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Science in Samin: Reconstructing Indigenous Knowledge of the Samin Community into Chemical Concepts for Contextualized Education

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Abstract: Chemistry is often perceived as abstract and disconnected from students' everyday lives. To address this gap, this study aims to identify indigenous knowledge within the Samin community of Blora Regency, Indonesia, and reconstruct it into formal chemical concepts to support contextualized chemistry education. A descriptive qualitative method was employed using an ethnographic approach, with data collected through interviews, observations, documentation, and literature review. The study focused on four traditional practices: Sambongrejo Samin batik making, Kareman tempeh fermentation, Wedang Cangruk herbal drink preparation, and Etawa goat farming. Each practice reflects chemical principles, including polymers, acid–base reactions, thermochemistry, fermentation, redox reactions, and environmental chemistry. The findings reveal that these cultural activities contain valuable scientific elements that can be integrated into chemistry curricula. The study concludes that reconstructing indigenous knowledge into scientific understanding enhances students' engagement and scientific literacy while promoting cultural appreciation. This research contributes to science education by providing a model for ethnoscience-based instruction, linking local wisdom with modern scientific frameworks, and supporting the development of culturally responsive and sustainable chemistry education.

Keywords: *chemical concepts; indigenous knowledge; indigenous science; samin community*

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INTRODUCTION

Chemistry is often perceived as an abstract, difficult, and isolated discipline from cultural and social dimensions (Rahmawati et al, 2017; Tawanda & Mudau, 2023; Chamizo & Ortiz-Millán, 2024). This perception reinforces the impression that chemistry is irrelevant to everyday life. Many traditional practices are also based on chemical principles and can be scientifically explained (Domenici & Chiocca, 2024). Therefore, chemistry education should not be confined to abstract theories but should emphasize real-life applications (Olude et al., 2024). One effective approach is to integrate local culture through ethnoscience, offering students more concrete, contextual learning experiences (Nurcahyani et al., 2021; Dewi et al., 2021). Previous studies have identified chemical concepts in traditional practices, including tempeh fermentation (Tamang et al., 2022), traditional medicine (Sumarni et al., 2022), and batik dyeing (Tresnawati et al., 2020). Suppose conventional wisdom is still alive in society and can be transformed into a more formal scientific form (Sudarmin et al., 2024). Incorporating local wisdom into scientific studies can significantly improve science education (Sumarni, 2018).

Despite extensive research on ethnoscience, little attention has been given to the indigenous knowledge of the Samin community in Blora Regency, Central Java, Indonesia. The region is notable for its natural resources and cultural heritage (Tohop et al., 2024). Geographically, Blora Regency is located in the eastern part of Central Java Province, covering 5.59% of the province's area. The Samin people, known for their philosophy of simplicity, honesty, and harmony with nature, preserve unique cultural practices that remain underexplored in relation to chemistry education (Rudianto et al., 2024). Sambongrejo Village, a designated Samin tourism village, offers a comprehensive view of Samin community life, including traditional arts, customs, and culinary practices (Kurniawati & Imawati, 2022). The Sambongrejo Samin Tourism Village offers educational experiences on various aspects of Samin community life, including traditions, customs, arts, and local wisdom. Among these are Sambongrejo Samin batik production, Wedang Cangruk herbal drinks, Kareman tempeh fermentation, and Etawa goat farming. It all of which holds educational and scientific value. Prior studies have demonstrated the presence of various chemical concepts in traditional practices, such as palm sugar production (Rayis et al., 2023), Troso woven fabric dyeing (Khusniati et al., 2023), and the identification of Indigenous community science as scientific knowledge in ethnomedicine (Sumarni et al., 2019).

Integrating Samin's local culture into chemistry instruction will enrich learning materials and make the experience more engaging and meaningful for students. Through this approach, students can see the direct application of chemical concepts in real life and their local culture, thus facilitating understanding and increasing their involvement in the learning process (Zidny et al., 2021). However, scientific studies on the relationship between Samin culture and chemistry remain limited and poorly documented. Identifying chemical concepts in Samin culture opens opportunities to integrate this knowledge into school chemistry learning. Especially nowadays, there is an urgent need to explore this knowledge before it is eroded by modernization (Sumarni, 2018). Therefore, support from various parties is needed to convert this (Anzalina et al., 2024).

Integrating Samin's local wisdom into chemistry learning is achieved by exploring and reconstructing the community's indigenous knowledge into chemical knowledge. This integration is expected to produce students who can apply science concepts and link various science materials to existing science knowledge in society, thereby improving students' science literacy (Sumarni, 2021). Science literacy is the key to understanding various aspects of science, ranging from issues arising in everyday life and the risks and benefits to the nature of science, including its relationship with the surrounding culture (Fasasi, 2017). Chemical literacy encourages learning science and technology and applying it to understand and appreciate nature as an invaluable source of learning (Ploj, 2022). This study aims to identify indigenous knowledge embedded in the cultural practices of the Samin community and reconstruct it into formal chemical concepts to support contextualized chemistry education. By doing so, the research seeks to bridge traditional wisdom with scientific understanding, fostering culturally relevant and meaningful learning experiences (Sumarni, 2021).

