



From Culture to Science: Exploring Scientific Knowledge in the Making of Wadi, a Traditional Dish of the Dayak and Banjar

Silvita^{1*}, Opik Prasetyo², Ulya Ruwaida², Zevira Fransisca Aurora², Rina Oktaviana²

¹Department of Biology Education, Faculty of Teacher Training and Education, Universitas Palangka Raya, Palangka Raya, Indonesia.

²Department of Biology Education, Faculty of Teacher Training and Education, Universitas Lambung Mangkurat, Banjarmasin, Indonesia.

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Corresponding Author:

Silvita

silvita@fkip.upr.ac.id

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Abstract: Traditional food processing practices often contain implicit scientific knowledge that can be systematically analyzed and explained using modern science. This study examines the scientific knowledge embedded in the traditional preparation of Wadi, a fermented fish product of the Dayak and Banjar communities. The research aims to identify and describe forms of scientific knowledge represented in each stage of the Wadi-making process. This study employed a qualitative descriptive method using documentation analysis. Data were collected from selected written and visual sources that clearly describe the stages of Wadi production. The data were analyzed by mapping traditional practices to scientific concepts in food science. The results indicate that the preparation of Wadi embodies multiple forms of scientific knowledge, including osmosis in the salting process, salt-based preservation through microbial inhibition, lactic acid fermentation, moisture control, and biochemical transformations such as protein hydrolysis. These findings demonstrate that traditional culinary practices are not merely cultural activities but also reflect systematic scientific knowledge consistent with principles of microbiology, biochemistry, and food preservation. In conclusion, the scientific knowledge identified in the making of Wadi has strong potential to support contextual and culturally relevant science learning by connecting everyday practices with formal scientific concepts.

Keywords: Local wisdom; Scientific knowledge; Wadi

Introduction

Traditional knowledge is increasingly recognized worldwide as an important source of scientific insight that can enrich modern science and support culturally responsive education. Among various forms of traditional knowledge, food processing practices are known to contain embedded scientific principles that can be used to strengthen contextual science learning and improve scientific literacy. Within this global context, Indonesia stands out as a country rich in diverse traditional cultures and culinary heritage, where many traditional foods offer valuable opportunities to connect cultural practices with scientific concepts (Wijaya, 2019).

Traditional foods not only reflect strong cultural identity but also contain various scientific knowledge with the potential to be integrated into science education (Gondwe & Longnecker, 2015). The ethnoscience approach, which connects local wisdom with modern scientific concepts, has therefore gained increasing attention as a way to make science learning more relevant and contextual for students (Cahyani & Fadly, 2024; Hikmawati et al., 2020).

One traditional food of particular interest is Wadi, a fermented fish product characteristic of the Dayak and Banjar communities in Kalimantan (Al-Hammam et al., 2023; Dewi et al., 2017; Soemarie et al., 2022). The process of making Wadi through stages such as salting,

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fermentation, and preservation involves scientific principles like osmosis, microbial activity, and biochemical changes (Aqel et al., 2024). This makes Wadi a relevant case for examining how traditional practices can illustrate essential scientific concepts.

Despite its scientific relevance and cultural importance, systematic studies that identify and describe the scientific knowledge embedded in the Wadi production process remain very limited. Existing research tends to focus on microbiological or chemical aspects of fermentation in general, without specifically linking these findings to local cultural practices or analyzing the complete sequence of Wadi production. Furthermore, previous studies predominantly employ experimental methods or interviews, while documentation-based analyses of Wadi production available online remain underutilized. This gap indicates that the scientific concepts underlying each stage of Wadi production have not been comprehensively mapped, limiting the potential of Wadi to serve as a culturally grounded learning resource in science education.

This study offers novelty by systematically analyzing the scientific concepts embedded in Wadi production through a qualitative descriptive approach based on documentation analysis. Unlike earlier studies that focus mainly on laboratory results or cultural descriptions, this study examines the documented stages of Wadi production to uncover the scientific principles involved, including osmosis, fermentation microbiology, and biochemical changes. The purpose of this research is to describe these concepts in detail so that they may serve as a foundation for developing ethnoscience-based science learning materials. The urgency of this work lies in its dual contribution: supporting the preservation of Indonesia's traditional cultural heritage while simultaneously enriching science education with meaningful, contextual, and culturally relevant learning resources.

