

DEVELOPING A SYSTEMS THEORY OF SCIENTIFIC AND TECHNOLOGICAL HOMOGENEITY IN GASTRONOMY: STRUCTURE, PROCESS, AND INNOVATION IN FUTURE FOOD ECOSYSTEMS

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ABSTRACT

This conceptual paper aims to design a systems theory of scientific and technological homogeneity in gastronomy by demonstrating how systems thinking can be applied to food science, gastronomic innovation, and technology management to create a unified whole that fosters innovation, sustainability, and future food ecosystem resilience. This study employs a conceptual research design that achieves its objectives by conducting a systematic review of the existing literature on gastronomy, systems theory, food science, managing innovation, digital transformation, and sustainability to establish theoretical foundations for scientific and technological homogeneity. The review identifies relevant systems theory concepts that can be leveraged to unify diverse fields of food science while actualising scientific theories related to future food ecosystem management. As a result, this paper proposes a systems theory that integrates key components, processes, and functions that promote scientific and technological homogeneity in gastronomy. This study actualises how knowledge, technology, gastronomic techniques, and ecosystems can be unified to achieve homogeneity in scientific and technological processes. The paper argues that scientific and technological homogeneity is actualised through a convergence of structural, process, and innovation-related aspects. This paper shows that technological and scientific homogeneity in gastronomy can be achieved by understanding and leveraging the key components that contribute to standardised scientific knowledge, technical expertise, institutional infrastructure, and collaborative networks in the field. The study actualises process homogeneity by describing processes such as knowledge unification, digital transformation, quality assurance, decision-making analytics, and continuous learning that facilitate standardised gastronomic procedures. This paper demonstrates that innovation homogeneity is realised through articulating the relevant processes that promote standardised, consistent, and continual development of culinary innovations that improve the quality, safety, and sustainability of food products, services, and ecosystems. This study concludes by arguing that systems theory is critical in sensitising various stakeholders on the

need for coherence in structures, processes, and systems to enhance future food ecosystem performance. This study makes a theoretical contribution to the existing body of knowledge by designing a systems theory of scientific and technological homogeneity in gastronomy that has not been emphasised in the previous research literature. The paper provides conceptual foundations for future process improvement, theoretical development, and policy studies in food science and technology, managing innovation, and sustainability.

1. Introduction

Gastronomy and Its Interdisciplinary Nature Essay

Gastronomy is undergoing a paradigm shift through the intersections of culinary practice and art, knowledge, restaurants, and cultural heritages, as well as through the growing importance of science, technology, entrepreneurship, tourism, and digitalisation. Thus, gastronomy becomes increasingly multi-professional and multi-competent, challenging the previous restaurant-centric understanding of this domain. GastronomyTech is one of the manifestations of these changes, as Galarraga and Martinez de Albeniz (2025) demonstrate in the Basque region, where the locus of innovation has shifted from the domain of haute cuisine restaurants to labs, research institutes, and innovation ecosystems, where chefs, scientists, researchers, entrepreneurs, and technologists interact in multifunctional innovation processes related to gastronomy, agri-food, tourism, health, biotechnology, and digitalisation.

At the same time, these processes raise questions about the transformation of the food paradigm and the multiple factors shaping present-day agri-food systems. In general, systems thinking is the most relevant approach to understanding food-related phenomena, as Zhang et al. (2018) suggest: complex interactions of food with ecological, economic, social, technological, and institutional processes must be understood within the framework of systems thinking. The current state and future development of gastronomy can also be considered as a system emerging from culinary practice and art, food production, processing, technology, consumption, tourism, and related phenomena.

Ecosystem thinking is one of the most relevant approaches to study such a system as a configuration of various actors and technologies. Granstrand and Holgersson (2020) define

innovation ecosystems as “relational configurations” that shape innovation processes in specific contexts through the interaction of “actors, activities, artefacts, and agentic relations.” Following these premises, one can speak of a similar approach to study the configuration of gastronomy, where various actors and technologies self-organize to create value through innovative processes. Granstrand and Holgersson (2020) draw attention to the fact that the modularization process inherent in ecosystems allows for “a greater variation in the ways in which different components and competences fit together.” This is a particularly interesting direction for the study of gastronomy, as the same culinary technologies can be combined in different ways to shape diverse products, services, and processes within the food service sector. Thus, the approach under consideration reveals the configuration-specific nature of the innovative development of gastronomy as a complex system.

In particular, the analysis of such a phenomenon as scientific and technological homogeneity is also of interest in this context. First, this study focuses on the concept and methodology for analysing the systemness of food and gastronomy ecosystems. Granstrand and Holgersson (2020) propose a definition of such a system as a “relational configuration” characterized by particular “dynamics and patterns of interaction among actors, activities, artefacts, and agentic relations.” Therefore, the main research question that arises at this stage is the theoretical framework that would allow us to understand the emerging nature of food and gastronomy ecosystems as systems with their own laws and regularities. Second, this study aims to reveal whether and how theoretical constructs for analysing food and gastronomy ecosystems as complex systems can be used to explain and predict “the ways in which different components and competences fit together” (Granstrand and Holgersson, 2020). At the same time, the concept of “fit together” denotes the possibility of achieving some degree of homogeneity in spite of the potential diversity of components and competences. Within the framework of the study of gastronomic systems, such concepts as scientific and technological homogeneity can be used as a basis for analysing the possibility of combining different competences. Third, this study is interested in the idea of scientific and technological homogeneity as a concept that could explain scientific and culinary practice as well as technological development in food service businesses. The word “homogeneity” is used in the sense of “fit together.” In this regard, the concept of

scientific and technological homogeneity implies the possibility of bringing together different scientific disciplines, managerial competences, culinary skills, and technologies within one product, service, or business.

