Vulnerability Assessment Frameworks and Food Fraud Mitigation Strategies

Karen Everstine, PhD
Senior Manager, Scientific Affairs
Decernis – FoodChain ID

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Agenda

- Introduction
- Recent fraud incidents
- Food Fraud Database
- Ingredient profiles
- Food fraud mitigation
- Recent developments
- Lessons learned

Decernis Services

All tied together by our Risk Management Dashboard for easy access & seamless monitoring

Horizon Scanning
Daily Risk Monitoring

Automatically tracks relevant, global regulatory notifications, scientific opinions, product recalls & warning announcements. Track substances, flag events & push info to others.

gComply
Regulatory Reference

Web-based regulatory reference database & library containing over 90,000 regulations across 212 countries.

gComply Plus
Product Analysis

Rule-based, intelligent, automated compliance analysis and reporting system; integrates with a company's PLM and ERP systems.

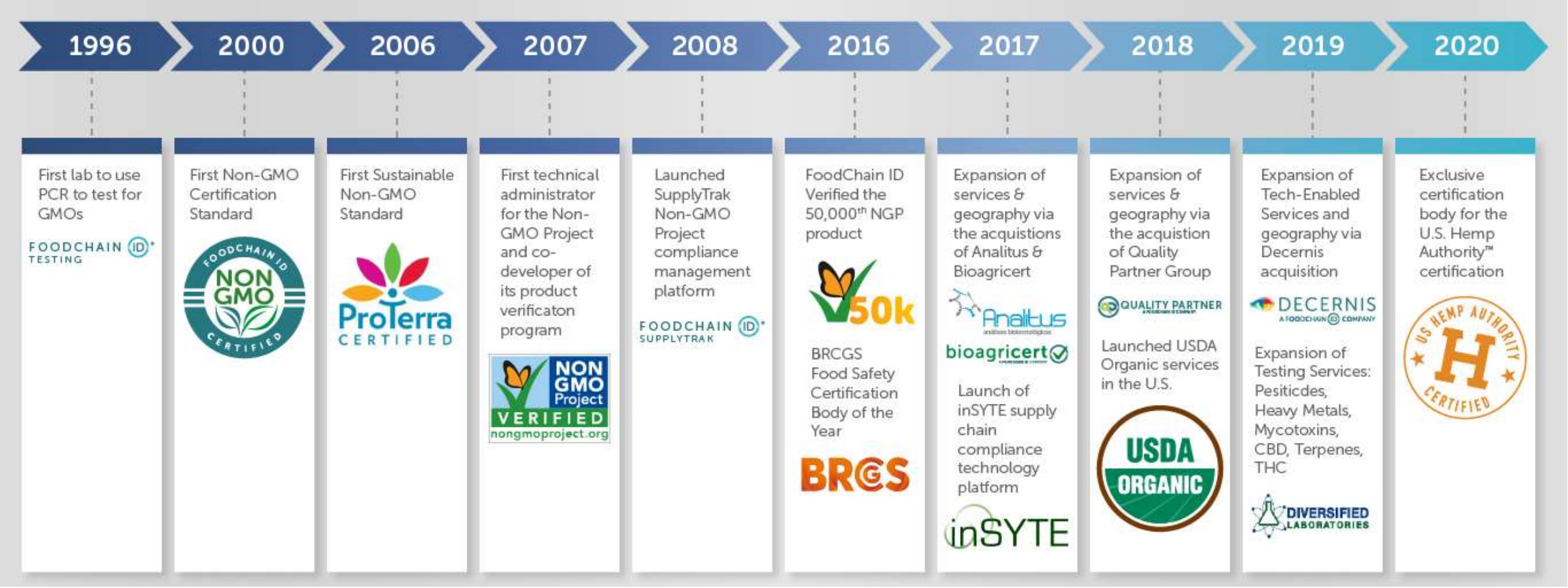
Food Fraud
FFD & HorizonScan™

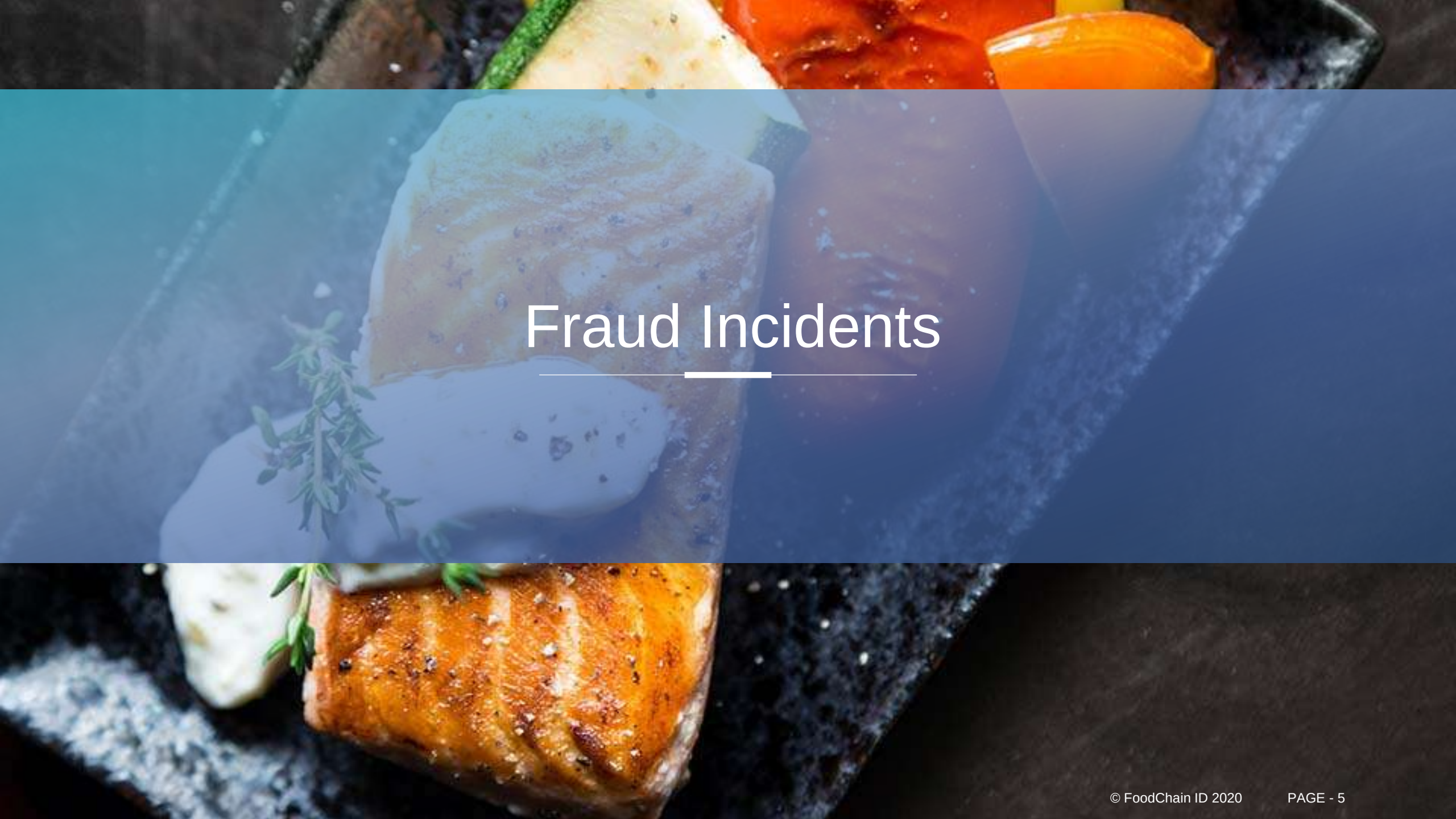
Continuously updated data on thousands of ingredients. Weekly alerts on new records. Supports GFSI & FSMA compliance.

