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Ethnoscience Study for Science Education Through The Process of Making *Sopi Timor* from Gewang Sap (*Corypha utan Lamk*.)

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Abstract. The Gewang plant (*Corypha utan Lamk*) is an endemic plant that grows in the dominant vegetation of Timor Tengah Selatan (South Central Timor Regency). Nira is obtained from the gewang tree (*Corypha utan Lamk*) by inserting the what flower stems and then stored in a container for further fermentation with a mixture of red oak (*Saccharum officinarum Linn*), the hanging roots of the chickpeas (*Ficus benjamina*), the stems of the schleichera (*Schleichera oleosa*), the stem of the beetle (*Ziziphus mauritiana L.*), and the forest stems. (*Piper aduncum L.*). This study aims to study and describe the process of making *sopi timor* and analyze the scientific concepts that exist in the process. Based on the results of the study of the production of this *sopi timor*, public knowledge of fermentation and separation of solutions can be used as one of the materials to teach science content in the classroom with a local cultural approach. In the relationship between ESD and a Merdeka curriculum, there is a similar pattern of teachers taking a role in studying science in a contextual way that can be sourced from local cultures. It is intended for students to engage in meaningful learning processes because the context of their learning is related to their daily lives. The results of this research can be used as recommendations in context-based chemistry, biology, and physics learning in accordance with the culture in the South Central Timor Regency.

Keywords: ethnoscience; ethnochemistry; fermentation; gewang

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INTRODUCTION

South Central Timor Regency is one of the regencies in the East Nusa Tenggara Province (Nusa Tenggara Timur/ NTT). The land in the South Central Timor Regency is predominantly characterized by a dry land climate (Alhamd et al., 2022). Consequently, not many types of plants can provide long-term benefits for the livelihoods of the South Central Timor Regency community. However, one type of endemic plant that grows well in the South Central Timor Regency is the Gewang Plant (*Corypha utan Lamk*). The Gewang Plant has the potential to be used as a raw material to produce various processed products that can help improve the economy of the South Central Timor Regency community (Naiola, 2007).

The Gewang Plant, belonging to the family Arecaceae and order Arecales, is a plant with a single trunk similar to a coconut tree, with slow trunk growth that can reach a height of around 15-20 meters (Alhamd et al., 2022). The Gewang Plant is a monocarpic type,

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which flowers once with a terminal flower, then fruits, and eventually, the plant dies (Balibangtan, 2019). The Gewang Plant can reach an age of about 30-40 years.

The Gewang Plant, which still grows wild in the South Central Timor Regency, is one of the species or types of plants that form dominant vegetation (Lalel et al., 2018). The Gewang Plant or "tune" as the South Central Timor Regency community calls it, is used by the local community for daily life as a raw material for making shelters, kitchen and household utensils, fences, ropes, woven items, livestock feed, traditional food, and drinks (Lalel & Kaho, 2018).

When processed into a beverage, the Gewang Plant is called *Sopi Timor*. *Sopi Timor* is a cultural heritage from ancestors that has been produced for generations. In several regions in South Central Timor Regency, it has its name, such as in the Amanuban area, it is called "*Tua*," in Amanatun it is "*Suna Likaf*," and in North Central Timor it is "*Tuak Nakaf*." For the South Central Timor Regency community, *Sopi Timor* is used in various events and cultural ceremonies, such as engagement ceremonies, weddings, and other family events (Mambur & Bria, 2022). Anthropologically, the beverage is understood as an addition to certain cultural rituals. In South Central Timor Regency, the reconciliation process is achieved with *Sopi Timor*, even becoming an important symbol in certain rituals (engagement) (Saba Agu et al., 2023). The community uses gewang as a traditional drink and processes it into *Sopi Timor*. The sap produced from the gewang tree has the potential to be a source of bioethanol. Gewang sap is obtained by tapping the flower stalk of the gewang, which is then collected in a container for fermentation (Ceunfin et al., 2020).

The Gewang Plant plays an important role in the lives of the South Central Timor Regency community, but the community's utilization patterns do not seem to follow the principles of sustainable use (environmental sustainability). Exploitation in nature is not balanced with its regenerative capacity. As a result, the gewang population has significantly declined from its environment and could eventually become extinct over time (Partomihardjo, 2009).

Considering the importance of the above, one of the efforts that can be made to achieve sustainable utilization of the gewang plant is to reconstruct the community's indigenous knowledge on how to process the gewang plant into traditional beverages. This reconstruction process is intended so that the indigenous knowledge of the South Central Timor Regency community is not limited to the South Central Timor Regency community. However, it can be accepted by the general public and specifically integrated into school science education.

