



Smartphone analyzers for on-site testing of food quality and safety

Issue 2 – December 2017



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In this issue:

Welcome

The FoodSmartphone work packages in five nutshells

Feature:
FoodSmartphone Open Days at RAFA2017

Quotes from the FoodSmartphone ESR blogs

Forthcoming events / meetings

Contact us

Welcome to the second FoodSmartphone e-Newsletter!

Dear reader and FoodSmartphone follower,

We proudly present you the second e-Newsletter of the Marie-Curie European Training Network 'FoodSmartphone'. It has been a challenge for our beneficiaries to organise all visa and work permits over the last months but now I am very pleased that all recruited early stage researchers (ESRs) have found their new home and are making progress in- and outside the lab. Several of them presented their early results during our Open Days events in a 'smart lab' at the Recent Advances in Food Analysis (RAFA2017) conference. But their life is so much more than science alone: complementary skills training, language courses, tourism: you can read all this and more in their weekly ESR blog at www.foodsmartphone.blog. Keep updated by signing up on our website and/or by following us on twitter (@FoodSmartphone) and tweet us using the hashtag #FoodSmartphone. Feel free to contact us at foodsmartphone@foodsmartphone.eu with any suggestions for improvement of this e-Newsletter, for future collaboration or dissemination opportunities, or for a friendly chat.



For now very best season's greetings and a happy 2018!

Michel Nielen, coordinator

The FoodSmartphone work packages in five nutshells

Key facts:

Grant Agreement:
720325 –

FoodSmartphone -
H2020-MSCA-ITN

Start date:

January 2017

Duration: 48 months

Volume: 2.8 M€

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www.foodsmartphone.eu

ESR Blogs:

foodsmartphone.blog

Twitter:

@FoodSmartphone

Facebook:

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YouTube:

[IXceX3TITzs](https://www.youtube.com/channel/UCeX3TITzs)

Overall objectives of FoodSmartphone:

- To study the supra-disciplinary challenge of smartphone-based analysis systems which have advanced biorecognition, signal transduction, microfluidic sample handling and image data handling solutions.
- To develop user-friendly, rapid integrated sample preparation and smartphone-compatible Apps, to ultimately ensure adequate field implementation for both professionals and to the future of Citizen Science.
- To develop a unique range of smartphone-based on-site screening demonstrators for food quality and safety issues of concern, viz. for antibiotics, pesticides, allergens, mycotoxins, food spoilage and marine toxins.
- To deliver, through high level training, a group of multidisciplinary scientists who can integrate (bio)analytical chemistry, physics, micro-engineering and ICT knowledge into a common supra-disciplinary goal, to combat major socio-economic challenges, such as maintaining a healthy, safe and fair food supply.
- To substantially improve the career prospects of early-stage researchers across academia, public research institutes and private industry sectors, including SMEs.

The project is organized in a matrix structure of 11 individual ESR projects (see Newsletter No1) and 5 cross-cutting R&D work packages; the latter are described below.



Novel biorecognition concepts. Ligand binding can be improved either by newly-developed binders, for example the aflatoxin aptamers studied in WP1, or can be realised by high-density ligand immobilisation. In FoodSmartphone WP1, DNA-directed immobilization (DDI) strategies will be studied in order to develop universal high-density chip platforms for multiplex analysis of any set of targets. Herein, oligonucleotide probes with well-known sequences are used for subsequent hybridization with their complementary oligonucleotides which were previously immobilized on the surface of a chip in order to spatially assemble (mixtures of) antibodies. DDI can not only provide greater





WP1 leader

M.-Pilar Marco (CSIC)



WP2 leader

Monique Bremer (RIKILT)



WP3 leader

Daniel Filippini (LIU)



WP4 leader

Huiyu (Joe) Zhou (QUB)

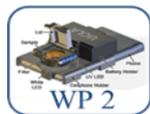


WP5 leader

Jana Hajslova (UCT)



immobilisation efficiency than conventional adsorption techniques, but also allows reversible immobilisation of biomolecules for re-usability of microarrays and biosensor chips.

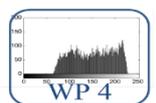


Optical and electrochemical sensing. The biorecognition events of WP1 should be visualised by rapid signal transduction at high sensitivity. In FoodSmartphone, both label-free approaches, such as SPR biosensing, electrochemical detection and improved labelling for optical detection will be studied. Beneficiary RIKILT successfully developed two QD-labelled fluoroimmunoassay platforms on a smartphone in collaboration with UCLA, while beneficiary LIU successfully designed an imaging SPR concept on a smartphone. But the QD-labelled smartphone assays suffer from long labelling incubation times and the labels are rather expensive. In order to improve that situation, carbon black nanoparticles (NPs) will be studied and one-step carbon NPs and QD-labelling strategies will be developed. In localised SPR biosensing, noble metal nanoparticles are excited by irradiation with incident photons yielding collective oscillations of the conduction electrons that results in the scattering of the light at a specific wavelength, for example in the visible range. LSPR-based smartphone read-outs will be studied for DDI- and conventionally-coupled antibodies and haptens. Electrochemical sensors are considered promising candidates for smartphone-based label-free detection. In order to support a confirmatory analysis follow-up in the lab, ligand binding assays will be interfaced with mass spectrometry for identification, either via surface extraction or desorption under ambient conditions.



