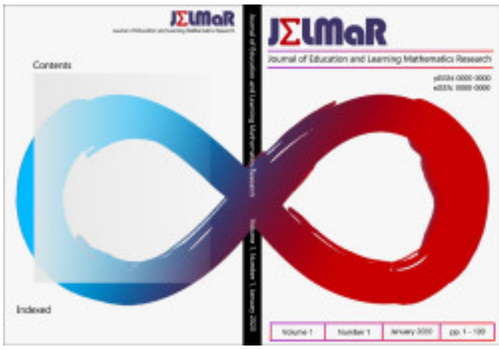

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Leveraging Local Culinary Heritage as a Context for Learning Mathematics

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***Abstract**: This study investigates how a diverse set of traditional Malang foods—including Mendol Tempe, Bakwan Malang, Tempe Chips, Cwie Mie, Rawon, Bakso Bakar, Putri Salju cookies, and Orem-Orem—can function as culturally grounded contexts for developing students' mathematical reasoning and model-construction competencies. Each food item reveals distinct mathematical structures: density and texture patterns in Mendol Tempe, irregular yet classifiable shapes in Bakwan Malang, fractal-like crisp patterns in Tempe Chips, proportional seasoning in Cwie Mie, time-based flavor development in Rawon, rotational symmetry in Bakso Bakar, geometric uniformity in Putri Salju, and combinatorial layering in Orem-Orem. Drawing on a philosophical perspective that positions mathematics as an interpretive lens for understanding real-world phenomena, students transition from sensory observation to formal modeling, constructing representations such as ratio models, time–intensity functions, geometric similarity models, rotational interval equations, and combinatorial structures. Findings indicate that embedding mathematical tasks in local culinary culture enhances conceptual understanding, promotes creative model construction, and strengthens culturally responsive pedagogical practices. This approach highlights the natural emergence of mathematical ideas from daily life experiences, making learning more meaningful, engaging, and contextually relevant.*

***Keyword**: ethnomathematics, local food, mathematics learning, cultural context*

INTRODUCTION

Mathematics learning in schools is frequently perceived as abstract and distant from students' everyday lives (Faradiba et al., 2022, 2023). Many students struggle to understand mathematical concepts because they cannot connect them to real experiences in their cultural environment. This challenge becomes especially visible in regions with rich cultural traditions, where learning resources rarely reflect local identity. To address this disconnect, mathematics education must incorporate meaningful contexts that resonate with students' lived realities, such as regional foods and culinary heritage (Buyco & Dalayap, 2025; Dosinaeng et al., 2025; Sari et al., 2025).

Ethnomathematics offers a theoretical lens to explore mathematical ideas embedded in cultural practices. Ambrosio (1985) emphasizes that different cultural groups develop unique mathematical knowledge through their routines, crafts, and daily activities. In the context of Malang, local foods such as tempe mendol, bakwan Malang, rawon, cwie mie, and keripik tempe carry inherent structures and processes that can illustrate mathematical concepts. Yet, the potential of these foods as instructional tools remains largely underrepresented in mathematics classrooms.

Local culinary products in Malang present authentic opportunities to contextualize mathematical ideas. The geometric shape of mendol offers examples of cylinders or irregular solids, while the slicing of bakwan for serving sizes supports the study of fractions and area. Meanwhile, the production of keripik tempe involves pattern designs in the slicing and arrangement process, which can be analyzed through symmetry and transformations. As noted by Payadnya et al. (2025)learners should be empowered as creators of knowledge, and these rich cultural artifacts allow them to do so through hands-on inquiry.

Despite such potential, conventional mathematics instruction in Malang schools continues to rely heavily on textbook problems that do not reflect students' cultural environments. This results in learning that feels distant and less engaging. Umasugi et al. (2022)argues that students construct deeper mathematical meaning when examples are rooted in familiar cultural settings. Incorporating Malang's traditional foods into instructional materials can therefore enhance relevance, motivation, and understanding.

