

Ethical Implications of AI in Food Technology: An Analysis of Let's Foodie

Addressing Bias, Fairness, and Cultural Sensitivity in AI-Powered Culinary Recommendations

MEREDITH, K, SALOIS

NINA, A, WERNICK

The integration of artificial intelligence (AI) into food technology, exemplified by the AI-powered platform Let's Foodie, promises enhanced personalisation and innovation in culinary experiences. However, this advancement raises significant ethical concerns, particularly around bias, fairness, transparency, and cultural sensitivity. This paper presents a comprehensive audit of Let's Foodie's AI system, focusing on its recipe recommendation algorithms. Our findings reveal substantial biases in the training data, a lack of cultural sensitivity, and limited dietary inclusiveness, leading to inequitable user experiences. We propose a multifaceted approach to mitigate these ethical risks, including enhancing data diversity, implementing cultural sensitivity checks, improving algorithmic fairness, and integrating robust user feedback mechanisms. By addressing these ethical challenges, Let's Foodie can provide more inclusive and respectful culinary recommendations, aligning with global standards for ethical AI practices and fostering greater user trust and satisfaction.

1 INTRODUCTION: ETHICAL ISSUES IN AI AND THEIR IMPLICATIONS FOR FOOD TECHNOLOGY

The introduction of artificial intelligence (AI) has transformed several industries, creating new prospects for innovation and efficiency. However, this fast progress raises crucial ethical concerns that must be carefully considered. The ethical concerns in AI are broadly defined as bias, fairness, transparency, and responsibility. These challenges are significant in AI applications requiring decision-making and customisation, where biases in data or algorithms might result in unfair or harmful consequences.

One of the most pressing ethical challenges in AI is prejudice, which may take many forms, including racial, gender, and cultural. These biases can exacerbate pre-existing disparities and are frequently the result of unrepresentative training data or poor algorithmic design. For example, AI systems trained on biased datasets may generate skewed findings penalising specific populations. Fairness in AI means ensuring these systems work impartially and produce equitable user results. Transparency and accountability are also crucial because consumers must understand how AI systems make decisions and who is responsible. Discovering and correcting biases or errors is difficult without transparency, undermining trust in AI technology.

In food technology, these ethical considerations take on new dimensions. Let's Foodie, an AI-powered platform that provides personalised recipes, must handle the complications of cultural sensitivity, data bias, and dietary limitations. Let's Foodie promises to improve culinary experiences by personalising recommendations to individual interests; however, this technique raises serious ethical concerns.


One specific concern is potential cultural insensitivity. AI systems may unintentionally promote culturally unsuitable or insulting recipes if not adequately developed. For example, offering a beef-based dish to someone from a culture where meat intake is prohibited would be disrespectful and damage the user's faith in the platform. Maintaining cultural sensitivity necessitates a thorough awareness of varied culinary traditions and the circumstances in which different meals are consumed.

Data bias is another major problem. Let's Foodie's ingredient and recipe databases must be inclusive to reflect worldwide culinary habits correctly. If the training data is primarily about Western cuisines, the AI's suggestions likely reflect this bias, marginalising non-Western culinary traditions. This lack of representation may alienate people from various ethnic origins while failing to suit their gastronomic demands and preferences. The implications of this are immense because the lack of diversity could imply certain cultures are not valuable enough to have their food shown or that dietary restrictions are not worth working around. Similar studies have emphasised the need for different datasets to reduce bias and improve the inclusivity of AI systems. For example, research in AI-driven healthcare has demonstrated that varied training data enhances diagnostic algorithm accuracy and fairness across different demographic groups.

Furthermore, Let's Foodie's customisation algorithm must consider dietary limitations frequently based on cultural, religious, or health-related habits. A successful customisation system must correctly analyse user profiles and preferences to prevent offering inappropriate recipes. This requires advanced algorithms capable of comprehending intricate dietary limitations and tailoring suggestions appropriately. Previous research has underlined the significance of flexibility in AI systems to guarantee that they meet individual requirements while maintaining ethical norms.

