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Plant and soil science perspectives on food allergies: Biological and chemical influences

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Abstract
Food allergies are a growing public health concern, with increasing prevalence and severity in many populations worldwide. This comprehensive review examines the biological and chemical factors influencing food allergies from a plant and soil science perspective. We explore how agricultural practices, soil health, plant physiology, and environmental contaminants contribute to allergenic potential in food crops. The review delves into the genetic modification of crops, plant physiology, and how these influence the production of allergenic proteins. Additionally, it addresses the impact of soil health and environmental contaminants on allergenicity. We discuss the implications of these factors on human health, highlighting the critical need for sustainable agricultural practices and robust monitoring systems. The review also outlines potential strategies for mitigating allergenicity through breeding hypoallergenic crops, improving soil health, and reducing environmental contaminants. These interventions aim to reduce the prevalence and severity of food allergies, contributing to safer and healthier food systems.

Keywords: Plants, Soil., food pathogens, public health, agriculture, environmental and chemical factors

Introduction

Food allergies, characterized by adverse immune responses to specific food proteins, affect millions of people globally. The incidence of food allergies has been rising, leading to significant public health concerns. Symptoms range from mild reactions, such as hives and digestive issues, to severe and potentially life-threatening anaphylaxis. Understanding the factors contributing to the increasing prevalence and severity of food allergies is essential for developing effective prevention and management strategies [1-3]. The complexity of food allergies involves various biological and chemical factors, including genetic predisposition, immune system responses, and environmental influences. This review focuses on the intersection of plant and soil science with food allergy research, highlighting how agricultural practices and environmental conditions contribute to the allergenic potential of food crops. By examining these factors, we aim to provide insights into mitigating food allergenicity and improving food safety. Food allergies represent a significant and growing public health concern worldwide, affecting individuals of all ages and backgrounds [4-6]. Defined as adverse immune responses to specific proteins in food, allergies can range from mild symptoms to severe and potentially life-threatening reactions, such as anaphylaxis. The prevalence of food allergies has notably increased over recent decades, with substantial implications for healthcare systems, food industries, and individuals' quality of life. The rise in food allergies is multifactorial, influenced by genetic predispositions, environmental exposures, dietary habits, and broader societal changes. While the exact reasons for this increase are complex and not entirely understood, various hypotheses point to interactions between genetic susceptibility and environmental factors. Understanding food allergenicity's biological and chemical determinants is crucial for developing effective prevention, diagnostic, and management strategies [7-9]. This comprehensive review focuses on the intersection of plant and soil sciences with food allergy research. It explores how agricultural practices, soil health, plant physiology, and environmental contaminants contribute to the allergenic potential of food crops.

By examining these factors, we aim to provide a nuanced understanding of how food allergens are produced, regulated, and managed in agricultural systems.

Genetic and Molecular Basis of Food Allergens

Food allergens are typically proteins that trigger specific immune responses in susceptible individuals. The genetic composition of food crops plays a critical role in determining their allergenic potential. Advances in genetic engineering and molecular biology have enabled researchers to identify and manipulate genes responsible for producing allergenic proteins in crops. Techniques such as CRISPR-Cas9 offer precise tools for modifying allergen-related genes, potentially leading to the development of hypoallergenic crop varieties [10].

Genetically modified (GM) crops, designed to enhance traits such as pest resistance or nutritional content, have raised concerns about unintended increases in allergenicity. Studies have shown that certain GM crops may express higher levels of allergenic proteins compared to their non-modified counterparts. Understanding the molecular mechanisms underlying allergen production in GM crops is essential for assessing their safety and regulatory approval [11].

Environmental Influences on Allergenicity

Environmental factors significantly influence the allergenic potential of food crops. Soil health, nutrient availability, water availability, and climate conditions can all impact plant growth and stress responses, which in turn affect allergen production. For example, nitrogen and sulfur availability in soil can influence the synthesis of allergenic proteins in crops. Sustainable soil management practices, such as organic farming and crop rotation, have been shown to reduce allergenic potential by promoting healthier plant growth and minimizing stress-induced allergen production. Moreover, environmental contaminants, including pesticides, herbicides, and industrial pollutants, pose additional challenges to food safety and allergenicity [12]. These chemicals can induce stress responses in plants, leading to increased production of allergenic proteins. Residues of pesticides on food products may also directly exacerbate allergic reactions in sensitive individuals. Evaluating the impact of environmental contaminants on food allergenicity is crucial for developing regulatory measures and sustainable agricultural practices that minimize risks to human health.

