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ETHNOSCIENCE STUDY OF SHRIMP PASTE AT THE MERANTI ISLANDS AS A REPRESENTATION OF CHEMISTRY LEARNING

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Abstract

This study explores the integration of ethnoscience into chemistry education by using the traditional shrimp paste production process in Meranti Islands Regency, Riau, Indonesia as a contextual learning resource. The research method used a qualitative descriptive case study approach, with data collection involving field observations, in-depth interviews with five shrimp paste producers (ethnographic data), and a review of scientific literature (scientific data). The findings indicate that the shrimp paste production process still heavily relies on inherited local knowledge and involves several stages: sorting and washing, crushing, molding, fermentation, drying, and heating over a fire. Each of these stages contains chemical aspects that can be analyzed through various approaches: a macroscopic approach (examining physical and chemical changes such as color, aroma, and texture), a submicroscopic approach (focusing on molecular and enzymatic interactions), and a symbolic approach (exploring chemical reactions such as hydrolysis, fermentation, and Maillard reactions). Furthermore, the study reveals that the community's knowledge of the shrimp paste production process is supported by scientific principles, as documented in the literature. The results suggest that shrimp paste production not only contributes to the local economy and cultural preservation but also holds significant potential for enhancing students' scientific literacy through an integrated chemical representation approach. The integration of these three levels of chemical representation is expected to provide students with a holistic and applied understanding of chemical concepts.

Keywords: Ethnoscience, Shrimp Paste, Representation, Chemistry Learning

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INTRODUCTION

Meranti Islands Regency is one of the regencies in Riau Province and is located near the Malacca Strait to the north, bordering Karimun Regency to the east, Bengkalis Regency to the west, and Siak and Pelalawan Regencies to the south (Turmudi, 2023). Meranti Islands Regency comprises nine administrative districts, with Selat Panjang in Tebing Tinggi District serving as the administrative capital. The region is situated at an elevation of 2–6 meters above sea level and features a relatively flat topography with a slope of less than 8%. The climate conditions include nearly uniform rainfall across the region, with an annual rainfall accumulation of 1,500–3,000 mm/year (Riyadi et al., 2022).

The local community in Meranti Islands Regency generally has a good understanding of their surroundings, as most residents have lived there for a long time and coexisted with nature, enabling them to know many ways to manage and utilize natural resources sustainably. In adapting to the environment, the community acquires and develops wisdom in the form of knowledge or ideas, customary norms, cultural values, activities, and tools as a result of abstracting environmental management. Local community knowledge is often used as an accurate guideline for developing life in their settlement environment (Fransiska, 2022).

Shrimp paste or *belacan* is a food ingredient that is very popular among many people in various regions of Indonesia, including the coastal areas of Meranti Islands Regency, which is known as one of the largest producers of shrimp paste in Riau Province. Shrimp paste is produced through the fermentation of *rebon* shrimp mixed with salt, a process that involves significant chemical and biological changes. This microbiological process, through it's rich flavors and scent and deep understanding of the microbiology and chemistry that interacts therein allow this fermentation process to be part of chemistry courses. Ethnoscience based on chemistry education can make students 'own culture as a source of understanding chemical concepts and improve students' scientific literacy (Andayani et al., 2021; Wibowo&Ariyatun, 2020; Al-Fialistyani et al., 2020).

Ethnoscience is a fusion of community traditional knowledge and scientific knowledge. In the teaching of science, ethnoscience links local knowledge in communities with the knowledge taught in schools of science. According to previous research, learning based on the ethnoscientific approach is expected to be able to improve students' chemistry literacies which influence their character forming and scientific understanding (Wibowo & Ariyatun, 2020; Al-Fialistyani et al., 2020).

Linking the learning of chemistry concepts with local culture, which is applied to making shrimp paste on Meranti Islands, students can understand and applied real life example about chemistry materials such as chemical reaction, physical change-chemical change and function of microorganisms in the fermentation process.

