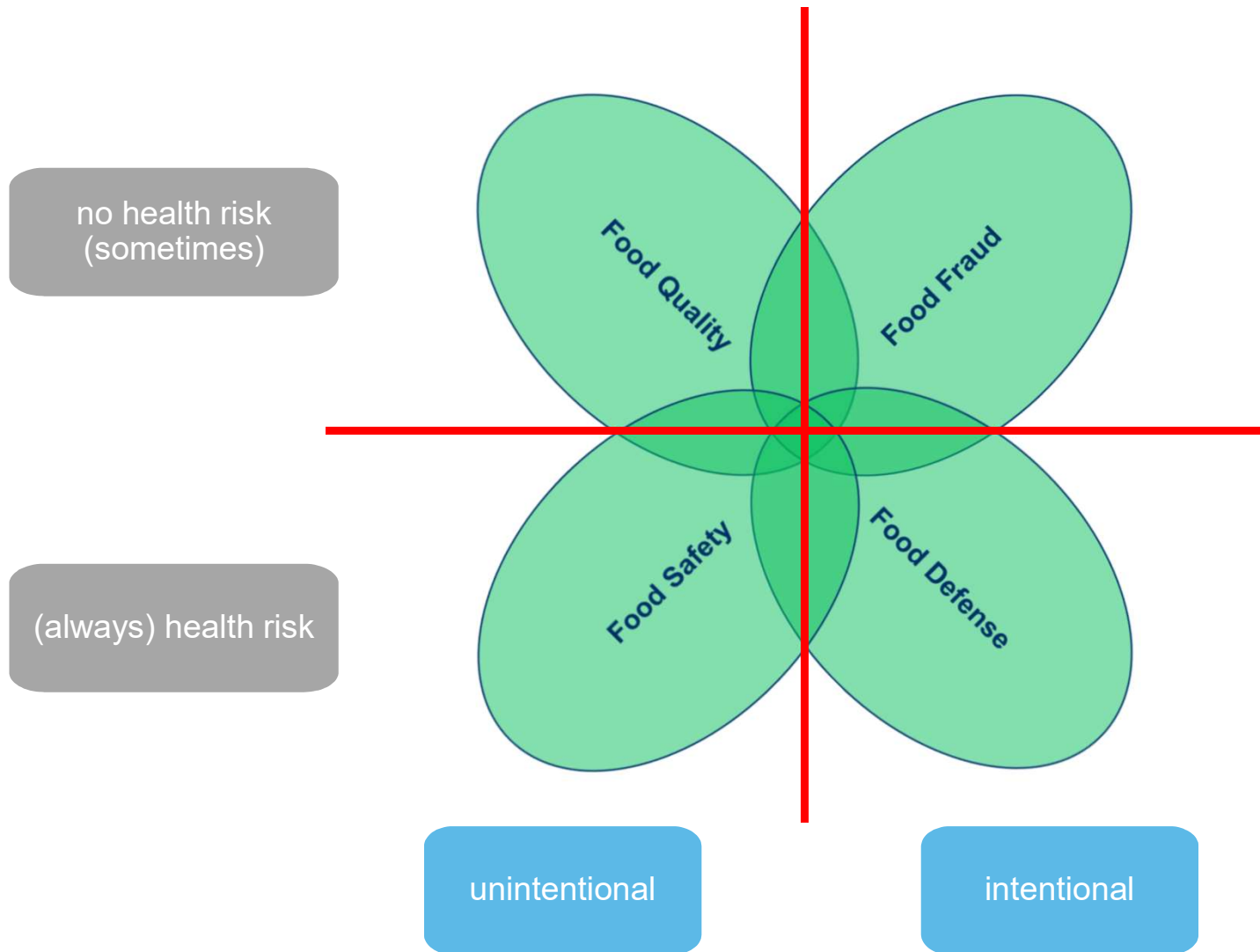




## Challenges for the implementation of analytical databases for official food authenticity controls

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Eurachem/AOAC-E webinar, 15.11.2022

