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Exploring Physics Concepts in the Moke Distillation: An Ethnoscience Study of the JA Mokeasa Village

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Abstract

This study aims to identify physics concepts in the moke refining process practiced by the community of Ja Mokeasa Village, Ende Regency, East Nusa Tenggara. Moke is a traditional beverage made from enau tree sap and holds important social and cultural value. This research employed a qualitative descriptive ethnoscience approach. Data were collected through two direct observations of the distillation process and in-depth interviews with two moke artisans, each lasting approximately 45–60 minutes. Data credibility was ensured through source and method triangulation by comparing observations, interviews, and documentation. Data analysis used the Miles and Huberman interactive model, including data collection, reduction, presentation, interpretation, and conclusion drawing. The findings reveal several physics concepts in the distillation process, such as temperature and heat, changes in states of matter, heat transfer mechanisms, and pressure relationships. The moke distillation process has the potential to be used as a contextual learning resource in science or physics education by integrating local wisdom with scientific concepts.

Keywords: Ethnoscience, physics concepts, moke distillation

INTRODUCTION

The people of East Nusa Tenggara, especially in Flores, have a close tradition with *moke*, a traditional drink that symbolizes brotherhood, friendliness, and social solidarity as part of Indonesia's cultural richness. *Moke* is a traditional drink produced from the sap of the enau tree (*Arenga pinnata*) through a distillation process (Putra, 2024). The manufacturing process begins with tapping the enau tree to obtain sap (*tuak* or *white moke*), which is then heated and distilled to produce *moke* (Bao et al., 2024). Initially, *moke* was produced mainly for the purpose of traditional ceremonies, but now it is also traded either directly or through intermediaries (Nugrahani, 2021). The process of distillation *of moke* stores a variety of scientific phenomena that are relevant to the learning of physics. One of the problems that is still often found in physics education is the low understanding of students of abstract concepts, especially in heat and temperature materials, heat transfer, changes in the form of substances, and thermodynamic processes (Saprudin et al., 2017). These concepts are generally taught through theoretical explanations and examples in textbooks that are less relevant to the real experiences of learners (Nurdiansah et al., 2019). Learners often have difficulty in establishing conceptual understanding and connecting the principles of physics to everyday life, so physics is seen as a difficult subject and far from their sociocultural context (Saminan et al., 2024). The integration of local knowledge in physics learning is one of the approaches that has the potential to overcome this problem (Hidaayatullaah et al., 2021)

The process of distillation *of moke* involves a variety of physics concepts that can be observed directly, such as heating, evaporation, condensation, and energy transfer. These phenomena make *moke* distillation an authentic learning context to learn the concepts of heat and thermodynamics. The use of cultural contexts that are close to students' lives can help them build understanding based on familiar experiences, thereby increasing conceptual mastery, learning engagement, and appreciation of local wisdom (Sholihah et al., 2021). This approach is in line with contextual and culturally responsive learning that emphasizes the interconnectedness between scientific concepts and the realities of students' lives.

For the people of Ja Mokeasa Village, particularly those in Mokeasa, the moke distillation process has become a sacred ritual aimed at preserving the purity of their ancestral heritage a devotion that extends far beyond mere economic value. The moke distillation process is still carried out using traditional methods, passed down from generation to generation, and continues to be preserved to this day (Makin et al., 2024). In community traditions, moke is consistently presented as an offering or a symbol of respect for ancestors and for guests in attendance (Saka & Nainggolan, 2019). Each drop of clear moke is carefully crafted through a precise traditional distillation process using simple, customary tools, beginning with clay pots (Owon, 2017) and traditional stoves, long bamboo tubes used to channel the vapor, as well as wood embers and spices that create its distinctive aroma and flavor (Keron et al., 2024). This original method not only preserves the strong and authentic taste of moke, but also reflects its role as the cultural core that bridges past and present generations through simple local wisdom (Serfiyani et al., 2020). As an essential element of local culture, nearly all residents of Mokeasa including school-age children have grown accustomed to the moke-making process.

Although it originates from inherited wisdom passed down orally without formal academic frameworks, the distillation of moke represents a harmonious natural process that operates in an orderly and precise manner. In local culture, there exists a form of wisdom that can enrich and enhance knowledge as well as learning materials across various levels of education (Normina, 2018). Through cultural context, students can recognize that scientific concepts are inherently present in everyday life, including in traditions, local technologies, and community practices (Delima et al., 2018). The moke distillation process encompasses traditional techniques, tools, and stages that can be utilized as exploratory materials in educational activities (Hau et al., 2021). Integrating local contexts into learning enables students to perceive physics not as external knowledge, but as an inherent part of their identity and daily experiences (Eliezanatalie & Deta, 2023). The traditional moke distillation process can be integrated into science learning by illustrating the concepts of heat, evaporation, condensation, and distillation (Lidi et al., 2022). The transformation of sap from the sugar palm through the distillation process to produce pure moke demonstrates how fundamental principles of physics operate naturally within traditional practices.

