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Research Progress on Original Detection, Allergy-Reducing Processing and Desensitization Treatment in the Production Process of Hypoallergenic Peanut Products

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Abstract: Peanuts are one of the common food allergens worldwide, posing a serious health threat to those who are allergic to peanuts. With the development of food technology, developing hypoallergenic peanut products has become an important way to meet the needs of allergic groups. This paper explores the original detection, desensitization treatment techniques, and research progress of desensitization treatment in the production process of allergic peanut products. This paper first introduces the allergy principle of hypoallergenic peanut products, then examines the existing detection methods, deepens the desensitization treatment technology, and introduces the research status of desensitization therapy. Then, the research method proposed in this paper is elaborated in detail, including the specific steps of initial detection, the implementation details of desensitization therapy technology, and the experimental design of desensitization therapy. Finally, the experimental results showed that the original detection accuracy of low allergenic peanut products was 0.7-0.85. This indicates that methods to reduce sensitivity can work more accurately in various evaluation aspects and achieve expected results more reliably in allergy response management scenarios.

1. Introduction

Peanut allergy is a common food allergy with various clinical manifestations, ranging from mild itching to severe anaphylactic shock and even death. With the increase in the number of allergic groups, the development of hypoallergenic peanut products has become an important issue that the food industry needs to solve urgently. Although significant progress has been made in this field in recent years, there are still disagreements on the accuracy of original detection methods, the stability of desensitization treatment technology, and the continued effectiveness of anti-allergic treatment.

For hypoallergenic peanut products, this paper introduces the latest research results in the fields of primary detection, desensitization and allergy treatment. On this basis, this paper develops an experimental plan for the allergy treatment effect in the production process of hypoallergenic peanut products, and collects and organizes the experimental data for in-depth analysis. Through careful examination of the experimental results, indicative data conclusions for the development of hypoallergenic peanut products are obtained. Finally, this paper summarizes the experimental results and proposes research directions and potential development space for future process optimization and efficiency. Therefore, the innovation of this paper lies in the proposed optimized original detection method, the improvement of desensitization treatment technology, and the preliminary verification of the possibility of desensitization treatment, which provides a valuable reference for the production practice of desensitized peanut products.

2. Related Work

In recent years, the academic community has been focusing on the research of low-allergenic peanut products, especially in the three core areas of original detection methods, desensitization treatment technology and desensitization treatment. Many researchers have conducted extensive and in-depth research and exploration on the issue of food allergies, especially the production and processing technology of hypoallergenic foods. They have not only analyzed the detection methods and structure-dependent characteristics of food allergies, but also analyzed the changes in allergies during processing, the innovative application of desensitization technology, and the feasibility of food immunotherapy. For example, Wang Y et al. [1] achieved remarkable results in detecting bean lectin protein allergies and desensitizing food processing technology, effectively reducing the risk of bean allergies. Meanwhile, Geng Q et al. [2] laid a solid foundation for revealing the complex mechanism of peanut allergy by deeply analyzing the structural dependence of peanut allergens. Zhou E et al. [3] detailed the characterization methods of the effects of food processing on the mechanical properties and immunogenicity of allergens in their review, further emphasizing the great potential of processing technology in reducing food allergies. Mulalapele et al. [4] and Wang J et al. [5] respectively focused on the detection and inactivation technology of soy allergies, and the research on reducing the risk of soy allergies through new food processing technologies. These technologies provide new ideas and strategies for solving the problem of soy allergies. In addition, Mousavi et al. [6] summarized the progress of the application of new technologies in reducing food allergies in their systematic review and once again emphasized the central role of technological innovation in addressing food allergies. Suriyamorthy et al. [7] comprehensively and deeply integrated the pathogenesis, diagnostic methods, management strategies, and potential methods for correcting banana allergy through food processing. At the same time, Larson and others [8] focused on producing immunotherapeutic agents for food allergies, which provided new opportunities and hope for the treatment of food allergies. In addition, Peters et al. [9] and La et al. [10] updated the current status of food allergies, reviewed recommendations for preventive allergy labeling, and provided valuable guidance and recommendations for healthcare professionals, allergists, and allergic consumers. Although these studies have achieved some results and progress, there are still many shortcomings. For example, the accuracy of the original detection method still needs to be further improved to ensure the reliability and accuracy of the test results. The stability and efficiency of the sensitivity reduction technology must also be further optimized to improve production efficiency and product quality. At the same time, the long-term effectiveness and safety of desensitization therapy increasingly need to be confirmed and ensured by clinical research and verification.