Supply Chain Management
Supplier Risk Monitoring

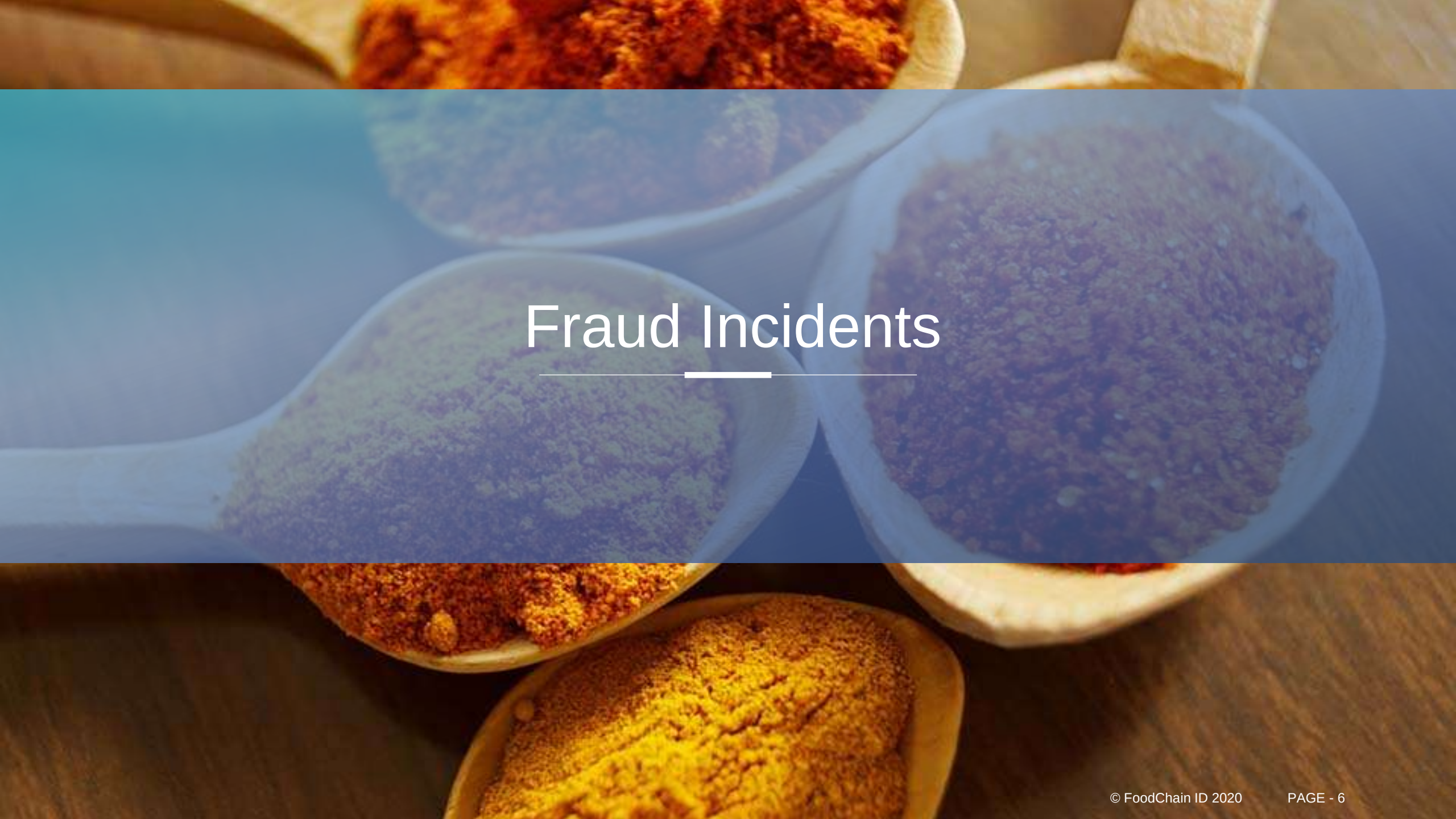
Manages all compliance documents including questionnaires, certificates, SDSs, lab results, to identify missing or out-of-date documents.

FoodChain ID





Fraud Incidents



Fraud Incidents

Fraud Incidents

Fraud Incidents

What is Food Fraud? (Decernis)

The intentional misrepresentation of foods or food ingredients for economic gain

- Dilution or substitution
- Artificial enhancement
- Use of undeclared, unapproved or banned biocides
- Removal of authentic constituents
- Misrepresentation of nutritional value
- Fraudulent labeling claims
- Formulation of a fraudulent product
- Counterfeits, theft overruns grey markets

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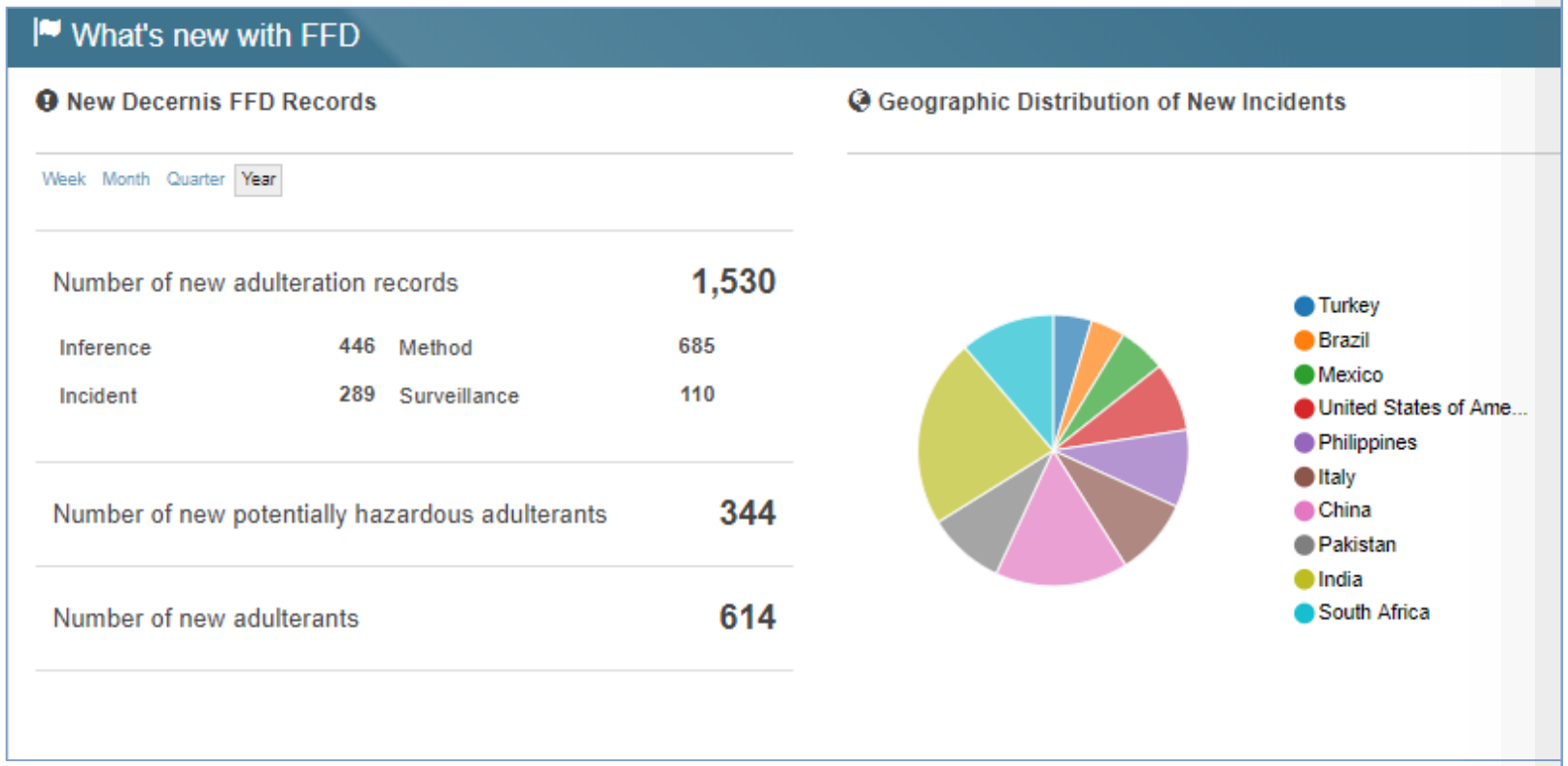
The Food Fraud Database



- Multiple data sources
- Curated by SMEs
- Method library
- Create/save profiles
- Assessment consultancy

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Record Types

Incident

- Documented occurrence
- Contextual information
- Geographic information

Inference

- Probable knowledge
- Inferred from published research
- Subject matter expertise

Surveillance

- Food product sampling
- Percentage out of specification
- Geographic information

Method

- Analytical methods research
- Testing range, LOD

Data Sources

- Media reports
- Government websites
- Recalls
- Scientific Literature
- Trade Associations
- Etc.