In summary, although AI provides excellent opportunities for individualised culinary experiences, it also raises substantial ethical concerns that must be addressed. Let's Foodie, like other AI-powered platforms, must manage concerns of cultural sensitivity, data bias, and dietary limitations to give fair, courteous, and inclusive suggestions. Let's Foodie may improve its AI system's credibility by drawing on current research and adopting strict ethical rules, resulting in a more equal and respectful implementation of AI in food technology.

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2 DETAILED DESCRIPTION

Artificial intelligence has revolutionised many industries by enabling automation and enhancing decision-making capabilities. However, these advancements also raise important ethical questions. Let's Foodie has several high-level ethical issues manifesting in its development and operation, particularly regarding bias, fairness, transparency, and cultural sensitivity.

2.1 High-Level Ethical Issues

2.1.1 Bias and Fairness: Bias in AI systems can arise from unrepresentative training data or flawed algorithmic design. In the case of Let's Foodie, bias might result from a recipe and ingredient database that predominantly features Western cuisines, thereby marginalising non-Western culinary traditions. This bias can lead to unfair recommendations that do not cater to diverse users.

2.1.2 Transparency: Transparency is needed so users can understand how AI systems make decisions. We also need transparency to identify and correct biases or errors. Let's Foodie must ensure users comprehend how their personalised recommendations are generated, fostering trust and accountability.

2.1.3 Cultural Sensitivity: Ensuring cultural sensitivity is essential for AI systems that generate content involving cultural traditions, such as recipes. If Let's Foodie shares recipes offensive to particular cultures, it could lose user trust and alienate some communities.

2.1.4 Dietary Inclusiveness: The system must be well-equipped to handle diverse nutritional requirements and restrictions. Ignoring dietary preferences may result in inappropriate and dangerous recommendations.

2.2 TECHNICAL MANIFESTATIONS OF ETHICAL ISSUES

2.2.1 Training Data Bias: The primary source of bias in Let's Foodie is the training data used to develop its algorithms. The AI will produce biased outputs if the dataset is skewed towards specific cuisines or ingredients. For instance, a database heavily weighted towards Western recipes will likely result in recommendations that do not adequately represent global culinary practices.

2.2.2 Algorithm Design: The design of the recommendation algorithm plays a critical role in how well it can adapt to diverse cultural recipes and dietary restrictions. An algorithm that does not incorporate diverse culinary data may fail to recognise the significance of non-Western ingredients or cooking methods, resulting in a lack of inclusivity in the AI's suggestions.

2.2.3 User Profile Personalisation: Personalisation algorithms must account for user preferences and restrictions. If the algorithm is not sophisticated enough to differentiate between dietary needs (e.g., gluten-free, vegan, kosher), it might provide unsuitable recommendations, compromising user trust.

2.2.4 Cultural Sensitivity in Recommendations: The AI system should be designed to prevent culturally insensitive recommendations. This requires avoiding ingredients that are forbidden in certain cultures. For example, recommending a pork-based recipe to someone from a culture prohibiting pork would be unacceptable.

2.3 EXAMPLES AND IMPLEMENTATION IN LET'S FOODIE

2.3.1 Data Collection and Diversity: To mitigate data bias, Let's Foodie needs to include a broad dataset that accurately reflects global culinary habits. This means actively seeking out recipes and ingredients from a wide range of cultures and ensuring that the dataset is balanced regarding representation.

2.3.2 Algorithm Adaptation: The algorithm's suggestions must accommodate various dietary requirements and ethnic recipes. For example, it should be able to convert traditional French cuisine into a vegan one or offer a gluten-free version of a typical Italian pasta dish while maintaining the original flavours and integrity.

2.3.3 User Profile Management: User profiles should be detailed and comprehensive, capturing dietary preferences and cultural and regional culinary habits. This can be achieved by allowing users to input their dietary restrictions and cultural preferences, which the AI can use to tailor its recommendations.

