pembelajaran berbasis sumber daya lokal yang mendukung pendidikan berkelanjutan dan pelestarian kearifan lokal.

A. Introduction

The utilization of local natural resources in various fields, including healthcare, pharmaceuticals, and education, is gaining increasing attention as a step towards sustainability and innovation. One approach that can be applied is the exploration of the potential of natural materials that have not been optimally utilized. In the field of life science, the study of bioactive compounds from local plants can provide benefits not only in health aspects, but also in the development of more contextualized experiment-based learning methods. The integration of contextual and culturally relevant approaches in science education has gained significant attention as a strategy to improve students' scientific literacy and critical thinking. Alamin et al. (2024) demonstrated that e-modules based on Contextual Teaching and Learning (CTL) significantly enhance science literacy among primary school students, particularly on topics related to energy transformation. Furthermore, Sihombing et al. (2025), through a systematic review, emphasized the value of incorporating local wisdom in science learning to foster environmental awareness and cultural appreciation. These studies collectively underline the urgency of developing innovative, locally rooted learning materials that not only support cognitive development but also promote sustainable education aligned with local contexts and values.

Balinese grape (*Vitis vinifera* L. var. Alphonso Lavalley) is one of the most widely cultivated plants in Indonesia, including in Bali. Based on data from the Central Statistics Agency (BPS) in 2022, grape production in Indonesia reached 19.872 tons, with Bali as one of the main producing areas. Grape skins, which are often considered waste, actually contain various bioactive compounds that have high potential in the health and pharmaceutical fields. A study showed that grape skin extract contains flavonoids, tannins, saponins, alkaloids, and polyphenols that have high antioxidant activity. In addition, research by Rastija et al. (2024) found that grape skin extract has new natural supplements to prevent and treat diabetes.

Phytochemical screening is one of the methods that can be used to identify the bioactive compounds present in natural materials. In the context of education, introducing this method can be part of an interactive, laboratory-based learning approach. A study demonstrated that an experimental approach in biology education improved students' conceptual understanding by 35% compared to lecture-based methods (Rahmawati et al., 2022). Furthermore, revealed that the implementation of project-based learning using natural materials could enhance students' critical thinking skills by up to 40% (Wahdah et al., 2023).

The integration of phytochemical screening of Balinese grape skin extracts in biology learning not only improves students' understanding of phytochemical concepts and secondary metabolites,

but also trains laboratory skills, analytical thinking, as well as applying the scientific method directly. In addition, this approach can introduce students to the potential utilization of local natural materials in various fields, including pharmaceutical, food, and cosmetic industries. Previous studies have focused more on the application of grape skin extracts in the pharmaceutical and food fields, while the integration of phytochemical exploration results into biology learning is still limited. For instance, Rastija et al. (2024) investigated the antidiabetic potential of grape skin extracts from indigenous Croatian white grapevine varieties, demonstrating significant antioxidant activity and inhibition of α -amylase and α -glucosidase enzymes. Similarly, Kurćubić et al. (2024) reviewed the valorization of grape pomace as a functional food ingredient, highlighting its antioxidant and antimicrobial properties, yet did not explore its educational applications. Furthermore, Ghosh and Kalpana (2025) examined the antioxidant potential of grape skin extract in pharmaceutical and cosmetic formulations, focusing on product development and stability testing, without addressing its use in science education.

Based on the literature and previous studies, there is a growing need to bridge the gap between scientific exploration of natural resources and educational practices that emphasize contextual and hands-on learning. While Balinese grape skins have been shown to contain high levels of bioactive compounds with antioxidant and antidiabetic potential, their use in science education particularly in practical laboratory settings remains underexplored. Integrating these natural materials into biology education not only supports concept mastery and scientific skills development but also fosters students' environmental awareness and appreciation for local biodiversity. Therefore, this study aims to perform phytochemical screening of Balinese grape skin extract and to develop a contextual, experiment-based biology learning model. The findings are expected to contribute to the creation of innovative teaching resources that promote scientific literacy and encourage sustainable use of local natural resources in education

B. Material and method

This study employed a mixed-method approach, combining qualitative and quantitative research methods. The population consisted of students at one of colleges in Bali, with samples selected using purposive sampling. Data were collected through practical laboratory assessments, observations, and student questionnaires. The qualitative aspect included the extraction process of Balinese grape peel, which was carried out using maceration with ethanol as a solvent, followed by phytochemical screening tests. Figure 1 show a flowchart for this research.

