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Culinary Innovation: Will the Future of Chefs' Creativity be Shaped by AI Technologies?

Abstract

The purpose of this paper is to propose artificial intelligence technologies as an innovative tool for designing recipes in culinary artistry. Since artificial intelligence technologies are widely used to generate content, we investigated the creation of recipes and consumers' acceptance of the sensory attributes of the final food product. Without additional guidance, the artificial intelligence program asked to create three recipes using the same ingredients (strawberry, chicken, and vine leaves). To test the overall liking and acceptance of the recipes, the hedonic test is applied to 118 untrained panelists. The results revealed that the overall acceptability scores for all three products are acceptable (≥ 6.0), with the lowest score of 6.58 ± 1.61 . Artificial intelligence has shown that it can be an efficient tool for professional chefs to shorten the creativity process and design unimaginable combinations. This research is a pioneering study that measures the reliability and ability of artificial intelligence in creating recipes, which is a culinary creativity process. With the hedonic tasting results, this study also shows the consumers' acceptance of new dishes.

Keywords: culinary innovation, culinary creativity, artificial intelligence, sensory evaluation, hedonic scaling

1. Introduction

In November 2022, OpenAI released a sophisticated artificial intelligence model, ChatGPT, for public use (Niszczota & Rybicka, 2023). This launch was met with great interest, and ChatGPT was used by more than 100 million people in that month, according to reports published in January 2023 (Hu, 2022). Conversational AI models such as ChatGPT and a similar chatbot, Google Bard, perform differently according to their intended use. For example, as a writer, you can get support on topics such as title selection and topic ideas (Hyken, 2023) or even ask ChatGPT to write a story directly.

As of mid-February, the Kindle store on Amazon had more than 200 e-books that listed ChatGPT as either the author or co-author (Bensinger, 2023). Processing vast amounts of data and designing new answers with artificial intelligence can offer various uses. GenAI possesses the ability to generate varied and realistic content, support creative exploration and innovation, automate tasks that consume time, improve personalization and recommendation systems, and contribute to advancements in various domains such as art, education, and medicine, among others (Fusté-Forné & Orea-Giner, 2023).

ChatGPT may play a role in various aspects of gastronomy. While developing new products, it can suggest new names and create dishes based on specific concepts. Moreover, it can accomplish this by utilizing ingredients available on the premises, avoiding the need for hard-to-find, unavailable ingredients (Carvalho & Ivanov, 2023).

To better understand, we asked ChatGPT, "How can I use ChatGPT in gastronomy?" ChatGPT listed the following possibilities:

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1. Recipe suggestions
2. Culinary tips and techniques
3. Ingredient substitution
4. Menu planning
5. Food and flavor pairing
6. Nutritional information
7. Food culture and history

This paper focuses on measuring the credibility of ChatGPT for recipe suggestions in the context of culinary innovation. We aimed to test the performance of ChatGPT while designing a creative new dish that precisely follows the full recipe. To measure this, a tasting event was conducted with semi-trained panelists, and evaluations of the meals created by ChatGPT were obtained with a 9-point hedonic scale. Analyzing data from hedonic rating tests enables the researcher to draw conclusions about the level of liking of a product or compare the scores assigned to several products within the context of the particular scale used (Kemp et al., 2011). The 9-point hedonic scale, introduced as an aid to menu planning for US soldiers in their canteens, has been one of the most widely used scales over the last 60 years (Wichchukit & O'Mahony, 2015). In food science, the hedonic scales are well tried and tested in consumer research for capturing liking data (Stone & Sidel, 1985).

2. Theoretical background

2.1. Culinary innovation & creativity and technologies

Culinary innovations for the food industry encompass a broad spectrum, including FMMSG food products and their formulations, various production and kitchen equipment, new molecules and ingredients, functional products, sustainable technologies, and numerous software designs such as integrated service systems and management tools.

