

ORIGINAL

Ethnochemistry-Based Chemistry Learning Media for Creativity: A Cognitive Analysis of Fermented Products from Riau, Indonesia

Medios de aprendizaje de química basados en la etnoquímica para la creatividad: un análisis cognitivo de productos fermentados de Riau, Indonesia

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ABSTRACT

Introduction: this study explores the integration of local wisdom from the Coastal Riau community, Indonesia, into chemistry education through an ethnochemistry approach focused on traditional fermentation practices. Locally produced fermented foods such as *dadih* (fermented buffalo milk), *durian acid* (fermented durian), *rebung acid* (fermented bamboo shoots), *jeruk maman* (fermented *Cleome* leaves), and *bekasam* (fermented fish) embody valuable biochemical processes rarely addressed in formal curricula. Incorporating these cultural contexts into chemistry learning aims to make abstract concepts more meaningful and foster students' creativity and scientific literacy.

Method: the research employed a Mixed Methods Sequential Explanatory Design. The qualitative phase involved interviews and participatory observations with traditional food producers in three regencies—Meranti, Pelalawan, and Rokan Hilir—to identify fermentation-based products and analyze their chemical principles. The quantitative phase involved expert validation (N=16) of the developed ethnochemistry-based learning media using the Content Validity Ratio (CVR) and Content Validity Index (CVI), followed by classroom implementation with 45 chemistry education students.

Results: five traditional fermentation products were identified, each illustrating chemical processes such as acid-base reactions, enzymatic catalysis, and microbial metabolism. The developed learning media achieved a CVI and CVR validity score of 91 %, confirming scientific accuracy and pedagogical suitability. Student creativity scores averaged 80, categorized as high, indicating that contextualized ethnochemistry learning effectively enhances creative performance.

Conclusions: ethnochemistry-based learning media grounded in local fermentation practices effectively bridge cultural experience and scientific theory, fostering creativity, scientific competence, and appreciation for Indonesia's cultural heritage.

Keywords: Chemistry Learning Media; Creativity; Ethnochemistry; Fermentation; Local Wisdom.

RESUMEN

Introducción: este estudio explora la integración de la sabiduría local de la comunidad costera de Riau, Indonesia, en la enseñanza de la química a través de un enfoque etnoquímico centrado en las prácticas

tradicionales de fermentación. Productos locales como el dadih (leche de búfala fermentada), el ácido durián (durián fermentado), el ácido de brotes de bambú, el jeruk maman (hojas de Cleome fermentadas) y el bekasam (pescado fermentado) representan valiosos procesos bioquímicos que rara vez se abordan en los programas formales, lo que dificulta la conexión entre la cultura y la ciencia. La incorporación de estos contextos culturales busca hacer los conceptos químicos más significativos y fomentar la creatividad y la alfabetización científica de los estudiantes.

Método: la investigación empleó un diseño mixto con enfoque explicativo secuencial. La fase cualitativa incluyó entrevistas y observaciones participativas con productores tradicionales en tres regiones (Meranti, Pelalawan y Rokan Hilir) para identificar productos fermentados y analizar sus principios químicos. La fase cuantitativa incluyó la validación de expertos (N = 16) del medio de aprendizaje desarrollado mediante el Índice de Validez de Contenido (CVI) y la Razón de Validez de Contenido (CVR), seguido de la implementación en clase con 45 estudiantes del programa de Educación Química.

Resultados: se identificaron cinco productos tradicionales de fermentación que ilustran procesos químicos como reacciones ácido-base, catálisis enzimática y metabolismo microbiano. El medio de aprendizaje desarrollado alcanzó una validez del 91 %, confirmando su precisión científica y pertinencia pedagógica. La creatividad estudiantil obtuvo una puntuación promedio de 80, considerada alta.

Conclusiones: los medios de aprendizaje basados en la etnoquímica, inspirados en las prácticas locales de fermentación, fortalecen el vínculo entre la experiencia cultural y la teoría científica, promoviendo la creatividad, la competencia científica y la valoración del patrimonio cultural indonesio.

Palabras clave: Medios de Aprendizaje de la Química; Creatividad; Etnoquímica; Fermentación; Sabiduría Local.

