



Pedetan Ethnochemistry Typical of Jembrana and it's Integration into Green Chemistry Learning

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Abstract

This study aims to explore the ethnochemical knowledge embedded in the traditional production of Jembrana's pedetan and to analyze its potential integration into high school green chemistry learning. This research is motivated by the limited ethnochemical studies that highlight local Balinese culinary, especially pedetan, and the absence of studies that specifically link the pedetan production process with the principles of green chemistry as a source of contextual learning. The study uses a qualitative approach with an ethnographic type. The research subjects involved *pedetan cooks* in Perancak Village, as well as literature sources in the form of books, scientific journals, and the chemistry syllabus of the Merdeka Curriculum. The research objects include local knowledge related to the ingredients and process of making *pedetan* along with the accompanying chemical phenomena, a study of the chemical content of the ingredients and their benefits, and their suitability with the learning outcomes of high school chemistry. Data collection was conducted through direct observation of the production process, in-depth interviews with informants, and documentation in the form of photographs, field notes, and supporting documents. Data validity was tested through triangulation, reference adequacy, and member checking to ensure consistency with information from informants. The results of the study showed that the main ingredients of *pedetan* consisted of three types of fish, namely lemuru (*Sardinella lemuru*), tambang (*Sardinella fimbriata*), and layang (*Decapterus*), as well as seven types of plant spices, namely turmeric (*Curcuma longa*), red chili (*Capsicum annuum* L.), galangal (*Alpinia galanga*), coriander (*Coriandrum sativum* L.), garlic (*Allium sativum* L.), lemongrass (*Cymbopogon citratus*), and aromatic ginger (*Kaempferia galanga* L.). The manufacturing process includes fish cutting, washing, soaking, seasoning, and drying, each of which involves various chemical phenomena. These findings have the potential to be integrated into high school chemistry education, particularly in green chemistry content, through green chemistry principles that align with the pedetan production process. This study recommends the development of broader ethnochemical studies, strengthening through experimental testing, and its use by teachers to support more meaningful contextual learning.

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INTRODUCTION

Chemistry instruction in high school plays a crucial role in helping students understand the materials, structures, properties, changes, and energy associated with chemical processes (Artini & Wijaya, 2020). However, chemistry is often

considered a difficult subject because it involves many abstract concepts, such as atoms, ions, molecules, chemical reactions, and energy changes, making it difficult for students to connect these concepts to everyday phenomena

(Nuraini *et al.* , 2025) . This situation leads to chemistry instruction that tends to be theoretical and lacking in context, resulting in low student interest and motivation. Therefore, a teaching approach is needed that can link chemical concepts to students' real-world experiences and cultural environments to make learning more meaningful.

One approach that can be used is ethnochemistry, which is the study of chemistry based on cultural practices, local knowledge, and the activities of traditional communities (Rahmawati *et al.* , 2025) . The ethnochemistry approach enables students to understand chemical concepts through real-world practices prevalent in society, such as traditional food processing, fermentation, the use of natural materials, and food preservation techniques (Rahman *et al.* , 2025) . In the context of the Merdeka Curriculum, this approach is relevant because learning is directed to be more contextual, applied, and based on students' real-world experiences (Gazali & Andriani, 2025) . In addition to strengthening conceptual understanding, ethnochemistry also plays a role in the preservation of local culture through the integration of local wisdom into science education.

One area of chemistry that is particularly relevant for integration through an ethnochemistry approach is green chemistry. Green chemistry is an approach to chemistry that emphasizes the design of processes and products that are safer, more efficient, produce minimal waste, are energy-efficient, and are environmentally friendly. Teaching green chemistry is important because it encourages students to understand that chemical activities are not only related to reactions and products but also to environmental sustainability and the wise use of resources. Therefore, teaching green chemistry requires contextual examples that are close to people's daily lives so that students can understand the concept of sustainability more tangibly.