In culinary literature, the utilization of information technology in culinary research has been studied from various perspectives. The culinary-focused innovation process was initially categorized by Harrington (2004) into four stages: culinary innovation formulation, culinary innovation implementation, evaluation and control, and innovation introduction. Building on Harrington's model, Ottenbacher and Harrington (2009) developed a process model for Michelin-starred chefs. Hu (2010) further established core competency factors for innovative culinary development, identifying seven competencies: product, culture, aesthetics, creativity, technology, management, and service. Table 1 presents culinary innovation and different approaches.

Table 1
Culinary process development & michelin-starred chef process

Comparison of culinary innovation stages		
Culinary process development model (Harrington, 2004)	Michelin-starred chef process (Ottenbacher & Harrington, 2008)	Core competency culinary innovation (Hu, 2010)
Culinary innovation formulation (Setting the stage, selecting the interdisciplinary team, planning and linking process, product definition, chefmanship, food science)	<ol style="list-style-type: none"> 1. Idea generation 2. Screening 3. Trial and error 4. Concept development 5. Final testing 6. Training (employees) 7. Commercialization 	<ul style="list-style-type: none"> • Product • Culture • Management • Service • Aesthetic • Creativity • Technology

Table 1 (continued)

Culinary innovation implementation (Formulation, prototype, benchmarking, sensory analysis)		
Evaluation and control (Consumer tasting, scale-up, process development, production transference, HACCP analysis)		
Innovation introduction (Support, continued feedback)		

Source: Harrington (2004); Hu (2010); Ottenbacher & Harrington (2007).

These studies show chefs or researchers initiate innovation by generating and correctly formulating ideas. In fact, (Horng & Hu, 2009) identified the steps for the creative culinary process as preparing new ideas, idea incubation, idea development, verification of culinary work and culinary performance. This idea-generation process for chefs has many limitations, including the chef's knowledge, seasonal products, cooking techniques, cost control, and the incorporation and understanding of new technologies. With scientific, cultural, and product-specific knowledge, a chef can create new flavours, textures, and styles of food, often requiring assistance from an equally skilled team (Borkenhagen, 2017). Additionally, consumer evaluation should be a part of the generation process, and an optimization-based approach should be proposed for the recipe creation (Shao et al., n.d.) so the initial ideas can meet the target market.

Since it is time-consuming and dependent on personal knowledge, this process can benefit from technologies such as artificial intelligence and software, which might help with screening or formulating culinary innovations. Many scholars suggested that with computer-assisted modelling, chefs could design products and menus more efficiently (Rodgers, 2008; Stierand & Lynch, 2008). Chefs could benefit from technological advancements through the idea generation stage, including innovative appliance technologies such as smart ovens, thermometers, sous vide machines or new molecular tools, and software that can help with flavor pairing, recipe creation or managerial tasks. Especially for chefs, using technological instruments and equipment is becoming a part of the recruitment process (Cawley, 2011).

Furthermore, even the technologies help the chefs in their daily tasks, the creation process, gathering the different flavor combinations together, and finding new ways to process ingredients still depends on personal judgement (Horng & Hu, 2008; Spence & Youssef, 2018). In early computational culinary creativity studies, researchers developed an artificial chef that creates original salad dishes, and they found that the best computer-generated salads were competitive with those made by humans (Cromwell et al., 2015), but only competitive, not better. Another research demonstrated a computational system that uses big data techniques to generate inventive and tasty meals (Pinel & Varshney, 2014). It has been described that algorithms form the foundation of a computational creativity system that can automatically or semi-automatically discover, design, and plan culinary recipes that are flavorful, novel, and healthy (Pinel et al., 2015).

According to Lee et al. (2020), who studied the creative philosophies and narratives of some of the most famous pastry chefs in the world, culinary creativity is a result of three factors: an impulsion attributed to one's imagination and sensitivities in perceiving the ordinary, the interaction of science and art, and symbolic and sensorial harmony-making. In the development process of culinary creativity, Horng and Hu (2009) identified idea preparation, incubation, development and verification of culinary work lead to culinary performance. Another study showed that creative culinary artworks have the following eight dimensions: professional technique, aroma, taste, and texture; color, modelling and arrangement; garnish; dishware; handling of ingredients; and overall assessment (Horng & Lin, 2009).

