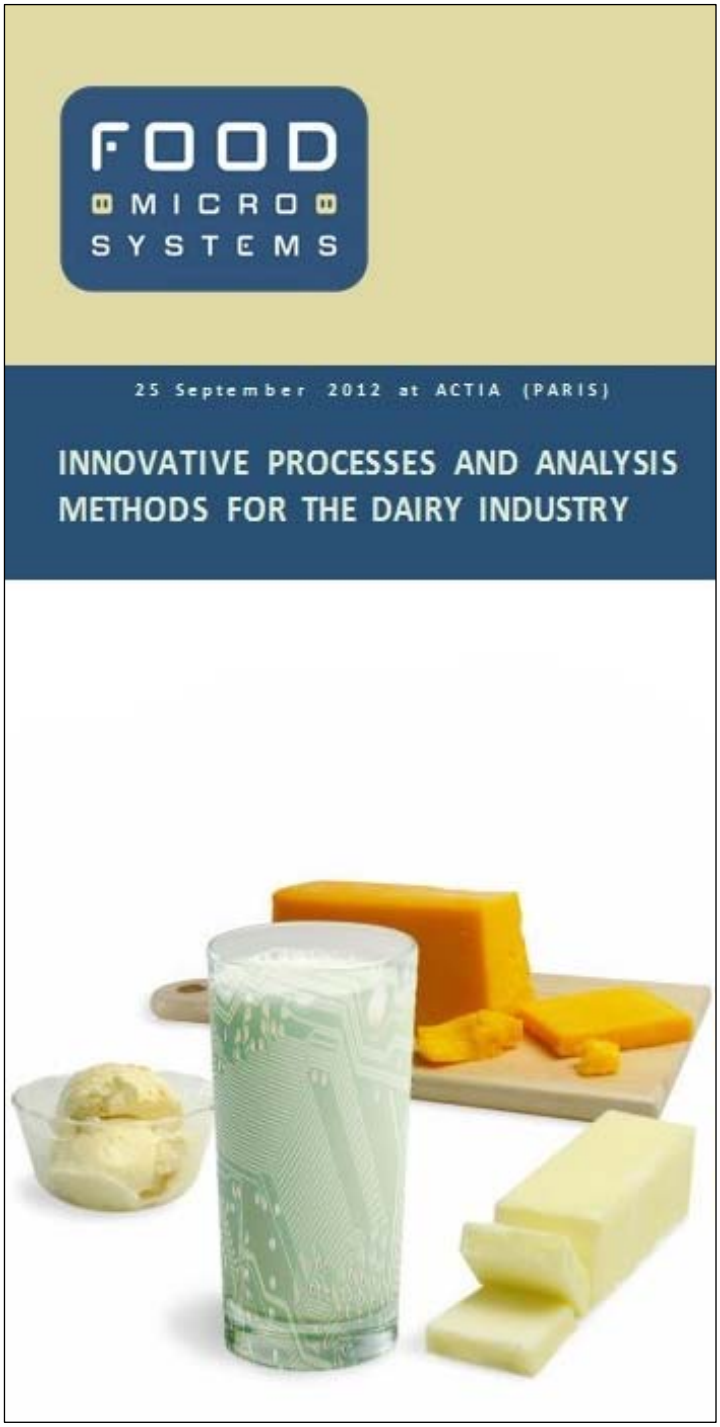
Notes from an Expert Workshop "Innovative Processes and Analysis Methods for the Dairy Industry" 25th Sept 2012 in Paris

International Expert Workshop

Innovative Processes and Analysis Methods for the Dairy Industry



How can Micro technologies and Smart Sensors help the Dairy Industry to improve food quality, reduce cost, and strengthen consumer confidence?
25th September 2012 at ACTIA, Paris, France

Acknowledgement

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FoodMicroSystems aims at initiating the implementation of microsystems & smart miniaturised systems in the food sector by improving cooperation between suppliers and users of microsystems for food/beverage quality and safety.

The project runs from September 2011 to August 2013, it involves nine partners and is coordinated by ACTIA (Association de Coordination Technique pour l'Industrie Agro Alimentaire, France). More information on the project can be found at http://www.foodmicrosystems.eu.