The concept of homogeneity in the context of scientific and technological fit can be understood as a characteristic of the configuration of scientific and technological components that allows for the interaction of their diverse sets within a complex technological system. This idea can be further developed in the context of food and gastronomy, where different actors offer their competencies, products, and technologies to create value. The concept under consideration draws attention to the possibility of finding harmony in combination, which may be a feature of many food and gastronomy ecosystems as complex systems that bring together diverse components, structures and competencies.

The scientific basis of the current research is the analysis of molecular gastronomy as a manifestation of scientific and culinary homogeneity. The application of scientific principles to culinary practice opens up new opportunities for transforming dishes through flavour, smell, and consistency due to the interaction of scientific and culinary competencies. In turn, the emerging processes of technological development in food and gastronomy can be considered within the framework of the systems approach, drawing on the analysis of food entrepreneurial ecosystems as complex adaptive systems (Elam et al., 2026).

Elam et al. (2026) conducted a systematic literature review of entrepreneurial ecosystems in the food sector and revealed their complex adaptive nature. This study sheds light on the systemness of food entrepreneurial ecosystems, with a focus on the context of place, people, purpose, and processes. In particular, the authors analysed 31 studies on food entrepreneurial ecosystems published in Scopus and Web of Science, which served as the basis for the current study. Thus, this study provides a theoretical basis for examining food and gastronomy ecosystems within the framework of systems thinking.

Given the research basis described above, the present study focuses on developing a Systems Theory of Scientific Technological Homogeneity in Gastronomy. In particular, this study examines the structure-process-innovation nexus of food and gastronomical ecosystems, with the systems approach serving as the theoretical framework. The

current understanding of food ecosystems is built upon the study of diverse agri-food systems, where the interaction of various actors leads to innovation processes. In this regard, the systems approach is useful for studying the mechanisms of scientific and technological homogeneity in gastronomic ecosystems as a basis for shaping their structure and processes. This study makes three primary contributions. First, an interdisciplinary understanding of gastronomy as a complex system is provided. Second, particular attention is paid to the concept of scientific and technological homogeneity, which serves as a mechanism for combining different components of the system. Third, the current study focuses on systems thinking and related approaches, including ecosystems thinking and modularity, to reveal the mechanisms for achieving homogeneity in various gastronomy systems.

2. Literature Review

The literature on gastronomy has progressively moved from a narrow focus on gastronomic techniques towards broader questions of food systems, innovation, technology, sustainability, and ecosystem development. This evolution is important to understand how scientific and technological knowledge becomes embedded within gastronomic practices. The literature can be organized around four interconnected streams: systems thinking in food and gastronomy, food ecosystems, gastronomic innovation ecosystems, and scientific and technological synthesis.

2.1 Systems Thinking in Food and Gastronomy

Systems thinking provides a useful basis for understanding food-related phenomena because food activities involve multiple linked components and feedback relationships. Zhang et al. (2018) argue that eco-agri-food systems involve interactions among ecological, economic, social, and institutional components. Their framework showcases feedback loops, interdependencies, and non-linear connections, demonstrating why food-related issues cannot be adequately comprehended through isolated activities. This perspective is relevant to gastronomy because culinary activities are connected with food production, processing, distribution, consumption, tourism, culture, and environmental conditions. Gastronomy therefore functions within a wider system in which changes in one component can influence other components. For example, technological changes in food production can affect food preparation techniques,

while altering consumer tastes can influence ingredient procurement and product development. Research on culinary science provides further support for this systemic perspective. Risbo et al. (2013) document the development of culinary science in Denmark and show how molecular gastronomy contributed to closer connections between gastronomy, food science, research, and education. This development indicates that scientific knowledge is increasingly incorporated into gastronomic practice rather than remaining external to it. Molecular gastronomy represents an important stage within this transformation. This demonstrates how chemistry can be used to understand culinary transformations and distinguish scientific investigation from technological application. Such work provides an important basis to understand gastronomy as a knowledge-intensive system in which scientific principles can inform culinary experimentation. The systems perspective therefore suggests that gastronomy should be studied through the relationships among food, people, knowledge, technology, organisations, and institutions rather than by treating the restaurant as an isolated unit.

2.2 Food Ecosystems and Interconnected Value Creation

The food ecosystem perspective extends systems thinking by focusing on actors, relationships, institutions, activities, and exchanges. Granstrand and Holgersson (2020) define innovation ecosystems as evolving configurations of actors, activities, artefacts, institutions, and relationships, including both complementary and substitute relationships. This definition is particularly relevant to food because innovation entails multiple actors whose resources and capabilities are interdependent. Within a food ecosystem, farmers, food processors, chefs, restaurants, scientists, universities, technology firms, entrepreneurs, tourism organisations, consumers, and decision-makers may contribute different resources and forms of knowledge. Their interactions can generate value that cannot be ascribed to a single actor. Systems thinking similarly stresses the interrelated nature of food production and consumption. Zhang et al. (2018) argue that food systems contain multiple flows and signalling mechanisms across ecological and socioeconomic domains. This suggests that food innovation should be studied through relationships between actors and system components rather than through isolated technological interventions. The ecosystem perspective is particularly useful for gastronomy

because culinary value is increasingly produced through networks. Ingredients may originate from specialised producers, scientific knowledge may come from universities and laboratories, technologies may be supplied by specialised firms, and consumer experiences may be shaped through tourism and digital channels.