Integrated sample preparation devices. Rapid and easy-to-use assays require (i) that the binding partners can reach each other without long incubation times due to mass transport limitations and (ii) that the sample handling is fully integrated; however, both are far from current reality.

Within WP3, different strategies will be followed to change that situation. Beneficiary LIU introduced a low-cost method for the production of microfluidic lab-on-chip (LoC) devices. That technology will be used to design and develop novel integrated fluidics and sample handling for iSPR ligand binding assays on a smartphone. As an alternative, biofunctionalised flow-through membranes and micro-sieves will be studied. Beneficiary Aquamarijn can produce sieves having controlled micro- or nano-pore sizes.. Thus, non-fouling bioaffinity membranes and microsieves will be extensively studied in WP3, including the option to combine them with pre-loaded reagents for autonomous operation. As a third option, disposable microfluidic paper-based analytical devices (μ PADs) will be studied, having immobilised enzymes and colour reagents within a wax-printed fluidic pattern on paper for the smartphone-detection of AChE-inhibitors. By doing these studies in parallel, in-depth knowledge will be gained about the most promising strategy for smartphones having integrated sample handling features.



Data handling and software tools for (i) handling the camera image data from optical multiplex ligand binding assays, (ii) handling the electronic data from electrode-array ligand binding assays, (iii) translation of the data into user-friendly "traffic light-type" outputs, while (iv) storage and transmitting the underlying analysis details (including time and

location data) to web-servers from stakeholders for further evaluation, in accordance with legal and privacy regulations. Image features may be extracted from different colour spaces (RGB) or hue saturation and intensity (HUI), using statistical means. These colour features must be calculated whilst appearing immune to image rotation and scaling. Unfortunately, they suffer from illumination changes. In WP4 we will integrate colour and shape features in a Bayesian framework so that data handling performance will become robust. To produce necessary qualitative and quantitative results, we will study a Kernel Support Vector Machine (SVM) technique to the classification step of the system. Apart from these novel image data strategies, within WP4 all the ligand binding assay (WP1) and detection (WP2) requirements will be translated into user-friendly Apps and web-links.



Demonstration of FoodSmartphone applicability and benchmarking.

Based on the EU Rapid Alert System for Food and Feed (RASFF) and consumer survey data, we selected the following key application demonstrators: testing of allergens in cookies, antibiotics in milk, pesticides in crops, medicinal plants and fruit juices, aflatoxins in nuts and cereals, marine toxins in shellfish, and food spoilage organisms in dairy products. The developed demonstrators will be first in-house validated as pre-screening method, aiming for <5% false-negative and a low as possible number of false-positive results. Key analytical parameters such as specificity, selectivity, detection capability ($CC\beta$), cut-off level and ruggedness, will be (wherever possible) assessed using EU Reference Laboratories guidelines for the validation of screening methods. The validation results will be benchmarked versus conventional immunoassays (ELISA and dipstick) and established confirmatory analysis methods (GC/MS, LC/MS). A selection of the developed prototypes

will be evaluated for on-site food quality and safety testing in the food industry and at consumers.

Feature: FoodSmartphone Open Days at RAFA2017



RAFA is the leading bi-annual conference on Recent Advances in Food Analysis and the 8th edition was organised, in Prague early November 2017 (www.rafa2017.eu). The FoodSmartphone concept was presented by Michel Nielen and further exemplified by Chris Elliott in an oral session devoted to *Smart portable and personalized food analysis systems*. ESRs Jordi Nelis, Javier Lou Franco, Yunfeng Zhao and Aristeidis Tsagkaris presented their first results and concepts at our Open Days in a so-called *Smart Lab* area. Other ESRs contributed through short videos and/or powerpoint presentations which were linked together into one continuous FoodSmartphone movie. On this occasion, conference attendees could meet our ESRs, watch live demos and video recordings from the ESR projects, get information on the FoodSmartphone objectives, and register as a stakeholder. Clearly, the FoodSmartphone project received a lot of enthusiasm and it was a pleasure to meet so many interested people. All video recordings will be available on our www.FoodSmartphone.eu website. A first introductory video has been posted on YouTube at <https://www.youtube.com/watch?v=IXceX3TITzs>.

Apart from scientific oral, poster and video presentations, FoodSmartphone also organised a draw for conference participants who registered as a stakeholder. Dr Jens Sloth from DTU, Denmark, was the lucky winner of a Lab2Go™ mobile allergen test system, kindly sponsored by our partner organisation Zeulab.