Roadmapping of Microsystems Technologies towards Food Applications (WP4 of the project)

The overall objective of the FoodMicroSystems Support Action is to initiate the implementation of microsystems & smart miniaturised systems in the food sector by improving cooperation between suppliers and users of microsystems for food/beverage quality and safety.

The objective of work package 4 is to develop "application driven technology roadmaps" that can draw the foundations for future collaboration between the food and microsystems sectors, support strategy decisions of research organisations and companies, and supply investors and funding bodies with guidelines to support their investment decisions.

Many thanks to all participants in our workshop and to all project partners (and subcontractor Henne van Heeren) for their additional contributions!

Please let us know if you have any comments, suggestions or if you like to contribute and/or participate in future meetings and workshops!

Responsible for this report

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All presentations, the flyer, and notes have been made available at www.foodmicrosystems.eu.

Expert Workshop "Innovative Processes and Analysis Methods for the Dairy Industry" 25th Sept 2012 in Paris

Objectives and Programme (invitation text)

This workshop will bring together specialists from the microsystems community with equipment providers and key players from the food industry. The objective is to assess opportunities & challenges and drivers & barriers for the use of micro technologies and smart systems in the food industry. The workshop will set the grounds to an application driven technology roadmap that can draw the foundations for future collaboration between the dairy industry and the microsystems community, support strategy decisions, and supply investors and funding bodies with guidelines to support their investment decisions.

Programme

09:30 Registration, Coffee and Networking
10:00 Welcome & Overview of the FoodMicroSystems Project and Funding Opportunities, Christophe Cotillon, ACTIA (The French Food Association), France
10:15 Opportunities for Microsystems in the Dairy Sector, Frans Kampers, Wageningen University, The Netherlands
10:45 Round the table introduction of all participants
11:00 FoodMicroSystems Roadmapping Methodology and the Dairy Supply Chain, Patric Salomon, 4M2C/enablingMNT, Germany
11:30 Coffee Break and Networking
11:50 Break-out session 1: New Microtechnologies for innovative processes in Dairy Production … and the needs of the Dairy Industry
12:30 Lunch Break and Networking
13:40 Break-out session 2: Microsystems for analysis and quality control for the Dairy Industry … and the needs of the Dairy Industry
14:20 Summary from Break-out sessions; discussion and questions; what are the major challenges?
14:50 Coffee Break and Networking
15:10 Break-out session 3: Drivers and barriers of using new (micro) technologies in the dairy production and supply chain
15:50 Summary and Conclusions: "R&D Project Needs", "Recommendations to the EU", "Challenging topics to be discussed further".
16:30 End of Workshop

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Fig. A-1.2 Workshop Invitation/Flyer (25th Sept 2012)

All participants had the opportunity to give a short introduction about their organisation's activity, their relation to dairy processing and to raise comments and questions for discussion, more specifically “to describe one or two (major) problems in Dairy Processing that you think might (possibly) be solved with new Microtechnologies or Smart Sensors”. These presentations are also available from www.foodmicrosystems.eu .

Notes from presentations and general discussion

For many microsystems proposed or demanded for the food sector, there have products already been developed and brought onto the market in medical diagnostics. Billions of Euros have been spent in developing technologies there. Using and adapting these to food applications is advisable.

Food will be a technology follower, unless there is an acute unmet need. (e.g. after the milk scandal in China).

Comment on importance of microsystems in food: consumer is much more interested in food safety then in food quality.

Huge steps have been made in the development and understanding of the emulsification and encapsulation processes, but the problem of affordable

manufacturing in large volumes is still not solved. TNO Netherlands investigates alternative ways of encapsulating using lasers.

The weakness of filtration and fractionation with microsieves is that there are plenty of good alternatives.

A replacement system is absolutely not allowed to cost more then the old system.

Pathogen detection: especially an area where using concepts from medical diagnostics is a realistic option.

If a farmer uses a test and detects a problem, it is not in his interest to destroy the batch! Therefore it might be advisable to have direct internet connection/RFID?

State of the art: soluble protein content in milk can be measured within 5 minutes offline by Amaltheys (but this will also cost 5-10 minutes of the operator time. Assume the operator cost at 60 Euro per hour, this will mean that even without disposables the test would cost 5-10 Euros.)