One of the applied learning strategies is learning from multiple representations, which consist of submicroscopic, macroscopic, and symbolic levels. Multimodal representations are representations that fuse text, real world images or graphics together. Learning with multiple representations is expected to bridge students' understanding of chemical concepts. Chemical representations are developed based on the sequence of observed phenomena, reaction equations, atomic and molecular models, and symbols. Johnstone in Herawati et al., (2013) distinguishes chemical representations into three levels: the macroscopic level, which is tangible and contains visible and tangible chemical substances; the submicroscopic level, which is also tangible but not visible, consisting of the particulate level used to explain the movement of electrons, molecules, particles, or atoms; and the symbolic level, which consists of various types of graphical and algebraic representations.

The integration of local wisdom into science education, especially chemistry, is increasingly recognized as an effective method to help students understand abstract chemical concepts. Ethnoscience-based learning connects science with the local community's culture and traditions, allowing students to learn science in a more relevant and applicable context. Therefore, the purpose of this study is to explore the process of making *belacan* as a contextual source in ethnoscience-based chemistry learning.

METHOD

Research Design

This study employed a descriptive qualitative case study approach, aiming to describe a phenomenon within its real context without testing cause and effect relationships. Descriptive case studies offer a rich and detailed portrayal of the case under investigation (Yin, 2014). The research was conducted in Sialang Pasung Village, Rangsang Barat District, Meranti Islands Regency, Riau Province, from August to September 2024. The descriptive qualitative case study method enabled the researchers to explore both the cultural and scientific aspects of traditional shrimp paste production through direct interaction with the community, and to subsequently relate the findings to the concepts covered in chemistry lessons.

Research Subject

The research subjects consisted of five traditional shrimp paste producers who transform shrimp into *belacan* using traditional techniques (Mr. R, Mr. A, Mrs. N, Mr. K, Mrs. S). These individuals were purposively selected based on their integral roles within the production chain and their experiential knowledge, allowing the study to capture in-depth, authentic insights into indigenous processing practices and the implicit scientific principles embedded within them.

Data Collection Techniques

This study utilizes both primary and secondary data sources. Primary data were collected through direct observation at each stage of the *belacan* production process, including sorting and washing, crushing, molding, fermentation, drying, and heating over fire. In addition, in-depth interviews with *belacan* producers were conducted to gather firsthand information about their experiences, techniques, and understanding of the process (ethnographic data). The interview questions for the five participants were: "what are the stages of the *belacan* production process and what is the meaning of each stage?" Their answers will be identified and grouped in the form of explanations to ensure their validity and reliability through participant opinion checks. Secondary data were gathered through a literature review of scientific sources, such as relevant journal articles, to support the theoretical framework and enhance the analysis of field data (scientific data).

Data Analysis Techniques

Data were analyzed using qualitative content analysis within the framework of a descriptive case study (Yin, 2014). This approach enabled a contextualized examination of traditional shrimp paste production, highlighting both cultural practices and the underlying scientific principles.

The analytical process began with an in-depth familiarization with field data, including interview transcripts, observational notes, and visual documentation. The data were then subjected to open coding, which facilitated the identification of recurring patterns related to indigenous knowledge and the physicochemical transformations involved in the fermentation process.

Next, the codes were synthesized into analytical categories that reflected cultural phenomena (e.g., artisanal inheritance, communal practices) and scientific relevance (e.g., enzymatic activity, salting effects, preservation kinetics). Through an inductive thematic analysis (Braun & Clarke, 2006), emergent themes such as embodied knowledge, local material sustainability, and implicit chemical literacy were identified.

Data triangulation across sources and participant roles enhanced the credibility of the interpretations (Patton, 2015). The presentation of the data involved organizing the results into clear thematic descriptions that represented the observed phenomena of the shrimp paste-making process, particularly through three levels of chemical representation: macroscopic, submicroscopic, and symbolic. The conclusion was drawn by linking the ethno-data from community knowledge with scientific data derived from journal articles. Finally, these themes were critically mapped onto core chemistry concepts to inform the development of culturally contextualized educational insights, thereby bridging ethnoscientific practices with formal science pedagogy.

RESULTS AND DISCUSSION

1. Traditional Knowledge in Shrimp Paste Production

Shrimp paste can be made from small-sized shrimp that live in large groups and only appear during a specific period in the rainy season (Sajriawati, 2022). Shrimp paste is a fermented shrimp product produced through a salting process without the addition of acid, then left to ferment. This product has a solid paste form that is traditionally processed with a blackish brown or reddish-brown color.

