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Digital Mapping of Fermented Foods for the Advancement of Gastronomy Tourism in Indonesia

Yerik Afrianto Singgalen[1*], Dorien Kartikawangi[2], Birgitta Narindri Rara Winayu[3]

[1*,2] Faculty of Business Administration and Communication, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia
[3] School of Bioscience, Technology, and Innovation, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia

Email: [1*]yerik.afrianto@atmajaya.ac.id, dorien.kartika@atmajaya.ac.id, birgitta.winayu@atmajaya.ac.id

Abstract

This research introduces a pioneering digital mapping framework for Indonesian fermented foods that integrates geospatial technologies with traditional gastronomic knowledge systems. Employing Rapid Application Development methodology on the Oracle APEX platform, the study establishes a comprehensive documentation infrastructure capturing the geographical distribution, production methodologies, and cultural significance of diverse fermentation practices across Indonesia's archipelagic landscape. The resulting prototype offers multifunctional capabilities through an intuitive interface design that serves preservation imperatives and tourism development objectives. Findings demonstrate that systematic digital documentation of fermented food traditions creates measurable economic opportunities through enhanced destination competitiveness, specialized culinary tourism routes, and improved market visibility for artisanal producers. The community-driven documentation protocols position local knowledge-holders as primary content contributors, while the system architecture establishes essential connections between geographical contexts and traditional fermentation techniques. This research addresses critical documentation gaps while establishing standardized protocols applicable beyond Indonesia to other regions with significant fermentation heritage. The digital mapping system ultimately functions as both a cultural preservation mechanism and a strategic asset for sustainable gastronomy tourism development, offering a replicable model for transforming endangered culinary knowledge into economically viable digital assets that benefit traditional food-producing communities.

Keywords: Digital Mapping; Fermented Foods; Gastronomy; Indonesia; Tourism

1. INTRODUCTION

The evolution of gastronomy tourism in Indonesia necessitates sophisticated digital mapping strategies for fermented foods, as these traditional culinary treasures remain insufficiently documented despite their significant cultural

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heritage value and economic potential. Digital cartography offers unprecedented opportunities to systematically catalog Indonesia's diverse fermentation practices, from tempeh production in Java to tape fermentation in Sumatra [1], [2]. This creates comprehensive gastronomic atlases accessible to international culinary enthusiasts and domestic travelers [3], [4]. Rigorous geospatial analysis reveals distinctive regional fermentation techniques correlating with unique microbial communities, geographical conditions, and traditional knowledge systems passed through generations, establishing fermented foods as authentic cultural expressions worthy of scholarly examination [5]. Implementing digital mapping methodologies enhances visibility for small-scale producers while preserving endangered fermentation techniques, stimulating local economies through increased gastronomy tourism ventures in previously overlooked regions [6]. This systematic documentation approach functions as both a cultural preservation mechanism and a tourism development catalyst, positioning Indonesia advantageously within the competitive global culinary tourism landscape where authenticity and distinctive food experiences increasingly determine destination selection among discerning travelers.

The imperative need for digital mapping of Indonesian fermented foods emerges from several converging factors within the rapidly evolving gastronomy tourism landscape. Technological advancements in digital cartography coincide with Indonesia's untapped potential in culinary tourism, creating an opportune moment for systematic documentation of fermented food traditions that face unprecedented threats from globalization and shifting dietary preferences. Economic analyses reveal substantial revenue potential through gastronomic tourism in peripheral regions, where traditional fermentation practices often remain concentrated yet economically undervalued despite representing significant intellectual property and cultural capital [7]. Methodological gaps exist in current documentation approaches, with scattered, inconsistent recording methods hampering practical preservation and promotion efforts. Digital mapping offers standardized protocols that address these deficiencies while providing adaptable solutions across Indonesia's diverse geographical contexts [8]. Temporal urgency characterizes this research need, as elder knowledge-holders of specialized fermentation techniques diminish annually, potentially resulting in the permanent loss of irreplaceable cultural techniques and microbiological knowledge developed over centuries. Such comprehensive digital mapping initiatives constitute vital interventions at this critical juncture, simultaneously addressing preservation imperatives while creating sustainable economic development pathways for communities through enhanced visibility in contemporary gastronomy tourism markets.

The primary objective of this digital mapping initiative encompasses both prototype design and analytical frameworks for Indonesian fermented foods, establishing methodological protocols that bridge technological innovation with

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gastronomy tourism development. Prototype design focuses on creating interactive cartographic representations integrating geographic information systems with multimedia documentation capabilities, allowing for precise geolocation of fermentation sites alongside comprehensive sensory profiles, production techniques, and cultural significance markers for each documented fermented food. Analytical methodologies employ multivariate approaches examining spatial distribution patterns of fermentation practices against demographic, environmental, and historical variables to identify correlations between geographic context and fermentation diversity across Indonesia's archipelagic landscape [9]. Prototype functionality optimizes user experience through intuitive navigation architectures and cross-platform accessibility, ensuring practical utility for diverse stakeholders, including culinary tourists, food researchers, and local tourism authorities [10]–[12]. Implementation strategies incorporate iterative testing protocols with targeted stakeholder groups, generating quantitative usability metrics alongside qualitative feedback to refine interface design elements and data visualization approaches. This dual emphasis on prototype development and analytical frameworks establishes a foundational infrastructure for sustainable documentation efforts, simultaneously creating technological tools for immediate application while generating analytical insights that inform the strategic development of gastronomy tourism corridors, highlighting Indonesia's fermented food heritage.