Previous studies have examined moke from social, cultural, and economic perspectives. However, there are still limited studies that specifically identify the physics concepts involved in the distillation process using an ethnoscientific approach. By examining moke distillation techniques in Mokeasa Village, this study presents new insights and connects them to physical concepts such as temperature and heat, phase changes, heat transfer, and the relationship between pressure and boiling point. This study confirms that moke distillation can serve as an ethnoscience-based contextual learning resource, as it not only documents local knowledge but also interprets it scientifically to support science learning rooted in local culture.

METHODOLOGY

This study employs a qualitative design with an ethnoscience approach to gain a deeper understanding of the moke distillation process as a form of community-based local wisdom and its connection to physical concepts. The ethnoscience approach was selected because it provides a framework for researchers to transform locally inherited knowledge into scientific understanding that can be explained conceptually. In this study, terms, practices, and local explanations related to *moke* distillation were identified through observation and interviews, then interpreted and translated into scientific concepts by examining the observed phenomena as well as the underlying physical processes.

The research was conducted in Ja Mokeasa Village, Ende District, Ende Regency, East Nusa Tenggara, taking into account the sustainability of traditional moke distillation practices and the active role of the community in preserving local wisdom. The selection of locations and informants is carried out purposively. The research subjects consisted of two informants who understood local practices and knowledge related to moke distillation, namely a moke artisan with more than thirty years of experience and a supporting informant. One of the informants was interviewed directly at the distillery and at the same time field observations were carried out to observe the stages of distillation, the use of tools, and physical phenomena that arise during the distillation process. Data were collected through two direct observations, semi-structured in-depth interviews lasting 45–60 minutes per informant, and documentation, including observations of local knowledge such as fire arrangements, bamboo joint density, and the use of *nao fibers* in the condensing process. Data from both informants are compared and confirmed through observation and documentation to increase the credibility of the research findings.

Data was collected through direct observation, in-depth interviews, and documentation. Observations were carried out using observation guidelines to examine the stages of *moke* distillation, the use of tools and materials, as well as emerging physical phenomena, such as heat transfer, evaporation, and condensation. In-depth interviews use semi-structured guidelines to explore the informant's local knowledge of distillation practices, tool functions, and hereditary knowledge. With the consent of the informant, the interview is recorded and transcribed to support data analysis. Documentation in the form of field notes, photographs, and audio and visual recordings is used to complete and triangulate the data. Ethical aspects are considered through the provision of *informed consent*, voluntary participation, and ensuring the confidentiality of informant information.

To ensure the validity and credibility of the data, this study employs triangulation method by comparing the results of observations, interviews, and documentation. Triangulation is carried out by confirming the same findings from various data sources, for example the heating process and the appearance of condensation in the distillation apparatus that are directly observed, explained by the informant in the interview, and supported by photographs and recordings during the distillation process. The data was analyzed using the Miles and Huberman interactive model which included data collection, data reduction, data presentation, and conclusion drawing (Rijali, 2019)

RESULTS AND DISCUSSION

THE MEANING OF MOKE AND ITS CULTURAL SIGNIFICANCE TO THE MOKEASA COMMUNITY

Mokeasa is located in Ja Mokeasa Village, Ende Regency, East Nusa Tenggara Province (NTT). The village is distinguished by its sustained maintenance of local traditions and indigenous knowledge, especially in the transformation of sap into the traditional drink known as moke. The name of Moke Asa Village holds symbolic significance intimately connected to the community's way of life. 'Moke' denotes a traditional beverage derived from enau palm sap, whereas 'asa' in the local dialect signifies a fence. Moke Asa can be understood as a village 'enclosed' by the sugar palm(*Arenga pinnata*). A key agricultural product of the Mokeasa community, the sugar palm, is processed into moke to create marketable value.

The abundance of enau palms in the area shapes both the cultural identity and daily life of the local community. Beyond its economic significance, moke also constitutes a vital element of their cultural heritage and communal practices. Moke holds a central role in Mokeasa traditions, particularly in the performance of various ceremonies and rituals. Moke carries symbolic meanings, including reverence for ancestors, a representation of communal solidarity, and an integral component of customs transmitted across generations. Moke is regarded as an essential element in traditional ceremonies. Over the years, the Mokeasa community has consistently ensured the presence of moke prior to traditional ceremonies, such that virtually no ceremony occurs without it. Moke constitutes a significant aspect of Mokeasa culture, embodying local wisdom and communal identity that has been transmitted across generations.

