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Research Article

Ethnoscience Study of Madura in the Process of Making Sarkoyo Herbal Medicine as a Learning Resource for Science Material

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Abstract. Sarkoyo herbal medicine is one of Madura's cultural heritages in Sumenep Regency that has become less known to the younger generation, resulting in its limited utilization in science education. This study aims to reconstruct local knowledge about the process of making Sarkoyo herbal medicine so that it can be used as a source of ethnoscience-based science learning. The study employed a mixed-methods approach with a sequential descriptive design. Quantitative data were obtained from 150 junior high school students through questionnaires, while qualitative data were collected through interviews with science teachers and herbal medicine makers, as well as through observations and documentation. Quantitative data were analyzed descriptively, while qualitative data were analyzed using the Miles and Huberman interactive model. The results showed that most students were familiar with Sarkoyo herbal medicine, but the integration of ethnoscience into science learning was remained low. The process of making Sarkoyo herbal medicine consisted of 12 stages containing science concepts such as homogeneous mixtures, heat transfer, and nutritional content, all of which are relevant to basic junior high school science competencies. Sarkoyo herbal medicine can be reconstructed as an ethnoscience-based science learning resource that integrated biology, chemistry, and physics, and thereby contributing to the improvement of students' knowledge, the preservation of Madurese local wisdom, and the implementation of the Merdeka Curriculum in schools, ultimately strengthening students' character and scientific literacy.

Keywords: ethnoscience; Sarkoyo herbal medicine; local wisdom; science education

INTRODUCTION

Education as stipulated in Law Number 20 of 2003, is a conscious and planned effort to create a learning environment that encourages the development of students' potential, including spiritual strength, self-control, personality, intelligence, noble character, and the necessary skills for individuals, society, the nation, and the state (Azzahra *et al*., 2024). According to a study by Rizova *et al*. (2020), the lack of quality education can significantly impact an individual's quality of life over an extended period (Firdaus, 2025). Therefore, educators and students must collaborate to create an effective learning environment. Three key components in the learning process include the curriculum as a guideline, teachers as facilitators, and the interaction between students, educators, and learning

resources (Rikizaputra *et al*., 2022). Science education can be enhanced by linking scientific concepts to everyday phenomena (Firdaus *et al*., 2025). At the junior high school level, understanding science concepts is crucial for developing analytical reasoning skills to explain events and solve problems (Pratiwi, 2022; Firdaus *et al*., 2024). Therefore, it is important to emphasize that science education should not only focus on conceptual understanding, but should also be directed towards developing various dimensions that support the formation of students' comprehensive competencies.

Science education in schools aims to develop students through four dimensions: products, processes, attitudes, and technology (Elisa *et al*., 2023; Firdaus *et al*., 2025). Science as a product encompasses conceptual, procedural, and metacognitive knowledge, consisting of facts, laws, principles, and theories that have been empirically validated (Arslan & Genc, 2024; Noushad, 2024). Teachers' ability to identify the categories of science content can facilitate the delivery of material through appropriate strategies (Muria & Budianti, 2021). Meanwhile, the process of science learning emphasizes the importance of direct experiences through investigations or experiments, which not only enhance students' understanding but also foster scientific attitudes (Mufidzah, 2024). Development in science education can be strengthened through a contextual approach that links scientific concepts to local culture, one of which is through the application of ethnoscience in learning.

Ethnoscience is a pedagogical strategy that creates a learning environment and experiences by integrating cultural elements into the learning process (Lidi *et al*., 2022). One cultural element that can be integrated is the community's system of knowledge, or indigenous science (ethnoscience), which differs from modern science. Science refers to systematically acquired knowledge obtained through the application of scientific methods. In contrast, ethnoscience refers to the knowledge of a community formed through socio-cultural constructions, which can be acquired through both scientific and non-scientific means (Mukti *et al*., 2022). The integration of ethnoscience in learning offers various benefits, including helping students understand meaningful local knowledge, engaging in cultural socialization based on local standards, and exhibiting attitudes and behaviors that align with local environmental principles (Syahputri *et al*., 2025). The application of ethnoscience in science education is very important for developing culture-focused education.

Culturally focused education is essential for students, as the application of this method fosters a sense of love for culture and nation. The process of learning that integrates culture into learning experiences is known as ethnoscience (Rikizaputra *et al*., 2022). Moreover, the study of ethnoscience in science education utilizes local knowledge as a learning resource or object, which can be incorporated into contextually presented lessons. Therefore, science education based on ethnoscience will integrate scientific concepts with local wisdom or culture (Kholidah *et al*., 2023). Ethnoscience refers to the indigenous knowledge held by a particular community. The goal of ethnoscience is to describe the environment from the perspective of the community under study. Meanwhile, the application of ethnoscience in the learning process aims to integrate local culture with teaching materials, thereby helping students understand content that is highly relevant to their daily lives. By using an ethnoscience approach, science learning can be conducted more scientifically and effectively (Siyati & Kamariyah, 2022). However, the implementation of ethnoscience in learning still faces a number of obstacles that require serious attention.

