Addressing the Emerging Risk of Food Fraud

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U.S. Pharmacopeia
The U.S. Pharmacopeia

Independent, not-for-profit science-based public health organization

A public standards-setting authority for drugs, dietary supplements, and food ingredients.

Established in 1820
To improve the health of people around the world through public standards and related programs that help ensure the quality, safety, and benefit of medicines and foods.
Core Compendial Programs

- The *United States Pharmacopeia* and the *National Formulary (USP–NF)*
- *Food Chemicals Codex (FCC)*
- *USP Dietary Supplements Compendium (DSC)*
- *USP Medicines Compendium (MC)*
- Reference Standards
- Other Resources
  - *Pharmacopeial Forum (PF)*
  - *FCC Forum*
  - *USP Dictionary*
  - *Chromatographic Columns*
The Standards Setting Process

- Transparent and science-based mechanism to develop new and revised quality standards
- Approval by independent, volunteer scientific expert committee
- Process driven by stakeholders (mostly industry)
- Process open to public input

Quality Standards for Medicines, Dietary Supplements, and Food Ingredients
The Frontline of Food Fraud Detection…

…Is an Epic Battle of Chasing Known and Unknown *Unknowns*

Criminal “engineers” adulterant to evade existing QA system

QA system reacts by developing new tests

The next adulterant is unknown!
• Food safety assumes a known composition

Food safety collapses to a singularity

The criminal’s ethics & knowledge define food safety throughout the whole supply chain
FCC: The Compendial Approach

Instead of developing methods to detect what shouldn’t be there...
...develop methods to characterize the “normal range” of what should be there

Advantage:
- Anything outside normal range is suspicious
- Capable of detecting known and unknown adulterants at EMA levels
The *Food Chemicals Codex (FCC)* is a compendia of internationally recognized scientific standards established to promote uniformity of quality and added assurance of safety for food ingredients.
Food Chemicals Codex

Helps

Minimum Quality Specifications

Analytical Methods to verify quality

Reference Materials to ensure good lab work

Authenticity
- Identity
- Purity
- Strength
- Impurities

Helps protect consumers and brand from risks of imitators and economic adulteration

Quality Standards for Medicines, Dietary Supplements, and Food Ingredients
### FCC Scope

**Food-grade chemicals**
- Emulsifiers, minerals
- Amino acids

**Processing aids**
- Enzymes, solvents
- Filter media, boiler water additives

**Foods**
- Fructose, dextrose, sucrose
- Whey, amino acids

**Flavoring agents**
- Natural and synthetic flavors
- Essential oils

**Functional food ingredients**
- Olestra, salatrim, high-oleic canola oil
- Diacylglycerol oil, lycopene, scFOS

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1966
(512 monographs)

2010
(~1100 monographs)
Better Understanding **Known Unknowns**
USP’s Food Ingredients Fraud Database

• Creating a baseline of fraud issues for materials used as food ingredients
  – More than 1300 entries to date, update with 800 more entries coming in 2013
  – Data sources:
    • 1980-2010, publically available, mostly English language
    • Scholarly articles: > 500
    • Media: > 90
## Search

Enter a search item below (e.g., an adulterant or an ingredient)

![Search](https://www.foodfraud.org)

<table>
<thead>
<tr>
<th>Ingredient Category</th>
<th>Ingredient</th>
<th>Adulterant</th>
<th>Reported Detection Method</th>
<th>Author/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein-based ingredients</td>
<td>Soy milk</td>
<td>Bovine milk proteins</td>
<td>HPLC-FID protein fingerprinting</td>
<td>Garcia and others 1997</td>
</tr>
<tr>
<td>Dairy products and milk derivatives</td>
<td>Milk (powder)</td>
<td>Whey</td>
<td>HPLC with fluorescence detection for cysteine</td>
<td>Ballin 2006</td>
</tr>
<tr>
<td>Dairy products and milk derivatives</td>
<td>Milk (powder)</td>
<td>Whey</td>
<td>GE on proteins</td>
<td>Basch and others 1985</td>
</tr>
<tr>
<td>Dairy products and milk derivatives</td>
<td>Milk (skim milk powder)</td>
<td>Pea protein</td>
<td>Non-targeted HPLC-ToF-MS with chemometrics</td>
<td>Cordewener and others 2009</td>
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<tr>
<td>Dairy products and milk derivatives</td>
<td>Milk (fluid, ovine)</td>
<td></td>
<td></td>
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<td>Milk (fluid, ovine)</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**CURRENT SEARCH**

Search found 160 items
- milk
  - milk
  - scholarly

**USING THE FILTERS**

Click filter to add
Click (-) to remove

**INGREDIENT CATEGORY**
- dairy (159)
- derivatives (159)
- milk (159)
- products (159)
- based (1)
- ingredients (1)
- protein (1)

**INGREDIENT**
- (-) milk
- fluid (114)
- powder (22)
- ovine (20)
- caprine (18)
- buffalo (14)
- water (14)
- fat (13)
Introductions

A database on food ingredient fraud has been developed by USP as a repository for reported types of fraud for specific food ingredients and associated analytical methods for detection. Such information can be useful to FCC users responsible for assessing existing and emerging risks and trends for economically motivated adulteration, authenticity, fraud, or counterfeiting issues for food ingredients. In addition, it can be useful for those managing the risk of food fraud by providing a library of detection methods reported in peer-reviewed scientific journals.