Challenges and Opportunities in Food Allergy Research

Despite significant advances in understanding food allergies, several challenges remain in mitigating their impact. The complex nature of allergic reactions, variability in individual sensitivities, and the evolving landscape of agricultural practices necessitate ongoing research and collaboration across disciplines. Integrating genetic, physiological, and environmental approaches is essential for developing holistic strategies to reduce allergenic potential in food crops. This review synthesizes current knowledge and identifies gaps in understanding the biological and chemical factors influencing food allergenicity. It underscores the importance of interdisciplinary research efforts to address the multifaceted challenges posed by food allergies. By fostering collaborations between plant scientists, allergists, agronomists, and public health experts, we can advance towards safer and more sustainable food systems that prioritize consumer safety and wellbeing. In the following sections, we delve into specific biological and chemical factors influencing food allergens, examining their roles, mechanisms, and implications for food allergy management. We also discuss emerging technologies and strategies aimed at mitigating allergenicity in food crops, emphasizing the potential for innovation and sustainable practices in ensuring food safety for all individualsextended introduction provides a broader context for understanding the complexities of food allergies and sets the stage for exploring the detailed biological and chemical factors influencing allergenicity in food crops [13-14].

Biological Factors

1. Genetic Modification and Crop Varieties

The genetic composition of food crops plays a critical role in their allergenic potential. Genetic modification, aimed at improving crop yield, pest resistance, or nutritional content, can inadvertently increase allergenicity. Certain genetically modified (GM) crops have been found to exhibit higher levels of allergenic proteins compared to their non-GM counterparts. This is due to the introduction or overexpression of proteins that can act as allergens.

For example, GM soybeans designed to be resistant to pests may express higher levels of certain proteins that are recognized as allergens by the human immune system. Similarly, other crops modified for enhanced nutritional content may unintentionally produce allergenic proteins. Understanding the genetic basis of allergenicity is essential for developing hypoallergenic crop varieties. Advanced genetic techniques, such as CRISPR-Cas9, allow for precise modification of allergen-related genes, potentially reducing allergenic proteins in crops.

2. Plant Physiology and Protein Expression

Plants produce a variety of proteins, some of which are recognized as allergens by the human immune system. The expression levels of these proteins can be influenced by plant stress, environmental conditions, and developmental stages. For instance, certain allergens are upregulated in response to drought, pest attacks, or nutrient deficiencies. Research into plant physiology can help identify critical stages and conditions that enhance allergen production [15-16]. Plant stress responses, such as those triggered by environmental factors, can lead to increased production of allergenic proteins. For example, drought conditions can cause plants to produce more stress-related proteins, some of which may be allergenic. Similarly, pest attacks can induce defensive proteins that also serve as allergens. Understanding these physiological responses is crucial for developing strategies to mitigate allergen production in crops [17-18].

Chemical Factors

1. Soil Health and Nutrient Management

Soil health significantly impacts the nutritional and allergenic profiles of food crops. Nutrient availability, particularly nitrogen and sulfur, affects protein synthesis in plants, including allergenic proteins. Sustainable soil management practices, such as crop rotation, organic amendments, and reduced chemical inputs, can influence the concentration of allergens in crops. Studies have shown that organic farming practices tend to produce crops with lower allergenic potential [19-21]. Healthy soils with balanced nutrient profiles support optimal plant growth and reduce stress, thereby minimizing the production of stress-related allergenic proteins. For instance, nitrogen-rich soils promote healthy plant development, reducing the need for plants to produce defensive proteins. Additionally, organic amendments, such as compost and biochar, improve soil structure and microbial activity, further supporting healthy plant growth and reducing allergenicity [22-24].

2. Environmental Contaminants

Pesticides, herbicides, and other environmental contaminants can alter the allergenic properties of food crops. These chemicals may induce stress responses in plants, leading to increased production of allergenic proteins. Additionally, residues of these chemicals on food products can directly affect human health. Evaluating the impact of environmental contaminants on allergenicity is crucial for developing safer agricultural practices [25].

The use of chemical inputs in agriculture can have unintended consequences on the allergenic potential of crops. Pesticides and herbicides may induce stress responses in plants, resulting in the production of allergenic proteins. Furthermore, residues of these chemicals on food products can exacerbate allergic reactions in sensitive individuals. Reducing the reliance on chemical inputs and promoting integrated pest management (IPM) practices can help mitigate these risks [26].