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journal homepage: www.elsevier.com/locate/lwt

Detection of durum wheat pasta adulteration with common wheat by infrared spectroscopy and chemometrics: A case study

Annalisa De Girolamo[a,*], Marcia Carolina Arroyo[b], Salvatore Cervellieri[a], Marina Cortese[a], Michelangelo Pascale[a], Antonio Francesco Logrieco[a], Vincenzo Lippolis[a]

[a] Institute of Sciences of Food Production (ISPA), CNR-National Research Council of Italy, Via G. Amendola 122/O, 70126, Bari, Italy
[b] INQUIMAE (UNS-CONICET), Department of Chemistry, Universidad Nacional del Sur, Av. Alem 1253, B8000CPB, Bahía Blanca, Buenos Aires, Argentina

ARTICLE INFO

Keywords:
FT-NIR/MIR spectroscopy
Durum wheat pasta adulteration
Rapid method
LDA
PLS-DA

ABSTRACT

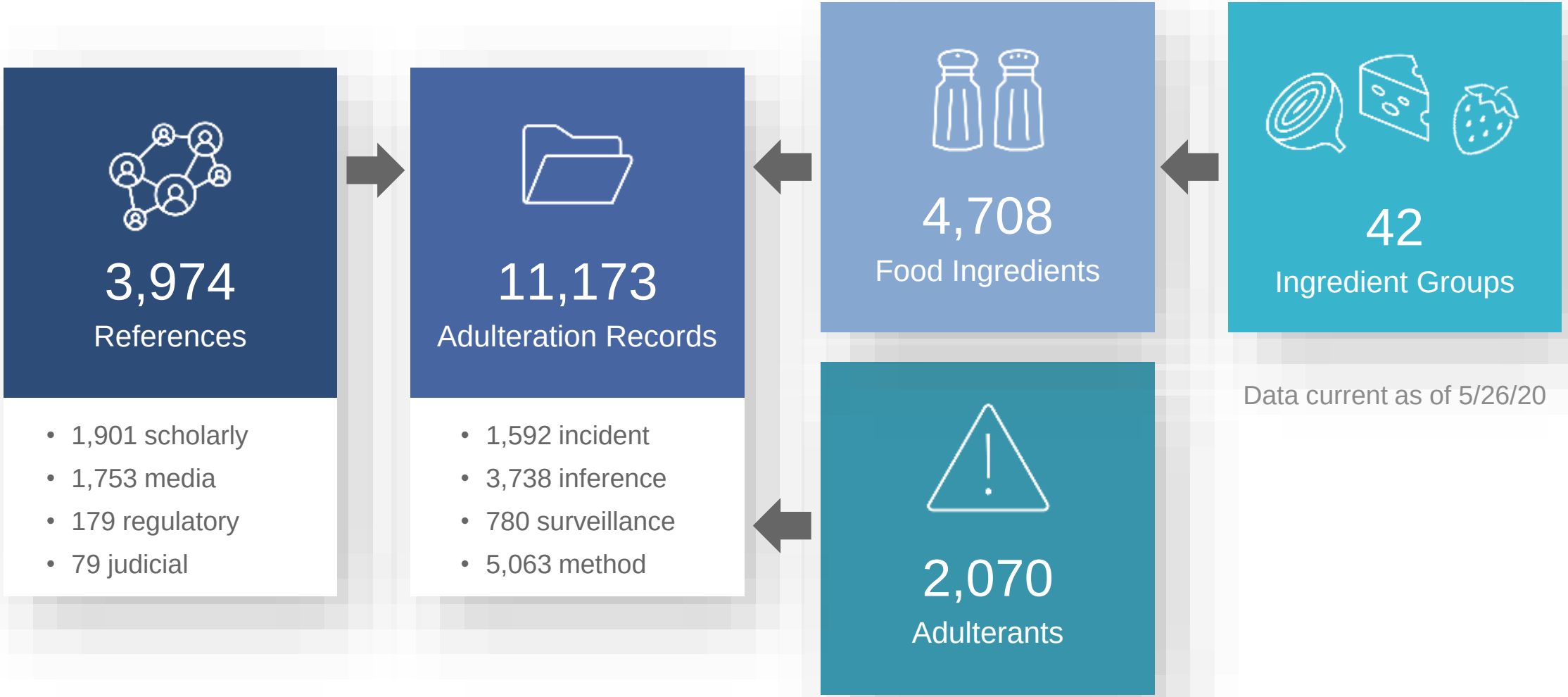
Fourier transform (FT) infrared spectroscopy, in combination with Partial-Least Squares Discriminant Analysis (PLS-DA) and Linear Discriminant Analysis (LDA), was used to discriminate commercial durum wheat pasta from Italy and Argentina for common wheat adulteration. Samples were analyzed by both near- and mid-infrared spectroscopy (FT-NIR, FT-MIR) and the performance results were compared. Classification models were developed and validated using Argentinean and Italian durum wheat pasta samples containing common wheat at levels up to 28% and lower than 0.5%, respectively (as determined by ELISA method). The first LDA and PLS-DA models grouped samples into three-classes, i.e. common wheat ≤ 1%, from 1 to ≤5% and > 5%; while the second LDA and PLS-DA models grouped samples into two-classes using a cut-off of 2% common wheat. The accuracy of the validated models were between 80 and 95% for the three-classes approach and between 91 and 97% for the two-classes approach. In general, the three-classes approach provided better results in the FT-NIR range while the two-classes approach provided comparable results in both spectral ranges.

Results indicate that FT-NIR and FT-MIR spectroscopy, in combination with chemometric models, represent a promising, inexpensive and easy-to-use screening tool to rapidly analyze durum wheat pasta samples for monitoring common wheat adulteration.

