DEVELOPMENT OF A NOVEL POINT OF CARE ALLERGEN DETECTION SYSTEM

Allergic reactions can occur on multiple levels of severity, from mild rashes to full body reactions. Anaphylaxis is defined as a life-threatening, full-body, allergic reaction which requires immediate medical attention. In the United States, around 5% of the population have experienced anaphylaxis (Turner et al., 2017). Of this 5%, certain groups are more at risk for anaphylaxis, including people with sensitivities to Immunoglobulin- E-mediated food-based allergies, also known as IgE-mediated allergies.

Allergic Reactions

IgE-mediated allergies are allergic reactions associated with the presence of immunoglobulin E in the body. Immunoglobulin E, upon interaction with certain proteins, triggers the release of histamines in the body. This release of histamines in the body then leads to varied levels of allergic reactions, from mild hives to full-body reactions like anaphylaxis. Although there are some solutions like epinephrine, which exist to delay the onset of life-threatening anaphylactic shock, the most encouraged method of allergic reaction prevention is simply avoidance. People with allergies are advised to prevent the risk of reaction by removing the allergen from their lifestyle. As a result, allergy sufferers often go to great lengths to avoid potential exposure to allergens. Many people with food allergies worry about issues like cross contamination in their day-to-day life. Despite the recent rise in labeling foods with common allergens, accidental consumption of an allergen can lead to a frightening reaction for the consumer (Ma et al., 2013). Around 8.6% of people who went to the emergency room visited because of allergy related concerns (Wood et al., 2014). Particularly in public dining, cross-contamination can occur at any point, causing concern for the safety of severe allergy sufferers. Around 9% of children in the United States have sensitivities to peanuts (Branum et al., 2009). To help prevent allergic reactions, the goal of this

project is to engineer a rapid allergen detection test that will accurately detect the presence of tree nuts in under fifteen minutes and is easy to use in public settings. Although rapid allergy detection has been explored before, research was primarily focused on use in the food services industry with cross contamination and analysis of cleaning processes.

Common Solutions

The work done in allergen detection has also been particularly focused on immunoassays and the use of antigens and antigen specific antibodies. Immunoassays utilize antibodies to detect proteins, making it an excellent model for allergen detection because food-based allergies are triggered by proteins in the food, however it cannot be easily incorporated in a public setting due to the amount of sample preparation required for accurate results. Another method often used in such devices is enzyme-linked immunosorbent assays (ELISA). The ELISA model works exceedingly well with allergen detection because of their ability to precisely identify specific proteins (Taylor et al., 2009). Lateral flow based ELISAs also yield accurate results in short periods of time.

Despite the advantages of the ELISA model, it is also prone to higher rates of false positives when compared to other methods and occasionally mistakes certain proteins for others. The sample inserted into the ELISA also must be prepared thoroughly, or the consumer runs the risk of overlooking certain proteins. One major concern with allergen detection through such reaction-based methods of protein detection in prepared food are the types of samples being tested. Raw food can be more easily identified for proteins because the food proteins have not been impacted by any chemical modifications. However, when combining foods and heat, certain proteins lose their immunoreactivity, meaning they will not react with the antibodies found in immunoassays. These proteins with decreased immunoreactivity pose a major risk due to their ability to interact with immunoglobulin E, meaning that they can still cause allergic responses and evade detection.

Spectroscopy

As of late, the field of allergen detection has begun research defined by their role in increasing portability and decreasing costs. For example, the use of spectroscopy, vibrational spectroscopy specifically, has been gaining traction in the food safety field due to its non-invasive detection capabilities and the portability of devices. Much work has been done on Raman spectroscopy in food safety. Vibrational spectroscopy is divided into smaller subcategories based on the interaction between the molecule and a light source. There are four things that can happen, when light hits a molecular sample. The sample can absorb the light, it can reflect the light, it can transmit it, or it can combine reflection and transmission in something known as transfection (Geraldes C. F. G. C., 2020). The two types of vibrational spectroscopy considered in this project; Raman and infrared spectroscopy, have distinct types of interactions with the sample.

Raman spectroscopy shines a concentrated light in the form of a laser on molecules. Some of the photons from the laser beam strike the molecule, energy is transferred from the photon to the molecule. This energy loss is unique for each molecule and corresponds with the Raman scatter. Since each molecule has a unique Raman scatter, we can use the unique scatter like a fingerprint for protein identification. In addition to Raman spectroscopy, infrared spectroscopy is another type of vibrational spectroscopy that we considered using with allergen detection. Like Raman spectroscopy, Infrared spectroscopy (IR) has a unique spectrum for each molecule. Although each method has its own advantages, there are disadvantages associated with both types of spectroscopies. IR spectra are sensitive towards water in the sample while Raman spectra are not due to the minimal Raman scatter that water has. As a result, to get a more accurate result of the molecule, Raman spectra will allow for better spectral results which are less impacted by environmental factors.

Problem Statement

Cross contamination poses a significant risk in public dining situations to allergy sufferers because of the lack of effective allergen detection devices that are easily accessible.

Objectives

Our long-term goal is to develop a rapid point of care allergen detection device that uses vibrational spectroscopy for protein identification, where the central hypothesis of this proposal is that the proteins that cause allergic reactions can and will be identified by spectroscopy. The rationale is that since allergic reactions are triggered by certain proteins, each protein would have its own unique spectroscopic identity. Thus, if a sample is scanned and the spectra aligns with the allergic reaction causing protein, then the sample contains the protein and could trigger an allergic reaction. The work we propose here will more effectively allow for consumers with food allergies to detect contamination and ideally decrease the number of allergic reactions occurring.

Objective 1: Determine the potential of vibrational spectroscopy when used to identify potential food allergens with varied samples

Objective 2: Creating a final product that can rapidly identify the presence of allergens.

The expected outcome of this work is a portable device that can identify the presence of peanut and tree nut allergens using vibrational spectroscopy.