Additionally, six contextual aspects that influence the process were shown to be essential for chefs to exhibit innovation. These include globalization, technology, science, and design, as well as politics, economy, education,

culture, and tourism (Özgönül & Öztürk, 2022). Also, creativity develops gradually over time rather than coming to fruition all at once. This creative process progresses through several stages or sub-processes, each of which, taken separately and collectively, contributes to the growth or production of the culinary artwork (Hornig et al., 2015). For the customers, culinary products can be considered creative based on how appropriate they are to the context and their overall liking of the products, and less so on the novelty aspect of the products (Roque et al., 2018). Technological advancements in the food industry may not always be welcomed at first (Motta & Martín, 2021). Still, overall implications certainly could change the understanding of food or even create value and meaning around food (Pilcher, 2016).

2.2. AI technologies and Chat GPT

Artificial intelligence (AI) is defined as “the pursuit of developing computers that can simulate human intelligence – specifically, learning, reasoning and self-correction” (Oracle Food and Beverage, 2019). The occurrence of AI is attributed to a meeting in July 1956 at Dartmouth College, where the term "Artificial Intelligence" was used for the first time. (Brunette et al., 2009). AI is the ability of computers or computer-controlled robots to perform tasks associated with intelligent beings (Copeland, 2023). What distinguishes intelligent systems from unintelligent ones is their ability to understand the context, acquire knowledge, and conclude based on previous experiences. Thus, they quickly and successfully respond to a new situation (Zlatanov & Popesku, 2019). Thanks to AI computers or computer-controlled robots, they can learn, think, and make decisions like human intelligence. This technology allows computers to perform human-like tasks and solve problems.

An intelligent computer uses AI to simulate human thinking and perform tasks autonomously. Developing intelligence in a computer system is defined as machine learning. Therefore, while AI and machine learning are closely connected, machine learning is considered a subset of AI (*Microsoft*). Two kinds of artificial intelligence systems - pure digital ones and digital-physical hybrids are usually called robots. Artificial intelligence systems can be classified as pure digital ones and digital-physical hybrids that are robots. Both systems are used in different parts of the tourism and hospitality industry for other purposes (Zlatanov & Popesku, 2019). A report by Oracle (2019) indicates that artificial intelligence (AI) and robotics will significantly impact the restaurant business by 2025. Such technologies may be helpful to enhance the efficiency of restaurant employees, perform repetitive and mundane tasks, speed up service, simplify interactions between businesses and guests, remove language barriers, and to improve personalization (Berezina et al., 2019; Ivanov & Webster, 2017). New AI models like ChatGPT can also be included in creation and creativity processes.

In recent years, advances in machine learning have led to the development of sophisticated digital content generation technologies, such as generative artificial intelligence (AI) (Hu, 2022). Generative modelling artificial intelligence (GAI) is a type of machine learning that can produce new content by analyzing patterns and probabilities in existing data. GAI operates in an unsupervised or partially supervised framework, generating realistic outputs without human intervention (Baidoo-Anu & Owusu Ansah, 2023).

The Generative Pre-trained Transformer (GPT) model is a type of generative machine learning technology that uses natural language processing (NLP) to generate human-like text from large amounts of publicly available digital data (Baidoo-Anu & Owusu Ansah, 2023). These models can write texts on various topics, from paragraphs to extensive research papers, and even have human-like conversations with people. GPT-3 is a very advanced artificial intelligence model that uses 175 billion parameters and is ten times the capacity of any model before it (Brown et al., 2020).

To explain Chat GPT, we wanted Chat GPT to define itself. We asked “Can you explain Chat GPT?” and therefore, it created this response:

“Yes, of course! Chat GPT, or GPT (Generative Pre-trained Transformer), is a large language model developed by OpenAI. It uses machine learning algorithms to understand human language and generate text like a human might say or write. It has been pre-trained on a large corpus of text data, which includes everything from books to websites to social media posts. This pre-training allows the model to understand the nuances of language and produce coherent, meaningful responses to questions or prompts.