Previous ethnomathematics studies have examined traditional crafts, architecture, and local games as sources of mathematical ideas. However, fewer studies have investigated culinary traditions, especially regional foods like those from Malang. Hendri et al. (2025)highlight the importance of culturally responsive assessment and instructional design, suggesting that more research is needed to broaden the resources available to teachers, including those drawn from local cuisine.

The preparation of traditional Malang foods involves numerous mathematical elements. For example, the recipe for cwie mie requires proportional reasoning in mixing sauces, the measurement of ingredients in grams or teaspoons, and time calculations for cooking noodles. Pathuddin et al. (2021)emphasize that students' understanding of measurement deepens through engagement with real objects and quantifiable attributes. These culinary processes thus provide practical contexts for mathematical exploration.

In addition to supporting conceptual understanding, using Malang local foods as learning contexts can strengthen students' appreciation of cultural heritage. Regional cuisines such as rawon Malang and bakso bakar form part of the identity of Malang communities, yet modernization often reduces their visibility in formal education. Wulandari et al. (2024)note that culturally relevant mathematics instruction can enhance students' sense of belonging and cultural pride, making learning more meaningful both academically and socially.

Nevertheless, several challenges persist. Many teachers may feel unprepared to incorporate cultural materials or lack access to structured instructional resources grounded in ethnomathematics. Curriculum demands also sometimes make teachers hesitant to include nonstandard examples. These issues highlight the need for empirical studies that document, analyze, and systematize the mathematical ideas inherent in Malang's local foods (Leton et al., 2025; Putri et al., 2025).

Considering these gaps, the present study aims to investigate mathematical concepts embedded in traditional foods of Malang and to analyze their potential as learning resources. Through qualitative exploration of culinary artifacts, preparation techniques, and cultural practices, this research identifies mathematical ideas such as geometry, ratio, measurement, patterns, and combinatorics within the region's culinary heritage. Such findings are essential for designing culturally responsive mathematics instruction.

The purpose of this study is to contribute to ethnomathematics both theoretically and practically. Theoretically, the study expands ethnomathematical inquiry by focusing on local Malang foods as culturally embedded mathematical resources. Practically, the study offers insights and concrete examples that teachers can use to develop contextualized mathematics lessons. By integrating the richness of Malang's culinary traditions into the mathematics classroom, learning can become more engaging, relevant, and culturally grounded for students in the region.

METHOD

This study employed a qualitative descriptive approach to explore and document the mathematical ideas embedded in traditional foods of Malang. A qualitative design was selected because ethnomathematical research requires an in-depth understanding of cultural practices, artifacts, and contextual meanings, which cannot be captured through quantitative procedures. The focus of this research was to interpret culinary representations and processes as sources of mathematical concepts relevant for instructional use.

The research subjects consisted of traditional food producers, culinary artisans, and local vendors in several areas of Malang, including Lowokwaru, Kedungkandang, and Kota Lama. Their daily practices in preparing foods such as mendol tempe, bakwan Malang, keripik tempe, and cwie mie provided authentic cultural contexts for identifying mathematical structures. Participants were selected using purposive sampling based on their experience and engagement with traditional culinary practices, ensuring that the data represented genuine and culturally grounded perspectives.

Data collection involved three primary techniques: observation, interviews, and documentation. Observations were conducted directly during the preparation, production, and serving of traditional foods to examine mathematical elements in shapes, measurements, proportions, patterns, and processes. Semi-structured interviews were conducted with food artisans to understand cultural meanings, preparation procedures, and implicit mathematical reasoning embedded in their practices. Documentation techniques included photographing food shapes, mapping preparation steps, and collecting written or oral recipes to support the triangulation of findings.