The theoretical contribution of this digital mapping research extends to multiple disciplinary domains, establishing novel intersections between gastronomy tourism theories, cultural heritage preservation frameworks, and digital cartography methodologies specifically contextualized for fermented food documentation. Conceptual advancements emerge through the development of taxonomic systems categorizing fermented foods based on production techniques, microbial communities, and cultural significance, creating standardized classification protocols applicable beyond Indonesia to other regions with rich fermentation traditions [13]. Methodological innovations manifest in integrating sensory profiling with geospatial data, yielding comprehensive documentation techniques that capture tangible production processes and intangible cultural knowledge associated with fermentation practices across diverse geographical contexts [14], [15]. Practical implications materialize across multiple stakeholder dimensions: tourism authorities gain data-driven decision support tools for creating specialized gastronomy tourism circuits highlighting fermented food attractions; small-scale producers receive enhanced visibility and market access through digital platform integration; and educational institutions acquire comprehensive learning resources documenting traditional knowledge that might otherwise remain fragmented or inaccessible. Economic benefits accrue through identifying high-potential gastronomy tourism corridors, enabling strategic infrastructure development and marketing initiatives tailored to visitor preferences ascertained through digital mapping analytics. This research ultimately bridges theoretical advancement with

pragmatic application, establishing replicable methodologies for documenting culinary heritage while simultaneously creating functional tools that enhance economic opportunities for communities through sustainable gastronomy tourism development.

The novelty of this digital mapping research lies in its unprecedented integration of multiple technological frameworks with traditional gastronomic knowledge systems, creating a first-of-its-kind documentation infrastructure tailored explicitly to Indonesia's fermented food heritage. Methodological innovation manifests through developing specialized algorithms that correlate geographical distribution patterns with microbial ecosystems and cultural practices, generating dynamic visual representations that transcend static cartography. The research pioneers application-specific adaptations of geographic information systems, incorporating augmented reality components that allow users to virtually experience production environments and sensory characteristics of fermented foods across diverse Indonesian localities [16]–[19]. Technological originality emerges in creating participatory mapping protocols enabling community-driven documentation, fundamentally altering conventional researcher-subject dynamics by positioning local knowledge-holders as primary content contributors rather than passive informants [20], [21]. This research introduces revolutionary documentation methodologies that preserve endangered cultural knowledge while creating economically viable digital assets for gastronomy tourism development. This represents a paradigm shift in how culinary heritage is documented, preserved, and strategically leveraged for sustainable tourism initiatives in developing economies.

Despite their significant cultural heritage value and economic potential, the diverse fermented food traditions across Indonesia's archipelagic landscape face critical documentation deficits. This insufficient documentation threatens the preservation of traditional culinary knowledge and opportunities for gastronomy tourism development. Digital cartography offers unprecedented opportunities to systematically catalog Indonesia's diverse fermentation practices, from tempeh production in Java to tape fermentation in Sumatra, creating comprehensive gastronomic atlases accessible to international culinary enthusiasts and domestic travelers. This research addresses several critical questions at the intersection of digital documentation, cultural preservation, and gastronomy tourism development: (1) How can Rapid Application Development methodology be effectively applied to create digital mapping infrastructure for Indonesia's fermented food heritage? (2) What documentation parameters are required to capture both geographical distribution patterns and the cultural significance of traditional fermentation practices? (3) How can Geographic Information Systems be synchronized with multimedia databases to enhance the documentation precision of production techniques influenced by microclimatic conditions? (4) In what ways can digital mapping of fermented foods contribute to sustainable gastronomy tourism development while preserving traditional knowledge systems?

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By addressing these questions, this study establishes methodological protocols that bridge technological innovation with gastronomy tourism development and analytical frameworks for examining spatial distribution patterns of fermentation practices across Indonesia's diverse geographical contexts.

2. METHODS

2.1 Rapid Application Development

The implementation of Rapid Application Development (RAD) as the framework for prototype design represents a methodologically sound approach, given the multifaceted requirements of digital mapping for fermented food documentation. RAD methodology facilitates iterative development cycles through its structured four-phase process: requirement planning, user design, construction, and cutover [22]. It enables expeditious prototype refinement while maintaining essential quality standards throughout the development timeline. The initial requirement planning phase establishes comprehensive documentation parameters through stakeholder consultation, ensuring alignment between technological capabilities and the actual documentation needs of Indonesia's diverse fermentation practices. User design phases incorporate continuous feedback loops from multiple stakeholder categories, including culinary experts, tourism authorities, and local producers, fundamentally enhancing interface usability and data representation accuracy before significant development resources are committed.

The construction phase benefits from a modular development approach inherent to RAD methodology, allowing parallel implementation of distinct mapping components, geographic information systems, multimedia documentation interfaces, and analytical tools, optimizing resource allocation and accelerating development timelines. RAD's particular suitability for this specialized digital mapping initiative is due to its emphasis on functional prototyping and stakeholder engagement, which are critical factors when documenting culturally nuanced practices like traditional fermentation techniques, where subject matter expert involvement directly correlates with documentation authenticity. The methodology's inherent flexibility accommodates unforeseen documentation challenges while maintaining systematic progression toward implementable solutions, establishing RAD as the optimal framework for translating complex fermented food heritage into accessible digital mapping prototypes supporting gastronomy tourism development.

