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# From Consumer Insights to Product Launch: An AI-Driven New Product Development Framework for Food-Based SMEs in ASEAN

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**ABSTRACT**

Food-based small and medium-sized enterprises (SMEs) play a vital role in employment generation, local entrepreneurship, and inclusive economic growth across ASEAN. Despite their importance, many food-based SMEs continue to develop new products through intuition-driven decisions, competitor imitation, and limited consumer feedback, increasing the risk of product failure, weak product-market fit, inefficient formulation, food waste, and unsustainable business performance. This paper proposes a Food-Specific AI Stage-Gate Framework, a conceptual framework that integrates artificial intelligence (AI) into a simplified Stage-Gate new product development (NPD) process tailored to the context of ASEAN food-based SMEs. Using a literature-based conceptual approach, this study synthesizes recent academic research and credible institutional reports on AI adoption, food innovation, nutrition, food safety, innovation management, and SME digital transformation. The proposed framework consists of six interconnected stages: consumer insight discovery, AI-assisted idea generation, concept screening, prototype and formulation development, market validation, and product lifecycle learning. Across the innovation cycle, AI functions as a decision-support capability through social listening, review mining, generative ideation, concept scoring, cost simulation, nutrition estimation, demand forecasting, sentiment analysis, and lifecycle monitoring. The novelty of this study lies in the development of a Food-Specific AI Stage-Gate Framework that integrates AI-enabled decision support with five food-specific gate criteria: Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability, thereby extending conventional Stage-Gate approaches to better reflect the requirements of food product commercialization in ASEAN food-based SMEs. The framework aims to reduce product failure risks while improving product success rates, shortening time-to-market, reducing food waste, strengthening customer retention, enhancing innovation capability, and supporting sustainable business growth. This study contributes both theoretically and practically by offering a structured roadmap for AI-enabled food innovation in ASEAN.

**Keywords:** Artificial Intelligence, New Product Development, Food Innovation, Food-Based SMEs, ASEAN.

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## Introduction

Food-based SMEs occupy a strategic position in ASEAN because they are closely linked to household consumption, local entrepreneurship, employment creation, agricultural value chains, and community-based innovation. The ASEAN SME Policy Index reports that SMEs represent more than 99% of firms in the region and remain central to employment, inclusive growth, innovation, digitalisation, and the transition toward greener economies (ERIA, ACCMSME, & OECD, 2024).

The ASEAN context is distinctive because many SMEs operate with small teams, limited capital, uneven digital maturity, and informal business routines. For food-based SMEs, these constraints are more complex because product development involves taste, safety, nutrition, shelf life, ingredient availability, packaging suitability, cost control, and operational consistency. Table 1 summarises ASEAN food SME characteristics that justify the need for a contextual AI-driven NPD framework.

Artificial intelligence should not be positioned merely as a digital marketing tool for SMEs. For food-based SMEs, AI can be more valuable when embedded into the entire new product development process. This paper therefore proposes a Food-Specific AI Stage-Gate Framework that links consumer insight discovery, idea generation, concept screening, prototype and formulation development, market validation, and product lifecycle learning.

**Table 1.** ASEAN Food SME Characteristics

| Characteristic | NPD implication | AI relevance | Sources |
|---|---|---|---|
| SME dominance in ASEAN | Innovation affects inclusive growth | AI can democratise insight and decision support | ERIA, ACCMSME, & OECD (2024) |
| Uneven digital maturity | Digital tools may not support structured NPD | AI should begin with simple data routines | Gálvez Nogales & Casari (2023) |
| Food-system resilience pressure | Product decisions must consider supply and waste | Forecasting can reduce uncertainty | Montesclaros et al. (2023); Kozono et al. (2024) |
| Resource-constrained R&D | Ideas are often tested informally | AI can screen ideas before trials | Le Dinh et al. (2025); Sánchez et al. (2025) |
| Quality, safety, nutrition, and sensitivity | Food products require specific gate criteria | AI supports but cannot replace validation | Ding et al. (2023); Agrawal et al. (2025) |

Despite growing discussions regarding AI adoption, digital transformation, and innovation management in SMEs, limited research has proposed an integrated AI-enabled innovation framework specifically designed for food-based SMEs in ASEAN. Existing studies generally examine AI applications in isolated business functions, such as marketing analytics, consumer insights, quality management, or operational efficiency, rather than integrating AI across the complete food product development process (Ding et al., 2023; Trabelsi et al., 2023).

