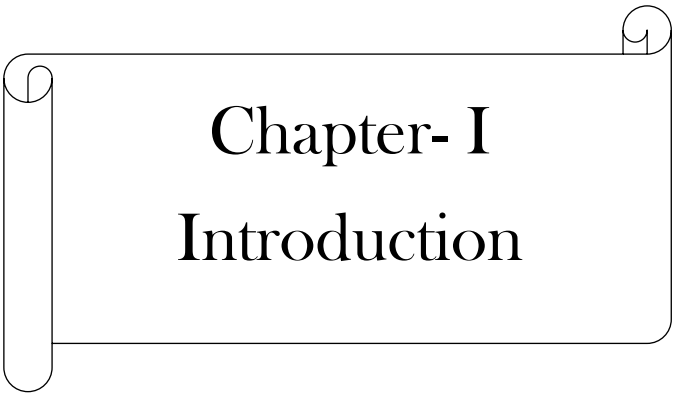
Chapter- I
Introduction

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1. Introduction

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In recent years the food industries are becoming more competitive and innovative. This is evident from the surge in new foods entering the market to attract consumers [11]. One of the important driving forces behind the innovative products and services from the food industry is a better comprehension of the consumer preference [4]. To meet the demands of the fine-dining businesses as well as to cater to the preference of the younger generations for ready-made meals, the food industry and services are continuing to expand. An extension of the argument is that a long-term viability and the competitiveness of the food industry are sustained through various innovative and research-based approaches for comprehension of the consumer preferences. This has been facilitated by the field of study named gastronomy. Gastronomy is a domain within food science that studies and provides a thorough grasp of consumer perceptions, expectations, and attitudes toward new food products, and thereby forms the foundation for the development of innovative food products [48].

Two perspectives are worth exploring: will the gastronomic knowledge make the food engineers more innovative, and how the food engineering knowledge help the food service sector to innovate better. This exploration may begin with an understanding of the application of gastronomic science, which involves development of a concept that is rich in ideas, quick to make decisions, and quick to deliver meals to the restaurant's menu [4]. Food engineers and scientists who would work with gastronomists can help the chefs to translate the concepts from food science literature into meals and use scientific methods and laboratory tools to ensure food safety. This will eventually help to scale-up culinary concepts into industrial operations [3]. At the same time with such an engagement, future engineers can be more innovative, creative, and be able to design and enhance present and future sustainable societal lifestyles. With such an integration of gastronomy, food engineering approaches would become more effective to contribute toward sustainability, safety, improved nutrition, and improved food use [3]. Hence, food engineering may work to enter the domain of food innovation and entrepreneurship through adoption of gastronomic pathway and to join the chefs in the role of innovation leaders [2]. Through

such a close collaboration the gain for the engineers from the gastronomic insights to food service innovation would diffuse to lead to an innovation in food manufacturing sector. At the same time, the chefs are likely to become more innovative, credible, and visible and to can ensure a long-term sustainability of our food system [3].

Additionally, the processes associated with the preparation of a meal in the food service sector require considerations similar to food manufacturing and which in turn may be supported effectively by professionals from the field of food engineering. Because Food engineering is traditionally associated with the processes related to processing, manufacturing and/or handling of food at industrial scales. Institutional food operators, professional chefs, and amateur cooks would benefit from utilizing the knowledge of food manufacturing. Different specific areas of interactions include understanding of transfer phenomena in cooking processes, scaling up gastronomic preparations for institutional uses, modelling changes in cooked food quality under real-world conditions, designing tasty and nutritious processed food, analysing the effects of cooking methods on the food matrices, and adapting new technologies to the kitchen level etc, [3]. However, based on a futuristic engineering perspective, artificial intelligence supported computational creativity is one of the important areas where food engineering can significantly contribute to the field of gastronomy.