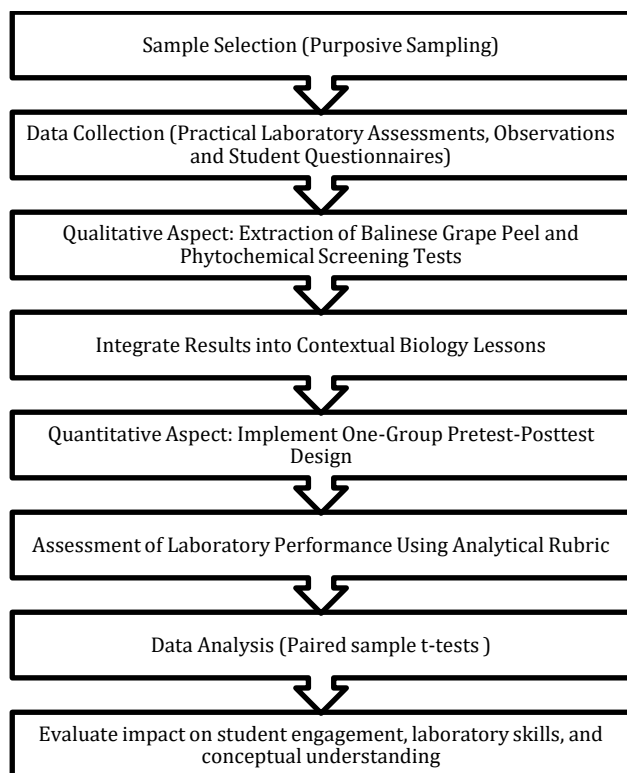


Figure 1 Research flowchart

Phytochemical screening was performed to detect the presence of flavonoids, tannins, terpenoids, alkaloids, and phenols using standard qualitative tests:

- 1) Flavonoids were tested using the by the addition of concentrated hydrochloric acid, then heated for 15 minutes in a water bath. The formation of a red or yellow color indicates a positive result for flavonoids, specifically flavones, chalcones, and aurones.
- 2) Tannins were identified using the ferric chloride test, by adding 1% FeCl_3 solution to the extract; a dark green or blue-black color indicated tannins.
- 3) Terpenoids were tested using the Salkowski test, where 2 mL of extract was mixed with chloroform and concentrated sulfuric acid; the appearance of a reddish-brown color at the interface indicated a positive result.
- 4) Alkaloids were tested using Mayer's reagent, where a few drops were added to the extract; the formation of a white or cream-colored precipitate confirmed the presence of alkaloids.
- 5) Phenols were tested using 1% ferric chloride; a blue-green coloration indicated a positive result.
- 6) Saponin test was carried out by adding 10 mL of hot water to the sample extract, allowing it to cool, and then vigorously shaking the mixture for 10 seconds. A positive result for saponins is indicated by the formation of stable foam measuring 1–10 cm in height that persists for at least 10 minutes and does not disappear upon the addition of one drop of 2 N hydrochloric acid.

The results were integrated into contextual biology lessons. To assess the effectiveness of the developed lesson materials, the study applied a one-group pretest-posttest pre-experimental design. Quantitative data were obtained from student's pretest and posttest scores, while qualitative data were gathered through open-ended questionnaire responses, interviews, and laboratory observations. These data provided insights into student's engagement, laboratory skills, and conceptual understanding. To evaluate student's practical laboratory performance, an analytical rubric was used, encompassing three key domains:

- 1) Procedural skills, including the accuracy in measuring, mixing, and handling reagents;
- 2) Scientific reasoning, such as the ability to formulate hypotheses, follow steps correctly, and interpret color changes in phytochemical tests;
- 3) Safety and teamwork, involving the proper use of personal protective equipment (PPE), tidiness, and collaboration during experiments.

Each domain was scored on a scale and scores were validated through triangulation with observational field notes and video recordings of student activities. In addition, students submitted individual lab reports containing procedural steps, observations, and reflections, which were assessed for completeness, accuracy, and depth of conceptual explanation.

These combined data provided a comprehensive insight into student's engagement, laboratory skills, and conceptual understanding, thereby strengthening the evidence that the contextual biology lessons using Balinese grape peel extract significantly enhanced students learning outcomes.