Furthermore, most existing AI-enabled innovation frameworks do not explicitly incorporate food-specific commercialization requirements, including quality assurance, food safety compliance, nutritional considerations, operational feasibility, and financial viability. These factors are critical determinants of product success in food industries, particularly for resource-constrained SMEs operating in ASEAN markets (Agrawal et al., 2025; Trott, 2021).

To address this gap, this study proposes a Food-Specific AI Stage-Gate Framework tailored for food-based SMEs in ASEAN. The framework integrates AI-supported decision-making across six stages of new product development while embedding five food-specific gate criteria: Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability.

The novelty of this study lies in the development of a Food-Specific AI Stage-Gate Framework that integrates AI-enabled decision support with five food-specific gate criteria: Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability, thereby extending conventional Stage-Gate approaches to better reflect the requirements of food product commercialization in ASEAN food-based SMEs. The framework aims to support evidence-based innovation decisions while reducing product failure risks and improving sustainable business growth outcomes. Accordingly, the objective of this study is to develop a conceptual framework that guides food-based SMEs in integrating AI into new product development while maintaining quality, food safety, nutrition, operational feasibility, and financial viability considerations.

## Literature Review

Agrifood SMEs in Asia and the Pacific are particularly affected by digital readiness gaps. Digitalization can increase efficiency and growth opportunities, but many businesses still face barriers related to connectivity, skills, finance, and wider enabling ecosystems (Gálvez Nogales & Casari, 2023). In ASEAN food systems, digital technology is also viewed as an enabler of supply chain resilience and food security, but adoption varies across countries, sectors, and firm sizes (Montesclaros et al., 2023).

New product development transforms market opportunities into commercially viable products. Innovation management literature emphasizes that NPD should connect creativity with evidence-based decision-making, commercial discipline, and cross-functional coordination (Trott, 2021). The Stage-Gate approach is relevant because it divides product innovation into stages of work and gates of decision, allowing firms to continue, revise, or stop projects based on evidence rather than intuition alone (Stage-Gate International, 2026).

AI has growing relevance in food innovation because it can process data from social media conversations, search trends, reviews, sales records, complaint logs, and production data. AI and big data support food quality, food safety, production, risk management, and consumer insight (Ding et al., 2023). Table 2 maps the literature support for each stage of the proposed framework.

**Table 2.** Literature Mapping Summary

| NPD stage | AI function | Food gate | Output | Literature |
|---|---|---|---|---|
| Consumer insight discovery | Social listening, review mining, trend analysis | Consumer relevance gate | Unmet need statement | Trabelsi et al. (2023); Min et al. (2023) |
| AI-assisted idea generation | Generative AI, menu ideation, flavour mapping | Feasibility gate | Idea pool | Kuhl (2025); Le Dinh et al. (2025) |
| Concept screening | Concept scoring, competitor mapping, benchmarking | Business case gate | Shortlisted concepts | Trott (2021); Stage-Gate International (2026) |
| Prototype and formulation | Cost simulation, nutrition estimation, ingredient alternatives | Quality, nutrition, food safety gate | Validated prototype | Ding et al. (2023); Agrawal et al. (2025); Amore & Philip (2023) |
| Market validation | Sentiment analysis, feedback clustering, sales dashboard | Launch readiness gate | Launch/revise/stop decision | Drydakis (2022); Le Dinh et al. (2025) |

| NPD stage | AI function | Food gate | Output | Literature |
|---|---|---|---|---|
| Product lifecycle learning | Repeat-order tracking, complaint classification | Lifecycle decision gate | Maintain, improve, extend, or discontinue | Quansah et al. (2022); Trabelsi et al. (2023) |

