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Ethnomathematical Analysis of Processing Techniques in Alame and Lemang: Traditional Foods of Padang Lawas

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ABSTRACT

Limited student understanding of contextual mathematical concepts remains a key issue in learning. This study aims to identify and analyze mathematical concepts in the preparation of traditional foods Alame and Lemang from Padang Lawas using an ethnomathematics approach. A qualitative descriptive-exploratory method was employed, with data collected through observation, semi-structured interviews, and documentation. Data analysis was conducted using the interactive model of Miles, Huberman, and Saldaña and validated through triangulation and member checking. The results indicate that Lemang preparation involves spatial geometry, geometric transformations, and heat distribution, while Alame applies ratios and proportions of ingredients, traditional measurement, and time and temperature estimation. Both techniques reflect principles of algorithm, order, and efficiency. These findings confirm that traditional culinary practices can serve as contextual mathematics learning media while contributing to the preservation of local culture.

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1. INTRODUCTION

Education plays an important role in shaping the quality of human resources. In addition to serving as a means of knowledge transfer, education also plays a role in fostering attitudes, skills, and values. Education is an important factor in building a nation's civilization [1], [2]. Through education, individuals are expected to be able to develop their potential, adapt to their environment, and make a positive contribution to society. Quality education is the main foundation in preparing a generation that is competent and able to face the challenges of modern life [3].

However, in the context of mathematics education, many students face difficulties in understanding the abstract nature of the material being taught, which leads to a loss of interest and difficulty in applying mathematical concepts in real-life situations [4]. This is a significant problem, because mathematics is the basis of various disciplines and skills needed

in the modern world [5]. Previous research shows that traditional teaching methods often fail to connect mathematical concepts with students' everyday experiences, resulting in less meaningful learning [6]. Therefore, there is a need for a more relevant and contextual approach to teaching mathematics, one that can connect theory with practice.

One promising approach is ethnomathematics-based learning. Ethnomathematics is an effort to understand and articulate mathematical ideas that arise in the cultural practices of communities [7]. Through ethnomathematics, mathematics learning can become more meaningful because students learn mathematical concepts that are connected to their daily lives [8] . This approach not only enriches mathematics learning, but also introduces students to the cultural values contained in their social lives.

Previous studies have shown the application of ethnomathematics in various aspects of culture, such as traditional games, traditional architecture, handicrafts, and cuisine [9], [10], [11]. For example, in traditional cuisine, mathematical concepts such as measurement, ratio, and geometry are found to be involved in the process of food preparation, such as in Lemang bamboo and Betawi ketupat [11], [12], [13]. This shows that mathematics is not only found in the classroom, but also in real life that is close to students.

However, although many studies have discussed ethnomathematics in a cultural context, few have raised cuisine as a research object, particularly in the analysis of mathematical concepts found in the processing of Alame and Lemang, which are typical of Padang Lawas. These traditional cuisines are rich in cultural value and contain mathematical principles such as ingredient measurement, ratios, cylindrical geometry, rotational symmetry, and heat distribution. This study focuses on analyzing the mathematical concepts found in the techniques used to prepare Alame and Lemang and explores their potential as a source of contextual learning in mathematics education based on local culture. This is a gap that has not been widely discussed in the literature, and it is hoped that it can make an important contribution to the development of mathematics education that is relevant and applicable to students.

Based on this background, the purpose of this study is to analyze the mathematical concepts found in the processing techniques of Alame and Lemang, which are typical of Padang Lawas, and to explore their potential as a source of contextual learning in mathematics education based on local culture. This study aims to address the gap in students' understanding of mathematics by integrating local culture, which is rich in mathematical values, into the learning process.

Theoretically, the results of this study are expected to enrich ethnomathematics studies, particularly in the context of traditional cuisine, which has been limited to date . This research is also expected to provide new insights into approaches to mathematics learning that connect theory with students' daily lives. In practical terms, the results of this study can be used as a reference for teachers in designing mathematics learning that is more contextual and relevant to students' cultures. Thus, mathematics learning becomes not only a means of cultural preservation, but also a medium for providing meaningful, interesting, and applicable learning experiences for students.

2. METHOD

This study uses a descriptive-exploratory qualitative approach to explore and describe mathematical concepts in the traditional food processing techniques of Alame and Lemang, which are typical of Padang Lawas [14] . The research subjects were traditional Alame and Lemang makers in Panyabungan Village, Hutaraja Tinggi District, Padang Lawas Regency, who were selected purposively based on their experience, with a total of 3–5 informants.

Data collection was conducted through direct observation, semi-structured interviews, and photo documentation. Secondary data was obtained through literature studies from articles, scientific journals, and relevant online sources. Data analysis used the Miles and Huberman model [15], which included: (1) data reduction to filter relevant information, (2) data presentation in the form of tables, narratives, and diagrams, and (3) concluding to identify mathematical concepts that emerged in the Alame and Lemang processing.