The instrument used in this research consisted of observation guidelines, interview protocols, field notes, and documentation sheets. Observation guidelines focused on identifying mathematical indicators related to geometry, ratio, measurement, symmetry, and pattern. Interview protocols were developed by adapting qualitative inquiry principles as suggested by Creswell & Guetterman (2019),emphasizing open-ended questions that allow participants to describe their cultural and procedural knowledge in depth. Field notes were used to record contextual details and researcher reflections during the data collection process.

Data were analyzed using content analysis techniques, which involved three stages: data reduction, data display, and conclusion drawing. In the reduction phase, all data from observations, interviews, and documentation were categorized based on emerging mathematical themes. During data display, the categorized information was organized into descriptive matrices and narrative summaries to identify recurring patterns. The final stage involved synthesizing the findings to reveal the mathematical concepts embedded in Malang's traditional foods and interpreting their relevance for mathematics learning.

Validity of the data was ensured through triangulation of techniques and sources. Observational findings were compared with interview responses and documentation results to ensure consistency. Member checking was conducted by presenting preliminary interpretations to selected participants to verify accuracy and authenticity. This process aligns with the principle of trustworthiness in qualitative research as described by Miles & Huberman (1994).

The research procedure was carried out in several sequential steps: preliminary study, field exploration, data collection, data organization, analysis, and reporting. The preliminary phase involved reviewing literature on ethnomathematics, Malang culinary traditions, and contextual learning. The field exploration stage included identifying culinary sites and participants. After completing data collection, all information was organized and analyzed systematically to uncover the mathematical structures present in Malang's traditional foods, which then served as the foundation for the findings presented in this study.

RESULT AND DISCUSSION

The findings of this study reveal that traditional foods of Malang contain diverse mathematical concepts embedded in their forms, preparation processes, and cultural practices. Observations and interviews with local food artisans show that culinary products such as mendol tempe, bakwan Malang, keripik tempe, and cwie mie demonstrate geometric structures, proportional reasoning, measurement systems, and pattern-based arrangements. These concepts appear naturally in the daily routines of food preparation, even though culinary practitioners do not explicitly identify them as mathematical activities.

Geometrical concepts were strongly reflected in the shapes and structures of traditional foods. For instance, mendol tempe is typically shaped into cylindrical or oval forms, which can be associated with three-dimensional geometry. The shaping process requires artisans to maintain consistent dimensions to ensure even cooking, implicitly involving concepts of volume, symmetry, and uniformity. Meanwhile, bakwan Malang, often cut into equal portions during serving, illustrates principles of fractions, area, and partitioning. These findings align with the perspective of Ambrosio (1985)that mathematical ideas naturally emerge from cultural artifacts and practices.

Proportional reasoning and ratios were observed predominantly in food preparation, particularly in recipes requiring precise mixing of ingredients. In the making of cwie mie, for example, the balance between soy sauce, oil, seasoning, and noodles must follow specific proportion patterns to maintain authentic flavor. Artisans described these mixtures not through numerical measurements but through experiential reasoning, such as "two spoonfuls for every handful of noodles." Such practices indicate functional mathematics that is culturally grounded, supporting the view ofPutri et al. (2025) that mathematical understanding develops within familiar cultural contexts.

Measurement concepts were embedded in both ingredient quantities and cooking times. The production of keripik tempe requires artisans to measure thickness consistently to achieve uniform crispiness. Variations in slicing thickness directly influence frying duration and texture, revealing a relationship between measurement and outcomes. These observations support Leton et al. (2025) argument that understanding measurement becomes meaningful when students interact with real-world measurable attributes.

Patterns and symmetry were also evident in Malang's culinary practices, especially in the slicing and arrangement of keripik tempe. The arrangement before frying must follow stable patterns to ensure even cooking. Moreover, the batik-like pattern of fermented tempe itself reflects natural geometric repetition. This characteristic makes tempe an effective learning medium for topics such as tessellations, transformations, and repeated patterns. These insights reinforce the idea that ethnomathematics can serve as a bridge between cultural artifacts and formal mathematical concepts (Khairunnisa et al., 2025).