### ASEAN Context for Food-Based SMEs

ASEAN presents a unique environment for food-based SMEs due to several structural characteristics. First, SMEs account for more than 99% of business establishments across ASEAN economies. Second, digital maturity remains uneven across countries, resulting in varying levels of readiness for AI adoption. Third, food businesses frequently operate in fragmented markets characterized by diverse consumer preferences, cultural differences, and localized demand patterns. Fourth, food products must comply with different regulatory requirements, labeling standards, and halal certification systems across ASEAN markets. Finally, many SMEs continue to face limitations in capital, digital skills, and formal innovation processes, increasing the risk of resource misallocation during product development. These characteristics justify the need for an ASEAN-specific AI-enabled innovation framework. (ERIA et al., 2024; Gálvez Nogales & Casari, 2023).

#### *Research Gap and Framework Novelty*

Existing studies have examined AI adoption in SMEs, digital transformation, and food innovation. However, most studies focus on specific business functions rather than integrating AI throughout the food product development process. Furthermore, existing innovation frameworks rarely incorporate food-specific commercialization requirements: Quality, Food safety, Nutrition, Operational feasibility, and Financial viability.

To address this gap, this study proposes a Food-Specific AI Stage-Gate Framework tailored for food-based SMEs in ASEAN. The framework integrates AI-enabled decision support across six NPD stages while embedding five food-specific gate criteria. The proposed framework extends conventional AI-enabled innovation models by incorporating the multidimensional requirements of food product commercialization.

## Method

This study employs a literature-based conceptual approach to develop a framework for AI-enabled new product development in food-based SMEs. This approach is appropriate because the objective of the study is to develop and refine a conceptual framework rather than test statistical relationships or hypotheses. The study synthesizes recent academic literature and credible institutional reports related to artificial intelligence, food innovation, Stage-Gate theory, nutrition, food safety, SME digital transformation, ASEAN SME development, and sustainable business growth. The conceptual foundation of the framework was derived from peer-reviewed journal articles, industry reports, and policy publications published between 2021 and 2025.

The analysis followed a thematic synthesis approach. First, the literature was reviewed to identify the characteristics of food-based SMEs in ASEAN and the major challenges associated with new product development. Second, AI applications identified in the literature were mapped to a simplified Stage-Gate process to determine how AI could support decision-making across different development stages. Third, five food-specific evaluation criteria: Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability, were integrated as gate mechanisms to reflect the multidimensional requirements of food product commercialization. The resulting framework was then organized into six

interconnected stages: consumer insight discovery, AI-assisted idea generation, concept screening, prototype and formulation development, market validation, and product lifecycle learning.

To enhance the framework's practical relevance and credibility, a conceptual expert validation was conducted. The preliminary framework was reviewed from the perspectives of food product development, food safety management, and SME business operations. This validation assessed the framework's completeness, relevance, practicality, and applicability in food-based SME contexts, with particular attention to the proposed AI applications, six-stage innovation process, and five food-specific gate criteria. Feedback from the review was used to refine the framework and ensure that it reflects both theoretical insights and practical considerations in food innovation.

**Table 3.** Conceptual Expert Validation Summary

| Expert Category | Area of Expertise | Key Feedback |
|---|---|---|
| Product Development Professional | Product Innovation and NPD (New Product Development) | The six-stage structure reflects practical food product development activities. |
| Food Safety Professional | Food Safety and Quality Systems | Quality, Food Safety, and Nutrition gates are essential before commercialization decisions. |
| SME Business Owner | Food Business Operations | Operational Feasibility and Financial Viability gates improve applicability for resource-constrained SMEs. |

Overall, the expert review indicated that the proposed Food-Specific AI Stage-Gate Framework is relevant and applicable to food-based SMEs. The experts particularly emphasized the importance of integrating Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability as gate criteria because these factors frequently determine product commercialization success in food businesses. The feedback also confirmed the practical relevance of combining AI-enabled decision support with a structured Stage-Gate process for food innovation.