Data validity was strengthened through source triangulation and member checks. During the research, research ethics principles were applied by maintaining the confidentiality of informants, ensuring voluntary participation, and requesting consent before data collection was carried out.

The results of this study are expected to show that the techniques of processing Alame and Lemang contain mathematical concepts that have the potential to be used as contextual learning media, while also supporting the preservation of the local culture of Padang Lawas as a source of meaningful learning.

3. RESULTS AND DISCUSSION

Padang Lawas, commonly known as Palas, is a regency located in North Sumatra and was formed as a result of the division of the Tapanuli Selatan regency. The Padang Lawas Regency was officially established on August 10, 2007, in accordance with Law Number 38 of 2007 of the Republic of Indonesia. The capital of Padang Lawas is Sibuhuan [16]. Padang Lawas itself has many local traditions, one of which is Alame and Lemang. Alame is also commonly known as dodol. Alame is usually made from a mixture of brown sugar, glutinous rice flour, and coconut milk, which is cooked until thick [12]. Both foods have high cultural value and are commonly served at traditional ceremonies and important holidays. The production process not only requires cooking skills but also involves mathematical elements such as the use of traditional measuring units, time management, heating processes, and the shape of the containers used [17].

1. The Process of Making Alame

Alame, often referred to as dodol khas Padang Lawas, is a traditional food made from a mixture of glutinous rice flour, coconut milk, brown sugar, white sugar, wheat flour, and vanilla. The mixture is cooked in a large pot until it thickens and turns dark brown, resulting in a chewy and sticky texture with a sweet and savory taste [18].

Figure 1. Alame

Based on the interview results, the main ingredients of Alame are used in specific proportions, namely 30-40 coconuts, 5 liters of sticky rice, 2 kg of wheat flour, 6-7 kg of brown sugar, 5 kg of white sugar, and vanilla for a distinctive aroma. The source explained that the correct proportions of ingredients are very important to produce Alame with a thick texture, dark brown color, and a distinctive sweet and savory aroma. The processing is done either collectively or individually, using a round pot with a diameter of about 90 cm and a depth of 30 cm, as well as a wood-burning stove. The coconut milk and sugar are heated while being stirred in a circular motion until completely dissolved, then the glutinous rice flour and wheat flour are added little by little with continuous stirring for 8-10 hours so that the dough cooks evenly without burning. This shows that the stirring technique and fire control are not merely culinary procedures, but also reflect the principles of measurement, proportion, and consistency, which are in line with the findings of [12] and [19] that precision in measurement and cooking processes affects the final quality of the product.

Mathematical Concepts in the Creation of Alame: Measurements (Standard and Non-Standard)

The main ingredients of Alame use different measurements: 5 liters of sticky rice, 6–7 kg of brown sugar, 5 kg of white sugar (standard units), and 30–40 coconuts (non-standard units). This demonstrates the application of measurement concepts in everyday life with a combination of standard and non-standard units. The ratio of brown sugar (6–7 kg) to white sugar (5 kg) is used to produce a balanced sweetness. This ratio concept is important because an incorrect ratio will affect the taste and texture of Alame. The ethnomathematics in this process can be identified as follows:

a) Ingredients: 5 liters of sticky rice, 6–7 kg of brown sugar, 5 kg of white sugar → standard units.
b) 30–40 coconuts → non-standard unit.
c) This shows the comparison between two measurement systems. In formal mathematics, this can be related to unit conversion and number systems.
d) Brown sugar (6–7 kg): white sugar (5 kg).
e) Mathematically, if we take 6:5, then the ratio = 6/5 = 1.2.
f) This shows the application of a simple ratio to maintain taste.

Figure 2. Measurement (Standard and Non-Standard)

Time Estimate

The comparison of brown sugar (6–7 kg) with white sugar (5 kg) is used to produce a balanced sweetness. This concept of ratio is important, because errors in comparison will affect the taste and texture of Alame.

The stirring process is carried out continuously for 8–10 hours. The skill of estimating time comes from experience, as the community does not use modern measuring tools, but rather the old method of cooking until the dough thickens perfectly. The stirring motion is carried out continuously in a circular direction. This repetitive pattern reflects the concept of rotation and cycle, where each rotation aims to maintain the consistency of the dough so that it does not burn.

Figure 3. Estimated Time for Making Alame

The ethnomathematics involved in this process can be identified as follows:

a) Stirring for 8–10 hours.
b) In mathematical terms, this can be written as a time interval of [8,10] hours.
c) People estimate time based on visual cues, in line with the concept of range in mathematics.
d) The stirring motion is circular and repetitive.
e) In mathematics, this includes repeated 360° rotations → resembling a periodic function.