Based on previous studies conducted by Saputri & Desstya (2023), it was found that many educators have not yet integrated local wisdom into the learning process, particularly in the subject of Science, making the achievement of learning objectives quite difficult. This result is further supported by research from Wilujeng *et al*. (2024), which indicates that educators' lack of utilization of the surrounding environment, which integrates local potential as a learning resource for students, is a key issue. Additionally, according to research by Alfiana & Fathoni (2022), many teachers still face difficulties in linking learning with ethnoscience due to insufficient training in creating teaching materials focused on ethnoscience, which limits teachers' understanding of integrating material with the environment. Therefore, innovative efforts are needed in science education that can integrate local culture so that the learning process becomes more relevant to students.

Incorporation of local culture into science education is an innovative approach that yields more meaningful learning experiences, facilitating students' comprehension of the subject matter (Zidny *et al*., 2021; Marosi *et al*., 2021). Education that integrates ethnoscience perspectives tends to attract students' interest and enhance their curiosity (Kantina *et al*., 2022). However, the lack of ethnoscience research in Sumenep Regency is a primary factor contributing to the low application of ethnoscience in the learning process. This situation is further exacerbated by science education that still heavily relies on government-issued textbooks, which do not fully reflect the cultural characteristics of students in the region. One example of the application of local culture in science education can be found in the local wisdom of the Madurese people, particularly in Sumenep Regency.

Madura Island has a variety of traditional herbs, especially in Sumenep Regency. One of them is Sarkoyo herbal medicine, a Madurese cultural heritage. Sarkoyo herbal medicine is a traditional herb that has been used by the Madurese people for many years. Made from coconut milk, eggs, ginger, sugar, and cloves, this medicine is believed to help maintain health, treat internal heat, and even relieve headaches. Although a number of ethnoscience studies have been conducted highlighting various local intelligences, such as the production of Gunung Krayan salt (Kantina *et al*., 2022), Banten-style milkfish satay (Kholidah *et al*., 2023), and smoked fish (Syahputri *et al*., 2025), studies on Sarkoyo herbal medicine from Madura have never been systematically addressed in the context of science education. In fact, Sarkoyo is a cultural heritage that is beginning to be abandoned by the younger generation and has great potential as a source of contextual learning. This research gap has led to a knowledge gap, namely the lack of efforts to reconstruct local knowledge about Sarkoyo into scientific concepts that are in line with the basic science competencies in junior high school. Therefore, this research is novel in that it reconstructs traditional knowledge of Sarkoyo into an ethnoscience-based science learning resource, which not only contributes to strengthening students' science literacy but also to the preservation of Madurese local wisdom and the implementation of the Merdeka Curriculum. The production of Sarkoyo herbal medicine can be used as a learning resource in science education, with a focus on specific competencies through natural production that supports the sustainability of human life. In addition, it aims to reintroduce cultural heritage that is increasingly forgotten by the community and reconstruct the traditional knowledge of the Madurese people in making Sarkoyo herbal medicine, transforming it into scientific knowledge that can be a source of science learning.

METHODOLOGY

Research Design

This study used a mixed-methods approach by combining quantitative and qualitative methods (Creswell & Creswell, 2018) to analyze the application of ethnoscience in the process of making Sarkoyo herbal medicine as a source of science learning. The quantitative approach was used to examine the relationship between variables that influence learning, while the qualitative approach, through interviews with teachers and herbal medicine makers, helped to explore meanings and contexts that cannot be measured statistically. This design was chosen so that the research results would be more comprehensive and able to show how local knowledge about Sarkoyo herbal medicine can be integrated into science learning.

Population and Sample

Population of this study consisted of three main groups, namely junior high school students in Sumenep Regency, science teachers, and Sarkoyo herbal medicine practitioners in the Sumenep area, Madura. The involvement of students aimed to determine their knowledge and perceptions of the integration of ethnoscience in science education, while interviews with teachers were conducted to gather information about the learning media and curriculum used, as well as to identify the extent to which schools have integrated ethnoscience into learning. Meanwhile, the participation of Sarkoyo herbal medicine makers was intended to obtain authentic local knowledge that has been passed down from generation to generation.

Student samples were taken from several junior high schools in Sumenep Regency using questionnaires. There were 150 respondents aged around 13-15 years, which is the appropriate age for early adolescence, an important stage in the development of scientific reasoning and the cultivation of appreciation for local culture (Maison *et al*., 2020). The sample of science teachers was selected through interviews to identify learning practices, media utilization, and their relevance to the applicable curriculum, particularly regarding the integration of ethnoscience in science learning.