DESCRIPTION OF LOCAL KNOWLEDGE AND THE TRADITIONAL PROCESS OF MOKE DISTILLATION

The people of Mokeasa Village continue to distill moke using simple apparatus, primarily constructed from natural materials. The primary equipment comprises a traditional furnace for combustion and a clay pot serving as a heating vessel for holding the sap. " The furnace is constructed from a combination of soil and stones, arranged to support the pot while directing heat to the bottom of the vessel. The use of dry wood as a heat source indicates the community's understanding that the distillation process requires a consistent and stable heat. The heat generated from burning wood produces thermal energy, which is transferred to the sap via the heating vessel until it reaches its boiling point and begins to evaporate. The furnace design used in the moke distillation process is presented in Figure 1.

Figure 1. Moke distilling furnace design

The steam produced during the heating process is flowed through a series of bamboo that functions as a steam channel as well as a natural condenser that connects the heating container with the container container. The series consists of two bamboo sticks of different sizes and positions. The first bamboo, locally called *bheto*, was larger in diameter by about two meters long and was mounted vertically on top of a clay pot to drain steam from the heating container. team is flowed to a second bamboo that is smaller in diameter, called a fairy, about six to seven meters long and installed at a certain inclination. This bamboo functions as a condenser where the steam undergoes cooling and condensation before flowing to the container at the lower end of the bamboo system. A simple schematic showing the steam path, condenser section, bamboo slope, and liquid collection point is presented to facilitate the interpretation of the physical processes that occur. The bamboo design that functions as a natural pipe in the moke distillation process is shown in Figure 2.

Figure 2. Bamboo range design

Within the hollow of the smaller bamboo, artisans typically position the sugar palm (referred to locally as 'nao') at a designated point within reach. The presence of these palm fibers aids in accelerating the condensation process by providing an additional surface for heat dissipation, thereby facilitating the faster conversion of steam into liquid, which then flows into the final collection container. At the connection points, it is essential to maintain a tight seal to prevent leakage, which could allow steam to escape prior to condensation, potentially reducing both the yield and quality of the distilled product. The activities of craftsmen who are closing steam leaks in the distillation process to minimize the loss of steam produced are shown in Figure 3.

Figure 3. Moke artisan is covering up steam leak

Regulating the fire temperature is a critical aspect of the refining process, carefully managed by the community to maintain the stability of heat produced by the wood embers. Empirically, the community recognizes that maintaining a stable temperature is crucial for determining the quality of moke, as excessive heat can lead to overheating and adversely affect the flavor, whereas insufficient heat can impede the evaporation process. The ability to regulate fire intensity is obtained through hereditary experience by utilizing local indicators, such as boiling sound and steam intensity, as a reference for adjustments. As one artisan put it, *"If the boiling sound is too loud and too much steam comes out, the fire must be reduced so that the moke is not damaged."* Field observations also show that craftsmen periodically adjust the amount of firewood based on changes in sound and the volume of steam produced. This knowledge not only demonstrates technical skills, but also reflects the wealth of local knowledge and traditional wisdom of the community. To achieve the distinctive flavor of moke, the community also incorporates various natural spices, the use of which is informed by ancestral knowledge transmitted across generations. Figure 4 shows a container used to hold the final result of the distillation process in the form of moke which has been formed through the steam condensation process.

Figure 4. Moke condensed containers

To produce high-quality moke, artisans typically distill sap from approximately 15 liters to yield around 2.5 liters of moke. . The ratio is based on the empirical experience of artisans who are considered able to maintain the balance of taste and quality of distillation results. One of the artisans explained that "*too much or too little distillation can affect the taste of moke, and potentially reduce the quality of spices due to a sub-optimal distillation process*". To maintain consistency of results, artisans usually give a measuring mark on the container as a guideline in controlling the volume of moke produced during the distillation process. From a scientific point of view, the variation in the volume of distillation results is related to the effectiveness of the evaporation and condensation processes, the degree of separation of components during heating, as well as the temperature stability maintained during distillation. Differences in these factors can affect the concentration of compounds formed in the final product. Consistency in ingredient composition and distillation process control is an important aspect in determining the quality of the moke produced.

