## DESCRIPTION OF COURSES

<table>
<thead>
<tr>
<th>Code</th>
<th>International Master degree PM3F</th>
<th>Code</th>
<th>Fall semester</th>
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<tbody>
<tr>
<td>ST 9</td>
<td>Food Engineering &amp; Food Science - Basics</td>
<td>FS1</td>
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<tr>
<td>ST10-1</td>
<td>Food safety and quality management - Basics</td>
<td>FS2</td>
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<tr>
<td>ST10-2</td>
<td>Product innovation and food safety management 2</td>
<td>FS3</td>
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<tr>
<td>ST11</td>
<td>Advanced tools and methodologies for food characterisation</td>
<td>FS4</td>
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<td>ST12</td>
<td>Innovative food processing</td>
<td>FS5</td>
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<td>ST13</td>
<td>Energy and sustainability</td>
<td>FS6</td>
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<td>ST14</td>
<td>Advanced process control</td>
<td>FS7</td>
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<td>LV3</td>
<td>International communication and leadership for engineers</td>
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### Specific to Fall semester

- Baking technology: FS8
- Baking process: FS9
- Food freezing and thawing: FS10
- Fruit juice technology: FS11
- Innovation and creativity: design thinking at the service of engineers: FS12
- Data science - basics and explorarion: FS13
- Data science - explain and predict: FS14
## Food Engineering & Food Science - basics

<table>
<thead>
<tr>
<th>Public concerned</th>
<th>Number of hours</th>
<th>Objectives</th>
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<tbody>
<tr>
<td><strong>Lectures</strong></td>
<td>22</td>
<td>Developing a food product based on the diversity of ingredients available today and on the understanding of their functional properties related to transformation processes:</td>
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<tr>
<td><strong>tutorials</strong></td>
<td>8</td>
<td>- Understanding the manufacture of various types of ingredients regarding their food sector</td>
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<tr>
<td><strong>Lab</strong></td>
<td>12</td>
<td>- Understanding the implementation of ingredients related to their functional properties</td>
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<td><strong>project</strong></td>
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<td>- Ingredients selection according to the manufacturing process and the target characteristics of the final product, including their role in the food structure, stabilization and organoleptic specificities.</td>
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<td>- Development of food products within formulation constraints (i.e. Clean label)</td>
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<td>- Evaluation of the food product properties (texture, stability, colour, nutritional characteristics...)</td>
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### Contents

- Grasp the uses of different types of ingredients in relation to their manufacturing processes: diversity of ingredients available on the market and their quality (protein, fibres, lipid ingredients and additives)

- Manufacture and handling of dry ingredients: characterization of powders properties (flow behaviour, rehydration, 

- Non-thermal stabilization process and consequences on food properties

- Behaviour of food products as a function of temperature

- Tutorials: formulation of a Clean label product, nutritional calculation...
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<thead>
<tr>
<th>Food safety and quality management - basics</th>
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<tr>
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<td>Lectures</td>
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<td>Lab</td>
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<td>ST 10-1</td>
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<td>ECTS : 1.5</td>
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**Contents**
- Understanding the Standards
- Elements of a Management System
- Certification and accreditation
- Practice through case studies

**Objectives**
To get the students the fundamental elements of Food Safety Management (Pre-requisite programs, HACCP...) and an overview of Risk Analysis with its three interconnected pillars:
- risk assessment
- risk management
- risk communication

Lectures and Tutorials will be illustrated by case-studies related to food industry.

**Food safety management and communication : 6 hours (lectures)**
- Pre-requisite programs, best practice, product and process controls
- Sampling, validation, verification
- Relevance of finished product testing; illustrations with various examples

**Communication:**
- Risk perception, risk communication,
- Communication adapted to various stakeholders: authorities, customers, consumers

**Quantitative risk assessment : 6 hours (lectures) - 6 hours (tutorials)**
- Introduction to probability, uncertainty and risk assessment modelling:
  - probability distributions illustrated through examples
  - uncertainty and variability
  - risk assessment modelling approach

**Chemical risk assessment:**
- Exposure assessment,
- Dose-Response model
- Practice through case studies

**Microbiological risk assessment:**
- Exposure assessment: inactivation, partitioning, growth
- CCP/ process criteria to meet an FSO (risk-based management)
- Practice through case studies
# Product Innovation & Food Safety Management 2

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<td>project</td>
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## Objectives

**Contents**
- Trends in industry and food safety impacts
- Microbial hazards along the food chain
- Predictive microbiology
- Methods of food stabilisation
- Shelf life determination

**Code**

| ST 10-2 | FS 3 | ECTS : 1.5 |
## Prerequisites

Basic knowledge on physical and organoleptic properties of foods  
Thermodynamics / Mass and energy balances  
Foundations in mathematics

## Contents

### Mechanical properties


### Thermal properties

Thermal conductivity, specific heat, enthalpy, glass transition measurement, differential scanning calorimetry.