There is an interest in bioreactors for testing during cheese processing; issues:
1) control variables: accurate and quick. 2) process state versus control variables,

Potentials for Microsystems in dairy processing: cleaning the processing line (detergents, biofilms, allergy); inline detection of pathogens; authenticity (also GM food); pesticides, herbicides, etc.

Fig. A-1.3 Discussion notes from presentations

Measurements along the food chain:

- Farmer: outgoing check
- Dairy company: incoming check, inline control, final test
- Retailer: check at time of sale
- Consumer: check at point and time of use

Some long term goals:

Cheese: during ripening: daily check on: Protein, fat, water, minerals, proteolysis[1] (different peptides), lipolysis[2] (Free Fatty Acids), water activity[3], F. V. Acids.

Milk may need hourly screening

Break-out sessions

2 Break-out sessions were organised with 3 parallel groups each to allow for a more in-depth discussion. From the 6 topics proposed, 5 were covered in the groups:

1. From cow to raw milk (Quality, contamination)
2. Measurement in process (on-line, in-line)
3. Quality control (analysis of final product)
4. Filtration (process innovation, micro sieves) – not covered in break-out session
5. Cleaning efficiency
6. Packaging / transport / tracking

Each break-out group had a moderator, who took notes and reported back to the overall workshop later. The following headlines/questions were prepared to guide the discussion in each group:

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Problem to be solved or Parameter to be improved

Opportunities / benefits / drivers for user (food industry / consumer)

Challenges / problems / barriers in the realisation
- from user (dairy industry point of view):
- from Microsystems supplier / research point of view:

Urgency / expectations on availability (3, 5, 10 years)

Key parameters / specification range

Other issue / discussion items

Fig. A-1.4 Headlines/questions to guide the discussion in break-out sessions

[1] Breakdown of proteins into smaller polypeptides or amino acids.
[2] breakdown of lipids and involves the hydrolysis of triglycerides into free fatty acids followed by further degradation into acetyl units by beta oxidation.
[3] was developed to account for the intensity with which water associates with various non-aqueous constituents and solids.

Notes from Break-out sessions

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Session 1, Topic: From cow to raw milk

Moderator: Frans Kampers

Problem to be solved	**Parameter to be improved**
Detection of residues (organic farming) In-line measurements of cell count or biological contamination (bacteria) Uptake by users (education level of farmers, connected to economy, low cost tests)	Cost of sensors

Opportunities / benefits / drivers for user (food industry / consumer)

If you can detect cows that have contaminants (bacteria, residues) in the milk soon enough you will be able to increase the value of the milk in the collection tank. Both for the farmer and for the dairy industry.

Screening for cows that are in the process of developing a health problem.

Challenges / problems / barriers in the realisation

- from user (dairy industry point of view):

Cost

How do you know that the organic milk is really from an organic farm?

- from Microsystems supplier / research point of view:

Provide a sensor that can measure certain parameters (somatic cell count, bacteria, residues) in the teat cup) during the milking (10-15 min).

Urgency / expectations on availability (3, 5, 10 years)

No clear answer

Key parameters / specification range

Time of measurement (10-15 min for the in-line measurement)

Cost (depending on application: in-line screening: very low; test of recovery of cows: 1 €)

Sensitivity (depends on regulation)

Reliability (less for screening, but no false negatives; for checks the reliability needs to be higher)

It is very difficult at this stage to specify more ranges

Other issue / discussion items

What is missing during the discussions is the knowledge of the end users (farmers, quality control organisations and dairy industry)

Fig. A-1.5 Break-out session 1: From cow to raw milk (Quality, contamination)

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Session 2, Topic: Measurements during the process (on-line)

Moderator: Olivier Chartier

Problem to be solved	**Parameter to be improved**
Non-destructive analysis	Acidification +++
In situ	Temperature ++
Non-intrusive (better) : problem for cleaning	Humidity (cheese)
No by-pass	Density
Continuous measurements are better	Products (≠ environment) :
Fast measurement	Microbio parameters
	Physical parameters
	Chemical parameters
	Protein, fat, lactose, dry matter
On-line : don't take a sample,	Residue previous batches
In-line : sample, multi-parameters very important	Residue detergent batches
Off-line : in laboratory	We have to make a difference between :
	Cheese - solid
	Milk – liquid
	Microbio quality (not today in continuous)
	Raw milk quality : protein, count somatic cells

Opportunities / benefits / drivers for user (food industry / consumer)

Better control of processing parameters of the product for increase yield and decrease waste.