Chat GPT can be used for various applications, including chatbots, text generation, and content creation. It can produce human-like responses to multiple prompts, from simple questions to more complex topics. However, it is essential to note that Chat GPT is not perfect and may sometimes produce nonsensical or inappropriate responses. Therefore, it is necessary to use it responsibly and with caution.”

3. Methodological approach

3.1. Research design

This research is designed to test the credibility of ChatGPT for menu development, which is a part of culinary innovation. Since ChatGPT can offer various advantages in gastronomy and culinary arts, it is essential to assess these features. Contributions to recipe design and easing creativity are some of the significant benefits of artificial intelligence. To create a new recipe, we chose three different ingredients: vine leaf, strawberry, and chicken, which are present in Turkey but are not used in recipes commonly or ever. Chicken, strawberry, and vine leaves were selected based on their volatile aromatic compounds and differences, which will be a more challenging task for ChatGPT to match the flavor. Chicken and strawberry cooked or uncooked volatile compounds are very different. Therefore, there will be no absolute match for aroma or flavor (Forney et al., 2000; Jayasena et al., 2013). There was no study on vine leaves and their aroma profiles since they are not mainly used except for a couple of usually stuffed dishes in Turkey.

Then, it is asked from ChatGPT to create three new recipes with those ingredients (recipes are given below). Recipes are applied precisely to test their credibility. After the cooking stage, samples are presented as suggested by ChatGPT.

Table 2
Recipe of “Chicken and strawberry stuffed vine leaves” which is created by ChatGPT

Ingredients:	Instructions:
12 large vine leaves, blanched	1. Preheat the oven to 375°F (190°C).
1 lb ground chicken	2. Mix the ground chicken, cooked rice, onion, parsley, mint, tomato paste, cinnamon, salt, and pepper in a large bowl.
1/2 cup cooked rice	3. Lay out one of the blanched vine leaves on a flat surface, with the smooth side facing down and the stem end pointing towards you.
1/4 cup finely chopped onion.	4. Place a spoonful of the chicken mixture in the center of the vine leaf.
1/4 cup chopped fresh parsley.	5. Add a spoonful of chopped strawberries on top of the chicken mixture.
1/4 cup chopped fresh mint.	6. Fold the bottom of the vine leaf up over the filling, then fold the sides in towards the center.
Two tablespoons of tomato paste	7. Roll the vine leaf up tightly into a cigar shape.
1/4 teaspoon ground cinnamon	8. Repeat with the remaining vine leaves and filling.
Salt and freshly ground black pepper.	9. Place the stuffed vine leaves in a baking dish, seam-side down.
1/2 cup fresh strawberries, chopped.	10. Pour the chicken broth and olive oil over the stuffed vine leaves.
1/4 cup chicken broth	11. Bake in the oven for 30-35 minutes or until the chicken is cooked and the vine leaves tender.
Two tablespoons of olive oil	12. Serve hot stuffed vine leaves, garnished with additional chopped strawberries if desired.

Table 3**Recipe of "Grilled chicken with strawberry and vine leaf salad" which is created by ChatGPT**

Ingredients:	Instructions:
For the chicken: Four boneless, skinless chicken breasts Two tablespoons of red wine vinegar Salt and freshly ground black pepper. For the salad: 12 large vine leaves 1/2 cup sliced fresh strawberries. 1/4 cup chopped fresh mint leaves. 1/4 cup chopped fresh parsley leaves. 1/4 cup crumbled feta cheese 1/4 cup sliced red onion. Two tablespoons of olive oil Two tablespoons of red wine vinegar Salt and freshly ground black pepper.	<ol style="list-style-type: none"> 1. Preheat a grill or grill pan over medium-high heat. 2. Brush the chicken breasts with olive oil and season with salt and pepper. 3. Grill the chicken for 6-8 minutes per side or until cooked through. 4. Remove the chicken from the grill and rest for 5 minutes before slicing. 5. Meanwhile, blanch the vine leaves in boiling water for 1 minute, then drain and pat dry. 6. Combine the sliced strawberries, chopped mint and parsley, crumbled feta cheese, and sliced red onion in a large bowl. 7. Whisk together the olive oil, red wine vinegar, salt, and pepper in a small bowl to make the dressing. 8. Add the blanched vine leaves to the bowl with the salad ingredients and toss to combine. 9. Drizzle the dressing over the salad and toss again. 10. Divide the salad among four plates and top each with sliced grilled chicken. Serve immediately, garnished with additional chopped fresh herbs and sliced strawberries if desired.