Bali, a region rich in culture, has various local practices that can serve as sources for contextual chemistry education; one of these is the preparation of Jembrana style (Rahmawati *et al.*, 2025; Wahyudiati, 2022; Zidny & Eilks, 2022). Pedetan is a traditional dish made from fish, such as lemuru fish (*Sardinella lemuru*), tambang fish

(*Sardinella fimbriata*), and layang fish (*Decapterus*), which are processed through seasoning, soaking, and sun-drying. In the production process, the community utilizes various natural spices, such as garlic, galangal, coriander, lemongrass, turmeric, red chili peppers, Aromatic ginger, and salt, as the primary ingredients for processing and preservation (Ahmad *et al.*, 2020; Bej *et al.*, 2026). This practice demonstrates the use of natural materials as an alternative to synthetic ones, the utilization of local resources, and natural drying using solar energy all of which reflect several principles of green chemistry, such as the use of renewable raw materials, the reduction of hazardous substances, and energy. Furthermore, in the pedetan production process, nearly all parts of the fish are utilized, and unused parts such as the fish head and internal organs are repurposed as animal feed. This practice aligns with the green chemistry principle of waste prevention and the use of easily degradable materials. The relatively simple, safe, and low-maintenance nature of the pedetan production process, which requires no special attention, aligns with the green chemistry principle of minimizing accident risks.

Several previous studies have examined the ethnochemistry of traditional dishes, such as sala bulek, pindang patin, smoked fish, rawon, and traditional Balinese spices. These studies indicate that traditional cuisine has the potential to be linked to scientific concepts and chemistry education (Abu & Mauraji, 2025; Munandar *et al.*, 2024). However, most research remains focused on identifying scientific concepts or the functions of traditional food processing and has not yet systematically linked them to the principles of green chemistry in chemistry education. Specifically, in the study conducted by Singapurwa *et al.* 's research (2022) examining the Jembrana style pedetan, the research was limited to the benefits of spices in the fish preservation process and has not yet explored the chemical composition of the spices, the chemical phenomena occurring during production, or the potential for integrating these into green chemistry education in high school. Furthermore, preliminary observations indicate local variations in the pedetan production process, such as the use of lemongrass and the application of two seasoning stages-wet seasoning and dry seasoning which have not been specifically addressed in previous studies.

To date, there has been no comprehensive study that explores the ethno-chemical aspects of the production of Jembrana's traditional pedetan while linking it to the principles of green chemistry as a source of contextual chemistry learning in high school. Consequently, the potential of local wisdom regarding pedetan as a medium for chemistry education has not been fully utilized, while chemistry instruction in schools remains largely abstract and disconnected from students' real-life experiences. Furthermore, teachers also face a shortage of locally-based learning resources that can be used to explain green chemistry concepts in a contextual and practical manner.

Based on these issues, this study aims to explore ethno-chemical knowledge in the production process of Jembrana-style pedetan through the identification of ingredients, chemical composition, benefits, and chemical phenomena occurring during production. This study also aims to analyze the relationship between the pedetan production process and the principles of green chemistry and to describe the potential for integrating it into high school chemistry education based on local wisdom. This study is expected to provide a theoretical contribution to the development of ethnochemistry and green chemistry studies based on local culture, while also providing a practical contribution to teachers in developing chemistry instruction that is more contextual, applicable, and meaningful.

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METHOD

Research Design

This study employs a qualitative approach using ethnographic research methods to explore ethno-chemical aspects in the pedetan-making process in Perancak Village and to integrate them into green chemistry education in high schools (Creswell & Poth, 2018). In this study, the researcher acts as the primary instrument (human instrument), directly conducting observations and interacting with research subjects without influencing natural conditions in the field. The research focuses on identifying materials, production processes, and local community knowledge related to pedetan production that are relevant to the concept of green chemistry.