Shrimp paste is widely consumed because of its various benefits (see Figure 1). From an economic perspective, Shrimp paste can increase the selling value of shrimp and is an effective solution for utilizing shrimp that spoils easily. In addition, shrimp paste is rich in nutrients that are important for human health.

Figure 1. Shrimp paste or *belacan*

Based on observations and in-depth interviews with five shrimp paste producers in Meranti Islands Regency, it was found that the *belacan* production process is still carried out traditionally based on the local wisdom of the village community, which has been passed down from generation to generation (Figure 2).

Figure 2. Shrimp paste production process

The shrimp paste production process begins with washing and sorting the *rebon* shrimp, where small fish mixed in must be separated to maintain the quality of the shrimp paste, preventing it from becoming smelly or discolored. The *rebon* shrimp are then ground into a fine paste, mixed with salt, and shaped into round balls of moderate thickness. The mixture is left to ferment for several days, causing changes in texture and flavor, followed by sun-drying, and then placed over a fire to extend its shelf life (Figure 3).

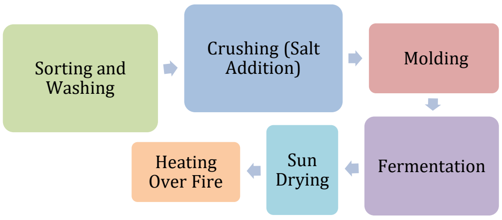


Figure 3. Stages of shrimp paste production

2. Chemical Representations in Traditional Practices

In chemistry education, understanding abstract concepts often requires the use of multiple levels of representation. Johnstone (1982) conceptualized three fundamental levels to describe chemical phenomena: the macroscopic, submicroscopic, and symbolic levels. These three levels are interconnected and essential for a comprehensive understanding of chemistry; however, students often struggle to move fluently between them. Effective chemistry instruction therefore requires deliberate integration of all three levels to support deeper conceptual learning and problem-solving skills.

The learning outcomes of chemistry topics in Merdeka curriculum from stage of process shrimp paste presented in Table 1.

Table 1. Relationship between stage of process shrimp paste and chemistry topics

Stage of Process	Chemistry Representation	Learning Outcomes of Chemistry Topics
Sorting and Washing	• Macroscopic (physical and chemical changes) • Submicroscopic (chemical structure and molecular reaction) • Symbolic (chemical equations and notation)	• To learn the observable properties of matter and physical changes. • To analyze real-world phenomena related to food processing. • To connect molecular-level composition to macroscopic properties (color, aroma, texture).
Crushing (Salt Addition)	• Macroscopic (changes in texture, aroma, color, and consistency of the paste) • Submicroscopic (osmotic pressure, lactic acid, volatile compounds, and amino acids) • Symbolic (reaction of protein hydrolysis)	• To learn solutions, osmosis, acids and bases, and biochemical processes in everyday contexts. • To connect microbial activity with chemical reactions. • To interpret and construct symbolic chemical equations from real-life biochemical reactions
Molding	• Macroscopic (minimizes air gaps, ensures uniform salt distribution) • Submicroscopic (molecular interactions and enzyme-catalyzed reactions) • Symbolic (chemical reactions in biological systems)	• To identify and explain physical changes in materials, particularly in food processing. • To builds scientific reasoning by connecting invisible processes to observable outcomes. • To write and interpret chemical equations that represent biological or environmental processes.
Fermentation	• Macroscopic (the taste, color, texture, and safety) • Submicroscopic (carbohydrates are fermented by LAB into lactic acid, lowering pH)	• To explain observable physical and sensory changes (color, odor, pH) during chemical processes like fermentation. • To support phenomena-based learning using traditional practices.