Table 4**Recipe of "Chicken and strawberry skewers with vine leaf pesto" which is created by ChatGPT**

Ingredients:	Instructions:
For the skewers: Four boneless, skinless chicken breasts cut into cubes. 1-pint fresh strawberries, hulled and halved 12 large vine leaves, blanched and drained Salt and freshly ground black pepper. Olive oil for brushing For the pesto: 12 large, blanched vine leaves 1/2 cup fresh basil leaves 1/4 cup pine nuts 1/4 cup grated Parmesan cheese. One clove of garlic, minced. 1/4 cup olive oil Salt and freshly ground black pepper.	<ol style="list-style-type: none"> 1. Preheat a grill or grill pan over medium-high heat. 2. Thread the chicken and strawberry halves onto skewers, alternating as you go. 3. Take each blanched vine leaf and wrap it around the skewer, covering the chicken and strawberry cubes as you go. 4. Brush the skewers with olive oil and season with salt and pepper. 5. Grill the skewers for 8-10 minutes, turning occasionally, until the chicken is cooked, and the strawberries are slightly charred. 6. While the skewers are cooking, make the vine leaf pesto. 7. In a food processor, pulse the blanched vine leaves, basil leaves, pine nuts, Parmesan cheese, and garlic until finely chopped. 8. Slowly pour the olive oil until the mixture is smooth and the motor is running. 9. Season with salt and pepper to taste. Serve the chicken and strawberry skewers hot, garnished with a spoonful of the vine leaf pesto. 10. Divide the salad among four plates and top each with sliced grilled chicken. Serve immediately, garnished with additional chopped fresh herbs and sliced strawberries if desired.

3.2. Sampling and participants

Three dishes are selected for hedonic taste: "chicken and strawberry stuffed vine leaves", "grilled chicken with strawberry and vine leaf salad", and "chicken and strawberry skewers with vine leaf pesto". Participants were provided comprehensive information about the study's conditions before each session. However, the specific details regarding the recipes generated by artificial intelligence were intentionally withheld until the study's conclusion to prevent potential bias. Participants were also informed to refrain from participating if they had food allergies or intolerances. Furthermore, they were assured they could withdraw from the study at any point. Once confirmed that all participants fully understood the study's conditions, those who chose to participate voluntarily were requested to sign a consent form.

All volunteers are selected from the untrained individuals. For the hedonic test, the criteria for choosing the panelists were determined based on the book 'Sensory Evaluation: A Practical Handbook' (Kemp et al., 2011). One hundred eighteen volunteers participated in this study, of which % 53 were female, and % 47 was male; all participants were aged between 17-48 years old and residing in İstanbul, Turkey.

Participants were seated in one room, preventing them from facing each other. The environment was carefully adjusted to ensure comfort regarding temperature, humidity, ventilation, noise, and lighting. Before the tasting began, an explanation of the test procedure was provided, and participants were informed that additional samples could be provided if necessary. The samples were labelled using a three-digit random code to maintain anonymity. Chicken and strawberry stuffed vine leaves are coded as 425, grilled chicken with strawberry and vine leaf salad as 429, and chicken and strawberry skewer with vine leaf pesto as 427. The average time to complete each evaluation was 5 minutes.