Research Subjects

The research subjects were selected using purposive sampling by choosing two traditional pedetan producers in Perancak Village. The selection of informants was based on the consideration that both are key actors directly involved in the pedetan production process, have extensive experience, and possess a detailed understanding of the traditional stages of pedetan processing. Furthermore, the two selected informants use a complex blend of spices in the pedetan-making process, whereas other production facilities use simpler spices and do not employ as comprehensive a blend as the two selected informants. Thus, the informants were deemed capable of providing relevant and in-depth data in line with the research objectives (Campbell et al., 2020).

Method of collecting data

The research instruments included observation guidelines, semi-structured interview guidelines, and documentation (Creswell & Poth, 2018). The observation guidelines were used to observe the materials, processing stages, use of tools, and traditional practices in the production of pedetan. The interview guidelines were used to elicit information regarding the informants' local knowledge of materials, production processes, and their relationship to chemical concepts. Documentation was conducted through photography, video recording, and the review of various written sources such as relevant articles, books, and scientific journals.

Data collection was conducted through non-

participatory observation, semi-structured interviews, and a literature review. Observation was carried out with the researcher acting as an observer without directly participating in production activities. Semi-structured interviews were conducted based on flexible question guidelines, allowing for a more in-depth exploration of information (Dejonckheere & Vaughn, 2019). Meanwhile, the literature review was used to supplement and strengthen the data from the observations and interviews.

Data Analysis Techniques

Data analysis was conducted qualitatively using the Miles and Huberman analytical model, which includes data reduction, data presentation, and drawing conclusions/verification (Miles et al., 2014). Data reduction was performed by selecting, focusing, and simplifying data from observations, interviews, and documentation in accordance with the research objectives. Next, the data were presented descriptively to make the relationships between the data easier to understand. The final stage involved continuous conclusion-drawing and verification based on the patterns and interrelationships of the data discovered during the research. The analysis process was conducted continuously from before the field research, during data collection, until after all the data had been collected.

Data Validity Test

Data validity was tested through methodological triangulation, reference adequacy, and member checking. Methodological triangulation was conducted by comparing data from observations, interviews, and documentation drawn from the same source. Reference adequacy was ensured by utilizing various scholarly sources, such as books, articles, journals, and supporting documentation, to strengthen the research findings. Additionally, member checking was performed by reconfirming the findings with informants to ensure consistency

between the data obtained and the information intended by the informants.

RESULTS AND DISCUSSION

Result

The results of this study were obtained through the analysis of observational data, interviews, and documentary studies on the traditional Jembrana pedetan-making practices in Perancak Village, Jembrana Subdistrict, Jembrana Regency. This study was conducted at two pedetan production sites with key informants, namely Mrs. Ni Wayan Muliarni and Mrs. Nengah Udiani. These two informants were selected because they have direct experience in the pedetan production process and have inherited knowledge of pedetan processing from generation to generation. The data analyzed included raw materials, spice ingredients, processing methods, the chemical composition of the spice ingredients, and the potential for integrating this knowledge into green chemistry education in high schools.

Basic Ingredients and Spices for Jembrana's Special Pedetan

Based on data analysis, the main ingredient used in making pedetan is local fish sourced directly from fishermen in Perancak Village. The types of fish used include lemuru, layang, and tambang, depending on the season and availability. The use of local fish demonstrates that the production of pedetan leverages the potential of local natural resources and is part of the traditional practices of the Perancak coastal community.

The spices used in making pedetan include both fresh and dried spices. The fresh spices used include garlic, galangal, coriander, lemongrass, turmeric, red chili peppers, aromatic ginger, salt, and mushroom broth. Meanwhile, the dried spices consist of garlic powder and coriander powder. These spices not only add flavor, color, and aroma but also help preserve the fish thanks to the bioactive compounds they contain

Table 1. Bioactive Compounds and Functional Roles of Spices Used in Jembrana's Traditional Pedetan

No	Name Indonesia	Name Latin	Sensory or Functional Role	Chemical content that produces these characteristics
1	Garlic	<i>Allium sativum</i> L.	Sharp aroma and savory taste	Allicin
2	Aromatic ginger	<i>Kaempferia galanga</i> L.	Strong aroma, and produces a spicy sensation	Phenolic and Essential Oils