For data analysis, paired sample t-tests were used to compare pretest and posttest scores, determining whether there was a significant improvement in learning outcomes ($p < 0.05$). Meanwhile, qualitative data comprising students' reflections, laboratory observations, and responses to open-ended questionnaire items were analyzed using thematic analysis. This involved an initial coding process, where recurring patterns and categories were identified, followed by theme development to extract key insights related to students' conceptual understanding, laboratory skills, and appreciation of local plant-based resources.

C. Results and discussion

The phytochemical screening of Balinese grape peel extract confirmed the presence of several bioactive compounds through various chemical tests. Flavonoids were detected using concentrated hydrochloric acid (HCl), which functions as a hydrolyzing agent, breaking glycosidic bonds in flavonoid glycosides and allowing the release of free flavonoids. The formation of a bright

red color indicates the presence of flavonoids, which are known for their antioxidant properties.

Phenols were identified using Ferric Chloride (FeCl_3), which forms colored complexes with phenolic hydroxyl groups, resulting in a blue coloration. The presence of alkaloids was confirmed through three different reagents: Mayer's reagent (potassium mercuric iodide) forms an insoluble yellow precipitate

with alkaloids, Dragendorff's reagent (potassium bismuth iodide) produces an orange precipitate, and Wagner's reagent (iodine in potassium iodide) results in a reddish-brown precipitate, all indicating the presence of alkaloids. Terpenoids were identified using concentrated sulfuric acid (H_2SO_4), which dehydrates and cyclizes terpenoid molecules, leading to a reddish coloration as a positive indication.

Table 1 Phytochemical screening of Balinese grape peel extract

Phytochemical Compound	Result	Description	Laboratory Skills Demonstrated
Flavonoid	+	A dull red color form	Accurate pipetting; safe handling of corrosive acids
Phenol	+	A blue color form	Precise reagent mixing; observation of subtle color changes
Alkaloid	+	A yellow precipitate form	Precipitation technique
	+	An orange precipitate forms	Dropwise reagent addition; note-taking of physical changes
	+	A reddish-brown precipitate form	Safety in handling iodine-based reagents
Terpenoid	+	A reddish color form	Layering technique; acid handling protocols
Tannin	+	A dark green color form	Comparative color analysis; precision timing
Saponins	-	No froth formation observed	Mechanical agitation

Description:

The positive sign (+) indicates the presence of the respective compound in the sample being tested and (-) indicate negative of compound.

Based on the Table 1, the extract of Bali grape skin contains several active compounds, including flavonoids, phenols, alkaloids, tannins, and terpenoids. These compounds exhibit biological activities that are relevant to various concepts in biology education. Flavonoids and phenols possess significant antioxidant properties, protecting cells from damage caused by free radicals. These compounds are crucial in the study of secondary metabolism and plant defense mechanisms, as well as in understanding human health, particularly in relation to degenerative diseases. Recent studies have shown that grape skin extract has high phenol and flavonoid content, which contributes to its antioxidant and hepatoprotective effects (Maryam et al., 2022). The protective biochemical mechanisms of *Vitis vinifera* against oxidative stress and other pathologies further highlight its importance in biomedical research (El-Elimat et al., 2022).

Alkaloids, as shown in recent research, have diverse pharmacological effects, including analgesic properties and the stimulation of the nervous system. These properties make alkaloids relevant in the study of human regulatory systems and basic pharmacology. The presence of bioactive compounds in grape by-products has been linked to antimicrobial and anti-inflammatory activities, reinforcing their significance in plant metabolism studies (Silva et al., 2022). Additionally, terpenoids have been identified for their antimicrobial and anti-inflammatory effects in various studies over the past few years, which ties into their importance in understanding plant metabolism and plant-environment interactions. Research on different grape varieties also confirms the presence of bioactive compounds across various parts of the plant, including the skins, seeds, and leaves, which further supports their pharmacological potential (Atak et al., 2021).

Tannins, another important phytochemical component, exhibit strong antimicrobial, antifungal, and antioxidant activities. They are widely studied for their role in plant defense against herbivores and pathogens. In human health, tannins have been linked to various benefits, including anti-inflammatory and astringent properties, as well as potential applications in managing microbial infections and oxidative stress-related diseases. Studies have also examined the role of tannins in food preservation and pharmaceutical applications due to their bioactive properties (Makkiyah et al., 2024). Moreover, the phytochemical composition of grape skin extracts is influenced by environmental factors and cultivation methods, which affect their bioactive potential (Astuti et al., 2023).