- **Food Fraud:**
  - ***CEN Workshop Agreement (CWA) 17369:*** „Intentionally causing or allowing a mismatch between food product claims and food product characteristics. (Note to entry: Financial gain is the most common motivation for food fraud)”
  - ***Global Food Safety Initiative (GFSI):*** “A collective term encompassing the deliberate and intentional substitution, addition, tampering or misinterpretation of food, food ingredients or food packaging, labelling, product information or false or misleading statements made about a product for economic gain that could impact consumer health.”
  - ***European Commission:*** “Any suspected intentional action by business or individuals for the purpose of deceiving purchasers and gaining undue advantage therefrom, in violation of the rules referred to in Article 1(2) of Regulation EU 2017/625.”
  - ***Food Standards Agency (FSA) (UK):*** “Deliberately replacing food on the market, for financial gain, with the intention of deceiving the consumer.”
- **Economically Motivated Adulteration (EMA):**
  - ***Food and Drug Administration (FDA) (USA):*** „The fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product and reducing the cost of its production, i.e. for economic gain.”
- **Food Crime (UK):**
  - „The situation where food fraud no longer involves random acts by ‘rogues’ within the food industry but becomes an organized activity perpetrated by groups who knowingly set out to deceive, and or injure, those purchasing a food product.”



modifiziert nach Spink & Moyer (2011), J. Food Sci; 76, R157ff



**Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017:** on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products

### ▪ Reasons & Articles

- (3) Union legislation provides for a wholesome, and that activities which contribute to the protection of consumers' interests in accordance with specific requirements
- (73) For the performance of official controls, including identifying possible violations to the rules including those relating to animal health and in the field of animal welfare, the competent authorities should have access to updated, reliable and consistent technical data, to research findings, new techniques and expertise necessary for the correct application of Union legislation applicable in those two areas. For that purpose, the Commission should be able to designate, and rely on the expert assistance of, European Union reference centres for the authenticity and integrity of the agri-food chain and for animal welfare.
- Article 97: Designation of European Union reference centres for the authenticity and integrity of the agri-food chain

### Mission:

Support of the official control bodies in the fight against food fraud also with respect to consumer protection.



## Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017: on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products

### Article 98

#### Responsibilities and tasks of European Union reference centres for the authenticity and integrity of the agri-food chain

The European Union reference centres for the authenticity and integrity of the agri-food chain shall be responsible for the following supporting tasks insofar as they are included in the reference centres' annual or multiannual work programmes that have been established in conformity with the objectives and priorities of the relevant work programmes adopted by the Commission in accordance with Article 36 of Regulation (EU) No 652/2014:

- a) providing specialised knowledge in relation to the authenticity and integrity of the agri-food chain and to the methods for detecting violations of the rules referred to in Article 1(2) of this Regulation perpetrated through fraudulent or deceptive practices, in relation to the forensic science applied to the areas governed by these rules;
- b) providing specific analyses designed to identify the segments of the agri-food chain that are potentially subject to violations of the rules referred to in Article 1(2) of this Regulation perpetrated through fraudulent or deceptive practices and helping to develop specific official control techniques and protocols;
- c) where necessary, performing the tasks referred to in points (a) to (h) of Article 94(2) of this Regulation, thereby avoiding duplication with the tasks of European Union reference laboratories designated in accordance with Article 93 of this Regulation;
- d) where necessary, establishing and maintaining collections or databases of authenticated reference materials, to be used to detect violations of the rules referred to in Article 1(2) of this Regulation perpetrated through fraudulent or deceptive practices; and
- e) disseminating research findings and technical innovations in the fields within the scope of their mission.



Communication/Coordination



Analyses



References / Databases



Information

- **Europe:**



- No ERC implemented so far

- **Germany:**



- Federal Ministry of Food and Agriculture has established the National Reference Centre for Authentic Food at the Max Rubner-Institut in line with the EU controls regulation in 2017

**NRZ**   
**Authent**

### MRI-Sites and NRZ-Authent-Teams







## Databases:

- Implementation and maintenance of databases with analytical results from authentic reference material  
→ consistent comparison and thus evaluation of food samples all over Germany
- Server: NRZ-Authent-own server since June 2021 (pilot)
- Analytical database projects (examples):
  - Honey-NMR database
  - Fats/oils database
- Knowledge database projects:
  - Methods collection of German official control laboratories
  - Knowledge database „crop plant collections in German botanical gardens”
- Data interpretation/evaluation (statistics):
  - Support of method validation in the § 64 LFGB working groups of the Federal Office of Consumer Protection and Food Safety (BVL)
  - White Paper „Essential terminology and considerations for validation of non-targeted methods“ (together with BVL (lead), CVUA Karlsruhe, JRC and QuoData)