1. Introduction

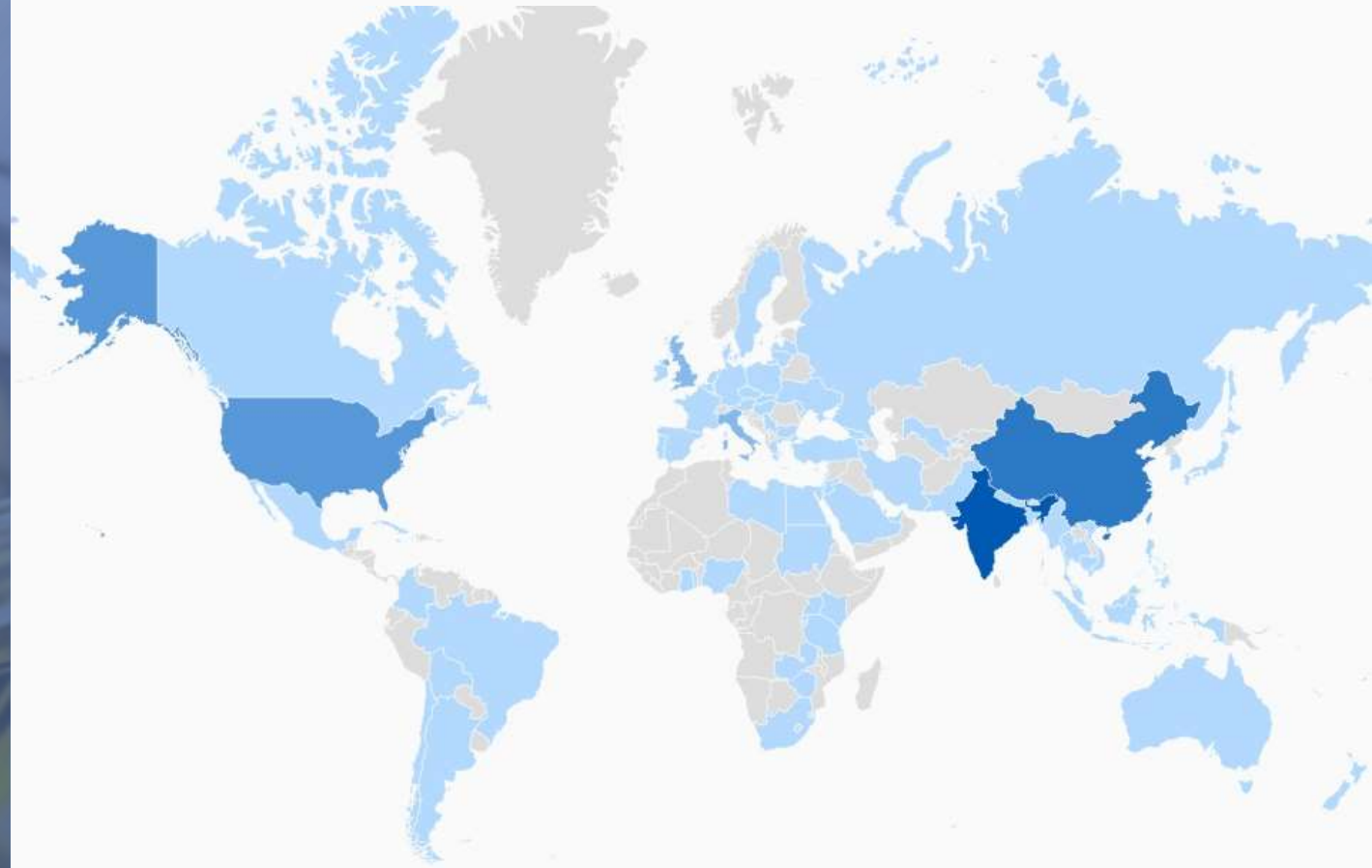
Pasta is one of the most common staple food and a key component of the Mediterranean diet representing an important source of carbohydrates and characterizing a healthy choice among carbohydrate-rich foods for its low glycemic index and high satiating ability. The pasta benefit economically by the undeclared addition of common wheat flour for durum wheat pasta production. The addition of common wheat flour is an adulteration that leads to a pasta product with a lower resistance to cooking and therefore to a pasta of lower cooking quality (Pauly, Pareyt, Fierens, & Delcour, 2013). As cross contaminations are frequent during growing, harvesting, and flour milling practices, the

Database Summary



Data current as of 5/26/20

Global Distribution of Food Fraud Incidents



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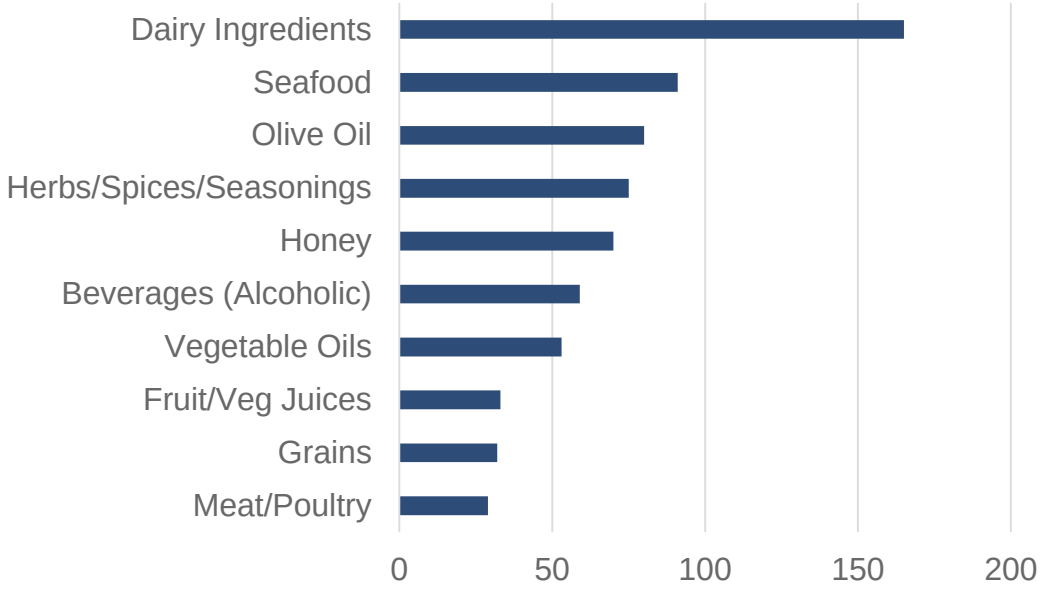
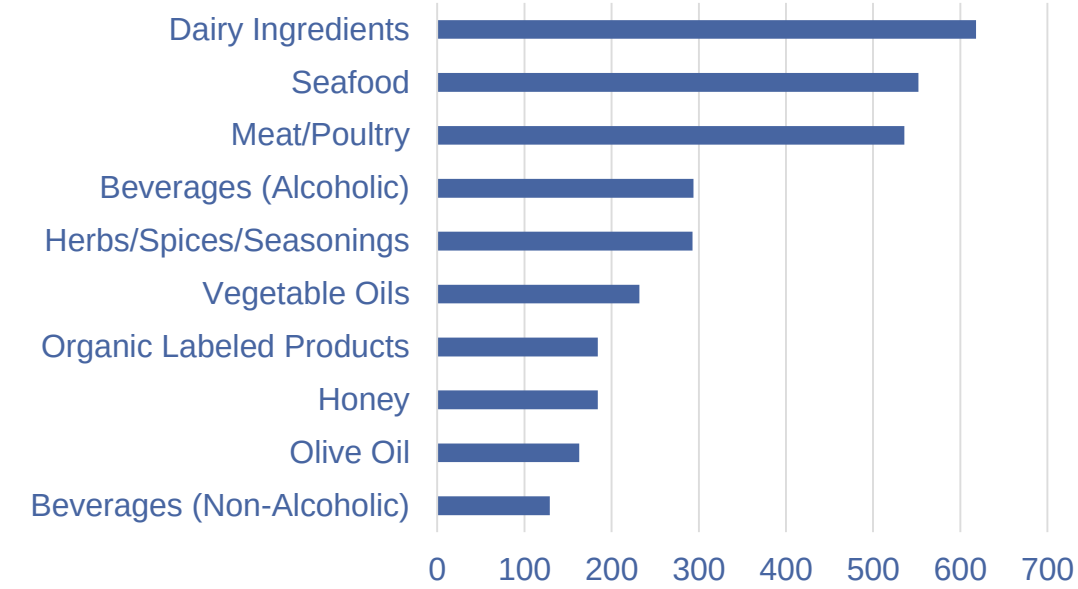
Ingredient Groups

- Beverages (Alcoholic)
- Beverages (Non-Alcoholic)
- Butter and Milkfat Products
- Cheeses
- Chocolate, Cocoa, and Candy
- Coffee
- Colors
- Cultures
- Dairy Ingredients
- Dairy Ingredients (from Animals other than Cows)
- Eggs and Egg Products
- Emulsifiers
- Enzymes
- Essential Oils, Oleoresins, and Natural Extractives
- Flavors
- Flavors (Natural)
- Fruit and Veg. Juices and Concentrates
- Grains
- Gums
- Herbs, Spices, and Seasonings
- Honey
- Lactose and Permeate Powders
- Meat and Poultry Products
- Milk and Cream
- Milk Powders
- Milk Protein Products
- Olive Oil
- Organic Labeled Products
- Plant-Based Protein Ingredients
- Preservatives
- Protein Concentrates and Isolates
- Rice
- Seafood and Seafood Products
- Sweeteners (Non-Nutritive)
- Sweeteners (Nutritive)
- Tea
- Tree Nuts and Peanuts
- Vegetable Oils
- Vinegars
- Vitamins and Minerals
- Whey Products
- Wines