**Results**

The synthesis indicates that AI can support food-based SME innovation most effectively when it is connected to specific NPD decisions. General AI adoption does not automatically improve product performance. AI becomes strategically valuable when it helps SMEs identify better insights, select better concepts, validate prototypes, reduce launch uncertainty, and learn from post-launch performance.

As presented in Figure 1, the proposed Food-Specific AI Stage-Gate Framework consists of six stages: consumer insight discovery, AI-assisted idea generation, concept screening, prototype and formulation development, market validation, and product lifecycle learning. Each stage is supported by AI tools, while progression across stages is governed by food-specific gate criteria requiring human evaluation and managerial judgment. Figure 1 illustrates the overall architecture of the proposed Food-Specific AI Stage-Gate Framework and the relationships among AI-enabled innovation activities, food-specific gate criteria, and sustainable growth outcomes.

The framework begins with Consumer Insight Discovery, where AI tools such as social listening, review mining, and trend analysis are utilized to identify unmet consumer needs, emerging preferences, and market opportunities. The objective of this stage is to ensure that product development is initiated based on evidence-driven consumer insights rather than assumptions or intuition. AI-enabled consumer intelligence has become increasingly important in modern food systems because it allows businesses to capture consumer preferences, behavioural patterns, and emerging market trends more efficiently than traditional approaches (Min et al., 2023; Kuhl, 2025).