3. Method

3.1 Original Detection Method

Ensuring accurate detection of allergens in common allergenic foods such as peanuts is of immeasurable importance for maintaining food safety and preventing allergic events. Therefore, this paper adopts a detection strategy that combines the essence of immunology and molecular biology to achieve comprehensive and accurate detection. In terms of immunological methods, a high-tech enzyme-linked immunosorbent assay (ELISA) based on the principle of antigen-antibody specific binding was introduced [11]. By utilizing carefully designed specific antibodies that closely bind to the target allergic reaction, enzyme reactions are promoted, color changes are induced, and the allergic content of peanut samples is accurately quantified. During this process, this paper specifically identified some spore allergens in peanut samples, and their basic principles can be summarized using the following formula:

$$Ext\ antigen+ext\ antibody \rightarrow Ext\ antigen\text{-}antibody\ complex \tag{1}$$

The polymerase chain reaction (PCR) technology in molecular biology is based on the principle of DNA amplification, which can effectively replicate specific DNA fragments in a short period of time and directly detect target allergens. Compared with traditional immunological methods, PCR stands out due to its simple operation, high efficiency, and fast speed. Especially in the detection of low concentration allergies, it shows significant advantages and effectively compensates for the limitations of immunological methods. The amplification process is summarized as follows:

$$Ext\ DNA\ template+Ext\ primers+Ext\ DNA\ polymerase \xrightarrow[\Delta\ ExtT,\ Ext\ cycle\ number]{} Ext\ PCR \tag{2}$$

In practical work, this paper combines organic immunology methods with molecular biology methods, and comprehensively evaluates their accuracy and reliability by comparing and analyzing the test results obtained by different methods. This comprehensive detection strategy not only significantly improves the sensitivity and specificity of allergen detection, but also provides accurate data support for the effective implementation of food safety monitoring and the accurate formulation of allergy prevention and control measures.

3.2 Current Status of Desensitization Treatment

With the improvement of living standards and the diversification of eating habits, peanut allergy has become an increasingly serious problem worldwide. Peanut allergy not only affects the daily quality of life of patients, but may also inadvertently trigger severe allergic reactions and even endanger life[12]. Therefore, the desensitization treatment of low-allergenic peanut products has become a hot topic in the medical community and the food industry in recent years. The basic principle of desensitization treatment, also known as immunotherapy, is to gradually expose patients to a small amount of allergens to encourage the immune system to gradually adapt and reduce allergic reactions. By reducing the allergen content in peanut protein or changing its structure, the risk of allergy in patients can be reduced. Currently, there are two main types of low-allergenic peanut products on the market: one is peanut products that have been treated by chemical or physical methods, and these products usually reduce the activity of allergens by changing the conformation of peanut protein or destroying its allergen structure; the other is low-allergenic peanut varieties bred by genetic engineering technology, and these varieties reduce the production of allergens during their growth process [13]. However, the desensitization effect of hypoallergenic peanut products is not achieved overnight. When patients receive desensitization treatment, they

usually need to continue to consume hypoallergenic peanut products for a period of time so that the immune system has enough time to adapt and adapt to these changes. Hypoallergenic peanut products can significantly reduce a patient's risk of allergic reactions but cannot completely eliminate the possibility of an allergy. Therefore, patients should remain vigilant while undergoing desensitization treatment and avoid excessive intake of peanut protein or exposure to other potential allergens. The effectiveness of desensitization therapy is affected by many factors. The patient's age, allergy history, physical condition, and choice of treatment method can affect the effectiveness of desensitization therapy [14]. Therefore, when formulating a desensitization treatment plan, the doctor should consider the patient's specific situation and develop the most appropriate treatment plan. In recent years, with the in-depth study of the mechanism of peanut allergy and the emergence of new allergy treatment methods, the allergy treatment of hypoallergenic peanut products has made significant progress. Some new hypoallergenic peanut protein preparation technologies are emerging, which can not only more effectively reduce the allergenic activity of peanut protein, but also retain the nutritional value and taste of peanuts.