No	Name Indonesia	Name Latin	Sensory or Functional Role	Chemical content that produces these characteristics
3	Coriander	<i>Coriandrum sativum L.</i>	Reduce water content in fish	Flavonoids and Linalool
4	Lemongrass	<i>Cymbopogon citratus.</i>	Reduces the fishy smell of fish	Oil essential oils and flavonoids
5	Galangal	<i>Alpinia galanga.</i>	Gives a slightly spicy sensation	Eugenol and galangin
6	Turmeric	<i>Curcuma longa.</i>	Provides a yellow color	Curcumin
7	Red Chili Pepper	<i>Capsicum annuum L.</i>	Provides a spicy sensation	Capsaicin

The identification results in Table 1 show that there are seven main spices used in the production of pedetan. Each ingredient has distinct chemical characteristics and contributes to the quality of the final product. Garlic contains *allicin*, which imparts a pungent aroma and savory flavor. *Allicin* is the primary volatile thiosulfinate compound formed catalytically when garlic tissue undergoes mechanical damage (Reiter et al., 2017). Galangal contains *phenolic* compounds and *essential oils* that produce a distinctive aroma and act as natural antimicrobial agents (Bej et al., 2026). Coriander (*Coriandrum sativum L.*) has a phytochemical profile rich in the monoterpene alcohol *linalool*, which acts as a broad-spectrum natural antimicrobial agent to inhibit contamination by pathogenic bacteria, making it highly promising for application as a natural preservative that is safe for health (Morshdy et al., 2024). Furthermore, lemongrass (*Cymbopogon citratus*) has been found to contain essential oils rich in citral and geraniol, which not only act as antioxidants but are also effective as deodorizing agents for neutralizing the natural fishy odor of fish (Anggraeni et al., 2018). turmeric (*Curcuma longa*) contains the compound curcumin, which provides a distinctive natural yellow pigment, while also possessing broad-spectrum antibacterial activity that effectively inhibits the growth of both Gram-positive and Gram-negative bacterial strains in food products (Fatimah et al., 2022). Meanwhile, red chili pepper (*Capsicum annuum L.*) contains capsaicin, which creates the spicy taste, as well as specific compound fractions known as capcyanosides, which possess strong antibacterial activity in inhibiting contamination by pathogenic strains in food ingredients (Bacon et al., 2017). aromatic ginger contains phenolic compounds that act as

natural preservatives or antimicrobial agents (Khairullah et al., 2021)

The Process of Making Jembrana's Special Pedetan

The results of the study show that the process of making pedetan involves several stages: fish preparation, cleaning, slicing, soaking, spice preparation, seasoning, drying, and packaging. First, the fish is cleaned of its head, bones, and innards. The fish is then cut open, or “dibedet,” into a butterfly shape, and washed under running water until all blood and debris are removed.

After cleaning, the fish are placed in a container filled with vinegar and ice cubes, then left to soak overnight. The vinegar helps reduce the fishy odor, while the ice cubes preserve freshness before seasoning. Lowering the temperature with ice cubes has proven crucial for maintaining the physical integrity of the meat tissue and inhibiting the proliferation of spoilage microbes before the fishery products enter the next stage of processing (Reiter et al., 2017). Once the soaking process is complete, the fish are rinsed again under running water to ensure the meat is clean before seasoning.

The next step is to prepare the spice paste. The wet spice paste is made by washing ingredients such as garlic, galangal, coriander, lemongrass, turmeric, aromatic ginger, and red chili peppers. After that, the ingredients are peeled, chopped, and ground using a blender. The chopping process increases the surface area of the ingredients, making them easier to grind and releasing their active compounds. The structural disruption of the plant's mechanical tissue triggers enzymatic interactions and facilitates the diffusion of bioactive marker compounds—such as phenylpropanoids and flavonoids—from the rhizome's cellular compartments more effectively

(Bej et al., 2026). During the grinding stage, salt, sugar, and flavor enhancers are added to achieve a balanced taste. In addition to the wet spices, dry spices made from garlic and dried coriander are also prepared and then ground.