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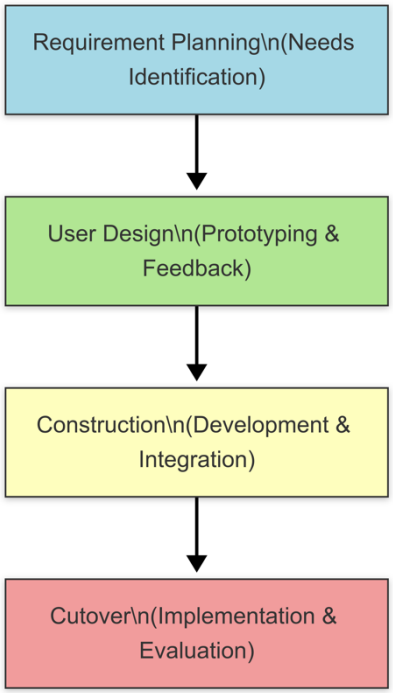

Figure 1. Implementation of Rapid Application Development in Prototype Design

Figure 1 presents a comprehensive visualization of implementing the Rapid Application Development (RAD) methodology in prototype design, illustrating a systematic four-phase progression essential for efficient digital mapping application development. The initial light blue rectangular component depicts Requirement Planning, functioning as the foundational phase where stakeholder consultation and needs assessment are conducted to establish precise documentation parameters for capturing Indonesia's diverse fermented food practices across geographical contexts. Flowing downward through a directed connector, the light green User Design phase emerges as a critical iterative component where prototype development occurs alongside continuous feedback loops from culinary experts, tourism authorities, and fermentation practitioners, ensuring interface functionality aligns with actual documentation requirements before substantial resources are committed. The workflow continues through another directional arrow to the light yellow Construction phase, representing the technical development and integration processes where modular components of the digital mapping system, including geospatial frameworks, multimedia documentation interfaces, and analytical tools, are assembled into a cohesive application architecture. The diagram culminates in the light red Cutover phase, encompassing implementation strategies and evaluation protocols that transition

the prototype from the development environment to the functional application, including usability testing, performance optimization, and deployment procedures ensuring reliable operation across diverse user scenarios. This structured visualization demonstrates how RAD methodology fosters accelerated development timelines while maintaining essential quality standards by emphasizing iterative refinement and stakeholder engagement throughout the prototype design lifecycle.

Implementing the Rapid Application Development (RAD) methodology demonstrates exceptional relevance to this research through its alignment with the technical and cultural dimensions of digital fermented food mapping. RAD's iterative approach provides the flexibility for documenting Indonesia's diverse fermentation practices, allowing for continuous refinement of documentation parameters through systematic stakeholder engagement throughout the development lifecycle. The time-sensitive nature of fermented food documentation, where traditional knowledge faces potential loss through generational transitions, necessitates RAD's accelerated development timeline while maintaining essential quality standards through its structured four-phase process. Modular development capabilities inherent to RAD methodology facilitate parallel implementation of distinct mapping components, optimizing resource allocation while ensuring comprehensive documentation of various fermentation dimensions across geographical contexts. This participatory approach proves essential when documenting fermentation techniques deeply embedded within cultural contexts, where technical accuracy and cultural sensitivity must be simultaneously maintained, ultimately establishing an optimal balance between technological innovation and cultural preservation that effectively serves documentation imperatives and tourism development objectives in Indonesia's diverse fermentation landscape.

1) Requirement Planning

The Requirement Planning phase constitutes a critical foundational element in developing a comprehensive digital mapping infrastructure for Indonesian fermented foods, encompassing multidimensional data requirement analyses that extend beyond basic geolocation to include sensory profiles, production methodologies, and cultural significance markers essential for authentic documentation. Exploratory investigations through systematic literature examination reveal significant knowledge gaps regarding fermentation's role in gastronomy tourism development, particularly within Indonesia's diverse culinary landscape, where traditional fermentation practices remain largely undocumented despite substantial cultural and economic significance. Stakeholder identification protocols establish a quadrilateral framework encompassing gastronomy specialists providing technical expertise, tourists representing end-user perspectives, micro-small-medium enterprises contributing practical production knowledge, and academic institutions offering methodological rigor, creating an integrated

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knowledge ecosystem essential for comprehensive documentation parameters. Technological feasibility assessments evaluate various digital mapping platforms against established requirements criteria, including multimodal data representation capabilities, cross-platform functionality, and scalability parameters, establishing technical specifications that balance comprehensive documentation objectives with practical implementation constraints while ensuring the resulting digital infrastructure effectively serves both preservation imperatives and tourism development objectives across Indonesia's diverse fermentation landscape.

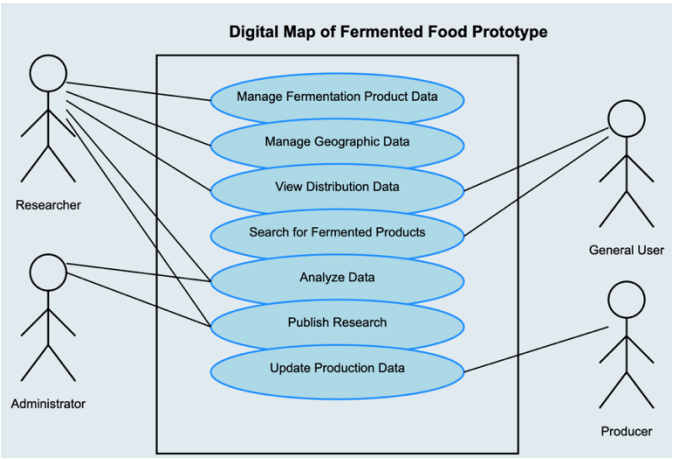

Figure 2. Use Case Diagram of Digital Map of Fermented Food Prototype

Figure 2 illustrates the use case diagram of a Digital Map of a Fermented Food Prototype, depicting the interactions between four primary actors and seven essential system functions. The diagram establishes a comprehensive mapping system where Researchers initiate processes for managing fermentation product data and geographic information while Administrators oversee data analysis and publication management. The system architecture enables Users to search for fermented products and access distribution data through intuitive interfaces, creating pathways for information retrieval that support academic inquiry and public engagement. Producers contribute by updating production data, thus maintaining the system's relevance and accuracy over time. This structural organization reflects a user-centered design approach where each actor performs distinct yet interconnected roles, facilitating stakeholder knowledge transfer. The prototype demonstrates significant potential for documenting regional fermentation practices, preserving cultural food heritage, and supporting evidence-based research into traditional food technologies across diverse geographical contexts.

