



Gastrolinguistic and Ethnomathematical Analysis of Pecel Madiun as a Contextual Resource for Culture-Based Mathematics Learning

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ABSTRACT

Purpose: This study aims to analyze the gastrolinguistic and ethnomathematical elements embedded in Pecel Madiun and explore their potential integration as a contextual resource for culture-based mathematics learning. The study addresses the limited use of local culinary culture as a learning resource despite its rich linguistic, cultural, and mathematical values. **Methods:** This study employed a descriptive qualitative approach using linguistic and mathematical ethnographic perspectives. Data were collected through observations, in-depth interviews, and documentation involving approximately 15 participants, consisting of Pecel Madiun sellers, spice makers, cultural practitioners, mathematics teachers, and junior high school students in Madiun, East Java, Indonesia. Data were analyzed using the interactive model of data reduction, data display, and conclusion drawing. **Findings:** The analysis identified various gastrolinguistic elements reflected in culinary terminology, symbolic meanings, and procedural language associated with Pecel Madiun. In addition, ethnomathematical elements were found in traditional measurement practices, proportional reasoning, geometric arrangements, and procedural patterns used in the preparation and presentation of the dish. The findings reveal the potential of integrating gastrolinguistic and ethnomathematical perspectives to provide meaningful cultural contexts for mathematics learning and to support the development of students' cultural literacy. **Research implications:** The findings suggest that local culinary traditions can be utilized as contextual resources in designing culture-based mathematics learning materials and curriculum enrichment programs. However, this study is limited to the descriptive identification of gastrolinguistic and ethnomathematical elements within the context of Pecel Madiun and does not evaluate their effectiveness in classroom implementation. Future studies are recommended to develop and empirically test learning models derived from these findings in broader educational settings. **Originality:** This study contributes to the literature by integrating gastrolinguistic and ethnomathematical perspectives in the analysis of a traditional culinary practice, offering a novel interdisciplinary framework for culture-based mathematics education.



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INTRODUCTION

Gastrolinguistic studies is an interdisciplinary branch that examines the relationship between language, food, and culture in a society. This concept is in line with the view [Neuman \(2019\)](#) and [Stano \(2015\)](#) that food is a system of signs that represent the social identity and symbolic value of society. Pecel Madiun as one of the traditional culinary of East Java contains a linguistic, symbolic, and historical narrative that can be analyzed through a gastrolinguistic approach. Every element in Pecel Madiun starting from the mention of ingredients, presentation techniques, to its social meaning reflects the process of cultural representation of the Madiun people. In contrast, ethnomathematics studies how different cultures develop mathematical practices in everyday activities ([Rosa, 2020](#); [Saxe, 2015](#)). The integration of gastrolinguistics and ethnomathematics offers a new space for studying how traditional culinary can become a culturally based mathematics learning medium. The relationship between the two creates a holistic understanding of culinary as a cultural artifact and simultaneously as a source of construction of mathematical concepts. Conceptually, this topic combines linguistic, cultural, and pedagogical dimensions that can be enriched in the context of Indonesian education.

Pecel Madiun has a wealth of cultural values, its use in learning is still very limited. Education in schools generally still adopts an abstract approach that is separate from the local cultural context; therefore, students are less able to relate mathematical concepts to real life. This is in line with the finding that learning that is far from reality causes students to have a low understanding of concepts ([Evagorou et al., 2015](#); [Rojas-Sánchez et al., 2023](#)). In the context of Madiun, traditional culinary art is rarely used as a learning medium, even though it has a pattern structure and procedures that can be studied mathematically. In addition, local languages and symbols in the mention of Pecel Madiun elements have not been widely studied as part of the culture-based learning process. This condition leads to the loss of opportunities to develop cultural literacy through learning. Another problem arises when students are not given the space to understand the local culture as a source of knowledge. Thus, there is an urgent need to evaluate the role of local culinary as a relevant source of learning.

Previous studies have mostly discussed ethnomathematics in the context of art, traditional games, and crafts, but have not reached gastrolinguistics as a source. Research on gastrolinguistics more often focuses on aspects of signs, meanings, and cultural communication without linking them to mathematical learning. This gap shows that there is an unexplored empty space related to the integration of the two approaches. Research gaps present opportunities to generate new findings that are more comprehensive and relevant ([Mulyadi et al., 2026](#); [Mumu et al., 2026](#)). In the context of Pecel Madiun, no research has analyzed culinary linguistic elements as an entrance to mathematics learning. This causes mathematical potentials such as serving patterns, seasoning proportions, and procedural structures to not be optimized. In addition, traditional culinary studies in learning are still treated as mere illustrations, not as scientific objects. Therefore, identifying this gap is an important basis for compiling new and more integrative research.

Integrating gastrolinguistics and ethnomathematics is an innovative alternative solution to address the lack of culture-based learning. This approach can strengthen the relationship between students' cultural experiences and the development of mathematical concepts in the classroom. Concrete representations that are close to students' lives make learning more meaningful ([Coles & Sinclair, 2019](#); [Stieff et al., 2016](#)). By making Pecel Madiun a learning context, students can understand mathematics through cultural activities that are familiar to them. In addition, the gastrolinguistic approach allows students to understand culinary language as a symbolic structure linked to mathematical processes. This integration can also increase cultural literacy because students are invited to reflect on the meaning of serving traditional food. This solution is in line with a culture-based curriculum that emphasizes the interconnectedness between local context and academic competence. Thus, the use of Pecel Madiun can be a relevant and applicable educational model.

