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The FoodAuthent Cloud: An Approach Towards A Comprehensive Authentication In Food Supply Chains Using Fingerprinting

Bartram, Tim*, Ritter, Eva*, Lehmann, Richard Joachim* and Esslinger, Susanne**

* GS1 Germany GmbH, Maarweg 133, 50825 Cologne, Germany

** German Federal Institute for Risk Assessment, Max-Dohrn-Straße 8-10, 10589 Berlin, Germany

tim.bartram@gs1.de, eva.wera.ritter@gs1.de, richard.lehmann@gs1.de, susanne.esslinger@bfr.bund.de

ABSTRACT

The research project FoodAuthent aims at establishing framework conditions and incentives to use fingerprinting procedures routinely for food authenticity purposes. In particular, the FoodAuthent system intends to enable the collection, analysis and utilization of chemical "fingerprints" of food products to provide evidence of the authenticity of food. For this purpose, cooperatively usable cloud-based food fingerprinting repositories together with standardised data analysis methods are set up as open-source and linked to a discovery service and batch-specific product information.

***Keywords**: Qualitative Data Analysis, Reliability, Supply Chain, Origin, Customer Satisfaction*

Introduction and Objective

Food crises often distort the confidence of consumers in companies and their products persistently. In this context, the use of forbidden additives in foods, as well as their incorrect declaration, e.g. regarding their origin, are reasons for mistrust. FoodAuthent is a research project funded by the Federal Ministry of Food and Agriculture until September 2019 on the subject of proof of origin of food. Its objective is, as a precursor to a harmonized authenticity testing of food products, to lay the foundations and incentives for the routine use of fingerprinting analysis in the food sector and official control. A holistic system including a fAuthent-Cloud is set up to create the necessary functionalities. Thus, the project results from FoodAuthent help all stakeholders along food chains to have a suitable procedure to control the authenticity of food, including authorities.

Methods and Solution

The verification of food identity (authentication) is of urgent importance in the current context of a growing market globalization. As a result, authentication is an indispensable aspect in today's consumer protection. However, detection of these adulterations is challenging because of increasing product diversity and the continuous development of new production technologies. Thus, intensive efforts are ongoing in analytical science to adapt the chemical analysis to requirements with a special regard to flexibility and reliability. In this context, the application of fingerprinting techniques has become increasingly important in recent years.
These procedures are usually basing on non-targeted spectroscopic and spectrometric data, facilitating the characterisation in form of a so-called chemical fingerprint. The subsequent statistical data analysis (optionally multivariate data analysis) enables the general identification of many deviations from the expected product, and therefore to answer a variety of authenticity issues, such as proof of botanical or geographical origin, or the identification of food fraud (addition of forbidden substances, e.g. melamine to milk products or methanol to vodka).

So far, numerous research studies investigate the applicability of the non-targeted approaches. For routine analysis, there are still crucial prerequisites missing, e.g. (i) standardised protocols describing the analytical procedure (ii) validated statistical data evaluation and (iii) uniform data exchange formats. Nevertheless, powerful commercial solutions are already available which are able to combine measurements from different instruments of the same type and vendor to evaluate the acquired data using one statistical model. However, the routine application of fingerprinting approaches is currently restricted to certain products, e.g. juice, wine and honey, often in conjunction with commercial solutions.

Figure 1 shows the general processing steps of the fingerprinting analysis, starting with an unspecific sample preparation, the instrumental analysis, along with the acquisition of the chemical fingerprint. The final step describes by data evaluation, where the new samples are to be compared with an authentic range of reference samples. The fAuthent-Cloud system is able to collect, analyse and process chemical fingerprint data of complex matrices, e.g. food to prove its authenticity. For this purpose, cloud-based fingerprinting databases are combined with methods of data analysis and batch-specific product information. This approach is shown in the Food-Authent project on the arbitrarily chosen product groups of hard cheese, edible oils and spirits.

