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EDITORIAL

# Battling food fraud by using untargeted analytics

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## 1 Introduction

We live in challenging times: global welfare has probably never been higher, yet the gap between the well-heeled and the poor is huge. The corona pandemic has revealed the vulnerability of supply chains. Furthermore, 2022 has brought another war to Europe—with huge effects on economies. Soon after the war in Ukraine started, everyone felt its consequences: gasoline prices skyrocketed, the energy supply was suddenly no longer guaranteed, inflation increased in an unknown manner for younger generations, and the living and food costs increased. However, because Ukraine is one of the largest exporters of agricultural products, the war affects global food markets way beyond the aforementioned cost drivers. Suddenly, the supply of sunflower oil, honey, and wheat—to exemplarily name three foods for which the Ukraine is a producer of global importance—is no longer secured. Interrupted supply chains of basic nutrients threaten the food provision in dependent nations, probably leading to subsequent crises in those countries. In the shadow of this potentially life-threating possibility, there is also an increased risk for food fraud.

## 2 Food fraud can be a hidden threat

Food fraud, also termed economically motivated adulteration (EMA) of food, can generally be best characterized as being a disagreement between the statement made on the food packaging label and its contents. This vague definition pinpoints one of the big problems associated with food fraud, namely that it is a broad, virtually unlimited field. At best, there is a suspicion that can be tested in a targeted manner by using a known marker. In the worst case, the adulteration manifestation is unknown and therefore, impossible to discover. This is linked to the fact that EMA is carried out intentionally, with the purpose of making profit. Food fraud is recognized as a threat to the consumer, with variable consequences for the individual. Such consequences might "merely" be a financial loss, e.g., when the consumer paid too much by buying an extra-virgin olive oil that is, in fact, tainted sunflower oil, or a jar of premium natural honey that has been produced from unripe harvested honey dried in an unapproved industrial process. However, cut spirits containing methanol or spices dyed with artificial Sudan Red colors can seriously damage human health and might even lead to death. Consequently, the most important quality management systems in the food segment, such as International Featured Standards (IFS) and Global Standard for Food Safety (BRC), call for food fraud mitigation strategies. Besides the aspects of consumer protection, this is an important part of protecting the industry itself, which generates critical contributions to gross domestic products on a global scale. In Europe, close to 16 million people worked in the food supply sector in 2019, corresponding to 8% of total employment.[1] However, for many foodstuffs fraud mitigation plans yet have to be developed. Consequently, food fraud presents a latent threat to the industry.

A good way of mitigating food fraud is a combination of organizational and testing measures. Organizational measures include—but are not limited to—clear specifications, fraud-specific audits, and the monitoring of the market, which brings us back to the present crises, namely the pandemic and the war in Ukraine. In the past, a sharp supply decline led to increased fraudulent activities, e.g., shortages in the hazelnut supply led to undeclared admixtures of other nuts, including peanuts with their associated health risk for allergic consumers (Opson VI). Hence with climbing energy costs, a closer look at the quality and authenticity of energy-intensive products may be warranted. However, particularly products that are directly affected by production shortage

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[1] https://ec.europa.eu/eurostat/de/web/products-eurostat-news/-/ddn-20200522-2. Accessed 18.07.2022.

and/or export problems, such as wheat, honey, and sunflower oil, should be re-evaluated in depth for fraud risk.

But organizational measures represent only one important pillar in battling food fraud. Another important part is testing. This can be as simple as comparing the color of the delivered commodities, measuring the pH value or another single, but well-established quality parameter. However, in most fraud cases, deviations are not that obvious, as deliberate actions often include the covering up of the intrinsic fraud. The real challenge is to identify fraudulent products that are unknown or that have no single analytical marker (physical, chemical and/or biological). In this context, so-called untargeted approaches are becoming increasingly important for testing by professionals. And prospectively, also for testing by consumers by using sensors on smartphones.