Stage of Process	Chemistry Representation	Learning Outcomes of Chemistry Topics
	• Symbolic (chemical reaction of fermentation)	
Sun Drying	• Macroscopic (physical changes: changes in color (darker), texture (firmer), aroma, and moisture) • Submicroscopic (dehydration at the molecular level, inhibiting microbial growth) • Symbolic (oxidation reaction)	• To identify and explain observable physical changes in a material due to external factors (heat, water content). • To understand how loss of water (H_2O) affects chemical stability and safety.
Heating Over Fire	• Macroscopic (physical and chemical changes) • Submicroscopic (thermal effects on biomolecules, chemical changes in food chemistry) • Symbolic (maillard reaction, decarboxylation)	• To identify and explain physical and chemical changes during thermal processing • To understand and write chemical equations related to biochemical transformations

3. Analysis by Production Stages: Ethnoscience Meets Chemistry

a. Sorting and Washing

From a macroscopic perspective, the sorting and washing process of *rebon* shrimp can be observed through physical changes such as size, color, and cleanliness. This ensures that only fresh and safe shrimp are used in the production of *belacan*. Studies have shown that students often struggle to transition from describing macroscopic properties to understanding submicroscopic processes. The use of methods that combine direct observation with visual representations has been proven to enhance the learning process (Al-Balushi & Al-Harthy, 2015; Van-Sertima et al., 2024). Strengthening the understanding of complex chemical concepts through visual aids is also supported by the literature on chemistry education (Talanquer, 2022).

Rebon shrimp like many other organisms, consist of simpler chemical substances such as proteins and fats at the submicroscopic level. During the sorting phase, high-quality shrimp are separated from those of lower quality. In the case of fermentation processes involving shrimp, knowing their chemical makeup is essential for explaining the functions of various ingredients during fermentation. Studies show that connecting submicroscopic phenomena with the macroscopic attributes helps students understand some concepts in chemistry better (Ryu et al., 2018; Agustina et al., 2021).

Students must grasp the relevance of the chemical symbols and notations that pertain to shrimp components from a symbolic point of view. For instance, the chemical transformations taking place during fermentation are represented using equations in biochemical pathways as they occur in both raw and processed forms. The ability to transition from macroscopic to symbolic understanding is essential for students' development in mastering chemical reactions comprehensively (Keiner & Graulich, 2020; Pazicni & Flynn, 2019).

The results of the interviews revealed that the indigenous knowledge possessed by the community (ethnographic data) indicates that "if *rebon* shrimp are mixed with other small fish, the resulting *belacan* will be of poor quality, with a slightly bitter taste, a black color, and poor texture" (Interview quotes from Mr. R & Mrs. N).

From a scientific perspective (scientific data), it is well established that the quality of properly selected and washed *rebon* shrimp directly impacts the quality of the resulting *belacan*. Shrimp that has been properly sorted and thoroughly washed will produce *belacan* with a brighter color, better taste, and longer shelf life (Sajriawati, 2022). The case described in this interview is also highly relevant for application in a Problem-Based Learning (PBL) approach in chemistry education. Learners may be assigned to investigate and analyze the mix up resulting in *belacan* quality issues stemming from the use of non-compatible ingredients, and subsequently devise ways to improve it. This fosters self-directed learning as students appreciate the essence of a food chemistry and its analytical, experimental, and problem-solving dimensions.

b. Crushing (Salt Addition)

From a macroscopic standpoint, there are considerable changes on texture, coloration, and aroma of the *belacan* produced. The process of crushing shrimp improves aroma while changing color and texture in a more microscopic sense. The rehydration of damaged cells results in a paste which soft despite rich balance on flavor complexity (Akonor et al., 2016; Gaffar et al., 2020). One way to determine the physical quality of the product is by measuring rehydration capacity, and microbiological stability (Akonor et al., 2016; Stefanny & Pamungkaningtyas, 2023).

At submicroscopic level, salts added with the pounded shrimp paste served as a preservative and, at the same time, as inoculum carriers of fermenting microbial population. Salt raises the osmolality of the medium, which prevents the proliferation of harmful microorganisms but encourages Lactobacillus and Tetragenococcus activities (Surya & Nugroho, 2024; Helmi et al., 2022). It has been reported the metabolite patterns from LAB metabolism during fermentation which includes the lactic acid production and or other volatile compounds that have contributed to the sensory attributes and safety of the product (Helmi et al., 2022; Sang et al., 2020). Other factors like temperature and fermentation time also contribute to the alteration of pH and of the chemical composition of shrimp paste (Helmi et al., 2022).