INTRODUCTION

Indonesia is a nation endowed with remarkable cultural diversity and abundant natural resources. These unique assets present valuable opportunities to enrich educational practices by integrating local wisdom, indigenous knowledge, and principles of sustainable development into the learning process.^(1,2) Harnessing this diversity within educational contexts can foster students' cultural awareness, environmental responsibility, and critical thinking, while also supporting national efforts to preserve cultural heritage and biodiversity for future generations.^(3,4)

Local wisdom, as a reflection of the long-standing interaction between communities and their environment, represents an underutilized yet powerful source of scientific insight.^(5,6) In various regions of Indonesia, traditional practices such as food preservation, natural dyeing, and herbal medicine embody empirical knowledge accumulated through generations. Integrating such knowledge into science education can deepen students' understanding of scientific principles by connecting them to culturally relevant experiences. Despite this potential, previous studies highlight that indigenous knowledge remains marginal in formal science curricula, which tend to rely on standardized, decontextualized content. This gap limits students' ability to relate abstract scientific concepts to real-world phenomena they observe in daily life.⁽⁷⁾

In the context of the Riau coastal region, local wisdom is strongly reflected in traditional fermentation practices used to produce foods such as salted fish, shrimp paste, and other preserved seafood.⁽⁸⁾ These products are not only integral to local diets but also represent key cultural and economic assets. For instance, shrimp paste production significantly contributes to household income and community livelihoods.^(7,9) However, although students in coastal communities are familiar with these products as consumers, studies have shown that their understanding of the underlying scientific principles such as microbial fermentation, biochemical transformations, and chemical reactions is still limited. This disconnect can lead to reduced engagement in learning, as scientific knowledge is perceived as abstract and disconnected from cultural experience.

Bridging this divide requires a contextualized learning approach that integrates ethnoscience and chemistry education.^(7,10) By exploring local fermentation processes as learning materials, students can observe chemistry in action within their own communities, thereby enhancing both scientific literacy and appreciation of cultural heritage.⁽¹¹⁾ Such integration not only strengthens conceptual understanding but also contributes to the preservation and potential innovation of traditional food production methods, aligning with the goals of sustainable development education.⁽¹²⁾

Therefore, this study investigates the local wisdom of the Coastal Riau community, with a particular emphasis on traditional fermentation practices, as a medium for contextual chemistry learning.⁽¹³⁾ The justification for this study lies in the need to (1) reduce the gap between students' everyday experiences and formal science instruction, (2) preserve and valorize indigenous knowledge within academic contexts, and (3) promote culturally relevant and sustainable approaches to science education.

The objective of this study is to identify types of local fermented products in Coastal Riau, explore their production processes, and analyze how the underlying chemical concepts can be effectively integrated into the chemistry curriculum.

METHOD

Type of Study

This research employed a Mixed Methods Sequential Explanatory Design, consisting of two sequential phases: a qualitative exploratory phase followed by a quantitative validation phase. The study is non-experimental and observational in nature, as it aimed to explore, describe, and interpret local ethnochemical knowledge rather than manipulate variables. The qualitative phase focused on identifying and analyzing traditional fermentation practices in the coastal areas of Riau, Indonesia, while the quantitative phase evaluated the validity and feasibility of the developed ethnochemistry-based learning media derived from the qualitative findings. The research flowchart can be seen in figure 1.