IDENTIFICATION OF PHYSICAL CONCEPTS IN THE MOKE REFINING PROCESS

The moke refining process practiced by the people of Mokeasa exemplifies the practical application of physics concepts in daily life. Although traditional in nature, each stage of the process demonstrates fundamental principles of physics, particularly those related to thermodynamics and heat transfer (Hau et al., 2021). The concepts identified include temperature and heat, changes in the form of substances, the mechanism of heat transfer, and the relationship between pressure and boiling point. To clarify the educational contribution of these local practices, the physics concepts found are mapped based on local practices, observed phenomena, scientific concepts, and their potential application in physics learning**.** The results of the physics concept mapping in the moke distillation process can be seen in Table 1.

Tabel 1. Pemetaan Etnosains Fisika Pembelajaran

Local Practices of Moke Distillation	Observed Phenomena	Physics Concepts
Heating palm sap using wood embers	The sap experiences an increase in temperature	Temperature and heat
Regulating fire intensity based on boiling sounds and steam	Changes in the heating rate	Heat transfer and thermal energy control
Formation of steam from the sap	Liquid changes into gas	Change of state (evaporation)
Steam flowing through bamboo	Steam moves toward the cooling bamboo	Heat transfer and fluid flow
Cooling process in the bamboo and nao fibers	Steam changes back into liquid	Condensation and heat release
Distilled liquid collected in the final container	Distillate is separated from the steam	Distillation and the relationship of boiling points

Figure 5. Distillation process

Temperature and Heat

Temperature and heat are important factors in the success of the moke distillation process. The heat generated from burning wood serves as an energy source, which is transferred to the sap via the heating vessel. Physically, this thermal energy increases the kinetic energy of the sap molecules, causing the particles to move more rapidly (Amaliah et al., 2022). In the early stages, the heat causes the sap to heat up until the more volatile components begin to form steam. This process does not simply involve boiling water or pure ethanol, but distillation of mixtures containing water, ethanol, and other volatile compounds. Evaporation occurs gradually according to the characteristics of the mixture and not at a single boiling point. The artisan regulates the intensity of the fire to maintain the stability of heat transfer during the distillation process. Too high heat can upset the balance of component separation and affect the taste of *the moke*, while too low heat can inhibit steam formation and decrease distillation efficiency..

Changes in Substance Forms (Evaporation and Condensation)

In the moke refining process, two primary phase-change mechanisms occur: evaporation and condensation. Evaporation takes place as the sap absorbs heat, causing its molecules to transition from the liquid to the gaseous phase. The steam that is formed then moves through the bamboo and experiences a drop in temperature due to contact with a colder environment. As a result, the kinetic energy of the molecules decreases so that the intermolecular force again dominates and the vapor turns into a liquid through the condensation process This distillation process involves not only a change in form, but also the separation of components based on the volatility or tendency of each component to evaporate under certain heating conditions (Gerbaud et al., 2019). Less volatile components tend to form vapor first and then condense, so this principle is the basis of physics and chemistry in the *process of distillation moke*

This whole series shows a cycle of change in existence:

Liquid → vapor → liquid as a fundamental principle in distillation

Heat Transfer (Conduction, Convection, and Radiation)

In the process of refining moke, heat transfer occurs through several mechanisms simultaneously:

1) Conduction
   Conduction occurs when heat from wood coals transfers directly to the bottom of the clay pot containing sap. The heat is then passed through the walls of the pot to the liquid inside. In addition, thermal transfer by conduction also occurs in parts of bamboo that come into contact with steam and the surrounding environment.
2) Convection
   Convection takes place inside the sap during the heating process. The sap at the bottom of the pot receives the heat first so that it becomes hotter and less tight, then moves up, while the cooler part descends to form a convection current that helps to evenly distribute the temperature. The convection mechanism also occurs in the flow of steam moving from the pot to the bamboo during the distillation process.
3) Radiation
   Radiation occurs when wood coals emit heat energy into the surrounding environment without the need for an intermediate medium. This heat emission is received by the surface of the clay pot and part of the surrounding bamboo, thus supporting the heating process and steam formation in the distillation system.

Pressure and Boiling Point

The distillation process is also associated with the concepts of pressure and boiling point, with pressure playing a critical role in determining the characteristics of evaporation. The boiling point of a liquid depends on the external pressure acting on its surface (Ohe, 2022). In a relatively open moke distillation system, steam moves from the pot to the bamboo mainly due to steam formation and temperature differences in the system, not due to large pressure differences. The slope of bamboo mainly functions to help the flow of condensation liquids through gravitational force and can reduce flow resistance during the process of steam movement and condensation (Sukamta et al., 2018). This traditional arrangement shows the implicit application of the principles of heat transfer, fluid flow, and thermodynamics in the moke distillation process.