Unlike earlier studies that focus mainly on laboratory results or cultural descriptions, this study shifts the perspective from culture to science by examining the documented stages of Wadi production to uncover the scientific knowledge embedded in this traditional practice. Through this documentation-based approach, the study identifies forms of scientific knowledge reflected in the making of Wadi, including knowledge related to osmosis, microbial activity during fermentation, and biochemical transformations occurring throughout the process.

The purpose of this research is to describe this scientific knowledge in a detailed and structured manner so that Wadi can serve as a meaningful foundation for developing ethnoscience-based science learning materials. The urgency of this work lies in its

dual contribution: helping preserve Indonesia's traditional cultural heritage while simultaneously enriching science education with accessible, contextual, and culturally relevant scientific knowledge. In this way, traditional practices such as Wadi production can become valuable resources for modern science learning.

Method

Type of Research

This study employs a qualitative descriptive approach to identify and describe the scientific knowledge embedded in the stages of Wadi production based on documentation studies from various online sources. This approach enables an in-depth analysis of systematically and structurally collected data, resulting in a comprehensive depiction of the scientific concepts inherent in the Wadi production process.

Time and Location of Research

This study was conducted from January to March 2025. The research did not take place in a specific physical location, as the data were collected through online documentation sourced from publicly available digital platforms. All analysis activities were carried out based on written and visual materials obtained from the internet, including websites, articles, blogs, videos, and other online documents that describe the stages of Wadi production.

Population and Sample

The population in this study consists of all online documents containing explanations about the production of Wadi. The sample in this study was determined using a purposive sampling technique. Only documents that fulfilled specific criteria were included in the analysis. Selected documents were required to provide detailed descriptions of the stages involved in Wadi production and present written or visual information that clearly illustrated each step of the process. In addition, the documents had to originate from credible and informative platforms, such as scientific articles, cultural blogs, culinary documentation pages, or educational videos. These criteria ensured that the data collected were relevant, reliable, and sufficiently comprehensive to support the identification of scientific knowledge embedded in the Wadi-making process.

Data Collection Technique

Data were collected from various websites, articles, blogs, videos, and online documents that provide detailed explanations of the Wadi production stages. The selection of data sources was based on the relevance,

completeness, and clarity of information regarding the production process.

The documentation study involved gathering and selecting written and visual information that describes the steps of Wadi production. All collected data were then organized and classified according to the stages of the production process.

Research Stages

The research was conducted through several systematic stages, as presented in Figure 1.

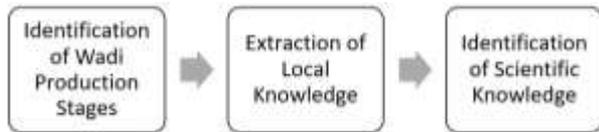


Figure 1. Research Stages

Identification of Wadi Production Stages

The first step involved reviewing all selected documents to extract detailed descriptions of the traditional process of making Wadi. Written and visual information from the documents was examined to identify each stage of the production sequence, starting from fish preparation to the fermentation period. These stages were then organized into a structured list to ensure consistency in further analysis.

Extraction of Local Knowledge

After identifying the stages of production, the researcher extracted the local knowledge embedded in each step. This information was derived from cultural explanations, traditional practices, and community

beliefs documented in the sources. The extracted local knowledge reflects how the Dayak and Banjar communities understand and carry out the Wadi-making process.

Identification of Scientific Knowledge

Each stage of the Wadi production process was then examined to determine the scientific knowledge embedded within it. Descriptions from the documents were analyzed to identify relevant scientific aspects such as microbial activity, osmosis, biochemical changes, and food preservation mechanisms. This step formed the basis for interpreting the scientific knowledge aligned with traditional practices.

Data Analysis

Data analysis was conducted using qualitative content analysis techniques. The analysis process included coding relevant texts and information to identify emerging scientific concepts such as fermentation, osmosis, and biochemical changes during the Wadi production process. The results of the analysis were presented descriptively to provide a comprehensive overview of the scientific knowledge contained within the process.

Results and Discussion

The scientific knowledge embedded in each stage of Wadi preparation is presented in the Table 1. The analysis includes two dimensions: local knowledge as practiced by the Dayak and Banjar communities, and the corresponding scientific explanation.

