Title: Standoff Raman Detection of Food Contamination

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Center of Excellence: Food Protection and Defense Institute (FPDI) (Emeritus)
COE Lead/Co-Lead Institution: University of Minnesota

Project Start Date: 07/2014
Project Completion Date: 12/2016
Project Status: Complete
Research Theme: Agent Behavior
Participating State(s): New York, Alabama, Minnesota
Participating Minority Serving Institution(s) (MSI): Alabama A&M University
Amount Awarded to Date: $197,009
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Abstract: This project investigated detection of contamination and economically motivated adulteration (EMA) in food products using standoff Raman spectroscopy. Unlike the traditional Raman approach, this technique remains largely unexplored for food sciences applications and has the potential to detect food contaminants/adulterants which could be toxic or laced with biological pathogens from a safe, non-contact distance of several meters. The technique is thus important for field and forensic applications needing minimum sample preparation protocol. The objective of this project was to demonstrate the viability of standoff Raman technique for detecting common adulterants in food items like melamine in milk, cheap/unhealthy edible oils in olive oil, calcium carbonate in flour etc. Using a 785 nm Raman spectrometer coupled to a small telescope, the technique was characterized for standoff distances in the range of 1-10 meters and for typical concentrations of 1-10% used in economically-motivated adulteration. Thus, adulteration of extra virgin olive oil with canola and grapeseed oils was demonstrated from near-contact and standoff distances up to 1 meter. Depending on the distance, the sensitivity for detecting adulteration was 2-5%. Likewise, feasibility of detecting adulteration of honey with high-fructose corn syrup and rice syrup was demonstrated. Adulteration in other food items like milk and flour was also investigated. For its potential for field detection, the technique was demonstrated to the Customs and Border Protection (CBP) personnel at the US-Canada border in Champlain, New York. The work has resulted in several conference presentations and refereed journal publications. The research formed the thesis of one Ph.D. and two M.S. students at the Alabama A&M University.

Project Type: Research
End User Engagement:
- Academic Community
- DHS Science and Technology Directorate
- DHS U.S. Customs and Border Protection
- Food and Drug Administration
- U.S. Department of Defense

Executive Summary (2017): The project involves detection of contamination and economically-motivated adulteration (EMA) in food by the standoff Raman spectroscopy technique. Unlike the traditional Raman approach, this technique remains largely unexplored for food sciences applications and has the potential to detect food contaminants/adulterants which could be toxic from a safe, non-contact distance of up to several meters. The technique is thus important for field and forensic applications needing minimum sample preparation protocol. The objective of this project is to
demonstrate the viability of standoff Raman technique for detecting common adulterants in food items like melamine in milk, cheap/unhealthy edible oils in olive oil, calcium carbonate in flour etc. The technique was characterized for near-contact distances and for standoff distances in the range of 1-10 meters. Typical concentrations of 1-10% of adulterants were used in these EMA related investigations. The Instrumentation includes a portable Raman system involving a 785 nm laser and a mini-spectrometer with a CCD detector. We have coupled the Raman system to a 2-inch telescope such that the complete system is portable and can be operated from the back of a truck either with batteries or with a gas-powered generator. Adulteration of Olive Oil with Grapeseed Oil and Canola Oil was detected at a concentration of 2.5% from a distance of 15 cm and at a concentration of 5% from a distance of 1 meter. Similarly, 1% concentration of Melamine in Baby Formula and 5% concentration of lime-dust in flour were detected from a distance of 1 meter. The sensitivity of these measurements increases as the distance decreases. We have also detected adulteration of honey with sweeteners like high fructose corn syrup and rice syrup by this technique at sensitivity of better than 5%. The project was characterized with several metrics including (i) standoff distance at which measurements can be made (ii) sensitivity or minimum concentration of contaminants that can be detected versus the standoff distance (iii) ability to make quantitative measurements of contaminants. Due to the potential of this technique for making measurements from a convenient distance, the stand-off Raman technique has the promise to be used for routine applications in food industry such as identifying food items and monitoring EMA at various checkpoints in the food supply chain and storage facilities. We demonstrated the potential of this technique to the Customs and Border Protection (CBP) personnel at US-Canada border checkpoint. Currently, there is no onsite facility at these checkpoints to detect EMA. The Raman technique has the potential to provide a fast onsite technique requiring no sample preparation. The technique also has the potential for detecting toxic chemicals on military sites which can end up polluting water and food resources.

Peer-reviewed journal articles produced from this project

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