2.3.4 Cultural Sensitivity Checks: Implementing cultural sensitivity checks involves external validation or consultation with culinary and cultural experts to ensure the AI's recommendations are respectful and appropriate. This could involve periodic reviews of the AI's output by a diverse panel of experts to catch any culturally insensitive suggestions.

Addressing these high-level ethical issues in developing and operating Let's Foodie's AI system is crucial for ensuring that the platform provides fair, inclusive, and culturally sensitive recommendations. By linking these ethical concerns to specific technical aspects, we can identify and implement strategies to mitigate potential biases and enhance the overall user experience.

3 REVIEW CURRENT APPROACHES TO AI AUDITING

3.1 KEY WORKS AND PROJECTS IN AI AUDITING

3.1.1 Design for Fairness in AI: Cooking a Fair AI Dish¹

- **Overview:** This thesis emphasises integrating fairness and ethical principles into AI development. The focus is bridging the gap between abstract ethical concepts and practical implementation in AI systems.
- **Methodology:** Simons proposes a framework that includes:
 - **Data Diversity Analysis:** Ensuring the training data is diverse and representative.
 - **Algorithmic Fairness Testing:** Evaluating algorithms for biases by simulating their outputs.
 - **Ethical Coaching:** Introducing an organisational role to support AI teams in creating fairer AI systems using a modular toolkit.
- **Relevance to Let's Foodie:** This framework can be adapted to evaluate the fairness of Let's Foodie's recipe recommendations, ensuring the AI system provides equitable suggestions for all users.

3.1.2 A Survey on Bias and Fairness in Machine Learning²

- **Overview:** This comprehensive survey categorises various types of bias in AI systems and provides insights into mitigating them.
- **Methodology:** The paper outlines biases in data, algorithms, and user interactions and discusses:
 - **Measurement Bias:** Bias from how data is collected and measured.
 - **Representation Bias:** Bias from non-representative samples.
 - **Algorithmic Bias:** Bias from design choices in algorithms.
- **Relevance to Let's Foodie:** By understanding these biases, Let's Foodie can implement strategies to minimise them, such as ensuring a representative dataset and reviewing algorithm design choices to avoid perpetuating existing biases.

3.1.3 Fairness in Design: A Tool for Guidance in Ethical Artificial Intelligence Design³

- **Overview:** This paper introduces tools and frameworks to guide the ethical design of AI systems, focusing on fairness and accountability.
- **Methodology:** It suggests methods such as:
 - **Value-Sensitive Design:** Incorporating stakeholders' values throughout the design process.
 - **Disparate Impact Analysis:** Assessing and mitigating the unequal impact of AI decisions on different demographic groups.
- **Relevance to Let's Foodie:** Implementing value-sensitive design can help ensure the AI respects diverse cultural and dietary values. At the same time, disparate impact analysis can prevent unequal treatment of different user groups.

3.2 POTENTIAL SOLUTIONS FOR LET'S FOODIE

Given the absence of direct solutions in the food technology domain, approaches from other fields can be adapted to address the ethical issues in Let's Foodie.

3.2.1 Adapted Data Diversity Analysis:

¹ (Simons, 2019)

² (Mehrabi et al., 2019)

³ (Shu et al., 2021)

- Implementation: Increase the variety of cultural and dietary representations in the ingredient and recipe databases. Update the database frequently to reflect recent trends and practices in international cuisine.
- Expected Outcome: This will mitigate bias in the AI's recommendations, ensuring a more inclusive representation of global cuisines.

3.2.2 Algorithmic Fairness Testing:

- Implementation: Develop tests to evaluate the AI's outputs for bias. For example, create test cases incorporating various cultural and dietary preferences and assess the AI's ability to offer suitable recommendations.
- Expected Outcome: Let's Foodie can ensure fairer and more equitable recipe suggestions by identifying and correcting algorithm biases.

3.2.3 User Feedback Integration:

- Implementation: Establish a feedback system allowing users to rate the AI's recommendations. Utilise these suggestions to hone and continuously enhance the AI's performance.
- Expected Outcome: A feedback-driven approach will help the AI system adapt to user needs more effectively, enhancing its personalisation capabilities.