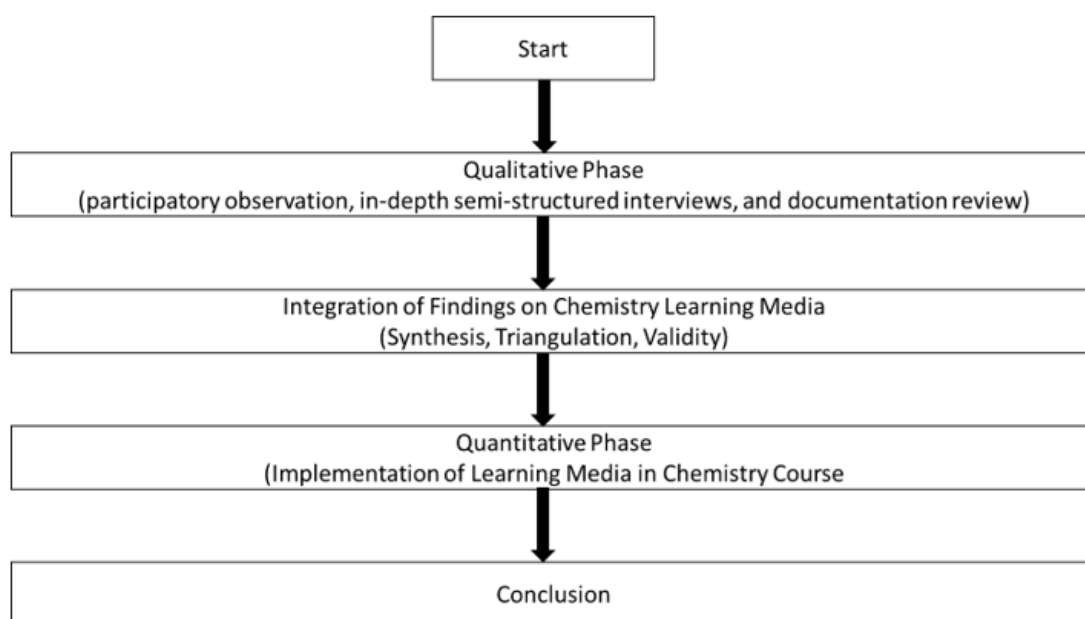


Figure 1. Research Flowchart

Universe and Sample

The research was conducted in three regencies located along the east coast of Sumatra Island, Indonesia: Meranti, Pelalawan, and Rokan Hilir. Each regency is shown in figure 2. These areas were purposefully selected because they represent the main centers of traditional fermented food production in Coastal Riau.



Figure 2. Research locations in Coastal Riau, Indonesia

The qualitative phase involved three key informants—traditional food experts and community leaders selected through purposive sampling based on the following criteria:

1. Recognized expertise and long-term experience (≥ 10 years) in producing traditional fermented foods such as salted fish, shrimp paste, and other preserved products.
2. Active involvement in community-level food production or local cultural preservation initiatives.
3. Willingness to participate and share indigenous knowledge.

The quantitative phase involved 16 expert validators: eight pedagogical experts and eight chemistry experts from Universitas Riau and collaborating institutions. The selection criteria were (1) relevant academic qualifications and (2) minimum five years of experience in chemistry education, curriculum design, or local wisdom-based learning. The implementation of the developed learning media was conducted among 45 undergraduate chemistry education students ($N = 45$) divided into nine groups, who participated voluntarily in the classroom trial.

Variables

The study consisted of two main categories of variables:

1. Qualitative variables: types of local fermented products, production processes, materials used, and chemistry-related concepts embedded in traditional knowledge.
2. Quantitative variables: indicators of content validity (accuracy, relevance, and feasibility) assessed using the Content Validity Ratio (CVR) and Content Validity Index (CVI) for expert evaluations.

Data Collection and Processing

Qualitative Phase

Data were collected using a multi-method qualitative approach combining participatory observation, in-depth semi-structured interviews, and document review.

1. Field Observation: researchers conducted a four-week immersion within selected coastal communities to observe traditional fermentation processes directly. Observations were recorded through field notes, photos, and informal discussions to capture the materials, steps, and socio-cultural context.
2. Interviews: semi-structured interviews were conducted face-to-face with the three selected community leaders in their local production settings. Each interview lasted approximately 60-90 minutes, guided by an interview protocol that included open-ended questions on the types of fermented products, production methods, local terminology, and perceived relationships between practice and scientific principles.
3. Data Triangulation: cross-verification was conducted through triangulation of sources (observation, interviews, and documentation) to enhance the validity and reliability of findings.

The emerging themes such as fermentation mechanisms, traditional materials, and cognitive chemistry connections served as the foundation for designing ethnochemistry-based learning media.

Learning Media Development

Based on the qualitative findings, an ethnochemistry-based learning media prototype was developed. This media integrated authentic examples, local terminology, and traditional fermentation processes to promote culturally responsive chemistry learning. The learning media developed in this study is specifically designed for undergraduate students enrolled in the Chemistry Education program, targeting third- or fourth-semester courses that cover fundamental chemical concepts and their real-world applications. The media aligns with the national chemistry education curriculum, with each instructional session mapped to a two-credit course load, requiring approximately 100 minutes of face-to-face instruction per meeting.

The primary learning outcomes include students' ability to:

1. Explain the chemical principles underlying traditional fermentation processes (e.g., microbial activity, acid-base reactions, and preservation chemistry).
2. Analyze local fermentation practices from a scientific perspective.
3. Design and present an innovative product prototype inspired by local wisdom.
4. Demonstrate creativity, problem-solving, and entrepreneurial thinking.

