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INTERPRETATION OF FTIR SPECTRA OF CRUDE EXTRACT OF RENGGAK FRUIT PEEL: DEVELOPMENT OF A CHEMISTRY MAGAZINE AS A SUPPLEMENT TO ORGANIC CHEMISTRY LECTURES

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ABSTRACT

This study was conducted to analyze the FTIR spectra of Renggak fruit peel extracts and present the interpretation results in the form of a chemistry magazine intended as supplementary reading for students. The extraction of Renggak fruit peels was performed using two solvents, ethanol and methanol. The research applied the 4D development model, which includes the stages of definition, design, development, and dissemination. The validity and feasibility of the magazine were evaluated through expert validation and student response assessments. Validation was carried out by three lecturers from the Chemistry Education program, while student trials involved 65 Chemistry Education students at the University of Mataram who had completed the course Determination of Organic Compound Structures. FTIR analysis of the ethanol extract revealed absorption bands corresponding to hydroxyl (OH), carbonyl (C=O), alkyl (CH), C–O bonds, methyl (CH_3), methylene (CH_2), and aliphatic hydrocarbon (C–H) groups. In contrast, the methanol extract showed absorption of OH, C=O, CH, CH_3, CH_2, and aliphatic C–H groups. The study produced an average reliability score of 96.25%. Based on the Aiken V index, the magazine achieved an average validity score of 0.91, categorized as very valid. Student responses indicated a practicality level of 90.3%, classified as very practical. These findings suggest that the chemistry magazine is suitable for use as a learning supplement.

ABSTRAK

Penelitian ini bertujuan untuk menafsirkan spektra FTIR dari ekstrak kasar kulit buah renggak serta menyajikan hasil interpretasi tersebut dalam bentuk majalah kimia sebagai bahan bacaan pendukung bagi mahasiswa. Ekstraksi kulit buah renggak dilakukan menggunakan dua jenis pelarut, yaitu etanol dan metanol. Penelitian ini menggunakan model pengembangan 4D yang meliputi tahap pendefinisian (define), perancangan (design), pengembangan (develop), dan penyebaran (disseminate). Tingkat validitas dan kelayakan majalah ditentukan melalui uji validasi oleh ahli serta uji respon mahasiswa. Validasi dilakukan oleh tiga dosen Pendidikan Kimia, sedangkan uji respon melibatkan 65 mahasiswa Pendidikan Kimia Universitas Mataram yang telah menempuh mata kuliah Penentuan Struktur Senyawa Organik. Hasil analisis FTIR ekstrak dengan pelarut etanol menunjukkan adanya serapan gugus hidroksil (OH), karbonil (C=O), alkil (CH), ikatan C–O, gugus metil (CH_3), metilen (CH_2), dan rantai hidrokarbon alifatik (C–H). Sementara itu, ekstrak metanol memperlihatkan serapan gugus OH, C=O, CH, CH_3, CH_2, dan C–H alifatik. Nilai reliabilitas rata-rata mencapai 96,25% dengan kategori reliabel. Validitas majalah berdasarkan indeks Aiken V memperoleh nilai rata-rata 0,91 dengan kategori sangat valid, serta respon mahasiswa menunjukkan tingkat kepraktisan sebesar 90,3%. Dengan demikian, majalah kimia ini layak digunakan sebagai suplemen pembelajaran.

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INTRODUCTION

Organic chemistry is a branch of chemistry that studies organic compounds. This scientific field plays a crucial role in human life because most products around us contain organic compounds, which are essential for living things (Pratama et al., 2023). Organic chemistry is a branch of chemistry that plays a crucial role in human life (Fauzi'ah & Diniaty, 2017). The course "Determining the Structure of Organic Compounds" is included in the Organic Chemistry course group in the Chemistry Education Study Program at the University of Mataram, along with Organic Chemistry 1, Organic Chemistry 2, Advanced Organic Chemistry, and Natural Product Chemistry.

The course "Determining the Structure of Organic Compounds" aims to provide an understanding of methods for determining the structure of organic compounds using spectroscopy. One instrument that uses spectroscopy principles is FTIR (Fourier Transform Infrared). Fourier Transform Infrared is infrared spectroscopy equipped with a Fourier transform for the detection and analysis of its spectra. Infrared spectroscopy is useful for identifying organic compounds because the highly complex spectra consist of numerous peaks that indicate the presence of functional groups, characterized by wavenumbers. Functional group analysis of a sample is performed by comparing the absorption bands formed in the infrared spectrum with the spectrum of a known reference compound.

FTIR spectroscopy is a widely used instrument because it is used to determine the vibrational spectra of molecules and is useful for predicting the structure of chemical compounds (Sanjiwani et al., 2020). Identification of organic compounds using an FTIR spectrophotometer can be performed qualitatively and quantitatively (Sari et al., 2018). (a) Qualitative analysis using FTIR spectroscopy is generally used to identify functional groups present in a compound being analyzed. (b) Quantitative analysis using FTIR spectroscopy is generally used to determine the concentration of analytes in samples.