METHODS

This study employed a descriptive qualitative research design with an ethnographic approach to explore and reconstruct the indigenous knowledge of the Samin community in Blora Regency, Indonesia. The ethnographic method was selected for its ability to capture cultural meanings, social interactions, and tacit knowledge through direct observation and participation (Spradley, 1980). The research was conducted in three stages: 1) preparation; 2) data collection and processing, and 3) analysis and interpretation. The research flow is illustrated in Figure 1.

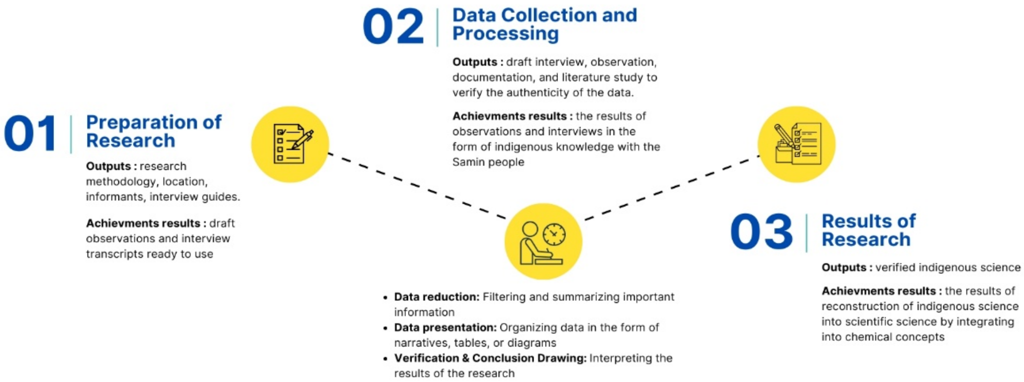


Figure 1. Research Flow

The ethnographic approach followed Spradley's (1980) model, including participant observation, interviews, documentation, and cultural artefact analysis. This approach enabled the researcher to uncover lived experiences and tacit knowledge embedded within community practices. Participants were selected purposively based on their involvement in preserving Samin cultural practices. Five key informants from the Sambongrejo Samin community, aged 30 to 80, were included. They consisted of PG (male, 60), Head of the Samin Sambongrejo Customary Council; PR (female, 40), LS (female, 50), LR (female, 70), and KR (female, 80), all of whom are native residents actively engaged in maintaining Samin traditions and local wisdom.

During the preparation phase, the researchers developed the research methodology, selected Sambongrejo Village as the study site, identified key informants, and designed semi-structured interview guides. Data were collected using multiple techniques to ensure credibility and enable triangulation. These included direct observation of traditional Samin practices such as batik production, food fermentation, and livestock management; in-depth interviews employing open-ended questions to uncover tacit knowledge and its cultural significance; and documentation in the form of photographs, field notes, and cultural artefacts to provide contextual evidence. Additionally, literature triangulation was conducted by examining local archives and prior ethnoscience studies to support data interpretation and deepen analysis.

Data were analyzed using thematic coding following Miles and Huberman's (1994) framework: data reduction, data display, and conclusion drawing. Relevant ethnoscientific phenomena were filtered, organized into Tables 1-4, and mapped onto chemical concepts. To ensure credibility, the study employed triangulation (data sources, methods, theories), member checking (informant validation), and peer debriefing with chemistry education experts. Finally, indigenous practices were aligned with core chemistry topics (e.g., acid–base, thermochemistry, redox) to produce a scientific narrative for culturally responsive chemistry instruction.

RESULT AND DISCUSSION

This research identified various chemical concepts embedded in the traditional practices of the Samin community, which were subsequently synthesized into a scientific understanding applicable to chemistry learning. Here are some examples of integrating Samin's local knowledge into chemistry concepts:

Table 1. Reconstruction of Indigenous Science into Scientific Science and its Integration into Chemical Concepts in Sambongrejo Samin Batik Making