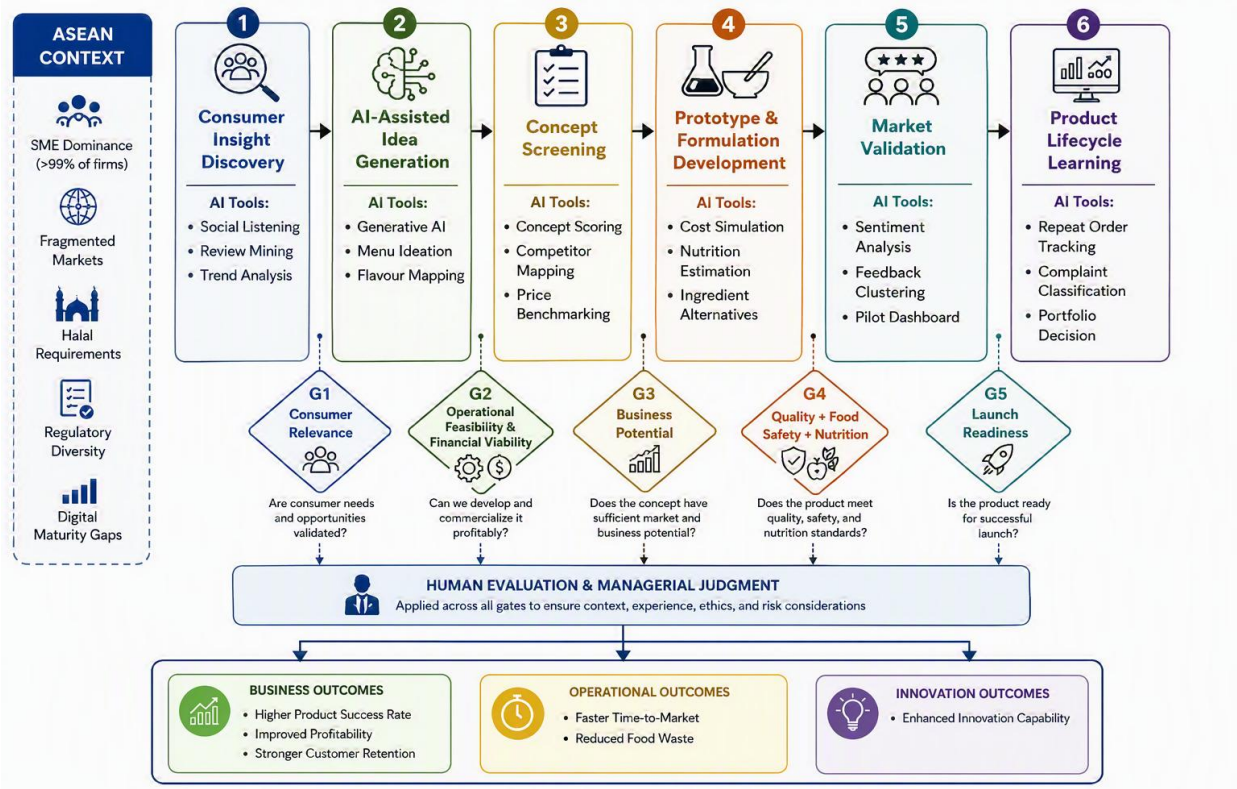



**Figure 1.** Food-Specific AI Stage-Gate Framework

The second stage, AI-Assisted Idea Generation, leverages generative AI, flavor mapping, and ideation tools to transform consumer insights into a portfolio of potential product concepts. AI enables SMEs to explore a wider range of innovation opportunities while reducing the time and cost associated with traditional brainstorming processes. Recent studies suggest that generative AI can accelerate innovation activities and support SME innovation capabilities by expanding idea exploration and improving creative problem-solving (Le Dinh et al., 2025; Kuhl, 2025).

The third stage, Concept Screening, focuses on evaluating and prioritizing ideas according to their market attractiveness, competitive positioning, and business potential. AI-supported concept scoring, benchmarking, and competitor analysis assist decision-makers in selecting concepts with the highest likelihood of commercial success. This stage aligns with contemporary innovation management literature emphasizing evidence-based decision-making and systematic evaluation before resource commitment (Trott, 2021; Sánchez et al., 2025).

The fourth stage, Prototype and Formulation Development, involves transforming selected concepts into tangible product prototypes. During this stage, AI can support ingredient optimization, cost simulation, nutrition estimation, and alternative formulation development. Recent advances demonstrate that AI can facilitate food formulation, nutrition analysis, quality control, and food manufacturing optimization, enabling more efficient product development processes (Agrawal et al., 2025; Ding et al., 2023).

The fifth stage, Market Validation, evaluates product readiness through pilot testing, customer feedback collection, sentiment analysis, and performance monitoring. The objective is to reduce launch uncertainty by gathering real-world evidence regarding consumer acceptance, purchase intention, and market response before large-scale commercialization. AI-powered sentiment analysis has become an effective tool for understanding customer perceptions, competitive positioning, and market acceptance in support of strategic business decisions (Taherdoost & Madanchian, 2023; Drydakis, 2022).

The final stage, Product Lifecycle Learning, emphasizes continuous improvement after product launch. AI tools can analyze repeat-purchase behavior, consumer complaints, sales performance, and

product reviews to generate actionable insights for product enhancement, portfolio management, and future innovation initiatives. Research suggests that AI-driven decision-support systems can improve organizational learning, risk mitigation, adaptability, and long-term innovation performance in SMEs and agri-food businesses (Trabelsi et al., 2023; Quansah et al., 2022).

Unlike traditional Stage-Gate models that primarily emphasize commercial and technical evaluations, the proposed Food-Specific AI Stage-Gate Framework incorporates five sequential gate assessments that support decision-making throughout the innovation process. These gates evaluate Consumer Relevance (G1), Operational Feasibility and Financial Viability (G2), Business Potential (G3), Quality, Food Safety, and Nutrition (G4), and Launch Readiness (G5). Together, these gate assessments ensure that projects progress based on both market evidence and food-specific commercialization requirements.

Across all stages and gates, AI functions as a decision-support capability rather than an autonomous decision-maker. Human evaluation and managerial judgment remain essential in interpreting insights, evaluating trade-offs, and making commercialization decisions. This design reflects the practical reality of food innovation, where technical, regulatory, operational, and strategic considerations frequently require expert assessment.