## Databases – A Building Block in Fighting Food Fraud

- It is rather difficult to obtain authentic food samples
- Food matrices are extremely complex and large numbers of datasets are often needed to compensate variabilities
- Owing to a lack of resources, individual facilities are rarely able to provide the required numbers of datasets by themselves
- Datasets must be protected from manipulation, hence requiring authorized access
- For comparability, datasets need to be uniform, i.e. comprise the same sets of metadata
- Data access must be quick and stable



In 2020 the NRZ-Authent started designing and creating analytical databases with datasets of authentic food samples

## Databases – Common Pitfalls I

- Datasets
  - were only available in formats unfit for proper serving (e. g. MS Excel)
  - were not accessible outside the facilities that generated them
- Data management was strongly customized/not standardized
- Databases were not properly maintained and became incompatible with current technologies

## Databases – Common Pitfalls II

- Lack of:
  - clearly defined analytical procedures (SOPs) the data were created with
  - mandatory specifications for the data
  - access management (interfaces, user rights management)
  - integrity of the datasets



incomplete, heterogenous, hardly comparable, outdated and strongly fragmented datasets with very limited access and risk of being manipulated

## Databases – How We Address These Issues

- Data are aggregated at a single location (“Single Source of Truth”)
- Data organization follows the FAIR principle (“**F**indable, **A**ccessible, **I**nteroperable, and **R**e-usable”)
- Data are made available through performant database management systems (DBMS)
- Data access is controlled through performant back-, frontends and APIs, sensitive entries are encrypted
- Programs are encapsulated in so called “containers” in order to maintain reproducibility of the data analysis
- Minimal requirements regarding the metadata are defined for each food matrix and enforced before data are written to the database
- Uniform data formats are used to allow automatic data exchange
- Databases are developed and hosted in-house by a consistent team of developers

## Databases – Development and Hosting are Time Consuming

### Start:

- Project planning (communication, problem understanding)
- Initial setup (project management, legal framework, designing, coding, testing)

### Permanent tasks:

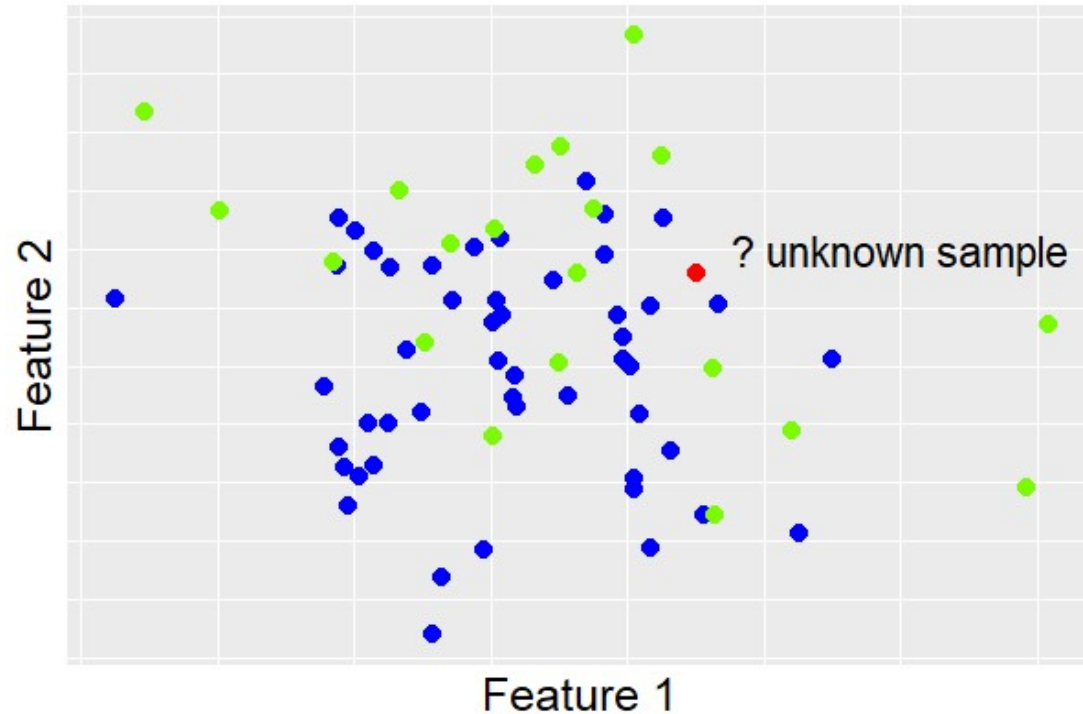
- Maintenance (ongoing corrections, updates, data security and protection)
- Performance optimization (easier to use, faster executions, the Vs: volume, velocity, variety, veracity, validity, value)
- Extensions (new aspects, new applications, new users)