Sample of Sarkoyo herbal medicine makers was selected using purposive sampling, namely native herbal medicine makers from the Sumenep community who have inherited knowledge about making Sarkoyo herbal medicine from generation to generation. These herbal medicine makers were selected based on their local knowledge. Sarkoyo herbal medicine was chosen as the focus of this study because this traditional drink is beginning to be forgotten by the community, making it important to document it and examine its potential as a source of science-based ethnoscience learning.

Combining quantitative data from students, qualitative data from teachers, and qualitative data from herbal medicine practitioners, this study uses triangulation of sources to gain a more comprehensive understanding of how Sarkoyo herbal medicine can be reconstructed into a source of science learning.

Instrument and Data Collection

Instrument used in quantitative data collection was a questionnaire consisting of two scales designed to measure the variables studied in students. This questionnaire used a 10-point Guttman scale for each item, facilitating data collection and statistical analysis. Meanwhile, the instruments used to collect qualitative data are interview guides, observation protocols, and documentation. These interview guides include open-ended questions to explore the challenges and obstacles faced by teachers in using learning media and curriculum, as well as to identify the extent to which schools have integrated ethnoscience into the science learning process.

Data collection technique used in this study for quantitative data is simple random sampling, which is a sampling technique in which every member of the population has an equal chance of being selected, so it is done randomly (Subhaktiyasa, 2024). Meanwhile, purposive sampling is used for qualitative data. Purposive sampling is a technique for selecting samples (Ahmad & Wilkins, 2024). In addition, according to research Sugiyono (2015), sample selection is based on certain criteria, such as sources who are considered to be most knowledgeable about the topic being studied. Furthermore, the research data includes the results of an analysis of local wisdom in a particular region with additional data sources taken from relevant articles. This data served as a basis for describing the findings, while additional data from related articles provides a more in-depth context, so this approach is designed to ensure the completeness of the data to validate the research findings. In addition, the literature review in this article is written based on aspects of ethnoscience and local wisdom.

Data Analysis

Data analysis in this study used a mixed methods design of sequential explanatory models, thereby systematically combining quantitative and qualitative analysis. Quantitative data obtained through student questionnaires were analyzed descriptively using frequency distributions with the help of Excel (Hafizah *et al*., 2022) to determine students' knowledge, perceptions, and attitudes toward ethnoscience in the production of Sarkoyo herbal medicine. The results of this quantitative analysis then became the basis for determining the focus of the qualitative stage. Meanwhile, qualitative data was obtained through interviews with teachers and herbal medicine makers, field observations, and documentation analyzed using an interactive model proposed by Miles and Huberman. The Miles and Huberman model consists of three interrelated components: data reduction, data presentation, and conclusion drawing or verification (Miles & Huberman, 1994; Zulfirman, 2022). These stages were carried out sequentially during the qualitative research process to manage and interpret the collected data, particularly data on the process of making Sarkoyo herbal medicine and the ethnoscience study contained therein. The stages of data collection and analysis are presented in Figure 1.

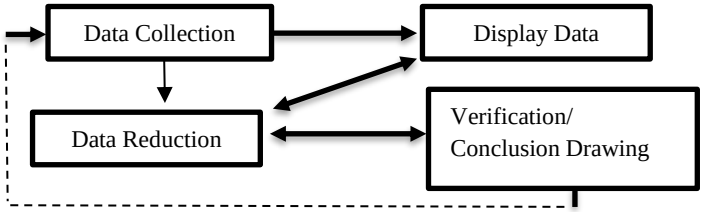

Figure 1. Stages of Miles and Huberman's data analysis model for qualitative data

Steps of interactive data analysis using the modified Miles and Huberman model from Wandi (2013), are as follows. In the data collection stage, researchers collect research data related to selected local wisdom through interviews, recording interview results, observation, and documentation. In the data reduction stage, researchers summarize, select key points, and focus on matters related to the selected local wisdom ethnoscience study. In the data presentation stage, researchers collected structured information and provided the possibility of drawing conclusions and making inferences. In the conclusion drawing or verification stage, researchers sought, tested, rechecked, or understood the meaning, regularity, patterns, explanations, flow, cause and effect, or propositions and described the findings.

RESULTS AND DISCUSSION

Results of the Study

These findings indicated that although students' prior knowledge of Sarkoyo herbal medicine was quite good, the implementation of ethnoscience in science education is still limited. Therefore, the development of ethnoscience-based teaching materials that highlight the process of making Sarkoyo herbal medicine can be an alternative to improve scientific concept understanding while strengthening the internalization of local cultural values. The questionnaire results are shown in Figure 2.