The "Structure Determination of Organic Compounds" course remains a challenge for Chemistry Education students at the University of Mataram. One reason is the abstract nature of the material, which lacks concrete examples. To address this issue, efforts are needed to improve the quality of learning. One way to address this is by providing supplementary learning materials in the form of reading materials that are expected to enhance students' understanding of the characteristics of abstract material. To determine the need for supplements in the Organic Chemistry group of courses, a survey was conducted by distributing a response questionnaire to students who had completed the organic chemistry group (Organic Chemistry I, Organic Chemistry II, Advanced Organic Chemistry, Natural Product Chemistry, and Determination of the Structure of Organic Compounds) in the form of a Google Form. The survey results indicated that 87.5% of students were interested in deepening their knowledge of the use of instruments in determining the structure of organic compounds and needed learning media in the form of engaging and practical reading materials.

Student reading materials include print media such as books, magazines, tabloids, newspapers, leaflets, and other printed materials that are informative, readable, and useful for students. One such resource is organic chemistry reading materials, which are essential for students studying organic chemistry as a field of study (Heliawati, 2018). Chemistry magazines are particularly engaging and frequently used (Sudianti et al., 2025). The survey also indicated that 87.5% of students agreed to use magazines as learning media as reading resources. Chemistry magazines have their own appeal to readers, such as an attractive and varied appearance and content, images that are packaged attractively and

displayed simply to make it easier to understand the concept (Sudianti et al., 2025).

Magazines are information-based media primarily dedicated to delivering current news (Fitria & Habibi, 2021). Magazines are a type of mass media generally consisting of a collection of printed and bound pages. They are published periodically and feature articles from various authors. In addition to articles, magazines also contain short stories, pictures, reviews, illustrations, and other features on each page (Sinaga & Triyanto, 2020). Each magazine edition has its own unique characteristics, evident in its cover design. The presence of pictures and illustrations makes the magazine more engaging, and the information and writing in the magazine is also quite detailed, making it easy to read (Fiidami et al., 2021).

Organic Chemistry learning in the Chemistry Education study program is currently linked to the potential of sasambo ethnoscience, in line with the vision and mission of the Chemistry Education study program, which is to conduct research in the field of Chemistry Education and develop Chemistry Education based on local wisdom. The renggak plant is widely used by the people of Lombok Island. Renggak is a member of the ginger family and is native to Indonesia. On the island of Lombok, this fruit is often used to treat headaches. Furthermore, this plant is a natural antioxidant that helps neutralize free radicals. This fruit has potential for therapeutic and culinary applications due to its content of several secondary metabolites, including alkaloids, steroids, flavonoids, terpenoids, and saponins, as determined by qualitative phytochemical analysis (Nufus, 2020).

Several studies have been reported on FTIR interpretation, including those by Damayanti et al. (2021) in an article entitled "Identification of Wave Numbers of Betel Leaves (Piper sp.) Using Fourier Transform Infrared Spectroscopy (FTIR) and Principal Component Analysis (PCA) Methods which concluded that the FTIR characteristics indicate the presence of the same functional groups for the three types of betel leaves tested, namely the C-H, C=O, C=N, C=C, C-N, C-O, and C-Cl groups in all red, green, and black betel leaves. Research by Mahmiah et al. (2023) in an article entitled Metabolite Profile of Ethanol Extract of Enhalus acaroides (L.F.) Royle, 1839 from East Nusa Tenggara which concluded that the results of the identification of secondary metabolite compounds of Enhalus acaroides obtained compound bond groups such as -OH or -NH groups (ν 3329.958 and 3252.176 cm^{-1}), C-H (ν 2921.204 and 2851.486 cm^{-1}), -C=O (ν 1641.169 cm^{-1}), C=C (ν 1517.243 cm^{-1}). Research by Ambarwati & Theresih (2018) in an article entitled Isolation and Identification of Secondary Metabolite Compounds from Mahogany Seeds (Swietenia mahagoni Jacq.) Using the Soxhlet Extraction Method with Ethanol Solvent concluded that there were O-H, C=O, C=C alkene functional groups, C-H aromatic, C-H aliphatic, and C-O functional groups.

This study aims to interpret the FTIR spectra of crude extracts of renggak fruit peels, the results of which will then be used as content in a chemistry magazine that will be developed for student reading materials.

METHODS

The research method used in this study is Research and Development (R&D), or Research-based Development. Research and Development (R&D) is a research method used to produce a specific product and test its effectiveness (Okpatrioka, 2023). This study employed the 4D development model, consisting of four stages: define, design, develop, and disseminate.

The define stage is the initial stage in the 4D model development research. This stage aims to determine and define the needs for reading supplements related to the magazine's content. This stage involves an initial needs analysis conducted through a literature review to seek and gather information to be used as content for the chemistry magazine to be developed. This stage also included an FTIR spectral analysis of the crude extract of renggak fruit peel, the results of which were used as magazine content and then linked to learning outcomes in the Organic Chemistry course

group.

The design stage involves creating the initial draft of the magazine. The chemistry magazine was designed using the Canva Pro application. Canva Pro is easy to use, offers numerous design templates, is accessible via the website or mobile app, provides canvases in various sizes, has a variety of design element options, is easy to find stock photos, and files can be saved or shared directly as links (Nur & Majid, 2024). Furthermore, this stage involves the preparation of the chemistry magazine's content, including documentation, the selection of chemical concepts related to the FTIR instrument and renggak fruit extract, the selection of the magazine's background, and the selection of the type, shape, and color of the text. The resulting product draft is called prototype 1, which covers both the writing and design aspects.