3.3. Statistical analysis

All collected data from the research were transferred to the analysis programs to make them suitable for analysis. IBM SPSS 25.0 and MS Excel programs were used to study the data obtained from the research. The acceptability test was carried out using a 9-point hedonic scale, anchored at the ends of 1 = "disliked extremely" to 9 = "liked extremely" for the following attributes: appearance, aroma, texture, taste, and general liking. The samples were accepted with grades ≥ 6.0 (Barbosa et al., 2023). The mean and standard deviation values are presented in Table 5. Pearson's correlations and principal component analysis were used to evaluate the relationship between the sensory attributes. Pearson correlation coefficient was used to determine the strength of the relationship by the criteria: ± 0.1 = weak, ± 0.3 = moderate and ± 0.7 = vigorous. $p < 0.05$ was considered statistically significant. All statistical tests were 2-tailed.

4. Results

All samples showed high sensory acceptance among participants regarding their appearance, taste, aroma, and texture, with the majority exhibiting average liking scores of approximately 7 (see Table 5). When evaluating the findings in Table 5, it can be concluded that the overall acceptability scores for all three products are close to the "like moderately" value. Although no standard recipes incorporate all three different ingredients together, it is still impressive that the general liking is high.

Table 5
Mean results of hedonic tasting

Dishes	Appearance	Taste	Aroma	Texture	Overall acceptability
427	6.14 \pm 1.83	6.78 \pm 1.53	6.88 \pm 1.69	6.52 \pm 1.60	6.58 \pm 1.61
429	6.75 \pm 1.77	7.81 \pm 0.97	7.16 \pm 1.16	7.36 \pm 1.09	7.53 \pm 0.87
425	6.49 \pm 1.88	7.25 \pm 1.30	7.31 \pm 1.58	6.71 \pm 1.69	7.12 \pm 1.16

Based on the hedonic evaluation of the "Chicken and strawberry skewer with vine leaf pesto," it can be observed that taste (6.14) and aroma (6.88) received the highest scores. Similarly, when examining the hedonic evaluation of the "Chicken and strawberry stuffed vine leaves," taste (7.25) and aroma (7.31) were the criteria with the highest scores. In the case of the hedonic evaluation of the "Grilled chicken with strawberry and vine leaf salad," taste (7.81) and overall acceptability (7.53) were identified as the criteria with the highest scores. Across all three products, appearance received the lowest score. This may be attributed to the fact that the products were presented solely as samples without paying attention to their presentation. When we compare the scores of 3 dishes, it is seen from Fig 1. that the dish with the highest liking scores is "grilled chicken with strawberry and vine leaf salad", coded 429. Although the rating score is not low, the dish with the lowest score is "chicken and strawberry skewer with vine leaf pesto".

Figure 1
Hedonic scores comparison of the recipes: taste, aroma, texture, appearance and general

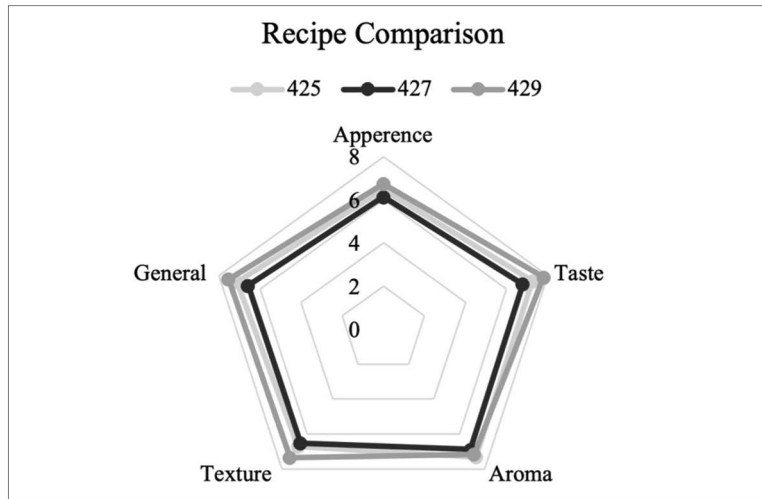


Table 6
Correlation coefficients of the relationship between sensory attributes in Sample 425 = Chicken and strawberry stuffed vine leaves, 427 = Chicken and strawberry skewer with vine leaf pesto, 429 = Grilled chicken with strawberry and vine leaf salad