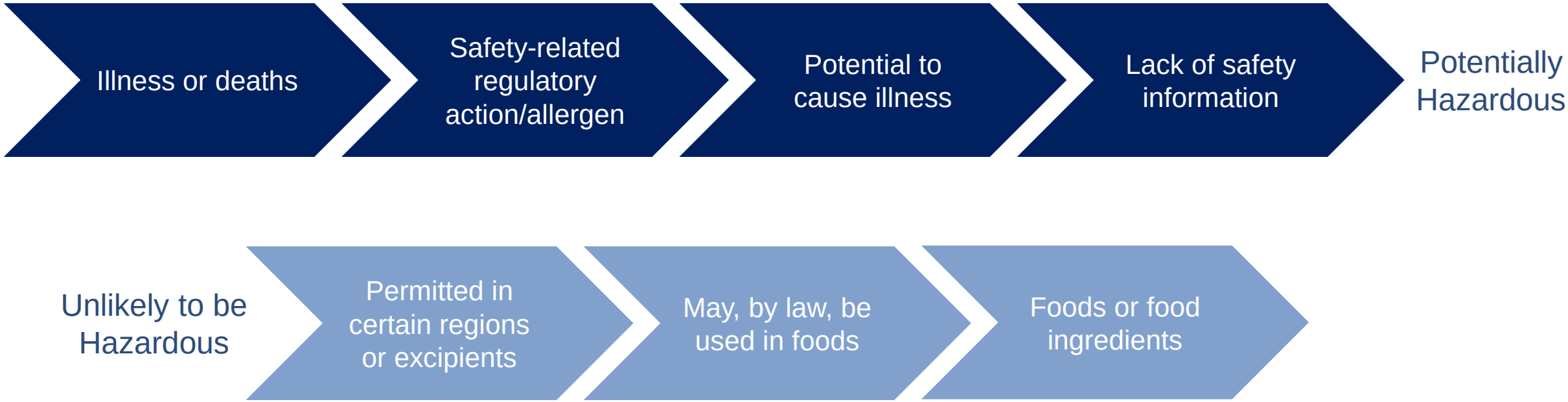
Commodity Group Trends





Source: Decernis Food Fraud Database

Hazard Classification

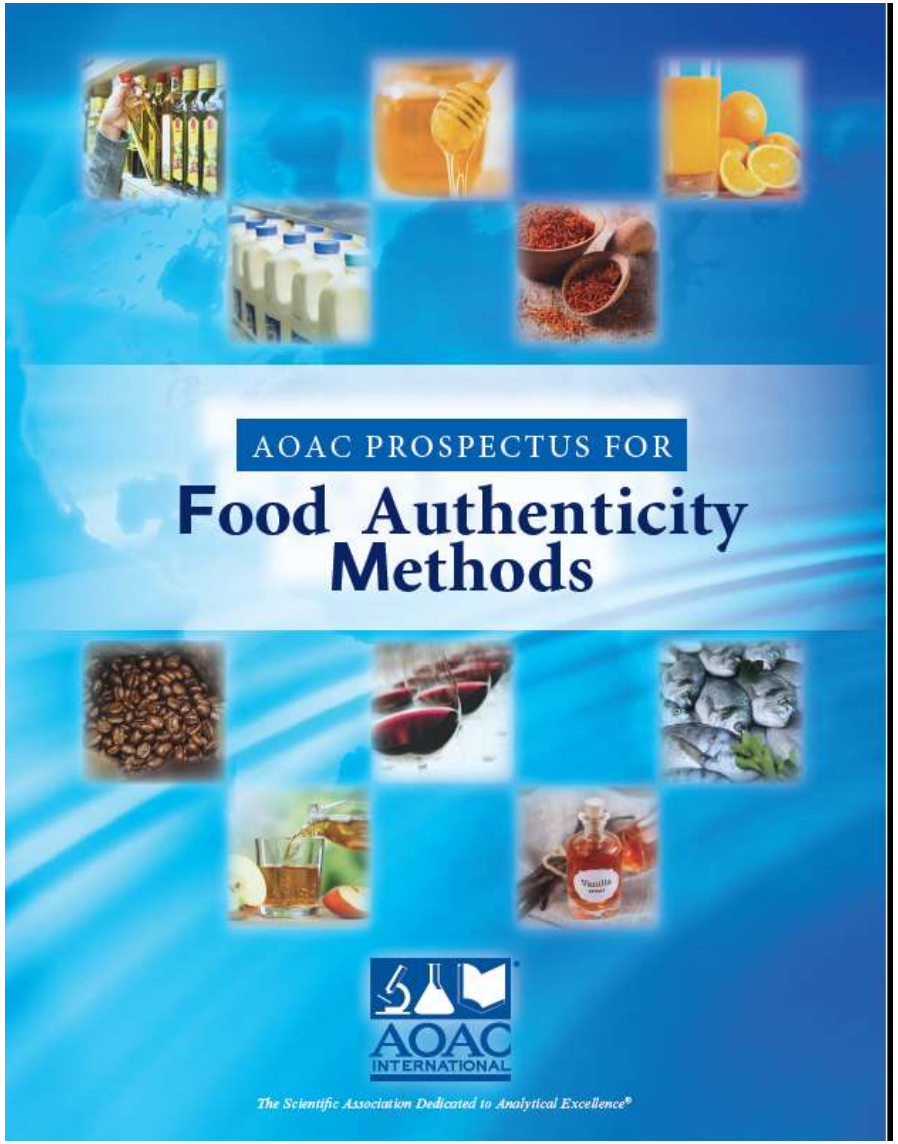


48% of records associated with at least one potentially hazardous adulterant (N=5085)

Source: Everstine, K., E. Abt, D. McColl, B. Popping, S. Morrison-Rowe, R.W. Lane, J. Scimeca, C. Winter, A. Ebert, J.C. Moore, and H.B. Chin. Development of a Hazard Classification Scheme for Substances Used in the Fraudulent Adulteration of Foods. *J. Food Prot*. 2018 Jan; 81(1):31-36.

AOAC Food Authenticity Methods Program

To address the analytical needs for combatting intentional and economically motivated food adulteration



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Ingredient Profiles – Olive Oil

263 records

74 adulterants

42 adulterants associated with >1 record

Oils
Sunflower
Soybean
Corn
Hazelnut
Canola
Peanut
Grapeseed

Colors
Chlorophylls
Copper Chlorophyllin
Beta-Carotene

Lower grade olive oil

- Misrepresentation of botanical origin
- Other substitution (oil grade)
- Geographic origin misrepresentation

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Ingredient Profiles – Honey

244 records

68 adulterants

31 adulterants associated with >1 record

Sugars
Cane sugar
HFCS
Rice syrup
Barley malt
Invert sugar syrup

Antibiotics
Chloramphenicol
Ciprofloxacin
Ampicillin
Enrofloxacin
Erythromycin

Alternate geographic origin

- Other substitution (botanical sugar source)
- Varietal substitution
- Geographic origin misrepresentation

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Ingredient Profiles – Milk

381 records

170 adulterants

86 adulterants associated with >1 record

"Proteins"
Melamine/analogues
Urea
Whey
Soy

Preservatives

Fats
Palm oil
Soy oil
Sunflower oil

Neutralizers

Starches
Flour
Maltodextrin
Arrowroot

- Artificial enhancement of apparent protein content
- Other dilution/substitution (starches, fats, etc.)
- Addition of a substance not approved for use in food