Quotes from FoodSmartphone ESRs on www.FoodSmartphone.blog



ESR1: Georgina Ross, RIKILT, Wageningen University & Research, The Netherlands:
Starting Dutch lessons has been a new and interesting experience. Although I am picking up loads of the vocabulary and finding Dutch okay to read, my pronunciation of the language is laughable. One of the first things you are told when you move to NL is "buy a bike", so that is what I did, never mind the fact that I hadn't ridden a bike in 10 years!



ESR2: Vincent O'Brien, RIKILT Wageningen University & Research, The Netherlands:
I'm used to the bus schedule being more of a suggestion in Ireland rather than the concrete set of times it is over here. My time as a PhD so far has seen me reading hundreds of papers, writing tens of thousands of words, meeting hundreds of fellow researchers and attending a variety of courses and seminars.



ESR3: Jordi Nelis, Queens University, Belfast, United Kingdom:
Of course, the fact that it will most likely drizzle at least a bit while you are there makes it even more likely that that beach will stay private for the rest of the day. I call the developed system The Bio End user Sensor Tree or BEST tree. It basically uses a decision tree that is based on simple questions like: Which compound do you want to detect? Do you have laboratory experience? Or, do you want your sensor to be portable? Answering these questions will narrow down the choice of sensors and finally direct you to an open source e-document where your options will be summarized.



ESR4: Javier Lou Franco, Queen's University, Belfast, United Kingdom:
There were two things that I had been told before moving here by my family and friends: "it can be hard sometimes to understand the English spoken by local people" and "get ready for the weather". So after the first months glued to the computer working on the literature review with particular interest in detection platforms for biosensors, I have started doing some lab work.



ESR5: Yunfeng Zhao, Queens University, Belfast, United Kingdom:
I did not realize the importance of our FoodSmartphone project until I was suffered from two severe gastroenteritis after my arrival in Belfast (my immune system was not ready to defend against the new bacteria). The gastroenteritis could have been prevented with the help of a smartphone based on-site food safety analysis system, and this experience had become a motivation for my research.



ESR6: Aristeidis Tsagkaris, University of Chemistry and Technology, Prague, CZ:
The capital of the Czech Republic is a unique place. The architecture of the city is really impressive and occurs everywhere and not only in the Old Town. Actually, I have the feeling that I live in a medieval castle. So, imagine yourself taking a snap of the paper strip and be informed through your FoodSmartphone application if your food is contaminated with pesticides or not.

ESR7: Raheel Ahmad, CSIC, Barcelona, Spain:



The task given to me was to develop a biosensor for ultrasensitive detection of biomolecules. I remained in shock for a time because I never read about DNA and protein before in my life. The joke came into mind which I listened in my college life, I was thinking, my situation would be like this after two years: a guy is sitting at home when he hears a knock at the door. He opens the door and sees a snail on the porch. He picks up the snail and throws it as far as he can. Three years later, there's a knock on the door. He opens it and sees the same snail. The snail says, „what was that all about“?



ESR8: Klaudia Kopper, CSIC, Barcelona, Spain:

It is really nice to be a part of a research group where people not only have a working relationship but are also friends. Here, most of the people you meet in your everyday life talk to you in Catalan or Spanish, usually they don't speak English, especially not at places, where you have to get the official papers. It is also a bit confusing, since some of my colleagues speak Spanish, while others mostly speak Catalan, so I am hearing a mixture of both at the same time.



ESR9: Sahl Sadegi, Linköping University (LIU), Sweden:

It is, therefore, our duty now more than ever before to bring our own contribution to the creation of a new generation of consumers who are not only more in control of their own food choices, but also consumers who become more concerned about the ethical practices or lack thereof in the global food network.



ESR10: Andriy Kuzmyn, Aquamarijn, The Netherlands:

Many houses in Netherlands, if not all, have large size windows in the front of their homes. Often those windows have no curtains. I believe it signifies the Dutch view of the world and maybe their more open mindset.



ESR11: Safiye Jafari, CSEM, Switzerland:

Sunny Switzerland, surprised! I found it hard to believe as well, particularly heard during the coffee break on a snowy day. Well apparently, the canton of Graubünden where I will work and to some extent live for the next three years has some of the best sunny weather in all Switzerland. Although I love winter and the snow had already made my day, it was nice to know that you can expect very good weather here too.

Forthcoming events / meetings



Belfast Summit on Global Food Integrity (ASSET 2018)

29–31 May 2018, Belfast, Northern Ireland, UK

Biosensors 2018

12–15 June 2018, Miami, FL, U.S.A.

FoodSmartphone Network-wide Summer School on Quality and Validation

18–22 June 2018, Prague, Czech Republic

Rapid Methods Europe (RME 2018)

5–7 November 2018, Amsterdam, The Netherlands

Final FoodIntegrity Conference

14–15 November 2018, Nantes, France

Recent Advances in Food Analysis (RAFA2019)

5–8 November 2019, Prague, Czech Republic

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