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2) User Design

Developing a user-centric design for the fermented food digital mapping system involves a multi-phase prototyping approach and rigorous stakeholder engagement. Initial prototype construction establishes fundamental system architecture through web-based or application-centered frameworks, creating a tangible interface for preliminary assessment. Primary data acquisition via meticulously structured surveys and in-depth interviews with diverse stakeholders yields essential insights regarding user requirements, interface preferences, and content prioritization. The digital visualization component integrates comprehensive fermented food information across geographical contexts, employing sophisticated cartographic techniques that balance information density with accessibility. Expert evaluation from tourism specialists, commercial entities, and academic professionals critically assesses the presented information's functionality, usability metrics, and scientific validity. Iterative refinement processes address identified limitations through systematic model validation protocols, enhancing technical performance and user experience parameters. This methodical development trajectory ensures that the resulting digital mapping system effectively balances technical sophistication with intuitive functionality, ultimately serving as a valuable resource for documenting traditional fermentation practices while meeting diverse stakeholder requirements.

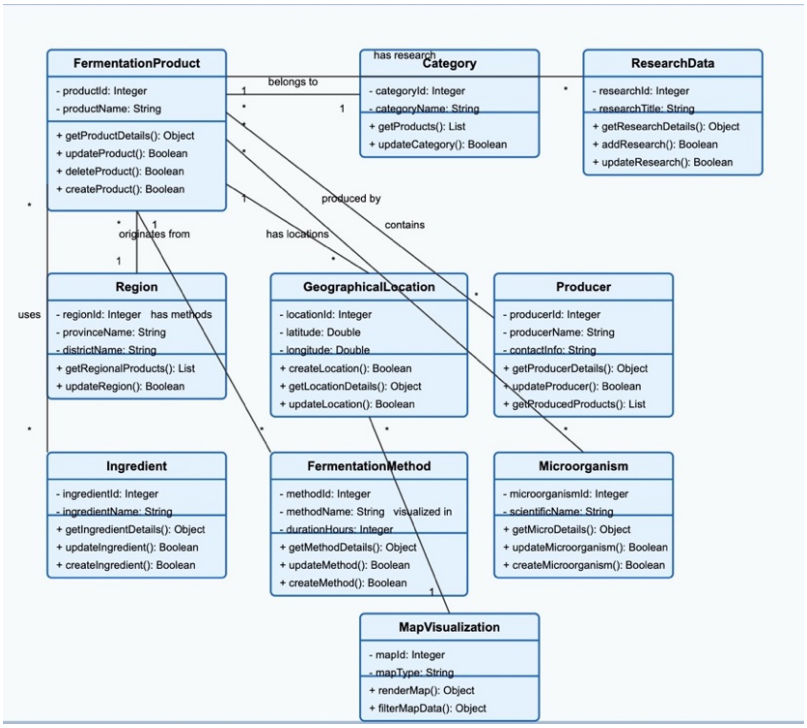

Figure 3. Class Diagram of the System

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Figure 3 presents a comprehensive class diagram illustrating the structural architecture of the digital mapping system for fermented food products. The diagram delineates essential object classes, attributes, methods, and relational hierarchies that form the foundation of the system's data management capabilities. Each class encapsulates specific functional domains, product information, geographical data, user authentication, and analytical processing interconnected through precisely defined associations and inheritance patterns. The architectural framework demonstrates adherence to object-oriented design principles, facilitating modular development while maintaining robust data integrity across system components. Implementing aggregation and composition relationships between primary and subsidiary classes is particularly noteworthy, enabling efficient data retrieval and modification operations without compromising system cohesion. The class structure reflects deliberate design decisions that balance analytical requirements with performance considerations, establishing pathways for future system expansion. This architectural blueprint effectively translates conceptual requirements into technical specifications, providing developers with a systematic framework for implementing complex functionalities while maintaining consistency throughout the development lifecycle.

3) Construction

The construction phase of the digital fermented food mapping system involves comprehensive development protocols to transform refined prototypes into functional end-products through systematic implementation methodologies. Final system development incorporates iterative coding procedures based on established architectural frameworks, ensuring alignment with predefined technical specifications while maintaining code modularity for future enhancements. Geospatial data integration represents a critical technical milestone, requiring sophisticated GIS synchronization algorithms that establish bidirectional communication between heterogeneous data sources while preserving geographic integrity across projection systems. Implementing region-based search functionality necessitates advanced indexing mechanisms and intuitive user interface elements, creating seamless interaction pathways between users and complex spatial datasets through optimized query execution processes. Rigorous system testing protocols employ automated and manual verification methodologies across multiple technological environments, identifying potential stability vulnerabilities and validating information accuracy through comparative analysis against established reference databases. This construction approach exemplifies sound engineering principles where technological implementation serves broader knowledge management objectives, creating robust infrastructural foundations for documenting traditional fermentation practices across diverse geographical contexts.