This literature establishes the importance of interdependence and ecosystem coordination; however, it provides less clarity on how different knowledge and technology components become compatible within the ecosystem. This gap is important for the present study.

2.3 Gastronomy as an Innovation Ecosystem

Gastronomic innovation has increasingly moved beyond the development of dishes within individual restaurants. Chesbrough et al., (2014), through the case of Chez Panisse, demonstrate how a restaurant can develop an open innovation ecosystem involving suppliers, chefs, staff, food writers, and other stakeholders. Their study stresses knowledge sharing, trust, and relationships as important elements of ecosystem development. Yun et al., (2020) provide further evidence by examining open innovation ecosystems in restaurants. They identify ingredient, recipe, and service innovation as interrelated forms of open innovation and show how external relationships can contribute to restaurant success. The results contest the assumption that restaurant innovation is generated entirely within organisational boundaries. Recent research provides stronger evidence of this change. Galarraga and Martinez de Albeniz (2025) examine the emergence of Gastronomy tech in the Basque Country and demonstrate how gastronomic innovation increasingly involves research centres, laboratories, innovation hubs, chefs, scientists, entrepreneurs, and technology-oriented organisations. Their results show that gastronomic innovation is becoming increasingly multidisciplinary and ecosystem-based. Digitalisation has accelerated this transformation. Hjalager (2022), examining 17 examples of digital food in tourism, identifies robotics, data-based restaurant services, capes, electronic platforms, augmented and virtual reality, and smart destinations as important areas of gastronomic innovation. These developments demonstrate that technology is increasingly embedded in culinary production, service, experience, and tourism.

Therefore, the literature establishes gastronomy as an emerging innovation ecosystem. However, the increasing diversity of actors and technologies

creates a coordination problem. Different actors possess different knowledge systems, technologies, objectives, and practices. The literature has established the relevance of collaboration but provides less theoretical explanation of how these heterogeneous elements achieve sufficient compatibility to function as an integrated system.

2.4 Scientific and Technological Incorporation in Gastronomy

Scientific integration has historically been associated with molecular gastronomy and culinary science. This demonstrates the relevance of chemistry to understand culinary transformations, while Risbo et al., (2013) show how molecular gastronomy contributed to the development of culinary science as an interdisciplinary field. Technological development has subsequently expanded the scope of gastronomic innovation. Contemporary gastronomy increasingly incorporates electronic platforms, robotics, data analytics, sensory technologies, biotechnology, and advanced food-processing techniques. Hjalager (2022) demonstrates how digital technologies are changing gastronomic tourism and food-related experiences. Modularity provides an additional theoretical perspective to understand this technical integration. Schilling (2000) develops a general theory of modular systems and explains how complex systems can be composed of specialised components connected through defined relationships. Applied to gastronomy, this viewpoint suggests that different technologies can retain specialised functions while becoming connected through compatible interfaces and processes. This distinction is important because technological incorporation does not require technological uniformity. A gastronomic ecosystem may contain multiple technologies and knowledge domains while still sustaining compatibility using shared standards, processes, and interfaces.

The reviewed literature demonstrates three important developments. First, systems research shows that food and gastronomy involve interrelated components and feedback relationships. Second, ecosystem research demonstrates that gastronomic innovation increasingly involves diverse actors operating across organisational boundaries. Third, culinary science and digital gastronomy research demonstrate the growing integration of scientific knowledge and technology into gastronomic practice. However, these streams remain relatively fragmented. The literature describes

interconnected actors, scientific knowledge, and technological innovation. However, it provides limited conceptualisation of the mechanism through which heterogeneous scientific and technological components achieve sufficient compatibility to operate as a coherent gastronomic ecosystem. This paper fills this gap by proposing scientific and technological homogeneity as a system-level construct. The concept refers to compatibility and alignment rather than uniformity. It recognises that culinary and technological diversity can remain while shared knowledge structures, standards, processes, and interfaces facilitate ecosystem coordination. The literature therefore provides the foundation for the proposed framework:

- Systems thinking → explains interdependence.
- Food ecosystems → explain actor relationships.
- Innovation ecosystems → explain collaborative value creation.
- Culinary science and technology → explain knowledge and technological incorporation.
- Modularity → explains compatibility among heterogeneous components.

Scientific and technological homogeneity → unites these perspectives into a proposed conceptual framework.

This gap provides the basis for the method and conceptual framework developed in the following sections.

3. Methodology

3.1 Research Design

This study adopts a conceptual research design to develop a Systems Theory of Scientific and Technological Homogeneity in Gastronomy. A conceptual approach is appropriate because the purpose of the study is not to test predetermined hypotheses using primary data, but to integrate recognized theoretical perspectives plus develop a new conceptual explanation of an emerging phenomenon. Jaakkola (2020) argues that conceptual studies should have an explicit research design and clearly explain how theories are selected, combined and used to generate theoretical contributions. She identifies theory synthesis, theory adaptation, typology, and model development as four approaches to conceptual

research. The present study primarily follows a theory synthesis and model development approach, bringing together systems theory, food ecosystem research, innovation ecosystem theory, culinary science, and modular systems theory to develop an integrated framework. The study also follows MacInnis's (2011) view that conceptual research may contribute by identifying relationships among existing concepts, proposing new conceptual distinctions, and developing new theoretical perspectives.

