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Development of a Chemistry Magazine with Content Interpreting GC-MS Spectrum of Renggak Fruit Peel Extract as a Supplementary Resource for Organic Chemistry Lectures

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Abstract: Mastering the interpretation of spectra, as Gas Chromatography-Mass Spectrometry (GC-MS) spectra, in organic chemistry lectures for the analysis of natural materials is an important skill that often poses a challenge for students. This is especially true for natural materials in the surrounding environment that may have future potential, such as renggak fruits. This study aims to determine the results of interpreting renggak fruit peel extracts for use as content in a chemistry magazine, the level of validity, and student responses to the chemistry magazine developed as an alternative supplementary reading material. Conducted within the Chemistry Education Study Program at Mataram University, this study utilized the Research and Development (R&D) methodology, following the 4D model framework. The interpretation of the GC-MS spectrum of renggak fruit peel was carried out by matching the spectrum data obtained with the library data. The validity of the magazine was assessed using Aiken's V formula, while the reliability of the assessment was calculated based on the Percentage of Agreement (R) between validators. Student responses to the magazine product were obtained through a practical test. The results of the GC-MS spectrum interpretation of the renggak fruit peel extract showed the presence of the compounds myristic acid, palmitic acid, stearic acid, oleic acid, elaidinsaeure, heptadecene- (8)-carbonic acid-(1), 2-monoolein, 2-monopalmitin, ambretollide, 6-(2,6,6-Trimethyl-1-Cyclohexenyl)-4-Methyl-(E)-4-Hexen-1-ol, and cis-9-Octadecenal. The chemistry magazine product obtained an average Aiken's V validity score of 0.83, which falls into the “Highly Valid” category, with an average validator reliability score of 91%. The results of the chemistry magazine trial among 2021 Chemistry Education students obtained a practicality score of 92%, categorized as “Very Practical” as supplementary reading material. In the future, further exploration is needed regarding the content and design of the magazine to be created.

Keywords: Chemistry Magazine; GC-MS Spectrum Interpretation; Renggak Fruit Peel Extract.

Introduction

Organic chemistry is one of a series of chemistry courses that students take. This course focuses on phenomena related to carbon compounds, which are usually abundant in nature. One of the courses in the organic chemistry curriculum offered to students in the Chemistry Education Study Program at FKIP, Mataram University, is Determination of Organic Compound Structures, which discusses the interpretation of spectra from a chemical analysis instrument. Its function is to provide information on how to determine and describe the organic compounds contained in a material.

Gas Chromatography-Mass Spectrometry (GC-MS) is often used to analyz compounds because it combines gas chromatography techniques with mass spectra to identify compounds while determining molecular weight and molecular formula [1]. GC-MS spectra results are analyzed by reading the spectra of two methods, namely gas chromatography with peak indicators based on the number of compounds contained in the sample, taking into account the retention time known from literature sources, and mass spectrometry, to further analyze the suspected compounds in a sample [2]. Analysis using GC-MS has proven to be a selective method for analyzing non-polar components and volatile essential oils, fatty acids, lipids, alkaloids, terpenoids, and steroids [3]

Plants have active chemical compounds that function as their life support. These active chemical compounds are categorized into primary and secondary metabolites [4]. Primary metabolites are compounds that play a role in plant cell growth and function, produced by plants [4]. Examples of primary plant metabolites are carbohydrates, proteins, and lipids. Secondary plant metabolites do not play a direct role in plant growth but are produced in certain amounts for various functions, such as antibiotics, pigments, toxins, effectors, enzyme inhibitors, and others [5]. These effects are also beneficial to humans, as evidenced by the fact that various plants have been used in medicine for centuries. Therefore, scientists continue to explore plants to extract and analyze the active chemical compounds within them [5].

One plant or natural material that can be analyzed for its active compounds is the renggak plant. Renggak (Ammomum dealbatum) is a plant belonging to the ginger family (Zingiberaceae) that is native to Indonesia [6]. In Lombok, the fruit of this plant is often used as a remedy for dizziness [7]. Additionally, this plant serves as a natural antioxidant, helping to ward off free radicals [7]. Based on phytochemical screening analysis of ethanol and methanol extracts of the fruit skin alone, it was reported to contain

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metabolite compounds that function as antioxidants, such as alkaloids, flavonoids, terpenoids, tannins, and saponins [8] [9].