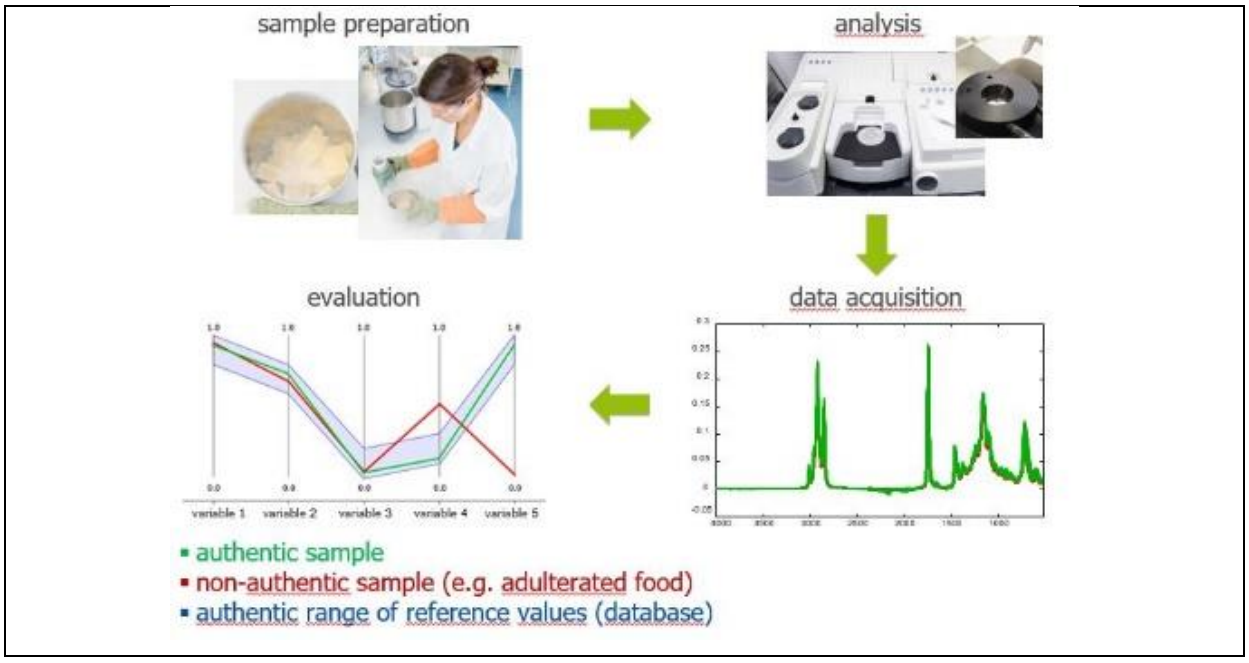

Figure 1: General workflow of fingerprinting analysis

The scientific and technical results of the joint research project are provided to the actors of the food industry such as companies, laboratories and authorities as free and open resources, as e.g. open source software. The project covers several use cases requiring a data access framework. This framework aims at enabling various stakeholders in the food sector accessing visibility events captured by governmental or commercial food laboratories, e.g. (a) inquire whether a specific product lot was checked for authenticity, (b) inquire details of an authenticity analysis and (c) validate that files containing relevant information for authenticity checks are genuine.

The resulting IT and communication cloud in FoodAuthent (fAuthent-Cloud) displayed in Figure 2 will cause benefits for different organizations in the food sector and enable them to create added value to their businesses or for the ease of their consumers. It is also intended to raise efficiency of laboratorial analysis because of enhanced collaboration between commercial, academic and authoritative food institutes. Finally, the fAuthent-Cloud will give a sound basis to more confidence and a broader reliability in product authenticity.

