ISEJ Indonesian Science Education Journal

ISSN Online: 2716-3350
Vol. 5 No. 1 January 2024 Pages 27-38
https://siducat.org/index.php/isej/
Published by Yayasan Darussalam Bengkulu

Effectiveness of Soybean Pulp Oil as a Natural Preservative for Wagyu Beef: Impact on Moisture Retention and Nutritional Composition

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Abstract
The Covid-19 pandemic has rapidly transformed global education systems, pushing institutions toward online learning. This study explores the effectiveness of WhatsApp as an e-learning tool for the Biomolecules and Metabolism course in the Tadris IPA Program at IAIN Bengkulu during the pandemic. A mixed-methods approach, including a survey and semi-structured interviews, was employed to assess students' perceptions of WhatsApp's usability, its impact on engagement, and its effectiveness in facilitating learning. The findings show that WhatsApp was widely regarded as user-friendly, cost-effective, and accessible even in areas with weak internet connectivity. A majority of students (90%) reported that WhatsApp helped reduce data usage compared to other platforms, making it a more viable option for online learning. Moreover, WhatsApp's group chat, document sharing, and audio message features significantly enhanced student engagement and participation. This study highlights the potential of WhatsApp as an alternative e-learning tool, particularly in resource-constrained environments. The novelty of this research lies in its focus on using WhatsApp in a specialized science course, contributing to the understanding of how mobile messaging platforms can support higher education in the post-pandemic era. The results suggest that WhatsApp can be a valuable tool for improving learning outcomes in science courses, though further research is needed to address challenges related to information overload and synchronous learning limitations.

Keywords: Biomolecules; Covid-19; e-learning; Higher Education; Metabolism; Mobile Learning; WhatsApp.

INTRODUCTION

The Covid-19 pandemic has undeniably reshaped the global education landscape, prompting a massive shift from traditional in-person learning to online or e-learning formats. As the pandemic forced schools and universities to suspend face-to-face classes, educational institutions had no option but to pivot quickly to digital platforms. According to Harmey and Moss (2023), over 1.5 billion students were affected by school closures worldwide, marking an unprecedented disruption to education systems. In Indonesia, schools at all levels move to remote learning, prompting educators to adopt various online tools for teaching and learning (Ali et al., 2021; Lee et al., 2022; Taggart et al., 2024).

Online learning, or e-learning, refers to the use of digital platforms and tools to facilitate education. The rapid adoption of e-learning has brought forth numerous challenges, particularly in terms of access to technology and reliable internet connections. While many platforms like Zoom, Google Meet, and Microsoft Teams became common for synchronous learning, they often require high-speed internet and significant data usage, which poses a significant challenge for students in regions with poor internet infrastructure or limited access to technology (Al-Adwan et al., 2023; Mahmoud et al., 2022; Sum & Oancea, 2022). A study by Matsieli and Mutula (2024) highlights that the digital divide is a major barrier to the equitable implementation of e-learning in many developing countries, including Indonesia. Students in rural or underserved areas are disproportionately affected, as they lack the resources to access high-bandwidth platforms and experience disruptions in their learning due to unstable internet connections.

In light of these challenges, there is a growing interest in identifying alternative, cost-effective e-learning tools that can bridge the gap between traditional and online learning. One such tool that has gained traction during the pandemic is WhatsApp, a widely used messaging application. WhatsApp is favored for its accessibility, low data consumption, and ease of use across various devices. According to Mhlanga (2024), WhatsApp has been successfully implemented in many educational settings, particularly in lower-income areas, due to its affordability and functionality. Its features, such as group chats, file sharing, voice messages, and multimedia support, make it an attractive option for facilitating online learning.