In addition to identifying mathematical elements, the study found that integrating local foods into mathematics learning enhances student engagement and strengthens cultural identity. Teachers who piloted small-scale demonstrations reported that students showed greater interest when mathematical ideas were connected to familiar foods. This aligns with Smaldino, Jasmani et al. (2024) notion that meaningful learning occurs when students are active participants in constructing knowledge. By examining traditional foods, students become explorers uncovering mathematics within their own culture.

The findings also suggest that food-based ethnomathematics activities can support conceptual understanding. For instance, students analyzing equal slicing of bakwan better understood fractions compared to textbook-only explanations. Similarly, conducting proportional reasoning through cwie mie recipes helped students internalize ratio concepts. These results demonstrate that cultural contexts not only make mathematics more relatable but also enhance comprehension of abstract concepts through hands-on experiences Amanah et al. (2025).

However, the study revealed challenges related to teachers' readiness and resource availability. Many educators expressed uncertainty about connecting cultural artifacts to curriculum standards. Some felt they lacked sufficient background in ethnomathematics. These challenges highlight the need for professional development and structured learning materials to support teachers in integrating local culture into mathematics instruction effectively (Hariastuti et al., 2022; Risdiyanti & Prahmana, 2018; Wedastuti, 2023).

Overall, the results indicate that Malang's traditional foods offer rich and practical sources of mathematical ideas that can be systematically incorporated into mathematics education. The discussion shows that cultural culinary practices are not merely cultural expressions but also reservoirs of mathematical thinking developed through everyday problem-solving. The findings confirm that ethnomathematics can serve as an effective pedagogical approach to contextualize abstract mathematical concepts, increase learning motivation, and preserve cultural identity through education.

Table 1. Mathematical Concepts Embedded in Traditional Foods of Malang

No	Traditional Food (Malang)	Cultural / Culinary Activity	Embedded Mathematical Concepts	Description of Mathematical Elements	Philosophical Background	Model Construction (How mathematical ideas emerge from observing the food)
1.	Mendol Tempe	Shaping fermented tempe mixture into cylindrical or oval forms	Geometry (3D shapes), symmetry, measurement	Consistency of height & diameter; symmetry in shaping; estimating volume for even frying.	Originating from the Singhasari era; the dark color symbolizes depth, balance, and harmony of natural elements.	Students measure color intensity using a grayscale chart and compare it with the number of kluwek used, constructing a quantitative relationship from visual color gradation. Linear color-intensity model: $I = ak + b$.
2.	Bakwan Malang	Cutting portions and arranging toppings	Fractions, partitioning, area	Equal slicing for serving; division of circular/irregular shapes; comparison of portion sizes.	A result of Javanese–Chinese acculturation; spherical shapes symbolize harmony and completeness.	Students observe radius and mass to explore the relationship between volume and density. $m = \rho\frac{4}{3}\pi r^3$.
3.	Tempe Chips	Slicing tempe into thin sheets and arranging for frying	Patterns, symmetry, transformation	Repeated natural patterns in tempe; arrangement patterns to ensure uniform frying; rotational/reflective symmetry.	Rooted in traditional Javanese tempe culture, considered a "democratic" food connecting all social classes.	Students measure thickness of many slices, plot distribution, and derive a natural statistical model. Normal distribution $X \sim N(\mu, \sigma^2)$.