Sample 425					
	Appearance	Taste	Aroma	Texture	General
Appearance		0.272**	0.542**	0.340**	0.679**
Taste	0.272**		0.596**	0.530**	0.699**
Aroma	0.542**	0.596**		0.531**	0.809**
Texture	0.340**	0.530**	0.531**		0.631**
General	0.679**	0.699**	0.809**	0.631**	
Sample 427					
Appearance		0.573**	0.560**	0.535**	0.742**
Taste	0.573**		0.595**	0.698**	0.849**
Aroma	0.560**	0.595**		0.687**	0.749**
Texture	0.535**	0.698**	0.687**		0.810**
General	0.742**	0.849**	0.749**	0.810**	
Sample 429					
Appearance		0.363**	0.111**	0.416**	0.584**
Taste	0.363**		0.306**	0.355**	0.778**
Aroma	0.111**	0.306**		0.207**	0.392**
Texture	0.535**	0.698**	0.687**		0.570**
General	0.584**	0.778**	0.392**	0.570**	

Correlation analysis showed that in all three samples, general liking of the product mostly correlated with taste and aroma. For sample 425, aroma and general liking (0.809) correlate most positively. For the sample 427, taste and general liking (0.849) has the most positive correlation. For the sample 429, taste and general liking (0.778) has the most positive correlation. Except for the sample 429 aroma and appearance, all the correlations were moderate (± 0.3) or strong (± 0.7)

5. Discussion and managerial implications

In this paper, we aim to measure whether chefs can use AI technologies efficiently as a tool in their culinary innovation process. The results showed that ChatGPT's recipes are acceptable in every dimension; thus, it is proven that assisted usage of ChatGPT can be beneficial. Also, the creative process of AI is quicker than

every possible technology for now, and the time limitation in culinary creativity is an important issue (Peng et al., 2013), AI seems to overcome this difficulty. Based on our research, the utilization of ChatGPT has the potential to assist innovations in culinary endeavors across various aspects, such as product development, cultural integration, and creative exploration, aligning with the core competency requirements outlined by Hu (2010). The table does not include human characteristics such as skill and positive perspective—the ChatGPT capabilities in these dimensions are summarized in Table 9.

Table 7
ChatGPT's observed capabilities in core competency dimensions

Hu's competency dimensions (2010)	Items	ChatGPT capabilities
Culture (9 items)	knowledge of ingredients' characteristics	Proposed cooking methods suited to selected ingredients
	knowledge of cooking culture	She suggested a traditional preparation method that was consistent with Turkish culinary knowledge.
	knowledge of the cultural history of the place of origin	It has not been tested
	knowledge of dietary habits	It has not been tested
Product (11 items)	knowledge of presenting products with an original flavour	The recipes created were new in flavour, and similar recipes couldn't be found
	knowledge of presenting healthy products	It has not been tested
	knowledge of products with a harmonious flavour	All recipes, in general, are highly accepted by our participants.
	Ability to create commercial products.	It has not been tested
	Ability to make products with a 'wow' feeling.	The originality of the recipes and flavours had a wow factor
	Ability to make products with vitality.	It has not been tested
Creativity (10 items)	Ability to make products safe and hygienic.	It has not been tested
	knowledge of basic culinary science	Suggested marination and cooking techniques show that it has basic scientific knowledge.
	knowledge of making decisions	It has not been tasted
	Ability to use divergent thinking.	Blending many cuisines and techniques showed divergent thinking
	Ability to find creative ideas.	All the recipes were creative and original, but since we listed the ingredients, there is a chance that it uses the same recipes for different people