Quantitative Phase

Based on the qualitative findings, an ethnochemistry-based learning media prototype was developed. This media integrated authentic examples, local terminology, and traditional fermentation processes to promote culturally responsive chemistry learning.

1. Expert Validation: the instrument was evaluated by 16 experts using a four-point Likert scale (1 =

not relevant to 4 = very relevant). Chemistry experts assessed: (1) accuracy of chemical knowledge and (2) integration of ethnochemistry. Pedagogical experts assessed: (1) alignment with learning outcomes, (2) pedagogical appropriateness, (3) engagement and motivation, (4) student-centered learning, and (5) format and structure.

2. Data Analysis: descriptive statistics were used to calculate average item scores, categorized as: 3,26-4,00 (very valid), 2,51-3,25 (valid), 1,76-2,50 (quite valid), and 1,00-1,75 (not valid). Quantitative validity was analyzed using Lawshe's (1975) Content Validity Ratio (CVR) and Content Validity Index (CVI) to determine the essentiality and overall scale validity.

The final media was refined according to expert feedback and implemented in a classroom setting, where students collaboratively developed creative learning products based on local fermentation knowledge.

Ethical Standards

Ethical approval for this study was granted by the Ethics Committee of Universitas Riau. All participants were informed about the study's objectives, procedures, and voluntary participation terms. Informed consent was obtained prior to data collection. Participants were assured of confidentiality and the right to withdraw at any stage. Data were anonymized and stored securely for academic use only.

RESULTS

Observation results of fermentation-based local products

Through field studies involving direct observation and interviews with local communities, five fermentation-based ethnochemistry products rooted in the local wisdom of the Coastal Riau community in Indonesia were identified. These traditional products include *Dadih* (fermented buffalo milk), *Durian acid* (fermented durian), *Rebung* acid (fermented bamboo shoots), *Jeruk maman* (fermented Cleome leaves), and *pekasam* (fermented fish). The sample of each product can be seen in Figure 3. Each product involves distinct indigenous fermentation processes utilizing natural microbial activity and local raw materials. The identification results show that these products represent local biochemical knowledge systems that naturally apply key chemical principles such as acid-base reactions, organic compound transformations, enzymatic processes, and microbial metabolism.

The collected data also indicate that these traditional fermentation methods have been transmitted through generations, maintaining both their cultural and practical value within the community. Based on these findings, the identified products were selected as contextual materials for the development of ethnochemistry-based learning media. The characteristics and fermentation stages of each product were documented and analyzed to be incorporated into student worksheets, enabling learners to examine the raw materials, fermentation duration, sensory changes, and related chemical processes that occur during production.

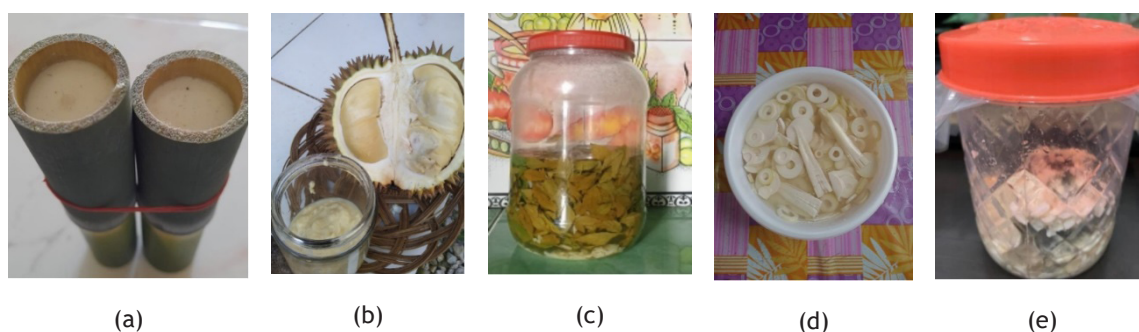


Figure 3. (a)Dadih, (b) Durian acid, (c) Jeruk Maman, (d)Rebung Acid, (e)Bekasam

Learning Media Product Result

The developed learning media was designed to connect community-based fermentation practices with chemical representations at the macroscopic, submicroscopic, and symbolic levels. This alignment ensures that students can visualize and understand the chemical processes underlying traditional products, thereby strengthening their conceptual comprehension of fermentation-related phenomena. The learning materials contextualize abstract chemical concepts through examples that are familiar to students, such as local fermented foods and beverages, making the content more relatable and meaningful.