Information regarding chemical compound analysis, especially the interpretation of chemical analysis instrument data, is generally obtained from reading materials such as books and the internet to support students' understanding of the material. This statement is also approved by 66.7% of Chemistry Education students at FKIP, Mataram University, according to a survey conducted during the initial observation for this study. However, students' interest in organic chemistry, including the interpretation of chemical analysis instrument data, is still quite low [10]. In general, most organic chemistry reading materials for students are translated books or written in English, which sometimes are quite difficult to understand and have many pages [10]. Making them ineffective and unattractive for students in learning organic chemistry, coupled with the broad and complex nature of organic chemistry material, causes students to find it difficult to understand this course material well [10].

An alternative reading source that can be used to understand the interpretation of data from a chemical analysis instrument is magazines. Magazines are a type of printed mass media communication to encourage reading and provide interesting and educational information for readers [11]. Magazines are categorized as learning resources in the form of reading materials, whose existence can provide new knowledge because the information presented in magazines is the latest information, which is expected to improve students' reading habits [11]. Thus, the use of magazines can potentially help students learn to better interpret data from chemical compound analysis instruments.

Research on the development of magazines as reading materials has been conducted extensively at the high school level, such as the study of magazines for high school students on the synthesis of benzene derivatives to facilitate students in learning about nitration reactions in benzene [12], a chemistry magazine on the basic laws of chemistry for 10th-grade students [13], developed a chemistry magazine on the subject of chemical elements for high school/MA grade XII students in the city of Mataram [14]. However, the development of chemistry magazines as supplementary reading materials remains underexplored for university students. Therefore, through this research, an organic chemistry magazine was developed that discusses the interpretation of GC-MS spectra of renggak fruit peel extracts as a supplementary reading material. Thus, this study aims to determine the results of interpreting GC-MS spectra of renggak fruit peel extracts, assess the validity, and evaluate student responses to the chemistry magazine developed.

Research Methods

This research uses the Research and Development (R&D) method, conducted at the Chemistry Education Study Program, Faculty of Teacher Training and Education, Mataram University. The research subjects consisted of expert lecturers and students from the 2021 batch who had taken courses in determining the structure of organic compounds, while the research object was a chemistry magazine containing interpretations of GC-MS spectra of renggak fruit peel extracts. This study used a 4D model with the stages of definition, design, development, and dissemination.

The research data are collected through questionnaires and documentation. The questionnaire was distributed in the form of a Google Form to obtain numerical data, suggestions, and criticism from students. Furthermore, supporting documentation, such as GC-MS spectra data and research documentation on renggak fruit, was also required for the magazine content.

The magazine validation instrument was scored using a 1-4 Likert scale. The data analysis technique to determine the validity of the magazine used Aiken's V formula as follows:

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

Description:
V = Validator agreement index
s = Score assigned by the validator minus the lowest score in the category used (s = r-Io, where r = validator's chosen category score and Io = lowest scoring score).
n = Number of validators.
c = Number of categories chosen by the validator.

The data calculated using the above formula will produce quantitative data that will be interpreted into qualitative data. The accumulated data is entered into Aiken's V categorization [15].

Table 1. Aiken's Index Category

No	Indeks scale	Category
1.	$V \leq 0.4$	Invalid
2.	$0.4 < V \leq 0.8$	Valid
3.	$0.8 < V \leq 1$	Highly Valid

The validity data obtained will be tested for reliability using the following formula [15]:

$$\text{Percentage of Agreement (R)} = [1 - \frac{A-B}{A+B}] \text{x } 100\ \%$$

Description:
A = The validator assessment result with the highest score.
B = The validator assessment result with the lowest score.
The data results are considered good if they have a comprehension index of 0.75 or 75%.