Computational creativity is a developing area of artificial intelligence, where computation is the key component. The emergence of high-throughput technologies in the recent times have enabled scientists to perform large-scale data analyses of experimental information in all research domains including the field of biological sciences [6]. Along with the incorporation of computer-supported analytics, the field of food science is also maturing to the point of becoming a field of quantitative research [80]. In its application to the field of gastronomy, a computational system uses big data approaches to generate innovative, flavourful, and possibly nutritious culinary meals [61]. The intelligent creation of meals with ideal flavour qualities has piqued the curiosity of chefs, culinary experts, and food processors [64]. An acceptance of such an approach is evident from an increasing number of reported research works based on the data about food ingredients, food recipes, food compositions, and food constituents including volatile compounds, food nutrients, etc [6].

In various reported works, large amounts of culinary data have been accumulated and analysed using computational approaches which has caused a shift in perspective to the

artistic outlook toward gastronomy [29]. The recipe collections which are troves of ingredient combinations and cooking processes, have been used to gather the insights about cooking fundamentals and yielding intriguing insights into both culinary foundations and user preferences. Data mining and network analysis methods have been applied to characterise and analyse the publicly available large-scale data on food combinations, food usage and food chemistry. Hence, the concept of 'computational gastronomy' is getting established and is continuing to expand as an increasing amount of data on food chemistry, sensory biology and food use are becoming available in the public domain [6]. Food companies and skilled chefs are reaping benefits to create new recipes considering the diversity in regional cuisine styles and personal food preferences.

Computational gastronomy is closely related to data mining, which is the search for patterns and trends in large amounts of data beyond simple analysis. An individual's sense of taste and smell determines most of the flavour they experience. However, uncertainty prevails on how does each sense play on the whole culinary experience. Based on the available body of research, food pairing helps to determine the ideal ingredient combination. A data-driven approach is expected to give a better insight into the ingredient preferences, which can be used to facilitate the possible modification of ingredient combination formulations. Thus, the computational gastronomic approach may be seen as modern engineering intervention to the creative domain of food service and may be explored further for having a better understanding about food preference from the perspectives of flavour.

A human's sense of taste and smell determines most of the flavour they experience. The whole food experience relies heavily on each sense, but how much each contribute is not predicted or determined. In this context, the food pairing hypothesis by Blumenthal [18] asserts that ingredients with similar flavour compounds, together are likely to develop better taste than ingredients with dissimilar flavour compounds. This hypothesis had led to the creation of many new and diverse combinations of ingredients in recipes and had helped researchers in the quest for unique ingredient combinations. Western cuisine, as one example, has shown pairings in line with the food pairing hypothesis, which means the ingredients in the recipes are more likely to share common flavour compounds. However, Asian and Indian cuisines are reported to show the opposite behaviour. The flavour pairing theory explains this negative food pairing behaviour for these cuisines based on the prevalence of non-dairy food ingredients. In recipes from Asian and Indian

cuisines ingredients with a greater number of shared compounds are less likely to be found together in the same recipe [5,39]. Above observation motivates the researchers to take up a geographic location based or region-specific study of food preference so that food developers find themselves to be accomplished enough to develop foods suitable to the societal lifestyles.

Every nation has historically been differentiated by a variety of regional cuisines, each of which reflects the nation's historical and cultural background. Traditionally, cultural cuisine refers to the food practices associated with any given culture that have been elaborated and transmitted over time [7]. It reveals a great deal about the people who live there, the types of crops they grow, and what their climate is like [80]. The culinary culture has evolved similarly to the variation in regional languages. Typically, these changes are encoded in the signature ingredient combinations of a cuisine's recipes. A cuisine is defined by its recipes, ingredients, and flavour molecules. As a result, it is possible to uncover underlying patterns in traditional recipes by analysing recipes, ingredients, and relevant features [75]. India has a variety of regional cuisines that exhibit the country's gastronomic diversity [39]. The Northeast part of India is a region with a strong cultural and geographical influence. This region is termed a ‘cultural area’ on the outside, or on the margins of three major academic ‘area study’ regions, viz., South Asia, Southeast Asia and East Asia [25]. Van Schendel [85] has commented that the region ‘is not only the Northeast borderland of South Asia but it can also be described as the north-western borderland of Southeast Asia’. An analysis of the food culture of the region based on the principles of flavour pairing is expected to highlight the cultural proximity to both the Indian sub-continent (South Asia) as well as South-East Asia and to garner benefits for regional development.