Ethnomathematical research by [Batiibwe \(2025\)](#) it shows that various cultural activities store mathematical concepts that can be used as teaching materials. Another study by [Wijaya \(2019\)](#) identified the mathematical elements of Javanese cuisine, but did not examine its linguistic aspects. On gastrolinguistic studies, [Rocillo-Aquino et al. \(2021\)](#) examined the linguistic meaning behind traditional food naming, but the research did not touch the realm of mathematics learning. In addition, some local research related to Pecel Madiun focuses more on history and cultural values without touching on integration into formal education. Thus, the separation of this field of study is still evident in the scientific literature. Previous studies have not combined these two disciplines into a learning model. This emphasizes the need for research that can fill this gap. By simultaneously examining these two aspects, this study moves beyond previous studies.

The main novelty of this research lies in the integration of gastrolinguistics and ethnomathematics in an integrated manner as the basis for the preparation of culture-based learning. No previous research has simultaneously analyzed Pecel Madiun from these two perspectives. This integrative approach allows for a richer understanding of traditional

culinary as a source of cultural mathematics and linguistics. In line with the view, methodological innovation can give birth to new understandings in interdisciplinary studies (Dalton et al., 2022; Kestra et al., 2025). By mapping the linguistic structure of the process of making Pecel Madiun and identifying its mathematical aspects, this study contributes novelty to the realm of cultural education. Another novelty lies in the preparation of learning models relevant to the local context. This integration also expands the scope of gastrolinguistic research in pedagogy. Thus, this study makes a theoretical and practical contribution to education and cultural preservation.

This state-of-the-art research refers to the latest developments in the study of culture, linguistics, and mathematics education. The field of ethnomathematics continues to develop, especially in the context of multicultural education (Batiibwe, 2025; Rosa et al., 2016). Meanwhile, the development of gastrolinguistics in recent years shows a tendency to study food as a complex cultural text. However, the integration of the two has not yet become mainstream research. Recent literature shows that culture-based education is an important concern in the face of global homogenization. In Indonesia, local studies generally only reach the stage of identify cultural values and do not develop learning models. Therefore, this study is important for the development of science as it offers a new approach. The built integrative framework is a marker of new developments in the use of traditional culinary education.

This research is urgent because current sociocultural changes have caused traditional culinary practices to begin to lose relevance among the younger generation. Culture will suffer erosion if it is not inherited in a living and functional context (Nunn et al., 2017; Zhang & Mace, 2021). Culture-based learning through Pecel Madiun can be an effective means of preservation while strengthening students' local identities. In addition, cultural integration in mathematics learning can increase motivation and understanding of abstract concepts. The urgency also lies in the weakness of national mathematics literacy which requires an innovative and contextual approach. The independent curriculum emphasizes strengthening the local context so that this research is very relevant to the needs of national education. On the other hand, the study of gastrolinguistics as part of cultural heritage has not been widely applied in formal education. Thus, this research is important to bridge cultural and pedagogic science in a more meaningful way.

Therefore, this study aims to analyze the gastrolinguistic and ethnomathematical elements embedded in Pecel Madiun as representations of local cultural knowledge and explore their potential integration as contextual resources for culture-based mathematics learning.

METHOD

Types and Approaches to Research

This study uses descriptive qualitative research to describe and analyze cultural phenomena in depth. The approaches used are linguistic ethnography and mathematical ethnography, which correspond to the concept Risku et al. (2022) that ethnographic research emphasizes the understanding of cultural meaning through direct interaction with the research subject. This approach was chosen to explore the gastrolinguistic aspects of Pecel Madiun and identify the mathematical patterns that appear in the process of making and presenting it. Qualitative research allows researchers to interpret the symbols, language, and cultural rules underlying these culinary traditions. In addition, this approach is relevant to view cultural practices in a naturalistic way, according to the view (Moschkovich, 2019). An integrative approach between gastrolinguistics and ethnomathematics is applied to produce a holistic understanding. Thus, the type and approach of this research strongly support the purpose of revealing the cultural and mathematical values in Pecel Madiun.

Subject or Data Source / Research Participant

The data source of this research consists of Pecel Madiun culinary actors, including sellers, spice makers, and local people who understand the culinary tradition. Participants were selected by purposive sampling, as recommended by Cowley & Kelliher (2023) to select informants who truly understand the cultural context being studied. In addition to culinary actors, junior high school students and mathematics teachers are also a source of supporting data to examine the potential for culinary integration in learning. Other data was obtained from documents in the form of historical records of Pecel Madiun, menus, culinary terms, and food serving procedures. Physical environments such as traditional markets, Pecel Madiun stalls, and processing kitchens are sources of observational data. The number of participants can grow according to the principle of data saturation. This diversity of data sources allows gastrolinguistic and ethnomathematical studies to be carried out in depth and comprehensively.