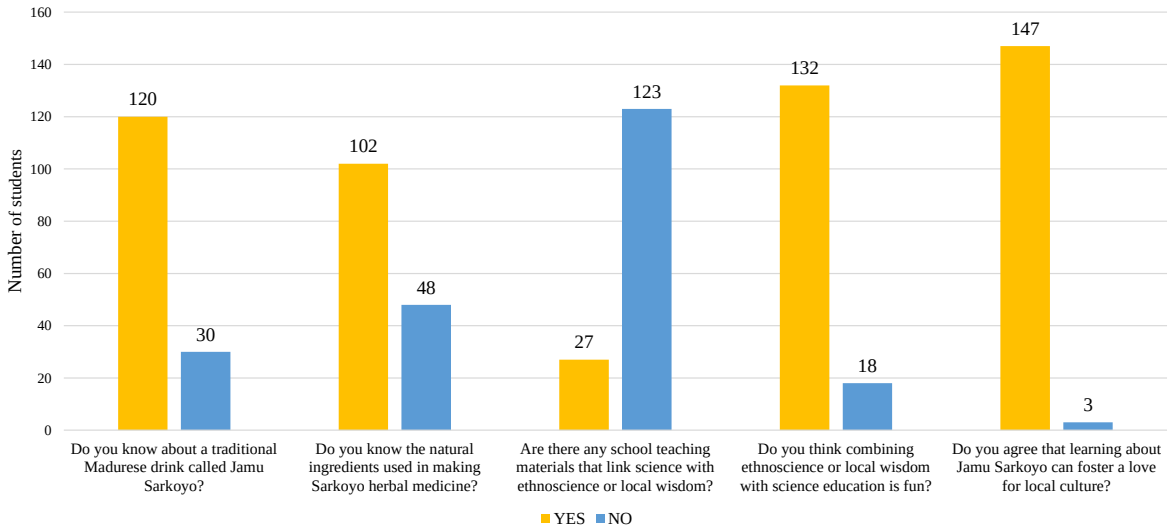

Figure 2. Results of the questionnaire on students' knowledge and perceptions of Sarkoyo herbal medicine ethnoscience

Results of the questionnaire analysis regarding students' knowledge and perceptions of JSarkoyo herbal medicine ethnoscience show that the majority of students are aware of this traditional Madurese drink. A total of 120 respondents stated that they knew about Sarkoyo herbal medicine, while 30 other respondents were not aware of it. Knowledge about the natural ingredients used in making Sarkoyo herbal medicine was also relatively high, with 102 students answering yes and 48 students answering no. However, the implementation of ethnoscience in science education in schools

is still low. This is evident from the finding that only 27 students stated that they had found a connection between science teaching materials and ethnoscience or local wisdom, while 123 students stated that they had never found it. This condition shows that the potential for utilizing ethnoscience, especially related to Sarkoyo herbal medicine, has not been optimized in learning. Ethnoscience in education is very important because it contains natural sciences that study natural conditions and phenomena (Silla *et al*., 2023). In addition, students' local knowledge can bridge indigenous science with scientific science, thereby providing a more complete understanding (Mukti *et al*., 2022). With this background, it is important to look at how students perceive the implementation of ethnoscience in learning.

Students' perceptions of the implementation of ethnoscience are very positive. A total of 132 students believe that combining ethnoscience with science learning is an enjoyable approach, while only 18 students disagree. Furthermore, 147 students agree that learning about Sarkoyo herbal medicine can foster a love for local culture, while only 3 students disagree. Through the application of ethnoscience, teachers can make learning more interesting, relevant, and meaningful (Lestari & Nabila, 2024). Ethnoscience also increases the relevance of learning, helps students connect scientific concepts with local life, and can increase interest and motivation in learning science (Sari *et al*., 2023). These positive findings are further reinforced by various studies showing the effectiveness of ethnoscience in improving the quality of learning.

These findings are in line with various studies that confirm the effectiveness of ethnoscience in learning. According to Anggraini & Asante (2024), students who use ethnoscience-based worksheets show greater learning outcomes than the control group. Furthermore, according to Pitri *et al*. (2025), ethnoscience has been proven to increase students' motivation, curiosity, and independence in learning, while also preserving local wisdom. Thus, the application of ethnoscience, especially in the context of Sarkoyo herbal medicine, has great potential to be integrated more widely into science education.

Integration with Science Concepts

Based on the research process conducted through observations and interviews with the Prenduan community in Sumenep, who possess the skill and knowledge of preparing Sarkoyo herbal medicine, it was revealed that the preparation of Sarkoyo herbal medicine is a tradition for the local community. It is typically consumed by families or served during special events, such as weddings and the month of Ramadan. The preparation of Sarkoyo herbal medicine is still carried out traditionally, on a small-scale production basis by the local people, passed down through generations from their ancestors. The stages of the Sarkoyo herbal medicine preparation process are depicted in Figure 3.