### Texture of foods

Assessment of mechanical properties by large deformation scale methods. Texture profile analysis and correlation with sensorial tests. Texture–structure relationships.

### Non-destructive methods to assess physical characteristics of foods

Spectrophotometry, X-rays Micro-tomography, Magnetic Resonance Imaging
## Innovative Food Processing

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<tbody>
<tr>
<td>Pm3F</td>
<td>Lectures 40 - 40 - 18</td>
<td>Designing and implementing innovative processes in food industries requires a high level based on many engineering skills. This module relies on several teaching units focusing on both technological and modeling aspects which are helpful to design efficient and innovative food processing units. The main objectives could be summarized as follows:</td>
</tr>
<tr>
<td>English Fall Semester</td>
<td>tutorials 12 - 10 - 6</td>
<td>- Understanding and setting up a modeling approach dedicated to food engineering problems,</td>
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<tr>
<td>PEPS</td>
<td>Lab / Project 30 - 20 - 16</td>
<td>- choosing the best technology to ensure optimal processing of food products,</td>
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<td>- dimensioning of a food processing unit by taking into account a scale-up approach and various constraints,</td>
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<td>ST 12</td>
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<td>- improving the global efficiency of processing from an optimization based methodology,</td>
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<td>- implementing newly designed processes.</td>
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### Prerequisites
- Applied thermodynamic (first and second principles),
- Heat transfer (conduction/convection/radiation phenomenon)
- Mass transfer (Fick's first and second laws based on diffusion and convection),
- Heat and mass balances
- Unit operations of chemical engineering
- Mathematical basis on ordinary and partial differential equations

### Contents

#### Process simulation
- Introduction to thermodynamic models (2h lecture)
- Practical work on demo stations (10h lab): How to model a unit operation? Which thermodynamic model and database to choose? (examples based on food engineering problems such as evaporation, concentration, cooling, drying,...)

*Process simulation software: PROSIM®

#### Modeling / Optimization
- Introduction to numerical modeling and optimization
- Equations based modeling for food engineering problems
- Optimization (implementation of optimization algorithms, i.e. Nelder Mead Simplex, Levenberg Marquardt, constraint optimization, ...)
- Multiphysics Modelling

#### Innovative processes
- High Pressure - Electrotechnologies - microwave - extrusion - Supercritical extraction CO2 - Electro Hydro Dynamics
## Contents

**Thermodynamics:** reminder on energy balance of components and/or equipments under steady-state and dynamic conditions. Heat loads estimation for a storage cold room and chilling/freezing processes. A project on a complete energy audit of a food industry equipment: minimum energy requirement, distribution of energy consumptions,...

**Refrigeration systems:** reminder on 1-stage vapor-compression system (energy and mass balances, p-h and T-s diagrams), multi-stage and cascade vapor-compression systems, alternative refrigeration systems (sorption, Peltier, acoustic, magnetic,...), international regulations on refrigerants, heat pump specificities,...

Advantages of thermal energy storage in food industry & precautions to consider.

**Energy efficiency:** pinch analysis methodology (flowsheet and data extraction, hot and cold composite curves, heat exchanger network), exergy analysis

**Life Cycle Assessment for the eco-design of an equipment:** methodology, impact on energy consumption and environment. Case study by using SimaPro 8
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<tr>
<td>Pm3F English Fall Semester BT 3</td>
<td>Lectures 8</td>
<td>To be able to understand dynamics of linear and nonlinear systems, and to implement relevant control systems, including parameter and state estimations (observers).</td>
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<tr>
<td>tutorials 8</td>
<td>Lab 4</td>
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<tr>
<td>project 10 - 0 - 0</td>
<td>Code ST 14</td>
<td>ECTS : 3</td>
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Contents

- Reminders about linear transfer functions and controllers
- State Space representation (linear and non linear)
- Linear quadratic control - state feedback
- Luenberger observer - Kalman Filter
- Introduction to nonlinear control
- Moving horizon state estimation
- project using Matlab*
Different lectures will be done, mostly related to the interactions between ingredients, formulation and process interactions. 4 major types of products will be considered, bread, cake, biscuits and dry cereal products such as rusk and crackers.