The analysis of student response data is used to determine the practicality of the magazine developed. This analysis technique uses the following formula [15]:

$$P = [\frac{f}{N}] \text{ x } 100\%$$

Description:
P = Final score
f = Score obtained
N = Maximum score

Once the practicality score has been obtained, grouping is carried out according to the criteria in Table 2 below [16].

Table 2. Practicality Criteria

Nilai	Criteria
75% < X ≤ 100%	Highly Practical
50% < X ≤ 75%	Practical
25% < X ≤ 50%	Not Practical
0% < X ≤ 25%	Highly Impractical

Results and Discussion

GC-MS Spectral Analysis of Renggak Fruit Peel Extract

Gas Chromatography-Mass Spectrometry (GC-MS) is a technique that combines gas chromatography with mass spectrometry [1]. Gas chromatography is used to detect volatile or easily evaporated compounds under high vacuum conditions and low pressure when heated [1]. Mass spectrometry is used to determine molecular weight, molecular formula, and generate charged molecules [1]. GC-MS spectrum data is divided into GC chromatogram spectra and MS fragmentograms [1]. Chromatograms contain information on extracted compounds, such as quantity, abundance, and retention time, which are influenced by the boiling point of the compound [1]. Fragmentograms contain information on the fragment patterns of each compound and the abundance of each fragment. The library data is used to confirm compounds based on fragment pattern similarities [1]

Analysis of the content of a natural material using a GC-MS instrument is conducted to determine the type of compound based on its physical properties. One example is the skin of the renggak fruit. The extraction of renggak fruit peel utilises two solvents: ethanol and methanol. Therefore, there is one gas chromatography chromatogram and two mass spectrum fragmentogram data. The following presents the gas chromatography spectrum of the renggak fruit peel extract.