Challenges / problems / barriers in the realisation

- from user (dairy industry point of view):

- Not much regulatory constraints (linked with cleaning – foreign bodies)
- Cost : depends on benefits
- Competing with simple/existing sensors
- Reliability
- Calibration
- Standardisation is not hot topic
- Specific case of Infant Formula
- Environment constraints: humidity, temperature, salt, biocompatibility
- Food contact material regulation

- from Microsystems supplier / research point of view:

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Urgency / expectations on availability (3, 5, 10 years)

As soon as possible

Solution that do not exist -> priority

Key parameters / specification range

Other issue / discussion items

Fig. A-1.6 Break-out session 2: Measurement in process (on-line, in-line)

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Session 3, Topic: Quality control (analysis of final product)

Moderator: Arnout Fischer

Problem to be solved	**Parameter to be improved**
we need online knowledge on mineral protein fat	know quicker than now final composition, often quality control is only back when it is already too late (hours-days is far too long for dairy)
We need a quick sensor for proteolysis; this is very important. Also important a sensor for the amount of a water and quality of water in products.	Proteins are often cut, proteolysis works but cannot measure quick enough Need to know fast also for perishables but also best marketing e.g. maturity of cheeses.

Opportunities / benefits / drivers for user (food industry / consumer)

A microsensor company is developing a quick sensor for proteolysis in milk, fluid. How to change for end product? These methods are optical – fluorescent, need to get it into a column – from sample taking to results 5 minutes – instead of 1 week. Still lab, not sure whether it can go to a microsystem yet. But inline non destructive testing in milk is already possible.
What does “accurate enough” mean, for maturation (sensorial) quality information is already an improvement, safety is something else entirely; nutritional quality is something else. So microsystems in sensorial – electrochemical would be great.

Detecting specific enzymes is possible, - perhaps the cutting peptide.
Finding key peptides. Phasing point of milk – global parameter size of molecules.
Cheeese is semisolid – important to make relevant differences much more than hard boundaries – but measuring average molecule size is important.

Test volumes – depends on size of cheese, also we sample cheeses, for large factories 10% is very good, 1% is measured. Most variation is within a single cheese more so than within a batch of cheeses, e.g. salt comes from the brine bath and may not reach the centre. 3 or 4 samples taken from a single cheese! Sensory test, colour, texture, no taste testing, than lab analyses for proteins, water calcium far necrolyses, (sometimes volatile free acids). 200-300 Euros for one cheese (=1 batch). Expensive!

(see page 2)

Fig. A-1.7 Break-out session 3: Quality control (analysis of final product), page 1

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Session 3, Topic: Quality control (analysis of final product)

Moderator: Arnout Fischer

(page 2)

Challenges / problems / barriers in the realisation

Smell is mix, but so is taste – so detecting aroma molecules would be interesting to track, - challenge remains to identify the right molecules – and to calibrate this.

Picking up even specific enzymes is long away – main concern is not the system but that it works consistently. Don't dare to make a time estimate.
Challenges: test between sensors and what proteins are needed.

- from user (dairy industry point of view):

Maturation is mainly cutting of proteins – large 150 C – are cut to large peptides – 30-40 amino acids – these are further cut to aminoacids. Maturation is mainly digestion large molecules becomes smaller. A global parameter for molecule size would be useful.

- from Microsystems supplier / research point of view:

Microsystems exist that can sense many parameters but it is not clear which chemicals to measure! Usually it can be done within 30 mins. What are the really important chemicals to measure? This can be cheap a microsystem. Are there dominant proteins? - alfacaseine and betacaseine are the important proteins.

Big challenge for microsystems to sample the heterogeneous product. Microsystems could look at heterogenouty, should not be too much different – so tracking would be nice. We can think but only think about multisensor devices, but would be destructive – ultrasounds – not micro solution, heterogeneous is macro in and out of itself. No near future micro solution.

Similar for butter yoghurt – texture ph electric microbiology – safety but also good bacteria/probiotics – important that they survive.