Metaphorically speaking, the making of *belacan* is not just an activity of making food but it carries with it the strong traditions and cultural values of a community. Shrimp paste is one of important product of Indonesian cuisine which have a high social and economic value (Rahman et al., 2023). This pattern of fermentation and preservation reflects generational local knowledge of food security. Involvement of the community in *belacan* making also represents the values of community sharing and cultural tradition (Rahman et al., 2023).

Chemical reactions principal that occurs during the composting process is protein hydrolysis, which is carried out by the proteolytic enzymes of bacteria. This process is a simplified version and has been depicted in Figure 4.

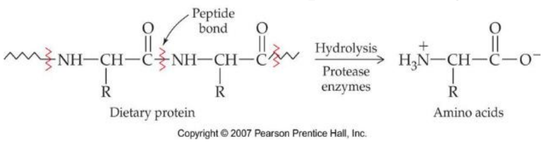


Figure 4. Reaction of protein hydrolysis

This process produces various chemical compounds, including amino acids that contribute to the distinctive umami flavor of shrimp paste. Additionally, the accumulation of lactic acid and other volatile compounds influences the product's organoleptic characteristics (Sang et al., 2020; Helmi et al., 2022).

According to local knowledge, "the addition of salt serves to improve the quality and durability of *belacan* by acting as a preservative, preventing it from spoiling quickly when wet, and enhancing its fatty and salty taste. The ratio of salt added is not critical, but if too much salt is used, the shrimp paste will become excessively salty; the key is to add just the right amount of salt" (Interview quotes with Mr. R & Mr. A).

Based on scientific principles, the crushing process releases proteolytic enzymes that enhance the umami flavor, while the addition of salt plays a role in preservation, controlling microorganisms, and improving both the taste and texture of the shrimp paste (Hajeb & Jinap, 2012). This process of making *belacan* offers excellent potential for practical learning in the field of food chemistry. Students can conduct experiments by adding varying amounts of salt and study its effect on the quality of *belacan*. This method of instruction not only involves chemical theory but also brings to students the ways in which chemical ideas are used in the production of food.

c. Molding

Physically, from a macroscopic point of view, the changes such as the color, aroma, texture, which occur during the manufacturing of shrimp paste could be observed. The production process can also be considered as an important stage of the process because, in summary, the development of these physical changes seems to be closely related to the chemical transformations that occur. Such a macroscopic viewpoint allows students to relate theory and practice by seeing measurable and real-world changes (Mahaffy et al., 2019). The translation from macroscopic observation to submicroscopic and symbolic can help students to fuse all their knowledge and understanding into a complete image of shrimp paste production (Ho, 2019).

Submicroscopic features are features of the particles and their interactions, being invisible to the naked eye, though not necessarily to the aid of a microscope. These are important information for interpretation of chemical reactions in the process of making shrimp paste. As one example, in shrimp paste production, there are microbiological reactions, which enzymes and microorganisms decompose complex substance into simpler ones (Taber, 2013). To understand this process, basic chemistry concepts (enzymatic reactions, molecular interactions on a submicroscopic level) have to be known, in order to interpret the chemical actions during production which occur here (Talanquer, 2022).

On the other hand, in this respect of use of symbols etc., education in chemistry is symbolic in nature in as much as it employs chemical symbols, formulae and equations of reactions. Furthermore, the knowledge on students' symbolic representation of chemical reaction can support their understanding of the cause-and-effect relationship of the substances in the reaction (Chen et al., 2019). In chemistry education, the three levels, submicroscopic, macroscopic, and symbolic, should be connected so that students can develop a comprehensive understanding of the properties and changes in matter (Taber, 2013; Talanquer, 2022; Pratama et al., 2023).

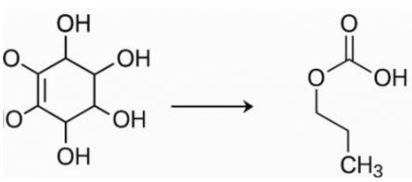
According to villagers, "the size of mold tile does not involve in taste of shrimp paste, but if English A small or moderate-sized binder, Thai fishermen will take more time to set up the binder. "And if the size is too small, or that it is too thin, the shrimp will be easily broken and the crumbled" (Interview quotes with Mr.A & Mrs.S).