Implications for Human Health

Understanding the biological and chemical factors influencing food allergies from a plant and soil science perspective has significant implications for public health. Identifying and mitigating allergenic triggers in food production can reduce the prevalence and severity of food allergies. Strategies such as breeding hypoallergenic crops, improving soil health, and minimizing environmental contaminants can contribute to safer food systems.

The increasing prevalence of food allergies necessitates a comprehensive approach to food production that considers allergenicity. By addressing the biological and chemical factors that influence allergen production in crops, we can develop safer agricultural practices and reduce the burden of food allergies on public health. Implementing these strategies requires collaboration between plant scientists, agronomists, geneticists, and public health experts [27].

Mitigation Strategies

1. Breeding and Genetic Engineering

Developing hypoallergenic crop varieties through traditional breeding or genetic engineering is a promising approach. Techniques such as CRISPR-Cas9 allow for precise modification of allergen-related genes. Collaborative efforts between plant scientists, geneticists, and allergists are essential for successful implementation.

Breeding programs aimed at reducing allergenicity can focus on selecting varieties with lower levels of allergenic proteins. Genetic engineering offers a more targeted approach, enabling the precise removal or modification of allergenic genes. These strategies require extensive research and testing to ensure the safety and efficacy of hypoallergenic crops [28].

2. Sustainable Agricultural Practices

Promoting sustainable agricultural practices that enhance soil health and reduce chemical inputs can lower the allergenic potential of crops. Practices such as cover cropping, organic farming, and integrated pest management contribute to healthier crops and reduced allergenicity. Sustainable farming practices improve soil health and reduce plant stress, thereby minimizing the production of allergenic proteins. Cover cropping and organic amendments enhance soil structure and nutrient availability, supporting robust plant growth. Integrated pest management reduces the reliance on chemical inputs, mitigating the impact of environmental contaminants on allergenicity [29].

3. Monitoring and Regulation

Implementing stringent monitoring and regulatory frameworks for genetically modified crops and environmental contaminants can help ensure food safety. Regular screening for food products' allergenic proteins and chemical residues is vital for protecting public health. Effective monitoring systems are essential for identifying and mitigating allergenic risks in food production. Regulatory frameworks should enforce rigorous testing of genetically modified crops for allergenicity. Additionally, monitoring the presence of chemical residues on food products can help prevent allergic reactions in sensitive individuals [31-50]. This table summarizes key studies and their findings related to biological and chemical factors influencing food allergies, highlighting their implications and relevance to food allergenicity from a plant and soil science perspective.

Table 1: Key Studies on Biological and Chemical Factors Influencing Food Allergies

Study	Focus	Key Findings	Implications for Food Allergies
Sicherer & Sampson (2014) [1]	Epidemiology of food allergies	Increasing prevalence of food allergies; genetic and environmental factors	Highlights the growing public health concern
Boyce *et al*. (2010)	Guidelines for food allergy diagnosis	Standardized guidelines for diagnosis and management of food allergies	Essential for consistent clinical practice
Sicherer & Sampson (2006) [4]	Food allergy overview	Pathogenesis, diagnosis, and treatment of food allergies	Comprehensive resource for understanding food allergies
Brough *et al*. (2015) [8]	Atopic dermatitis and food allergies	Atopic dermatitis increases sensitization to peanut antigen	Shows interaction between skin conditions and allergies
Savage *et al*. (2016) [9]	Histamine intolerance	Complexities in understanding histamine intolerance	Emphasizes need for further research
Luo *et al*. (2018) [11]	Genetic modification and allergens	GM crops can have higher allergenic protein levels	Importance of genetic screening in GM crops
Smith *et al*. (2019) [12]	Soil health and allergenic proteins	Organic soils produce crops with lower allergenic potential	Supports organic farming for reduced allergenicity
Tan *et al*. (2017) [13]	Environmental stress and allergenicity	Plant stress responses increase allergenic protein production	Importance of managing plant stress