The development stage is the stage where the conceptualized product is developed according to the material, student needs, and illustrations. Expert validation testing (prototype I) is conducted, followed by revisions based on suggestions and input, product trials (prototype II), and user trials to test the magazine's feasibility. At this stage, the product design is developed into a finished product, and expert validity testing and trials (feasibility testing) of the magazine are conducted repeatedly to ensure that the product meets the established specifications. The expert validity test phase assesses the journal's validity using an instrument comprising graphical elements, content appropriateness, presentation appropriateness, and language appropriateness. The validation was conducted by three validators, consisting of three Chemistry Education lecturers. The feasibility test was conducted on 65 Chemistry Education students who had completed the "Determination of Organic Compound Structure" course. Students were given a trial run by submitting the journal document, followed by an assessment or questionnaire, with responses consisting of questions. Product revisions were made based on the suggestions provided.

The validation data was then analyzed and its validity measured using the Aiken V index formula, with the following equation:

$$V=\frac{\Sigma s}{n(c-1)} \quad \ldots 1)$$

Description:

V = Validator agreement index regarding content validity

s = Score determined by the validator minus the lowest score in the category used (s = r-Io, where r = score of the validator's chosen category and Io = lowest scoring score).

n = Number of validators

c = Number of categories selected by the validator

Table 1. Aiken index categories

No	Indeks Range	Categories
1.	V≤0,4	Less Valid
2.	0,4<V≤0,8	Valid
3.	0,8<V≤1	Very Valid

The student questionnaire responses were analyzed using a descriptive method by determining the feasibility level of the developed chemistry magazine using the following formula:

$$P = [f/N] \times 100\% \quad \ldots 2)$$

Where:

P = Final score; F = Score obtained;

N = Maximum score

Table 2. Practicality Criterias

No	Percentages	Criterias
1.	0-20	Unpractical
2.	21-40	Less Practical
3.	41-60	Quite Practical
4.	61-80	Practical
5.	81-100	Very Practical

The next stage is the dissemination stage of the chemistry journal product (disseminate). The dissemination stage is the final stage of the development of the chemistry journal, which

contains the interpretation of the FTIR spectra of crude extracts of the renggak fruit peel. In this final stage, the developed journal is distributed to the Chemistry Education study program and the Laboratory as a library.

RESULT AND DISCUSSION

FTIR Spectra Analysis of Crude Extract of Renggak Fruit Peel

The crude extract of renggak fruit peel was analyzed using an FTIR instrument. FTIR is a widely used instrument because it functions to determine the vibrational spectrum of molecules and is useful for predicting the structure of chemical compounds (Sanjiwani et al., 2020). The results of characterization using the FTIR instrument with renggak fruit peel samples using ethanol solvent obtained infrared spectra as shown in Figure 2 and Table 3 below

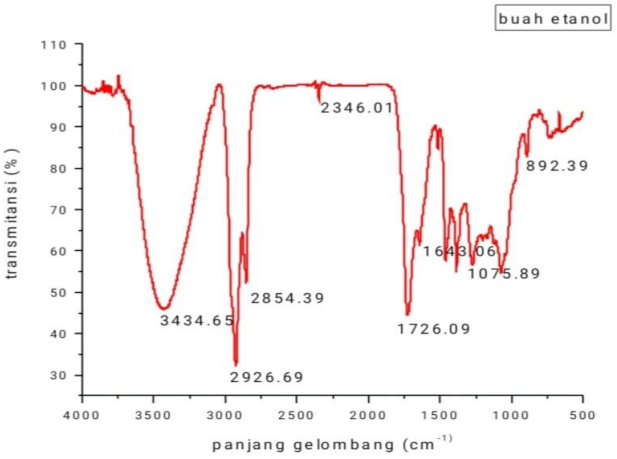


Figure 2. Results of IR spectra of crude extract analysis of Renggak fruit with ethanol solvent

Table 3. Results of FTIR Spectra Interpretation with Ethanol Solvent

No.	Wavenumber (cm^{-1})	Bond absorption
1	3434.65	Hydroxyl Group(OH)
2	892.39, 2926.69, & 2854.39	Alkyl Group (CH)
3	2346.01	Carbon Dioxide Group (CO_2)
4	1643.06 & 1726.09	Carbonyl Group (C=O)
5	1075.89	Ether Group (C-O-C)

Based on the interpretation of the FTIR spectra of crude renggak fruit peel extract using ethanol as a solvent, the following results were obtained:

3434.65 cm^{-1} → O-H (hydroxyl) stretch

This absorption is very broad and strong, indicating the presence of an -OH group. This could be from alcohol, phenol, or carboxylic acid. In the context of fruit extracts, this is most likely from phenolic compounds, flavonoids, and organic acids. Ethanol also contains -OH, but its presence in the extract indicates the presence of a polar compound.

2926.69 and 2854.39 cm^{-1} → Aliphatic C-H stretch (sp^3)

This indicates the presence of methyl (–CH_3) and methylene (–CH_2–) groups. This is common in fatty acids, long-chain alcohols, lipids, or esters. The combination of these two peaks supports the presence of aliphatic alkyl compounds in the extract.

2346.01 cm^{-1} → C≡C or CO_2 Stretch

This is generally an interference from CO_2 in the air, as ethanol readily absorbs CO_2. Alternatively (if not an interference), it could be the presence of a nitrile (C≡N) or alkyne (C≡C) group, although these are rarely found in natural fruit compounds.