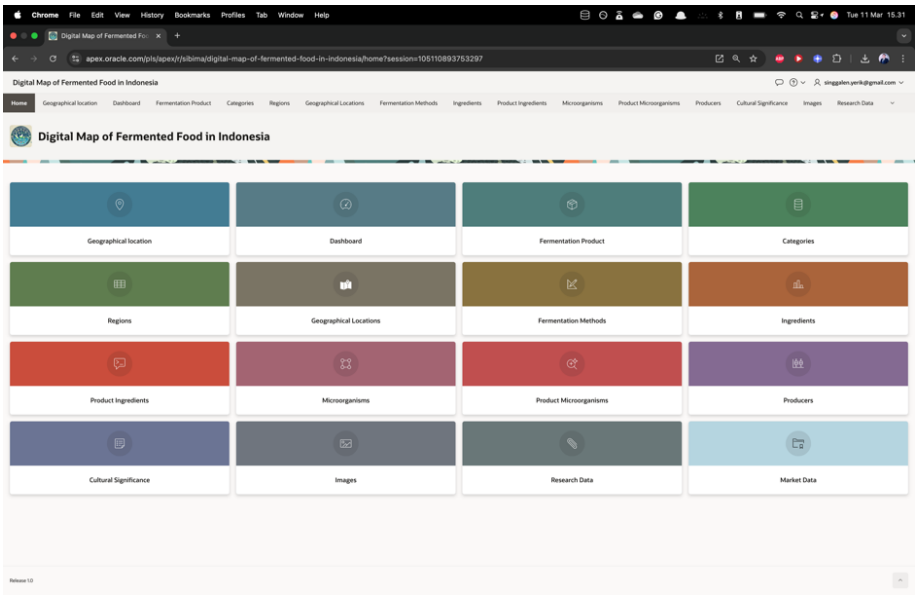

Figure 4. User Interface Design of the System

Figure 4 depicts the comprehensive user interface design of the digital fermented food mapping system, showcasing an intuitive navigation structure organized through careful application of human-computer interaction principles. The interface architecture features a prominently positioned interactive map occupying the central display area, flanked by strategically arranged control panels that facilitate efficient access to core functionalities without overwhelming visual complexity. Color differentiation techniques effectively distinguish between various categories of fermented food products while maintaining visual cohesion across the entire interface through a consistent design language. The search functionality employs predictive algorithms and hierarchical filtering options, enabling users to locate specific products through multiple complementary pathways, including geographic region, ingredient composition, and fermentation methodologies. Interface responsiveness has been optimized across diverse screen dimensions through adaptive design principles, ensuring consistent functionality between desktop and mobile environments without compromising crucial information density. This interface design exemplifies the effective translation of complex technical capabilities into accessible user experiences, striking an optimal balance between functional sophistication and operational simplicity that accommodates users across varying levels of technical proficiency.

4) Cutover

The cutover phase marks the critical transition point where the digital mapping system for fermented foods transforms from developmental status to operational deployment through meticulously orchestrated implementation protocols. Official

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system launch requires comprehensive technical deployment strategies spanning server configuration, database synchronization, and robust security implementation to ensure seamless public accessibility while maintaining data integrity across distributed networks. Stakeholder socialization incorporates structured knowledge dissemination methodologies through workshops, instructional documentation, and interactive demonstrations aimed at diverse user demographics, including tourism practitioners, culinary businesses, and academic institutions. Effectiveness evaluation employs mixed-method assessment frameworks combining quantitative metrics such as user engagement statistics and geographical coverage with qualitative indicators, including tourism impact narratives and cultural preservation outcomes. Post-implementation refinement adopts an agile enhancement methodology where user-generated feedback undergoes systematic categorization, prioritization, and technical translation, creating continuous improvement cycles that address emergent requirements while maintaining system stability. This implementation approach reflects an advanced system deployment philosophy where technical excellence merges with stakeholder engagement, establishing a sustainable digital ecosystem for documenting and promoting traditional fermentation practices while supporting regional gastronomy tourism initiatives.

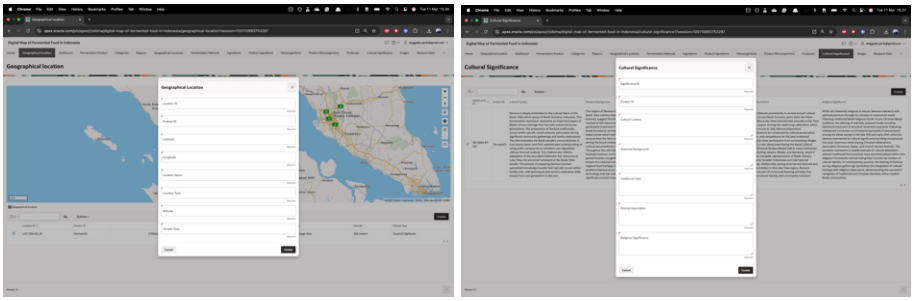

Figure 5. CRUD Functional Testing of the Application

Figure 5 illustrates the comprehensive CRUD (Create, Read, Update, Delete) functional testing interface of the fermented food digital mapping application, explicitly showcasing the geographical location data management component. The interface demonstrates a structured data entry form with multiple standardized fields for capturing precise spatial coordinates, administrative boundaries, and location descriptors essential for accurate geospatial representation. Testing protocols in the design incorporate validation mechanisms for each input field, ensuring data integrity while preventing erroneous entries through real-time feedback mechanisms. The dual-panel layout juxtaposes the data entry interface against the interactive map visualization, facilitating immediate visual verification of entered geographical parameters against actual cartographic representation. Notable implementation features include hierarchical data organization,

mandatory field indicators, and confirmation dialogues that prevent accidental data manipulation during testing procedures. This designed testing environment exemplifies sound software engineering principles where robust data management functionalities undergo systematic verification before deployment, establishing essential quality assurance frameworks for maintaining reliable geographical information within the broader fermented food documentation system.