3.2 Literature Identification and Selection

The conceptual framework was developed through a structured review of literature covering:

- Systems theory and systems thinking
- Food and gastronomic ecosystems
- Gastronomic and food innovation
- Molecular and culinary science
- Digital gastronomy and food technology
- Innovation ecosystems and
- Modular systems and technological incorporation

The literature search prioritised Scopus and Web of Science-indexed journal literature, supplemented where theoretically necessary by established academic books and book chapters. Priority was given to peer-reviewed studies with direct relevance to gastronomy, food ecosystems, innovation, technology integration, and systems theory.

The review focused particularly on literature that could explain three theoretical dimensions:

- Structure: Actors, institutions, knowledge resources, networks, and technical infrastructure.
- Process: Knowledge exchange, coordination, experimentation, standardization, feedback, learning, and modification.
- Innovation: Culinary, technological, organisational, experiential, and sustainability-oriented innovation.

3.3 Theoretical Synthesis

Following Jaakkola (2020), the study synthesizes concepts from different theoretical traditions rather than treating them as independent streams of literature. Systems theory gives the overarching perspective for explaining interdependence and feedback. Ecosystem theory explains relationships among actors and complementary resources. Innovation ecosystem theory explains collective value creation and technological interdependence. Modularity theory gives a basis for understanding how specialized technological components can remain distinct while achieving interoperability via interfaces and system architecture. The synthesis is used to identify a theoretical gap. Existing studies explain how gastronomic ecosystems are structured and how innovation occurs. Still, they provide limited conceptual explanation of how heterogeneous scientific and technological components achieve sufficient compatibility for coordinated ecosystem functioning

3.4 Concept Development

The concept of scientific and technological homogeneity was developed through conceptual integration of the reviewed literature. The construct is defined as the degree to which scientific knowledge, technical capacities, standards, processes, and interfaces become sufficiently aligned to facilitate interaction, knowledge exchange, and innovation between heterogeneous gastronomic ecosystem actors. The conceptualization deliberately distinguishes homogeneity from uniformity. Homogeneity refers to alignment and compatibility at the level of knowledge, processes, standards, and interfaces. It does not imply that culinary traditions, technologies, organisations, or cultural practices become identical. This distinction enables the framework to support the coexistence of technological coordination and culinary diversity.

3.5 Framework Development

The final framework organizes the synthesized concepts within three interconnected dimensions:

Structural alignment → Process integration → Innovation integration

Structural alignment concerns the configuration of ecosystem actors, institutions, knowledge infrastructures, networks, and technologies. Process integration concerns the means by which these

components interact, including knowledge exchange, experimentation, coordination, learning, and feedback. Innovation integration concerns the conversion of these resources and processes into gastronomic innovations. The framework embraces a feedback mechanism through which innovation outcomes generate new knowledge and learning, leading to further adaptation of the ecosystem. This demonstrates the dynamic character of conceptual models and is consistent with Jaakkola's (2020) argument that conceptual frameworks ought to explain relationships among constructs rather than merely classify existing literature.

3.6 Theoretical Propositions

Rather than developing empirically verifiable hypotheses, the study obtains conceptual propositions from the theoretical synthesis. Propositions specify conceptually plausible relationships among structural alignment, process integration, scientific and technological homogeneity, innovation and ecosystem outcomes. The propositions are intended to provide a springboard for future empirical testing through quantitative, qualitative, or mixed-method research. This approach is consistent with the role of conceptual research in generating theoretical explanations and identifying relationships that can subsequently be examined empirically (MacInnis, 2011).

3.7 Methodological Strictness

Methodological strictness in this conceptual study is established through four principles:

- Theoretical relevance: sources were selected according to their relevance to the research problem
- Theoretical integration: concepts were synthesized across established research streams rather than presented as isolated findings
- Conceptual clarity: scientific and technological homogeneity is explicitly distinguished from technological uniformity
- Traceability: each major element of the proposed framework is grounded in recognized theoretical or empirical literature
- The framework was therefore developed through a transparent sequence of literature identification, theoretical synthesis, concept development, and proposition formulation.

4. Conceptual Framework

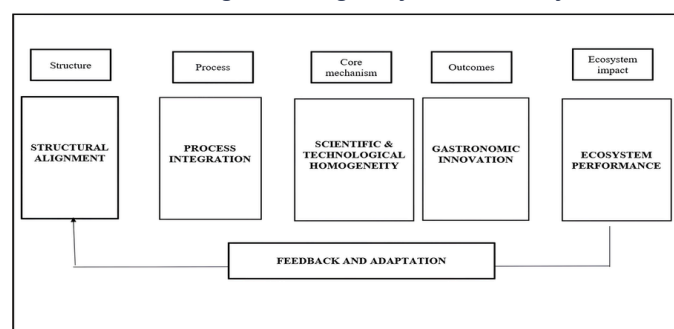
The preceding literature review demonstrates that interactions among culinary knowledge, scientific expertise, technological skills, entrepreneurial activity, institutions, and consumers increasingly characterize gastronomy. However, existing literature tends to examine these items through separate perspectives, including systems thinking, food ecosystems, innovation ecosystems, culinary science, and technological innovation. The present study merges these perspectives to propose a Systems Theory of Scientific and Technological Homogeneity in Gastronomy. The framework is based on the proposition that gastronomic ecosystems require sufficient scientific and technological alignment to coordinate heterogeneous actors and resources. This agreement does not imply uniformity. Rather, it refers to compatibility in knowledge, processes, standards, technological interfaces, and innovation practices.