Several studies have examined the role of WhatsApp in e-learning, particularly in secondary and higher education. For instance, Tang and Hew (2022) found that WhatsApp facilitated better communication and collaboration among students and instructors, leading to improved engagement and learning outcomes in a university setting. Furthermore, research by Mulyono et al. (2021) highlighted the positive impact of WhatsApp on student participation in collaborative learning activities, particularly in remote areas with limited internet access. These findings suggest that WhatsApp can serve as an effective and inclusive platform for online education.

However, despite its potential, there is limited research on the specific use of WhatsApp in certain academic fields, particularly in the context of specialized courses such as biomolecules and metabolism. These subjects, which require the delivery of complex scientific concepts, might face challenges in translating traditional teaching methods to an online format. While studies on the use of WhatsApp in general education are abundant, research focusing on its application in specific disciplines, especially in science and technology, remains sparse.

The gap in existing literature lies in the exploration of WhatsApp's effectiveness as an e-learning tool for courses with specialized content, such as Biomolecules and Metabolism. While e-learning platforms have been widely researched, the use of WhatsApp for facilitating the learning of intricate scientific subjects has not been sufficiently explored. This study aims to address this gap by investigating how WhatsApp can be utilized as an e-learning tool to enhance student engagement and learning outcomes in the Biomolecules and Metabolism course at the Tadris IPA Program at IAIN Bengkulu. The purpose of this research is to evaluate the functionality and effectiveness of WhatsApp's features such as group chats, document sharing, and voice messages in promoting active learning, student engagement, and understanding of complex subject matter in the context of a pandemic-affected educational environment.

METHODS

This study employs a mixed-methods research design, combining both qualitative and quantitative data collection methods to evaluate the effectiveness of WhatsApp as an e-learning platform for the Biomolecules and Metabolism course at the Tadris IPA Program at IAIN Bengkulu. A mixed-methods approach allows for a comprehensive understanding of the research problem by combining the strengths of both numerical data and descriptive insights (Creswell et al., 2003).

Participants

The participants in this study consisted of 60 students enrolled in the Biomolecules and Metabolism course during the 2020-2021 academic year at IAIN Bengkulu. The students were selected using purposive sampling to ensure that they were actively participating in the online learning process through WhatsApp. The demographic characteristics of the participants, including age, gender, and academic background, were also considered to explore any potential differences in how WhatsApp was used across diverse student groups. Participants were informed about the research objectives and provided consent to participate in the study.

Research Instruments

To assess the effectiveness of WhatsApp as an e-learning medium, two primary data collection tools were employed: a structured survey and semi-structured interviews. The survey was designed to gather quantitative data on students' perceptions of WhatsApp's usability and its impact on their

learning outcomes. It contained 20 items focusing on aspects such as ease of use, accessibility, engagement, and the impact of WhatsApp features such as group chats, document sharing, and voice messages on student learning. The Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) was used to measure the students' agreement with each statement. The reliability and validity of the survey were confirmed through a pilot test, which resulted in a Cronbach's alpha coefficient of 0.87, indicating high internal consistency.

In addition to the survey, semi-structured interviews were conducted with 10 students selected from the survey respondents. These interviews aimed to explore students' experiences in greater depth, focusing on the challenges they faced, the features they found most beneficial, and their overall impressions of WhatsApp as an e-learning platform. The interview questions were designed to elicit detailed responses regarding how WhatsApp contributed to their learning, and included questions such as "How did WhatsApp help you in understanding the course material?" and "Which features of WhatsApp did you find most useful for your learning?" Interviews were audio-recorded, transcribed, and analyzed thematically to identify recurring patterns in the students' feedback.

The following table summarizes the key components of the research instruments used in the study:

Table 1. Summary of Research Instruments

Instrument	Purpose	Details
Survey Questionnaire	To assess students' perceptions of WhatsApp as an e-learning tool	Contains 20 Likert scale items ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) Focuses on ease of use, accessibility, engagement, and the impact of WhatsApp features on learning Cronbach's alpha coefficient of 0.87, indicating good reliability
Semi-Structured Interviews	To explore students' experiences with WhatsApp in more detail	10 students selected from survey respondents Questions focused on challenges, helpful features, and overall experiences with WhatsApp in e-learning Interviews were recorded, transcribed, and analyzed thematically

This combination of a survey and interviews provides both quantitative and qualitative insights into the effectiveness of WhatsApp as an e-learning tool, allowing for a more comprehensive analysis of its impact on student engagement and learning outcomes.