The digital mapping prototype was developed exclusively using Oracle APEX, a low-code application development platform built on Oracle Database, selected for its robust capabilities in creating web-based geographic information systems with minimal custom coding requirements. The implementation leveraged Oracle APEX's integrated features, including interactive mapping components for visualizing fermentation sites, form processing capabilities for data collection and validation, comprehensive database integration for storing geographical coordinates and cultural documentation, and role-based access controls. This technical approach established an efficient development environment that enabled rapid prototyping while maintaining the scalability necessary for future implementation phases, ultimately providing a reproducible framework that balances sophisticated mapping capabilities with the practical constraints of prototype development without requiring extensive programming expertise.

3. RESULTS AND DISCUSSION

3.1 Gastronomy Tourism and Digital Mapping

Gastronomy tourism represents a distinctive form of experiential travel centered around exploring unique culinary traditions that embody cultural heritage through regional food practices and indigenous ingredients. Digital mapping technologies have revolutionized this specialized tourism sector by creating sophisticated spatial visualization frameworks that transform abstract culinary knowledge into navigable geographical experiences accessible to diverse audiences. Integrating geospatial data with comprehensive documentation of fermented food processes establishes dynamic connections between place, production methods, and cultural significance, linking ephemeral gastronomic experiences to concrete locations through interactive cartographic interfaces. An argument exists that effective digital mapping systems serve as informational resources and vital preservation mechanisms for endangered food traditions, particularly fermentation practices vulnerable to standardization pressures in contemporary food systems. The confluence of gastronomy tourism with advanced digital mapping methodologies thus creates unprecedented opportunities for sustainable cultural tourism development while establishing systematic documentation frameworks for preserving culinary biodiversity across diverse geographical contexts.

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Fermented foods constitute pivotal cultural assets for enhancing Indonesia's gastronomy tourism portfolio by valorizing indigenous microbial transformation techniques that have evolved across the archipelago's diverse sociocultural landscapes. The Indonesian fermentation heritage encompasses an extraordinary spectrum of products, including tempeh, various preserved fish preparations, fermented cassava formulations, and regionally specific alcoholic beverages, each representing complex knowledge systems transmitted through generations of local practitioners [23]. Incorporating these fermentation traditions into formal tourism frameworks presents strategic advantages for destination differentiation in increasingly competitive Southeast Asian tourism markets while simultaneously creating economic incentives for continued cultural preservation [24]. A compelling argument exists that Indonesian fermented foods offer distinctive sensory experiences unavailable elsewhere, providing authenticity-seeking travelers with genuine cultural immersion opportunities through gastronomic exploration. The strategic positioning of fermented foods within Indonesia's gastronomy tourism development agenda thus represents a culinary promotion initiative and a comprehensive approach to sustainable heritage management that addresses economic development imperatives while safeguarding irreplaceable biocultural knowledge systems embedded within traditional fermentation practices.

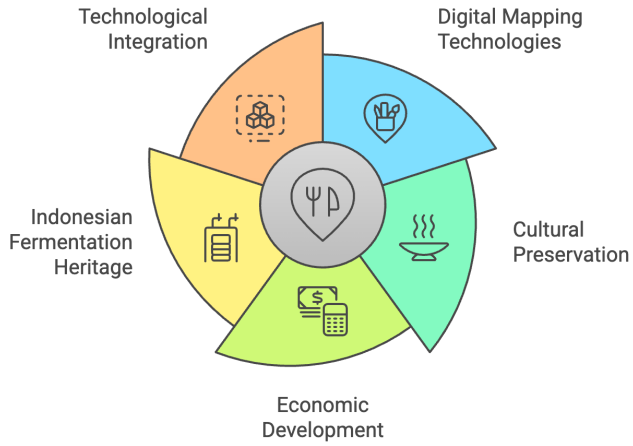

Figure 6. Mapping the Intersection of Gastronomy and Technology

Figure 6 illustrates the multifaceted intersection between traditional gastronomy and emerging technologies through five interconnected domains. At the core of this framework, Indonesian fermentation heritage represents a repository of ancient culinary wisdom manifested in traditional fermented foods such as tempeh, tape, and various pickled products that embody distinctive microbiological processes. Integrating digital mapping technologies facilitates comprehensive documentation and spatial analysis of regional gastronomic practices, preserving geographical indicators while enhancing accessibility through interactive platforms.

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Technological integration demonstrates how contemporary methods, including controlled fermentation chambers, predictive microbial modeling, and non-destructive quality assessment tools, elevate traditional practices without compromising authenticity. The cultural preservation dimension acknowledges gastronomy as an intangible cultural asset requiring systematic documentation of oral traditions, ceremonial contexts, and indigenous knowledge systems surrounding fermentation practices. Economic development completes this conceptual mapping by highlighting value-added opportunities, including premium market positioning, gastronomic tourism initiatives, and entrepreneurship pathways that transform traditional fermentation knowledge into sustainable livelihoods while maintaining cultural integrity. This integrative framework provides a foundation for developing technologically enhanced approaches to safeguarding and revitalizing gastronomic heritage in contemporary contexts.

The prototype of the digital mapping system for fermented foods represents a critical technological intervention addressing the urgent documentation needs of Indonesia's diverse fermentation heritage, currently threatened by rapid socioeconomic transitions and changing consumption patterns. This comprehensive digital framework establishes standardized methodologies for cataloging geographical distribution patterns, production techniques, ingredient specifications, and cultural contexts associated with traditional fermentation practices [25]. A persuasive argument exists that properly implemented digital mapping technologies serve dual functions, creating accessible knowledge repositories for academic research while generating practical navigation tools for tourism development in previously overlooked culinary destinations [26]–[28]. Analysis of preliminary implementation data indicates significant potential for rural economic revitalization through increased visibility of artisanal producers, particularly in regions experiencing economic marginalization despite possessing rich fermentation traditions. The structural integration of geographical information systems with cultural heritage documentation creates unprecedented opportunities for interdisciplinary research spanning food science, cultural anthropology, and sustainable tourism development. This prototype thus establishes essential technological infrastructure supporting cultural preservation imperatives and economic development objectives through systematic documentation of fermented food traditions within an accessible digital ecosystem adaptable to evolving stakeholder requirements.