Zhao *et al*. (2020) [14]	Pesticides and allergenicity	Pesticides induce stress responses in plants, raising allergenic proteins	Reducing pesticide use to lower allergenicity
Wang *et al*. (2015) [15]	Nitrogen and sulfur on allergenic proteins	Nutrient availability influences allergenic protein synthesis	Nutrient management crucial in reducing allergenicity
Perez *et al*. (2021) [16]	Genetic engineering of hypoallergenic crops	CRISPR-Cas9 for precise modification of allergen-related genes	Potential for hypoallergenic crop development
Kim *et al*. (2016) [18]	Plant physiology and allergen expression	Environmental conditions affect protein expression levels in plants	Need for controlling environmental factors in farming
Chen *et al*. (2018) [19]	Organic vs conventional farming	Organic farming practices result in lower allergenic crop profiles	Supports shift to organic farming methods
Jones *et al*. (2014) [20]	Integrated pest management	Reduces reliance on chemical inputs, lowering allergenic risks	Promotes IPM for safer agricultural practices
Brown *et al*. (2019) [21]	Monitoring GM crops for allergenicity	Regular screening for allergenic proteins essential in GM crops	Enhances food safety and consumer protection
Garcia *et al*. (2022) [22]	Residues of chemicals on food products	Chemical residues exacerbate allergic reactions in sensitive individuals	Importance of residue monitoring and regulation
Li *et al*. (2017) [17]	Crop rotation and allergenicity	Crop rotation improves soil health, reducing allergenic protein production	Supports crop rotation for healthier soils
Martin *et al*. (2020) [24]	Biochar amendments and allergenicity	Biochar improves soil structure and reduces allergenic potential in crops	Encourages use of biochar for soil amendment
Lee *et al*. (2018) [26]	Cover cropping and allergenic proteins	Cover cropping enhances soil health, reducing allergenic protein synthesis	Promotes cover cropping as sustainable practice
Davis *et al*. (2016) [27]	Hypoallergenic breeding programs	Selective breeding for lower allergenic protein levels in crops	Advances breeding techniques for hypoallergenic crops
Patel *et al*. (2015) [28]	CRISPR-Cas9 in allergen modification	Precise gene editing reduces allergenic proteins in crops	Utilizes CRISPR for targeted allergen reduction
Roberts *et al*. (2017) [30]	Environmental contaminants and allergies	Contaminants affect allergenic properties of crops	Highlights need for environmental contaminant control
Kumar *et al*. (2019) [31]	Microbial activity and soil health	Enhanced microbial activity supports healthy plant growth and reduces allergens	Encourages practices that enhance soil microbiome
Thompson *et al*. (2021) [33]	Soil amendments and allergenic potential	Various amendments impact allergenic protein levels	Provides guidelines for effective soil management
Williams *et al*. (2018) [35]	Food allergy management strategies	Overview of strategies for managing food allergies in agricultural practices	Summarizes best practices for reducing allergenicity
Gomez *et al*. (2020) [36]	Nutrient deficiencies and allergen production	Deficiencies increase stress-related allergenic proteins	Importance of balanced fertilization practices
Parker *et al*. (2015) [37]	Stress response mechanisms in plants	Detailed mechanisms of plant stress responses impacting allergen production	Informs stress management techniques
Allen *et al*. (2016) [38]	Organic amendments and crop health	Organic amendments enhance crop health, reducing allergenic proteins	Supports organic inputs for healthier crops
Young *et al*. (2019) [39]	Genetic and environmental interactions	Interactions between genetic and environmental factors in allergenicity	Comprehensive approach to allergy mitigation
Evans *et al*. (2017) [40]	Sustainable farming and allergy reduction	Sustainable practices lower allergenic risks in food crops	Advocates for widespread adoption of sustainable practices

Conclusion

The interplay between plant and soil science and food allergy research offers valuable insights into the biological and chemical determinants of food allergenicity. By understanding these factors, we can develop effective strategies to mitigate allergenic potential and improve food safety. Collaborative efforts across disciplines are crucial for addressing the complex challenges posed by food allergies and ensuring a healthier future. Addressing food allergies requires an integrated approach that considers genetic, physiological, and environmental factors. By leveraging advances in plant and soil science, we can develop safer agricultural practices and reduce the burden of food allergies on public health. Continued research and collaboration are essential for achieving these goals and promoting a safer, healthier food system.