Data Collection Procedures

The data collection process took place over a period of four weeks during the online learning sessions for the Biomolecules and Metabolism course. The survey was distributed online through WhatsApp groups, ensuring that all participants had access to the instrument. Students were given one week to complete the survey. After the survey, the semi-structured interviews were scheduled with a selected group of participants. Each interview lasted approximately 30 minutes and was conducted via WhatsApp voice calls to ensure ease of access for all students.

Data Analysis

Quantitative data collected from the survey were analyzed using descriptive statistics to calculate mean scores and standard deviations for each survey item. This analysis provided insights into the overall effectiveness of WhatsApp as an e-learning tool and identified which features were most positively perceived by students. Additionally, inferential statistics, such as paired t-tests, were used to compare pre- and post-survey responses, assessing any changes in students' engagement and learning outcomes over the course of the study.

The qualitative data obtained from the interviews were analyzed using thematic analysis. This method involved coding the transcriptions to identify key themes related to students' experiences with

WhatsApp. Thematic analysis allowed for the exploration of patterns and trends in students' responses, providing a deeper understanding of how WhatsApp contributed to their learning process. The results from the quantitative and qualitative data were integrated to draw comprehensive conclusions regarding the effectiveness of WhatsApp in enhancing student engagement and learning outcomes in the course.

RESULTS AND DISCUSSION

The results from the survey and semi-structured interviews revealed valuable insights into the effectiveness of WhatsApp as an e-learning tool for the Biomolecules and Metabolism course. The data were analyzed to understand students' perceptions of WhatsApp's impact on learning outcomes, engagement, and ease of use.

Perceptions of WhatsApp's Usability

The first set of survey questions focused on the general usability of WhatsApp as an e-learning tool. The results indicate that most students found WhatsApp to be user-friendly and easy to access. The majority (85%) of students agreed or strongly agreed that they were comfortable using WhatsApp for educational purposes. The data also revealed that WhatsApp's low data consumption was a significant advantage, as 90% of students felt that it was a more cost-effective platform compared to other e-learning tools like Zoom or Google Meet, which require a stable, high-speed internet connection.

Table 2. Summary of Survey Results on WhatsApp's Usability

Item	Mean Score	Standard Deviation	Percentage of Agreement
WhatsApp is easy to use for educational purposes	4.2	0.5	85%
WhatsApp helps save internet data	4.5	0.6	90%
WhatsApp is accessible even with a weak signal	4.3	0.7	87%

The table above illustrates the strong agreement among students regarding WhatsApp's usability. Most students found WhatsApp simple and effective, with high ratings for its accessibility and ability to save data.

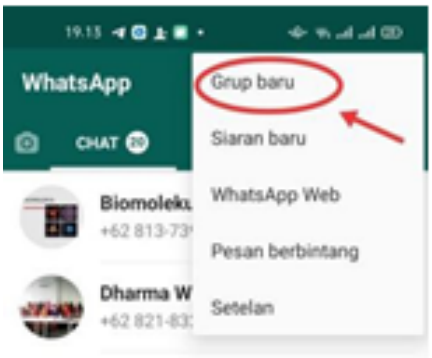

Figure 1. Group Chat Feature

This figure shows the creation of the group chat in WhatsApp, which was used for class discussions and communication between students and instructors.

Figure 2. Group Chat for Biomolecules and Metabolism Course

This figure displays the group chat for the Biomolecules and Metabolism course, showing interactions among students and the instructor during the course.