1726.09 cm^{-1} → C=O Stretch (carbonyl)

Very typical for carboxylic acids, esters, aldehydes, and ketones. In fruit extracts, this

may originate from free fatty acids, methyl/ethyl esters of organic acids, and natural aromatic aldehydes. Relatively high values (above 1720 cm^{-1}) are consistent with esters or aldehydes.

1643.06 cm^{-1} → C=C or C=O Stretching (conjugated)

Can indicate the presence of: C=C in an aromatic ring or unsaturated compound. C=O of the carbonyl group conjugated with another group (e.g., double bond or aromatic). Matches the structure of flavonoids, phenolic acids, or other aromatic compounds in fruit.

1075.89 cm^{-1} → C–O or C–O–C Stretching

Common in alcohols, ethers, and esters. This supports the presence of polar compounds such as glycosides, esters, or simple polysaccharides.

892.39 cm^{-1} → Out-of-plane bending (aromatic C–H)

Indicates the presence of a disubstituted aromatic structure. Usually associated with the position of substitution on the benzene ring (meta-, para-, or ortho-). In fruit extracts, it supports the presence of aromatic compounds, such as flavonoids or phenols.

The results of FTIR spectroscopy characterization of the renggak fruit peel sample in methanol solvent are shown in Figure 3. This spectrum provides information on the functional groups present in the renggak fruit peel sample, reflected by peaks at specific wavelengths. Further results regarding the FTIR spectra are presented in Table 4 as follows:

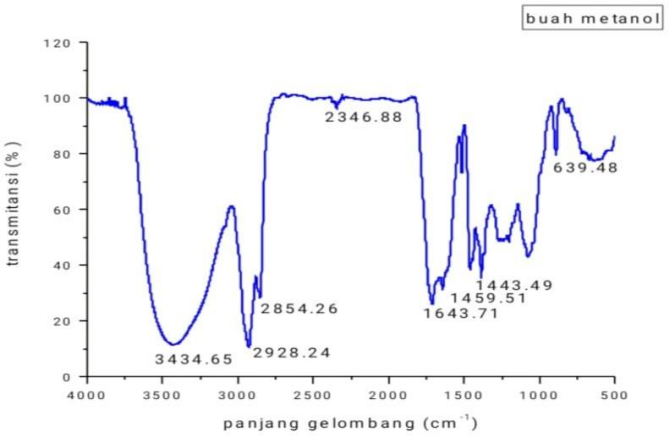


Figure 3. Results of IR spectra of crude extract analysis of Renggak fruit with methanol solvent

Table 4. Results of FTIR Spectra Interpretation with Methanol Solvent

No.	Wavenumber (cm^{-1})	Bond absorption
1	3434.65	Hydroxyl Group(OH)
2	2928.24 & 2854.26	Alkyl Group (CH)
3	2346.88	Carbon Dioxide Group (CO_2)
4	1643.71	Carbonyl Group (C=O)
5	1459.51 & 1443.49	Methil and Methilen Group (C-O-C)

Based on the interpretation of the FTIR spectra of crude renggak fruit peel extract using methanol as a solvent, the following results were obtained:

3434.65 cm^{-1} → -OH (hydroxyl) group

This is a broad and intense absorption band, typical of the O-H stretching of alcohols or carboxylic acids. Because the sample was dissolved in methanol, it is possible that some of the contribution comes from the methanol itself. However, if it is associated with the fruit (a natural product), it most likely originates from phenolic, alcohol, or carboxylic acid groups in secondary metabolites such as flavonoids or phenolic acids.

2928.24 cm^{-1} and 2854.26 cm^{-1} → C-H aliphatic (sp^3)

These peaks indicate the presence of C-H stretching from alkyl groups (methyl and methylene). These are commonly found in long-chain hydrocarbons or lipid compounds, such as fatty acids, esters, and volatile compounds.

2346.88 cm^{-1} → C≡C or C≡N (triple stretch)

A band in this region could indicate the presence of a C≡C group (alkynes), which is rarely found in natural compounds. C≡N (nitriles) can be found in synthetic aromatic compounds, but also in some natural compounds. However, this band could also originate from atmospheric CO_2, which often appears as an interference (common in FTIR).

1643.71 cm^{-1} → C=C or C=O

A peak around 1640 cm^{-1} could indicate C=C stretching (in the aromatic ring or double bond of alkenes) or C=O stretching of the carbonyl group (if shifted slightly downward due to hydrogen bonding). In the context of fruit extracts, this could indicate the aromatic C=C of flavonoids, or the C=O of carboxylic acids or esters (especially if accompanied by an OH group).

1459.51 cm^{-1} and 1443.49 cm^{-1} → C-H Bending

Indicates the presence of CH_2 and CH_3 (deformation/insertion) that support the aliphatic chain. The appearance of these two bands close together indicates the presence of methyl and methylene structures, such as those found in fatty acids or long-chain alcohols.

639.48 cm^{-1} → Fingerprint vibration

This band falls within the fingerprint region and can be associated with C–X vibrations (usually C–Cl, C–Br, or disubstituted aromatic vibrations). However, in natural contexts, it can also reflect hindered aromaticity or complex polyphenol structures.

Developing a Chemistry Magazine Using a 4D Model

Chemistry Magazines are developed using a 4D model that includes four stages: define, design, develop, and disseminate.