The learning activities were structured to encourage active engagement through guided inquiry, class discussions, and product-based projects. The accompanying student worksheets include tasks such as observing fermentation stages, identifying and mapping chemical reactions, and designing innovative, value-added products based on local fermentation techniques. These activities promote experiential and culturally

responsive learning while deepening students' appreciation for local heritage.

Furthermore, the developed media aligns with Indonesia's strategic educational vision to foster creativity and innovation by integrating Riau's ethnoscientific knowledge into formal chemistry instruction. The integration of culturally relevant materials within experiential learning tasks enhances students' creativity, scientific competence, and awareness of the connection between science and culture. The cover of the learning media in the form worksheets can be seen in figure 4.

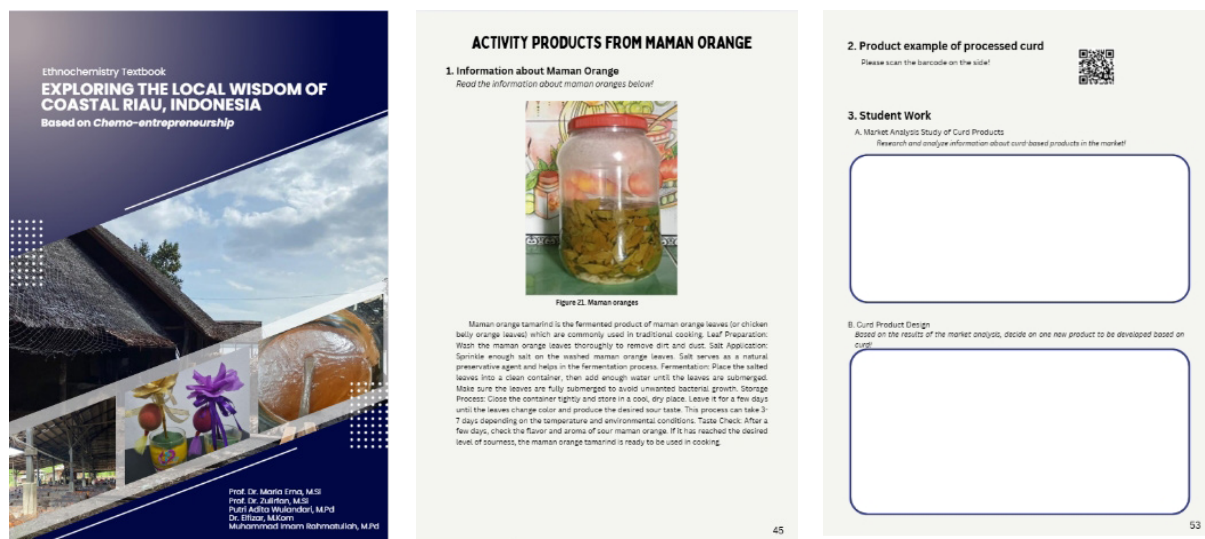


Figure 4. Learning Media in the form of Student Worksheets

Results of Learning Media Validation

The validation results indicated a high level of validity, with the media achieving a validity score of 91 %. The two-round validation process comprised an initial qualitative assessment to gather comprehensive expert feedback, followed by a second round focused on obtaining quantitative validation data for the revised media. The resulting CVR and CVI values for each aspect of the media are presented in table 1.

No.	Aspect Evaluated	Item Description	CVI	CVR
Chemistry Experts				
1	Scientific Accuracy	Accuracy of scientific concepts	1,00	1,00
2	Integration and Relevance of Ethnochemistry	Relevance to syllabus/competency goals	1,00	1,00
3	Pedagogical Accuracy and Learning Engagement	Use of clear, student-friendly language	1,00	1,00
4	Design and Visual Quality	Layout, readability, illustrations	1,00	1,00
5	Cultural Sensitivity and Inclusivity	Integration of local wisdom/context	1,00	1,00
Pedagogy Experts				
1	Content Accuracy	Accuracy of scientific concepts	1,00	1,00
2	Curriculum Alignment	Relevance to syllabus/competency goals	1,00	1,00
3	Language Clarity	Use of clear, student-friendly language	0,875	0,75
4	Cultural Relevance	Integration of local wisdom/context	1,00	1,00
5	Student Engagement Potential	Ability to motivate and engage students	1,00	1,00

Results of Learning Media Implementation

The results of the implementation of learning media show that students have strong creative performance, with an overall average score of 80, which is in the high category. The detail of the score shows in figure 5.