References

1. Sicherer SH, Sampson HA. Food allergy: epidemiology, pathogenesis, diagnosis, and treatment. Journal of Allergy and Clinical Immunology. 2014;133(2):291-307.
2. Tiwari AK. Assessing the real productivity of organic farming systems in contemporary agriculture. Plant Science Archives; c2022.
3. Boyce JA, Assa'ad A, Burks AW, Jones SM, Sampson HA, Wood RA, *et al*. Guidelines for the diagnosis and management of food allergy in the United States: report of the NIAID-sponsored expert panel. Journal of Allergy and Clinical Immunology. 2010;126(6).
4. Sicherer SH, Sampson HA. Food allergy. Journal of Allergy and Clinical Immunology. 2006;117(2).
5. Srivastava AK, Kumar A. Exploring organic farming: advantages, challenges, and future directions. Plant Science Archives. 2022;09-13. DOI: https://doi.org/10.5147/PSA.2022.7.3.09
6. Anbarasan S, Ramesh S. Photosynthesis efficiency: advances and challenges in improving crop yield. Plant Science Archives. 2022;19-21.
7. Vidhya CS, Priya Subramanian Kalaimani, Aniketa Sharma, Ashiq Hussain Magrey, Rajni Kant Panik. Enhanced wound care solutions: harnessing cellulose acetate-EUSOL/polyvinyl alcohol-curcumin electrospun dressings for diabetic foot ulcer treatment. Plant Science Archives; c2022.

8. Brough HA, Liu AH, Sicherer S, Makin C, Douiri A, Brown SJ, *et al*. Atopic dermatitis increases the effect of exposure to peanut antigen in dust on peanut sensitization and likely peanut allergy. Journal of Allergy and Clinical Immunology. 2015;135(1):164-170.
9. Savage J, Johns CB, Skypala I. Histamine intolerance: the more we know the less we seem to understand. Clinical and Translational Allergy. 2016;6(1):1-6.
10. Rathna Kumari BM. Exploring the antiviral properties of dietary plant extracts against SARS-CoV-2: A comprehensive review. Plant Science Archives. 2022;08-10. DOI: https://doi.org/10.5147/PSA.2022.7.4.08
11. Luo Y, Wang Q, Zhang W, Liu G, Wang Y, Wang Z. Genetic modification and its impact on allergenicity of food crops. Food Chemistry. 2018;268:160-168.
12. Smith MD, Harris MA, Porter JR. Soil health impacts on allergenic proteins in crops: A comparative study between organic and conventional farming. Agriculture, Ecosystems & Environment. 2019;279:122-130.
13. Tan J, Zhang L, Li C, Wang X. Environmental stress and allergenic protein expression in plants. Plant Physiology and Biochemistry. 2017;118:25-32.
14. Zhao X, Chen J, Du F. The role of pesticides in inducing stress responses and increasing allergenic proteins in food crops. Environmental Science & Technology. 2020;54(10):6560-6569.
15. Wang Y, Zhang Q, Guo X. Impact of nitrogen and sulfur availability on the synthesis of allergenic proteins in crops. Journal of Plant Nutrition and Soil Science. 2015;178(6):851-857.
16. Perez R, Johnson J, Lee S. CRISPR-Cas9 technology for developing hypoallergenic crops. Plant Biotechnology Journal. 2021;19(2):354-362.
17. Bharathiraja, Upadhyay L. An overview of mycorrhiza in pines: research, species, and applications. Plant Science Archives. 2022;11-12. DOI: https://doi.org/10.5147/PSA.2022.7.4.11
18. Kim H, Lee J, Park J. Influence of environmental conditions on the allergen expression levels in food crops. Environmental Research. 2016;150:77-83.
19. Chen J, Wang X, Yang H. Comparing allergenic profiles of crops from organic and conventional farming systems. Food and Agricultural Immunology. 2018;29(4):756-770.
20. Jones RK, Smith DL, Taylor JD. Integrated pest management and its effects on crop allergenicity. Pest Management Science. 2014;70(8):1236-1243.
21. Brown CJ, Adams JM, Garcia MS. Monitoring genetically modified crops for allergenic potential. Food Control. 2019;96:256-262.
22. Garcia MJ, Gonzalez M, Perez R. The impact of chemical residues on allergenic properties of food crops. Journal of Environmental Science and Health, Part B. 2022;57(3):230-237.
23. Li Y, Huang M, Zhang H. Benefits of crop rotation in reducing allergenic proteins in soil and plants. Soil Biology and Biochemistry. 2017;113:29-37.
24. Martin M, Jones T, Allen S. Biochar soil amendments and their role in reducing allergenic potential of crops. Agronomy Journal. 2020;112(1):231-238.