The framework consists of three interconnected dimensions:

- Structural Alignment
- Process Integration
- Innovation Integration

These dimensions operate dynamically through feedback and modification.

Figure 1. Proposed Systems Theory of Scientific and Technological Homogeneity in Gastronomy



4.1 Structural Alignment

Structural alignment represents the configuration of actors, institutions, knowledge resources, technological infrastructures, and networks within the gastronomic ecosystem. Innovation ecosystems depend on interdependent actors and complementary resources instead of isolated organisational capabilities (Adner, 2017; Granstrand

& Holgersson, 2020). In gastronomy, these participants may include chefs, restaurants, food producers, scientists, universities, research centers, technology firms, entrepreneurs, tourism organisations, consumers, and government institutions. Galarraga and Martinez de Albeniz (2025) demonstrate how these actors increasingly interact through Gastronomytech ecosystems. Structural alignment therefore creates the conditions for scientific and technical integration. It does not require structural uniformity. Different actors can retain specialized capabilities while participating in a common ecosystem.

Proposition 1: Structural alignment among culinary, scientific, technological, institutional, and entrepreneurial actors facilitates scientific and technological incorporation within gastronomic ecosystems.

4.2 Process Integration

Structural alignment alone cannot produce ecosystem-level integration. Actors must interact by processes that enable knowledge exchange, experimentation, coordination, standardization, learning, and modification. Knowledge exchange is particularly important because gastronomic innovation increasingly occurs at the intersection of different disciplines. Scientific knowledge can inform culinary experimentation, while culinary experience can generate new scientific questions. Galarraga and Martinez de Albeniz (2025) demonstrate the importance of multidisciplinary interaction in Gastronomytech. Feedback is also important in uncertain innovation environments. Dattée *et al.*, (2018) show that firms operating within uncertain ecosystems continuously revise their strategies as a reaction to ecosystem developments. This logic can be extended to gastronomy, where emerging technologies and transforming purchaser expectations require continuous experimentation and modification.

Proposition 2: Process integration through knowledge exchange, coordination, experimentation, standardization, and learning strengthens scientific and technological homogeneity.

4.3 Scientific and Technological Homogeneity as the Core Construct

Scientific and technological homogeneity represents the central construct of the framework. It is conceptualised as the degree of compatibility

among scientific knowledge, technological capacities, standards, processes, and interfaces within a gastronomic ecosystem.

The construct contains four linked elements:

- Knowledge alignment: shared scientific concepts, terminology, methods, and evidence.
- Technological compatibility: capacity of different technologies to operate within the same ecosystem.
- Process alignment: compatibility of procedures, standards, and operational practices.
- Interoperability: capacity of technological and knowledge systems to exchange information and coordinate activities.

The concept builds on systems and modularity perspectives. Schilling (2000) demonstrates that complex systems can contain specialized components connected through system architecture and interfaces. This supports the argument that homogeneity can occur at the level of interfaces rather than components. Thus:

Proposition 3: Scientific and technological homogeneity happens when heterogeneous ecosystem components achieve sufficient compatibility in knowledge, technology, processes, and interfaces to support coordinated interaction.

4.4 Gastronomic Innovation

Innovation integration refers to the conversion of scientific knowledge, technological skills, and ecosystem resources into new gastronomic products, processes, experiences, services, and business models. Research demonstrates that gastronomic innovation increasingly goes beyond the restaurant. Chesbrough *et al.*, (2014) show how open innovation can involve external partners and stakeholders, while Yun *et al.*, (2020) demonstrate the relevance of open innovation ecosystems to restaurants. Galarraga and Martinez de Albeniz (2025) add further evidence to the emergence of multidisciplinary Gastronomytech ecosystems. Digital technologies provide additional chances for innovation. Hjalager (2022) identifies robotics, electronic platforms, data-based services, augmented and virtual reality, and smart destinations as emerging areas of gastronomic innovation.

Proposition 4: Scientific and technological homogeneity strengthens the capacity of gastronomic ecosystems to integrate and diffuse culinary, technological, organisational, and experiential innovations.

4.5 Feedback and Modification

The proposed framework is dynamic rather than linear. Innovation generates new knowledge, consumer responses, technological learning, and market information. These outputs feed back into the ecosystem and influence subsequent experimentation and modification. This is consistent with systems thinking, in which feedback relationships influence system behaviour over time (Zhang et al., 2018). It is also consistent with complex adaptive system perspectives applied to food entrepreneurial ecosystems (Elam et al., 2026).

The feedback mechanism can therefore be represented as:

Innovation → Feedback → Learning → Adaptation → Structural and Process Adjustment → New Innovation

Proposition 5: Feedback and ecosystem learning continuously reshape scientific and technological homogeneity by enabling gastronomic ecosystems to adjust to technological, market, environmental, and cultural changes.