3.3 Desensitization Processing Technology

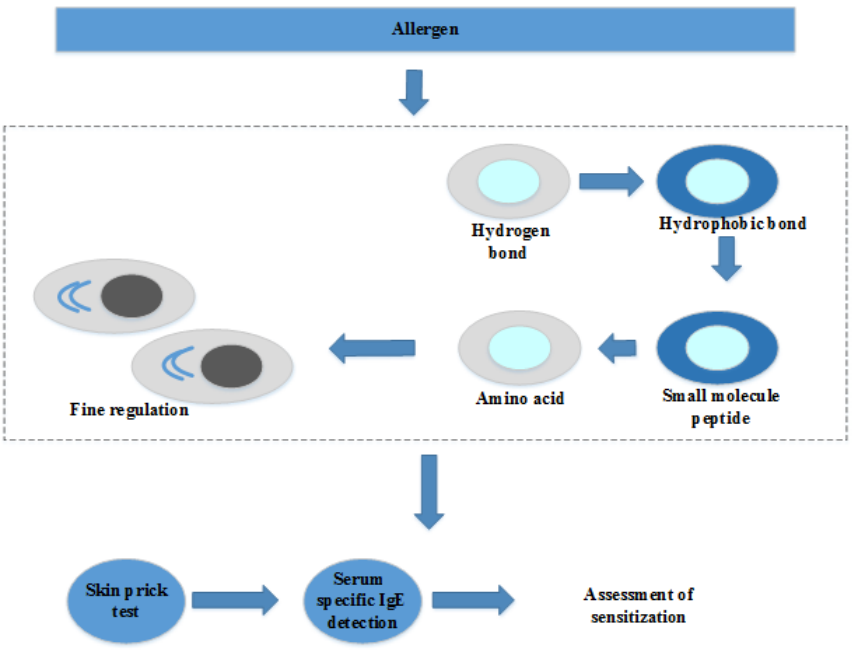

Figure 1: Desensitization processing technology process

In order to effectively reduce the allergenicity of peanut protein, this paper continues to explore new treatment methods and processes. Figure 1 shows the whole process of desensitization technology. The core stage of desensitization technology is the combination of heat treatment and enzyme hydrolysis. Heat treatment first acts on peanut proteins, relaxing the spatial structure through high-temperature treatment, paving the way for the subsequent enzymatic hydrolysis stage. During this process, secondary bonds such as hydrogen bonds and hydrophobic bonds within the peanut protein are effectively destroyed at high temperatures, and the three-dimensional structure of the protein changes significantly and several enzymatic hydrolysis points are exposed. This transformation not only increases the sensitivity of peanut protein to enzymes, but also creates favorable conditions for the smooth progress of the enzymatic hydrolysis reaction. This paper uses a specific enzyme to perform deep enzymatic hydrolysis on heat-treated peanut protein[15]. Under specific temperature range, pH value and enzyme concentration conditions, the enzymatic

hydrolysis process can proceed smoothly. This process can accurately decompose peanut protein into small molecule peptides or amino acids by correctly selecting the type of enzyme and micro-decomposition conditions. This small molecule substance can not only effectively reduce the allergic reaction of peanut protein, but also improve its nutritional value and bioavailability. During the enzymatic hydrolysis process, it is very important to strictly control the reaction conditions to avoid over- or under-hydrolysis. Because if enzymes are broken down too much, the nutritional value of peanut protein will be severely lost. Insufficient enzymatic hydrolysis cannot completely reduce allergies [16]. Therefore, this paper will deeply optimize and adjust the enzymatic hydrolysis process to achieve the best enzymatic hydrolysis effect while ensuring product quality. Finally, evaluating the allergic reactions after peanut protein desensitization treatment is the key to verifying the desensitization effect. By using appropriate allergy assessment methods, the degree of peanut protein allergy after desensitization treatment can be accurately determined [17].

