INDUSTRIAL SOLUTIONS ON FARMING & FOOD SECURITY

ADVANCED SENSING FOR FOOD QUALITY

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Global trends and Market Requirements are pushing the FOOD sector towards a new era:

- Cost efficiency at all levels (O&M, waste reduction, production)
- Productivity and competitiveness
- Sustainability
- From community to individuals
- Quality controls and worldwide regulations
- Everything driven by Industry 4.0 and IoT paradigms
AGRI-FOOD & FARMING
BENEFITS OF ADVANCED SENSING

Regulations (safety, control of the production process)
Ensure Quality
- Prevention, minimize risks in a process
- Composition
- Along the whole chain
- Final product aesthetics/category

Brand, traceability, esteem

Product valorization
More and better information to make decisions

Sustainability, production optimization
ADVANCED SENSING: A CHALLENGING PROCESS

**Principle**
- Electrochemical
- Optics
- 2D/3D imaging
- Fluorescence
- Ultrasonic

... 

**Detection method**
- Analytic chemistry
- Espectroscopy
- Microscopy
- Colorimetry
- Artificial vision

... 

**Integration**
- Electronics & Communications
- COTS sensors
- Mechanics and fluidics
- Materials
- Data processing and analytics

...
FROM LAB TO IN/ON-LINE

KEY PARAMETERS IN FOODS & BEVERAGES

Vis-NIR SPECTROSCOPY

FLUIDS
TRANSMITTANCE, ABSORBANCE

<table>
<thead>
<tr>
<th>Fluids</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>WINE</td>
<td>alcoholic grade</td>
</tr>
<tr>
<td>CIDER</td>
<td>alc, fructose, acids</td>
</tr>
<tr>
<td>MILK</td>
<td>fat content</td>
</tr>
<tr>
<td>OLIVE OIL</td>
<td>acidity</td>
</tr>
</tbody>
</table>

SOLIDS
REFLECTANCE

<table>
<thead>
<tr>
<th>Solids</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRUITS</td>
<td>%Brix</td>
</tr>
<tr>
<td>TOMATO</td>
<td>%Brix</td>
</tr>
<tr>
<td>NUTS</td>
<td></td>
</tr>
</tbody>
</table>

Diagram showing components: Spherical mirror 1, Diffraction grating, Spherical mirror 2, Fluidic cell, Detector.
FROM LAB TO IN/ON-LINE

DETECTION OF ALLERGENS & PESTICIDES

ELECTROCHEMICAL DETECTION SYSTEM

SAMPLE HOMOGENIZATION

PROTEIN EXTRACTION

LIQUID-SOLID PHASE SEPARATION

EXAMPLE: DETECTION OF TROPOMYOSINE IN PRAWN EXTRACTS

Real samples

LOD < 1ppm
TOWARDS INDUSTRY 4.0 IN FARMING

NON-DESTRUCTIVE INSPECTION
FULLY AUTOMATED

2D/3D Imaging, IR, Multi-spectral

Product classification (shape, size, color, maturity…)

Defects in products

Composition (key parameters)

Deep Learning

Detection of pests and weeds in crops
Precision agriculture, site specific crop manag.,…
ENABLING BIG SCALE MONITORING
LOW COST DISTRIBUTED SENSING
WIRELESS AND EASY TO DEPLOY SOLUTIONS

- Integration of low cost commercial sensors
- Wireles Sensor Networks and IoT communication
- Ultra low power + Energy Harvesting
- Plug, Play & Forget
- Distributed datalogging
- Cloud-based advanced processing and analytics

Welfare and environmental monitoring
(in farms, agriculture, retail, transportation)

Cold chain supervision and traceability
DEVELOPING ADVANCED SENSORS: THE PROCESS

IDEA
NECESSITY
OPPORTUNITY

MEASUREMENT
PRINCIPLE
VALIDATION AND
PROOF OF CONCEPT
S1

FUNCTIONAL
PROTOTYPES AND
TESTBENCHES
S2

DESIGN,
DEVELOPMENT,
PRESERIES
S3

SUPPORT TO
CERTIFICATION,
QUALIFICATION
AND MARKING
S4

PRODUCT
LIFETIME
CONSULTANCY
S5
ALIGNED WITH FOOD&FARM SECTOR NEEDS

Addressing a broad set of requirements:

- Compatibility with health and sanitation regulations
- In-line operation
- Non-destructive measurements
- Robust and autonomous devices
- Cost efficiency
- Portable and highly integrated solutions
- Sensitivity, precision and reliability
- Connected and secured
DEVELOPING ADVANCED SENSORS
SOME CASE STUDIES
Ad-HOC WineNIR

Functional prototype to monitor alcoholic grade during wine fermentation
- Transmittance NIR sensor (1750-2200nm)
- Temperature self-compensation
- Low cost
- Designed for an easy integration into wine barrels
- On-line measurement, remote sending of data for further storage and analysis.

Pre-validated comparing 8 different wines

Compatible with health and sanitation reqs.

Easy to use and operate
IN-LINE PARTICLE COUNTER

**Advanced sensor for fluids**
- Continuous measurement
- In-line microscopy
- In production for lubricant fluids
- Embedding CMOS sensor, optics and emitter
- In-device image processing and basic chemometrics
- IoT-ready for remote monitoring and control

**Applicability in FOOD**
- Detection and classification of bubbles/solids (e.g. beer market)
- Proof of concept currently ongoing to monitor phytoplankton
NIR SOLUTIONS

WATER IN OIL

NUT SHORTING

NDA protected
COLOR SENSORS

AROMA IN FLUIDS

FLUID OXIDATION
Advanced sensing is a MUST for food quality

Many direct and indirect advantages: safety, efficiency, production optimization and control, quality assurance, brand positioning,…

Complex process requiring a multidisciplinary team of experts

- Validate a measurement principle
- Functional prototype
- Development up to product stage
- Certification and qualification
- Support during product lifetime

“When you can measure what you are speaking about, and express it in numbers, you know something about it”

Lord Kelvin (1824-1907)