Process	Indigenous Knowledge	Indigenous Science	Chemical Concepts
Fabric selection	*Primis* and *prima mori* fabrics differ in quality and texture	The fabric used in batik production contains various polymer compounds (Sudarmin et al., 2020). Primisima mori is a high-quality, bleached plain-weave fabric with finer yarns (Tex 9.0–10.2), while prima mori has slightly coarser yarns (Tex 12.3–15.5) and a lighter weight (85–100 g/m²) (Murwati, 2005; Rumiyati et al., 2022).	Polymer
Dyeing process	Wax is applied using a canting tool heated on a stove	A canting is a pen-like tool used to collect molten hot wax. A canting tulis/cap is made of copper/copper (Cu), a conductor metal (Izza & Indyah, 2019). Wax melts upon heating due to heat transfer until thermal equilibrium is reached, while vapor flow aids the upward movement of hot air from the heat source (Wijaya et al., 2024).	Chemical elements Thermochemistry
Coloring process	Applying Remazol dyes, the wax-resist technique	Remazol dyes, as synthetic compounds with reactive groups, form covalent bonds with fibers. Their aqueous solutions are polar and thus immiscible with the nonpolar wax, following the 'like dissolves like' principle (Izzah et al., 2020). Remazol dye powders dispersed in water form a sol-type colloid, with dye particles as the dispersed phase. These colloids cause turbidity in batik wastewater due to suspended residues (Soedjono et al., 2021)	Chemical bond Colloid
Fixation process	Using *water glass* (sodium silicate) to lock the color	Color fixation involves metal-containing agents that form coordination complexes with dye molecules, rendering them water-insoluble. Variations in fixative composition can result in different color outcomes (Izzah et al., 2020). Waterglass, or sodium silicate (Na_2SiO_2), is synthesized from silica sand and sodium carbonate and is commonly used as a fixative in textile processing (Allali & Bella, 2024)	Chemical bond Chemical compound
Wax Removal Process	Boiling fabric in hot water with soda ash	Wax removal requires adequate heat, typically achieved by immersing the fabric in hot water, to melt and detach residual wax from the surface (Izzah et al., 2020). Soda ash (Na_2CO_3), a water-soluble alkali, aids wax removal by loosening fabric tension and increasing wax solubility, thus revealing the batik motif more effectively. (Izza et al., 2019). When dissolved in water, soda ash (Na_2CO_3) forms an alkaline solution by hydrolyzing to produce OH^- ions, as shown in the following reaction: $CO_3^{-} + 2H_2O \rightleftharpoons H_2CO_3 + 2OH^{-}$	Thermochemistry Chemical compound Acid-base
Drying process	Fabric is sun-dried and aerated outdoors.	Sun drying is a traditional method in which moisture evaporates as water vapor. The drying rate is influenced by air temperature, fabric properties, airflow, and surface area (Gluesenkamp et al., 2021).	Thermochemistry

Table 2. Reconstruction of Indigenous Science into Scientific Science and its Integration into Chemical Concepts in Kareman Tempeh Making

Process	Indigenous Knowledge	Indigenous Science	Chemical Concepts
Material preparation	Using imported soybeans and wrapping with teak leaves.	Soybean (*Glycine max (L). Merr.*) is a legume from the Fabaceae family, which is well-suited for tempeh production due to its high nutritional value and phenolic compounds with antioxidant and antimutagenic properties (Romulo & Surya, 2021; Haliza et al., 2016; Zhang et al., 2021).	Macromolecules
		Teak leaves provide natural aeration and moisture retention, creating optimal conditions for mold growth. Adequate oxygen circulation stabilizes humidity and temperature, ensuring proper fermentation (Bharadwaj et al., 2021).	Reaction rate
		Teak leaves contain pigments such as anthocyanins, which act as antioxidants and natural pH indicators. Young leaves also contain pheophytin, carotene, pelargonidin, chlorophyll, and other anthocyanin derivatives (Wahyuni et al., 2020; Suryanti et al., 2020).	Acid-base
	Tempeh yeast is used to speed up tempeh's cooking time.	Yeast initiates tempeh fermentation by producing hyphae that bind soybeans into a compact, white mass. Enzymes such as amylase, secreted by *Rhizopus oligosporus*, drive the biochemical transformation (Benabda et al., 2019).	Fermentation
Soaking Process	Soaking soybeans aims to make them soft and not sour.	Soaking softens the soybean structure, facilitates skin removal, and promotes hydration. This process also initiates mild lactic acid fermentation, creating an acidic environment suitable for fungal growth (Darmajana, 2012; Atmojo, 2012).	Biochemistry
Cutting process	Beans are halved before cooking	Cutting soybeans increases surface area, enhancing heat transfer during boiling and accelerating fermentation by increasing the frequency of molecular collisions (Surya, 2024)	Reaction Rate
Boiling Process	Boiling soybeans still uses dry forest firewood to ensure even cooking.	Wood fuel combustion, involving the oxidation of cellulose, hemicellulose, and lignin, is a redox reaction that produces CO_2, H_2O, heat, and ash. The reaction below illustrates complete combustion. $C_6H_{10}O_5 + 6O_2 \rightarrow 6CO_2 + 5H_2O$ + heat Moisture in wood affects its physical properties and can influence combustion efficiency (Ardhana et al., 2023).	Redox Reaction
Fermentation Process	Adding yeast before wrapping and storing for days	Fermentation involves *Rhizopus* spp. converting complex substrates into simpler compounds under anaerobic conditions. Mixing tempeh starter into soybeans initiates the growth of white mycelium, forming a compact structure. The process also releases CO_2 and ethanol as byproducts (Sun et al., 2022)	Chemical Reaction Equations

