Systemic Strategies for Comprehensive Authenticity Control

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Worldwide, food fraud most commonly affects goods such as olive oil, fish and organic foods, as well as commodities such as spices, tea, cocoa, coffee or nuts. Globally, revenue from counterfeit or adulterated raw materials and foods amounts to tens of billions of euros every year. This figure highlights the fact that the quality control strategies practiced to date are unequal to the problem. Compared to centuries past, contemporary challenges are therefore considerably more complicated and, due to the global material cycles now in place, include determining the commodity type (e.g. variety), identifying the exact geographical origin (e.g. to verify a product as a regionally-protected food) and distinguishing between specific types of production (ecological and sustainable vs. conventional agriculture).

To give the consumer peace of mind, more reliable strategies and solutions are required, capable of facilitating the unique characterization of raw materials. This process must also attend to the fact that many of our "modern-day fraudsters" also have a scientific background and a sound working knowledge of the methods used within corporate quality control or regulatory surveillance. As a consequence, product fakery can be modified and refined to an extent where detection becomes ever more problematic. As a general rule, the authenticity or originality of starting materials can be determined using a sufficient quantity of valid and stable biomarkers – especially in terms of interaction with the environment.

At the HAMBURG SCHOOL OF FOOD SCIENCE we have developed a comprehensive system to tackle food fraud. It consists of three stages: (i) food fingerprinting, (ii) food targeting and (iii) food sensing.

Food Fingerprinting – Hypothesis-free and objective: As a first step in differentiating a selection of sample populations, one option is to perform non-target screening for the individual component groups (genome, proteome, metabolome and isotopolome). These hypothesis-free fingerprinting strategies enable the identification of marker substances by a process whereby the comparably large volumes of data obtained are reduced via multivariate analysis to the compounds exhibiting the greatest variance, contributing to distinctions between the sample populations. Ultra-high-resolution instrumentation-based methods (HR-MS, NGS etc.) are also

applied, so as to maximize the quality of the data and thus increase the likelihood of teasing out divergences between the individual sample populations.

Food Targeting and Food Sensing – Quantitative,semi-quantitative or qualitative targeted analyses based on instrumental approaches (LC-MS, GC-MS, ICP-MS, PCR etc.) or bioassays using antibodies or aptamers (microarrays, LFA) can then be run on one or a couple of markers (mini fingerprints) identified by the above process to achieve their absolute quantification (food targeting) or a simple qualitative answer in the case of LFAs or microarrays (food sensing). While instrumental approaches like mass spectrometry are known since decades rapid analysis based on the combination of Lateral Flow Assays (LFA) and aptamers are very new. Aptamers are short synthetic single-stranded oligonucleotides and often described as nucleic acid antibodies. Various studies showed that both aptamers and antibodies could reveal affinity constants up to low nano- or in best cases to pico-molar range.

The talk is going to give an overview about state-of-the art approaches to experimentally cover the originality of food starting materials.

Some selected papers from the HAMBURG SCHOOL OF FOOD SCIENCE:

Automatized Enrichment of Sulfanilamide in Milk Matrices by Utilization of Aptamer Linked Magnetic Particles
Fischer, Christin; Kallinich, Konstanze; Klockmann, Sven; Schrader, Jil; Fischer, Markus
Journal of Agricultural and Food Chemistry (in press) (2016)

Aptamer-based trapping of Phytosphingosine in Urine Samples
Fischer C, Klockmann S, Wessels H, Hünniger T, Schrader J, Paschke-Kratzin A, Fischer M.
J Biotechnol. 2016 Sep 13. pii: S0168-1656(16)31504-8. (2016)

Metabolite targeting: Development of a Comprehensive Targeted Metabolomics Platform for the Assessment of Diabetes and its Complications
Ernst Meiss, Philipp Werner, Clara John, Ludger Scheja, Nadja Herbach, Jörg Heeren, Markus Fischer
Metabolomics 12, 52 (2016)

Food Sensing: Selection and Characterization of DNA Aptamers to Alicyclobacillus Spores for Trapping and Detection from Orange Juice
Tim Hünniger, Christin Fischer, Hauke Wessels, Antonia Hoffmann, Angelika Paschke-Kratzin, Ilka Haase, Markus Fischer
Journal of Agricultural and Food Chemistry 63, 2189-2197 (2015)

Food Targeting: A real-time PCR assay targeting 16S rDNA for direct quantification of Alicyclobacillus spp. spores after aptamer-based enrichment
Tim Hünniger, Christine Felbinger, Hauke Wessels, Sophia Mast, Antonia Hoffmann, Anna Schefer, Erwin Märtlbauer, Angelika Paschke-Kratzin, Markus Fischer
Journal of Agricultural and Food Chemistry 63, 4291-4296 (2015)

Food Profiling: Characterization of the Ecuadorean Type CCN-51 of Theobroma cacao L. using microsatellite markers
Luise Herrmann, Christine Felbinger, Ilka Haase, Barbara Rudolph, Bernhard Biermann, Markus Fischer
Journal of Agricultural and Food Chemistry 63, 4539-4544 (2015)

Food Sensing: Aptamer-Based Trapping of B. cereus Spores with Specific Detection via Real Time PCR in Milk
Christin Fischer, Tim Hünniger, Jan-Hinnerk Jarck, Esther Gesine Frohnmeyer, Constanze Kallinich, Ilka Haase, Uli Hahn, Markus Fischer
Journal of Agricultural and Food Chemistry 63, 8050-8057 (2015)

just in time-Selection: A rapid semi-automated SELEX of DNA aptamers using magnetic separation and BEAMing
Tim Hünniger, Hauke Wessels, Christin Fischer, Angelika Paschke-Kratzin, Markus Fischer
Analytical Chemistry 86, 10940-10947 (2014)

DNA-based Differentiation of the Ecuadorian Cocoa Types CCN-51 and Arriba Based on Sequence Differences in the Chloroplast Genome
Luise Herrmann, Ilka Haase, Maike Blauhut, Nadine Barz, Markus Fischer
Journal of Agricultural and Food Chemistry 62, 12118-12127 (2014)

Loop-mediated isothermal Amplification (LAMP) based Method for rapid Mushroom Species Identification
Franziska Vaagt, Ilka Haase, Markus Fischer
Journal of Agricultural and Food Chemistry 61, 1833-1840 (2013)

Loop-mediated Isothermal Amplification (LAMP): Methods for Plant Species Identification in Food
Felix Focke, Ilka Haase, Markus Fischer
Journal of Agricultural and Food Chemistry 61, 2943-2949 (2013)

Real-time PCR-Assays for the Quantitation of rDNA from Apricot and other Plant Species in Marzipan
Ilka Haase, Philipp Brüning, Reinhard Matissek, Markus Fischer
Journal of Agricultural and Food Chemistry 61, 3414-3418 (2013)