Therefore, this study aims to examine and describe the process of making *Sopi Timor* and analyze the scientific concepts involved. The results can be used as recommendations for contextual Chemistry and Biology learning in line with the culture in South Central Timor Regency.

METHOD

This study employed a descriptive qualitative approach, namely a literature review. Primary data was obtained from online data sources, such as a documentary video from YouTube by a South Central Timor Regency community member. The documentary video was then studied to collect data on extracting gewang sap, ferment it, and performing simple distillation on gewang sap. One *Sopi Timor* artisan reconfirmed the data collected from the documentary video to ensure the data aligns with current field conditions. The video data

source can be accessed at the link of YouTube Video https://www.youtube.com/watch?v=ZKvgDETzVGI&t=308s.
Additional supporting data includes information from 28 related articles that support the researchers' findings. The analysis focuses on making Sopi Timor in the South Central Timor Regency. The research steps are seen in Figure 1.

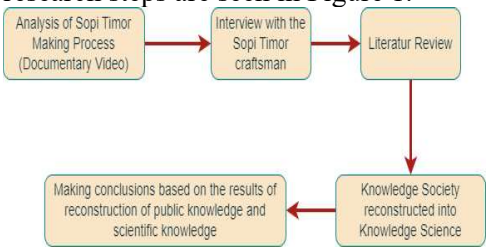


Figure 1 Research method

RESULTS AND DISCUSSION

Production of Sopi Timor

Preparation Stage of Gewang Sap Raw Material

The preparation process for making *Sopi Timor* begins with tapping gewang flower stalks as the primary raw material. Gewang sap is then combined with natural ingredients as traditional additives to enhance the beverage's flavour through fermentation. The gewang sap and its mixtures are stored in a closed container for four days before being cooked.

Respondents mentioned using natural ingredients to maximize the function of *Sopi Timor* itself. The natural ingredients added include red sugarcane *(Saccharum officinarum Linn)*, aerial roots of the banyan tree *(Ficus benjamina)*, branches of the kesambi tree *(Schleichera oleosa)*, branches of the Indian jujube tree *(Ziziphus mauritiana L.)*, and forest betel *(Piper aduncum L)*. It is believed that these natural ingredients help improve the quality of sleep resulting from fatigue from working in the fields. Thus, consuming a small amount of *Sopi Timor* daily is considered normal. The benefits of these natural ingredients are also commonly used in traditional medicines by the community.

Production Stage

After being left to sit for four days, the gewang sap is then cooked in a closed container. The cooking process is still traditional, using a 2-meter-long bamboo for distillation with a 1-meter-high support. The community has long used this traditional distillation technique to produce *Sopi Timor*. The quality of *Sopi Timor* produced in each village in the South Central Timor Regency varies in flavour. This variation is influenced by factors such as the height of the support, the length of the bamboo used in distillation, and the different natural ingredients mixed with the sap in each village. These differences result in *Sopi Timor* with distinct and unique flavours, aromas, and colours.

Respondents noted that *Sopi Timor* can last for months if stored correctly. The community's practice is to store *Sopi Timor* in round houses in tightly closed glass bottles, which are then kept in boxes. This technique is believed to maintain the quality of *Sopi Timor*.

Figure 2 Stages of *sopi timor* production

Scientific Concepts in the Process of Transforming Gewang Sap into *Sopi Timor*

Education for Sustainable Development (ESD) is an essential part of the agenda to respond to the demands of the 21st century. Concerning ESD, teachers are required to prepare future generations to face upcoming challenges and possess adequate skills to compete in an increasingly consumerist society.

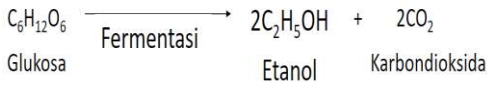
Generally, ESD is integrated with environmental ecology, as well as social and economic aspects. To support the implementation of ESD, sustainable behaviour, such as proper management of natural resources, is encouraged (Zuhaida & Widodo, 2023).

In Science education at schools, students are expected to be equipped with scientific attitudes that will help them manage every piece of information they obtain. The relationship between ESD and the independent curriculum follows a similar pattern, where teachers play a role in teaching science contextually, with sources potentially drawn from local culture (Mahendrani & Sudarmin, 2015). This approach aims to make the learning process meaningful for students as it relates to their daily lives (Mahendrani & Sudarmin, 2015).

Local culture-based learning emphasizes a system or knowledge specific to a community (local wisdom) (Rosyidah et al., 2013). Referring to indigenous knowledge, it can be examined whether this knowledge can be described from a scientific perspective. Hence, the accuracy of this indigenous knowledge can be tested and empirically validated (Nisa' et al., 2015).