By the action of molding, compressed the dough to density. The less air space in the dough the better for fermentation time. Compaction also helps in the uniform distribution of salt for microbial control and maintaining the water content (Sajriawati, 2022). This also allows in chemistry education for the mention of physical properties such as solid structure, density and tensile strength. Students can learn how the microscopic structure of a substance (in this instance, shrimp paste) is affected by its size and shape. This idea can be generalized to the production process; how the chemical constituents lead to the physical strength of materials.

d. Fermentation

Macroscopically, the fermented shrimp paste exhibits a significant difference in texture and color between the initial semi-soft paste and the final thick and dark-colored one (Kim et al., 2014). In the physical aspect, acid production and a low pH might also be seen as indirect variables for fermentation success (Borgers et al., 2019). These macroscopic observations have substantial education relevance as they provide students with visual indicators of genuine changes thus allowing them to make an intuitive relation of these chemical changes (Murlida etal., 2022).

The emphasis of investigation is of rather submicroscopic character, including the interrelations of molecules and of the microbiological processes which take place during fermentation. Being a fermented food shrimp paste depend much on the role played by lactic acid bacteria (LAB). Studies have shown that Lactobacillus species (Lactobacillus plantarum and Lactobacillus paracasei) are dominantly present in belacan. These bacteria metabolize proteins and carbohydrates into lactic acid as well as convert it into other compounds via series of biochemical reactions (Ilyanie et al., 2023; Muzaifa et al., 2023). Such a mechanism can be sketched by the elementary reaction in Figure 5.



Glucose $C_6H_{12}O_6$ Lactic Acid $C_3H_6O_3$

(Helmi et al., 2022)

Figure 5. Reaction of fermentation (glucose change to lactic acid)

This reaction represents the conversion of glucose to lactic acid in fermentation; this is the substantial factor for the typical taste and flavor of shrimp paste.

On the other hand, the symbolic component of chemistry is the employment of symbols and equations to depict the reactions. During shrimp paste fermentation, not only lactic acid is produced but protein is converted, which is catalysed by protease enzymes produced by LAB, to peptides and amino acids (Muzaifa et al., 2023). This chemical representation not only illustrates the micro-level processes of fermentation but also provides a symbolic foundation that enhances students' understanding. These chemical equations are essential for explaining how biochemical components change during fermentation (Ilyanie et al., 2023).

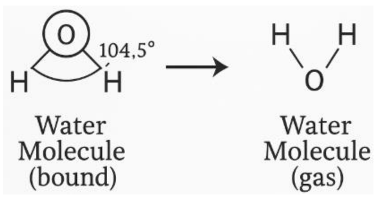
According to the interview results, it was found that "aging for too long causes decay, and the longer it decays, the more maggots will appear, making it impossible to process into shrimp paste. If the fermentation process is too fast, the shrimp paste will not taste good because the decay process is insufficient. If the fermentation process is too long, the shrimp will rot, affecting the taste and making the shrimp paste bitter" (Interview quotes with Mrs. N & Mrs. S).

This aligns with scientific explanations that the fermentation process of *belacan* involves a series of chemical reactions that alter the chemical composition of the raw materials (Liu et al., 2022). In chemistry education, the phenomenon of decay can be used to teach chemical decomposition reactions and biochemical processes in food. Students can explore how the chemical compounds formed during decay affect the organoleptic qualities (taste, smell, texture) of products. This discussion can then be expanded to include topics on acid-base reactions and redox reactions in both fermentation and decay processes."

e. Sun Drying

l Macroscopic characteristics are reflected in the physical alterations of the shrimp paste during the sun-drying method. Quantifiable changes on the color and texture and aroma of the finished product can be visually demonstrated to students to compare between sun-dried and un-sun-dried products. Decreasing moisture, the moisture not only improves the flavor of the product as well as the shelf stability of the product, but also contributes to the texture changes that occurred in the shrimp paste, making it drier and harder, providing for better possibilities to use in several products (Dolgun e t al., 2020; López et al., 2016). Products dried by optimal sun drying with >2 hours average sunlight exposure are better in quality than those dried by other drying method (Karnilawati et al., 2023).