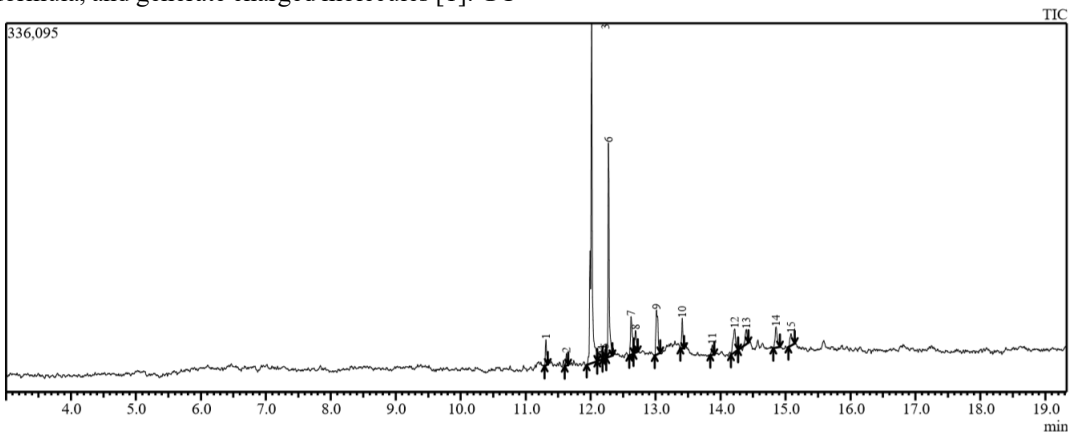

Figure 1. GC Spectra Of Ethanol Extract From Renggak Fruit Peel

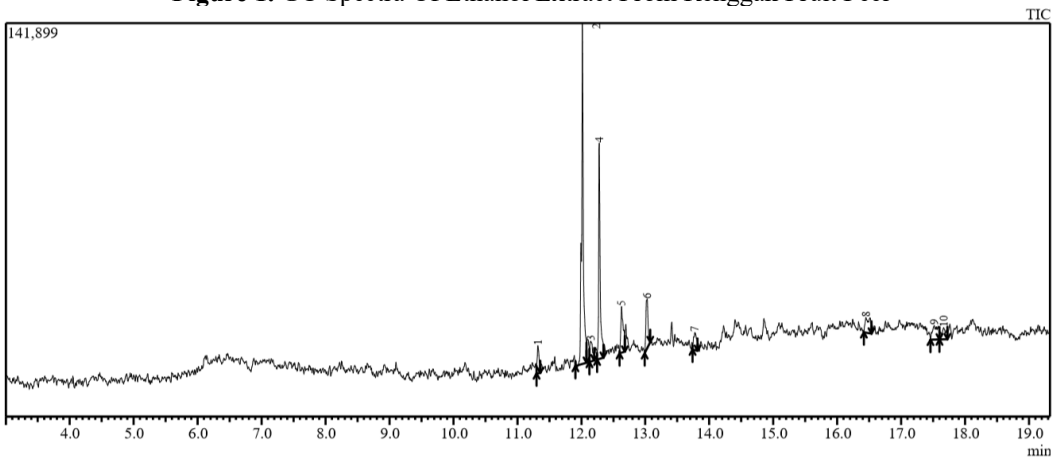

Figure 2. GC Spectra Of Methanol Extract From Renggak Fruit Peel

Figure 1 shows 15 peaks in the ethanol extract chromatogram, and Figure 2 shows 10 peaks in the methanol extract chromatogram, indicating the compounds present in the renggak fruit peel with relatively similar retention times for both spectra. Then, the resulting compounds were characterized using mass spectra and the Wiley 7 data library. The Wiley data library is known for providing information about compounds using its EI database. The goal is to make it easier to identify possible compounds from a sample whose compound content is unknown [17].

Tables 3 and 4 confirm that the compounds contained in the renggak fruit peel extract have different retention times and abundances. The difference in retention time is due to each compound mixture having its own duration when remaining in the chromatography column, which is calculated from the injection point until the compound undergoes elution. Compound separation is detected by the detector as a chromatogram peak, along with the retention time of the compound. Compounds with lower boiling points will separate and be read first by the detector [18]. Abundance can be assessed from the percentage area, where this value indicates the relative concentration between compounds in the sample, or to estimate the absolute concentration when using internal or external standards [19].

Fatty acid compounds were detected in ethanol and methanol extracts of renggak fruit peel. Both data showed

the presence of saturated fatty acids, namely myristic acid, palmitic acid, and stearic acid. Then, unsaturated fatty acids, namely oleic acid, elaidic acid, and heptadecene-(8)-carbonic acid-(1). Based on the percentage area, palmitic acid (40.34% in the ethanol extract and 39.99% in the methanol extract) and oleic acid (19.38% in the ethanol extract and 21.57% in the methanol extract) were the most abundant fatty acids and compounds in the renggak fruit peel extract. Myristic acid (Rt = 11.311 in ethanol extract and Rt = 11.320 in methanol extract) was the compound with the lowest retention time, and Oleic acid (Rt = 13.013 in ethanol extract and Rt = 13.027 in methanol extract) had the highest retention time among all compounds in both renggak fruit peel extracts. Fatty acids are commonly found in fruit peels because they play a role in cell membrane phospholipids, contributing to specific functions, metabolism, and signalling pathways [20].

Table 3. GC-MS Spectra Data Results of Ethanol Extracts from Renggak Fruit Peels

No. Peak	Compound Name	Retention Time (Rt)	Area (%)	Base Peak (m/z)	Molecular Formula
1.	*Myristic acid*	11.311	2.48	73	$C_{14}H_{28}O_2$
2.	*6-(2,6,6-Trimethyl-1-Cyclohexenyl)-4-Methyl-(E)-4-Hexen-1-ol*	11.627	1.06	137	$C_{16}H_{28}O$
3.	*Palmitic acid*	12.015	40.34	43	$C_{16}H_{32}O_2$
4.	*No hit compound*	12.17	2.70	-	-
5.	*Ambrettolide*	12.221	1.20	67	$C_{16}H_{28}O_2$
6.	*Oleic acid*	12.276	19.38	55	$C_{18}H_{34}O_2$
7.	*Elaidinsaeure*	12.625	5.68	55	$C_{18}H_{34}O_2$
8.	*Stearic acid*	12.691	3.49	43	$C_{18}H_{36}O_2$
9.	*Oleic acid*	13.013	7.09	55	$C_{18}H_{34}O_2$
10.	*cis-9-Octadecenal*	13.411	2.78	55	$C_{18}H_{34}O$
11.	*2-Monoolein*	13.872	1.21	55	$C_{21}H_{40}O_4$
12.	*2-Monopalmitin*	14.215	4.84	43	$C_{19}H_{38}O_4$
13.	*2-Monopalmitin*	14.395	2.07	43	$C_{19}H_{38}O_4$
14.	*cis-9-Octadecenal*	14.853	3.39	55	$C_{18}H_{34}O$
15.	*2-Monopalmitin*	15.083	2.28	43	$C_{19}H_{38}O_4$