Figure 3. Stages of the Sarkoyo herbal medicine manufacturing process (Personal Document)

Figure 3 shows the traditional steps in making Sarkoyo herbal medicine, starting from grating coconut and preparing the main ingredients such as ginger, eggs, and brown sugar. After the ingredients are filtered and mixed, the mixture is then boiled to produce a herbal drink that is ready for consumption. The entire process is carried out traditionally using simple household appliances by the people of Madura. Figure 1 above illustrates that the process of preparing Sarkoyo herbal

medicine, as practiced by the local community, involves 12 steps. This information was revealed through observations and interviews conducted with the community. The first step is grating the coconut. The second step is to add a small amount of water to the grated coconut and then strain it to extract the coconut milk. The third step involves grating ginger. The fourth step is to add a little water to the grated ginger, squeeze it, and then place the ginger extract into the container used for the coconut milk. The fifth step is adding one free-range egg to the mixture of coconut milk and ginger extract. The sixth step involves adding palm sugar to the mixture in moderation. The seventh step is thoroughly mixing all the ingredients until they are well combined. The eighth step is pouring the herbal mixture into an aluminum bowl. The ninth step is placing the bowl containing the mixture into a pot of water for the steaming process. The tenth step is to steam the herbal mix for approximately 10 minutes, until it thickens, and water forms beneath the coagulated coconut milk and egg mixture. The eleventh step is inspecting the herbal medicine; if it has thickened and clumps have formed, it indicates that the Sarkoyo herbal medicine is ready. Finally, in the twelfth step, the Sarkoyo herbal medicine is prepared for serving and consumption.

Preparation of Sarkoyo herbal medicine by the Prenduan community in Sumenep, particularly those skilled in its traditional formulation, generally follows 12 stages (Figure 1). Each stage is an essential prerequisite for the next, ensuring that the final product of the herbal medicine is of high quality, both in terms of flavor, consistency, efficacy, and shelf life.

The first step is grating the coconut. The second step involves squeezing the grated coconut to obtain pure coconut milk, which serves as the primary component in the preparation of Sarkoyo herbal medicine. Coconut milk serves as the base ingredient, binding all other components together while providing a smooth texture and distinctive flavor. The quality of the coconut milk is greatly influenced by factors such as water content, pH level, and free fatty acids. A study by Diana *et al*. (2023) demonstrated that coconut milk with a water content of approximately 60.4%, a pH of 6.2, and free fatty acids below 0.1% exhibits good quality and stability. Therefore, optimal quality coconut milk is crucial in determining the success of the Sarkoyo herbal medicine, both in terms of flavor and nutritional value.

Third step is grating the ginger. The fourth step involves adding water to the grated ginger, squeezing it, and mixing the ginger extract with the coconut milk. Ginger is chosen as an additional ingredient due to its active compounds, such as gingerol, shogaol, and zingiberene, which possess antioxidant and anti-inflammatory properties. Research by Mao *et al*. (2019) revealed that ginger contains bioactive components like gingerol, beta-carotene, capsaicin, caffeic acid, curcumin, and salicylates, which enhance the immune system and help alleviate mild health issues such as nausea, digestive problems, and minor infections. The addition of ginger extract to Sarkoyo not only enriches the flavor and aroma but also enhances the medicinal properties of the herbal drink, making it a traditional immunity booster.

Fifth step involves adding one free-range egg to the mixture of coconut milk and ginger extract. Free-range eggs are selected because they are rich in vital nutrients, including iron, vitamin B12, high-quality proteins, and amino acids that are beneficial for the body. According to Tirtawati *et al*. (2023), regular consumption of free-range eggs can increase hemoglobin levels due to their easily absorbed iron content and the role of vitamin B12 in red blood cell formation. The inclusion of eggs in Sarkoyo not only enhances the nutritional value but also contributes to the texture and thickness of the herbal medicine, improving overall stamina.

Sixth step is adding an appropriate amount of palm sugar to the mixture. Palm sugar is chosen as a natural sweetener, which not only enhances the taste of Sarkoyo with its distinctive flavor but also provides essential nutrients for the body. Palm sugar contains various minerals such as calcium, phosphorus, and iron, as well as sucrose, fructose, and glucose that support the body's energy metabolism. Research by Arziyah *et al*. (2022) indicates that the addition of palm sugar improves the organoleptic properties of beverages, particularly in terms of color and flavor, which are highly favored by consumers.

Seventh step is stirring all the ingredients to ensure uniformity. Stirring is crucial to ensure that the coconut milk, ginger, egg, and palm sugar blend homogenously. According to Dasopang *et al*.

(2025), the speed and duration of the homogenization process impact the chemical and visual quality of coconut milk, including its pH, TSS (total soluble solids), and color. While the particle size does not significantly change, homogenization improves the consistency and stability of the coconut milk used as the base ingredient for the beverage. The stirring process in making Sarkoyo is essential to guarantee the stability and quality of the herbal medicine.

Eighth step is pouring the herbal mixture into an aluminum bowl. The choice of an aluminum bowl is to support even heating or steaming in the subsequent step. Aluminum is an excellent thermal conductor, which helps distribute heat evenly throughout the herbal mixture. A study by Sari *et al*. (2023) found that among various metal materials tested, such as aluminum, iron, and brass, aluminum exhibited the highest rate of heat transfer, reaching an average of 325.5 watts at 80°C, twice the heat transfer rate of iron (±147.1 watts) and brass (±218.5 watts). This result demonstrates the effectiveness of aluminum in heat transfer. By using aluminum containers, the entire Sarkoyo herbal mixture receives consistent heat during steaming, ensuring optimal cooking without uneven heating.