4.6 Culinary and Cultural Diversity as a Boundary Condition

The framework does not presume that homogeneity is always desirable. Gastronomy benefits from diversity, particularly that of culture and cuisine. An overreliance on technology may lead to a diminishment of experimentation, uniqueness, and diversity. The framework thus views coordinated diversity as optimal. Uniformity in science and technology will provide compatibility and coordination, while diversity in cuisine and culture will provide experimentation and differentiation. Schilling's (2000) concept of modularity is related to this discussion, as it also involves the notion that different parts of a system can be specialized while still being connected via common methods. The same can be said for culinary and cultural traditions in food systems (Feldman & Wunderlich, 2023).

Proposition 6: The positive influence of scientific and technological homogeneity on gastronomic innovation is augmented by the presence of

culinary and cultural diversity.

4.7 Ecosystem Outcomes

The interdependence between structure, process, innovation, and scientific and technological homogeneity may produce certain ecosystem-level outcomes. Innovation capability: increased ability to develop and diffuse new gastronomic offerings-

- Resilience: enhanced response to emerging technologies, market forces, and ecological disruptions
- Sustainability: more extensive use of resource reduction, recycling, upcycling, sustainable sourcing, and other methods
- Competitiveness: improved capacity to design innovative value propositions
- Consumer value: expanded product-line breadth and personalization options

This proposition does not suggest that these outcomes are automatically generated by technology adoption but rather that their creation requires varying levels of technology incorporation into the ecosystem.

5. Discussion

The conceptualised framework views scientific and technological homogeneity as a coordination mechanism that emerges in gastronomic innovation ecosystems. The framework synthesizes systems thinking, food ecosystem theory, innovation ecosystem research, culinary science, and modularity to understand the processes through which individual technologies and actors contribute to collective innovations in gastronomy. The framework highlights a change in emphasis from a narrow technical individualistic focus in food innovation research to relations and their role in enabling food technologies' application in novel ways.

5.1 From Restaurant-Centred Gastronomy to Ecosystem-Based Gastronomy

The first implication of the conceptualisation is the shift from the restaurant-centric view of gastronomic development to an ecosystem-centred approach and the associated change in the role of restaurants. Previous literature highlights the role of the chef in driving and steering the processes of

food innovation occurring in the restaurant (Rungtusanansun et al., 2018). However, open innovation research highlights the value of networks and the role of restaurants in engaging and integrating external innovators (Chesbrough et al., 2014; Yun et al., 2020). The emergence of Gastronomytech highlights this tendency, and Galarraga and Martinez de Albeniz (2025) show how gastronomic innovation increasingly involves research centres, labs, and technology developers in driving changes.

Thus, gastronomy is turning into an innovation ecosystem in which know-how and competencies are distributed across different types of organisations. This conceptualisation builds on this stream of research to highlight that the increasing diversification and multiplication of actors in the innovation ecosystem lead to the need for new modes of coordination. Scientific and technological homogeneity addresses this need by providing a way through which different technologies can be combined and shared.

5.2 Homogeneity as Compatibility Rather Than Uniformity

Central theoretical insight of the framework is the distinction between homogeneity and uniformity. Homogeneity is conceptualised at the level of scientific knowledge, technological interfaces, standards, and processes. In contrast, uniformity implies that ecosystem actors embrace comparable technologies, practices, and culinary approaches. This distinction is important because gastronomy depends on diversity of the ingredients. Culinary traditions, local knowledge, ingredients, cultural practices, and experimentation contribute to innovation and differentiation. Therefore, technological incorporation should not eliminate variation.

The modularity perspective developed by Schilling (2000) helps to explain this relationship. Complex systems can contain specialised components while remaining integrated through the appropriate interfaces. Applied to gastronomy, different technologies and knowledge systems can remain specialised while achieving compatibility using shared standards and processes. Therefore, the theory introduces the idea of coordinated diversity, in which system-level compatibility may coexist with diversity at the component level.

5.3 Structure as the Foundation of Integration

The framework proposed in this study assumes that scientific and technological homogeneity starts with structural alignment. The ecosystem's participants need access to institutions, research resources, technological means, networks, and knowledge databases in general. This argument is in line with innovation ecosystem scholarship. Adner (2017) insists that structure defines the relationship between dependent and interacting agents in an ecosystem. Granstrand and Holgersson (2020) offer a similar view, outlining key elements, namely, actors, activities, artefacts, institutions, and relationships, as central to innovation ecosystems.

In gastronomy, one might speak of structural alignment as the basis for engaging chefs, food scientists, technology designers, universities, food producers, entrepreneurs, and tourism operators. Galarraga and Martinez de Albeniz (2025) illustrate this process with the Gastronomytech ecosystem as a rising framework. In turn, structural alignment should not be conflated with organisational integration. Actors who operate independently can be engaged in an ecosystem network. This consideration is particularly relevant to the gastronomic context because experts with diverse organisational affiliations can contribute to developing new food technologies. In addition, the framework proposed in this paper does not assume that structural alignment generates scientific and technological homogeneity *de novo*. Instead, such homogeneity emerges through interactions. Knowledge exchange, technological experiments, standardisation, feedback, and learning processes promote the establishment of shared concepts and compatible approaches. This is an essential point because scientific and culinary knowledge often involve fundamentally different paradigms. Dattée et al., (2018) note that in such cases, ecosystem participants must modify their activities constantly through continuous learning cycles. Similar observations can be made regarding new gastronomic technologies. It takes time for food producers and chefs to learn novel techniques and define their potential applications.

Therefore, the framework assumes that gastronomic innovations are not exempt from the dynamics of related markets. Compatibility is a changing phenomenon that requires constant attention to emerging technologies, customer preferences, scientific breakthroughs, and sustainability considerations. Finally, the framework does not propose an innovation-centric perspective.