Table 4. GC-MS Spectra Data Results of Methanol Extracts from Renggak Fruit Peels

No. Peak	Compound Name	Retention Time (Rt)	Area (%)	Base Peak (m/z)	Molecular Formula
1.	*Myristic acid*	11.320	3.41	73	$C_{14}H_{28}O_2$
2.	*Palmitic acid*	12.016	39.99	43	$C_{16}H_{32}O_2$
3.	*No hit compound*	12.144	3.61	-	-
4.	*Oleic acid*	12.278	21.57	55	$C_{18}H_{34}O_2$
5.	*Heptadecene-(8)-Carbonic acid-(1)*	12.628	7.57	55	$C_{18}H_{34}O_2$
6.	*Oleic acid*	13.027	7.07	55	$C_{18}H_{34}O_2$
7.	*No hit compound*	13.773	3.48	-	-
8.	*No hit compound*	16.448	4.94	-	-
9.	*No hit compound*	17.515	5.12	-	-
10.	*No hit compound*	17.664	3.24	-	-

Confirmation of saturated and unsaturated fatty acid compounds was performed through characterization by mass spectra. Myristic acid was characterized by the appearance of a molecular ion peak at m/z 228 with a base peak at m/z 73. Palmitic acid was characterized by the appearance of a molecular ion peak at m/z 256 with a base peak at m/z 43. Stearic acid was characterized by the appearance of a molecular ion fragment peak at m/z 284 with a base peak at m/z 43. Oleic acid was characterized by the absence of a molecular ion fragment peak due to its instability, marked by the appearance of a peak at m/z 254 originating from ethylene release, with a base peak at m/z 55. Elaidinsaeure and heptadecene-(8)-carbonic acid-(1) are both characterized by the appearance of a molecular ion fragment peak at m/z 282 with a base peak at m/z 55, the difference being the presence of an ion fragment at m/z 208 in elaidinsaeure and an ion fragment at m/z 207 in Heptadecene -(8)-Carbonic acid-(1) as the initial release of its alkyl chain.

Monoglyceride compounds were detected in the ethanol extract of renggak fruit peel, namely 2-monoolein and 2-monopalmitin. The compound 2-monoolein (Rt = 13.872) had a shorter retention time than 2-monopalmitin (Rt = 14.215). The compound 2-monopalmitin (4.84%) was more abundant than 2-monoolein (1.21%), but overall, the abundance of both compounds was relatively low in the ethanol extract of renggak fruit peel. Characterization of 2-monoolein with mass spectra produced a molecular ion fragment m/z 356 with a base peak fragment m/z 55 originating from an alkene ion fragment. The characterization of the 2-monopalmitin compound revealed a molecular ion fragment m/z 330 with a base peak fragment at m/z 43 originating from a butane fragment.

Aromatic compounds were detected in the ethanol extract of renggak fruit peel, namely ambretolide and 6-(2,6,6-trimethyl-1-cyclohexenyl)-4-methyl-(E)-4-hexen-1-ol. Ambrettolide or oxacycloheptadec-8-en-2-one (Rt = 12.221) is a cyclic ester aromatic compound with an abundance of 1.20%. Characterization of the ambretollide compound by mass spectroscopy revealed molecular ion fragments m/z with a base peak fragment m/z 67 originating from tropylium or pentadienyl ions ($C_5H_7^+$). The compound 6-(2,6,6-Trimethyl-1-Cyclohexenyl)-4-Methyl-(E)-4-Hexen-1-ol (Rt = 11.627) is an aromatic alkenol compound with an abundance of 1.06% characterized by mass spectra with the appearance of a molecular ion fragment peak m/z 236 with a base peak fragment at m/z 137 originating from the C10H17+ ion.