Figure 1. Pedetan and Drying Process

Once the marinade is ready, the fish are arranged on a wooden board to dry. The surface of the fish is then evenly coated with the marinade using a brush. Once the entire surface of the fish is coated with the wet seasoning, the fish is sprinkled with dry seasoning. The final step is sun-drying for two days until the fish reaches the optimal level of dryness. Other observations indicate that drying can take three to five days, depending on weather conditions and the desired level of dryness. Once dry, the pedetan can be packaged and is ready for market.

Ethnochemical Knowledge in Making Pedetan

Analysis shows that the practice of making pedetan incorporates ethno-chemical knowledge reflected in the use of natural ingredients, seasoning techniques, soaking, and drying. This knowledge stems from the community's empirical experience, passed down from generation to generation. Although the community does not always use scientific terms to describe the process, these practices are related to chemical concepts such as diffusion, osmosis, food preservation, organic compounds, antimicrobial activity, physical changes in materials, and water reduction.

The process of grinding spices, for example, causes the tissue of these ingredients to break down, allowing active compounds to be released more easily. In garlic, tissue breakdown triggers the formation of allicin through the interaction of the compound alliin with the enzyme alliinase. In coriander, the release of volatile components such as monoterpene alcohol compounds (linalool) through mechanical processes has been shown to damage the permeability of the cell membranes of harmful microbes, thereby effectively acting as a natural bio-preservative in food (Bej et al., 2026). In turmeric, the grinding process helps release

curcumin, which imparts a yellow color. Meanwhile, the use of salt in spices not only provides a salty taste but also facilitates the penetration of spices into fish tissue via osmosis. During the osmotic dehydration of fish meat, a large concentration gradient triggers rapid water withdrawal from the fish meat cells, accompanied by the entry of solutes or salt penetration into the fish muscle fibers (Pantuhan et al., 2026)

Integration of Research Results into Green Chemistry Learning

Jembrana-style pedetan has the potential to be integrated into high school chemistry education, particularly in the context of green chemistry. This integration is based on the relationship between the materials, processes, and chemical principles involved in the production of pedetan. The scope of the research findings that can be used as learning resources includes the types of spices used, the chemical compounds in the spices, the seasoning process, soaking, drying, and the use of natural materials and solar energy in its processing

In general, the results of this integration can be linked to several chemical concepts. First, the use of natural spices can be linked to the study of organic compounds and functional groups. Second, the use of vinegar in preserving fish can be linked to acid-base concepts. Third, the seasoning process can be linked to the concepts of diffusion and osmosis. Fourth, the drying process can be linked to water reduction, physical changes in materials, and the use of solar energy. The utilization of solar energy in the food drying process has been shown to significantly and efficiently reduce meat moisture levels, decrease harmful microbial loads, and support the principles of environmentally friendly renewable energy efficiency within food security systems (Deef et al., 2023). Fifth, the use of natural materials and solar drying can be linked to the principles of green chemistry, particularly the use of safer materials, the utilization of renewable resources, and energy efficiency.

Based on the research findings, the traditional Jembrana-style pedetan can be utilized as a contextual and practical local context in chemistry education. These findings indicate that the process of making pedetan has the potential to be integrated into green chemistry education in 10th grade high school. Learning activities may include observing the ingredients of pedetan

seasoning, identifying the chemical compounds contained in the spices, analyzing the application of green chemistry principles in the production process, and discussing the relationship between local culture, chemistry, and environmental sustainability. The implementation of green chemistry education at the high school level is crucial for introducing environmentally friendly science concepts and principles to students at an early stage, thereby fostering their awareness and ability to address various environmental challenges (Oyelekan & Salihu, 2022). Furthermore, integrating ethno-chemistry concepts into chemistry education has proven effective in contextualizing chemistry material through phenomena relevant to students' daily lives, bridging local culture with school science, and strengthening appreciation for traditional local wisdom (Chibuye & Singh, 2024). Thus, the results of this study not only produce scientific documentation regarding the Jembrana-specific pedetan but also provide a foundation for the development of ethno-chemistry-based chemistry learning relevant to the local cultural context.