To understand the food consumption patterns and availability, nutritional value, medical values, and associated cultural and social dynamics of the tribal communities of Northeast India, it is necessary to explore, analyse and document the ethnic foods consumed by these communities [73] It is the authenticity and uniqueness of the society's traditional food culture that appeals to tourists, thereby bears the potential to promote culinary tourism in the area. There is a need to develop various effective strategies for marketing indigenous and authentic foods to promote culture and sustainable development in society [14]. In their attempt to identify the pattern of food pairing in Indian cuisines, Jain et al. [39] have studied eight geographically and culturally prominent regional cuisines from

India viz., *Gujarati, Bengali, Maharashtrian, Jain, Punjabi, Mughlai, South Indian and Rajasthani* where a negative food pairing behaviour was reported as a common trend. The information obtained on the ingredient preferences can lead to the possibility of modifying ingredient combinations which can be carried out using the flavour pairing algorithms. These algorithms generate alternative recipes using existing domain knowledge which allows the computational systems to enter the creative domain of cooking. As a result, flavour pairing has been demonstrated to be a useful tool for both recipe generation and recipe recommendation [5].

1.2 Scope of work

Around the turn of the 20th century, as far as consumers are concerned, ample food availability, convenience, and low prices did not satisfy their needs. As passive participants several questions plagued them, including how food is produced, why they should contain food additives, and how healthy and secure processed foods are [2]. To make better-informed decisions about our food choices it is important to understand human dietary trends and food preferences as culture and nutrition are closely related [89]. As regional cuisines vary from one region to another, variations in flavour preferences lead to variations in the foods that people choose to eat. However, regional cuisines that are geographically close to one another have some flavour characteristics and factors including genetics, environment (geographic and cultural), current health demands, diet balance, and others, have an impact on users' food preferences [94]. With the variety of regional cuisines illustrating the diverse culinary culture and practices, one might wonder if the ingredient combinations are affected by any general patterns in contemporary meals that go beyond personal tastes [5].

Food pairing behavior at the level of cuisines, recipes and ingredients have been extensively explored and studied on the eight regional cuisines of India viz., *Gujarati, Bengali, Maharashtrian, Jain, Punjabi, Mughlai, South Indian and Rajasthani* with the help of online repositories data on recipes. However, food pairing behavior in Northeast regional cuisines have not been explored yet. For primary data on flavour choice, food innovation at the food service level has potential to find a place at manufacturing sector. However, there is a gap of understanding, and no specific roadmap is currently available.

The present work was undertaken to find such a roadmap through finding answers to few questions with respect to Northeast cuisines like, (a) If there is any bias for food

ingredients - at the level of individual ingredient and/or in combinations, (b) can the flavour level information be used to explain the choice of ingredient combinations, (c) whether the food choices offer flexibility for replacement of ingredients leading to create newer combinations by modification, and (d) can the ingredient/flavour level information be utilized for creating newer combinations.

In an attempt to find answers to above questions, the scope of the utilized information remains limited to geographic location of Northeast India i.e., in the states of Assam, Arunachal, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, and to offer explanations of the preference based on flavour pairing theory. The information regarding food ingredients, their chemical makeup in terms of flavour compounds, and their combination as seen in food recipes, were collected and computational gastronomy concepts were applied to gain an insight into the conceptual underpinnings of the cooking as well as consumer preferences. Suitable statistical tools were employed to quantify the contributions of individual ingredients and the combination of ingredients in imparting a unique feature to the cuisines of the various states. Depending on the principles underlying the food pairing behaviour in the cuisines from the region, ingredient combinations are explored to fulfilling the consumer's specific requirements.

1.3 Aim and objectives

This research was undertaken for studying the flavour pairing behaviour in food recipes, taking data from a region for which there is no such report yet, and applying the computational gastronomic approach for exploring the possibilities, which was achieved by the following objectives:

Objective-1: To characterize and analyse traditional food recipes from Northeast India for ingredient pairing behaviour

Objective-2: To apply data-driven similarity analysis for intra- and inter-regional cuisine similarities to the food recipes from Northeast India

Objective- 3: To apply a generative hypothesis for developing recipes based on food ingredients used in Northeast India

Objective- 4: To explore the ingredient combinations for food development with consumer preference based on ingredient pairing behaviour

1.4 Thesis structure

The present chapter provides an introduction to the field of the research and highlights the motivation and objectives of the current research towards the end. The remaining chapters are organised as follows:

Chapter 2: This chapter of the thesis elucidates the reported work conducted by researchers that are relevant to the current work.