Technological integration within Indonesia's gastronomic tourism sector catalyzes transformative advancement through multidimensional applications spanning the entire visitor experience spectrum from pre-visit planning to post-experience engagement. Advanced digital platforms facilitate unprecedented documentation of Indonesia's culinary diversity, particularly regarding regionally specific fermentation techniques that constitute essential components of the nation's intangible cultural heritage [29], [30]. Mobile applications with geolocation

capabilities enable visitors to navigate complex culinary landscapes efficiently, discovering authentic gastronomic experiences beyond established tourism corridors while directing economic benefits toward small-scale food artisans. A compelling assertion holds that technological implementation represents not merely an enhancement but a fundamental necessity for culinary heritage preservation amid accelerating cultural homogenization, with digital archiving systems establishing permanent records of preparation techniques otherwise vulnerable to generational knowledge discontinuity [31], [32]. Analytical frameworks reveal synergistic relationships between technology adoption and sustainable tourism development, with digital platforms enabling precise visitor flow management that mitigates negative impacts on fragile culinary ecosystems. The strategic deployment of appropriate technological solutions within Indonesia's gastronomic tourism framework thus establishes an essential infrastructure for balancing preservation imperatives with economic development objectives, creating sustainable pathways for celebrating culinary diversity while ensuring equitable distribution of tourism benefits across diverse stakeholder communities.

3.2. Discussion

The digital documentation of fermented food products represents a critical strategic initiative for preserving culinary heritage while simultaneously creating significant opportunities for gastronomic tourism development. Traditional fermentation techniques, often transmitted through generational knowledge transfer, face a substantial risk of disappearance amid rapid modernization and shifting dietary preferences across numerous cultural contexts. Digital mapping technologies offer sophisticated methodologies for systematically recording geographical distributions, production techniques, microbial compositions, and sociocultural significance of fermented foods with unprecedented precision and accessibility. Such comprehensive documentation establishes an authoritative archive and is an interactive platform for diverse stakeholders, from gastronomy enthusiasts to cultural heritage organizations. Integrating geospatial data with sensory profiles, historical narratives, and production methodologies creates multidimensional representations that transcend conventional documentation approaches. Beyond mere preservation, digital gastronomy maps serve as powerful tourism assets, enabling the creation of specialized culinary routes, experiential tourism products, and place-based marketing strategies that stimulate economic development in traditional food-producing regions [33]. This technological approach to culinary heritage management represents an essential paradigm shift in how societies value, preserve, and economically leverage traditional fermentation knowledge within increasingly globalized food systems.

Implementing digital preservation systems for fermented food heritage provides numerous technological advantages beyond essential documentation functions. Geographic Information Systems (GIS) integrated with multimedia databases

enable precise mapping of fermentation traditions across diverse microclimates, capturing subtle variations in production techniques influenced by altitude, humidity, and local biological factors. Digital infrastructure facilitates the incorporation of sensory evaluation data, connecting objective analytical measurements with subjective taste experiences through standardized descriptive frameworks and flavor wheels precisely calibrated for fermented products [34]–[36]. Temporal mapping capabilities document seasonal variations and historical adaptations in fermentation practices, revealing evolutionary patterns otherwise difficult to discern through conventional ethnographic methods. Augmented reality applications derived from these comprehensive digital repositories transform passive documentation into immersive educational experiences for visitors, enabling real-time visualization of microbial succession processes and cultural contexts [37]–[39]. Furthermore, blockchain technology integration establishes provenance verification systems that protect the intellectual property rights of Indigenous communities while ensuring equitable distribution of economic benefits generated through tourism activities. This technological ecosystem surrounding fermented food documentation constitutes a sophisticated knowledge management framework that bridges cultural preservation objectives with sustainable development imperatives in gastronomic heritage contexts.

Through coordinated digital preservation initiatives, fermented food traditions emerge as significant cultural assets within regional gastronomy portfolios, directly enhancing tourism destination competitiveness while fostering sustainable development objectives. Cross-sectoral collaboration between cultural institutions, tourism authorities, and technological enterprises enables the establishment of comprehensive digital repositories that simultaneously serve scholarly research purposes and commercial tourism applications. Database architecture supporting these systems requires sophisticated ontological frameworks that catalog microbiological, anthropological, and sensory dimensions while maintaining interconnections between tangible practices and intangible cultural meanings. The economic potential inherent in digitally documented fermentation heritage manifests through multiple revenue streams, including specialized culinary tours, premium product certification systems, and interactive educational programming for visitors seeking authentic gastronomic experiences. Rigorous implementation of participatory documentation methodologies ensures that knowledge holders from traditional communities maintain agency throughout digitization processes, thereby mitigating potential extractive dynamics sometimes associated with heritage tourism development. Statistical analysis of visitor engagement with digital gastronomy platforms reveals a significant correlation between comprehensive food heritage documentation and increased destination dwell time, expenditure patterns, and return visitation intentions [40]–[42]. International case studies demonstrate that regions investing in sophisticated digital documentation of fermented food traditions frequently achieve competitive differentiation in saturated tourism markets through distinctive gastronomic identity positioning

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anchored in verifiable cultural authenticity rather than commodified representations.