## Ongoing Project - Honey Database

- Database of  $^1\text{H}$ -NMR-Spectra from honey samples
- Project partners: Honey- and NMR-experts of different food control authorities in Germany
- SOP for data generation was created and evaluated by the project partners
- Authenticity of the samples is validated using well-established analytical methods (sugar contents, organoleptic testing, pollen analysis, ...)
- Data formats of the database entries and analytical data were defined up front
- Each entry of sample and measurement data in the database has a unique identifier (UUID); file names include these UUIDs

## Food Authenticity Testing

Is there a match between the food product characteristics and the corresponding food claims?



- Development of an analytical measurement method
- Generation of a reference database of authentic samples
- Learning a decision rule



## Method development

Method does not exist, before all parts (analytical measurement method, reference database and decision rule) are available.

- Change of the SOP
- Change of the Database
- Change of the Decision rule



New method

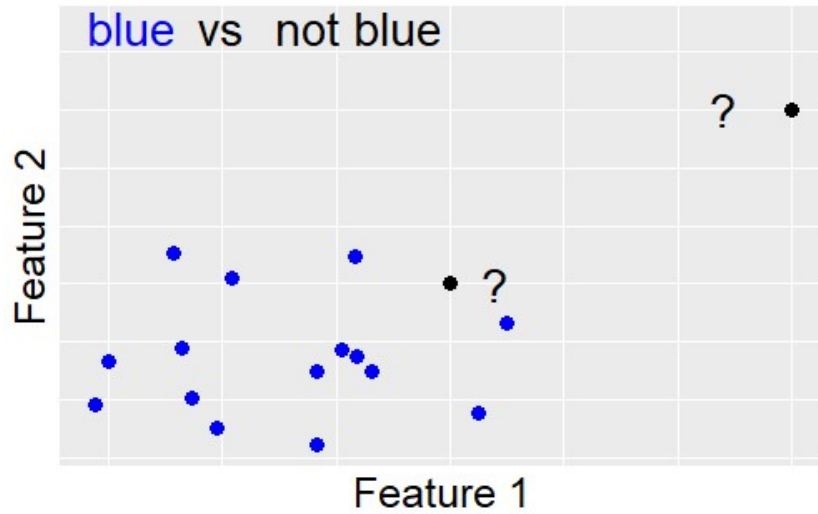
## Build-up the database

- Initial setup of a database is constructed without the knowledge of the comparison logic (decision rule).
- Explorative data collection (datahub)
- Number of datasets in the database grows up with the time (due to the limited availability of authentic reference samples).
- The intended use may be changes.

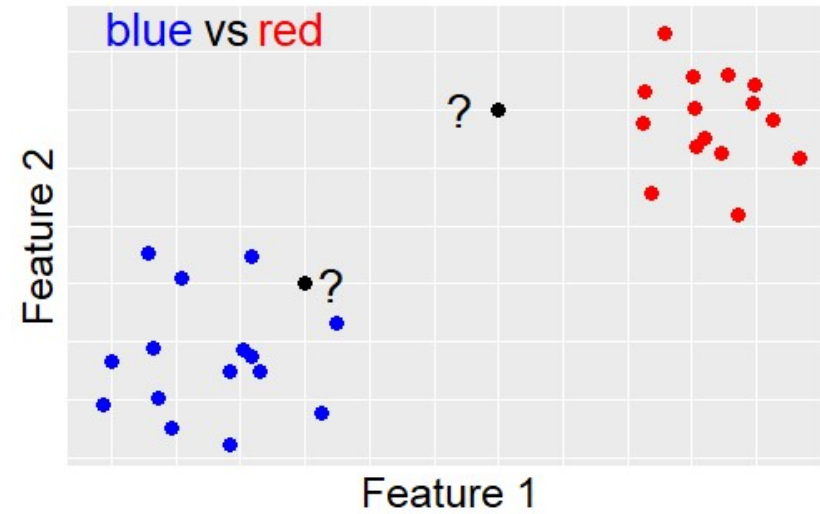
# Number of classes involved in one decision