Define Stage

The define stage involves an analysis process to gather necessary information and analyze the difficulties faced by students who have completed the "Determination of the Structure of Organic Compounds" course. The initial analysis was conducted to obtain information about the conditions faced by Chemistry Education students related to the "Determination of the Structure of Organic Compounds" course, followed by data collection and analysis.

Based on the analysis conducted through a Google form, it was discovered that students were having difficulty understanding the material on FTIR spectra interpretation and were interested in deepening the use of the instrument in determining the structure of organic compounds. In addition to analyzing the material's difficulties, an analysis of the learning media used by the students was also conducted. The analysis revealed that students needed learning media as an engaging and practical reading resource. Based on the information from the material analysis and the difficulties faced by the students, the use of learning media, namely chemistry magazines, is one solution that will be developed as student reading material.

The content on FTIR spectra in the magazines to be presented was analyzed in Magazines on FTIR Spectra Interpretation. The plant selected for FTIR Spectra Interpretation was the skin of the renggak fruit. The renggak plant is a native plant of Lombok Island, so the designed magazine has ethnoscientific value.

Design Stage

The design stage was conducted after obtaining data from the definition stage. Based on the analysis of difficulties faced by students, the researcher concluded that the media used by students were still textbooks or other relevant media. Designing a chemistry magazine required a design that met the needs based on the data collected. The chemistry magazine was designed using the Canva Pro application. Canva Pro is easy to use, offers numerous design templates, is accessible via the website or mobile

app, provides canvases in various sizes, has a variety of design element options, is easy to find stock photos, and files can be saved or directly shared as links (Nur & Majid, 2024). The media design was as follows:

Media Format Selection

The media format to be designed is a science magazine featuring FTIR spectra. The concept includes a foreword, an introduction, FTIR spectra of crude extracts of renggak fruit peel, FTIR spectral interpretation results, and games for evaluating the existing material.

Table 5. Sections of a Magazine

Magazine Sections	Content	Pages
Opening - Cover and Introduction	Cover (header, serial number, magazine title, images related to the interpretation of the FTIR spectra of the skin of the renggak fruit)	-
	Editorial page (editorial greetings, editorial team, and table of contents of the magazine).	1
Content	Introduction to renggak, including classification and morphology, renggak fruit, renggak leaves, renggak flowers, renggak abundance and the content and benefits of renggak fruit. Organic analysis and instruments in organic analysis.	2-9
	Interpretation of FTIR spectra of crude extract of renggak fruit peel	10-13
	The use of FTIR instruments in life	14
	Application of FTIR instruments in various fields	15-16
Closing	*Word search*	18

Initial Design

In the initial design stage, the title of the reading material, theme, color and image selection, concept determination, and material selection are determined. The magazine is compiled after the content and FTIR spectra interpretation results have been obtained. The initial design of the magazine can be seen in Figure 4 below.

Figure 4. Initial Design of Material Content

Development Phase

The goal of the development phase is to produce a valid chemistry journal by conducting validation with validators. The validators' criticisms, suggestions, and input are used as a reference for improving the design of the journal, resulting in a valid chemistry journal. The validators' suggestions and input are shown in Table 6.

Table 6. Validator's Suggestions and Input

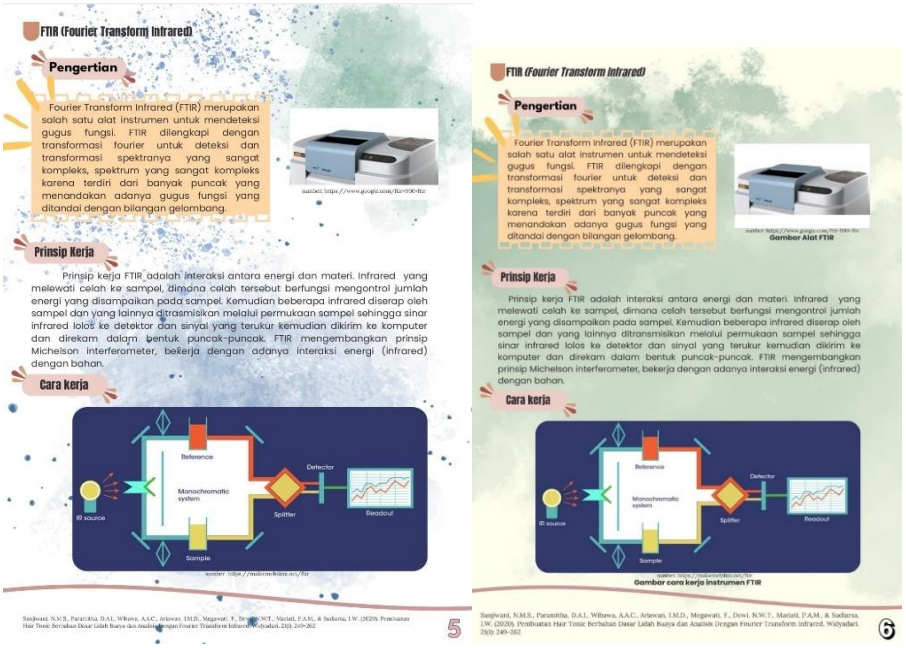
No	Suggestions and Feedback	Correction
1.	Change the magazine layout design so that the color and font combination matches	Changing the appearance of the cover which originally consisted of a picture of a renggak fruit and the title to a picture of a replaced renggak fruit and a picture of the results of a rough extract of renggak fruit skin and a combination of other ornaments.
2.	Provide a caption for each image	Provide descriptions of images in magazines
3.	Changing the layout design of the chemistry magazine to be consistent with one color	The suggestion that has been made is to be consistent in every color used.
4.	When writing units, pay attention to consistency without spaces.	Correct the writing of units so that everything is consistent (example: writing the unit cm^{-1})
5.	Pada bagian kegunaan instrumen FTIR diberikan poin-poin	In the section on the use of the FTIR instrument, points are given.
6.	Enlarged image	The suggestions given have been implemented, namely, clarifying and enlarging the image.
7.	Enlarged footnotes	Footnote text is enlarged so it is easier to read.