Data Collection Techniques

Data collection techniques include observation, in-depth interviews, and documentation. Observation is carried out in a participatory manner following the concept Khot & Mueller (2019) to understand the interaction patterns, cooking process, serving structure, and culinary terms used. In-depth interviews were conducted with Pecel Madiun sellers,

spice makers, cultural figures, teachers, and students to obtain linguistic, procedural, and perception data regarding mathematical values in the culinary process. Documentation is used to collect data in the form of photos, videos, notes of culinary terms, recipes, and presentation patterns of Pecel Madiun. These three techniques are used triangulation to ensure the validity of the data, as stated by Santos et al. (2020). In addition, the use of diverse techniques helps researchers find richer meanings from the data obtained. The data collection technique is used continuously until it reaches saturation.

Participants and Data Collection

The study involved 21 participants selected through purposive sampling, consisting of five Pecel Madiun vendors, three spice makers, two cultural figures, three mathematics teachers, and eight junior high school students. Data collection was conducted over a three-month period, from January to March 2025. Data were gathered through participant observation, semi-structured interviews, and documentation. Individual interviews lasted approximately 30–60 minutes, depending on the participants' availability and the depth of information provided. Additional follow-up interviews were conducted when necessary to achieve data saturation and ensure the completeness of the collected information.

Ethical Considerations

Prior to data collection, all participants were informed about the purpose of the study, the procedures involved, and their right to withdraw from the research at any time without consequences. Written informed consent was obtained from all adult participants. For junior high school students, permission was obtained from the school administration, and written consent was secured from parents or legal guardians before participation. Student assent was also obtained prior to interviews. All data were treated confidentially, and the identities of the participants were anonymized throughout the research process.

Research Instruments

The main instrument in this study is the researcher himself who plays the role of data collector, processor, and interpreter, according to the view Yoon & Uliassi (2022) that the researcher is a key instrument in qualitative studies. Supporting instruments include semi-structured interview guides, observation sheets, and document analysis guidelines. The interview guide serves to direct the researcher to explore specific aspects of gastrolinguistics and ethnomathematics. The observation sheet was used to record the activities, symbols, sequence patterns, size of materials, and the structure of the presentation of Pecel Madiun. Other instruments in the form of recording devices, cameras, and notebooks are used to strengthen the results of data collection. Instrument validation is carried out through expert judgment to ensure the feasibility of interview and observation guidance in the context of the research. Thus, research instruments have been prepared to support the needs of comprehensive analysis.

Research Procedure

The research procedure is carried out through several stages. First, the preparation stage, which involves compiling a research plan, determining the location, and licensing related parties. Second, the data collection stage, namely carrying out systematic observations, interviews, and documentation at the research site. Third, the data reduction stage, where irrelevant data is filtered and focused on gastrolinguistic and ethnomathematical aspects. Fourth, the data analysis stage, which is interpreting data based on linguistic, cultural, and mathematical categories. Fifth, the triangulation stage cross-checks between sources, methods, and theories. Sixth, the stage of presenting results, that is, compiling findings in narrative and thematic form. The seventh stage is drawing conclusions, and the last is the preparation of a complete research report.

Data Analysis Techniques

Data analysis techniques using interactive models Miles et al. (2014) include three main stages. First, data reduction, namely the selection, focusing, and simplification of data from observation, interviews, and documentation. Second, data presentation organizes data in the form of matrices, categories, and thematic narratives to facilitate interpretation. Third, drawing conclusions, namely interpreting linguistic patterns, cultural symbols, and mathematical concepts found in Pecel Madiun. Gastrolinguistic analysis is carried out through the identification of culinary terms, symbolic meanings, and language structures, according to the theory (Rojas-Rivas & Cuffia, 2022). Ethnomathematical analysis is based on the identification of patterns, sizes, comparisons, procedures, and mathematical structures in culinary activities according to (Janiola, 2024). Data triangulation techniques and theories are used to ensure the validity of the

analysis. Thus, an in-depth analysis is carried out to gain a comprehensive understanding of the integration of gastrolinguistics and ethnomathematics.

RESULTS

Gastrolinguistic Findings on Pecel Madiun

Research shows that Pecel Madiun has a complex linguistic structure that reflects the cultural identity of the local community. Terms such as *peanut ulek*, *sambel pecel*, *kulupan*, and *blenyek* function as cultural markers and describe the culinary naming system that is inherited from generation to generation. The findings show that each term has a semantic function, for example, *kulupan* refers to the processing technique of vegetables that are boiled without spices, while *blenyek* describes the consistency of thick pecel sauce. This study confirms the view [Barthes \(2017\)](#) that food is not only an object of consumption, but also a system of signs. The use of local language by sellers and makers of Pecel Madiun strengthens social cohesion and becomes a medium for informal cultural value inheritance. Observations also show that there are oral texts that set norms, such as local proverbs about the continuity of pecel flavors. Thus, the linguistic aspect in Pecel Madiun has strong cultural value and can be used as educational study material.