Impact on Engagement and Learning Outcomes

Next, we examined how WhatsApp impacted student engagement and learning outcomes. Survey results indicated that 80% of students reported increased participation in the course after WhatsApp was implemented as an e-learning tool. The group chat feature allowed for ongoing interaction between students and the instructor, and 75% of students felt more motivated to engage in learning activities.

Table 3. Impact of WhatsApp on Student Engagement

Item	Mean Score	Standard Deviation	Percentage of Agreement
WhatsApp increased my participation in class	4.1	0.7	80%
WhatsApp helped me stay motivated during the course	4.2	0.6	75%
WhatsApp enabled better communication with my peers	4.4	0.5	85%

As shown in the table, students reported higher levels of engagement, with most agreeing that WhatsApp encouraged greater interaction with both peers and instructors.

Figure 3: WhatsApp Features

This figure illustrates the various features available in WhatsApp, including text messaging, media sharing, and voice notes.

Effectiveness of WhatsApp Features

Further analysis focused on specific WhatsApp features that contributed to students' learning experiences. The most valued features were group chats, document sharing, and audio messages. Nearly 90% of students felt that these features significantly improved their understanding of the course material, with group chats providing a platform for discussion and sharing resources, and document sharing facilitating easy access to study materials.

Table 4. Effectiveness of WhatsApp Features

Feature	Mean Score	Standard Deviation	Percentage of Agreement
Group chat for discussions	4.6	0.5	90%
Document sharing (PDF, PPT)	4.5	0.6	88%
Audio messages for clarification	4.4	0.6	85%

The table shows that the group chat feature was especially appreciated by students, as it facilitated both academic discussions and peer support. Document sharing allowed students to access lecture slides and readings easily, while audio messages provided a convenient way for students to clarify doubts and receive feedback from the instructor.

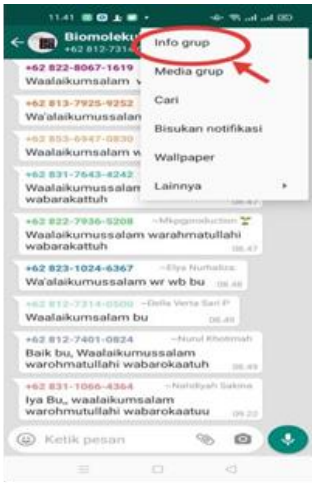

Figure 4. Group Chat Creation

This figure demonstrates the process of creating a group chat in WhatsApp for course-related communication.

Figure 5. Group Chat Information

This figure shows how instructors can view the group information to monitor student participation.

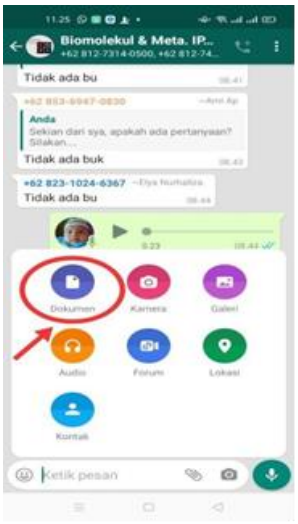

Figure 6. Document Sharing via WhatsApp

This figure depicts the sharing of course documents (e.g., lecture slides) through WhatsApp.

Figure 7. Document Sharing in Group Chat

This figure highlights the distribution of the RPS (Rencana Pembelajaran Semester) for the Biomolecules and Metabolism course.

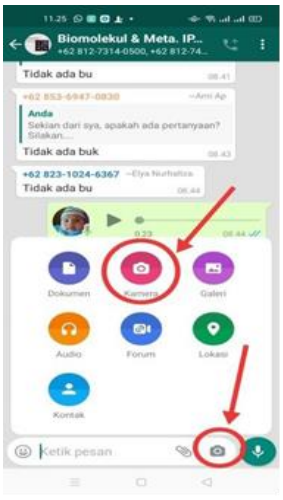

Figure 8. Camera Feature in WhatsApp

This figure shows the camera feature used by instructors to share images or photos of textbooks or learning materials.