To see more clearly the results before and after correction, please see Figure 5.

(a) **(b)**

Figure 5. a) Cover design before correction; b) Cover design after correction

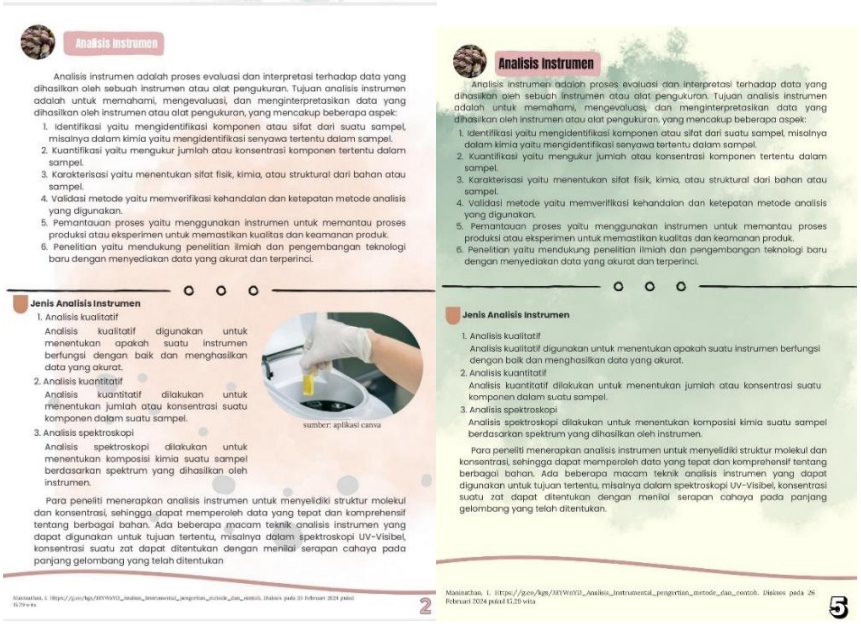
The cover design of the chemistry magazine can be seen in Figure 5. The appearance of the cover was changed, which originally consisted of a picture of the renggak fruit and the title, to a picture of the renggak fruit which was replaced and a picture of the results of the crude extract of the renggak fruit and a combination of other ornaments.



(a) **(b)**

Figure 6. a) Image before correction; b) Image after correction

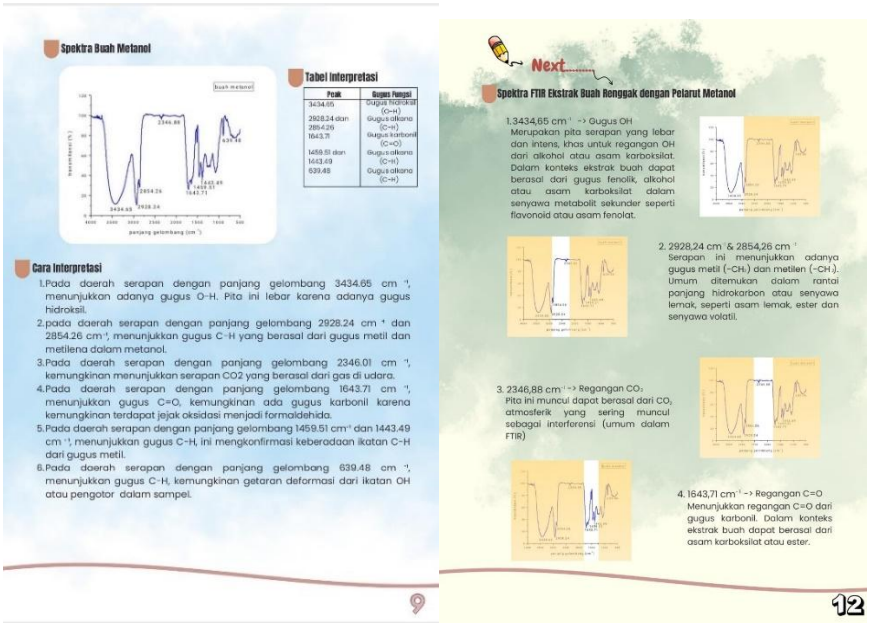
The magazine design display in Figure 6 has undergone improvements to the image captions. You can see the difference in the magazine image captions before and after the improvements, so you can understand the images displayed.



(a) **(b)**

Figure 7. a) Layout color design before repair; b) Layout color design after repair

The color design of the chemistry magazine layout can be seen in Figure 7. Improvements were made to the color of the magazine layout. The difference in the design of the chemistry magazine layout is consistent with one color, namely green.