Table 3. Reconstruction of Indigenous Science into Scientific Science and Its Integration into Chemical Concepts in Wedang Cangruk Distinctive Drinks

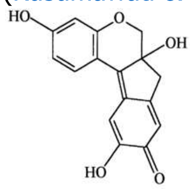
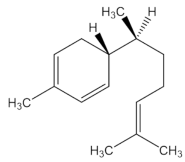
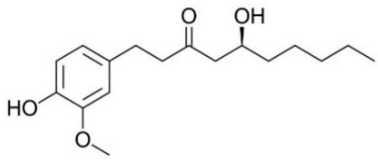
Process	**Indigenous Knowledge**	**Indigenous Science**	**Chemical Concepts**
Ingredient selection	Using ginger, lemongrass, sappan wood, pepper, and cinnamon	The ingredients of *Wedang Cangruk*—such as ginger, lemongrass, and cinnamon—contain antioxidant compounds including gingerol, shogaol, brazilin, and various terpenoids. Sappan wood contributes red pigments via compounds such as brazilin, saponins, tannins, and gallic acid (Kusumawati & Muslim, 2019).  Brazilin  Zingiberen  Gingerol	Chemical Compounds
	Red color from sappan wood	Sappan wood has the scientific name *Caesalpinia sappan* L. It turns red when placed in water (Vij et al., 2023). Sappan wood can be used as an indicator label because it is readily soluble in water and exhibits a distinctive colour at a specific pH. Sappan extract with a pH value of 5 is yellow (Kurniawan et al., 2023).	Acid-Base
Boiling Process	Boiled with water until the aroma and color are extracted	The ingredients are boiled together, enabling heat transfer and extraction of bioactive compounds. This process is exothermic and enhances the release of antioxidants and flavor compounds (Kumar et al., 2021; Wijaya et al., 2024)	Thermochemistry
Separation Process	Filtered, and sugar is added while still hot.	The dissolution of active compounds from ginger, lemongrass, and sappan wood into boiling water represents a solvent extraction process, followed by filtration to separate solid residues from the extract (Sumarni et al., 2022) Sugar solubility increases with temperature, allowing it to dissolve more rapidly and uniformly in hot or warm water (Astuti et al., 2022).	Chemical Separation Chemical Solutions

Table 4. Reconstruction of Indigenous Science into Scientific Science and its Integration into Chemical Concepts in Etawa Goat Farming

Process	Indigenous Knowledge	Indigenous Science	Chemical Concepts
Food Process	Goats are fed with lamtoro leaves instead of grass	*Leucaena leucocephala* (lamtoro) leaves, rich in protein and energy, are used as the primary feed due to their nutritional efficiency and availability (Mandey et al., 2015; Dilaga et al., 2022).	Macromolecules
Processing Process	Goat manure is used as an organic fertilizer in rice fields. It is usually used to grow corn.	Livestock manure is rich in essential nutrients (e.g., N, P, K, Ca, Mg, S, Fe, Cu) that support plant growth and soil fertility. Unlike chemical fertilizers, organic manure provides a prolonged nitrogen release, enhancing nutrient retention in soil (Ahn et al., 2021; Zhou et al., 2022).	Chemical Elements
	Goat manure is hard and hot, which can damage plants. Burn it first until it is dry and crushed. Usually, dung burning is mixed with the rest of the goat's food stalks and is called pediang.	Fresh goat manure contains high levels of ammonia (NH_3), making it 'hot' and potentially harmful to plants. Fermentation reduces toxicity and enhances nutrient availability. Phosphorus levels can be increased by adding organic sources such as shells, bones, or wood ash (Sun et al., 2018).	Chemical Compounds
		Decomposition during composting enables dynamic equilibrium, gradually releasing nutrients for plant uptake. Factors influencing decomposition include fertilizer type and particle size, microbial activity, soil moisture, nutrient content (N, C, K, P), pH, temperature, and aeration (Rao & Subba, 1994; cited in Astuti, 2005).	Chemical Equilibrium
Maintenance Process	The goat barn is like a house on stilts, so the floor is clean and does not get dirty quickly.	Ground-level livestock cages increase the risk of disease due to moisture accumulation. Elevated cages improve sanitation by allowing waste to fall through, reducing dampness and limiting the growth of pathogens, parasites, and fungi (Fikri et al., 2020).	Chemical Environment

This research was conducted on the Samin people in Sambongrejo Village, Blora Regency. Blora Regency is one of the regencies in Central Java Province, located in the limestone mountains and directly adjacent to East Java. One of the local cultures in Blora is that of the Samin people. Geographically, Sambongrejo Village is located in the eastern part of Blora Regency, specifically in Sambong District, Central Java Province. Figure 2 shows an area of about 21.84 km^2 on the map. Since its establishment in 2018, Sambongrejo Village has become a famous developing tourism village in Blora Regency. One of this village's main attractions is the *Sedulur Sikep* Literacy Village, also known as Samin Village.