No.	Aspek Gastrolinguistik	Data Verbal (Ujaran/ Teks)	Konteks Data	Makna Linguistik	Fungsi dalam Praktik Kuliner	
1.	Leksikon (Bahasa Kuliner)	"Pecel Madiun nganggo kacang tané sing iso digoreng dhowe, cabai rawit, kencur, lan daun jeruk." (Penjual Pecel Madiun)		Wawancara dengan penjual saat menjelaskan bahan utama pecel.	Penggunaan kosakata khas kuliner lokal: "kacang tané", "cabai rawit", "kencur", dan "daun jeruk" menunjukkan leksikon spesifik yang melekat pada budaya kuliner Pecel Madiun.	Menegaskan identitas bahan tradisional dan membedakan Pecel Madiun dari pecel di daerah lain.
2.	Verba Prosedural (Bahasa Proses)	"Kacang tané digorengi tak goreng nganti matang, terus diulek bareng gula merah lan bumbu liyo." (Penjual Pecel Madiun)		Wawancara dan observasi proses pembuatan bumbu pecel.	Kata kerja "digoreng", "diulek", menunjukkan tahapan prosedural dalam pembuatan bumbu pecel.	Memberi petunjuk langkah-langkah memasak secara berurutan dan menjaga konsistensi rasa.
3.	Nomina Kultural (Benda & Istilah Khas)	"Pecel iki nganggo timun, kecambah, sayur godhong, lan rempeyek gembus." (Penjual Pecel Madiun)		Penjelasan penjual saat menyebutkan pelengkap/isi pecel.	Istilah "sayur godhong" dan "rempeyek gembus" adalah nomina kultural yang tidak selalu ditemukan di daerah lain.	Menunjukkan kekhasan budaya kuliner dan memperkuat citra lokal Pecel Madiun.
4.	Ungkapan Deskriptif (Sensoris)	"Sambel pecel iki legit, gurih, lan nduwèni aroma kencur sing khas." (Penjual Pecel Madiun)		Wawancara saat menjelaskan cita rasa pecel.	Penggunaan kata sifat deskriptif "legit", "gurih", dan "khas" menggambarkan kualitas rasa dan aroma pecel.	Membangun persepsi dan pengalaman sensoris yang menarik minat konsumen.
5.	Pragmatik (Bahasa dalam Interaksi)	"Niki, Bu, tak suèki porsi normal nggèh? Pedasé kepéngin pinten?" (Penjual Pecel Madiun)		Interaksi penjual dengan pembeli saat penyajian pecel.	Tuturan menggunakan ragam bahasa santun dan akrab (kromo alus/ngoko alus) untuk menghormati pembeli dan membangun kedekatan.	Menciptakan hubungan sosial yang harmonis antara penjual dan pembeli serta meningkatkan kenyamanan bertransaksi.

Figure 1. Gastrolinguistic Findings on Pecel madiun

Source: Results of observations, interviews, and documentation (May 2026)

The findings indicate that the terminology used in Pecel Madiun reflects local cultural knowledge and culinary traditions. Several participants explained that the naming and preparation of Pecel have been transmitted across generations. One Pecel vendor stated:

"We learned how to make pecel from our parents. The names of the ingredients and the method for making it have been used for a long time in the Madiun community." (PV-02)

This statement demonstrates that gastrolinguistic elements are embedded in intergenerational cultural transmission and local culinary practices.

Procedural Structure and Cultural Patterns in the Making of Madiun Pecel

The results of the study show that the process of making Pecel Madiun follows a stable and inherited procedural pattern. Starting from the selection of ingredients, the preparation of vegetables, the composition of spices, to the serving pattern, everything follows relatively fixed rules. Each stage has a *ritualistic sequence*, showing that this culinary is not only a cooking activity, but also a cultural expression. For example, the order of grinding beans always starts with

beans, chili peppers, garlic, and then seasonings, which are linguistically and culturally considered "sacred sequences." Pecel Madiun sellers carry out the process with the same repeating pattern every day, so that consistency of taste and culinary identity is created. This strengthens the concept of cultural structure according to [Buckley \(2017\)](#), who states that regular behavior patterns are part of the system of meaning of society. These patterns are also an entrance to study mathematical elements in culinary. Thus, these results confirm the integration of symbols, procedures, and cultural meanings in Pecel Madiun.

No.	Tahap Proses	Foto	Uraian Proses	Makna/ Tujuan	Sumber Data
1	Menyiapkan bahan utama		Menyiapkan kacang tanah, cabai, bawang putih, kencur, gula merah, garam, dan bahan pelengkap lainnya.	Memastikan kualitas bahan agar cita rasa pecel Madiun terjaga.	Observasi dan dokumentasi (15 Mei 2024)
2	Menggoreng kacang tanah		Kacang tanah digoreng hingga matang dan beraroma harum, kemudian didinginkan.	Menghasilkan kacang yang renyah dan aroma yang khas sebagai dasar sambel pecel.	Observasi (15 Mei 2024)
3	Mengulek bumbu		Kacang, cabai, bawang putih, kencur, garam, dan gula merah diulek hingga halus dan tercampur rata.	Membentuk sambel pecel dengan tekstur "blenyek" yang lembut dan kental.	Observasi dan wawancara (16 Mei 2024)
4	Merebus sayuran (kulupan)		Berbagai sayuran seperti bayam, kangkung, taoge, dan kacang panjang direbus sebentar hingga matang.	Menjaga tekstur sayuran tetap segar, warna hijau, dan tidak lembek.	Observasi (16 Mei 2024)
5	Penyajian pecel		Sayuran yang telah direbus ditata di atas piring/daun pisang kemudian disiram sambel pecel dan diberi pelengkap seperti rempeyek atau tempe.	Menyajikan pecel dengan komposisi seimbang antara rasa, warna, dan tekstur.	Observasi dan dokumentasi (17 Mei 2024)
6	Penyiraman sambel		Sambel pecel disiram merata di atas sayuran sesuai selera konsumen.	Memberi cita rasa khas dan meningkatkan selera makan.	Observasi (17 Mei 2024)