The sustainable growth outcomes of the framework can be grouped into three dimensions. Business outcomes include higher product success rates, stronger customer retention, and improved profitability. Operational outcomes include faster time-to-market and reduced food waste. Innovation outcomes include enhanced innovation capability and continuous organizational learning. These outcomes demonstrate how AI-driven new product development can support sustainable business growth beyond short-term sales performance by improving both innovation effectiveness and operational efficiency (Drydakis, 2022; Trabelsi et al., 2023).

**Conceptual Propositions**

Based on the literature synthesis and the proposed Food-Specific AI Stage-Gate Framework, a series of conceptual propositions is developed to guide future empirical testing. These propositions explain the expected relationships between AI-enabled innovation activities, food-specific gate criteria, and sustainable business growth outcomes among food-based SMEs.

P1: AI-enabled consumer insight discovery positively improves product-market fit by enabling food-based SMEs to identify unmet customer needs and emerging market trends.
P2: AI-assisted idea generation positively enhances innovation quality and concept diversity in food product development.
P3: AI-supported concept screening improves resource allocation efficiency by reducing the likelihood of pursuing low-potential product concepts.
P4: AI-enabled prototype and formulation development reduces product development costs and accelerates time-to-market.
P5: AI-supported market validation improves launch readiness and reduces product failure risk.
P6: AI-driven product lifecycle learning increases customer retention and supports continuous innovation capability.
P7: The integration of Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability gates strengthens the relationship between AI adoption and sustainable business growth.

**Discussion**

The primary contribution of this study lies in the development of a Food-Specific AI Stage-Gate Framework, which extends traditional Stage-Gate thinking by integrating AI-enabled decision support with food-specific commercialization requirements. Unlike conventional AI-enabled innovation models, the proposed framework embeds five critical gate criteria : Quality, Food Safety, Nutrition, Operational

Feasibility, and Financial Viability, across all stages of the new product development process. By incorporating these multidimensional assessment criteria, the framework addresses the unique challenges of food product commercialization that are often overlooked in generic innovation frameworks (Trott, 2021; Ding et al., 2023; Agrawal et al., 2025).

A distinctive feature of the proposed framework is its gate structure. While conventional Stage-Gate approaches typically focus on technical and commercial feasibility, the proposed framework introduces food-specific gate assessments that reflect the realities of food product commercialization. The inclusion of Consumer Relevance, Operational Feasibility, Financial Viability, Business Potential, Quality, Food Safety, Nutrition, and Launch Readiness enables a more comprehensive evaluation process throughout product development.

The proposed framework strengthens the linkage between Stage-Gate theory and artificial intelligence applications. In a traditional Stage-Gate process, each stage generates information to support go or no-go decisions. In contrast, the proposed framework enhances the quality, speed, and evidence base of these decisions by utilizing AI tools to support consumer insight discovery, idea generation, concept evaluation, prototype development, market validation, and post-launch learning. Consequently, AI functions not merely as an automation tool but as a strategic decision-support capability that improves the effectiveness of innovation management and innovation outcomes (Kuhl, 2025; Trabelsi et al., 2023).

The prototype and formulation stage represents a particularly important contribution of the framework because it reflects the distinctive characteristics of food innovation. AI can support ingredient optimization, cost simulation, nutrition estimation, formulation documentation, and sensory feedback analysis. However, commercialization decisions must still be guided by human expertise, particularly regarding food safety, quality assurance, sensory acceptance, shelf-life performance, regulatory compliance, and nutritional suitability. This perspective is consistent with recent studies suggesting that AI should complement rather than replace human expertise in food manufacturing, nutrition management, and quality assurance systems (Agrawal et al., 2025; Ding et al., 2023).

Product formulations often require multiple iterations before achieving the desired balance between consumer acceptance, nutritional targets, ingredient availability, cost requirements, and manufacturing feasibility. Even when consumer testing results are positive, commercialization success is not guaranteed because ingredient costs, supply stability, manufacturing capability, and regulatory requirements may change over time. Consequently, successful food innovation requires balancing consumer preferences with technical feasibility, operational readiness, and business sustainability.