Figure 2. Location Map of Samin Sambongrejo Village,
Blora Regency, Central Java, Indonesia

The community in Sambongrejo Village is identical to "*Sedulur Sikep Samin*". The name "*sikep*" means teaching, referring to ancient Javanese teachings. The "*sikep*" teaching implies that humans must know right from wrong, or good from evil. The culture of honesty, harmony, and kindness is always preserved in the daily life of the Sambongrejo Samin community. The village's indigenous people jointly manage Sambongrejo Tourism Village. Sambongrejo Tourism Village has the vision to build a creative, advanced, and cultured community. As well as the mission of realizing a safe, orderly, clean, calm, beautiful, friendly, and memorable environment; increasing tourism potential in all fields; and increasing the role of the Sambongrejo Village community in the development of Sambongrejo Tourism Village.

This research explores and reconstructs the community's indigenous knowledge into scientific knowledge. Based on interviews and in-depth observations of various informants, this study reveals the chemical concepts embedded in Samin's local culture. The local wisdom explored includes making Sambongrejo Samin Batik, Kareman Tempeh speciality food, Wedang Cangruk speciality drinks, and cultivating Etawa goats. The results of informant interviews were identified to show whether each conversation involved chemical concepts. The Sambongrejo Samin Batik is distinguished by motifs that reflect the local environment and cultural identity of the Samin community. These include teak leaf patterns, representations of agricultural products such as rice, corn, and cassava, and the Garuda symbol (see Figure 3). The prominence of teak leaves in the design is rooted in the geographic reality that the surrounding forested areas are extensively planted with teak trees. Meanwhile, the inclusion of harvest motifs symbolizes the community's agrarian way of life, where farming is the primary livelihood and nature plays a central role in sustaining daily needs.

The emergence of batik production in Sambongrejo serves as an alternative economic activity, complementing traditional farming and providing an additional source of income for the community. To preserve the cultural authenticity of Samin Batik, the batik-making process is integrated into daily life, typically carried out alongside farming duties. As a result, production levels tend to fluctuate seasonally, declining during the rainy season due to increased agricultural workload, and rising during the dry season when farming activities subside. Batik production is conducted collectively, without hierarchical labor divisions, underscoring the Samin values of egalitarianism, cooperation, and social harmony. This communal approach reinforces cultural cohesion and ensures the transmission of traditional knowledge through shared practices.

Figure 3. Examples of Typical Motifs of Sambongrejo Samin Batik

An informant, identified by the initials LS, who is the owner of "Omah Batik Samin Sambongrejo," provided detailed insights into the complete batik production process, from the initial to the final stages. According to ethnographic inquiry, two main types of batik are produced in Sambongrejo: *hand-drawn batik* (*batik tulis*) and *stamped batik* (*batik cap*). The primary materials used in the batik-making process include batik wax, synthetic dyes, sodium silicate (commonly referred to as waterglass), soda ash, and water. The tools employed include a canting (a traditional pen-like tool for wax application), metal caps (for stamping), a wok for melting wax, an electric stove, foam brushes, and large pots for dyeing.

Q : "What is the first step to prepare?"
LS : "Fabric selection….. written batik uses primis type fabric because the material is smoother, if printed batik uses prima type fabric......."
Q : "What type of coloring is used?"
LS : "..... coloring using dye powder ..... mixed with water, ... the name is Remazol."
Q : "How is the process of making this batik?"
LS : "Written batik is usually designed first. .... is dyed using wax/night. .... is colored using the technique of smearing the color a little bit. .... finished coloring is left for two days and then dyed in a water glass, hung overnight so that it drops, then just boiled with boiling water and a little soda ash mixture ..... after that, it is dried in the sun."
Q : "Why do you use soda ash?"
LS : "To make it quick……"

The information provided reflects the community's indigenous knowledge, rooted in lived experience and transmitted through practice. The complete batik production process as practiced in Sambongrejo is illustrated in Figure 4.

(A) **(B)** **(C)** **(D)**

Figure 4. (A) The batik canting process, (B) Coloring process, (C) Fixation and wax removal process, (D) Researcher with Mrs LS (Samin Sambongrejo Batik Maker)

The interview excerpt reveals that the informant possesses in-depth and practical knowledge of the batik-making process in the Sambongrejo Samin community. A critical initial stage in the process is fabric selection. *Primis* fabric is preferred for hand-drawn (*batik tulis*) due to its smoother texture, while *prima* fabric is commonly used for stamped (*batik cap*) techniques. The informant demonstrates familiarity with the use of Remazol, a synthetic dye widely used in modern batik production. The batik-making process begins with determining the motif or pattern, followed by wax application using a *canting* for hand-drawn batik, or a pre-made metal stamp for stamped batik, as illustrated in Figure 5. After dyeing, a fixation process is carried out by immersing the fabric in a sodium silicate (waterglass) solution overnight. This step ensures the durability of the colors.