Furthermore, we believe that artificial intelligence can mimic the creativity of chefs because creativity is primarily founded on knowledge and ways of new thinking. According to (Pinel & Varshney, 2014), culinary creation is merely about gathering data (knowledge, ingredients, techniques) and formulating combinations, which ChatGPT or any other artificial intelligence can do within a few seconds (Pinel et al., 2015). Also, instead of new materials or procedures, creativity is more closely tied to novel applications and combinations of new ingredients and techniques (Jimenez-Mavillard & Suarez, 2022). The general acceptance of the sensory evaluation results indicates the same outcome: we can use AI technologies to benefit chefs' creativity. For food companies and restaurant managers, it is also a technology to be celebrated since AI technologies can create a better climate for creativity, as it will support the idea incubation and development stages (Leung & Lin, 2018) suggested with no cost.

Upon examining the created recipes in detail, it has been observed that they are mostly consistent and reliable. However, it was noted that the recommended amount of 1/4 cup of olive oil in the pesto recipe was insufficient to achieve homogeneity with the other ingredients. Consequently, the pesto sauce did not blend properly. It is suggested that using 1/2 cup of olive oil instead of the recommended amount could yield better results. Furthermore, in the recipe "chicken and strawberry skewers with vine leaf pesto," the technique of skewering and grilling chicken and strawberries wrapped in vine leaves resembles the Turkish cuisine dish "sardine in vine leaves." However, incorporating vine leaves alongside basil in the pesto sauce within the same

recipe proves to be a wise choice regarding color harmony and as a cost-effective alternative to basil. Despite lacking the sharp taste and aroma of basil, the vine leaves do not overshadow the distinctive character of pesto sauce. It is impressive that artificial intelligence, which offers new suggestions by scanning the recipes on the internet while creating a recipe, gives a harmonious suggestion in this respect.

6. Conclusion and future research

In conclusion, this study only demonstrated the assistance of AI technologies and knowledge-based utilization. We do not believe this program would be highly beneficial without fundamental knowledge and skills. It seems that it can only be a valuable tool for skilled professionals.

In this study, the command we gave to ChatGPT was creating a recipe based on three ingredients. For further studies, ChatGPT can be restricted and commanded, including techniques that want to be implemented, style or origin of cuisine, and menu style or type depending on the needs of the chefs. Chefs can upload their pantry and create seasonal or timely menus for their restaurants or special events. Any restaurant's concepts and styles can be introduced, and they can be asked to accommodate any specific style.

For the recipe creation and innovation process, a more detailed analysis can be done with an integrated restaurant business, including management practices, employee productivity, forecasting, benchmarking, etc. Gaining a larger market share and venturing into new markets has become more accessible for restaurant establishments, courtesy of innovative applications (Bertan, 2020).

Furthermore, culinary curriculums might benefit from artificial intelligence (AI) supported courses to encourage future chefs to cultivate a creative mindset towards designing sustainable menus, zero-waste kitchen practices and food waste management. The transition to more intelligent food systems using artificial intelligence (AI) is already recognized as one of the most potent tools for solving complicated issues and carrying out various tasks. Implementing these tools in gastronomy education might help design better food systems with diverse, innovative food products to meet future consumer needs.

The number of studies on using ChatGPT (or other artificial intelligence tools) for gastronomy is relatively low. This research is a pioneering study that measures the reliability and ability of artificial intelligence in creating recipes, which is a culinary creativity process. It is thought that the literature can be enriched with studies such as using different artificial intelligence models in other areas for gastronomy (for example, the use for restaurant design concept creation) in future studies.

Practical implications

- Incorporating artificial intelligence is believed to enhance the creative aspects of professional chefs during the culinary process.
- AI may be a supportive tool for chefs, allowing them to cultivate and enhance novel culinary perspectives.
- There is potential for AI to streamline the ideation phase, thus saving significant time and expediting the creative process.
- AI can contribute to creating comprehensive concepts and menus tailored to specific preferences and ingredients.
- Its application extends to designing food products that are functional, healthier, generate zero waste, and align with sustainability goals.
- AI can also play a role in crafting sustainable systems for food production.

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