The database will be available mid-2012 in a searchable format on USP’s website at: www.usp.org. This chapter presents the information currently available in the database in tabular format, divided into two sections. Table 1 contains information from scholarly literature (e.g., scientific journal articles) and includes information on analytical methods of detection. Table 2 contains information from media-based articles reporting on food fraud collected by USP and does not include analytical methods of detection. Each entry in these two tables represents a unique food ingredient/adulterant/report combination. Entries are organized using the following food ingredient categories:

- Cereals, grains, and pulses
- Colors
- Dairy products and milk derivatives
- Flavor chemicals
- Fruit juices, concentrates, jams, purées, and preserves
- Functional food ingredients
- Gum
- Meats
- Milk
- Natural flavoring complexes
- Oils
- Other
- Protein-based ingredients
- Seafood
- Spices
- Sweeteners
- Wines, musts, spirits, liquors, and vinegars

Three terms are used to categorize the type or nature of food fraud reported: “Replacement”, “Addition of,” or “Removal of...”

“Replacement” is used to describe incidents resulting in the complete or partial replacement of a food ingredient or valuable authentic constituent with a less expensive substitute. This is typically achieved through the dilution or extension of an authentic ingredient by adding an adulterant or mixture of adulterants with the intention of circumventing standard measures for quality control. One example is the addition of melamine to milk to artificially increase apparent protein contents measured by total nitrogen methods. Other examples are the addition of water and citric acid to lemon juice to fraudulently increase the titratable acidity of the final juice product and overtreating frozen fish with extra water (ice) to increase the apparent weight of the product. This category also includes false claims and non-declarations including:

- False declaration of geographic, species, botanical, or varietal origin. Examples include the substitution of less expensive cow’s milk for sheep’s or goat’s milk. It can include also false declaration of origin to evade taxes or tariffs, for example, the import of catfish into the USA from Vietnam labeled as grouper to avoid anti-dumping duties or transhipment of Chinese shrimp through Indonesia to avoid anti-dumping duties.
- False declaration of production process such as the fraudulent labeling of a synthetically derived flavor chemical as being “naturally” derived.

“Addition” is used to describe incidents resulting in the addition of small amounts of a non-authentic substance to mask inferior quality ingredient. An example is the addition of a color additive to paprika to enhance the color of poor quality materials.

“Removal” is used to describe incidents resulting in the removal of an authentic and valuable constituent without the purchaser’s knowledge. For example, the removal of non-polar constituents from paprika (e.g., lipids and flavor compounds) is done to produce paprika-derived flavoring extracts. The sale of the resulting “defatted” paprika which lacks valuable flavoring compounds as normal paprika is a fraudulent practice.

Table 1: Scholarly Reports on Food Ingredient Fraud and Analytical Methods for Detection

<table>
<thead>
<tr>
<th>Ingredient Category</th>
<th>Ingredient</th>
<th>Adulterant</th>
<th>Type of Fraud</th>
<th>Publication Year</th>
<th>Reported Detection Method and Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals, grains, and pulses</td>
<td>Billets flour</td>
<td>Chalk powder</td>
<td>Replacement</td>
<td>2009</td>
<td>Wet-chemical tests for adulterant (Gupta and Panchal 2009)</td>
</tr>
<tr>
<td>Cereals, grains, and pulses</td>
<td>Cereal flakes</td>
<td>Melamine</td>
<td>Replacement</td>
<td>2010</td>
<td>HPLC-MS for adulterant (Burma and</td>
</tr>
</tbody>
</table>
USP’s Skim Milk Powder Project

- Objective: To develop and validate a “tool-box” of methods for the skimmed milk powder matrix that will exclude economically adulterated materials
  - Including both known and unknown adulterants

Collaborative effort:
> 15 organizations and 45 scientists
Steering Committee

Identification Procedures
- Non-Targeted w/ Chemometrics
  - NIR
  - Raman
  - NMR
  - LC-HRMS and MALDI-MS
- Semi-Targeted w/ Chemometrics
  - Intact Protein Fingerprinting
  - Amino Acid Fingerprinting

Assay Procedures
- Modified Total Nitrogen
- Total Amino Acids
- Colorimetric

Analytical & Reference Materials
- Authentic Materials
- Adulterated Materials

Spectral Libraries

USP Skim Milk Powder Advisory Group

= Research area
= Current research sub-team
= Proposed future sub-team

Chemometrics
Infrastructure
• **Approach**: Compare NIR spectrum of unknown sample to library of non-adulterated sample “signatures” using multivariate/chemometric tools
  ➢ Looks normal OR looks abnormal
• **Status**: Feasibility and proof-of-concept established in multiple single lab studies
• **Conclusions so far**: Can pick up both protein and non-protein adulterants as low as 0.05-5%
How to Interact With USP

- Attend any Expert Committee or Advisory Panel Meeting as Observer
- Electronic Forum (free and open to the public)
- Stakeholder Forum
- Annual Science Meeting
- Workshops
- Free e-Newsletters
- www.usp.org

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Questions