Instead, it advocates for understanding the role of innovative processes in the overall system behaviour. In this respect, the proposed approach resonates with open innovation scholarship. Chesbrough et al. (2014) describe how restaurant owners use external R&D to generate novel ideas, while Yun et al. (2020) demonstrate how ingredients, recipes, and services can be designed through open innovation ecosystems. Innovation scholarship helps explain the role of gastronomic technology and scientific homogeneity.

Gastronomytech literature is replete with studies illustrating that modern gastronomic innovations require scientific research and culinary knowledge (Galarraga & Martinez de Albeniz, 2025). In other words, scientific and technological homogeneity promotes knowledge exchange and overall compatibility. Theoretical interdependence can be illustrated by the following sequence:

Knowledge diversity → interaction → compatibility → integration → innovation

The main contribution of the framework proposed in this paper is conceptualising compatibility as an intervening condition between knowledge diversity and innovation. Another implication concerns the need to consider gastronomic ecosystems as adaptive systems. Ecosystems must respond to ever-changing technological, culinary, political, and market conditions. In other words, the scientific and technological underpinning of such systems cannot remain static. This point is linked to systems thinking, which conceptualises feedback as a vital mechanism for ensuring system adaptation (Zhang et al., 2018). Elam et al. (2026) employed a similar approach, outlining the key implications of complex adaptive system theory for food entrepreneurial ecosystems. Specifically, Elam et al. (2026) noted that food entrepreneurial ecosystems involve multiple interacting actors and are subject to continuous change.

In the framework proposed in this paper, feedback mechanisms can originate in various areas:

- Consumers
- Chefs
- Technology design
- Scientific research
- Markets
- Regulatory environments
- Ecological conditions

In turn, feedback impacts subsequent interactions,

culinary experiments, and technology design, thereby shaping the entire ecosystem configuration. Thus, scientific and technological homogeneity involves a continuous cycle of:

Interaction → experimentation → feedback → learning
→ adaptation → renewed interaction

Finally, there is a contribution of the framework to the scholarly understanding of sustainable gastronomy. Technological design and operations can promote sustainability goals by minimising food waste, optimising resources, ensuring traceability, promoting sustainable sourcing, and managing food waste, among other things. At the same time, such outcomes require the engagement of all stakeholders and a due consideration of their needs. Richardson and Fernqvist (2024) highlight the crucial role played by chefs in general and the Gastronomytech ecosystem in particular, in advancing sustainable gastronomy and food democracy. In other words, sustainability is a system-level property that emerges through continuous interactions between culinary and non-culinary stakeholders.

Therefore, the framework proposed in this paper conceptualises scientific and technological homogeneity as a necessary, but insufficient condition for sustainable gastronomic development. In particular, compatibility enables the sharing of resources and knowledge within the ecosystem. Meanwhile, a diverse set of actors can promote innovative sustainability solutions tailored to the needs of specific communities.

Four theoretical points emerge from this analysis.

- Firstly, this paper demonstrates that modern gastronomic innovations tend to be ecosystem-driven rather than confined to individual restaurants.
- Second, scientific and technological homogeneity enables organisational coordination without forcing actors to adopt identical solutions.
- Third, structural alignment and process integration are key to achieving the desired level of technological compatibility.
- Fourth, feedback and adaptation mechanisms make such homogeneity a dynamic concept

Therefore, the theoretical mechanism follows the line of reasoning depicted below

Structural diversity → Structural alignment → Process integration → Scientific and technological homogeneity → Innovation → Ecosystem outcomes → Feedback and modification

The contribution of this paper is conceptualising a dynamic framework that makes it possible to reconcile technological and gastronomic diversity.

Table 1: Summary of Theoretical Propositions

Proposition	Core relationship
P1	Structural alignment supports scientific and technological integration
P2	Process integration can strengthen scientific and technological homogeneity
P3	Compatibility among heterogeneous components produces homogeneity
P4	Homogeneity can strengthen innovation integration
P5	Feedback and learning continuously reshape homogeneity
P6	Culinary and cultural diversity can strengthen the innovation benefits of technological alignment

Hence, the proposed theory suggests that the future of gastronomy depends not simply on more technology, but on the capacity of gastronomic ecosystems to combine diverse technologies and knowledge systems through compatible structures, processes, and interfaces. This provides the foundation for the theoretical and applied implications discussed in the next section.

6. Limitations

The main limitation of the current conceptual paper is that it only provided theoretical foundations for future research without testing any of the suggested theoretical frameworks. The next step is to develop a robust theoretical framework based on the ideas introduced in the paper and test the proposed conceptual model. Second, the paper drew ideas from several different fields of study, including systems theory, culinary and food studies, multi-industry ecosystems, and innovation studies. Each of these fields may have different theoretical orientations and terminologies that could limit the applicability of some of the suggested frameworks. Third, this study introduced the concept of

scientific and technological homogeneity as a precursor to coordinated diversity. As such, there is a need to conduct further research to fully operationalise the proposed term and validate the suggested measurement constructs. Lastly, the present paper suggested that future studies should further investigate the homogeneity/diversity nexus in the context of future gastronomic and food ecosystems.