Table 1. Identify Scientific Knowledge in the Making of Wadi (Bakrie, 2020)

Stage of Process	Local Knowledge	Scientific Knowledge
Fish is gutted, filleted, and washed clean	Cleaning the fish is important to remove dirt, blood, and unpleasant odor.	Washing removes surface microbes and reduces spoilage risk. A basic food hygiene and safety measure.
Fish is mixed with crushed salt (10:1 ratio)	Salt is used to preserve the fish and enhance flavor	Salt creates a hypertonic environment that draws out water (osmosis) and inhibits microbial growth.
Mixture is stored in a large jar for 24 hours (initial salting)	Fish is left for a day to allow the salt to penetrate and start the preservation process.	Salt penetration initiates dehydration and microbial inhibition
Fish is removed and rinsed again	Washing again removes excess salt and prepares the fish for the next stage.	Rinsing adjusts salt concentration to prepare conditions for fermentation microbes.
Fish is drained for 10 minutes	Draining prevents too much moisture that might spoil the mixture.	Reducing water content limits unwanted microbial activity; moisture control is essential in fermentation.
Fish is mixed with 3% palm sugar	Palm sugar adds flavor and helps with preservation.	Palm sugar provides fermentable sugars for lactic acid bacteria.
Mixed with 4% roasted ground rice	Ground rice is believed to aid in fermentation and prevent spoilage.	Roasted ground rice adds carbohydrates and acts as a carrier for natural microbes that promote lactic acid fermentation.

Stage of Process	Local Knowledge	Scientific Knowledge
Mixture is stored in a sealed jar	Sealing is essential to protect the fish from contamination and air exposure.	Anaerobic conditions are crucial for lactic acid bacteria to thrive and carry out fermentation.
Fermentation takes place for 3 days	Fish is left to "sour" or ferment, which gives Wadi its distinctive taste and preservation.	Lactic acid fermentation occurs pH drops, spoilage bacteria are suppressed, flavor compounds and acids are produced.

The process of making Wadi, a traditional fermented fish product of the Dayak and Banjar communities, consists of several stages that are not only culturally meaningful but also scientifically rich. Each step in the preparation reflects fundamental scientific concepts, particularly in microbiology, biochemistry, and food preservation (Gondwe & Longnecker, 2015).

Initial Cleaning of Fish

The process of making Wadi begins with cleaning the fish. Scientifically, washing the fish serves as an essential hygiene practice to reduce the microbial load and to remove blood, mucus, and other surface contaminants (Abuhlega & Ali, 2022; Ziarati et al., 2022). This initial sanitation step is crucial in minimizing the risk of spoilage and in preparing the substrate for controlled fermentation (Khairina & Khotimah, 2006).

This finding aligns with previous studies showing that initial washing reduces contamination and supports safer fermentation environments (Farak et al., 2022; Sheng & Wang, 2021).

Salting Process

The cleaned fish is mixed with finely crushed salt in a 10:1 ratio. Salt functions as a natural preservative by creating a hypertonic environment that draws water out of microbial cells through osmosis (Hallsworth, 2022; Hameed et al., 2025). This causes crenation, where microbial cells shrink due to water loss, disrupting their metabolism and inhibiting their growth. Additionally, high salt concentrations exert selective pressure that favors halotolerant and potentially fermentative microorganisms such as lactic acid bacteria (LAB), which are essential for the next phase of fermentation (Bakrie, 2021).

Initial Salt Penetration

Following this, the salted fish is allowed to rest for approximately 24 hours, allowing for deeper salt penetration and further reduction of water activity (Hasan et al., 2023; Piyawardhana et al., 2022). Lowering water activity is a well-established food preservation strategy that restricts the growth of spoilage organisms by limiting the availability of free water (Al-Hammam et al., 2023; Teixeira et al., 2025).

Rinsing and Draining

The fish is then rinsed and drained. Although it might seem contradictory to rinse after salting, this step is important to adjust the salt concentration to a level more favorable for beneficial fermentative microbes. Excessive salt can inhibit Lactic Acid Bacteria (LAB) activity (Hernández-Gómez et al., 2021; Jiang et al., 2021). Draining for 10 minutes further reduces surface moisture, limiting conditions that could support the growth of undesirable microbes and supporting a more stable fermentation environment (Chu et al., 2023).

Addition of Palm Sugar

The addition of 3% palm sugar provides simple carbohydrates such as glucose and sucrose, which serve as fermentable substrates for LAB. Through anaerobic fermentation, these bacteria metabolize the sugars into lactic acid. Lactic acid plays a dual role in lowering the pH to inhibit spoilage and pathogenic microorganisms, and in contributing to the characteristic sour flavor of fermented products (Djumaty & Dey, 2022; Ibrahim et al., 2021; Mokoena & Omatola, 2021; Zapasnik et al., 2022).