Figure 2. Procedural Structure and Cultural Patterns in the Making of Madiun Pecel

Source: Results of observations, interviews, and documentation (May 2026)

Ethnomathematical Findings in the Process of Making and Presenting Pecel Madiun

The research found that the process of making Pecel Madiun contains various mathematical concepts that are relevant to learning. First, there is a concept of measuring the amount of nuts, brown sugar, chili, and other spices that use traditional units such as handhelds, slices, and spoons. Second, there is the concept of proportions and comparisons, for example, the ratio of spices between nuts and brown sugar that must be maintained to achieve a certain consistency. Third, there is a geometric pattern in the presentation of vegetables that are arranged in a circular or layered manner according to the style of each seller. Fourth, the process of watering pecel sauce follows a consistent curved trajectory, forming a visual pattern that can be mathematically analyzed. These findings confirm the view ([Wijaya et al., 2015](#)) that cultural activities contain mathematical practices that can be studied contextually. Informants state that they unconsciously follow certain patterns of calculation and proportions even though they do not use formal units. Thus, Pecel Madiun is proven to contain rich and authentic ethnomathematical potential.

No.	Aktivitas	Foto	Konsep Matematis	Penjelasan Matematis	Contoh pada Pecel Madiun
1	Takaran bahan Menggunakan satuan tradisional.		Pengukuran (non-standar)	Menggunakan satuan tidak baku seperti genggam, sendok, siung, dan ruas yang dapat dikonversi ke satuan baku.	1 genggam kacang $\approx$ 100 gram 2 sendok makan gula merah $\approx$ 30 gram
2	Perbandingan bumbu Menjaga keseimbangan rasa.		Perbandingan/ Rasio	Perbandingan jumlah bahan yang digunakan untuk memperoleh rasa yang seimbang.	Perbandingan kacang : gula merah = 5 : 1 (5 bagian kacang untuk 1 bagian gula merah)
3	Pengukuran kekentalan sambel Menentukan tekstur sambel pecel.		Estimasi dan Kuantifikasi	Menentukan tingkat kekentalan secara kualitatif yang dapat dikuantifikasi menggunakan skala.	Skala kekentalan sambel: 1 = encer, 2 = sedang (blenyek), 3 = kental
4	Penataan sayuran Menyusun sayuran di atas piring/daun pisang.		Pola Geometris (Simetri & Lingkaran)	Sayuran disusun membentuk pola lingkaran dengan distribusi yang seimbang (simetri radial).	Sayuran ditempatkan melingkar dengan jarak relatif sama, membentuk simetri radial.
5	Penyiraman sambel Menyiram sambel di atas sayuran.		Pola Kurva/ Lintasan	Gerakan menyiram membentuk lintasan melengkung (spiral) yang dapat dimodelkan secara geometris.	Lintasan spiral dari pusat ke luar membentuk pola kurva.

Figure 3. Mathematical Concepts in Pecel Madiun
 Source: Results of observations, interviews, and documentation (May 2026)

No.	Jenis Pola Geometris	Foto Penyajian	Deskripsi Pola	Representasi Geometris	Keterangan
1	Pola Lingkaran (Konsentris) Sayuran disusun melingkar mengelilingi pusat sambel.		Bahan makanan disusun membentuk lingkaran dengan sambel sebagai pusat. Susunan ini menciptakan keseimbangan visual dan memudahkan saat penyajian.		- Pusat (titik pusat): sambel - Jari-jari: jarak sambel ke batas sayuran - Mencerminkan keseimbangan dan kesatuan rasa
2	Pola Radial (Simetri Putar) Penataan sayuran mengelilingi pusat sambel dengan jarak sama.		Sayuran dibagi ke dalam beberapa bagian yang tersusun simetris terhadap titik pusat sambel sehingga terlihat rapi dan menarik.		n = jumlah bagian sayuran - Sudut pusat tiap bagian = $360^\circ/n$ - Menunjukkan prinsip simetri dan pembagian sama besar
3	Pola Segitiga Berlapis Tumpukan sayuran membentuk susunan bertingkat menyerupai segitiga.		Penyusunan bahan membentuk struktur bertingkat dari alas lebar ke puncak sempit sehingga menyerupai bentuk segitiga.		- Alas lebar, puncak sempit - Mencerminkan stabilitas dan estetika visual - Prinsip geometri dimensi dua (segitiga)
4	Pola Spiral (Lintasan Penyiraman Sambel) Sambel disiram dari pusat ke luar membentuk gerakan spiral.		Gerakan penyiraman sambel membentuk lintasan spiral yang bergerak dari pusat ke luar secara melingkar berputar.		- Jarak antar putaran konstan - Contoh pola kurva dalam geometri - Memberi distribusi rasa lebih merata
5	Pola Persegi Panjang (Penyajian di Atas Alas) Pecel disajikan di atas piring atau alas daun pisang berbentuk persegi panjang.		Alas daun pisang berbentuk persegi panjang yang membatasi area penyajian sehingga membentuk bidang datar dengan sisi berpasangan sama panjang.		- Memiliki 2 pasang sisi sejajar - Diagonal sama panjang - Contoh bangun datar dalam geometri