7. Implications

The present conceptual paper advanced several theoretical contributions that have practical implications for future research, as well as for industry and policy. First, the paper provided a theoretical foundation for future empirical studies on the emergent multi-industry ecosystems that go beyond the restaurant and the role of chefs to encompass a wider set of stakeholders, such as scientists, technology firms, universities, entrepreneurial actors, suppliers, and tourism agencies (Chesbrough et al., 2014; Galarraga & Martinez de Albeniz, 2025). Second, the article introduced scientific and technological homogeneity as a new theoretical construct that can guide future studies on the mechanisms through which various culinary, cultural, and technological solutions can be orchestrated to achieve collective value. Third, the study built a conceptual foundation for future research on the role of systems thinking in innovation ecosystems, as reflected in the proposed structure/process/information nexus (Adner, 2017; Granstrand & Holgersson, 2020). Fourth, the paper drew theoretical support from the notion of modularity to argue that technological solutions in the future gastronomic ecosystem will be mutually compatible, even if they are designed independently (Schilling, 2000). Lastly, the conceptual article advanced the idea of coordinated diversity, which is simultaneously characterised by a high degree of technological alignment and diversity of culinary and cultural solutions.

For restaurants and other gastronomic businesses, the paper suggested the need to consider partnering with scientists, universities, technology firms, producers, and tourism agencies to advance collective learning and innovation. The study also suggested that technology firms need to invest more in modular and interoperable technologies that follow design principles to ensure that multiple firms' technologies can operate together seamlessly. For universities and research institutes, the paper recommended fostering interdisciplinary collaborations and partnerships with the industry

and policymakers to advance a holistic approach to future gastronomic ecosystems. For policymakers, the paper suggested supporting gastronomic innovation by developing much-needed gastronomy hubs, food tech incubators, university-industry research partnerships, and shared laboratories to support future gastronomic innovations. The paper also urged policymakers to support the application of emerging technologies to advance sustainable gastronomy while also promoting the need to respect local culinary traditions (Richardson & Fernqvist, 2024). Finally, for the gastronomic tourism sector, the study recommended the need to include digital technologies, local producers, and cultural resources, and culinary experiences to develop broader multi-ingredient innovation ecosystems (Hjalager, 2022).

8. Conclusion

This conceptual paper advances a Systems Theory of Scientific and Technological Homogeneity in Gastronomy to theorise how more varied scientific, technological, culinary, entrepreneurial, and institutional factors can come together in a unified gastronomic ecosystem. The paper addresses the need to interpret gastronomy in broader systems thinking terms as a multi-industry ecosystem that encompasses culinary, scientific, digital, entrepreneurial, tourist, and other functions. The underlying premise is that future gastronomic ecosystems will be characterised not by uniformity but by compatibility, as their essential ingredient. Scientific and technological homogeneity refers to the level of scientific knowledge, technological sophistication, standardisation, processes, and interfaces required for effective interactions between diverse agents and technologies in a gastronomic ecosystem. The notion of scientific and technological homogeneity is advanced to reconcile the need for uniformity within a given gastronomic ecosystem while also recognising the value of culinary and cultural diversity as a critical driver of imagination and differentiation.

The framework presented in this paper was built around three key aspects of integration: structural, process, and innovation-related. Structural alignment had to do with the configuration of a given set of agents, institutional frameworks, knowledge infrastructure, technological equipment, and networks within a gastronomic ecosystem. Second, the term process integration encompasses knowledge exchange, coordination, experimentation, standardisation, learning, feedback, and modification processes that facilitate

collective learning and adaptation. Finally, innovation incorporates the translation of relevant resources and processes into culinary, technological, organizational, experiential, and other values. The paper also advanced the concept of coordinated diversity to describe the combination of sufficient technological alignment for collective learning and adaptation while simultaneously recognising the value of diverse culinary, cultural, technological, knowledge, and entrepreneurial solutions in a given gastronomic ecosystem. The paper concluded that future gastronomic ecosystems will be dominated not by technological uniformity but by the ability to leverage scientific uniformity to drive coordinated culinary and cultural diversity.

The main theoretical contribution of this study was to link systems theory and innovation ecosystems to the realm of food and culinary sectors while also advancing the concept of scientific and technological homogeneity and coordinated diversity as critical to future gastronomic ecosystems. Scientific and technological homogeneity acted as the key intermediary force linking the structural and process aspects of culinary ecosystems to their innovative outcomes. The term homogeneity also recognises that such uniformity is a dynamic concept that is constantly influenced by consumer and market forces, scientific discoveries, technological advancements, and other factors. The paper stressed the importance of scientific and technological homogeneity for the emergence of the new field of Gastronomytech, where chefs, scientists, and technology designers will collaborate to advance social, culinary, and economic values (Galarraga & Martinez de Albeniz, 2025). The proposed framework suggested that future gastronomic ecosystems will be characterised not by the dominance of a given technology but by the ability to combine different technologies and knowledge to form complex but cohesive systems. As a result, the paper concluded that the future of the gastronomic ecosystem will be determined not by uniformity or isolated culinary innovations but by the capacity to combine scientific and technological homogeneity with diverse culinary, cultural, and entrepreneurial values. The proposed systems theory thus provided a theoretical foundation for empirical research on future gastronomic ecosystems.

Concluding Theoretical Proposition

Scientific and technological homogeneity will enable gastronomic ecosystems to achieve system-

level coordination and orchestration of diverse culinary, cultural, and technological solutions. At the same time, culinary and cultural diversity will provide the much-needed heterogeneity for innovativeness and adaptation capacity.

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