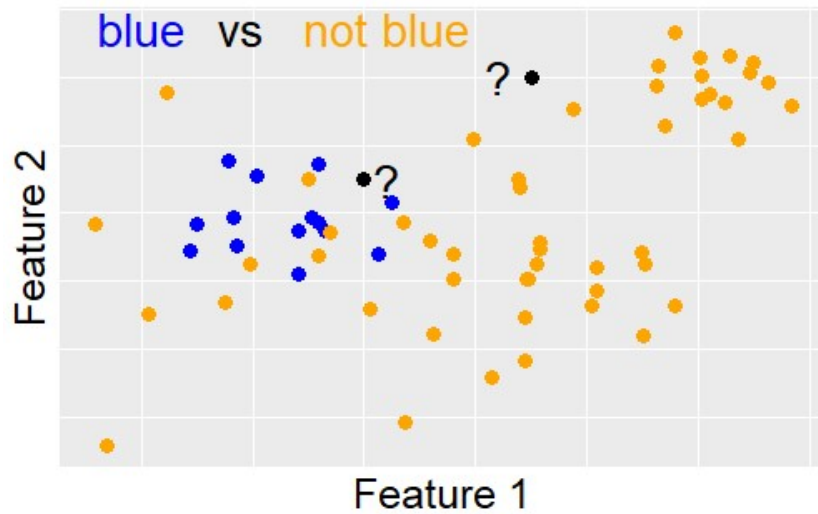
### One Class Problem



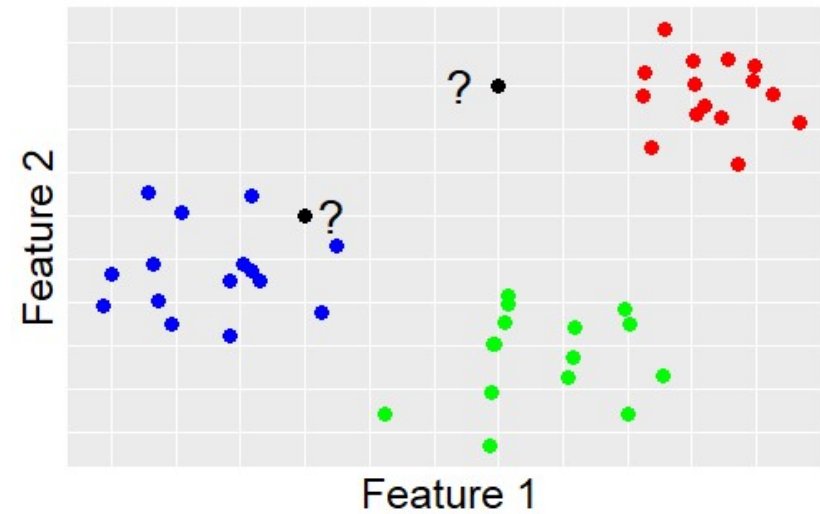
### Two Class Problem



### Two Class Problem



### Multi Class Problem



## Method Validation

Not clearly indistinguishable:

- difficulty and complexity of the problem
- suitability of the used methods
- data quality

in particular for highly data-driven technologies like machine learning

Are the applied methods fit for its intended use?

- comprehensive validation of the complete process as a whole
- use of standardized and international accepted methods

## Summary

- Building of authentic food databases is connected with the data interpretation.
- The complete process has to be considered as a whole.
- Partnerships are a necessity (knowledge, sample collecting, data generating).
- Harmonization and standardization of the input data is essential including the analytical measurement methods, the meta data and the exchange formats.
- Operation of databases must be regarded not as one-time actions but rather as ongoing tasks and needs a consistent in-house team.
- Implementation of the FAIR principle to ensure long-term benefits.



**Thank you for your attention!**

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