The next stage involves removing the wax through a boiling process in hot water mixed with soda ash, which acts as a color fixative and helps detach residual wax and sodium silicate from the fabric. The dyed fabric is then suspended on bamboo racks to allow excess solution to drip off naturally. The final drying stage is conducted under direct sunlight but under controlled conditions to prevent color distortion from excessive heat. Challenges identified in the batik production process include a shortage of labor and limited time availability, particularly during the wax-removal stage. This step is labor-intensive, as the sodium silicate residue strongly adheres to the fabric, requiring substantial physical effort to eliminate.

Figure 5. Motif of Sambongrejo Samin Batik Stamp

The production of Sambongrejo Samin Batik provides valuable insights into the materials, tools, and processes involved in traditional batik-making. This indigenous knowledge serves as a foundation for reconstructing scientific understanding, particularly from a chemical perspective. Each step—ranging from fabric selection, dyeing, fixation, wax application, to drying—reflects underlying chemical concepts such as solubility, phase changes, dye-substrate interactions, and thermal decomposition. Table 1 summarizes the reconstruction of indigenous knowledge into scientifically interpreted stages based on interviews and observational data. This reconstruction demonstrates how local practices can be systematically analyzed through the lens of chemistry, offering opportunities for integration into ethnoscience-based chemistry education. Such integration promotes contextual and culturally responsive learning, enhancing students' engagement and chemical literacy while fostering appreciation for local cultural heritage.

The traditional batik-making process in the Sambongrejo Samin community reflects embedded chemical concepts that align with formal scientific understanding. The selection of primisima and prima mori fabrics reveals a localized understanding of polymer characteristics, where primisima's fine, dense weave facilitates smoother wax application and better dye absorption, consistent with its cellulose polymer content (Murwati, 2005; Rumiyati et al., 2022). The use of canting tools for wax application introduces principles of thermochemistry, specifically heat transfer and phase change (Wijaya et al., 2024). The dyeing process with Remazol dyes, which involves covalent bonding with fabric fibers and colloid formation in aqueous systems, reflects the application of chemical bonding, polarity, and colloid chemistry (Izzah et al., 2020; Soedjono et al., 2021). Fixation with waterglass (sodium silicate) promotes coordination complex formation (Allali & Bella, 2024), while wax removal using soda ash illustrates base hydrolysis and the practical applications of acid-base reactions (Izza & Indyah, 2019). These stages collectively showcase how indigenous batik-making serves as a culturally grounded platform for teaching thermochemistry, colloids, and acid-base concepts in chemistry classrooms (Sudarmin et al., 2020; Izzah et al., 2020).

Observations indicate that *Kareman Tempeh* is a traditional food product made by members of the Sambongrejo Samin community and is preserved through generational practice. Its distinctive feature lies in its preparation method, which uses *godhong jati* (teak leaves) instead of modern packaging materials, reflecting a commitment to traditional ecological knowledge (see Figure 6). The term *"kareman"* is derived from the Javanese language, meaning "favorite" or "something highly favored." This name reflects the cultural significance of Kareman Tempeh as a preferred daily food item and a special dish served during traditional ceremonies and social gatherings. Its continued production not only highlights the community's culinary heritage but also serves as a medium for cultural identity and sustainability.

(A) (B) (C) (D)

Figure 6. (A) Soaking soybeans, (B) Fermenting soybeans, (C) Wrapping soybeans with teak leaves, (D) Researcher with KR (Kareman Tempe Maker)

Q : *"What are the characteristics?"*
PR (1) : *"…….. it is different, I think it tastes different and better, especially since the wrapper uses teak leaves."*
KR (2) : *"…..this wrapper uses teak leaves."*
Q : *"How is the manufacturing process from start to finish?"*
KR (2) : *"The process starts with soaking soybeans for one night, then cooking them, separating them from their skins, soaking them a second time, adding yeast, and finally wrapping them in teak leaves. ……. five-day process*

Based on the interview excerpt, KR (2), a producer of *Kareman Tempeh*, described the complete production process. It begins with soaking soybeans overnight to soften the beans, facilitate skin removal, and reduce antinutritional compounds. The soybeans are then boiled, peeled, and mechanically halved using a local device known as a *selep*. A second overnight soaking is performed to prevent sourness during fermentation. After draining, the soybeans are inoculated with tempeh starter and wrapped in teak leaves (*godhong jati*). The wrapped beans are incubated in an environment with optimal temperature and humidity. Fermentation typically takes three days, resulting in tempeh with a distinct teak aroma, solid texture, and a white mycelium structure evenly covering the surface.