Unsaturated aldehyde compounds, namely cis-9-Octadecenal, were detected in the ethanol extract of renggak fruit peel. This compound had retention times of 13.411 minutes and 14.853 minutes because it was detected twice at peak 10 and peak 14. The abundance of this compound was higher at peak 14 (3.39%) than at peak 10 (2.78%). This compound was characterized by mass spectra with the appearance of the C16H29O+ ion fragment peak (m/z 237) from the molecular ion that released ethyl. The base ion fragment peak is at m/z 55, which probably comes from the C4H7+ ion.

Compounds were detected at several peaks, including oleic acid, 2-monopalmitin, and cis-9-octadecenal, in the renggak fruit peel extract. In addition, there are several peaks that are not identified as a compound labelled "No hit compound". This can occur due to several possibilities, such as the presence of isomers or derivatives of the compound, fragmentation of contaminants producing similar peaks, or the method of matching the spectrum with the library data, which can produce ambiguous or duplicate results [17]. Furthermore, the Wiley library data used is not well curated [21], and its accuracy is lower than that of other libraries, such as NIST, because its true positive rate is less than 88% [17].

Development of Chemistry Magazine

The result of this development is a magazine containing interpretations of renggak fruit peel extract as supplementary reading material for students in organic chemistry. The magazine was developed using the 4D development model, which consists of four stages: definition, design, development, and dissemination.

The define stage produced the information needed to develop the magazine. It began with findings of problems experienced by students of the Chemistry Education Study Program at Mataram University, which led to the students' need for additional reading materials in studying organic chemistry courses. This stage also determined the material and collection of references needed to create a chemistry magazine, specifically related to GC-MS instruments for analyzing organic compounds and their relationship with the Course Learning Outcomes (CPMK) of the organic chemistry group.

The design stage was carried out after the definition stage. This stage aims to obtain an initial draft/prototype of the magazine product [22]. This stage begins with sorting the references and supporting documentation to be included in the initial magazine. The initial magazine is compiled with reference to the storyboard that has been created, and the design is adjusted according to the selection of the magazine's background, font type, color, style, and size. Overall, the magazine design was created using the Canva Pro website/application because it has several advantages, such as ease of access, providing various templates and design references that facilitate magazine design, providing various graphic elements such as illustrations and icons that support the magazine's graphics, and text customization features to edit text according to the desired style, and many more [23].

Figure 3. Initial Magazine Design Example

The magazine is designed in A4 size and dominated by green and white colors. In general, the magazine consists of a cover page, an introduction, a closing section, and a bibliography. The cover page contains general information about the magazine, including its title. The introductory section contains greetings from the editorial team, a table of contents, and a brief overview of the editorial team. The main section of the magazine features selected materials,

including an analysis of instruments in organic chemistry, GC-MS, and the interpretation of GC-MS spectra of renggak fruit peel extracts. The closing section contains conclusions and a crossword puzzle related to the material presented. The bibliography section contains reference sources presented on each page.

The storyboard was created to serve as a reference for the overall layout of the magazine sections to make it more organized. Figure 3 illustrates examples of magazine designs created based on the storyboard. Prototype 1/the initial draft of the magazine, can be seen in Figure 3.

The development stage was carried out to produce the final form of the magazine, following revisions based on input from experts and practitioners, as well as test results. At this stage, the magazine was validated by three validators consisting of two lecturers from the Chemistry Education Study Program and one lecturer from the Chemistry Study Program, Mataram University. The three validators assessed the initial draft of the magazine in four aspects, namely graphic design, presentation, content, and language. Suggestions and comments were obtained at this stage. Revisions were also made to incorporate the suggestions and comments provided by the validators, resulting in prototype 2, the final magazine product. After that, the final magazine was tested and received 42 responses from students. Students also assessed the four aspects of the magazine, including its attractiveness, suitability of the material/content, language, and benefits. Suggestions and comments were also gathered during this activity to improve the magazine.