Phytochemical screening of Balinese grape peel revealed the presence of bioactive compounds such as flavonoids, tannins, terpenoids, alkaloids, and phenols, all of which possess significant pharmacological potential. The laboratory findings not only contribute scientifically to the utilization of local resources but also serve as a strong foundation for developing contextualized teaching materials in phytochemistry education. The integration of these screening results into practical laboratory sessions proved effective in enhancing student learning outcomes, as reflected in the significant increase in average scores from 66.70 in the pretest to 78.48 in the posttest.

This improvement suggests that contextualized, research-based laboratory activities offer a more engaging and effective learning experience compared to traditional instructional methods. By working directly with locally sourced plant materials and real experimental data, students are better able to grasp abstract biochemical concepts, such as the identification and classification of phytochemical compounds, their biological relevance, and methods of analysis.

Table 2 Paired samples t-test results

Variable	Mean		Mean ± std. dev	Correlation	P- value
	Pretest	Posttest			
Pretest and posttest	66.70	78.48	11.78 ± 4.45	0.893	0.001

Based on the Table 2, the paired samples t-test revealed that practical-based learning using Balinese grape peel as a teaching resource significantly improved students' conceptual understanding of phytochemistry. The students' average posttest score increased by 11.78 points compared to the pretest, with a significance value of $p = 0.001$ ($p < 0.05$). This indicates that the learning intervention delivered through contextual and hands-on approaches was highly effective in enhancing student comprehension. These findings are consistent with those of Fajri et al. (2022), who reported that experiential learning methods significantly enhance students grasp of complex topics such as phytochemistry. For instance, Ma (2024) demonstrated that cognitive context-based modeling instructional strategies significantly improved students' understanding of biology concepts by actively engaging them in constructing mental models connected to real world contexts. This approach not only deepens conceptual comprehension but also fosters critical thinking and meaningful learning. Okereke et al. (2024) conducted biology students in Nigeria and found that those taught difficult biology concepts using a context-based instructional method significantly outperformed peers taught with conventional lectures.

It is important to acknowledge the limitations of this study regarding sample diversity. The investigation focused solely on one local grape variety, *Vitis vinifera* L. var. Alphonso Lavallee, which constrains the generalizability of the findings especially considering that phytochemical composition can vary substantially among different grape varieties. Each variety exhibits unique phytochemical profiles influenced by both genetic and environmental factors, implying that the screening outcomes and the efficacy of contextual learning approaches may differ if other varieties are examined. Caution should be exercised when generalizing these results. Future studies encompassing multiple local grape varieties from diverse regions are recommended to provide a more comprehensive understanding. Such research would not only enhance educational methodologies grounded in local natural resources but also facilitate the identification of a broader spectrum of phytochemical potentials applicable to teaching materials based on local wisdom.

Furthermore, the correlation value of 0.893 between the pretest and posttest scores indicates a very strong relationship, suggesting that students with better initial understanding still achieved significant improvement after engaging in the practical sessions. This supports the findings of who highlighted that

active participation in laboratory activities fosters mastery of fundamental scientific skills and improves students' observational abilities, particularly in recognizing color changes or precipitate formation key indicators in phytochemical tests. The use of local natural resources, such as Balinese grape peel, also adds value by creating a direct connection between theory and real-world application, thereby enhancing student engagement and motivation.

In addition to academic gains, integrating local resources into the curriculum had a positive impact on students' environmental and cultural awareness. Following the practical session, students showed increased appreciation for the potential of local plants as valuable sources of bioactive compounds in pharmaceutical and health contexts. Mashigo et al. (2024) affirmed that incorporating indigenous knowledge into science education helps bridge modern science with traditional heritage, enriching students' learning experience in a holistic manner. Therefore, this contextual approach to teaching not only improves learning outcomes but also plays a strategic role in cultivating environmental awareness and scientific character among students.

The relevance of these phytochemical compounds extends beyond their biochemical properties, as they offer valuable opportunities for contextual learning within educational settings. The bioactive constituents identified in *Vitis vinifera* L. var. Alphonso Lavallee serve as tangible examples to illustrate core concepts in biochemistry, pharmacology, and natural product chemistry. Incorporating these findings into teaching can help students bridge the gap between theoretical knowledge and practical applications, fostering deeper engagement and comprehension.