(a) **(b)**

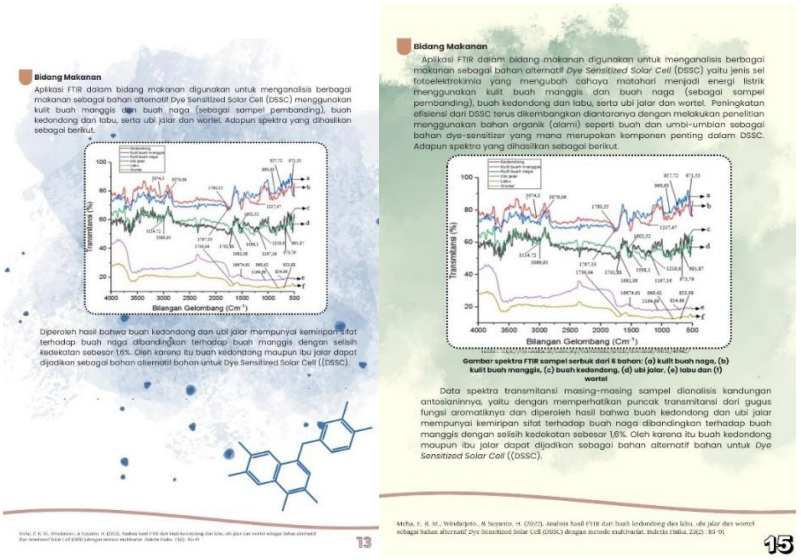
Figure 8. a) Writing units before correction; b) Writing units after correction

The magazine design display in Figure 8 shows improvements in the writing of units. There is a difference in the writing of the cm^{-1} unit which originally used spaces and after the improvements it is without spaces.

(a) **(b)**

Figure 9. a) FTIR usability design before improvement; b) FTIR usability design after improvement

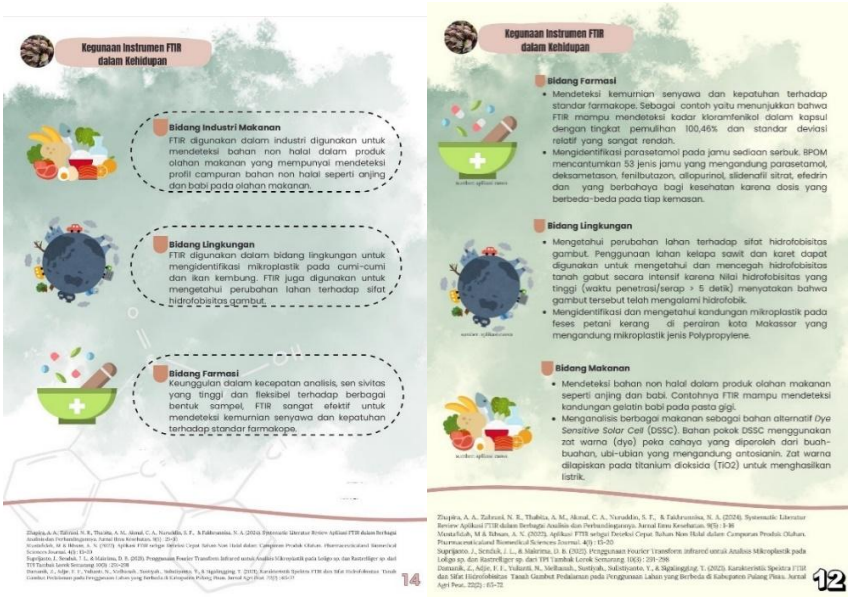
The appearance of the chemistry magazine design in Figure 9 has been improved in the design of FTIR usability, there are differences in the material on the use of FTIR instruments in the pharmaceutical, environmental and food fields, previously using sentences as bullet points.



(a) **(b)**

Figure 10. a) Image size before correction; b) Image size after correction

The magazine design display in Figure 10 has been improved in terms of image size. The difference can be seen in the enlarged image to make it easier to understand the image display.



(a) **(b)**

Figure 11. a) Footnote font size before correction; b) Footnote font size after correction

The magazine design in Figure 11 has been improved by increasing the font size. The footnotes have been enlarged for readability.

Validation and Reliability Analysis

The validation of the magazine "Interpretation of FTIR Spectra of Crude Extract of Renggak Fruit Peel" was conducted by three validators. The validators' assessment results were accompanied by suggestions for questions that received low scores. The aspects assessed were: (1) Graphics, (2) Presentation, (3) Content Appropriateness, and (4) Language (as seen in Figure 12).