Ninth step involves placing the aluminum bowl containing the herbal mixture into a pot of water for the steaming process. Steaming is chosen because it provides moist heat that envelops the ingredients evenly without direct contact with water, thus reducing the risk of burning and preserving nutrients that are sensitive to high heat. Research by Moyo (2024) indicates that steaming preserves more vitamins and minerals than direct boiling, as water contact is minimal and the temperature is lower. Therefore, the use of steaming in preparing Sarkoyo helps preserve the bioactive compounds and nutrients in the coconut milk, ginger, egg, and palm sugar more effectively than direct heating.

Tenth step is to steam the herbal medicine for approximately 10 minutes, until it thickens, forms clumps, and water appears beneath the coagulated coconut milk and egg. This process involves the coagulation of egg proteins and the stabilization of the coconut milk emulsion, resulting in the characteristic texture of Sarkoyo. Research by Riyada (2022) shows that steaming at 85 °C causes the egg emulsion to transition from a liquid (sol) to a semi-solid (gel) due to protein coagulation. This process creates clumps as proteins denature and bind together to form a solid structure that can trap water and fat. Coconut milk also responds similarly to heating. Additionally, research by Putranto *et al*. (2022) indicates that appropriate heating duration reduces water content and enhances emulsion stability. This process yields a desirable texture and improves shelf life.

Eleventh step involves observing the herbal mixture in the bowl. If the texture has thickened, clumps have formed, and liquid has separated around the mixture, this signals that the coagulation and emulsification processes are complete, indicating that the Sarkoyo herbal medicine is ready. This consistency is the result of the stable bonding between egg proteins and coconut milk fats after heating.

Finally, the twelfth step marks the readiness of the Sarkoyo herbal medicine to be served and consumed. At this stage, the herbal medicine exhibits its characteristic consistency, aroma, and flavor, with the nutrients having blended optimally, making it ready to deliver functional health benefits, particularly in terms of energy recovery and immune support.

Reconstruction of Indigenous Knowledge into Scientific Knowledge

Based on the interviews conducted, it was found that the entire process of preparing Sarkoyo herbal medicine, ranging from selecting natural ingredients to mixing, processing through steaming, and finally serving, embodies a wealth of local knowledge (indigenous science) that can be correlated with scientific knowledge. This local knowledge has been passed down through generations in Madurese culture. Therefore, the process of preparing Sarkoyo herbal medicine can be utilized as a learning resource in Science education, including subjects such as Biology, Physics, and Chemistry. The reconstruction of indigenous knowledge into scientific knowledge is illustrated in Table 1.

Based on the reconstruction of local knowledge into scientific knowledge as shown in Table 1, it can be seen that the process of making Sarkoyo herbal medicine contains various scientific concepts that are relevant to science learning. However, to make it clearer and more systematic, the stages of developing local knowledge into ethnoscience-based teaching materials need to be visualized in the form of a flowchart. This diagram provides a comprehensive overview of the flow from the

identification of community knowledge to the process of developing it into a learning resource that is integrated with the curriculum, as shown in Figure 4.