The making of Kareman Tempeh is not merely a traditional practice but also represents Indigenous knowledge that can be reconstructed into scientific understanding. Table 2 presents the reconstruction of this Indigenous knowledge into scientific terms, highlighting relevant chemical concepts derived from interviews and observations. As shown in Table 2, each stage, from raw material selection, soaking, and boiling to fermentation, involves key chemical principles such as protein denaturation, enzymatic activity, microbial fermentation, and environmental conditions affecting microbial growth. This transformation of traditional practices into scientific knowledge serves as a valuable foundation for integrating ethnoscience into chemistry education. By applying an ethnoscience approach, the chemical concepts underlying the making of Kareman Tempeh can be contextualized, making learning more relevant to students' daily lives. Such integration not only deepens students' understanding of chemical phenomena but also fosters awareness of the dynamic interaction between culture and science.

The preparation of Kareman Tempeh reveals how indigenous food processing embodies biochemical and microbial concepts. The soaking and boiling stages soften the soybeans, initiate hydration, and promote protein denaturation (Romulo & Surya, 2021). Wrapping in teak leaves, rich in anthocyanins, not only provides a favorable environment for mold growth but also introduces a natural pH indicator system (Wahyuni et al., 2020; Suryanti et al., 2020). Fermentation driven by *Rhizopus oligosporus* demonstrates the application of enzymatic activity, reaction rate, and redox reactions in a natural setting (Benabda et al., 2019). This process can be directly connected to reaction kinetics and biochemical transformations relevant to the curriculum. By reconstructing these traditional methods, educators can contextualize topics such as macromolecules, acid-base chemistry, and fermentation to enhance students' engagement with everyday science (Sun et al., 2022).

The findings reveal that *Wedang Cangruk* serves as a customary welcome drink in the Sambongrejo Samin community. The name *"cangruk"* originates from the Javanese term meaning "to sit and chat," reflecting its social function in encouraging casual conversation among guests. As a culturally rooted herbal beverage, *Wedang Cangruk* is prepared using natural ingredients such as ginger, lemongrass, sappan wood (*Caesalpinia sappan*), pepper, and cinnamon. Typically served warm, this drink is known for its body-warming properties, thanks to the thermogenic effects of its spices. The preparation and serving of *Wedang Cangruk* exemplify the integration of traditional knowledge, social values, and phytochemical properties (see Figure 7).

Figure 7. Wedang Cangruk Speciality Drink

Q : *"What are the ingredients, ma'am?"*
PR : *"……..ingredients are ginger, lemongrass, secang, peppercorns, cinnamon, and a little sugar.."*
Q : *"How is the manufacturing process?"*
PR : *"Easy…. The ingredients are boiled together, filtered, and then given sugar to make it sweet."*

Based on the interview excerpt, the informant, the producer of Wedang Cangruk, outlined the beverage's ingredients and preparation method. The process is relatively simple: ginger, lemongrass, sappan wood (*Caesalpinia sappan*), pepper, and cinnamon are boiled together in water. The decoction is then filtered to remove the solid residues, and sugar is added to sweeten the drink. *Wedang Cangruk* is traditionally served warm, either as a daily beverage or as a special drink for welcoming guests. The exploration of *Wedang Cangruk* within Indigenous knowledge offers an opportunity to reconstruct traditional practices into a scientific understanding. Table 3 summarizes the reconstruction of local knowledge into scientific terms, highlighting chemical concepts such as extraction, solubility, diffusion, and the role of bioactive compounds. Each stage of preparation, from boiling to filtration and sweetening, involves basic chemical principles that can be contextualized in chemistry education.

The integration of Indigenous knowledge into science learning through an ethnoscience approach enables a more meaningful and culturally relevant learning experience. By linking chemical concepts with everyday cultural practices, students can develop a deeper appreciation for the interaction between science and local traditions, thereby enhancing both chemical literacy and cultural awareness. Wedang Cangruk, a herbal drink made with ginger, sappan wood, lemongrass, and spices, embodies the principle of phytochemical extraction by boiling. Compounds such as gingerol, shogaol, and brazilin demonstrate the role of natural antioxidants and pigments in traditional beverages (Kusumawati & Muslim, 2019). Brazilin's color shift under varying pH conditions is an authentic example of a natural acid-base indicator (Kurniawan et al., 2023). The filtration of solids and addition of sugar while hot introduce concepts of solubility and chemical separation, which are foundational in solution chemistry (Sumarni et al., 2022; Astuti et al., 2022). The preparation process also highlights exothermic reactions during boiling (Kumar et al., 2021). Such practices demonstrate the integration of thermochemistry, extraction, and acid-base concepts in daily cultural routines, supporting culturally relevant science instruction. The Samin community of Sambongrejo is known for its modest, sustainable way of life, with livestock farming a key part of their daily livelihood. Among the livestock raised, *Etawa* goats have been cultivated in the village since 1986. A notable characteristic of their livestock management is the use of elevated stilt-style goat pens, designed to maintain cleanliness and facilitate easier maintenance (see Figure 8). The elevated structure allows waste to fall through, preventing accumulation and minimizing the risk of disease. This traditional innovation reflects the community's practical adaptation to environmental and hygienic needs. The preference for *Etawa* goats stems from their relatively high market value and ease of care, making them an economically viable choice for the community. The integration of traditional knowledge and practical design in goat farming exemplifies how cultural practices intersect with local agricultural strategies.