Figure 4. Geometric Patterns in Pecel Madiun
 Source: Results of observations, interviews, and documentation (May 2026)

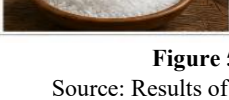
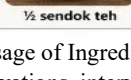
No.	Bahan	Foto Bahan	Satuan Tradisional yang Digunakan	Takaran (Contoh)	Perkiraan dalam Satuan Baku	Keterangan
1.	Kacang tanah goreng		 1 genggam	1 genggam penuh (kacang yang menutupi telapak tangan)	≈ 100 gram	Takaran utama untuk membuat sambel pecel.
2.	Gula merah		 2 sendok makan	2 sendok makan (gula merah serut)	≈ 30 gram	Memberi rasa manis khas pada sambel pecel.
3.	Cabai rawit		 5 buah	5 buah cabai rawit (sesuai selera)	≈ 10-15 gram	Menentukan tingkat kepedasan.
4.	Bawang putih		 2 siung	2 siung bawang putih (ukuran sedang)	≈ 10 gram	Memberi aroma dan rasa gurih.
5.	Kencur		 1 ruas	1 ruas kencur (seukuran ruas ibu jari)	≈ 3-5 gram	Menambah aroma segar dan khas pada sambel pecel.
6.	Garam		 ½ sendok teh	½ sendok teh garam	≈ 2-3 gram	Penambah rasa dan penyeimbang cita rasa.

Figure 5. Dosage of Ingredients with Traditional Units
 Source: Results of observations, interviews, and documentation (May 2026)

No.	Aspek yang Diukur	Foto Pengukuran	Alat Ukur	Hasil Pengukuran	Keterangan
1.	Berat sambel pecel per porsi		Timbangan digital	80 gram per porsi (sambel pecel)	Takaran ini menghasilkan cita rasa yang seimbang dengan sayuran.
2.	Berat sayuran (kulpun)		Timbangan digital	120 gram per porsi (sayuran)	Komposisi sayuran bervariasi namun rata-rata dalam rentang ini.
3.	Berat total satu porsi pecel		Timbangan digital	220 gram per porsi (total pecel lengkap)	Berat ideal satu porsi untuk konsumsi sekali makan.
4.	Diameter alas piring saji		Penggaris/meteran	24 cm	Ukuran alas piring yang umum digunakan pedagang pecel Madiun.
5.	Tinggi tumpukan sayuran		Penggaris/meteran	6 cm (rata-rata tinggi tumpukan)	Tinggi tumpukan mempengaruhi kenyamanan saat penyajian dan proporsi sambel.
6.	Jarak siraman sambel dari pusat ke tepi		Penggaris/meteran	± 7 cm dari pusat hingga tepi sayuran	Pola penyiraman membentuk jarak yang merata agar rasa terdistribusi dengan baik.

Figure 6. Measurement Data
 Source: Results of observations, interviews, and documentation (May 2026)

Observations revealed that proportional reasoning is frequently applied during the preparation of peanut sauce. A spice maker explained:

" Usually, three cups of peanuts are mixed with one cup of brown sugar to balance the flavor of the seasoning."
(SM-01)

This practice illustrates the use of proportional relationships in traditional culinary practices.

Ethnomathematical Elements in Pecel Madiun

1. **Measurement Concepts**
Field observations showed that traditional measurements were commonly used during the preparation of Pecel sauce. Rather than using digital scales, participants relied on practical measuring tools such as glasses, spoons, and hand-based estimations. During an observation session, a spice maker used approximately three glasses of peanuts, one glass of palm sugar, and half a glass of tamarind solution to prepare the sauce. This practice reflects the application of informal measurement concepts in daily culinary activities.
2. **Proportional Reasoning**
The preparation of pecel sauce also demonstrates proportional reasoning. Participants consistently adjusted ingredient quantities according to the desired volume while maintaining the same ratio among ingredients. One spice maker explained that increasing the amount of peanuts required a proportional increase in palm sugar and seasoning to preserve the characteristic flavor of Pecel Madiun. This practice illustrates the application of ratio and proportion concepts in local culinary traditions in Indonesia.
3. **Geometric Patterns**
Observations further revealed geometric arrangements in the presentation of Pecel Madiun. Vegetables were arranged around the center of the plate, and peanut sauce was placed in the middle, forming a circular composition. This arrangement reflects geometric concepts related to circles, symmetry, and spatial organization, which can be contextualized in mathematics learning.