Table 1. Reconstruction of indigenous knowledge into scientific knowledge

No	Topic	Indigenous Knowledge	Scientific Knowledge
1	Coconut Selection	Old coconut because it has a lot of coconut milk.	Old coconut is chosen as the best raw material because the maturity level of the coconut endosperm significantly affects its physicochemical characteristics (such as brix, fat, and total solids), thus producing more coconut milk with high fat and nutritional content (Konadu *et al*., 2023).
2	Soaking and Washing	The materials will be clean and easy to boil.	The soaking and washing stages are crucial in the processing of traditional herbal ingredients, particularly for removing dirt, reducing antinutritional compounds, and facilitating the extraction of active ingredients for cooking or use. However, this process is also recognized as one of the primary sources of water usage in the natural ingredient processing industry, generating liquid waste containing organic and inorganic compounds that can pollute the environment (Safitriyawi *et al*., 2024). Therefore, implementing clean production strategies with a focus on water use efficiency and wastewater management is crucial for improving the sustainability of processes, enhancing product quality, and minimizing environmental impact (Akbari & Moslem, 2025).
3	Use of Coconut Milk	Coconut milk can strengthen the immune system.	Coconut milk is widely used in food and beverage processing because it enhances aroma, flavor, and nutritional value, while also improving the texture of food (Lina, 2022). Besides its distinct taste, coconut milk also contains essential nutrients, including fat, protein, carbohydrates, vitamins, and minerals, that are beneficial for health (Meilizar *et al*., 2024). Saturated fatty acids, such as lauric acid, also offer additional benefits to the body (Dasopang *et al*., 2025).
4	Boiling Coconut Milk	To make it more savory and last longer.	Boiling coconut milk triggers the release of lauric acid, a substance with antimicrobial properties (Dasopang *et al*., 2025). Additionally, boiling with coconut milk can reduce the fishy odor and enrich the aroma of food (Syefani & Nuraeni, 2024). However, it is essential to pay attention to the temperature and duration of boiling because excessive cooking time may reduce the content of specific vitamins, although it can enrich flavor and texture (Permata & Abdiel, 2025).
5	Egg Selection	Free-range chicken eggs are better.	Free-range chicken eggs are preferred because they have a better taste and chewier texture compared to regular eggs (Elu *et al*., 2024). Free-range chicken eggs have equivalent or even better nutritional value in certain aspects (protein, vitamins, minerals) compared to commercial chicken eggs, although their cholesterol levels tend to be higher (English, 2022). Furthermore, free-range eggs contain 12.80% protein, 11.5% fat, 0.75% carbohydrates, and 74.0% water, making them a high-nutrient food source for animals (Amalyadi & Yanti, 2025).
6	Use of Eggs	It can relieve pain or discomfort.	Eggs are rich in various vitamins and minerals needed by the body, such as vitamin A, riboflavin, folic acid, vitamins B6 and B12, choline, iron, calcium, and phosphorus. Although the iron content in eggs is not as high as in red meat, eggs are still effective in reducing inflammation. This is due to the vitamin A content in eggs, which plays a key role in relieving pain and inflammation (Sherly & Kamidah, 2024).
7	Use of Ginger	To warm up the body.	Ginger is believed to be an effective remedy for warming the body, relieving nausea, and enhancing blood circulation. Additionally, ginger serves as a tonic to improve overall health and alleviate various ailments (Ahnafani *et al*., 2024).
8	Adding Palm Sugar	To make it sweeter.	Palm sugar is a natural sweetener that is safe for the body and offers various benefits, including boosting the immune system, acting as an antioxidant source, preventing anemia, stabilizing cholesterol levels, warming the body, improving blood circulation, and treating internal heat (Aprianto *et al*., 2024).
9	Stirring	To mix everything.	Stirring is the process of mixing two or more substances to create a homogeneous mixture (Eggl & Schmid, 2022). Additionally, stirring can help create a suspension of solid particles, accelerate heat transfer between liquids and heat sources, and mix miscible liquids (Miller *et al*., 2025).

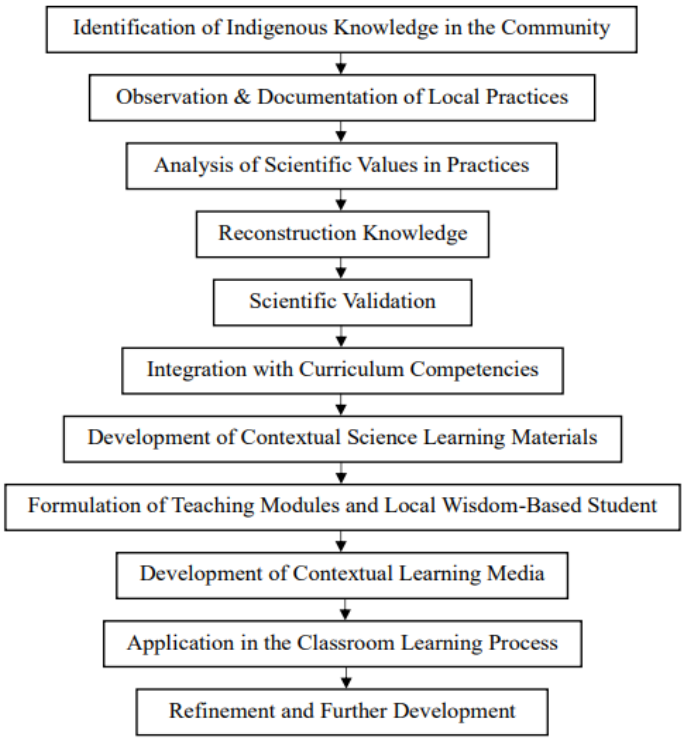

Figure 4. The development of ethnoscience-based science teaching materials for science education

Through the stages shown in Figure 4, the process of developing ethnoscience in science education becomes more focused and measurable. Each step, starting from the identification of local knowledge to its application in the classroom, demonstrates the continuity between local culture and scientific concepts. Thus, this flowchart not only emphasizes the importance of strengthening scientific knowledge of traditional knowledge, but also provides a clear framework for teachers to integrate local wisdom values into teaching materials. This framework can increase the relevance of science learning while preserving the culture of the local community.

Application in learning

Sarkoyo herbal medicine, a traditional concoction of the Madurese community and a form of local wisdom in Sumenep Regency, can be utilized as a learning resource for Junior High School Science through the transfer of indigenous knowledge into scientific knowledge. Thus, this ethnoscience study can serve as a valuable contextual resource for science learning. The integration of Science concepts with Sarkoyo herbal medicine, linked to the basic competencies of the Junior High School Science curriculum, is presented in Table 2.