Discussion

The research findings indicate that Jembrana-style pedetan is a traditional culinary product that reflects the integration of local community knowledge, the utilization of natural resources, and food processing practices passed down through generations. The use of local fish combined with various spices demonstrates that the coastal communities of Jembrana have developed effective food processing and preservation strategies based on empirical experience. These findings indicate that pedetan not only holds cultural and economic value but also possesses scientific value that can be analyzed through the perspectives of ethnochemistry and green chemistry.

The spices used in the production of pedetan serve a purpose that goes beyond flavor and aroma; they also play a role in maintaining product quality. Garlic contains allicin, which has antibacterial activity (Kristiananda et al., 2022). Galangal contains essential oils and phenolic compounds that contribute to antimicrobial activity (Fitriansyah et al., 2024). Coriander contains flavonoids and linalool, which have antioxidant potential (Hijriah et al., 2022). While lemongrass contains citral and geraniol, which

help reduce the fishy odor of fish.

Additionally, turmeric contains curcumin, which functions as a natural colorant (Febriawan et al., 2020). Aromatic ginger contains bioactive compounds, such as terpenoids, phenolics, and trans-ethyl p-methoxycinnamate, which act as anti-inflammatory, antioxidant, and antibacterial agents (Wang et al., 2021). While red chili contains capsaicin, which provides a spicy sensation and has the potential to inhibit microbial growth (Khoerunisa et al., 2024). The presence of these various bioactive compounds indicates that the use of spices in pedetan serves not only as a flavor enhancer but also as part of a traditional food preservation system.

From an ethno-chemistry perspective, the practice of making pedetan demonstrates how communities utilize natural materials based on knowledge gained through experience and passed down from generation to generation. Ethnochemistry views cultural practices as containing scientific concepts that can be explained through chemistry (Azizah & Premono, 2021). Although communities do not describe the pedetan-making process using scientific terminology, the various steps involved demonstrate the empirical application of chemical principles. The selection of specific spices is a concrete example of how communities utilize the chemical properties of natural ingredients to achieve specific goals. The use of garlic, turmeric, lemongrass, coriander, and galangal demonstrates an empirical understanding that these ingredients can enhance flavor while extending the shelf life of products. Scientifically, this ability is related to the presence of bioactive compounds that possess antimicrobial and antioxidant activity. Thus, the traditional practices carried out by the community actually represent a form of local chemical knowledge that developed before the advent of modern scientific explanations.

Ethnochemical aspects are also evident in the fish processing stages. Soaking in vinegar and ice water demonstrates the use of acidic conditions and low temperatures to inhibit the rate of spoilage (Tsironi et al., 2020). The acidic conditions produced by vinegar can inhibit the growth of certain microorganisms while helping to reduce the fishy odor (Rastina et al., 2022). Meanwhile, the use of ice serves to lower the temperature, thereby slowing down the activity

of enzymes and spoilage microorganisms. The seasoning stage also demonstrates the application of the concept of diffusion, namely the movement of spice molecules from areas of high concentration toward fish tissue with lower concentrations (Zainuri et al., 2022). Furthermore, the sun-drying process reduces moisture content and water activity, thereby inhibiting the growth of spoilage microorganisms (Nufus, 2025). These findings demonstrate that the practice of making pedetan is a concrete example of the relationship between culture and science. The local knowledge that has developed within the community is found to have a scientific basis that can be explained through concepts in chemistry, biochemistry, and food microbiology.

