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File: ■ Adulteration
■ Economically Motivated Adulteration
■ Food

HC 071346-487

Date: December 31, 2013

RE: Common Characteristics of Food Adulterations

Everstine K, Spink J, Kennedy S. Economically motivated adulteration (EMA) of food: common characteristics of EMA incidents. *J Food Prot*. April 2013;76(4):723-735.

Economically motivated adulteration (EMA) of food products is the adulteration of foods for financial gain. EMAs have occurred throughout history. In the US, adulteration of foods is defined and prohibited by the Federal Food, Drug, and Cosmetic Act and the Federal Meat Inspection Act – the former under the regulatory authority of the Food and Drug Administration (FDA) and the latter under the Department of Agriculture.

Adulteration consists of omitting any valuable constituent, substituting another substance wholly or in part, concealing damage or inferiority, or adding any substance to increase weight or bulk, reduce quality or strength, or make a product appear better than it is. Most adulterants are benign, but less expensive than some constituent of the food, and with enough similarity to deceive. The FDA's definition of EMA includes tobacco (*Nicotiana tabacum*), cosmetics, pharmaceuticals, and medical devices and equipment. "Food fraud" more generally includes EMA, economically motivated misbranding, theft, diversion, simulation, smuggling, and counterfeiting products. If an adulterant is toxic or allergenic, serious public health consequences may result. Instances of EMA reveal weaknesses in quality control and testing that could be exploited for intentional harm. In contrast to unintentional, accidental outbreaks of foodborne pathogens or contamination, EMAs are planned to be secret. Detection presents challenges to the food industry and regulators.

While large-scale EMA incidents have been discussed in scientific literature, most smaller incidents, once discovered, are covered only in the media. The authors searched for and reviewed both journal and mass media articles for reports of food-specific EMAs since 1980; it is unclear exactly when the search terminated but the article was submitted for publication on September 9, 2012. They identified 137 EMA incidents and grouped them into 11 food categories: fish and seafood (24 incidents), dairy products (15), fruit juices (12), oils and fats (12), grain products (11), honey and other natural sweeteners (10), spices and extracts (8), wine and other alcoholic beverages (7), infant formula (5), plant-based proteins (5), and other foods (28). Major incidents in each category are discussed. The authors stress that these are only adulteration schemes that were eventually discovered; hundreds more EMAs must go on successfully every day.

More importantly than the particular EMAs they describe, the authors analyzed them for commonalities. Weaknesses in testing and regulation are often exploited, like the use of

nonspecific nitrogen tests as a proxy for protein content in dairy products. This allowed for one of the best-known and most tragic EMAs, the deliberate adulteration of dairy foods in China with non-nutritive melamine, causing 300,000 people to become ill and six infant deaths in 2008. Unfortunately, the same nonspecific nitrogen test is still used, and there are new reports of adulteration of Chinese dairy products with hydrolyzed leather protein. The US Pharmacopeia recommends a compendial test strategy, focused on analyzing what should be present in a sample rather than what should not be present. Regular testing at specific points along the supply chain for a food product is a primary defense against EMAs. For fish and seafood, where the morphological characteristics of the species are removed in processing, there is a need for inexpensive and widely available genetic testing methods. Genetic databases for fish have been compiled by the FDA, the National Marine Fisheries Service, and Canada's University of Guelph. DNA barcoding methods, however, are still cost-prohibitive at the retail level.

A lack of adequate standards is also a risk factor for EMAs: in a case involving heavily adulterated honey, defendants were found not guilty because the state had not set standards for honey's purity; this has also factored in EMAs involving olive (*Olea europaea*) oil.

Along with inadequate test methods and standards for some foods and continuing efforts by EMA perpetrators to circumvent them, a long, complex supply chain is a risk factor for many foods. Cheap Chinese honey may be bought and sold several times, and its provenance altered, before illegal importation to the US. Spices and extracts often have long supply chains and are bought and sold many times before reaching retail sale.

One potential indicator of an undiscovered EMA might be unexpected allergic reactions to a food. Dilution of olive oil with peanut (*Arachis hypogaea*) or tree nut oils or substitution of gluten or soy (*Glycine max*) protein in meat-based products might cause such reactions. Regulators must also look to nontraditional data sources for potential adulterants. In a case of diethylene glycol (DEG) adulteration of wine, the novel adulterant was discovered by a tax office; with no immediate harmful effects to consumers' health, this EMA might have continued much longer. Market data also offer clues to potential EMAs.

Two striking similarities of EMAs discussed are their apparent ease and large scale. Of 96 samples of fish sold in New York and Toronto retail outlets, 91 had a barcode match in the species database; 24 (26%) of these were misidentified. Multiple seafood fraud surveys have shown similar results. Mislabeling occurs most often at the wholesale level or retail point of sale rather than when fish are caught. In the Chinese melamine contamination case, adulteration was well-organized, had gone on for over three years, and occurred at 22 Chinese dairy companies. Fruit juices, oils and fats, bulk products, and alcoholic beverages can often be adulterated with little risk of detection.

Industry trade groups, with economic incentive to protect the integrity of their products, can be of great assistance in developing standards and providing independent quality certification. The ability to detect and prevent challenging, ever-changing EMAs must be seen as a strong defense against deliberate acts of food sabotage or terrorism.

—Mariann Garner-Wizard

The American Botanical Council has chosen not to reprint the original article.