3.2.4 Cultural Sensitivity Audit:

- Implementation: Regularly review the AI's recommendations for cultural appropriateness. Consult with culinary and cultural experts to validate the recipes and ensure they respect cultural norms.
- Expected Outcome: This should prevent culturally insensitive recommendations, thus fostering greater user satisfaction.

3.2.5 Sustainability Assessment:

- Implementation: Evaluate the environmental impact of the recommended recipes, promoting sustainable cooking practices.
- Expected Outcome: Encouraging sustainability will enhance the ethical standing of Let's Foodie and attract environmentally conscious users.

By reviewing and adapting current approaches to AI auditing, Let's Foodie can address the ethical issues of bias, fairness, transparency, and cultural sensitivity. Implementing these methodologies will ensure that the AI system provides equitable, respectful, and personalised recipe recommendations, ultimately enhancing the user experience.

4 METHODOLOGY FOR AUDITING

To ensure a complete and comprehensive audit of AI-generated recipes, we will apply a precise and systematic process that includes four essential components: data review, algorithm testing, user profile evaluation, and a cultural sensitivity assessment.

The data evaluation procedure thoroughly examines the diversity and inclusivity of the ingredient and recipe database. This will be accomplished by utilising precise metrics and criteria to assess the representation of other ethnicities, dietary requirements, and ingredient diversity. Our goal is to discover gaps or biases in the present database by analysing the breadth and depth of the components and recipes. This procedure will entail comparing ingredient variety to worldwide dietary statistics to ensure complete coverage. For example, we will look at the prevalence of staple components from other cuisines, such as South American quinoa and potatoes, East Asian soy products, and a range of Indian spices and legumes. This detailed assessment will help us understand how well the database accommodates varied ethnic eating patterns and identify areas for improvement.

The next phase is algorithm testing, which involves evaluating AI-generated recipes' uniqueness, practicality, and cultural sensitivity. This review will employ factors such as balance, feasibility, and appeal to ensure that the recipes are novel, practicable, and appealing to a wide range of users. We will simulate

numerous culinary conditions and dietary requirements to assess the AI's capacity to develop unique and practical recipes. For example, the AI's capacity to convert a traditional Italian pasta dish to gluten-free or produce a vegan version of a traditionally French meal would be rigorously evaluated. By doing so, we will determine if the AI can preserve the flavour and attractiveness of these foods while making them accessible to persons with special dietary needs.

User profile evaluation is a vital component that involves creating and evaluating various user profiles to determine the efficiency of tailored suggestions. We will create user profiles that reflect multiple cultures, nutritional preferences, and culinary abilities worldwide. To assess the AI's ability to recommend culturally appropriate and appealing recipes, ingredients commonly used in various cultures will be entered, such as rice, beans, and corn for Latin American profiles, lentils, chickpeas, and spices for South Asian profiles, and fish, soy, and rice for East Asian profiles. The review will use quantitative measures, such as user satisfaction scores and qualitative user comments. By considering varied culinary histories and nutritional habits, we will ensure that the AI can cater to various personal tastes and cultural preferences, increasing its value and relevance across areas and cultures.

Finally, the cultural sensitivity assessment will include a comprehensive examination of recipes to verify that they are culturally suitable. This process will entail external validation or consultation with culinary specialists and cultural academics to ensure the recipes adhere to cultural standards and customs. We will pay close attention to the context in which ingredients and cooking processes are employed, ensuring that the AI does not accidentally develop recipes perceived as insensitive or unsuitable. For example, particular foods or cooking procedures may have significant cultural or religious meanings that must be observed. Working with specialists from diverse cultural backgrounds will help us guarantee that the AI's suggestions reflect and appreciate cultural variety.

Our multimodal auditing procedure will thoroughly analyse the AI-generated recipes' inclusivity and cultural sensitivity, ensuring they fulfil high diversity, practicality, and appeal requirements. This thorough technique will improve the AI's output quality and promote higher user pleasure and cultural respect, making the AI a valued tool for users worldwide.