- complex products heterogeneous
- soft parameters for sensory quality – we need to know exactly which proteins important
- no quick solutions all out solutions for non destructive within products measuring

Urgency / expectations on availability (3, 5, 10 years)

Key parameters / specification range

Other issue / discussion items

more collaboration needed.

Fig. A-1.8 Break-out session 3: Quality control (analysis of final product), page 2

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Session 5, Topic: Cleaning efficiency

Moderator: Olivier Chartier

Problem to be solved	**Parameter to be improved**
Alarm to indicate when/how to clean	Biofilm thickness/composition
Alarm which indicates when it's clean: indicator of efficiency of cleaning. Measurement of cleanliness.	Chemical residues
Diminish consumption of water, chemical products, energy, time	Thickness "pierre de lait"

Opportunities / benefits / drivers for user (food industry / consumer)

Clean less (number and duration), better, at the right time (when it's necessary).

Challenges / problems / barriers in the realisation

- from user (dairy industry point of view):

- Places to measure (dead volume)
- Long term stability of sensors
- Resistance to alkaline/acid
- In place during production & cleaning -> food contact material

- from Microsystems supplier / research point of view:

- Detection of biofilms is complicated because it's living organism
- Environmental conditions: detergent, hot water…

Urgency / expectations on availability (3, 5, 10 years)

High priority because of the price of extra consumption of water, energy, detergent…

Key parameters / specification range

Other issue / discussion items

Fig. A-1.9 Break-out session 5: Cleaning efficiency

Problems in the Dairy supply chain that might (possibly) be solved with new Micro technologies or Smart Systems

Session 6, Topic: Packaging / transport / tracking

Moderator: Arnout Fischer

Opportunities / benefits / drivers for user (food industry / consumer) and challenges / problems / barriers in the realisation

Smart pack, temperature time - all tags are too expensive, in pharma it is ok but for food too expensive. Egg and hen problem – is it volumes of production, - consumer does not want to pay much. No willingness to pay. Safe enough, in shops
Colour tag for fish – meat, food industry prevented it because they fear the consumer may not behave responsibly, the consumer may leave it out in the open and then return it.

Transport within chains seems much more likely right now, for internal chain control, who should pay? If it reduces thrown away products, misfit in systems – increase efficiency in production at the end of the chain we throw it away.

Active package for cheese, cheese does plastic, other packaging – bioactive packaging recyclable packaging. Added value in intelligent packaging. Packaging telling maturity, might be interesting.

Consumer packaging far too expensive – silicon based microsystems will never be cheap enough. Individual product probably too expensive, but for batches – might be interesting to track the actual trucks rather than the system. Printed labels and sensors interesting; expected 5-10 years to market.

Important to know where what products are at one time, important in case of outbreak to find everything in a batch very fast? GPS in delivery system – need to combine different tracking systems that integrate truck-product-supermarkets systems – well beyond microsystems but more of systems integration.

Audit the system, track the system and see whether parameters are set right. BPA in plastics – how to replace these plastics or remove transfer, lotus systems may solve some of the migration of molecules to products. Lotus inside a bottle may be nice – but possible – probably not in foreseeable future. Secondary coatings interesting.

View of the delivery chain – from the side of the customer – do I get what I pay for? Are they delivering quality food? Special label on top end food? Customer wants more assurance of quality food? - High quality foods – but volumes are probably too low to apply microelectronics – advantages of scale are not enough for the volumes.

Cost depends heavily of volumes levels needed – is it cost effective to miniaturise! - At least for silicon based products setup cost high, single units small. Printed electronics – first printed electronics might come around in 5 yrs time? May solve it, in any case less than 20 yrs.

Industry integration is important. But be aware no real industry people in this field.

Fig. A-1.10 Break-out session 6: Packaging / transport / tracking

List of Participants

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Break-down of Participants

21 external participants (from 8 countries), amongst them:

- 7 representing the Food Industry,
- 14 technology suppliers (representing the Microsystems community)

14 partners of the FoodMicroSystems project, amongst them:

- 5 representing the Food Industry,
- 2 technology suppliers (representing the Microsystems community)
- 3 specialists in Microsystems AND Food
- 4 project management / consulting