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Food Fraud Mitigation

“Short list” of ingredients

Contributing factors to fraud

- Supply Chain
- Audit Strategy
- Supplier Relationship
- Supplier History
- Susceptibility of QA Methods
- Testing Frequency
- Geopolitical Considerations
- Fraud History
- Economic Anomalies

Source: https://www.usp.org/sites/default/files/usp/document/our-work/Foods/food-fraud-mitigation-guidance.pdf

Vulnerability & Impact Assessment

1. **Contribution to vulnerability**
2. Impact evaluation
3. Overall vulnerability characterization

		Contribution to Vulnerability				
	Contributing Factor	Low *	Medium-Low *	Medium *	Medium-High *	High *
Controllable Factors	Supply chain	Firm vertically integrated	Supplier vertically integrated	Supplier manufactures	Upstream supplier manufactures	Open market
	Audit strategy	Robust, onsite with numerous anti-fraud measures	Robust, onsite, with limited anti-fraud measures	Immature, onsite, with limited anti-fraud measures	Immature onsite audit strategy with no anti-fraud measures; or strategy with limited anti-fraud measures in development	No onsite audits being used
	Supplier relationship	Trusted supplier and previously purchased ingredient(s)	Trusted supplier and new ingredient	Established supplier and some relationship	Established supplier and no prior relationship	Unestablished supplier and no prior relationship
	History of supplier regulatory, quality, or safety issues	No known issues	Few minor issues, quickly resolved	Recurrent issues or resolution concerns	Multiple persistent issues indicating lack of responsiveness to concerns; some evidence of inadequate controls	Strong evidence of quality or safety concerns; inadequate controls
	Susceptibility of QA methods and specs	More than sufficiently characterizes ingredient and can detect known and potentially unknown adulterants	Moderately sufficient to characterize ingredient and detect known adulterants	Moderately sufficient to characterize ingredient but some known adulterants may not be detected	Limited characterization of ingredient and limited screening for select adulterants	Limited to no characterization of ingredient and some known adulterants will not be detected
	Testing frequency	Intensive-every lot tested by buyer	Random lots tested by buyer	Testing done at yearly or other limited intervals as part of supplier qualification	No testing done, reliance on Certificate of Analysis	No testing done, COA either not present or not specific to lot/shipment
	Geopolitical Considerations	Single component ingredient sourced from a single geographic origin of low concern	Ingredient comprised of two to several components sourced from geographic origin(s) of low concern	Ingredient comprised of a single to few components that have originated or transited through a region or regions with some geopolitical concerns	Ingredient comprised of several components; some originated or transited through regions with some geopolitical concerns	Ingredient comprised of one or more components that originated or transited through one or more regions exhibiting several characteristics of geopolitical concern
Uncontrollable Factors	Fraud history	No reports or few known reports with no or unknown validity	Low to moderate number of reports with limited or unknown validity	Moderate number of reports with limited degree of validity	Moderate number of reports with good degree of validity; or High number with limited validity	High to moderate number of reports, some with high degree of validity, and/or evidence of an ongoing incident
	Economic anomalies	Nothing unusual	Isolated cases	Frequent but unrelated cases	Common but focused cases	Common and broad cases

Vulnerability & Impact Assessment

1. Contribution to vulnerability
2. **Impact evaluation**
3. Overall vulnerability characterization

	Low		Moderate		High
Food Safety	Food grade-known safe	Food grade-No known risks	Food grade-known sub-population risks	Non-food/non-food grade-unknown risks	Non-food/non-food grade-known risks
Economic Impact	No significant balance sheet impact		Operational Risk		Enterprise risk
Potential Multipliers					
Focused Consumption	No focused consumption	Temporally focused	Low level	Potential target populations	At-risk populations
Nutritional Sufficiency	No sufficiency impacts		Important micro-nutrient food	Core food for a sub-population	Primary/critical sub-population food
Public Confidence	Specific food	Specific commodity	Industry sector	Industry wide	Authorities & industry

Source: USP Food Fraud Mitigation Guidance

Vulnerability & Impact Assessment

1. Contribution to vulnerability
2. Impact evaluation
3. **Overall vulnerability characterization**

			Contributing Factors (Composite of Step 1)				
			1	2	3	4	5
			Low	Medium-Low	Medium	Medium-High	High
Potential Impact (Composite of Step 2)	A	Low Economic	New controls optional	New controls optional	New controls optional	New controls optional	New controls should be considered
	B	Moderate Economic	New controls optional	New controls should be considered	New controls should be considered	New controls should be considered	New controls strongly recommended
	C	Low Public Health/High Economic	New controls optional	New controls should be considered	New controls should be considered	[illegible]	New controls strongly recommended
	D	Moderate Public Health/High Economic	New controls optional	New controls should be considered	New controls strongly recommended	New controls strongly recommended	New controls strongly recommended
	E	High Public Health/High Economic	New controls optional	New controls strongly recommended	New controls strongly recommended	New controls strongly recommended	New controls strongly recommended

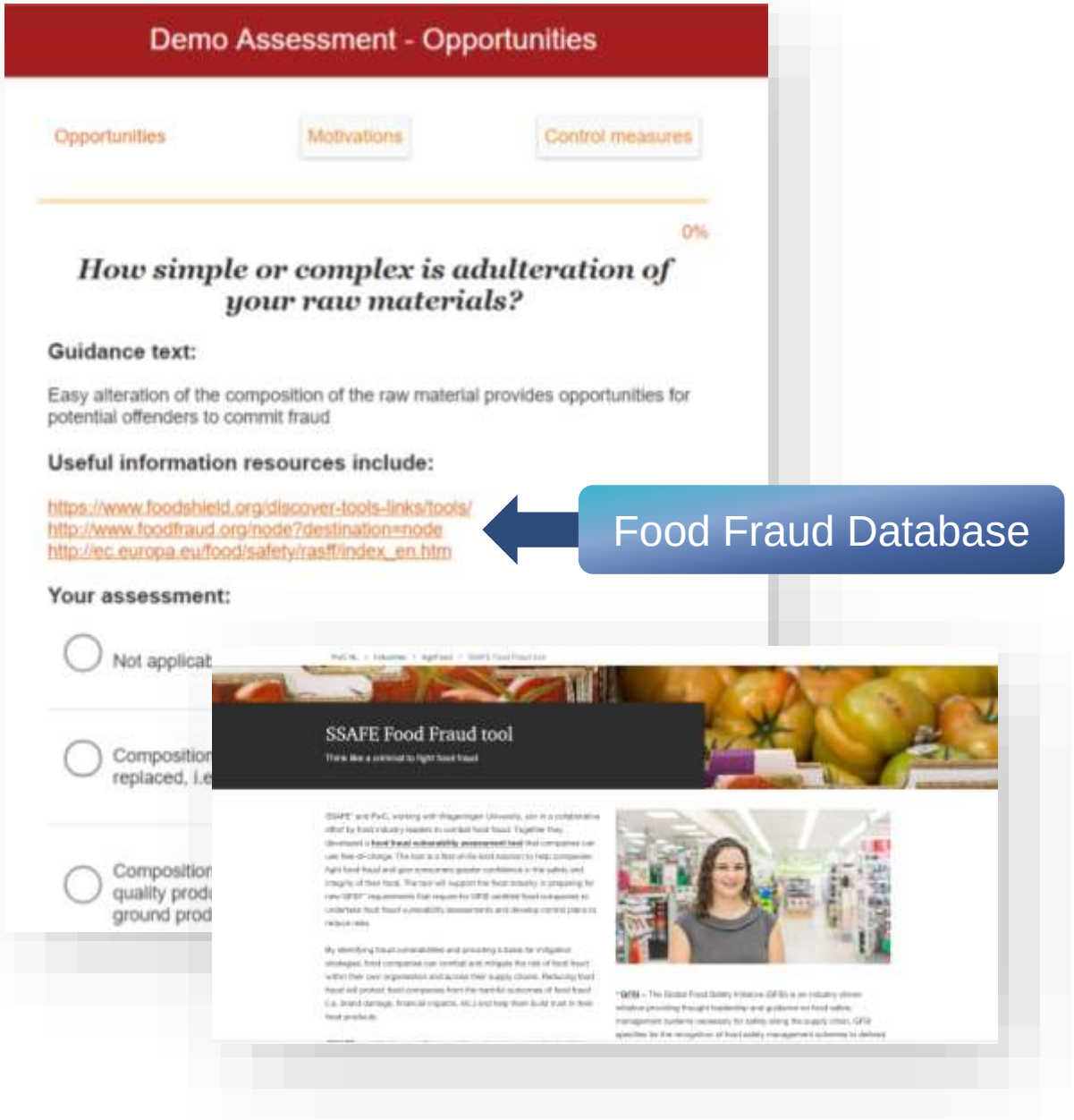
Source: USP Food Fraud Mitigation Guidance