Validity of Chemistry Journal with Content Interpretation of GC-MS Spectra of Renggak Fruit Skin Extract

The validity results of the magazine were obtained from expert validation tests during the development stage. The three validators provided assessments based on four key testing aspects: graphics, presentation suitability, content suitability, and language suitability. All three validators are Chemistry Education and Chemistry department lecturers who are already experts in their field. The following presents the data from the validity test results for the chemistry magazine that has been created.

Table 5. Magazine Validity Test Results

Assessment Aspect	Aiken's V value	Category
Graphics	0.86	Highly Valid
Presentation Suitability	0.80	Valid
Content Suitability	0.80	Valid
Language Suitability	0.80	Valid
Average Score	0.83	Highly Valid

Table 5 shows the results of the expert validation test analysis, indicating that Aiken's V value for each assessment aspect meets the validity criteria. The graphic aspect received the highest score of 0.86, categorized as "Highly Valid," while the presentation, content, and language aspects each received a score of 0.80. The overall validity score average of 0.83, categorised as "Highly Valid", indicates that this chemistry magazine product is feasible and ready to be tested on students after undergoing revisions. The high score for the graphic aspect shows that the chemistry magazine meets the graphic criteria, which include the appropriate size of the magazine, consistency of the cover layout, appropriate choice of colors, appropriate choice of font format and style, and appropriate choice of background.

The validity results for the other three aspects show an average score of 0.80, categorised as "Valid". This similarity in scores is due to several statements that influence each other. Based on the suggestions provided by the validators, the key aspect that needs revision is the mass spectrum material. Errors in the concept of molecular ions and the interpretation of mass spectra render the explanation of this mass spectral material incoherent and confusing for readers of this magazine, thereby affecting the scores of the three aspects.

Validators ' assessments may also reflect other sources of error. Based on the suggestions provided by the validators, other influencing factors include incomplete image references, spelling errors, ineffective sentence selection, and the selection of elements that make the magazine pages appear unbalanced. Therefore, several parts of the magazine need to be revised before being tested on students.

The assessments from the validators need to be tested for reliability to determine the consistency of the assessments that have been given. Reliable results from measurements taken on the same group will provide relatively similar results if the aspects being measured do not change, even if they are measured at different times and in different situations [24]. This means that the less variation or the lower the difference in scores obtained from the validators, the more reliable or the higher approval of the validators regarding the scores given on the same indicators. The results of the reliability test of the validator's assessment are presented in the following table.

Table 6. Validator Assessment Reliability Test Results

Assessment Aspect	Percentage of Agreement	Category
Graphics	95%	Reliabel
Presentation Suitability	89%	Reliabel
Content Suitability	85%	Reliabel
Language Suitability	92%	Reliabel
Average Score	91%	Reliabel

Table 6 shows the aspect with the highest percentage of agreement (R) of 95%. Next, the language suitability aspect ranks second with a score of 92%, followed by the presentation suitability aspect with 89% and the content suitability aspect with 85%, resulting in an overall average percentage of agreement (PA) for all aspects of 91%. This score indicates that the validators' assessment of the magazine is considered to have a high level of consistency because it exceeds the predetermined standard score of 75% and all of the aspects are reliable [15]. The high percentage is due to the small difference between the average scores given by the validators who gave the highest and lowest scores, and vice versa.

The magazine was revised based on the suggestions and comments of the validators that can be seen as an example at Figure 4, resulting in several changes to the magazine before it was tested, such as improvements related

to the concept of molecular ions, interpretation of MS spectra, improvements in word/sentence writing, improvements in chemical formula writing, and the addition of supporting elements and documentation.