5 CONDUCT THE ETHICS AUDIT AND DESCRIBE THE FINDINGS

5.1 Step-by-Step Audit

The first stage in our audit was a thorough assessment of Let's Foodie's ingredient and recipe database to ensure its diversity and inclusion. We examined the representation of various ethnic cuisines and nutritional requirements to detect any biases in the dataset. This audit was critical for understanding the breadth and depth of the database's ingredients and recipes and ensuring they accurately reflected worldwide culinary traditions.

Next, we assessed the AI-generated recipes' novelty, practicality, and cultural sensitivity. This phase involved modelling a variety of culinary settings and dietary requirements to determine the AI's capacity to develop culturally suitable and appealing dishes. Our objective was to see if the AI could modify classic dishes to satisfy specific dietary requirements while preserving the original flavours and integrity.

We then examined many potential demands, including vegan, vegetarian, halal, lactose sensitivity, and gluten-free. This test is intended to determine the AI's ability to tailor suggestions to various human tastes and cultural backgrounds. We wanted to see if the AI could handle a wide range of personal preferences and cultural norms by assessing user satisfaction ratings and qualitative feedback.

Finally, we meticulously analysed the AI-generated recipes to ensure cultural appropriateness. This approach requires checking with a range of various recipes online to determine which meals are true to that specific culture. We rated these recipes on a scale of 1 (not authentic) to 5 (extremely authentic).

5.2 Compiling Findings

The findings from our data collection audit revealed several insights into the ingredient and recipe database:

- **Culinary Representation:** The dataset predominantly features Western cuisines, with limited representation of non-Western culinary traditions.
- **Dietary Inclusiveness:** There is a lack of diverse dietary options, particularly for vegan, gluten-free, and culturally specific diets.

Table 1: Data Collection Audit Table

Cuisine	Number of Recipes
American	81
Asian	10
Italian	7
Latinx	7
Middle Eastern	6
Indian	5
African	3
General European	2
Mediterranean	1

During our algorithm testing phase, we discovered many important issues:

- **Bias in Recommendations:** The AI tended to propose dishes from Western cuisines, indicating a bias in the training data.

- **Practicality of Suggested Recipes:** Although recipes tended to be practical and realistic, there were times when the AI failed to adjust classic dishes to satisfy specific nutritional demands appropriately. Or it suggested dishes that were not actual recipes, like basil leaf-infused oil or sauteed vegetables.

The study of recipe authenticity revealed more indications of prejudice and inclusion issues:

- **Cultural Appropriateness:** The AI struggled to provide culturally relevant suggestions for non-Western user profiles, such as offering beef-based foods to profiles where beef intake is considered culturally incorrect.
- **User Satisfaction:** User satisfaction scores revealed a lower satisfaction rate among users from non-Western backgrounds, indicating the algorithm's bias.

Table 2: Authentication Scores Table

Cuisine	Score Average
Italian	4.11
American	3.92
Middle Eastern	3.5
Asian	3.35
Indian	3.16
African	2.5
Latinx	2.47
General European	2

The cultural authenticity study revealed substantial reservations about the AI's recommendations. In some instances, the AI offered culturally inappropriate recipes, such as pig-based foods, mixed with countries where pork is outlawed. Many cultures were barely even represented, even when ingredients specific to those cultures were submitted. Often, these ingredients only produced Western recipes. Culinary experts acknowledged that several dishes violated cultural norms and customs, highlighting the need for more cultural sensitivity inspections.⁴

5.3 Additional Findings

There were some potential algorithm difficulties. The AI showed difficulties altering traditional dishes to satisfy specific dietary requirements while maintaining authenticity. For example, AI-generated vegan versions of typically meat-based foods sometimes lacked the intricacy and richness of flavour inherent in the original recipes.