The submicroscopic phenomena in the sun-drying stage are closely connected with molecular activities that increasing evaporation of water and dehydration are taking place. This drying procedure aims to considerably minimize spoilage microorganisms and spoilage-causing enzymes (Cáceres et al., 2017; Saha et al., 2022). For instance, the wet fermentate products can allow the growth of disease-causing bacteria. Thus, sun-drying, which creates a low moisture product, is necessary to ensure safety and the overall shelf life of the product. At the submicroscopic scale, this water evaporation can be described by the following reaction as the evolution of H_2O molecules from the shrimp paste structure (Figure 6).

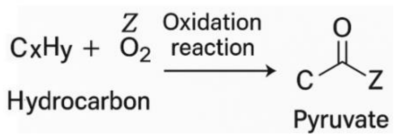


H_2O *(l)* H_2O *(g)*

(Saha et al., 2022)

Figure 6. Reaction of release water molecules

The symbolic aspects of the drying process can be explained by representing dehydration reactions through chemical and symbolic equations. Students are taught to translate observations into equations that describe more complex processes in Figure 7.



(Sarkar et al., 2021)

Figure 7. Reaction of oxidation

The elements C, H, and O represent carbon, hydrogen, and oxygen in the organic compounds that make up the proteins and fats in *belacan*, while Z indicates the number of water molecules lost during drying. By understanding these symbols, students not only learn about the chemical reactions taking place but also their broader impact on product quality and consumer perception.

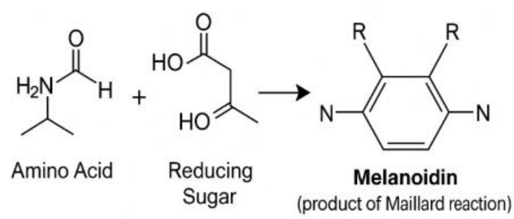
According to the local community, "Drying depends on the weather and the thickness of the shrimp paste. If it is thick, one day is not enough to dry the shrimp paste, even in hot weather. It takes at least 2-3 days. If the shrimp paste is not dried properly, it will rot and attract worms and flies, resulting in failure in the *belacan* production process" (Interview quotes with Mr. K & Mrs. S).

The drying process mentioned in the interview can serve as teaching material for food chemistry practical, where students can conduct experiments to observe the effect of material thickness and weather conditions on drying quality. In this experiment, students can measure the moisture content of food products at various stages of drying and observe its impact on product quality. Sun-drying is effective in reducing moisture levels to a safe threshold for preservation. Air temperature and sunlight intensity play significant roles in the drying process. Higher temperatures accelerate water evaporation, while strong sunlight helps the drying process occur more evenly.

f. Heating Over Fire

The physical changes in the shrimp paste upon heating are visibly discernible at a macroscopic level. This allows students to see that the color changes from light to dark, sometimes even black in some cases and demonstrates the characteristic smell. Moreover, an oil layer can be generated on the surface of the shrimps paste, promoting a better appearance and extended shelf life (Negrete-Romero et al., 2021). This aids students to appreciate the effect of heat from boiling on the appearance and sensory qualities of shrimp paste.

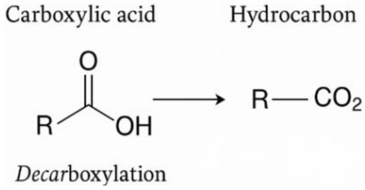
At the level of the submicroscopic, cooking shrimp paste on a fire leads to chemical reactions at the molecular level. The proteins in the shrimp paste are denatured during heating, causing a change in their physical structure (Melini et al., 2019). This also triggers the Maillard reaction in which amino acids and reducing sugars react causing a non-enzymatic browning to occur, forming the new molecule melanoidin, which is responsible for the color and taste of the shrimp paste. This process can be depicted as shown in Figure 8.



(Hansen, 2018)

Figure 8. Reaction of maillard

This reaction shows that thermal effect and the heating time significantly affect the shrimp pastes final quality. With the symbolic dimension is aimed at modeling the chemical transformations during heating. Decarboxylation reactions Besides the Maillard reaction, decarboxylation reactions can occur, and they are illustrated in Figure 9.



(Deveci et al., 2023)

Figure 9. Reaction of decarboxylation

This reaction accounts for the carbon dioxide evolved at elevated temperatures, effecting the aroma and the taste of the final shrimp paste. The use of chemical equations and symbols is essential to help students understand the chemical mechanisms behind this traditional process.