In practice, many food-based SMEs do not have dedicated research and development teams or formal Stage-Gate procedures. Product concepts are often selected based on owner intuition, competitor imitation, or limited customer feedback. While such approaches may occasionally result in successful products, they also increase the risk of product reformulation, market mismatch, and inefficient resource allocation. Furthermore, a product concept that appears attractive from a market perspective may still fail commercialization because of food safety concerns, quality inconsistencies, operational constraints, or financial limitations. The proposed framework therefore seeks to provide a structured yet practical decision-making approach that integrates consumer insight, food safety, nutrition, operational feasibility, and financial viability within a single innovation process.

Product development projects rarely follow a fully linear process in real business environments. Consumer preferences can change rapidly, formulation challenges may emerge unexpectedly, and resource limitations often require development teams to revisit earlier decisions. For many SMEs, innovation therefore involves continuous adjustment rather than a strictly sequential process. The proposed framework is intended to provide structured guidance while maintaining sufficient flexibility for practical implementation.

Furthermore, the framework emphasizes that AI should function as a decision-support capability rather than a decision-making substitute. While AI can accelerate data processing, generate actionable insights, and improve forecasting accuracy, critical commercialization decisions must remain

under human oversight. This perspective is consistent with recent studies suggesting that AI delivers the greatest value when combined with managerial expertise, organizational judgment, and domain-specific knowledge rather than operating autonomously (Le Dinh et al., 2025; Sánchez et al., 2025).

This principle is particularly important in the food industry, where product success depends not only on market attractiveness but also on compliance with quality standards, food safety requirements, nutritional expectations, operational capabilities, and financial sustainability. Accordingly, the proposed framework incorporates five food-specific gate criteria such as Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability to ensure that innovation decisions are evaluated holistically before products advance to subsequent development stages. This gate structure extends conventional AI-enabled innovation models by integrating multidimensional commercialization requirements that are often overlooked in generic innovation frameworks (Ding et al., 2023; Agrawal et al., 2025).

The framework also addresses a persistent challenge faced by many food-based SMEs in ASEAN, where product development decisions are frequently influenced by intuition, competitor imitation, and limited consumer feedback because of resource constraints and varying levels of digital maturity. By embedding AI tools throughout the innovation process and linking them with structured gate assessments, SMEs can improve evidence-based decision-making, allocate resources more effectively, and reduce the likelihood of product failure (Gálvez Nogales & Casari, 2023; ERIA, ACCMSME, & OECD, 2024). Consequently, the proposed Food-Specific AI Stage-Gate Framework provides a practical roadmap for leveraging AI to strengthen innovation performance while maintaining product quality, food safety, nutritional value, operational readiness, and long-term business viability.

The ASEAN context further strengthens the relevance of the proposed framework because food-based SMEs in the region operate under conditions of fragmented markets, varying regulatory requirements, halal compliance considerations, and uneven levels of digital maturity. Furthermore, SMEs account for more than 99% of business establishments across ASEAN economies and often face limitations in resources, digital capabilities, and formal innovation processes. These contextual factors increase the complexity of innovation decisions and reinforce the need for structured AI-supported decision-making processes tailored to ASEAN food businesses (ERIA, ACCMSME, & OECD, 2024; Gálvez Nogales & Casari, 2023). The framework therefore embeds ASEAN contextual considerations directly into its architecture rather than treating them as external environmental factors.

Unlike large food manufacturers, many SMEs operate with limited technical resources and often lack access to consumer research, nutrition expertise, food safety specialists, and structured product validation systems. Consequently, product development decisions frequently involve substantial uncertainty, particularly during concept selection, formulation development, and commercialization planning. AI-enabled decision support may help reduce these uncertainties while preserving the role of human expertise in critical decision-making.

Despite its potential benefits, AI adoption may be constrained by data quality issues, implementation costs, employee readiness, and limited digital capabilities. These challenges are particularly relevant for SMEs that often lack dedicated digital transformation resources and structured data management systems. As a result, AI should be viewed as a complementary tool that supports managerial decision-making rather than a complete solution to innovation challenges.