Vulnerability Assessment Examples

Contributing Factor	Vulnerability Score – Sugar	Vulnerability Score - Rice
Fraud History	Medium	High
Geopolitical factors	Medium-high	High
Economic “anomalies”	Medium-low	Medium
Supply chain complexity	Medium-low	Medium-high
Audit strategy	Medium-high	Medium-high
Supplier relationship	Low	Medium-low
History of quality/safety issues by supplier	Low	Medium-low
Susceptibility of QA methods	Medium-low	High
Testing frequency	Medium-high	High

SSAFE/PwC Tool

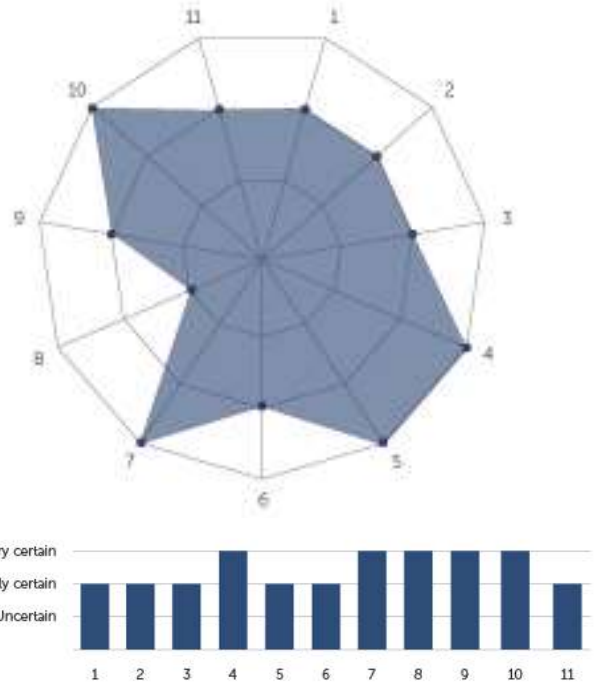
- Opportunities
- Motivations
- Control Measures