In the latter part of this stage, interviewees reported that, "If you don't put it over the fire, it won't be [good] for long. Heating on open fire is to prolong its shelf life. However, it still requires sun-drying, as even with the aid of fire, the process would be challenging and time-consuming. Shrimp paste can be kept up to a month if it's not kept in the refrigerator" (Interview quotes with Mr. K & Mr. A).

Science tells us that cooking your shrimp paste over fire dries out even more moisture from leftover sun-dried shrimp. This inhibits spoilage microorganisms and prolongs the shelf life of the shrimp paste. The direct heat exposure, leads to volatile compound formation that gives flavor and aroma to the shrimp paste. By applying heat over fire, the paste becomes harder and denser, meeting the needs of an end product. Due to this firm texture, packaging is easier (Dewi et al., 2020).

The heating fire is not at all any simple physical process; various chemical reactions are responsible and these must be learnt by students to admire this kind of traditional way of making food (Kano et al., 2012). In laboratory exercises students may gain experience in food treatment and learn some chemical principles of protection of food. This may also inspire students who will have to struggle to grasp the interdependence of all physical processes and chemical reactions leading to safe food of high quality.

4. Integration into Chemistry Education

The inclusion of ethnoscience in chemistry teaching can be a relevant means of constructing meaning to the school sciences through cultural practices. The results of this study illustrate how the indigenous production practices of traditional shrimp paste (*belacan*) in the Meranti Islands could be used as a meaningful context to facilitate students' learning on chemical phenomena. Each operation that forms part of the production, sorting, fermentation, sun-drying and heating, manifests transformations and interactions which are consistent with the three forms of chemical representation categorized by Johnstone (1982) as 'macroscopic', 'submicroscopic', 'symbolic'.

Through engaging local knowledge in formal Science, students are able to grow in their concept construction and scientific literacy. On the macroscopic level, students can see color, texture, and aroma changes on food; on the submicroscopic level, participants discover molecular interactions, enzymatic reactions, and microbial work; and on the symbolic level, learners can represent those processes using chemical equations and reaction models. This kind of alignment facilitates the process of cognitive development and promotes the ability to shift amongst representations, a critical skill in chemistry learning.

This strategy is in line with what is required under the Merdeka Curriculum that promotes contextual inquiry learning that is based on the community and learners' sociocultural context. Inclusion of The Local Tradition in the curriculum not only can enhance the chemistry learning but also can support the nation prosperity, cultural identity and sensitivity of the sustainability. Traditional knowledge systems can be scientifically validated and can be good educational resources as shown in this study. In this regard, the inclusion of an ethnoscience perspective in chemistry education accomplishes not only an improvement of content mastery, but the development of a culturally-relevant pedagogy capable of connecting indigenous wisdom with current science.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Theres the stage of shrimp paste or *belacan* in Meranti Islands Regency is local wisdom, the inheritance of the process of producing traditional fermented shrimp paste in Meranti Islands Regency is a view heritage of the traditional society with a high value of local wisdom which is contain strong scientific elements, especially in Chemistry. Every step of production from sorting and washing, crushing, molding, fermentation, drying, to heating over a fire involves chemical reactions that can be analyzed through three levels of approach: macroscopic (visual changes such as color and texture), submicroscopic (interactions between molecules and microorganisms), and symbolic (representation in the form of chemical reactions). The application of these three dimensions in ethnoscience-based chemistry education provides a learning experience that is relevant to the cultural context of students, while contributing to the preservation of local culture and the improvement of comprehensive scientific literacy. Through this study, it was also obtained that the knowledge of the community that has been passed down from generation to generation is in line with scientific knowledge obtained from literature review.

Suggestions

The suggestions that can be given are the traditional process of shrimp paste production in the Meranti Islands Regency be further explored as a valuable resource for contextual science education. Educators should consider incorporating this local wisdom into chemistry instruction, particularly to highlight chemical and biological reactions occurring in everyday cultural practices. This approach not only enriches science learning through ethnoscience integration but also plays a crucial role in preserving cultural heritage. Future collaborative efforts between teachers, cultural practitioners, and researchers are encouraged to expand the development of locally grounded educational materials that promote both scientific literacy and cultural identity.

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