Figure 8. Stage House-shaped Goat Cage

Q : *"How is it maintained?"*
LS (1) : *".......Here, all the cages are on stilts. Most food is taken from the forest and given lamtoro, rarely fed with grass."*
PG (2) : *".....the cage is made on stilts…"*
Q *"Is the goat dung utilized?"*
LS (1) : *"Usually, from food scraps such as lamtoro, there is wood .... burned in the afternoon, called pediang, to repel mosquitoes. The dirt is placed on top and left overnight; it will be destroyed. So it is like making compost."*

The Samin community's innovative approach to using Etawa goat manure as an organic fertilizer demonstrates a profound understanding of both traditional ecological practices and fundamental chemical principles. The manure undergoes a processing technique known as *pediang*, which involves partial combustion using dried *lamtoro* (Leucaena leucocephala) stems. This method reduces ammonia content, preventing root damage from direct application, while also addressing odor issues and improving livestock hygiene through the mosquito-repelling properties of the smoke. This traditional practice reflects a sophisticated form of thermal pre-composting. Recent studies confirm that thermal treatment of organic matter can enhance nutrient availability, control pathogens, and support microbial activity, which are essential to sustainable agriculture (Ferreira et al., 2020). The resulting ash, often applied to cornfields and mixed with peat, improves soil structure and promotes nutrient cycling, illustrating key environmental chemistry concepts such as redox reactions and thermal decomposition (Usodri et al., 2024).

Furthermore, the use of elevated stilt-style goat pens demonstrates the community's intuitive application of sanitation principles. By enhancing aeration and facilitating dry waste collection, this design reduces pathogen growth, aligning with agroecological sanitation research that emphasizes the importance of hygienic waste management in livestock farming (Wen et al., 2020). Such community-driven innovations exemplify the integration of traditional knowledge with scientific reasoning, making them valuable assets in ethnoscience-based chemistry education. The reconstruction of these practices validates indigenous knowledge systems and connects sustainable local solutions to modern scientific curricula. By highlighting their scientific relevance, this study not only acknowledges the cultural richness of Samin practices but also promotes a more contextual, inclusive, and responsive science education (Umoh et al., 2023).

Future research should explore indigenous knowledge from other cultural communities to uncover diverse scientific concepts embedded in traditional practices. Empirical studies are needed to assess the effectiveness of ethnoscience-based learning in improving students' scientific literacy and cultural awareness. Additionally, developing curriculum-integrated teaching materials and promoting interdisciplinary collaborations will strengthen the role of indigenous knowledge in contextual science education. Policy-level research is also recommended to support the integration of ethnoscience into national education systems.

CONCLUSION

The results of this study conclude that four main indigenous practices of the Samin community-Sambongrejo batik making, Kareman tempeh fermentation, Wedang Cangruk herbal drink preparation, and Etawa goat farming-contain embedded scientific elements relevant to chemistry. These cultural practices were successfully identified and systematically reconstructed into formal chemical concepts, including polymers, thermochemistry, acid–base reactions, chemical bonding, fermentation, redox processes, and environmental chemistry. This reconstruction demonstrates that indigenous knowledge can be effectively transformed into structured scientific understanding that aligns with key topics in chemistry education. The integration of local wisdom into chemistry instruction provides a meaningful, context-rich learning experience for students. By connecting scientific concepts with everyday cultural practices, students are more likely to engage with the subject matter, enhance their conceptual understanding, and develop a deeper appreciation for their own cultural heritage. This approach strengthens scientific literacy while fostering respect for indigenous traditions. In addition to its pedagogical value, this study makes a unique contribution to science education by proposing a model of culturally responsive instruction grounded in the integration of traditional ecological knowledge. The approach validates indigenous practices as legitimate sources of scientific insight and supports the development of inclusive learning frameworks. The findings of this research can serve as a practical reference for educators, curriculum designers, and policymakers in developing locally relevant learning materials. By embedding indigenous knowledge within formal education, it is possible to support sustainable education practices that not only preserve cultural identity but also empower students to apply science meaningfully within their own communities.

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