Geometry (Cylinder/Circle)

The container used is a round cauldron with a diameter of ±90 cm and a depth of ±30 cm. The shape of the container resembles a cylinder, which influences the circular stirring technique for heat distribution.

Figure 4. Alame Making Pot

The ethnomathematics involved in this process can be identified as follows:

a) Round cauldron with a diameter of 90 cm → radius r = 45 cm. Depth h = 30 cm.
b) This shape resembles a tube.
c) This shows the application of the concept of cylindrical shapes in everyday life.

2. The Process of Making Lemang

Lemang is a traditional food from Padang Lawas made from sticky rice and coconut milk, cooked in young bamboo lined with banana leaves to produce a distinctive aroma and taste. Based on the interview results, the young bamboo used has a diameter of 5-10 cm and a length of 30-50 cm, and is lined with banana leaves on the inside to prevent the dough from coming into direct contact with the bamboo and to make it easier to remove the lemang after it is cooked.

Figure 5. Lemang

The soaked sticky rice is mixed with coconut milk and salt, then carefully placed into bamboo tubes in stages so that the texture is neither too dense nor too loose. The filled

bamboo is then arranged at an angle facing the fire in a traditional stove and baked for 5-6 hours while being turned periodically so that it cooks evenly. The resulting lemang has a soft texture, a distinctive aroma of coconut milk and bamboo, and a brownish outer layer [20].

The process of making lemang involves ethnomathematics, including measuring the volume of ingredients, comparing dough ratios, setting baking times, and understanding the cylindrical shape of bamboo as a cooking vessel. The selection of bamboo and banana leaf lining demonstrates local wisdom in the effective use of natural resources [21]. Lemang is usually served at traditional ceremonies, important days, or family celebrations, reflecting the traditions and cultural values of the Padang Lawas community. These findings reinforce the concept of ethnomathematics, which emphasizes that cultural practices, including culinary practices, can be used as a medium for contextual mathematics learning through measurement, comparison, and understanding of geometric shapes in everyday life.

Mathematical Concepts in Making Lemang

Cylinder Geometry

The bamboo used is cylindrical in shape with a diameter of ±8–10 cm and a length of ±50–60 cm. From this shape, the concepts of cylindrical shapes, diameter, radius, height, and volume arise. The volume of sticky rice + coconut milk must match the capacity of the bamboo so that the lemang cooks perfectly.

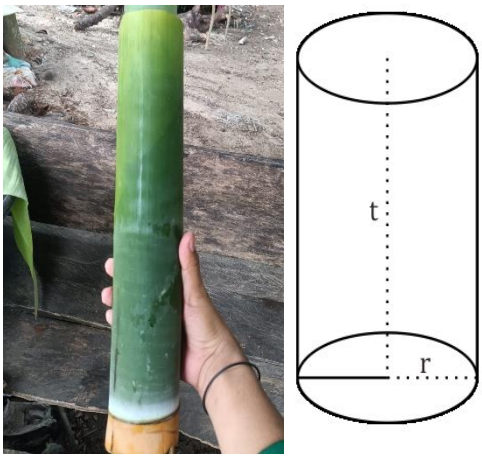

Figure 6. Bamboo for Lemang

The ethnomathematics involved in this process can be identified as follows:

a) The bamboo used for the Lemang container is cylindrical in shape with a diameter of ±8–10 cm and a length of ±50–60 cm.
b) From this, the concepts of cylindrical shape, diameter, radius, height, and volume emerge.
c) The volume of sticky rice + coconut milk must match the capacity of the bamboo so that the Lemang cooks perfectly.

Ratios and Proportions

The ratio of coconut milk to sticky rice is set at a specific ratio, for example, 1 liter of coconut milk for 1 medium-sized bamboo. This demonstrates the application of the 1:1

ratio concept in everyday life. Incorrect proportions will affect the quality of the lemang (too soft or too hard).

Figure 7. Ratios and Proportions

The ethnomathematics involved in this process can be identified as follows:

a) The ratio of coconut milk to glutinous rice is set at a specific ratio, for example, 1 liter of coconut milk to 1 medium-sized bamboo.
b) This demonstrates the application of the 1:1 ratio concept in everyday life.
c) Errors in proportions will affect the quality of Lemang (too soft or too hard).

Rotation (Geometric Transformation), Time Estimation, and Heat Distribution Optimization

The bamboo is rotated every ±30 minutes during 3–4 hours of baking. This rotational movement is a representation of rotation in geometry. The concepts of rotation angle and rotational symmetry arise naturally. The baking time of 3–4 hours reflects skill in estimating duration. The community determines doneness not with a stopwatch, but from visual cues (bamboo color) and aroma. This is related to the concepts of time intervals and ranges. Rotating the bamboo aims to maintain heat distribution for even cooking. Mathematically, this is related to the concepts of rotational symmetry and angle division (360°), where each side receives equal heat exposure.