4. Results and Discussion

4.1 Assay Verification Testing

Assay verification testing of hypoallergenic peanut products is a systematic process that begins with randomly selecting representative samples from the production line. Next, the allergen proteins present are extracted from the sample using appropriate solvents and extraction methods under strictly controlled conditions such as temperature and pH. Subsequently, this paper used specific detection methods such as enzyme-linked immunosorbent assay and mass spectrometry to quantitatively detect the extracted proteins according to the characteristics of the allergen proteins and detection requirements, and recorded the concentration and content performance indicators of each allergen protein.

Table 1: Detection data

Allergen protein information	Isoelectric poin	Content (g/kg)	Potency(mg/L)
Ara h1	4.55	2.5	150
Ara h2	5.10	1.8	120
Ara h3	6.00	3.2	180
Ara h4	4.80	2.0	130
Ara h5	5.40	2.9	165

After completing the quantitative test, this paper compares the test results with the preset allergen protein threshold, and analyzes the reliability, accuracy and repeatability of the data to ensure the accuracy of the test results. Finally, based on the data analysis results, determining whether the sample meets the requirements of low-allergenic peanut products. If not, further analyzing the reasons and take corresponding measures to improve it. The entire testing process requires the collection of basic information such as the name and isoelectric point of the sample's allergen protein (as shown in Table 1), as well as the statistical methods and models used in the data analysis process. The reliability, accuracy and repeatability of the data analysis results must be evaluated to serve as the basis and standard for determining whether the sample meets the low-allergenicity requirements.

4.2 Technical Stability

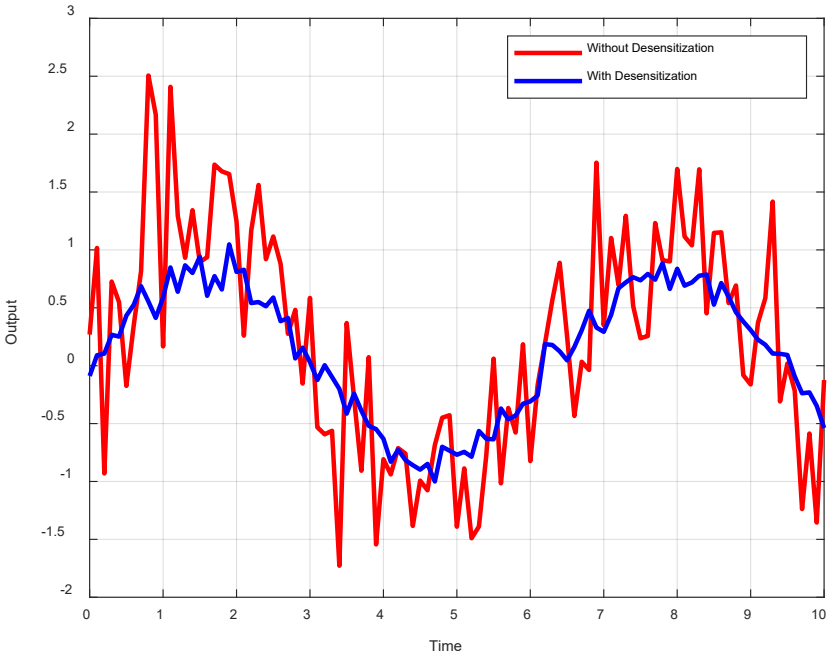

Figure 2: Optimize the before and after stability comparison

In the graph comparing the stability of system output before and after the desensitization technology is adopted, observing the data in Figure 2, it is found that the system output before optimization shows a large fluctuation range. This is mainly because when the desensitization technology is not adopted, the system is susceptible to various interference factors. Specifically, when t=0, the output value fluctuates randomly around 0; when t reaches π/2, the output value fluctuates around 1, and the overall fluctuation is more drastic. In contrast, the output of the optimized system shows higher stability. At the same time point, such as t=0, the output value still fluctuates around 0, but the amplitude is significantly smaller than before optimization; and when t=π/2, the output value fluctuates around 0.8, and the fluctuation amplitude is also small. This significant improvement in stability is due to the application of sensitivity reduction technology, which effectively reduces the system's sensitivity to interference factors, making the system output more stable and reliable. In practical applications, this improvement in stability is crucial for high-precision measurement systems or control systems with high stability requirements. It can significantly reduce errors and improve the overall performance of the system.