Chapter 3: This chapter describes the procedure followed in conducting a systematic investigation to address the research questions of this study. It encompasses a description of the materials and methods of their preparation, methodology for their data collection including a description of the algorithms used, and the framework for data interpretations used in the pursuit of fulfilling the objectives.

Chapter 4: This chapter presents the findings of the investigation in five sections (sections 4.1 to 4.5), conducted to find solutions to the research questions stated in the objectives. The findings are critically analysed by relating them to the theoretical understandings, and/or research findings of earlier workers.

Section 4.1: This section deals with the characterization and classification of the regional cuisines to examine the existing trend of food ingredient usage and to validate the shared compound hypothesis. These results are related to objective 1

Section 4.2: This section deals with the similarity analysis for regional cuisines. The regional cuisine similarities were quantified using data-driven approaches. These results are related to objective 2

Section 4.3: This section deals with the generation of recipe composition based on identified consumer preference for ingredient pairing. These results are related to objective 3

Section 4.4: This section deals with the development of alternative recipe by ingredient replacement for customised specifications with the application of flavour network theory. These results are added to objective 4

Chapter 5: This chapter deals with the concluding remark of each objective with its future scope. Suggestions for future research and limitations are also included in this chapter. In addition, the thesis contains references and appendix of tables.

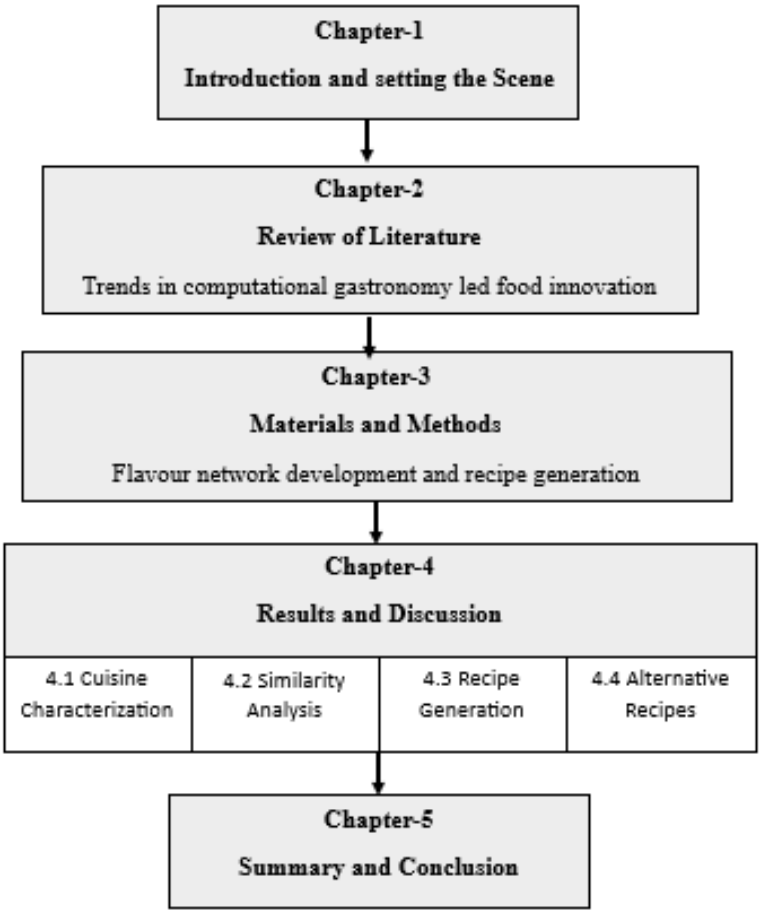

Fig 1.1 Graphical representation of the thesis structure