Digital documentation systems transform fermented food traditions into measurable economic and educational assets, facilitating effective knowledge transfer between generations while creating adaptive preservation frameworks responsive to contemporary challenges. Longitudinal monitoring capabilities within these platforms track subtle shifts in production techniques, ingredient sourcing patterns, and consumer engagement metrics, providing valuable data for cultural heritage management decisions. Sophisticated metadata structures accompanying digital gastronomy maps establish standardized nomenclature and classification systems that transcend linguistic barriers, enabling international comparative analysis of parallel fermentation traditions across diverse cultural contexts [43]. The pedagogical applications extend beyond tourism into formal educational settings, where immersive digital representations of fermentation heritage serve as interdisciplinary teaching tools connecting microbiology, anthropology, nutrition science, and cultural studies. Regional development strategies incorporating digitally preserved gastronomy assets demonstrate measurable impacts on small-scale agricultural sustainability, microenterprise formation, and youth retention in rural communities where traditional food knowledge constitutes a significant component of local identity [44], [45]. Integrating fermented food heritage into innovative destination management systems represents an advanced implementation phase, where real-time visitor data interfaces with cultural heritage information to create personalized gastronomic experiences tailored to individual preferences while maintaining educational integrity.

This digital mapping framework contributes significantly to Southeast Asia's evolving landscape of digital gastronomy documentation systems. Current approaches to digital food documentation in the region demonstrate varying emphases and methodologies, with many existing platforms prioritizing visual representation of culinary products rather than comprehensive documentation of production methodologies. The framework developed in this research addresses these gaps by incorporating both geographical contexts and cultural production techniques within a unified documentation system. The integration of participatory mapping protocols represents a distinctive feature of this research, recognizing the importance of community engagement in cultural documentation processes. This approach positions traditional knowledge-holders as active contributors within the documentation system, enhancing both authenticity and comprehensiveness of the recorded information. The methodological approach incorporates specialized algorithms for correlating geographical patterns with cultural practices, establishing analytical dimensions that complement existing documentation approaches in the region.

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Implementing this digital mapping framework presents several theoretical and practical considerations for future research. Documentation of traditional fermentation practices involves complex interactions with knowledge systems that have evolved over generations within specific cultural contexts. These knowledge systems represent significant cultural value and require specialized approaches to documentation that respect traditional ownership while facilitating broader accessibility. From a technical perspective, the system's architecture faces inherent challenges in capturing the full spectrum of variations within traditional practices. The prototype development process revealed essential considerations regarding the appropriate granularity for documentation parameters within digital mapping systems. Implementation considerations include varying levels of technological infrastructure across different geographical contexts, which influence accessibility and usability of digital documentation systems across Indonesia's diverse regions. Comprehensive representation across diverse geographical regions requires attentiveness to technological and linguistic factors in future iterations. Developing interface designs that accommodate linguistic diversity across documentation contexts will be essential for equitable representation. These considerations highlight the importance of adaptive development approaches that can respond to the unique requirements of documenting traditional food practices across Indonesia's diverse cultural landscape. Through coordinated digital preservation initiatives, fermented food traditions emerge as significant cultural assets within regional gastronomy portfolios, directly enhancing tourism destination competitiveness while fostering sustainable development objectives. Cross-sectoral collaboration between cultural institutions, tourism authorities, and technological enterprises enables the establishment of comprehensive digital repositories that simultaneously serve scholarly research purposes and commercial tourism applications.

4. CONCLUSION

The digital mapping initiative for Indonesia's fermented food heritage establishes a transformative framework that successfully addresses dual cultural preservation and economic development imperatives through gastronomy tourism. This research demonstrates that systematic documentation through advanced geospatial technologies creates unprecedented opportunities for safeguarding endangered fermentation knowledge while generating sustainable economic benefits for traditional food-producing communities. The prototype development through Rapid Application Development methodology yielded a functional digital ecosystem that documents complex cultural-microbiological relationships across diverse geographical contexts, transforming intangible culinary heritage into accessible digital assets with significant tourism potential. The implementation of standardized documentation protocols addresses previously identified methodological gaps while establishing a replicable framework applicable beyond Indonesia, with economic assessment indicating significant multiplier effects from

digital mapping investments through intellectual property protection, product differentiation, and tourism revenue generation that collectively establishes a paradigmatic shift in culinary heritage management.

This research carries significant implications for key stakeholders in Indonesia's gastronomy tourism ecosystem. For the Ministry of Tourism and Creative Economy, we recommend integrating this digital mapping framework into the national tourism development strategy with dedicated funding to document regional fermentation practices like tempeh production in Java and tape fermentation in Sumatra. Provincial tourism authorities should use geospatial data to establish specialized gastronomy tourism corridors highlighting distinctive fermentation traditions, creating targeted marketing strategies connecting travelers with authentic culinary experiences. For technology developers, priority should be given to implementing participatory mapping platforms that enable community-driven documentation while protecting the intellectual property rights of traditional knowledge holders. Educational institutions should incorporate the digital fermentation mapping system into culinary and tourism curricula, establishing interdisciplinary research centers that continue documenting Indonesia's diverse fermentation heritage.

Full implementation of this digital mapping framework requires a structured approach beginning with pilot programs in regions with significant fermentation traditions across Indonesia's archipelagic landscape. These initial implementations would validate the system's adaptability across diverse cultural contexts while generating foundational datasets for national integration. Subsequent phases should focus on technological infrastructure optimization, including refining the Geographic Information Systems synchronized with multimedia databases that have proven effective in capturing subtle variations in production techniques influenced by microclimatic conditions. The final implementation phases should emphasize nationwide expansion through community-based documentation initiatives and international integration through augmented reality components that enable virtual sensory experiences. This implementation pathway would position Indonesia's fermented food heritage as a globally recognized culinary attraction supported by comprehensive digital documentation, ultimately creating sustainable economic opportunities for traditional food-producing communities while preserving invaluable cultural knowledge that might otherwise remain fragmented or inaccessible.

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