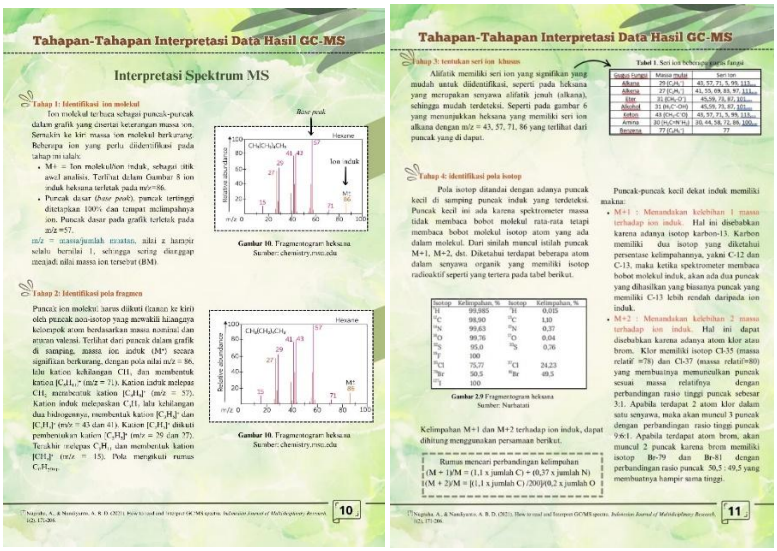

Figure 4. Examples of magazine revisions

Student Response to Chemistry Magazine with Content on the Interpretation of Reggak Fruit Peel Extract

Student responses were obtained from a trial test of the revised magazine during the development stage. Field trials for this magazine were conducted online by distributing response questionnaires in the form of Google Forms to 2021 Chemistry Education students who had taken the course on determining the structure of organic compounds. This trial was conducted to determine the practicality of the magazine. The practicality of a learning medium refers to the ease of use of the medium, which is developed for students and teachers, making the learning process more meaningful, interesting, and enjoyable, and providing benefits and encouragement for increased creativity in learning (Milala et al., 2022).

Table 7. Magazine Trial Test Result

Assessment Aspect	Total Score	Maximum Score	Final Score	Category
Attractiveness	2020	2184	92%	Highly Practical
Content Suitability	627	672	93%	Highly Practical
Language	467	504	93%	Highly Practical
Benefits	458	504	91%	Highly Practical
Average Score			92%	Highly Practical

Table 7 shows that student assessment of the magazine was divided into four aspects, each represented by a set of statements. Thirteen statement items were on the aspect of attractiveness, four statement items on the aspect of content suitability, three statement items on the aspect of language, and three items on the aspect of benefits. Based on the results of the practicality test data analysis of the magazine on 42 chemistry education students of the 2021 batch, the percentage of practicality for all aspects, in terms of attractiveness, content suitability, language, and usefulness, was 92%, 93%, 93%, and 91%, with an average percentage of 92%. This percentage falls into the category of highly practical as supplementary reading material.

Conclusion

Based on the aims, the results of the research and discussion can be concluded that the interpretation of the GC-MS spectra of renggak fruit peel extract shows that renggak fruit peel contains Myristic acid, Palmitic acid, Stearic acid, Oleic acid, Elaidinsaeure, Heptadecene- (8)-Carbonic acid-(1), 2-monoolein, 2-monopalmitin, Ambretollide, 6-(2,6,6-Trimethyl-1-Cyclohexenyl)-4-Methyl-(E)-4-Hexen-1-ol, and cis-9-Octadecenal. This material is published in an organic chemistry lecture supplement in the form of a magazine developed using the 4D model. The average validity score of the magazine by three validators using the Aiken V assessment was 0.83, categorized as “Highly Valid,” which means that the magazine is suitable for testing, although it still needs revision. The validators' assessment of the magazine was reliable, with an average agreement score of 91%. The average student response to the magazine was shown by a practicality score of 92%, which falls into the “Highly Practical” category as supplementary reading material.

Author’s Contribution

Rahmawati: contributed to the conceptualization of the study, development of the chemistry magazine, preparation and interpretation of GC–MS spectra of renggak fruit peel extract. B. L. N. S. Masruri: contributed to instructional design, validation of the magazine content as a supplementary learning resource, and data analysis related to

student learning needs. S. W Al-idrus: contributed to research supervision and served as the corresponding author.

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