The indigenous knowledge of the South Central Timor Regency community about making *Sopi Timor* has been passed down through generations, making it an essential part of official events to this day. *Sopi Timor* is an alcoholic beverage processed by the local community through fermentation and simple distillation.

Simple distillation separates chemical substances based on the difference in their evaporation rates or volatility. In the distillation process, the mixture of sap is boiled to produce vapour, which is then condensed into liquid form. Since gewang sap has a boiling point between 70-76°C, it will evaporate first. The residue in the container that does not evaporate is water. Here is the simple reaction equation when glucose in sap is converted into ethanol:



Gewang sap samples contain more than 10% sugar, making the sugar fermentable into ethanol. The following details of the chemical contents of fresh gewang sap are listed in Table 1.

Table 1 Chemical contents of fresh gewang sap

No	Type of Analysis	Sap	Sugar Water	Mash	Sopi
1	Fructose (%)	4.0	4.5		
2	Glucose (%)	3.5	4.6		
3	Saccharose (%)	3.6	8.9		
4	Water (%)	85.2	80.1		
5	Alcohol (%)			6.4	7.0
6	Malate (ppm)			11.5	
7	Citrate (ppm)			4.6	
8	Glutamate (ppm)			7.9	
9	Tannate (ppm)			8.4	

Source: (Naiola, 2008)

Villagers understand how to make *Sopi Timor* using simple distillation techniques with bamboo equipment. *Sopi Timor* is an alcoholic drink resulting from the fermentation of gewang sap with natural ingredients. The fermentation process occurs at room temperature (28-30°C) for four days. The following details of the results of the chemical analysis of *Sopi Timor* are listed in Table 2.

Table 2 Chemical analysis results of *sopi timor*

No	Type of Analysis	Sap	Sugar Water	Mash	Sopi	Flour
1	Fructose (%)	4.0	4.5	-	-	-
2	Glucose (%)	3.5	4.6	-	-	-
3	Sucrose (%)	3.6	8.9	-	-	-
4	Water (%)	85.2	80.1	-	-	-
5	Carbohydrate (%)	-	-	-	-	6.4
6	Alcohol (%)	-	-	6.4	7.0	-
7	Tannins (%)	-	-	-	-	6.4

Source: (Naiola, 2004)

The results of the phytochemical tests on *Sopi Timor* can serve as information for explaining content in classroom learning. Teachers can leverage commonly known knowledge among students. This effort is a strategy for creating a learning environment by integrating culture into the learning process (Imansari et al., 2018). Teachers use cultural references to provide new knowledge about how community knowledge can be scientifically explained (Setiawan et al., 2017). The following are examples of some community knowledge reconstructed into scientific knowledge as shown in Table 3.

Table 3 Reconstruction of Indigenous Knowledge in Making *Sopi Timor*

Indigenous Knowledge	Scientific Explanation
1. gewang sap is tapped in the morning to produce a good taste. 2. The tapping process can take 20-30 consecutive days.	1. The photosynthesis rate is high in the morning and midday, resulting in high sugar levels. During photosynthesis, plants use light energy to convert CO2 into sugar. The photosynthesis rate decreases in the afternoon, affecting the sugar levels produced. The sugar content in sap also influences the alcohol content during fermentation. 2. The *Aracaceae* family (palms) can reach 25 meters in height and have a trunk diameter of up to 65 cm. Preliminary research (Alhamd et al., 2022) suggests that the Aracaceae family can store and absorb 200 litres of water. Parenchyma cells in the Aracaceae family are found in the roots, trunk, and leaves, with the largest water storage capacity in the trunk. This allows sap to be harvested for 20-30 consecutive days.
Freshly tapped sap tastes sweet.	Freshly tapped sap tastes sweet due to the presence of compounds: fructose (4%), Glucose (3.5%), Sucrose (3.6%), and Water (85.2%) (sugar content > 10%). Fresh sap has a pH of about 5-6 (Ceunfin et al., 2020).
Sap that has been collected for a few hours tastes sour and foamy.	Sap stored for several hours tastes sour and foamy due to the high sugar content, leading to fermentation aided by microbial activity, which gradually turns it acidic (Hotijah et al., 2020). Sugar-containing sap can undergo alcohol fermentation at room temperature (26˚C), producing alcohol after 28 hours, characterized by foaming, alcohol aroma, sediment, and color change. The sour taste is due to microbial activity breaking down sugar into organic acids (Hotijah et al., 2020).
The sap is stored for fermentation in a closed container for 4-6 days to produce a delicious taste of *sopi Timor*.	Sap is stored for fermentation in a closed container for 4-6 days to achieve the desired taste of *Sopi Timor*. The fermentation time varies depending on sugar content, temperature, and other factors. According to Hadi et al. (2013), the average fermentation time for sap is 75.3 - 78 hours or about three days. Each fermentation period differs based on several factors, including the sugar content of the material. The highest alcohol content is achieved after 120 hours of fermentation due to the stationary phase of microbial growth, where the sugar for Saccharomyces cerevisiae has been fully broken down (Andriani et al., 2015). The increase in Saccharomyces cerevisiae cells will be rapid up to the first 48 hours after inoculation in the medium. After 48 hours, cell growth will