Therefore, pedetan can be viewed not only as a traditional culinary product but also as a representation of the ethno-chemical knowledge of the Jembrana community, which deserves to be documented and studied scientifically. The results of this study also expand upon the findings of Singapurwa *et al.*'s research (2022) who stated that pedetan seasoning plays a role in fish preservation. This study not only confirms this preservative function but also identifies the chemical compounds involved in the process and explains the underlying scientific mechanisms. Furthermore, this study found variations in the use of ingredients and processing steps, such as the use of lemongrass and the application of two types of spices: wet spices and dry spices. These findings indicate that pedetan-making practices exhibit diversity that evolves according to the experience and needs of the local community.

In addition to incorporating elements of ethno-chemistry, the pedetan production process also aligns with the principles of green chemistry. Green chemistry emphasizes the design of products and processes that reduce the use and formation of hazardous substances while improving resource efficiency (Dalimunthe & Darmana, 2026). Although pedetan production has evolved as a traditional practice and was not specifically designed based on the concept of green chemistry, several green chemistry principles can be identified in its production process. The principle of waste prevention is evident in the direct use of raw materials and spices through a relatively simple process, resulting in minimal waste. The production process does not involve stages that generate

large amounts of byproducts, as is common in many modern industrial processes. Additionally, the use of locally caught fish helps reduce material loss due to long-distance distribution.

The principles of less hazardous chemical syntheses and designing safer chemicals are reflected in the use of natural spices as flavor enhancers and preservatives. The various spices used contain bioactive compounds that help maintain product quality without requiring synthetic additives that could potentially have negative impacts on health or the environment. The use of these natural ingredients indicates a trend toward safer and more sustainable processing methods (Putra et al., 2023). The principle of safer solvents and auxiliaries is evident in the use of water, ice, and vinegar as process aids. These three materials are relatively safe to use and do not produce residues harmful to the environment. The use of vinegar as an acidifying agent also demonstrates the utilization of simple, readily available, and environmentally friendly materials compared to certain synthetic chemicals.

The design for energy efficiency principle is one of the most clearly applied principles in the production of pedetan. Drying is carried out by utilizing solar energy, thereby minimizing the need for external energy. This use of solar energy not only reduces energy consumption but also lowers emissions that would potentially be generated if the drying process were conducted using fossil-fuel-powered equipment or large-scale electricity (Venkateswarlu & Reddy, 2024). The principle of using renewable feedstocks is evident in the use of local fish and spices derived from renewable biological resources. All primary ingredients used come from the surrounding environment, thereby supporting the sustainable utilization of local resources. In addition to reducing dependence on imported materials, this practice also strengthens food security and the economy of coastal communities. The principle of reducing derivatives is evident because the processing is carried out directly without requiring complex chemical modification steps. The fish undergo only cleaning, soaking, seasoning, and drying before packaging. The simplicity of this process demonstrates efficiency in material use and production stages.

The principle of design for degradation is reflected in the use of natural materials whose

waste is relatively easily biodegradable. Spice residues and other organic materials have high biodegradability potential, thus preventing the accumulation of persistent pollutants in the environment. Meanwhile, the principle of inherently safer chemistry for accident prevention is also evident because the production process takes place under relatively safe conditions without the use of hazardous chemicals, high pressure, or extreme temperatures that could pose accident risks. Although the principles of atomic economy, catalysis, and real-time analysis for pollution prevention are not explicitly evident in the practice of making pedetan, the presence of various other principles indicates that this traditional dish possesses characteristics consistent with the concept of sustainability. Thus, pedetan can serve as a contextual example in illustrating the application of green chemistry principles that are closely tied to people's daily lives.