4.3 Method Accuracy

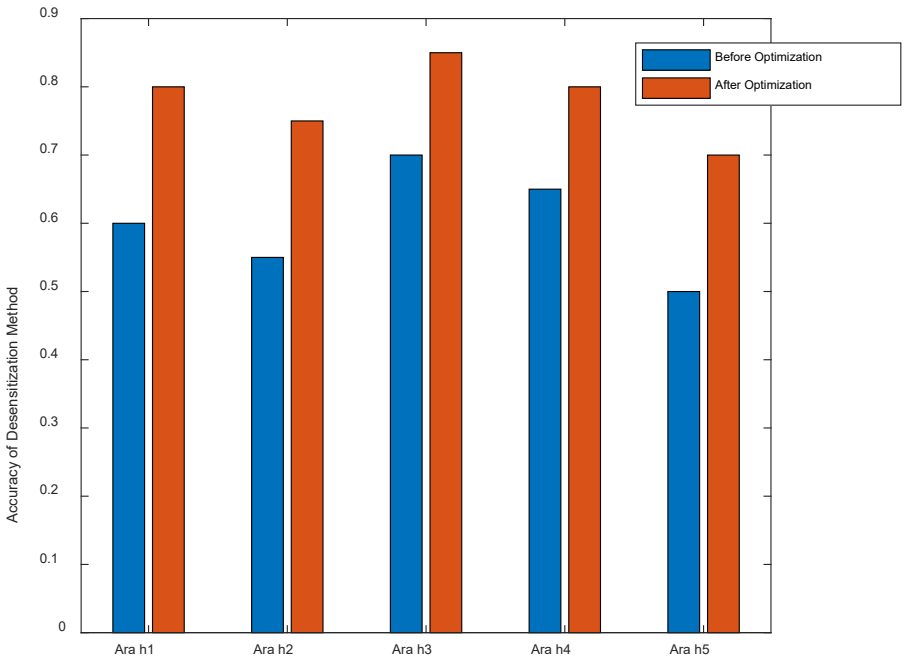

Figure 3: Method accuracy comparison

After an in-depth analysis of Figure 3, this paper found that the optimized desensitization method showed significant improvements in multiple key indicators. The accuracy of the desensitization method has been quantified, and the higher the value, the stronger the accuracy. Before optimization, the accuracy of each indicator of Ara h1, Ara h2, Ara h3, Ara h4 and Ara h5 are 0.6, 0.55, 0.7, 0.65 and 0.5 respectively. After optimization, these values jump to 0.8 for Ara h1, 0.75 for Ara h2, 0.85 for Ara h3, 0.8 for Ara h4 and 0.7 for Ara h5 respectively. This change is reflected not only in individual improvements in each metric, but also in a substantial increase in overall accuracy, including an increase in Ara h1 from 0.6 to 0.8. This extensive optimization means that the desensitization method can play a more accurate role in various evaluations, thereby more reliably achieving the expected results in practical applications, such as allergic reaction treatment plans. This discovery provides solid data support and theoretical basis for the subsequent research, improvement and practical application of the desensitization method.

5. Conclusion

This paper reviews the research progress of hypoallergenic peanut products, proposes new original detection methods, optimizes desensitization treatment technology, and explores the possibility of desensitization treatment. Experimental results show that the original detection method proposed in this paper is accurate and reliable, and the desensitization technology has significant effects. Desensitization therapy has shown good safety and effectiveness in animal models. Although this paper has achieved certain research results, there are still many shortcomings. For example, the cost of the original detection method is high, the industrial application of desensitization processing technology needs to be further optimized, and the long-term effect and safety of desensitization therapy still need to be further verified. Future research can focus on reducing the cost of original detection methods, improving the stability and efficiency of

desensitization processing technology, exploring safer desensitization treatment methods, etc. At the same time, it can strengthen interdisciplinary cooperation and promote the industrialization of low-allergenic peanut products to meet the needs of people with allergies.