Indigenous Knowledge	Scientific Explanation
	stabilize or tend to decrease, depending on the pH, nutrient concentration, and alcohol concentration in the medium (Banoet & Sudana, 2016).
Adding other natural ingredients enhances the flavour and serves as a sleep aid (improving sleep quality).	**Red Sugarcane** *(Saccharum officinarum Linn):* Its nutritional content offers several health benefits, including boosting energy, counteracting free radicals, improving digestion, maintaining liver health, and supporting kidney function. **Kesambi Bark** *(Schleichera oleosa)*: Traditionally, parts of the kesambi plant have been used for treating skin diseases, dysentery, and snake bites. This plant also contains high levels of vitamin C, which acts as an antioxidant. In South Central Timor Regency, kesambi wood is used to inhibit the growth of E. coli bacteria. Phytochemical tests on kesambi bark extract indicate the presence of triterpenoids, phenolics, alkaloids, and flavonoids. **Bidara Tree** (*Ziziphus mauritiana L.*): Benefits include managing diabetes, potential as an anticancer agent, and traditional uses for treating health issues such as asthma, diarrhea, fatigue, fever, high blood pressure, and inflammation. **Hanging Roots of Banyan** (*Ficus benjamina*): Known to contain phenolic compounds that function as antioxidants. Phytochemical tests on banyan hanging root extract reveal flavonoid compounds. Flavonoids in banyan hanging roots play a role in inhibiting lipid peroxidation by scavenging free radicals with their hydrogen atoms from OH groups, thus reducing or preventing reactions between free radicals and unsaturated fats. **Wild Betel Leaf** (*Piper aduncum L.*): Known for its medicinal properties, including wound healing, stopping vomiting, reducing nausea, improving digestion, acting as an antiseptic, and killing bacteria, fungi, and viruses.
Sopi Timor is distilled using moderate heat with a simple separation technique based on the principle of simple distillation—separation based on substances' different boiling points.	Distillation Principle: The principle of cooking *sopi Timor* is based on simple distillation, a method of separating chemical substances based on differences in volatility. The mixture is boiled to vaporise during distillation, and the vapour is then condensed back into liquid form. Substances with lower boiling points will vaporize first. In distillation, the mixture is boiled to produce vapour, which is then condensed into liquid form. The substance with the lower boiling point evaporates first. The residue in the container is water that does not evaporate with alcohol due to the difference in boiling points (water content in sap is 80%).
The quality of *Sopi Timor* is evaluated by its flammability.	The alcohol content is an organic compound with an -OH group attached to an aliphatic or cyclic chain carbon atom. Alcohols are weak acids, volatile, and flammable.
Sopi Timor can be stored for over six months if the container is tightly closed and kept off direct contact with the ground/floor. *Sopi Timor* tastes the same if stored in a lopo or roundhouse.	Like other biological (enzymatic) processes, to maintain the quality of the fermentation result, the recommended storage temperature is generally between 27 – 32°C. *Sopi Timor*, produced through fermentation, is a pure alcohol isolate with antimicrobial properties that can prevent the growth of bacteria and fungi, allowing it to last for a long time. However, storing *Sopi Timor* in an airtight container and away from direct sunlight is important to maintain its quality.

During fermentation, one of the microorganisms involved is the species *Saccharomyces cerevisiae.* The presence of this yeast helps convert glucose into ethanol and CO2. *Saccharomyces* is a single-celled microorganism that lacks chlorophyll and belongs to the eumycetes group. It grows well at a temperature of 30°C and an acidity of 4.8. Some advantages of *Saccharomyces* in the fermentation process include its rapid reproduction, resistance to high alcohol levels, tolerance to high temperatures, stability, and quick adaptability. The growth of *Saccharomyces* is influenced by the addition of nutrients such as carbon as a carbon source, nitrogen obtained from the addition of urea or ammonium sulfate, ammonium and peptone, minerals, and vitamins. The following classification of Saccharomyces is shown in Table 4.