Integration of Gastrolinguistics and Ethnomathematics in the Context of Learning

Research shows that the integration of these two approaches is not only theoretically possible, but also practically relevant in learning. The math teachers interviewed acknowledged that the context of the local culture can increase students' motivation and understanding if presented appropriately. Culinary terms such as *ulekan*, *kulupan*, and *sambel pecel* can be used to introduce the concepts of sequence, procedure, and classification. Meanwhile, mathematical concepts such as measurements, patterns, and proportions can be linked to pecel cooking activities. This combination is able to produce learning that is closer to the students' daily experience, in accordance with the Realistic Mathematics Education approach put forward [Fredriksen \(2021\)](#). Students involved in the initial study showed high enthusiasm when mathematics was associated with the local cuisine they were familiar with. This condition reflects the great potential for the implementation of culture-based mathematics learning through Pecel Madiun. Thus, gastrolinguistic-ethnomathematical integration has been proven to be able to build contextual and meaningful learning experiences.

Cultural Representation as a Learning Resource Based on Local Context

Research shows that Pecel Madiun functions as a strong cultural representation medium and can be used as a learning resource. Pecel Madiun is not only a food item, but also a narrative about the history, economy, and social values of the Madiun people. The language used in the interaction between sellers and buyers reflects the value of Javanese politeness, while the process of serving food shows the value of precision, harmony, and balance. These elements can be integrated in math learning through narratives and cultural projects. Teachers can take advantage of stories and cultural patterns in Pecel Madiun to introduce mathematical concepts holistically. These findings are in line with the idea [Uzunboyly & Altay \(2021\)](#) regarding the importance of multicultural education that connects culture with subject matter. Thus, the cultural representation of Pecel Madiun has high relevance to build learning based on the local context. The results of the study reinforce the urgency of cultural preservation through integration in the curriculum.

Contribution of Findings to Culture-Based Learning Models

This study found that Pecel Madiun can be used as a cultural learning model that integrates language, meaning, and mathematics. This contribution arises from mapping linguistic structures, culinary procedures, and mathematical patterns that can be transformed into learning activities. Teachers can design worksheets based on pecel cooking activities, such as measuring ingredients, calculating the proportions of spices, or analyzing serving patterns. This learning model also allows students to simultaneously develop cultural literacy and high-level thinking skills. This research supports the view [Saxena et al. \(2020\)](#) that learning must take advantage of the concrete experiences of

students. Research findings suggest that this approach can increase student engagement and strengthen understanding of concepts. Therefore, Pecel Madiun can be used as an innovative and relevant cultural learning model for local education.

Community Response

Eight of the ten community participants expressed positive views regarding the use of Pecel Madiun as a learning resource. One cultural figure commented :

Most participants expressed positive views on using Pecel Madiun as a contextual learning resource.

A mathematics teacher commented:

" Students find it easier to understand mathematical concepts when the examples used come from the culture they are familiar with in their daily lives." (MT-02)

Similarly, a student stated:

" Learning math using the example of Pecel Madiun makes the subject feel more relevant to our daily lives." (ST-04)

DISCUSSION

The results of the study show that Pecel Madiun is not just a culinary product, but a sign system that contains cultural meaning. These findings are in line with the view [Parasecoli \(2019\)](#) which affirms that food is a language system, where every term, cooking technique, and serving structure conveys a specific cultural message. Terms such as *kulupan*, *blenyek*, and *sambel ulek* not only mark culinary objects, but also map the social identity of the people of Madiun. The culinary language used by sellers shows that communication in the kitchen and market is a linguistic practice that preserves tradition. In the context of gastrolinguistics, language becomes a medium to nurture people's collective memory of traditional foods. Therefore, the linguistic meaning of Pecel Madiun shows the process of cultural inheritance through culinary symbols. These findings confirm that regional cuisine remains alive through language practices that continue to be reproduced in daily life.

The results of the study also found that the order of making and serving Pecel Madiun follows a fixed pattern that is inherited from generation to generation. This is in line with the theory [Gamsakhurdia \(2020\)](#) that culture is a *pattern of meanings transmitted historically*, where routine behaviors such as cooking contain symbolic values. The order of grinding beans, mixing spices, and serving styles shows the cultural structure embedded in culinary practices. This practice also shows the existence of discipline and precision which is seen as part of the work ethics of the Javanese people. Procedural patterns that are repeated daily form a stable cultural system. Thus, the cooking process of Pecel Madiun is not just a technical activity, but a representation of cultural values such as order, harmony, and balance. These findings reinforce the argument that any culinary act can be read as a cultural text.

Ethnomathematical findings in Pecel Madiun support the view [D'Ambrosio & Rosa \(2017\)](#) that mathematics is present in every cultural activity through informal practices of measurement, pattern, comparison, and calculation. The use of traditional units such as "handheld," "iris," and "pinch" indicates the existence of a consistent and mathematically observable non-formal measurement system. The presentation of vegetables arranged in a circle and layers shows geometric patterns that can be used in mathematics learning. Even the consistent watering trajectory of the spice depicts a visual curve that can be mathematically analyzed. These findings reinforce that local culture is a source of authentic and relevant mathematical concepts for students. Therefore, Pecel Madiun is a contextual medium for teaching culture-based mathematical concepts.