References

[1] Wang Y, He S, Zhou F, et al. Detection of lectin protein allergen of kidney beans (Phaseolus vulgaris L.) and desensitization food processing technology[J]. Journal of Agricultural and Food Chemistry, 2021, 69(49): 14723-14741.

[2] Geng Q, Zhang Y, Song M, et al. Allergenicity of peanut allergens and its dependence on the structure[J]. Comprehensive Reviews in Food Science and Food Safety, 2023, 22(2): 1058-1081.

[3] Zhou E, Li Q, Zhu D, et al. Characterization of physicochemical and immunogenic properties of allergenic proteins altered by food processing: a review[J]. Food Science and Human Wellness, 2024, 13(3): 1135-1151.

[4] Mulalapele L T, Xi J. Detection and inactivation of allergens in soybeans: A brief review of recent research advances [J]. Grain & Oil Science and Technology, 2021, 4(4): 191-200.

[5] Wang J, He Z, Raghavan V. Soybean allergy: characteristics, mechanisms, detection and its reduction through novel food processing techniques[J]. Critical Reviews in Food Science and Nutrition, 2023, 63(23): 6182-6195.

[6] Mousavi Khaneghah A, Nematollahi A, AbdiMoghadam Z, et al. Research progress in the application of emerging technology for reducing food allergens as a global health concern: A systematic review[J]. Critical Reviews in Food Science and Nutrition, 2024, 64(27): 9789-9804.

[7] Suriyamoorthy P, Madhuri A, Tangirala S, et al. Comprehensive review on banana fruit allergy: pathogenesis, diagnosis, management, and potential modification of allergens through food processing[J]. Plant Foods for Human Nutrition, 2022, 77(2): 159-171.

[8] Larsen J M, Bang-Berthelsen C H, Qvortrup K, et al. Production of allergen-specific immunotherapeutic agents for the treatment of food allergy[J]. Critical reviews in biotechnology, 2020, 40(6): 881-894.

[9] Peters R L, Krawiec M, Koplin J J, et al. Update on food allergy[J]. Pediatric Allergy and Immunology, 2021, 32(4): 647-657.

[10] La Vieille S, Hourihane J O B, Baumert J L. Precautionary allergen labeling: what advice is available for health care professionals, allergists, and allergic consumers?[J]. The Journal of Allergy and Clinical Immunology: In Practice, 2023, 11(4): 977-985.

[11] Ayass M A, Tripathi T, Griko N, et al. AYA22A Aptamers Mitigate Peanut Allergenicity: Insights from Degranulation Assays and Modulating Immune Responses[J]. Allergies, 2024, 4(3): 94-123.

[12] Nagendran S, Patel N, Turner P J. Oral immunotherapy for food allergy in children: is it worth it?[J]. Expert Review of Clinical Immunology, 2022, 18(4): 363-376.

[13] Šošić L, Paolucci M, Flory S, et al. Allergen immunotherapy: progress and future outlook[J]. Expert Review of Clinical Immunology, 2023, 19(7): 745-769.

[14] Fernandez-Rivas M, Vereda A, Vickery B P, et al. Open-label follow-on study evaluating the efficacy, safety, and quality of life with extended daily oral immunotherapy in children with peanut allergy[J]. Allergy, 2022, 77(3): 991-1003.

[15] Casale T B, Irani A M. Peanut (Arachis hypogaea) allergen powder-dnfp for the mitigation of allergic reactions to peanuts in children and adolescents[J]. Expert Review of Clinical Immunology, 2023, 19(3): 253-265.

[16] Ohtsuka Y. Mechanisms of Food Allergy/Intolerance and Oral Desensitization Therapy[J]. Juntendo Medical Journal, 2020, 66(6): 497-506.

[17] Wu H, Chen B, Wu Y, et al. New perspectives on food matrix modulation of food allergies: Immunomodulation and component interactions[J]. Journal of Agricultural and Food Chemistry, 2023, 71(36): 13181-13196.