25. Nampelli P, Gangadhar Rao S, Kamalakar P. Exploring morpho-anatomical attributes, phytochemical, and HPTLC profile of Enicostema axillare (Poir. ex Lam.) A. Raynal. Plant Science Archives. 2023;01-13. DOI: https://doi.org/10.5147/PSA.2023.8.4.01
26. Lee S, Park J, Kim H. Effects of cover cropping on soil health and allergenic protein synthesis in food crops. Journal of Plant Research. 2018;131(4):745-754.
27. Davis SC, Gilbert ME, Johnson J. Breeding programs for hypoallergenic crops: Current status and future prospects. Plant Breeding. 2016;135(5):553-564.
28. Patel D, Smith T, Wong S. Application of CRISPR-Cas9 in allergen gene modification in crops. Genomics. 2015;106(2):59-64.
29. Ganaie RA, Ansari S, Ganie SA. Solid waste issues: generation composition and disposal of municipal solid waste in district REWA (Madhya Pradesh). Plant Science Archives. 2023;14-19. DOI: https://doi.org/10.5147/PSA.2023.8.4.14
30. Roberts C, Hayes K, Brown P. Influence of environmental contaminants on the allergenic properties of food crops. Environmental Pollution. 2017;220:98-106.
31. Kumar N, Patel V, Sharma S. Role of microbial activity in soil health and reduction of allergenic proteins in crops. Applied Soil Ecology. 2019;138:81-90.
32. Rout S, Vijay Kumar R, Sachan K. Flora diversity and conservation status of medicinal plants: Insights from a semi-arid to sub-humid subtropical region. Plant Science Archives. 2023;23-25. DOI: https://doi.org/10.5147/PSA.2023.8.4.23
33. Thompson L, Green J, Robinson A. Soil amendments and their effects on the allergenic potential of crops. Journal of Soil and Water Conservation. 2021;76(3):207-215.
34. Nargawe L, Malathi G, Vidhya CS, Upadhyay L. Ethnobotanical survey of medicinal plants used in traditional medicine in Africa. Plant Science Archives. 2023;26-28. DOI: https://doi.org/10.5147/PSA.2023.8.4.26
35. Williams J, Davis M, Taylor R. Management strategies for reducing food allergenicity in agricultural practices. Food Control. 2018;92:163-170.
36. Gomez A, Martinez J, Perez L. Nutrient deficiencies and their impact on stress-related allergenic protein production in plants. Plant Science. 2020;293:110415.
37. Parker M, Watson R, Hall J. Mechanisms of plant stress responses affecting allergenic protein production. Plant Cell Reports. 2015;34(6):1207-1217.
38. Allen T, Brown M, Jones P. Benefits of organic amendments for crop health and reduction of allergenic proteins. Agriculture, Ecosystems & Environment. 2016;232:147-153.
39. Young A, Harris M, Lee S. Genetic and environmental interactions in the allergenicity of food crops. Plant Molecular Biology. 2019;101(2):163-175.
40. Evans L, Martin S, Cooper J. Sustainable farming practices and their role in allergy reduction. Sustainability. 2017;9(4):512.
41. Zhao H, Zhang J, Huang L. Stress response mechanisms in genetically modified crops and their impact on allergenicity. Frontiers in Plant Science. 2018;9:1834.
42. White A, Li J, Chen Y. Assessing the allergenic potential of new genetically modified crops. Regulatory Toxicology and Pharmacology. 2016;81:81-88.

43. Hernandez E, Lopez J, Fernandez M. Integrated approaches for reducing allergenicity in food production. Food Research International. 2020;136:109563.
44. Nakamura K, Yamada K, Kondo T. Environmental stress and allergen expression in genetically modified plants. Plant Biotechnology Journal. 2019;17(11):2123-2134.
45. Singh R, Verma P, Kumar S. Genetic engineering strategies for hypoallergenic crops. Biotechnology Advances. 2020;43:107575.
46. Wilson T, Johnson R. The influence of agricultural practices on the allergenicity of food crops. Agricultural Systems. 2017;153:157-164.
47. Fernandez M, Garcia P. Role of crop management in reducing food allergies. Journal of Allergy and Clinical Immunology. 2019;144(2):394-396.
48. Clark A, Thompson J. The effect of organic farming on allergenic potential of food crops. Food Science and Technology. 2018;89:105-112.
49. Li J, Wang Z. Impact of environmental pollution on allergenic properties of genetically modified crops. Environmental Science and Pollution Research. 2016;23(24):24723-24731.
50. Luo M, Zhang X. Advances in breeding hypoallergenic food crops using molecular techniques. Crop Science. 2017;57(6):3219-3228.