The integration of gastrolinguistics and ethnomathematics in learning is supported by theory [Maass et al. \(2019\)](#) which states that mathematics must be understood as *human activity* and learned through the real context of students' lives. When mathematics is explained through Pecel Madiun cooking activities, students find it easier to connect abstract concepts with everyday experiences. The results of the interviews showed that students were more interested in learning mathematics when the material was associated with local culinary experiences. Teachers also see that culture-based learning can increase student engagement and enrich teaching methods. This approach is in line with the principles of Realistic Mathematics Education (RME) which emphasizes the interconnectedness between mathematics and the real world. Thus, the integration of local cuisine in learning is an effective and contextual strategy.

The findings show that Pecel Madiun can function as a source of cultural literacy in learning. This view is in line with the theory [Spring \(2017\)](#) which states that multicultural education needs to connect local culture with the curriculum so that students can understand their identity. Culinary languages such as *ulekan*, *kulupan*, and *sambel pecel* reflect local values and can be used to develop cultural literacy skills. Learning that raises culinary culture helps

students understand local history, social structure, and the values of the Madiun community. Thus, gastrolinguistics is not only relevant for language studies, but can be integrated as learning materials that enrich the learning experience. These findings confirm that local cuisine can be a powerful source of interdisciplinary learning.

The positive response from culinary actors, teachers, and students shows high social support for the implementation of culture-based learning. Community participation in local culinary preservation supports the concept of cultural participation according to [Mpuangnan & Ntombela \(2024\)](#) which emphasizes the importance of community involvement in research and education. Culinary actors view the use of Pecel Madiun as a learning medium as a way to maintain cultural sustainability. Teachers consider that this approach enriches the variety of Mathematical learning and increases student interest. Thus, this social support is an important factor in the successful implementation of culture-based learning in schools. These findings show that the integration of Pecel Madiun in learning is not only feasible, but also culturally accepted by the community.

This study makes an important contribution to the development of culture-based learning models. From a theoretical perspective, this research connects gastrolinguistics and ethnomathematics as two interdisciplinary approaches that can support contextual learning. [Pole and McGee \(2025\)](#) views on real experiential learning support the finding that Pecel Madiun can be used to develop students' thinking skills. From a practical perspective, the results of this study provide a model of learning activities that teachers can adopt to develop culture-based materials. This study shows that Pecel Madiun has strong educational value and deserves to be integrated into the curriculum. Thus, this study enriches the local context-based learning literature while strengthening cultural preservation efforts.

Despite its contributions, this study has several limitations. First, the participant composition was relatively limited and involved only a specific group of Pecel Madiun vendors, spice makers, cultural figures, mathematics teachers, and junior high school students. Second, the study focused exclusively on the cultural context of Pecel Madiun within a single community, which may limit the transferability of the findings to other culinary traditions or regions. Third, the study did not collect formal student learning outcome data because its primary objective was to explore the gastrolinguistic and ethnomathematical potential of Pecel Madiun rather than evaluate instructional effectiveness. Finally, the research employed an exploratory qualitative design, meaning that the findings should be interpreted as providing contextual insights and theoretical possibilities rather than causal evidence regarding educational impact. Future studies are therefore encouraged to develop and empirically test instructional models based on these findings using broader participant groups and quantitative or mixed-method approaches.

CONCLUSION

This study demonstrates that Pecel Madiun contains rich gastrolinguistic and ethnomathematical elements that can serve as meaningful contextual resources for culture-based mathematics learning. The findings reveal the presence of mathematical concepts such as measurement, ratio, proportion, geometric patterns, and procedural reasoning embedded in the preparation and presentation of Pecel Madiun, alongside linguistic and cultural meanings that reflect local knowledge and traditions. These findings suggest that educators and curriculum developers may utilize Pecel Madiun as a contextual learning medium by designing learning activities that engage students in analyzing ingredient ratios, calculating proportional quantities, exploring geometric arrangements of food presentation, and connecting mathematical concepts with local cultural practices. Nevertheless, the findings should be interpreted within the scope of the study's limitations, including the relatively small purposive sample, the focus on a single cultural community, and the absence of formal measurements of student learning outcomes. Therefore, future research is recommended to develop and empirically evaluate instructional models based on Pecel Madiun and other local cultural practices through broader participant groups and quantitative or mixed-method approaches to examine their effectiveness in enhancing students' mathematical understanding and cultural literacy.

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AUTHOR CONTRIBUTION STATEMENT

AS & AUK contributed to conceptualization, methodology, supervision, validation, writing original draft, and writing review & editing. SM & RH contributed to methodology, formal analysis, investigation, resources, and writing review

& editing. AS & FA contributed to data curation, investigation, project administration, and writing original draft. All authors have read and approved the final version of the manuscript.

AI DISCLOSURE STATEMENT

The authors used ChatGPT (OpenAI) during the preparation of this work for limited language editing and grammar improvement. After using the tool, the authors carefully reviewed and revised the manuscript and take full responsibility for the accuracy, integrity, and content of the publication.

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