## 3 What are untargeted approaches?

This term subsumes the process of actual untargeted testing as well as the process of an untargeted development of testing methods. Typically, both utilize more than one parameter being analyzed by chemometric methods. This can reveal a correlation with authenticity-relevant meta-information, such as variety, absence of substituents or country of origin. Chemometric methods are basically statistical methods capable of detecting patterns and correlations in analytical data and include machine-learning as well as other artificial intelligence approaches. The subject quickly gains complexity when trying to define the term 'untargeted' as sometimes the term 'non-targeted' is used synonymously. Complexity is fueled by the use of imprecise language and arbitrarily chosen definitions, resulting in babel. Ultimately, 'untargeted'/'non-targeted' shall be applied when either the target of the test is not defined or the no targets are present at the start of the development of an, e.g., classification method.

Now, does untargeted testing mean that we need to test for unknown unknowns? In principle, this is possible by defining an etalon (normal), e.g., a set of analytical data of a reference group, and testing for any deviation from the defined etalon. The application of such a test is truly untargeted and indeed very powerful for detecting unexpected and/or new adulterations. In the context of applying precise language, one should also refrain from using the term 'methods' instead of 'testing'. Precisely, there are different untargeted testing methods for the different modes of adulteration in various food matrices studied by analytical technologies.

However, in conjunction with the term 'methods' the term 'untargeted' is often used for tests, where at the time of a method development, the difference in the datasets belonging to different groups is unknown and unspecified. Typical examples constitute the identification of markers for, e.g., classifying groups of authentic food and food that has been diluted with some sort of a substitute. With a successful method development, at least one physically, chemically, and/or biologically defined variable is obtained that correlates with the investigated problem. These well-defined variables will now constitute the analytical markers. The latter might not necessarily be constructed of one variable only, but could also constitute a mathematical relationship between two or more variables. They actually represent the targets for any new test sample, and such a test is indeed targeted! As stated above, this methodology is frequently imprecisely called 'untargeted (or non-targeted) methods'. Due to this linguistic similarity, misunderstandings happen in the communication between experts in the respective analytical methods and other stakeholders of the food sector. By using imprecise language and by carrying over similarly used terms from related fields ultimately a scenario has emerged where new untargeted approaches often suffer from an unwarranted lack of trust among non-experts.

## 4 Conclusion

Certainly, many aspects of these novel methodologies need to be fine-tuned, and the field has to learn how to deal with them. This involves a definition of requirements for reference samples, the number of reference samples needed for building models, the chosen algorithm, and the means for a reliable method validation, and much more. We have to face the challenge that the problems and food matrices and the tools selected to investigate them are so diverse that there will hardly be a one fits all solution. Stakeholders in the food sector have to accept the fact that results in food fraud testing are often neither black nor white, but gray. This is frequently expressed as 'not typical' rather than 'adulterated' or 'authentic'. Admittedly, such a wording is difficult when deciding whether or not to buy a batch of commodities or whether a result is conclusive enough, e.g., to prosecute a suspicious food producer. Nonetheless, untargeted approaches are extremely important for quick screening methods that offer time and cost advantages over conventional (sometimes more specific) methods. They make testing faster and bring testing closer to production, allowing an even denser grit of control throughout the supply chain. They might also enable consumers to carry out tests with their smartphones. Moreover, untargeted approaches are important for fast changing scenarios. New crises and technological progress in adulteration methods demand the fast reassessment of fraud risks and tests that can quickly be adapted for new challenges. Even in cases in which untargeted approaches fail to provide clear-cut results for certain samples, they might lead to and warrant more specific and

expensive tests. From this perspective, there is hope that research involving untargeted approaches will increase. Part of this should be clear and precise communication utilizing comprehensible terms suitable for the fostering of confidence and application in a multidisciplinary environment. In recent years, there were promising examples for screening methods that are nowadays routinely used to battle food fraud by using multivariate markers derived from untargeted method developments. Using the very same measurement they often even allow for true untargeted testing thereby enabling detection of deviations not intentionally looked for. Hopefully, more applications will follow raising the barrier for food fraud, thereby creating a stable and safe market for both producers and consumers.

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