Addition of Roasted Ground Rice

The mixture is then combined with 4% "samu" (roasted ground rice), which contributes both complex carbohydrates and potentially beneficial native microorganisms. Scientifically, "samu" not only enriches the substrate but may also introduce fermentative microflora that act as natural starters (Bakrie, 2021; Wardani et al., 2025). The heat treatment during roasting may activate enzymes or preserve microbes that support spontaneous fermentation (van Boekel et al., 2010).

Creating Fermentation Conditions

The mixture is stored in tightly sealed jars to create anaerobic conditions, which are essential for the growth of lactic acid bacteria (Yadav & Prakash, 2024). In the absence of oxygen, LAB dominate the microbial population and carry out fermentation efficiently, producing organic acids that further preserve the product and develop flavor (Anggraini & Mustakim, 2025; Mau et al., 2024; Oktaviani et al., 2021).

Fermentation Phase

Fermentation occurs over a period of three days, during which significant microbiological and biochemical transformations take place (Gao et al., 2025; Giuffrè & Giuffrè, 2024). Proteins in the fish undergo partial hydrolysis into peptides and amino acids, some of which contribute to umami taste (Bai et al., 2022; Bruno et al., 2019). At the same time, the production of lactic acid gradually lowers the pH, stabilizing the product by creating an inhospitable environment for harmful microbes (Rawoof et al., 2020). This process reflects a typical lactic acid fermentation, relying on microbial ecology and enzymatic activity to enhance both safety and flavor (Anumudu et al., 2024; Wang et al., 2023).

The results of this study are supported by several researchers who highlight that traditional food-processing techniques inherently contain scientific knowledge, even if such knowledge is not explicitly stated by the local communities. Permata et al. (2024) explain that traditional practices often embed microbiological, biochemical, and physical principles that can be uncovered through ethnoscience approaches. Their work shows that indigenous food preparation methods can serve as rich sources of scientific concepts for education.

Similarly, traditional foods embody empirical knowledge that aligns with modern scientific understanding, particularly in processes involving heating, salting, fermentation, and preservation (Knorr & Augustin, 2023; Permata et al., 2024; Zhang et al., 2025). These findings reinforce the view that cultural food-processing methods reflect systematic observations and accumulated practical experience.

Research by Muttaqin et al. (2025) further supports this perspective, demonstrating that local culinary practices often involve natural fermentation, osmosis, and microbial transformations. Their study on traditional food preparation in local communities shows that these processes are consistent with the principles of microbiology and food science.

These supporting studies affirm that traditional food preparation, including Wadi production, is deeply grounded in scientific knowledge. They demonstrate that indigenous communities employ effective preservation and processing techniques based on long-standing empirical understanding, which modern science can now explain using microbiological and biochemical principles. This evidence strengthens the argument that traditional cuisine provides a valuable foundation for contextualized, culturally relevant science education (Kamila et al., 2024; Sari et al., 2023).

In conclusion, the traditional method of Wadi preparation demonstrates a strong alignment between indigenous knowledge and modern scientific principles.

Practices involving osmosis, microbial inhibition, moisture control, and fermentation are highly consistent with scientific understanding in food science. This integration of local traditions with scientific knowledge presents an excellent opportunity to contextualize science education, making it more meaningful, relevant, and culturally grounded for learners.

Conclusion

The process of making Wadi, a traditional dish of the Dayak and Banjar communities, contains various forms of scientific knowledge, including fermentation, osmosis, salt-based preservation, and biochemical changes. Each stage of its preparation reflects the community's practical understanding of natural mechanisms that are also explained in modern science. These findings indicate that local culinary practices can serve as a rich source for bridging cultural traditions and scientific concepts, and they hold strong potential to be integrated into contextual science learning. By using Wadi as a real-life example, science education can become more relevant, meaningful, and closely connected to students' everyday experiences.

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Author Contributions

Conceptualization, S.; methodology, S.; validation, O.P., and U.R.; formal analysis, S.; investigation, S.; resources, O.P.; data curation, S.; writing, S.; review and editing, S., O.P., U.R., Z.F.A.

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Conflicts of Interest

The authors declare no conflict of interest.

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