Students can further explore how these compounds are used in real-world contexts, particularly in the fields of medicine and industry. For instance, many phytochemicals found in grapes, such as flavonoids and resveratrol, are widely studied for their antioxidant, anti-inflammatory, and cardioprotective effects. Understanding these biological activities enables students to appreciate the significance of natural products in drug discovery, nutraceutical development, and functional food industries. Additionally, the extraction and application processes offer practical insights into industrial biotechnology and quality control measures, which are critical components in pharmaceutical manufacturing and food science.

By connecting the phytochemical profiles from local grape varieties to broader medical and industrial

uses, students develop a holistic perspective on the value of natural resources. This approach not only enriches their scientific literacy but also encourages innovation and sustainable utilization of biodiversity. Ultimately, integrating such contextual learning strategies based on local natural resources cultivates environmental awareness, promotes local cultural heritage, and equips students with skills relevant to multiple scientific and professional domains.

In addition to the improvements observed in test scores, students demonstrated a deeper engagement with the subject matter through various activities. For example, in subsequent lessons, many

students were able to connect the phytochemical concepts learned through the Balinese grape peel extract to other local plants, recognizing similar bioactive compounds in the materials used in other experiments. Some students applied their new knowledge in their project work, where they explored the potential uses of other local plant extracts in medicine and food preservation. This applied understanding of phytochemistry extended beyond the classroom, with several students sharing findings in group discussions and using the knowledge gained to critically evaluate scientific articles on plant-based pharmaceutical applications (see Table 3).

Table 3 Opportunities for developing learning outcomes based on Balinese grape skin extract

Lesson theme	Conceptual understanding	Metacognition	Science process skills	Cultural appreciation
Phytochemical screening of Balinese grape peel extract	(a) Understanding the concept of secondary metabolites and the role of bioactive compounds (flavonoids, tannins, saponins, etc.)	Phytochemical screening of Balinese grape peel extract	(a) Understanding the concept of secondary metabolites and the role of bioactive compounds (flavonoids, tannins, phenols, etc.)	Phytochemical screening of Balinese grape peel extract

The analysis of responses using the 5-point Likert scale showed significant improvement ($p < 0.05$) in conceptual understanding, laboratory skills, and appreciation of local natural resources after the implementation of the culture-based lessons. Students demonstrated a deeper understanding of secondary metabolites and their health benefits by engaging in active learning involving Balinese grape peel extract. Laboratory-based activities, such as phytochemical screening and color-change interpretation, allowed students to apply biological theories in practical contexts. These experiences were instrumental in reinforcing concepts related to antioxidant activity and the real-world relevance of biology. Students displayed a deeper comprehension of secondary metabolites and their health benefits through active learning with Balinese grape peel extract. This aligns with the findings of Ambarwati and Wilujeng (2023), who reported that electronic worksheets incorporating local biodiversity and culture enhance students' motivation and understanding in biological learning.

Laboratory-based activities, including phytochemical screening and the interpretation of color changes, enabled students to apply biological theories in practical and meaningful contexts. These activities reinforced the connection between biological concepts and their real-life applications, particularly in understanding the antioxidant properties of bioactive compounds. Supporting this, Milella et al. (2023) demonstrated a strong correlation between the phenolic profiles of grapes and their antioxidant and anticancer activities, confirming the pharmacological potential of locally-sourced grape peel. Local plant-based learning also proved effective in fostering students' metacognitive awareness. Reflective

practices such as learning journals and guided peer discussions encouraged students to become more aware of their own learning strategies. According to Adiansyah et al. (2023), metacognitive awareness is positively correlated with cognitive learning outcomes among biology education students, suggesting that increased self-awareness enhances comprehension and strategic thinking during the learning process.

Contextualizing lessons with the use of local medicinal plants encouraged a greater appreciation for biodiversity and cultural heritage among students. Many students indicated that laboratory experiences helped them value the scientific and cultural importance of local resources. Guslinda et al. (2024) similarly reported that teaching materials grounded in local wisdom significantly improved environmental literacy and conservation values among students, further supporting the educational value of integrating ethnobotanical knowledge into science education. Phytochemical screening of Balinese grape peel extract revealed the presence of flavonoids, phenols, alkaloids, tannins, and terpenoids. Each compound was identified using specific chemical reagents, demonstrating their potential pharmacological relevance. Research by Krasteva et al. (2023) and Elsherif et al. (2024) confirmed that grape seed and peel extracts possess strong antioxidant and antimicrobial properties, reinforcing the scientific validity of incorporating such extracts into biology lessons.