- **Data Representation Gaps:** The AI generation did not represent certain cuisines well. For example, African and Latinx dishes were underrepresented, perhaps leading to the marginalisation of people from these cultures.
- **Ingredient Availability:** Some AI-generated recipes included components not widely accessible in specific places, making it impossible for people to attempt them. This impacts the suggestions' practicality and accessibility.

By solving these difficulties, Let's Foodie may improve its AI system and provide more varied, inclusive, and culturally sensitive culinary recommendations. This enhancement will assist in increasing user trust and happiness and ensure that the platform caters to a worldwide audience with diverse dietary demands and cultural preferences.

6 PRESENT FINDINGS AND CONCLUSIONS

6.1 Discussion of Findings

The ethics audit of the Let's Foodie AI Recipe Generator revealed several significant ethical issues, primarily revolving around data bias, cultural sensitivity, and dietary inclusiveness. The initial ethical concerns identified were indeed substantiated through the audit, indicating both ethical risks and areas needing compliance improvements.

⁴ (Letourneau & Pigeon, 2023)

- **Data Bias and Representation:** The audit confirmed a substantial recipe and ingredient database bias. The database predominantly features Western cuisines and lacks adequate representation of non-Western culinary traditions. This bias directly affects the AI's ability to provide equitable and diverse recipe recommendations. Users from non-Western backgrounds reported lower satisfaction scores, underscoring the need for a more inclusive dataset.
- **Cultural Sensitivity:** The AI demonstrated a need for more cultural awareness in its recipe suggestions. Instances of the AI recommending culturally inappropriate dishes highlighted the AI's insensitivity. This issue is critical as it can alienate users and erode trust in the platform.
- **Dietary Inclusiveness:** The AI struggled to adapt recipes to meet diverse dietary needs. Although it could generate practical recipes, the variations often lacked authenticity. This was especially true for diets requiring significant alterations, like vegan or gluten-free versions of traditionally meat-based dishes.
- **Algorithm Bias:** The algorithmic bias was evident in the recommendations' predominance of Western dishes. This bias suggests that the AI's training data and algorithm design do not sufficiently account for a global user base's diverse culinary practices and dietary restrictions.

6.2 Conclusions and Recommendations

The audit revealed critical ethical risks related to data bias, cultural insensitivity, and dietary exclusivity. These issues undermine the AI's inclusivity, leading to a user experience that does not adequately cater to diverse cultural and nutritional needs.

Recommendations for Mitigating Ethical Risks:

1. **Enhance Data Diversity:** Expand the recipe and ingredient database to include a broader range of cuisines and dietary practices. Actively seek out and incorporate recipes from underrepresented cultures to ensure the AI can provide more inclusive recommendations.
2. **Implement Cultural Sensitivity Checks:** Develop a framework for cultural sensitivity validation involving consultations with culinary and cultural experts. Regularly review the AI's output to ensure it respects cultural norms and does not produce offensive or inappropriate recommendations.
3. **Improve Algorithm Fairness:** Conduct rigorous algorithmic fairness testing to identify and correct biases. Develop test cases that reflect diverse user-profiles and dietary needs to ensure the AI can provide equitable and practical recommendations for all users.
4. **User Feedback Integration:** Establish a robust feedback system where users can rate and comment on the AI's recommendations. Use this feedback to refine and continuously improve the AI's performance and inclusivity.
5. **Regulatory Compliance:** Ensure the AI system complies with relevant regulations and ethical guidelines. For example, adhering to the principles outlined in the AI Ethics Guidelines by the European Commission and the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems can provide a robust ethical framework.
6. **Link to Regulations and Guidelines:** The findings align with ethical guidelines emphasising fairness, transparency, and inclusivity in AI systems. Ensuring compliance with these regulations mitigates ethical risks and enhances user satisfaction.

By addressing these ethical issues, Let's Foodie can significantly improve its AI system, providing fair, culturally sensitive, and inclusive culinary recommendations. This will enhance the user experience and align the platform with ethical AI practices, fostering greater trust and adoption amongst a global user base.

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APPENDICES

A.3 Detailed Excel Dataset Analysis

Please see the attached excel dataset we used for the audit.