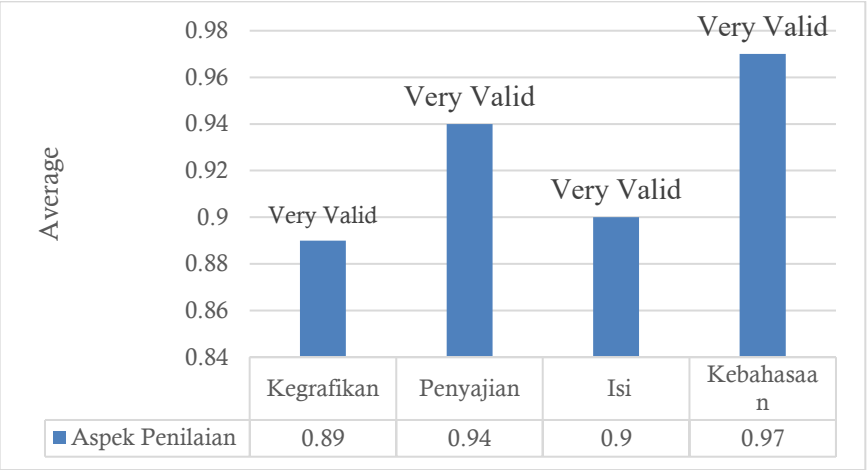


Figure 12. Chemical Magazine Validation Results

The linguistic aspect received an average V score of 0.97, categorized as very valid. The linguistic aspect received the highest average score compared to other aspects. This is evident from the statement that received the highest V score, namely 1, related to communicative sentence formulation, using standard Indonesian, and avoiding words or phrases that could lead to multiple interpretations or misunderstandings. One important aspect of media is the linguistic aspect. The linguistic aspect in media such as magazines plays a crucial role because language is a tool used to convey thoughts or ideas (Septiana et al., 2020). Based on the results of the validity test for the chemistry magazine, the average score for all four aspects was V = 0.91, categorized as very valid.

In addition to the validation analysis, the chemistry magazine was also subjected to a Percentage of Agreement (PA) analysis to determine the consistency of assessments between validators. Based on the results of the PA analysis, or inter-validator reliability, the average inter-validator reliability for the chemistry journal for the components of graphical accuracy, content appropriateness, presentation appropriateness, and language was 96.25%, with percentages of 97%, 96%, 96%, and 96%, respectively, falling into the reliable category. High reliability values indicate consistent, accurate, and reliable measurement results. This means the resulting data can be trusted and used as a basis for decision-making, theory development, and increasing researchers' and data users' confidence in the validity and reliability of the research results. Reliability indicates the extent to which the measurement results are credible. Measurement results must be reliable, meaning they must have a high level of consistency and stability (Sanaky et al., 2021).

Practicality of Chemistry Magazine

The next stage was a practicality test of the chemistry journals, conducted on 65 students who had completed the Determination of Organic Compound Structure course. The aim was to obtain student feedback on the developed chemistry journals to measure their practicality. The student response questionnaire used consisted of 23 statement items, of which 13 statement items were for the attractiveness of the magazine, 4 statement items were for the material component, 3 statement items were for the language component, and 3 items were for the benefits component, which can be seen in Figure 13.

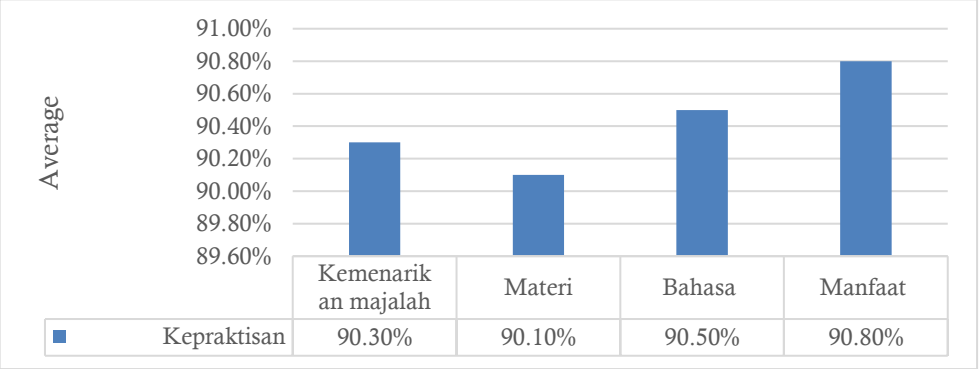


Figure 13. Practical results of the student response questionnaire

Based on the questionnaire results, 90.3% of students reported that the chemistry magazine "FTIR Spectra Interpretation of Crude Extracts of Renggak Fruit Peel" increased their interest in FTIR Spectra Interpretation. Meanwhile, 90.8% of students stated that the chemistry magazine "FTIR Spectra Interpretation of Crude Extracts of Renggak Fruit Peel" provided benefits and increased their knowledge, especially regarding FTIR Spectra Interpretation. An overall analysis, considering the magazine's attractiveness, content suitability, ease of use, and usefulness, yielded a practicality score of 90.3%, classified as very practical. This aligns with research by Meliana (2024), who developed a chemistry magazine, which demonstrated a practicality score of 85.87%. Therefore, it can be concluded that this magazine successfully addressed most of the challenges students faced in understanding FTIR Spectra Interpretation material.

According to Kintono and Rifai (2017), a material is considered good if it meets quality aspects, including validity and practicality. This chemistry magazine-based reading material is considered practical because it focuses on objectives and is tailored to the reader's ability level. The students being tested must have taken the required courses, ensuring relevance to the material presented. The format and design are designed to be engaging, and the presentation is engaging.

Dissemination Stage

The dissemination stage is the final stage of the research and development phase. At this stage, the researcher provided several media samples to the Chemistry Education study program and the Chemistry Education Laboratory. The research results were also published as an article.

CONCLUSION

The chemistry journal was designed using a 4D development model, focusing on visual aspects. The content page is divided into several sub-chapters tailored to the FTIR spectra interpretation material in the Organic Compound Structure Determination course. A word search feature is designed on the final page for readers to use to self-assess their knowledge. Based on the research results, the chemistry journal achieved an average validation score of 0.91, categorized as very valid, and an average reliability score of 96.25%. The developed chemistry journal received positive feedback and demonstrated a practicality rating of 90.3%, categorized as very practical.

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