The integration of local plant-based materials into culture-based and hands-on laboratory lessons significantly enhanced students' conceptual understanding, scientific process skills, and appreciation for local biodiversity. Statistical analysis

showed a marked increase in learning outcomes, with a strong correlation between pretest and posttest scores. These findings confirm that local resources, when presented through culturally responsive pedagogy, can simultaneously foster academic achievement and environmental consciousness (Fahmi et al., 2021).

Furthermore, culture-based learning was effective in enhancing students' metacognitive awareness and cultural appreciation. Reflective exercises, such as learning journals and guided peer discussions, helped students become more conscious of their own learning strategies. Simultaneously, the contextual use of local medicinal plants inspired a greater appreciation for biodiversity and its conservation. Qualitative data from discussions and journals revealed that students relied on the evidence they generated during laboratory experiments to make sense of new information. This connection between experience and theory made the learning process more meaningful and facilitated a smoother integration of new knowledge.

This study concludes that the phytochemical screening of Balinese grape peel extract successfully identified several bioactive compounds, including flavonoids, phenols, alkaloids, tannins, and terpenoids. Each compound was confirmed through specific chemical tests, indicating their presence and potential pharmacological relevance. These compounds are known for their antioxidant, antimicrobial, anti-inflammatory, and health-promoting properties, making the extract not only scientifically valuable but also a meaningful resource for contextual learning in biology education.

The integration of this local plant-based extract into culture-based and hands-on laboratory lessons significantly improved students' conceptual understanding, scientific process skills, and appreciation for local biodiversity. Statistical analysis revealed a notable increase in learning outcomes, supported by a strong correlation between pretest and posttest scores. Furthermore, students' reflective responses indicated heightened metacognitive awareness and cultural appreciation. This demonstrates that embedding local natural resources into biology curricula enhances both academic achievement and environmental consciousness, positioning the Balinese grape peel as a strategic educational tool for promoting science grounded in local wisdom. Suganob et al. (2024) highlight the value of incorporating cultural and sustainability-based projects into biology education to promote ecological awareness and responsible citizenship among students. Furthermore, *in vitro* and *in vivo* studies could be conducted to assess the bioactivity of the extract, such as its antioxidant capacity, anti-inflammatory potential, or antimicrobial properties. From an educational perspective, longitudinal studies could examine the long-term impact of culture-based

lessons on students' scientific literacy and environmental attitudes across diverse educational settings.

This study has identified several bioactive compounds flavonoids, phenols, alkaloids, tannins, and terpenoids in the extract of Balinese grape peel, each demonstrating significant pharmacological potential. Integrating this local plant-based extract into culture based, hands on laboratory lessons notably enhanced students' conceptual understanding, scientific process skills, and appreciation of local biodiversity, as evidenced by a significant increase in posttest scores and strong correlation between pretest and posttest results. Unlike previous research focused mainly on the pharmacological aspects of grape extracts, this study innovatively applies the phytochemical findings to contextual biology education, bridging theory with real-world applications while fostering cultural and environmental awareness. These findings have important implications for future biology education by promoting locally relevant, experiential learning that supports both academic achievement and environmental stewardship. Limitations include the study's focus on a single grape variety, which may limit generalizability due to phytochemical variability across varieties. Future research should explore multiple local grape varieties and assess bioactivity through *in vitro* and *in vivo* studies, as well as investigate the long-term impact of culture-based lessons on students' scientific literacy and environmental attitudes across diverse educational settings

D. Conclusion

Based on the results and discussion, it can be concluded that the peel extract of Balinese grape (*Vitis vinifera* L. var. Alphonso Lavallee) contains several important bioactive compounds, including flavonoids, phenols, alkaloids, tannins, and terpenoids, which were successfully identified through phytochemical screening using specific chemical reagents. These findings not only reinforce the pharmacological value of local plants as sources of antioxidants, antimicrobials, and anti-inflammatory agents but also provide significant scientific contributions to biology education through the application of research findings as contextual and culturally-based teaching materials. The integration of this local plant-based extract into culture-based and hands-on laboratory lessons significantly enhanced students' conceptual understanding, scientific process skills, metacognitive awareness, and appreciation of local biodiversity. However, the study is limited by its focus on a single local grape variety, which may restrict the generalizability of the findings due to potential variations in phytochemical profiles across different varieties. Therefore, future research should explore multiple local grape varieties from diverse regions, assess the bioactivity of the extracts through *in vitro*

and in vivo studies, and conduct longitudinal research to evaluate the long-term impact of culture-based learning on students' scientific literacy and environmental awareness.

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