CORRELATION OF LOCAL KNOWLEDGE WITH SCIENTIFIC PHYSICS CONCEPTS

The moke distillation practices of the Mokeasa community implicitly incorporate various principles of physics throughout the production process. A prominent example is the regulation of the flame during sap heating, which demonstrates a practical understanding of the concepts of temperature and heat. Artisans recognize that excessive heat can compromise the quality of moke, whereas insufficient heat may impede the evaporation process. The temperature range of 70–80°C mentioned in the *moke distillation process* (Mardiyah, 2018) is understood as the empirical heating range used by craftsmen to maintain the stability of the process, rather than as a single boiling point of the heated liquid. This is because fermented sap is a mixture of water, ethanol, and other volatile compounds that have different evaporation characteristics (Raju et al., 2024). Therefore, temperature regulation in this range is more related to efforts to maintain steam formation and optimal quality of distillation results. This practice reflects the local knowledge of the community in balancing the efficiency of distillation and the taste of *moke*, while also being in line with the principle of physics that heat energy affects the kinetic energy of molecules and the rate of evaporation (Amaliah et al., 2022).

In the moke distillation process, artisans utilize bamboo of varying diameters and lengths. Based on the results of field observations, the inside of the bamboo is cleaned from the bulkhead so that it forms an elongated cavity for steam flow. Large-diameter bamboo, which is generally installed vertically on top of the pot, is about two meters long and serves to drain steam from the heating container. Meanwhile, smaller diameter bamboo is installed lengthwise with a length of about six to seven meters to support the cooling process and condensation of steam towards the container.

The field findings are in line with previous research that showed that the use of bamboo of a certain size and length affects the smooth flow of steam as well as condensation efficiency in the distillation process (Bao et al., 2024; Ceunfin et al., 2021). According to Agua et al., 2023, the appropriate proportion of bamboo helps the condensation process take place more effectively, while heating for too long can affect the flavor character of the distilled product (Raju et al., 2024). Thus, the selection of bamboo dimensions in *moke* distillation is not only based on traditional practices, but also relates to energy balance, fluid flow, and condensation efficiency. The placement of palm oil (Nao in the local language) in bamboo also shows the community's practical understanding of the heat transfer process. Palm oil serves as an additional medium that expands the contact surface between the steam and the cooler environment, thereby accelerating the release of heat from the steam. This process is similar to the process of distilling sopi from palm sap in the study of Agua et al., (2023) which uses palm leaves as a medium to direct steam flow and accelerate the condensation process. This condition helps the condensation process so that the moke liquid can flow to the final container

The placement of palm oil (referred to locally as 'nao') within the bamboo demonstrates the community's practical understanding of heat transfer. Palm oil functions as an additional medium that increases the contact surface between the steam and the cooler environment, thereby accelerating heat dissipation. This process is analogous to the distillation of sopi from palm sap, as reported by (Agua et al., 2023), where palm leaves are used to guide steam flow and enhance condensation. In the context of education, the practice of *moke* distillation can be utilized as a learning resource for contextual physics. Teachers can develop simple investigative activities to observe heat transfer and phase changes through distillation simulations, as well as guide learners to analyze the relationship between heating, steam formation, and condensation in traditional distillation systems.

Local practices in moke distillation implicitly reflect fundamental principles of physics, including heat transfer, phase changes, and pressure regulation. This indicates that indigenous knowledge possesses a scientific foundation that can be analyzed and explained through physical theory. Studies have confirmed the relevance of moke distillation for science education: (Hau et al., 2021)highlighted that the process encompasses various physics concepts that can be developed into scientific knowledge for school learning. Similarly, (Lidi et al., 2022) emphasized that moke distillation can serve as an ethnoscience context, enabling contextualized science learning that is meaningful, active, and culturally grounded. Collectively, these findings demonstrate that moke distillation not only embodies relevant physics concepts but also holds significant potential as an ethnoscience-based learning resource, enhancing learning meaningfulness, student engagement, and the integration of local culture into science education

CONCLUSION

Based on the research findings, the moke distillation practices of the Mokeasa community represent not only a cultural tradition but also embody various physics concepts that can be scientifically interpreted, including temperature and heat, phase changes, heat transfer, and the relationship between pressure and the distillation process. These findings indicate that moke distillation has the potential to serve as a contextual and meaningful ethnoscience-based resource for physics learning. This study has several limitations, including the involvement of only two informants, its predominantly qualitative and descriptive scope, the absence of direct measurements such as temperature and alcohol content, and the lack of classroom implementation or instructional validation. Therefore, further research involving broader participation, direct scientific measurements, and educational testing is needed to strengthen scientific validation and support its application in physics education.

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