The findings of this study indicate that pedetan has great potential to be utilized as a learning context for ethno-chemistry and green chemistry in high school. The use of local contexts in learning can help students understand the relationship between chemical concepts and the phenomena they encounter in their daily lives. This approach aligns with various studies showing that ethno-chemistry-based learning can improve students' learning motivation, science literacy, critical thinking skills, and conceptual understanding (Ariani et al., 2024; Insiyroh Anisatul, 2023; Robo et al., 2021). In the Merdeka Curriculum, pedetan can be integrated into the Green Chemistry curriculum in Phase E (10th grade). This context aligns with learning outcomes that emphasize students' ability to analyze the application of chemical principles to support environmental sustainability and to evaluate the impact of a process on the environment and society. Additionally, pedetan can be used in carbon compound lessons through the identification of the structures and functional groups of compounds such as allicin, curcumin, capsaicin, eugenol, flavonoids, citral, and linalool. In acid-base lessons, students can analyze the role of vinegar in the fish-soaking process and the effect of pH on microbial activity.

Learning activities can be designed contextually and project-based. Students can observe the ingredients of pedetan, identify the

chemical compounds present in spices, analyze the function of each ingredient in the preservation process, and map the principles of green chemistry that emerge in its production. The activity can be followed by group discussions, the creation of scientific posters, infographics, or simple projects such as designs for local food products that apply sustainability principles. Through these activities, students not only gain conceptual understanding but also develop critical thinking, scientific communication, collaboration, and problem-solving skills. Learning assessment can be conducted comprehensively through diagnostic, formative, and summative assessments. Diagnostic assessments are used to identify students' initial understanding of food preservation and the utilization of natural materials. Formative assessments can be conducted through group discussions, student worksheets, and presentations of analysis results. Meanwhile, summative assessments can take the form of project reports, scientific posters, infographics, or presentations that evaluate students' ability to connect chemical concepts with local cultural practices. With this approach, learning is not only oriented toward mastering concepts but also toward developing 21st-century competencies and an appreciation for local wisdom.

Overall, the research findings indicate that the traditional Jembrana pedetan possesses strong scientific, environmental, and pedagogical value. From an ethnochemical perspective, the practice of making pedetan reflects the utilization of local knowledge that can be explained through modern chemical concepts. From a green chemistry perspective, the production process demonstrates the application of various sustainability principles, particularly the use of renewable raw materials, energy efficiency, the use of safer materials, and waste reduction. Meanwhile, from a pedagogical perspective, pedetan has the potential to serve as a contextual learning resource capable of linking chemical concepts with local culture and sustainability issues. Therefore, this study not only contributes to the documentation of the traditional knowledge of the Jembrana community but also provides a scientific foundation for the development of green chemistry teaching materials based on ethnochemistry that are relevant to the implementation of the Merdeka Curriculum.

CONCLUSION

Based on the research findings, it can be concluded that the production of Jembrana-style pedetan utilizes various spices such as garlic, galangal, lemongrass, turmeric, coriander, galangal, and chili peppers, which contain chemical compounds that play a role in shaping the flavor, aroma, color, and potential health benefits. The production process includes cleaning and cutting the fish, soaking it in ice and vinegar, processing the spices, and drying, which involves various chemical phenomena such as diffusion, protein denaturation, and oxidation. This study successfully identified and analyzed the ethno-chemical aspects at each stage of making Jembrana-style pedetan and linked them to the principles of green chemistry, which have not been extensively studied in the context of traditional Balinese cuisine. These findings indicate that the ethno-chemistry of pedetan has the potential to be integrated into green chemistry education in high schools as a contextual learning resource based on local wisdom. Such integration can foster more meaningful learning that is relevant to students' lives, while supporting improved understanding of chemical concepts, science literacy, and awareness of the sustainable use of local resources.

RECOMMENDATION

Based on the research findings presented, the authors offer several recommendations. Future researchers are encouraged to expand the exploration of local knowledge from various regions and develop more diverse, ethnochemically based teaching materials for chemistry lessons. Researchers in the field of pure chemistry are encouraged to conduct experimental investigations to validate the chemical composition of spices used in beef jerky. Teachers and educational staff can utilize the results of this research as context-based teaching materials, for example, by inviting practitioners or conducting field trips to make chemistry lessons more practical and connected to local culture.

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