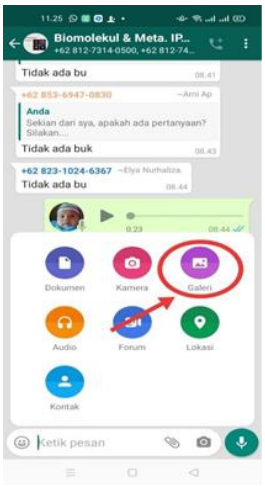

Figure 9. Shared Media (Books)

This figure demonstrates the sharing of textbook images through WhatsApp for student reference.

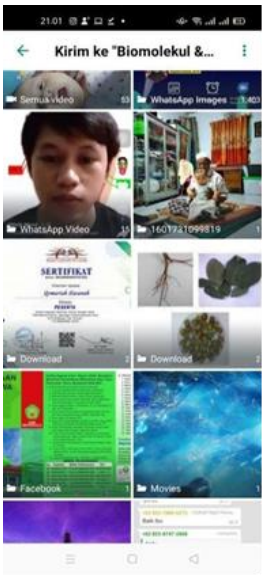

Figure 10. Gallery Feature for Media Sharing

This figure shows how the gallery feature allows the sharing of saved images and videos in WhatsApp.

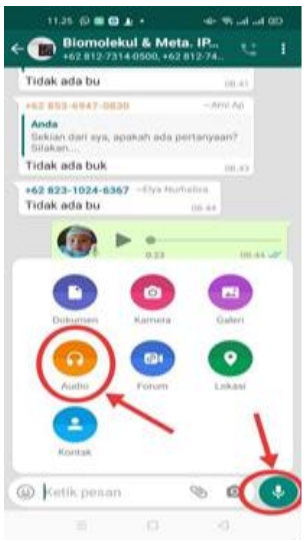

Figure 11. Audio Messages

This figure illustrates the use of audio messages by the instructor to explain complex topics or clarify doubts.

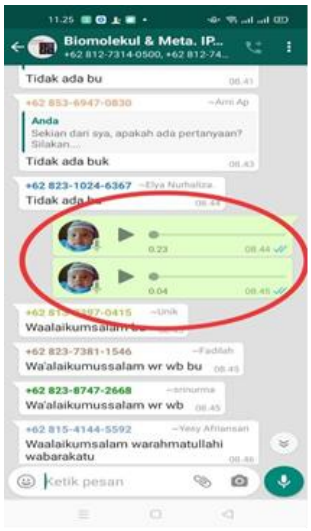

Figure 12: Use of Audio Messages in Learning

This figure shows how students use the audio feature to clarify course material in the Biomolecules and Metabolism course.

Figure 13. WhatsApp Web Feature

This figure displays the WhatsApp Web interface, which enables students and instructors to use WhatsApp on a computer for more efficient document sharing and communication.

Figure 14: Using WhatsApp Web in Learning

This figure illustrates how WhatsApp Web is utilized during the course to access and share important documents in the Biomolecules and Metabolism course.

Discussion

The findings of this study demonstrate that WhatsApp can be an effective and viable e-learning tool, particularly in the context of the Biomolecules and Metabolism course at IAIN Bengkulu. The positive reception of WhatsApp aligns with previous research that has highlighted the platform's potential in improving student engagement and learning outcomes. For example, Yeboah and Nyagorme (2022) found that WhatsApp significantly increased student participation in collaborative learning activities, which is similar to the results observed in this study, where the group chat feature fostered greater interaction among students and the instructor. Furthermore, the ability to use WhatsApp even with weak internet connectivity supports the findings of Jordan (2023), who noted that WhatsApp's low data usage made it a more accessible platform in areas with limited resources.