Figure 8. The process of turning lemang

The ethnomathematics in this process can be understood as follows:

a) The bamboo is rotated every ±30 minutes during the 3–4 hours of baking.
b) This rotating motion is a representation of rotation in geometry.
c) The concepts of rotation angle and rotational symmetry arise naturally.

d) The 3–4 hour baking time reflects skills in estimating duration.
e) This relates to the concepts of time intervals and ranges.
f) Mathematically, this relates to the concepts of rotational symmetry and angle division (360°), where each side receives balanced heat exposure.

Table 1. Classification of Mathematical Concepts in the Making of Alame and Lemang Based on Education Level

Educational Level	Concepts in Alame	Concepts in Lemang
Elementary School (Grades 4–6)	Understanding standard units (liters, kilograms) and non-standard units (coconuts). Comparing simple measurements (6 kg of brown sugar vs. 5 kg of white sugar). Calculating the stirring time (8–10 hours).	Comparing bamboo sizes (diameter 8–10 cm). Simple comparison (1 liter of coconut milk: 1 bamboo). Calculating the number of bamboo rotations in 1 hour (2 times).
Junior High School (Grades 7–9)	Calculating the ratio of brown sugar: white sugar (6:5 = 1.2). Recognizing the shape of a cylinder through a round pot. Understanding the stirring rotation pattern (repeated circular motion).	Calculate the volume of a cylindrical bamboo. Determine the number of rotations during baking (3 hours = 6 times, 4 hours = 8 times). Understand the angle of rotation (360° per rotation).
High School (Grades 10–12)	Calculate the volume of the cylindrical container ($V = \pi r^2 h$, where r = 45 cm, h = 30 cm). Analyze stirring as a periodic function. Relate the stirring time to the concept of a time interval [8,10] hours.	- Calculate the volume of bamboo ($V = \pi r^2 h$, where r = 5 cm, h = 60 cm). Analyze the rotation of bamboo with rotational symmetry and a 360° angle division. Relate the duration of roasting to the time interval [3,4] hours.

The classification of mathematical concepts in the making of Alame and Lemang can be integrated into learning at every level. In elementary school, students can be introduced to standard and non-standard units and simple comparisons, in line with *measuring* activities[10] . In junior high school, the concepts develop into ratios, cylinder volumes, and rotations, as explained[9] that cultural practices can be a bridge to formal concepts. In high school, students can analyze volume using the formula $V = \pi r^2 h$, periodic functions, and rotational symmetry, in line with the idea[3] that ethnomathematics enriches learning with real cultural contexts. Ethnomathematics-based learning not only enriches students' learning experiences but also connects school mathematics with real cultural contexts.

This study shows that the process of making Alame and Lemang involves mathematical concepts such as measurement, ratios, cylindrical geometry, rotational symmetry, and time estimation. When compared to previous studies, [12] only highlights the aspects of measurement and cylinder geometry in Lemang, [22] emphasizes the concept of ratios in *sticky rice cakes*, [23] examines the geometry in Betawi ketupat, while [24] researches the mathematical elements in *eggshells* and Osing snacks.

The main difference in this study lies in its focus on Alame, a traditional food from Padang Lawas that has never been discussed in previous ethnomathematics studies. These findings expand the scope of ethnomathematics research in Indonesia and reinforce the idea that traditional cuisine is not only culturally valuable, but also has great potential as a source of mathematics learning [25] .

The implications for education are significant. The results of this study open up opportunities for teachers to integrate local cultural contexts into mathematics learning, so that abstract concepts can be understood through real activities that are close to students' lives. With this approach, learning is not only more contextual and meaningful but also contributes to strengthening cultural identity while increasing student motivation and learning outcomes.

4. CONCLUSION

This study confirms that the processing of traditional Alame and Lemang foods, which are typical of Padang Lawas, has the potential to be used as a medium for contextual mathematics learning while also supporting the preservation of local culture. The integration of ethnomathematics principles in learning can increase the relevance, motivation, and understanding of mathematical concepts in a more meaningful way for students.

This study has limitations, namely its focus on specific types of food in Padang Lawas, so the findings may not be fully generalizable to other traditional cuisines in different regions. Therefore, further research is recommended to develop ethnomathematics-based learning media from various culinary traditions and evaluate its effectiveness in improving students' understanding of mathematics at various levels of education.

In general, the results of this study make an important contribution to society by raising awareness of the educational value of everyday cultural practices and encouraging the preservation of traditional cuisine as part of a local identity rich in mathematical value.

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