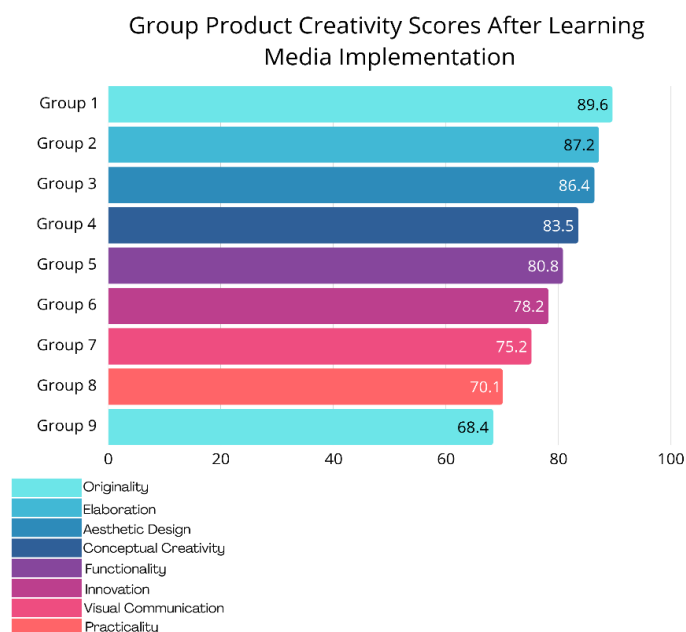


Figure 5. Group Product Creativity Scores After Learning Media Implementation

Creativity assessment of student projects following the implementation of the learning media revealed that most groups attained high to very high creativity levels. Groups 1-3 scored between 86,4 and 89,6, demonstrating originality, elaboration, and aesthetic integration of chemistry with cultural contexts. Mid-level groups (4-7), scoring 75,2-83,5, produced conceptually sound but less innovative outputs, focusing more on accuracy and structure. Groups 8 and 9, with scores below 71, showed moderate creativity, relying on conventional presentation formats and limited design novelty, indicating a need for enhanced scaffolding to encourage divergent thinking and experimentation.

Overall, 77,8 % of groups achieved high or very high creativity, confirming that project-based and context-rich learning media promote creative problem-solving, collaboration, and self-expression key competencies for 21st-century education. These findings corroborate previous research highlighting the effectiveness of authentic, media-based learning environments in fostering innovation. To further improve creativity, future implementations should emphasize continuous feedback, peer review, and exposure to diverse creative media formats, particularly to support moderate-performing groups.

DISCUSSION

The exploration of fermentation-based ethnochemistry products in the Coastal Riau community revealed that traditional practices such as the production of dadih, asam durian, rebung acid, asam jeruk maman, and bekasam embody key chemical concepts relevant to organic chemistry, biochemistry, and physical chemistry. Cognitive analysis of ethnoscience products in this study is as follows:

1. Dadih fermentation illustrates key chemistry concepts, in organic chemistry and biochemistry. The process involves lactic acid production a carboxylic acid with hydroxyl and carboxyl groups demonstrating acid-base equilibria, pH variation, and enzyme catalysis through *Lactobacillus plantarum* activity. This bacterium hydrolyzes lactose anaerobically over 48 hours, producing lactic acid that acidifies and preserves the milk. Fermentation in bamboo vessels provides a natural microenvironment for moisture balance and microbial growth, resulting in probiotic-rich dadih with a shelf life of 2-4 days at room temperature. The process highlights protein denaturation, milk coagulation, and colloidal stabilization, linking to concepts of chemical equilibrium, reaction kinetics, and phase behavior.^(14,15,16,17,18)

2. The cognitive analysis of ethnochemistry using durian acid explores how students construct chemical understanding through traditional fermentation contexts. As a local fermented product from Riau, durian acid connects indigenous knowledge with modern chemistry, involving carbohydrate breakdown, organic acid production, and pH changes—illustrating acid-base equilibrium, redox reactions, and enzyme catalysis. This model supports a progression from basic comprehension of fermentation stages to higher-order skills like analysis and evaluation.^(19,20,21,22,23)