Based on the source analysis conducted in Table 2, it was found that the explanation of the process of preparing Sarkoyo herbal medicine is closely related to several basic competencies within the Science curriculum. This will help teachers connect science concepts with the herbal preparation process. The connection between the basic competencies and the components involved in the preparation process can serve as a contextual learning resource for students. With this understanding, students will develop a greater appreciation for local wisdom and cultural values, which are also fundamental to the objectives of national education.

Providing learning materials related to the values, traditions, norms, or local culture within the students' environment is one approach that teachers can use to support curriculum policies. According to a study by Annisha (2024), the integration of local wisdom values within the context of the Merdeka Curriculum not only preserves local culture and traditions but also strengthens the educational foundation for students across various life aspects. Furthermore, according to

Rikizaputra *et al*. (2022), many teachers still struggle to connect Science material with the local wisdom present in their environment, a concept known as ethnoscience.

Table 2. The relationship between sarkoyo herbal medicine and basic science competencies

No	Basic Competency (KD)	The Concept of Science in Sarkoyo	Example of Class Assignment	Assessment Idea
1	KD 3.3: Explain the concepts of pure substances (elements, compounds) and mixtures, as well as their physical and chemical properties in everyday life.	The preparation of Sarkoyo involves a homogeneous mixture (coconut milk + ginger + palm sugar + eggs).	Students were asked to make a chart distinguishing pure substances and mixtures from Sarkoyo materials.	Worksheet analyzing pure substances vs. mixtures (concept accuracy rubric).
2	KD 3.5: Analyzing temperature, heat, expansion, heat transfer.	The heating/steaming process of Sarkoyo demonstrates conduction, protein coagulation, and emulsion stability.	Simple experiment: observe physical changes (egg coagulation, changes in coconut milk when heated).	Practical report with criteria: process description, heat concept, conclusion.
3	KD 3.7: Describe the diversity of genes, species, and ecosystems.	Sarkoyo ingredients (coconut, ginger, free-range chicken eggs) represent biodiversity.	Group discussion: identifying the conservation potential of natural materials used in Sarkoyo.	Group presentation with assessment of scientific aspects + environmental awareness.
4	KD 3.11: Explaining additives and addictive substances and their effects.	Sarkoyo uses natural ingredients without synthetic additives.	Case study: compare traditional beverages (Sarkoyo) with modern packaged beverages (synthetic additives).	The written test consists of analytical questions (essays) about the benefits and risks of additives.

CONCLUSION AND LIMITATIONS

Conclusion

This study shows that the process of making Sarkoyo herbal medicine by the Madurese people, especially in Sumenep Regency, contains a wealth of traditional knowledge (ethnoscience) that can be systematically reconstructed into scientific concepts and effectively utilized as a meaningful learning resource for science education. Empirical findings show that the preparation process, which involves 12 stages, facilitates a clear integration between biological, chemical, and physical concepts, such as homogeneous mixtures, heat transfer, and nutritional content, which are directly relevant to the junior high school science curriculum. In addition, the mixed-methods approach revealed that students had positive perceptions of ethnoscience integration, with the vast majority agreeing that this approach was enjoyable and fostered a love for local culture. This positive attitude among students strongly supports the application of local wisdom in the classroom. This integration of science and culture strengthens the connection between subject matter and students' daily lives, while instilling an important sense of appreciation for local culture and strengthening scientific literacy. Therefore, Sarkoyo herbal medicine can be effectively utilized as an additional ethnoscience-based learning resource that supports the implementation of the Merdeka Curriculum in schools, which ultimately strengthens students' character and scientific literacy.

Limitations

Although this study provides valuable insights into the potential of Sarkoyo herbal medicine as a source of science learning, several limitations must be acknowledged. The specific qualitative sample, namely herbal medicine practitioners in the Sumenep region, as well as the limited coverage of schools in Sumenep Regency, limit the generalization of findings on the reconstruction of local knowledge to cultural or educational contexts outside Madura. This study focuses on knowledge reconstruction and analysis of students' and teachers' initial perceptions of ethnoscience integration, thus neglecting the evaluation of the effectiveness of the final product. This study does not present

longitudinal data and does not consider how the long-term impact of ethnoscience-based teaching materials can influence the strengthening of students' character and scientific literacy. Further research is needed to address these limitations, including the development of ethnoscience-based teaching modules and student worksheets using Sarkoyo herbal medicine ethnoscience-based learning media, as well as validation of feasibility by experts and measurement of the effectiveness of teaching materials integrated with Sarkoyo herbal medicine using test instruments such as science literacy test sheets in the form of pre-tests and post-tests on students in a controlled classroom environment (quasi-experimental) that can be presented with a participatory approach, where students are encouraged to be active and to ensure that the materials developed are in line with the needs and cultural context, such as Sarkoyo herbal medicine, of the students.

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