4.	Cwie Mie Malang	Measuring ingredients and mixing sauces	Ratio, proportion, measurement	Proportional mixing of seasoning (e.g., tablespoons vs. noodle weight); balancing flavor ratios.	The harmony of taste reflects the philosophical idea that balance arises from proportional relationships. Small changes in sauce proportionality create noticeable differences, revealing the sensitivity of ratios.	Students observe the relationship between noodle mass and sauce composition. By adjusting tablespoons of seasoning against noodle weight, they create a proportionality model of flavor balance. *Flavor–ratio model:* **F = c (S/W)** where S = sauce amount, W = noodle weight, c = taste-intensity constant.
5.	Rawon Malang	Mixing spices, timing the cooking process	Measurement, time, sequencing	Consistent measurement of spice paste; cooking duration affecting flavor depth; step-by-step procedural sequencing.	Cooking Rawon emphasizes sequence and time—philosophically reflecting that processes unfold in ordered steps where duration shapes outcomes.	Students record how increasing cooking duration deepens color or flavor intensity, then map steps into a quantitative time–effect model. *Time–intensity model:* **I = a t + b**, similar to color-grayscale modelling (e.g., number of kluwek).
6.	Bakso Bakar	Grilling while rotating skewers	Geometry, angle, rotational motion	Turning skewers at equal angles to ensure even roasting; estimation of rotation intervals.	Even roasting symbolizes fairness and symmetry—each side of the meatball receiving equal heat. This reflects rotational balance and periodic motion.	Students observe the angle used when rotating skewers for uniform cooking and develop a model describing equal angular intervals. *Rotational interval model:* **θ = 360° / n**, where n = number of turns for one full roasting cycle.
7.	Putri Salju Malang (cookies)	Shaping dough and portioning	Geometry, symmetry, repetition	Circular/crescent shapes; maintaining uniform thickness and mass for equal baking time.	Uniform cookie shapes represent identity, symmetry, and order—philosophical ideas that regularity produces predictability.	Students measure dough mass and thickness to maintain uniform baking. They construct a geometric similarity model linking diameter, thickness, and volume. *Shape–consistency model:* **V = π(r²)(h)** with constraints $r \approx r_0$, $h \approx h_0$ for uniform batches.

8.	Orem-Orem	Layering rice cake, broth, and toppings	Combinatorics, volume, area	Arrangement of ingredients; volume of serving bowls; counting combinations of toppings.	Layering ingredients expresses structured combination—showing that variations in order and count produce different outcomes, a reflection of combinatorial reasoning.	Students count arrangements of toppings and layers, modeling the possible combinations in serving bowls. *Layer–combination model:* $\mathbf{C = n! / (n_1!\, n_2!\, \ldots)}$ depending on repeated ingredients.

The integration of traditional Malang foods as mathematical observation objects demonstrates how everyday culinary practices naturally embody measurable, structural, and relational properties. By situating mathematics within familiar cultural artifacts, students not only uncover proportionality, geometry, sequencing, and combinatorics, but also learn to construct models grounded in real sensory experiences—such as flavor balance, color intensity, rotational movement, and layering patterns. This approach reinforces the idea that mathematical thinking emerges organically from attentive observation of the world, allowing learners to reinterpret routine actions as quantifiable phenomena. Ultimately, these food-based modeling tasks foster deeper conceptual understanding, cultural appreciation, and the development of authentic problem-posing skills that extend beyond the classroom (Oouder & Amit, 2019; Wiryanto et al., 2022; Zaenuri & Dwidayati, 2018).

CONCLUSION

This study illustrates that traditional Malang foods provide a rich and authentic context for mathematical exploration and model construction. By observing culinary processes—such as balancing flavors, sequencing cooking steps, rotating skewers, shaping dough, and layering ingredients—students naturally encounter fundamental mathematical ideas embedded in everyday life. The philosophical lens applied in each task helps students recognize mathematics not as an abstract discipline detached from reality, but as a way of interpreting patterns, relationships, and structures that already exist in cultural practices. Through this approach, learners develop stronger conceptual understanding, heightened awareness of mathematics in their surroundings, and improved modeling competencies. Ultimately, integrating local food traditions into mathematical learning supports culturally responsive pedagogy while promoting creativity, critical thinking, and meaningful engagement with mathematical concepts.

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