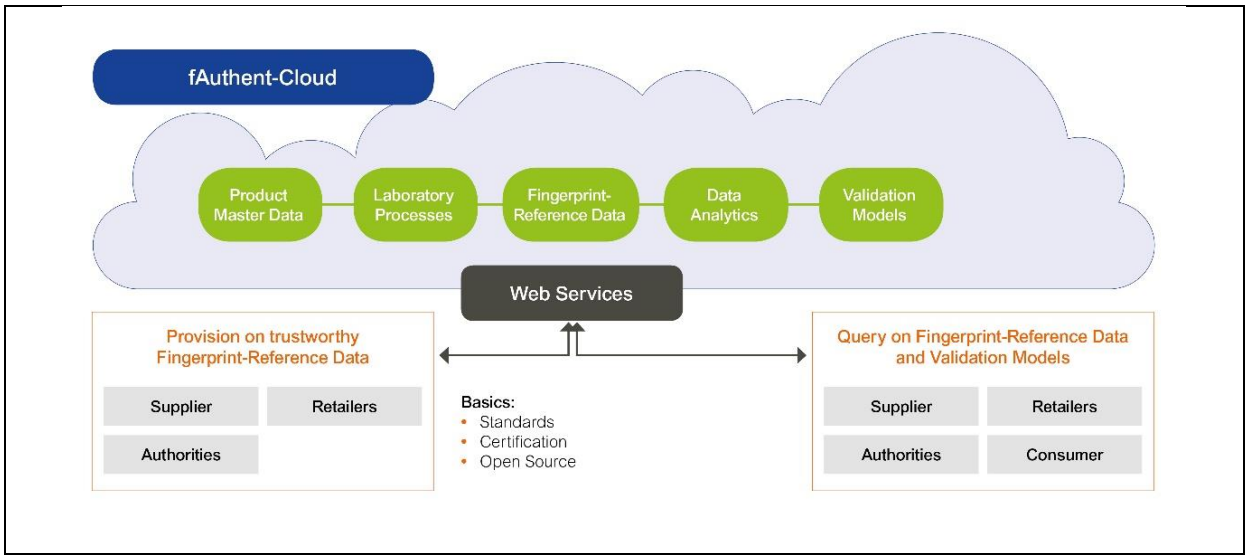

Figure 2: Schematic representation of the FoodAuthent overall concept

Access Control

Figure 3 shows the three main components of the fAuthent-Cloud (Metadata APIs, EPCIS Event APIs and Analysis APIs) and its forward and backward oriented APIs (application programming interfaces) for user management and storage. To manage metadata and master data for individual samples, fAuthent-specific Metadata APIs are offered. The EPCIS (Electronic Product Code Information Services) Event APIs build the connection to the Discovery Service and the related lot-based product data of fTRACE. The description of the necessary procedures for sample preparation, a mathematical workflow model and derived fingerprints are part of the Analysis APIs. APIs are secured with a role-based Access Control to ensure privacy of the data owners. Access to the raw and binary data stored in the storage API can only take place indirectly via one of the higher-level interfaces.

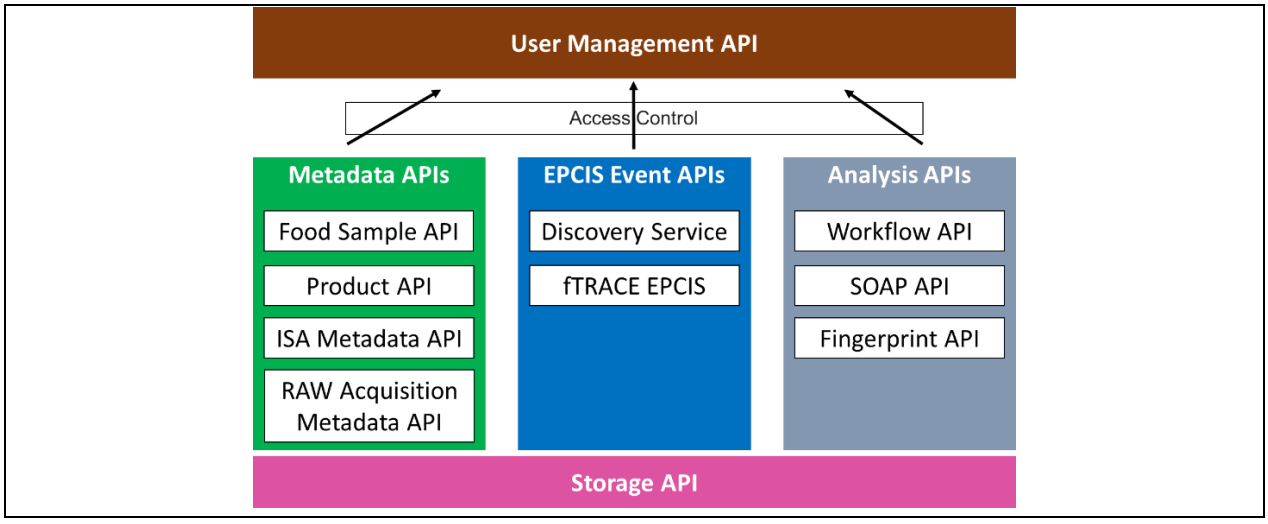

Figure 3: Basic principle of the fAuthent-Cloud

This cooperative solution provides in addition an outstanding functionality that ensures that the integrated discovery service does not accidentally unveil subjects, objects, locations and frequency of queries by hashing relevant values. In September 2018, a global expert group within GS1 agreed on a proposal to standardize a URI syntax for representing hashed data attributes, e.g. the Business Transaction. A cryptographic hash function is a

special form of a hash function (scatter value function) which is collision-resistant. It is almost impossible to find two different input ethics that give an identical hash value. In the future only authorized entities will get access to information about the use of stored data in the distributed repositories.

Conclusion and Outlook

FoodAuthent develops a novel system for collection, analysis and utilization of product data for authenticity in the food sector. Therefore, the system integrates new (open-source) software tools for the analysis of analytical data, standardized data analysis methods, cloud-based and cooperative product fingerprinting databases as well as software solutions for, e.g. consumers, companies and public authorities. One main question remains: How to convince market participants to follow and trust this approach, so it actually works efficiently? Even when the scientific and technical results of the project will be provided as open and standard-based solutions, including open source software, to the stakeholders in the food industry their implementation to real business seems to be postponed to a next progress step.

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