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Protecting our food: Can standard food safety analysis detect adulteration of food products with selected chemical agents?

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A B S T R A C T

The food we eat and water we drink is routinely tested for a range of biological and chemical contaminants, which can be hazardous to human health, as part of food safety legislative requirements. The vulnerability of the food industry to deliberate contamination events, rather than naturally occurring events, was explored as one aspect of the EU FP7 project EDEN (End-User Driven Demo for CBRNe). We wanted to investigate if routine food safety testing could detect deliberate contamination with three chemical contaminants and three matrices (cooked ham, sugar and water). The contaminants selected had to be hazardous to human health at levels in the final food product that could occur with a deliberate contamination event.

Standardised reference panels were developed and homogeneity and stability were tested prior to distribution for food safety chemical testing, as required by EU legislation, in the meat food chain (cooked ham and water) and the sugar food chain (sugar and water). Each reference panel contained 11 samples analysed in triplicate (33 analyses per matrix). The meat food chain panels contained bromadiolone (a rodenticide) in the meat and sodium trifluoroacetate (a simulant for a toxic pesticide) in the water at levels from 0 to 4000 parts per million (ppm). The sugar food chain panels contained mercury chloride in both the sugar and water, at levels from 0 to 12 500 ppm. The food safety standard chemical analysis methods were compared to the following external laboratory methods for the meat food chain panels: liquid chromatography coupled to mass spectrometry for meat and nuclear magnetic resonance spectroscopy for water. Inductively coupled plasma with mass spectrometry was used to analyse the sugar food chain panels containing both sugar and water samples. Neither the meat nor the sugar food safety methods detected contamination in any of the samples whilst the external laboratory correctly identified and quantified the contaminants in all the samples.

The results for these three contaminants (bromadiolone, sodium trifluoroacetate and mercury chloride) are not surprising given that they are not the target of today's food safety testing procedures. These limited results are of note and highlight food chain vulnerability to deliberate contamination events with novel contaminants. The EDEN project is exploring a 2-level approach: screening food with non-specific detection tools which are supplemented by targeted detection tools when an alert is triggered. This approach could lead to increased consumer protection whilst simultaneously reducing the economic burden of testing and product recall for the industry.

Abbreviations: CBRNe, Chemical, Biological, Radiological, Nuclear and explosive; EDEN, End-User Driven Demo for CBRNe; EU, European Union; EU FP7, European Union Seventh Framework Programme; FAO, Food and Agriculture Organization; HACCP, Hazard Analysis and Critical Control Points; ICP-MS, Inductively Coupled Plasma Mass Spectrometry; ICUMSA, International Commission for Uniform Methods of Sugar Analysis; GC-MS, Gas Chromatography Mass Spectrometry; GFAAS, Graphite Furnace Atomic Absorption Spectrometry; LC-MS, Liquid Chromatography Mass Spectrometry; MRLs, Maximum Residue Levels; NMR, Nuclear Magnetic Resonance; PCB, Polychlorinated Biphenyl; WHO, World Health Organisation.

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1. Introduction

Routine food safety testing is carried out, according to legislative requirements [1–8], in food products to detect biological and chemical contaminants that can occur naturally or accidentally during the food production process. Deliberate contamination of our food chain is thankfully a very rare event. However, the potential consequences of a deliberate attack can be disproportionately large [9]. The European Union (EU) Bio-preparedness Green paper [10] concluded that the existing food safety framework needed to be complemented by a new framework that included security aspects, such as food defence practices.

The asymmetrical threats that food defence practices hope to prevent, or respond to, stand in contrast to naturally or accidentally occurring contamination events (Fig. 1). Food safety testing is based on scientific knowledge of the critical points during the food production process combined with an understanding of the likelihood of natural and accidental contaminating agents in that food chain, the HACCP (Hazard Analysis and Critical Control Points) principles [11]. Using the same approach in food defence could be problematic where the motivation for an attack can be political, criminal or economic and the agents used may be novel to the food chain in question [12,13]. Historically we have global evidence of malicious contamination events from both a criminal and terror perspective ranging from the addition of foreign matter to food and drink products (physical, like metal objects, as well as chemical contaminants), contamination of an allergen free production facility with allergenic material, to the infection of salad bars with *Salmonella* bacteria by a cult [12,14].

The EDEN project, End-User Driven Demo for CBRNe, is a large EU FP7 project in the field of societal security with one aspect addressing potential CBRNe incidents in the food chain. One of the aims of EDEN is to shorten response time after an event as well as increasing food chain resilience with the development of affordable and rapid detection tools. End-users were asked to identify gaps and needs in prevention, preparedness, response and recovery to CBRNe incidents in the food chain [15,16]. Scenarios were developed based on exploring these further [17] and novel tools are currently under development to meet some of the gaps. The first step towards measuring an effect of EDEN was the establishment of the baseline response and resilience within the food chains being studied. The EDEN project wanted to explore how vulnerable different food products were to deliberate contamination and whether current food safety methods would be able to detect contamination in the final food products. The food chain products chosen for testing were processed ham, granulated white sugar and water. Water was chosen as it is used in the production process as well as being a simpler analysis matrix than meat and sugar. The efficacy of standard food safety testing methods at detecting the chemical agents, chosen during scenario development, was compared to testing at an external chemical identification laboratory, not affiliated with the food industry.

2. Standard food safety methods

Food safety programs prevent unintentional contamination of food products and refer to conditions and practices able to preserve the quality of the food. They aim to prevent contamination and foodborne disease. The EU food safety programs are based upon the HACCP principles. HACCP is a systematic risk analysis approach used for the identification, evaluation, and control of food safety hazards [18].

	Protection principle	Contaminants	Cause and Motivations	Prevention (legislation)
Food Safety	To ensure food safe to eat, free from naturally occurring infectious/toxic contaminants	A limited number of known pathogens and contaminants, that can cause foodborne illness	Naturally or accidentally occurring in the food chain	EU and national legislation: based on hazard assessment/risk analysis principles for each food chain
Food Defence	To prevent/ mitigate the effects of a deliberate attack on the food chain	Very wide range possible contaminants, depends on resources and knowledge of perpetrator	Random act, underlying financial, behavioural or ideological motivation	No EU or national legislation, only guidelines.

Fig. 1. The differences in food safety and food defence regarding protection principle, contamination, cause and motivations and prevention.

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