The framework contributes to both innovation management and food innovation literature in three important ways. First, it shifts the discussion from general AI adoption toward AI-driven food innovation management. Second, it integrates AI applications into a structured Stage-Gate-oriented NPD process that spans the entire innovation journey, from consumer insight discovery to product lifecycle learning. Third, it introduces a Food-Specific AI Stage-Gate Framework that explicitly incorporates Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability as gate criteria, thereby extending existing innovation frameworks to reflect the realities of food-based SMEs better.

These contributions provide both a theoretical foundation for future empirical research and a practical roadmap for AI-enabled innovation among ASEAN food-based SMEs operating under resource constraints and varying levels of digital maturity. Moreover, the proposed framework offers a basis for future quantitative testing and cross-country validation within ASEAN, enabling researchers to examine the relationship between AI adoption, food-specific gate implementation, and sustainable business growth outcomes (Trabelsi et al., 2023; Le Dinh et al., 2025; Sánchez et al., 2025).

## Conclusion

This paper develops the Food-Specific AI Stage-Gate Framework as a conceptual framework to reduce the risk of product failure among food-based SMEs in ASEAN. The framework positions AI as a decision-support capability across six NPD stages, from consumer insight discovery to product lifecycle learning, while incorporating five food-specific gate criteria: Quality, Food Safety, Nutrition, Operational Feasibility, and Financial Viability. These gate criteria reflect the unique characteristics of food product development, where commercialization decisions must consider not only consumer acceptance and market potential but also product quality, safety, nutritional suitability, operational readiness, and financial sustainability.

This study is conceptual in nature and relies primarily on literature synthesis and conceptual expert validation. Future studies should conduct empirical testing across ASEAN food-based SMEs to validate the proposed relationships and assess the practical impact of the framework. The study contributes to the literature by extending Stage-Gate theory through the integration of AI-enabled decision support and food-specific commercialization gate criteria tailored to the context of ASEAN food-based SMEs.

The paper argues that food-based SMEs should not use AI solely for promotional content creation or marketing automation. Instead, AI can support more strategic product development decisions by helping SMEs identify consumer needs, generate innovative product ideas, improve concept evaluation, optimize formulations, monitor quality feedback, forecast demand, and learn from post-launch performance. However, AI should remain a co-pilot rather than a replacement for human expertise in product development, nutrition, quality assurance, and food safety management.

In practice, many food-based SMEs continue to rely on owner intuition, informal customer feedback, and limited market information when making product development decisions. While such approaches may occasionally lead to successful products, they can also increase the risk of resource misallocation, product failure, and commercialization challenges, particularly in resource-constrained environments. Food product development requires balancing consumer expectations, quality and food safety requirements, operational feasibility, and commercial objectives, often with limited data and technical resources.

The proposed Food-Specific AI Stage-Gate Framework therefore offers a structured yet practical and evidence-based approach that supports better innovation decisions without requiring sophisticated R&D infrastructure. Overall, the framework provides both a theoretical foundation for future research and a practical roadmap for food-based SMEs seeking to leverage AI to improve innovation effectiveness, reduce product development risk, and achieve sustainable business growth in the ASEAN region.

## Recommendations

Food-based SMEs should strengthen fundamental data management practices, including sales records, customer feedback, complaint logs, recipe documentation, ingredient cost records, and repeat-order tracking. AI implementation should be introduced gradually according to organizational readiness. In the initial stage, AI can support consumer insight discovery, idea generation, and feedback classification. As data maturity improves, AI can be applied to concept scoring, cost simulation, demand forecasting, and product lifecycle decision-making.

Universities, incubators, industry associations, and policymakers should support food-based SMEs through AI literacy programs, food innovation training, and digital capability development rather than focusing solely on digital marketing initiatives. Such support can help SMEs adopt AI more effectively within product development processes while maintaining quality, food safety, nutritional, and commercial considerations.

Future empirical research should validate the proposed framework through case studies, surveys, or longitudinal studies involving healthy catering businesses, cloud kitchens, home-based culinary SMEs, and functional food startups across Indonesia and other ASEAN countries.

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