3. The making of asam jeruk maman involves key chemical reactions during fermentation. First, lactic fermentation by *Lactobacillus spp.* converts glucose ($C_6H_{12}O_6$) into lactic acid ($C_3H_6O_3$), increasing acidity and giving the product its sour taste. This illustrates organic chemistry concepts such

as carboxylic acids, hydroxyl groups, acid-base behavior, and pH variation, while also demonstrating natural preservation through chemical equilibrium and buffer systems. Second, salt (NaCl) lowers the pH and promotes lactic acid bacteria growth while inhibiting pathogens. This highlights solution chemistry concepts ionic compounds, osmotic pressure, and reaction kinetics as salt concentration affects reaction rate, pH, and product quality. Third, enzymatic hydrolysis of pectin in plant cell walls softens leaf texture, exemplifying biochemical catalysis and molecular transformation in fermentation.^(24,25,26,27)

4. The cognitive analysis of rebung acid (fermented bamboo shoots) explores how students build chemical understanding through contextual learning rooted in local culture. Produced by traditional fermentation in Riau, *rebung* acid connects indigenous knowledge with scientific concepts, involving microbial conversion of carbohydrates into lactic acid. This process demonstrates key chemistry principles such as acid-base reactions, redox processes, and enzymatic catalysis, helping students relate abstract concepts to real-world phenomena.^(28,29)

5. The cognitive analysis of bekasam, a traditional Indonesian fermented fish, illustrates how indigenous knowledge can deepen students' chemical understanding. Over seven days, lactic acid fermentation ($C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$) lowers pH and creates the sour flavor, demonstrating organic acid formation, redox, and acid-base chemistry. Simultaneously, proteolysis and lipid oxidation show enzyme activity and physical chemistry principles such as colligative properties and osmosis. Certain microbes, like *Aspergillus terreus* and *Monascus purpureus*, even produce lovastatin, linking traditional fermentation to biotechnology and pharmaceutical chemistry.^(30,31)

The present study extends these findings by providing concrete evidence that local fermentation practices can be systematically analyzed and transformed into structured learning materials aligned with curriculum objectives. From a cognitive perspective, engaging with these fermentation processes helps students move from basic factual recall toward analytical and evaluative reasoning. The stepwise investigation of observable changes such as texture modification, pH variation, and microbial activity facilitates the construction of mental models that link macroscopic observations with submicroscopic and symbolic representations.

Integrating ethnochemistry into chemistry education also aligns with Indonesia's Merdeka Curriculum and the principles of Education for Sustainable Development (ESD),⁽²⁸⁾ which advocate contextual, culture-based learning. By situating chemistry instruction within authentic cultural practices, this approach supports not only scientific competence but also the preservation of intangible heritage and sustainable local industries. The present study thus reinforces the view that the intersection of culture and science can enrich both domains—supporting cognitive, affective, and entrepreneurial dimensions of chemistry education.⁽²⁴⁾

Overall, the discussion suggests that ethnochemistry grounded in traditional fermentation practices is an effective pedagogical strategy for linking scientific understanding with cultural identity. It validates local wisdom as a legitimate source of scientific insight while fostering creativity and sustainability awareness among future chemistry educators.

CONCLUSIONS

This study aimed to identify traditional fermented products from the Coastal Riau community, explore their production processes, and analyze how the underlying chemical concepts can be integrated into chemistry education. The findings highlight that incorporating local wisdom particularly traditional fermentation knowledge into learning media provides a meaningful bridge between scientific theory and cultural practice.

More broadly, the study underscores the value of ethnochemistry as a pedagogical approach that situates chemistry learning within students' cultural contexts, thereby fostering scientific literacy, cultural awareness, and creative thinking. By linking indigenous knowledge with modern science, chemistry education can become more relevant, inclusive, and responsive to sustainability goals.

Ultimately, this work contributes to the broader discourse on contextual and culture-based science education, emphasizing that integrating ethnoscientific knowledge into curricula is not merely an act of preservation but a strategic approach to developing future educators who are scientifically competent, culturally grounded, and innovation-oriented.

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CONFLICT OF INTEREST

There was no conflict of interest.

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