Table 4. Classification of Saccharomyces

Kingdom	*Fungi*
Phylum	*Ascomycota*
Subphylum	*Saccharomycotina*
Class	*Saccharomycetes*
Order	*Saccharomycetales*
Family	*Saccharomycetaceae*
Genus	*Saccharomyces*
Species	*Saccharomyces cerevisiae*

Source: Khazalina (2020)

This type of microbe is facultative, meaning it has two mechanisms for obtaining energy. If there is air during the fermentation process, the microbe's energy is obtained from aerobic respiration, and if there is no air, energy is obtained from *anaerobic* respiration. The energy from aerobic respiration is used for cell growth and development, so there is no increase in alcohol content (Eka & Halim, 2009). The Saccharomyces microbe contains two enzymes, invertase and zymase. Invertase is a catalyst that converts sucrose into glucose, while zymase converts glucose into ethanol and CO2 (Ariyani et al., 2015). In the fermentation process, the efficiency of *Saccharomyces* in *anaerobic* conditions is more advantageous as it produces more ethanol (Eka & Halim, 2009). Saccharomyces cerevisiae has a high fermentation capacity for glucose, fructose, galactose, and maltose, and it is resistant to relatively high alcohol levels and other microbes (Baihaki et al., 2013).

After the fermentation process, the distillation stage is carried out to separate the alcohol and water present in the gewang sap. The distillation principle separates chemical substances based on differences in boiling points (Novita et al., 2023). The following image is an example of a simple distillation apparatus setup.

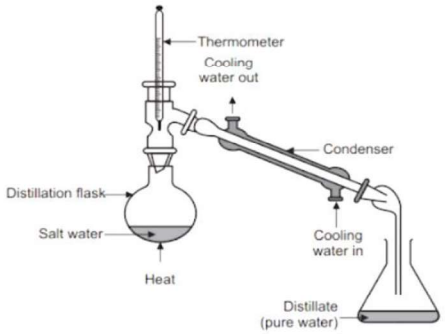


Figure 3 Sample of a simple distillation apparatus setup
(Source: www.pharmaguideline.com)

During the distillation process, the sap mixture is boiled to create vapour, which separates and is collected in a container (Saputro et al., 2023). Alcohol, with a boiling point of 70-78°C, will evaporate first, while the water in the gewang sap remains in the boiling container. Here are the details of the materials that can be linked to the community's knowledge of making *Sopi Timor*.

Table 5 Science material in relation to the *sopi timor*-making process

Subject	Core Material	Basic Competences
Chemistry, High School Grade X/I	Matter Changes and Mixture Separation	3.1 Analyzing matter changes and mixture separation in various ways. 4.1 Performing mixture separation through practical experiments based on physical and chemical properties.
Chemistry, High School Grade XII/I	Colligative Properties of Solutions	3.1 Analyzing the causes of colligative property phenomena in solutions related to vapour pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure. 4.1 Presenting analysis results based on experimental data related to vapour pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure in solutions.
Biology, Middle School Grade VII/I	Classification of Living Things	3.2 Classifying living things and objects based on observed characteristics. 4.2 Presenting classification results of living things based on observed characteristics.

Subject	Core Material	Basic Competences
Biology, High School Grade X/I	Microorganisms	3.5 Understanding microorganisms (fungi, viruses, protists, and bacteria) based on characteristics, roles, and reproduction. 4.5 Demonstrating microorganisms based on characteristics, roles, and reproduction.
Physics, Middle School Grade VII/I	States of Matter and Their Changes	3.1 Investigating the properties of substances based on their states and their applications in daily life.

CONCLUSION

Based on the research results, it can be concluded that the process of making *Sopi Timor* can be integrated into Chemistry and Biology lessons in class. The *Sopi Timor*-making process consists of preparation and processing stages. The preparation stage includes tapping the flower stalks of the gewang tree, collecting gewang sap, and mixing ingredients such as red sugarcane *(Saccharum officinarum Linn)*, hanging roots of the banyan tree *(Ficus benjamina),* the trunk of the kesambi tree *(Schleichera oleosa),* the trunk of the bidara tree *(Ziziphus mauritiana L.)*, and wild betel *(Piper aduncum L.).* This mixture is then covered and left for four days before distillation. The processing stage involves distillation. Through each stage of the *Sopi Timor*-making process, the Indigenous knowledge of the village community can be reconstructed into scientific knowledge whose accuracy can be proven. The related Chemistry and Biology materials include analyzing matter changes and mixture separation, conducting practical experiments on mixture separation and changes in the states of matter, and understanding microorganisms based on their characteristics and roles.

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