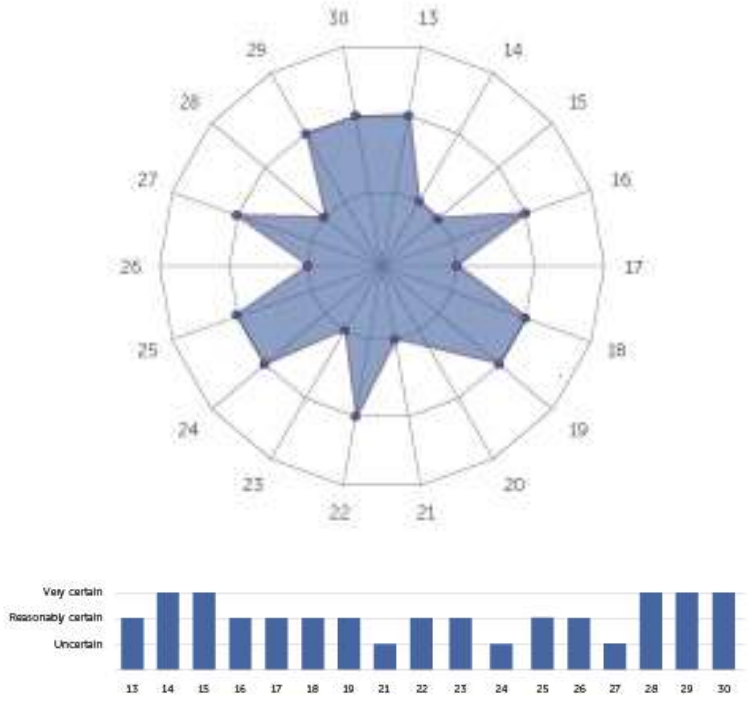
Food Fraud Database

SSAFE/PwC Tool

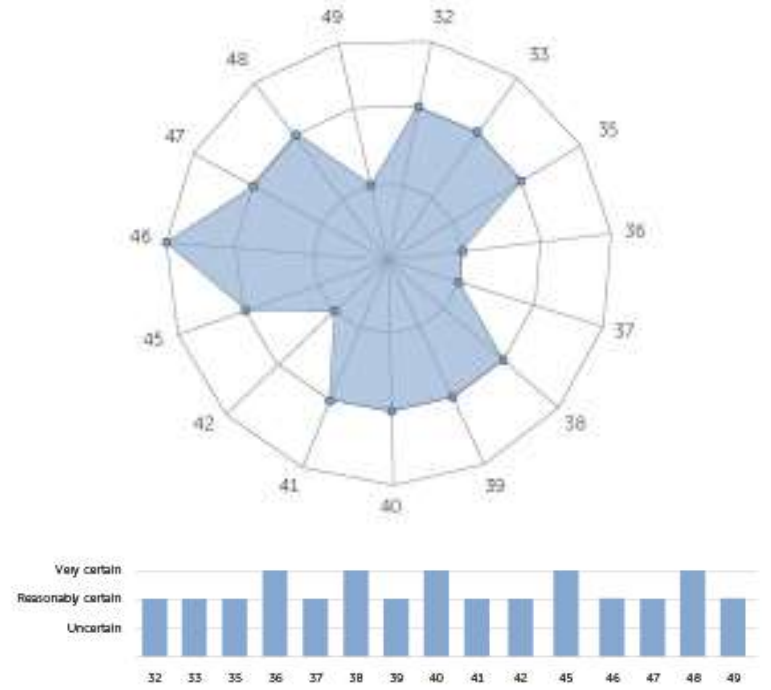
Opportunities



Motivations



Control Measures

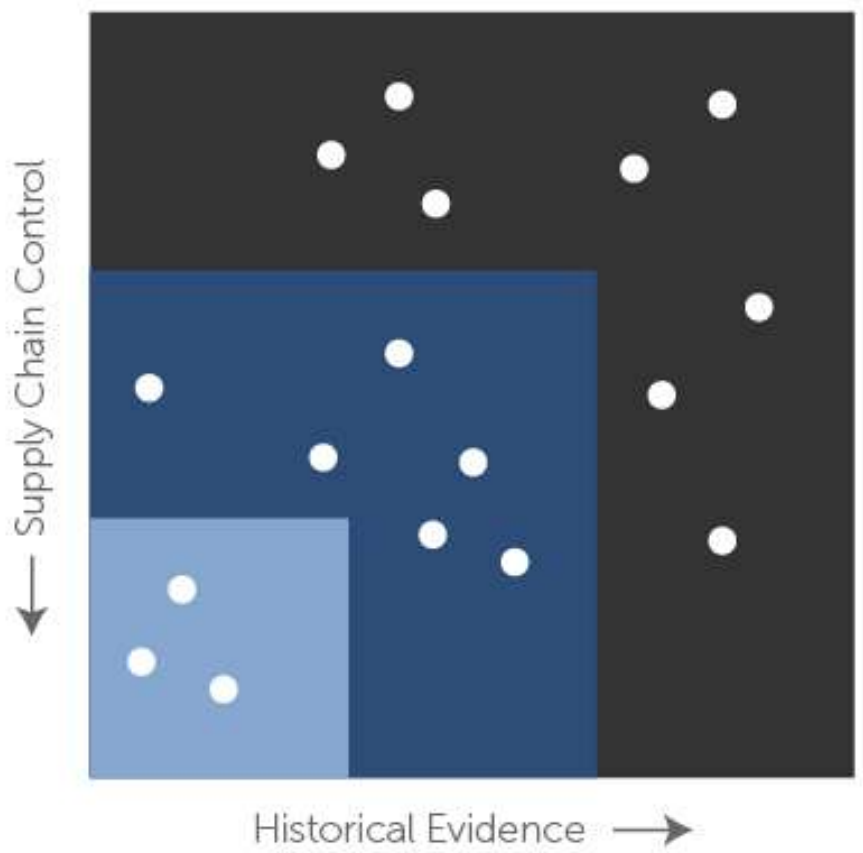


Limitations in FFVAs

- Appropriately grouping and prioritizing
- Evaluating the vulnerability of multi-component finished products
- Collecting and evaluating supporting data
- Evaluating public health and economic impacts
- Resource constraints at small/medium-sized companies and in developing countries
- Understanding and creating standards for fraud-focused analytical detection methods
- Evaluating fraud vulnerability in food packaging

Barrere, V., Everstine, K., Théolier, J., Godefroy, S., 2020. Food fraud vulnerability assessment: Towards a global consensus on procedures to manage and mitigate food fraud. Trends Food Sci. Technol. 100, 131–137. https://doi.org/10.1016/j.tifs.2020.04.002

Ingredient Screening Process



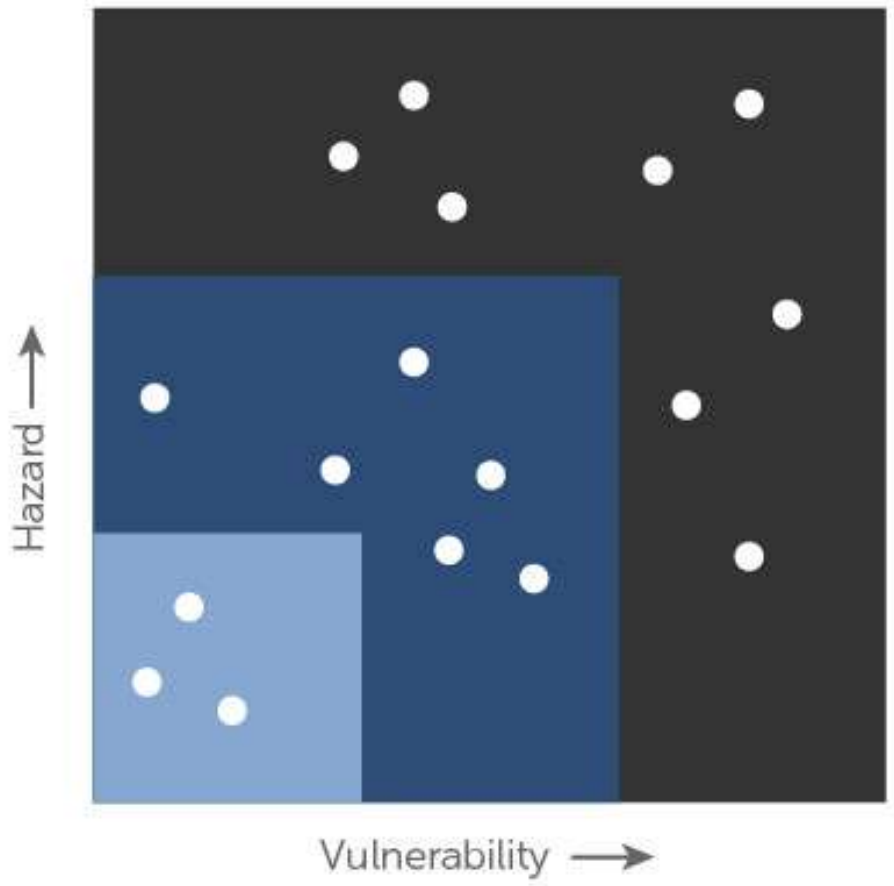
Supply chain control:

- Degree of vertical integration
- Established supplier
- No history of quality/safety issues

Historical evidence of fraud risk:

- Number of incident records
- Hazard classification of adulterants

Ingredient Screening Process



Vulnerability:

- Number of incidents
- Number of inference records
- Physical form
- Alternate grades available

Hazard:

- Number of adulterants
- Hazard classification of adulterants

Food Fraud Mitigation – Lessons Learned

- Pre-screen is helpful for large portfolios of ingredients
- Take vertical integration into account
- Risk is best managed at the ingredient level
- Strong supplier relationships are important
- You know more about your supply chain than anyone
- Pay particular attention to claims
- The process should be routinely monitored & updated

Recent Updates

- International Association of Food Protection (IAFP) Professional Development Group – Food Fraud PDG
- *Food Chemicals Codex* olive oil and honey standards
- Publication: “Food Fraud Vulnerability Assessment: Towards a global consensus on procedures to manage and mitigate food fraud” (https://www.sciencedirect.com/science/article/pii/S0924224420304313)
- Book – *Food Fraud - A Global Threat with Public Health and Economic Consequences* (https://www.elsevier.com/books/food-fraud/hellberg/978-0-12-817242-1)
- Food Safety Tech - Food Fraud Resource Center (https://foodsafetytech.com/food-fraud-resource-center/)
- AOAC Food Fraud Working Groups (Targeted and Non-Targeted Methods)

Food Fraud Newsletter

Available for download at https://decernis.com/shop/

Food Fraud Newsletter

April 2020

Understanding and Combating Spice Fraud Webinar Q&A

Decernis and USP hosted a joint webinar on April 15 titled "Understanding and Combating Spice Fraud" (if you missed it, you can access a recording HERE.) The speakers included Steven Gendel and Tongtong Xu from USP and Karen Everstine from Decernis. Dr. Everstine discussed the history of fraud in spices, shared some recent examples of spice fraud, and talked about some of the attributes of spices that make them particularly prone to fraud. Dr. Xu provided an update on USP's work to further the development of analytical methods to detect artificial colors in spices. These fit-for-purpose methods included a non-targeted screening using thin-layer chromatography and a targeted approach for 25 illegal colors using LC-TQMS. Finally, Dr. Gendel talked about the importance of public standards in combating spice fraud and how USP standards support authenticity throughout the supply chain.

We responded to some follow-up questions from the webinar below:

Q: Do we have any rapid test methods to find out adulteration?
A: There is no single answer for all foods and all potential adulterants. Several of the non-targeted methods that have been developed can be very rapid once the system has been set up and validated. These can include the use of hand-held sensors. Please see the FCC non-targeted method guidance for details on how to develop and implement this approach.

Q: Is most of the adulteration found in ground spices and why?
A: While it is true that adulteration of ground spices may be easier to carry out and harder to detect, there have been a number of instances where whole spices have been adulterated. This can include mixing in seeds that look like the spice or treating the spice with colors to make them appear to be higher quality.

Q: Can you describe the labeling of cinnamon on food labels and what spices can be labeled as cinnamon?
A: On supplement labels have different labeling requirmenets. To all sources of spices can be labeled as cinnamon on a food label, the expensive varieties like ceylon and chepaer, i.e., mexican. The FDA has recognized three species of cinnamon as Generally Recognized as Safe for use in food (21CFR182.10). Regarding labeling, there are different requirements for labeling of foods and dietary supplements. In general, it is possible to determine which is appropriate in any situation by considering the intended use and marketing of the substance. The American Botanical Council also has information that may be helpful.

Q: Are there any established cross contamination limits for adulterating spices with colorants?
A: There are not specific limits regarding cross contamination for spices. It is expected that colorants will not be used unless there is a regulatory approval for use of a particular color with a particular spice. Beyond this, facilities should have effective Good Manufacturing Practices in place to prevent cross contamination.

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Questions?

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keverstine@decernis.com