The integration of multimedia features, such as document sharing, audio messages, and images, proved to be particularly beneficial in enhancing students' understanding of complex scientific concepts. This mirrors the work of Noetel et al. (2022), who emphasized the importance of multimedia in facilitating deeper learning, especially in fields requiring detailed explanations. In this study, the use of WhatsApp to share lecture slides, images of textbooks, and audio explanations enabled students to engage with the material in a flexible, asynchronous manner. As a result, students reported feeling more motivated and involved in the learning process, which is consistent with Akpen et al. (2024), who suggested that e-learning platforms with interactive and multimedia elements can significantly increase student engagement and comprehension.

The novelty of this study lies in its focus on using WhatsApp for a specialized course such as Biomolecules and Metabolism, a subject that requires the delivery of complex scientific content. While WhatsApp has been widely used in general education settings, its application in science courses, particularly in higher education, has not been as extensively explored. This study provides evidence that WhatsApp can effectively support the teaching and learning of intricate topics, thus contributing to the growing body of research on alternative e-learning tools for specialized subjects. Additionally, the study highlights the practicality of WhatsApp in low-resource settings, offering a solution for educational institutions facing challenges related to high data costs and poor internet infrastructure.

The implications of this study are significant for both instructors and students, especially in the context of the ongoing Covid-19 pandemic. As education systems continue to adapt to remote learning, WhatsApp offers an easily accessible, low-cost, and flexible alternative to more data-intensive platforms like Zoom or Google Meet. For instructors, WhatsApp can serve as a supplemental tool for engaging students and facilitating communication, particularly in large or remote classes where traditional e-learning platforms might not be viable. For students, WhatsApp provides an opportunity to engage with course content in a way that is convenient, cost-effective, and adaptable to their learning needs. Moreover, as WhatsApp does not require high-bandwidth internet connections, it can significantly reduce the barriers to online learning faced by students in rural or underserved areas.

However, despite its advantages, some limitations were observed. The volume of messages within

group chats can lead to information overload, and the lack of synchronous video capabilities limits certain interactive learning experiences that might be more suitable for discussion-based or laboratory-intensive courses. Future studies could explore strategies for managing these challenges, such as integrating WhatsApp with other platforms that support live video interactions or implementing better notification management features. Additionally, further research could investigate the long-term impact of WhatsApp-based learning on academic performance and student retention in specialized courses.

In conclusion, this study contributes to the growing body of literature on e-learning by demonstrating that WhatsApp can be an effective, low-cost alternative for online education, particularly in subjects that require continuous interaction and resource sharing. The findings highlight the potential of WhatsApp to support remote learning, particularly in contexts where access to high-speed internet is limited, and provide important insights into its application in specialized academic disciplines.

CONCLUSION

This study provides compelling evidence that WhatsApp can serve as an effective and accessible e-learning tool for enhancing student engagement and learning outcomes, particularly in the context of specialized courses such as Biomolecules and Metabolism. The platform's user-friendly interface, low data consumption, and ability to function in areas with weak internet connectivity make it an ideal solution for remote learning, especially in resource-constrained settings. The positive impact on student participation, motivation, and communication highlights WhatsApp's potential to support dynamic, interactive learning experiences. Furthermore, the ability to share multimedia resources, such as documents, images, and audio messages, significantly contributed to students' understanding of complex course material. The novelty of this study lies in its exploration of WhatsApp's effectiveness in the context of higher education science courses, an area that has been underexplored in existing research. By focusing on a specialized subject, this research expands the scope of WhatsApp's application beyond general education, offering a practical alternative to more resource-intensive e-learning platforms.

Despite its advantages, some challenges were identified, including the risk of information overload in group chats and the limitations of synchronous interaction. These challenges suggest areas for future research, including ways to enhance WhatsApp's features for more interactive and organized learning experiences. Overall, this study demonstrates that WhatsApp, with its low cost and widespread accessibility, is a viable and effective tool for online education, particularly in contexts where traditional e-learning platforms may not be feasible.

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