A factory will be visited during the teaching session.

The wheat flour and other flours

Improvers in bread baking

Enzymes, emulsifiers,

The texture of cereal products

Staling of bread

Baking powder

Case of cake products; recipes, processes; and strategy in sugar reduction

Case of biscuit products; recipes and strategy in sugar reduction

Case of salty cereal products, crackers and rusks processes
## Contents

The baking industry – introduction from flour to different products

Dough mixing and lamination

Fermentation & Enzymes

Ovens and Baking technology

Cooling, freezing, storage

Tutorials fermentation, enzymes and baking powder

### Baking Process

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<td>English Fall Semester</td>
<td>Lectures 9</td>
<td>The global objective is to discover the baking industry as a whole. Different processes for different products; the lectures will cover all stages of the process for preparation of different products such as bread and frozen croissant. A focus will be done on important steps that are often bottleneck in the baking industry such as fermentation, baking and refrigeration after baking.</td>
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<td>tutorials 7</td>
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<td>Lab 7</td>
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## Food Freezing & Thawing

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<td>English Fall Semester</td>
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<td>The global objective is to discover the freezing and thawing processes, which are heavily used in the food industry. The impact of these processes on the quality of foods, as well as the evolution of quality during frozen storage will be outlined.</td>
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<td>tutorials</td>
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### Code

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<td>FS 10</td>
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### Contents

- Food freezing; regulations and food quality
- Freezing process – conventional & freezing time
- Freezing process – innovations
- Quality loss during storage
- Frozen food structure; image analysis
- Food thawing; regulations and quality issues
- Thawing processes – conventional & thawing time
- Thawing processes – non conventional
- Teaching Lab Food Freezing
- Teaching Lab cryogenic freezing
## Fruit Juice Technology

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<thead>
<tr>
<th>Public concerned</th>
<th>Number of hours</th>
<th>Objectives</th>
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<tbody>
<tr>
<td>English Fall Semester</td>
<td>Lectures 2</td>
<td>The global objective is to discover the fruit juice technology with emphasis on the effect of each stage of the production on the physical properties and the final quality of the product. The process will be applied to apple juice.</td>
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<tr>
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<td>tutorials 2</td>
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<td>Lab 8</td>
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### Contents
- Fruit processing applied to apple juice
- Physico-chemical measurements and thermal treatment
- Apple juice production on pilot plant
Design thinking is a process initially used by designers to innovate from existing uses or to invent. It can be used to solve problems based on user needs and develops solutions for them (products, services, experiences, new form of management ...). This approach can thus be applied to very varied sectors (industry, teaching, hospitals...), from marketing to management through technology. This teaching unit should allow students to have a more global vision of innovation management through the application of design thinking to an innovation project.

**Contents**

1) Presentation of the innovation process by using the design thinking and of the innovation project

2) Generation and development of new ideas

3) Transcription of idea(s) in realization steps

4) Present the result of your thinking in a creative way, to convince potential users

5) Technical and practical development of the idea

6) Evaluation of your product or concept (technical analysis, sensory analysis, survey, fe;
In order to provide safe, nutritious, healthy and palatable products, food industries collect large amounts of data related to process, quality, research and development, consumer insights etc. This leads food practitioners from various areas to perform data analysis on a daily basis. Furthermore, data analysis is becoming increasingly sophisticated requiring statistical and computer science technical skills, which fit under the umbrella of Data Science.

The aim of this course is to provide the very first operating level:
- To learn application of basic statistics and data visualization in food industries;
- To become familiar with R, the language of reference for statistical computing and graphics;
- To get insight into the data and provide synthetic results;
- To learn multivariate statistical methods for data exploration purpose.

Technical skills
- Application of data analysis methods to summarize and visualize data
- Use of the R language for data processing and analysis
- Interpretation of statistical results and communication

Introduction to Statistics with R

We begin by introducing the R language with some basic elements. Then, we define the nature of data issued from various collections (experiments, surveys, sensors ...). Finally, we show some useful data manipulation tools.

Discover the R language with some basic programming concepts;
Understand the nature of data and their collection;
Experiment useful data manipulation functions.

Get insight into the data

This part is devoted to univariate and bivariate statistics to summarize one variable and investigate the relationship between two variables. We show how graphical displays together with numerical outputs can provide synthetic results.

Summarize one / two variable(s) with descriptive statistics;
Presents summaries with Tabular and graphical displays.

Synthesize the data into an easy and understandable form

This part covers the main multivariate analysis techniques to deal with several variables. Principal Component Analysis aims at transforming a large number of correlated variables into a few uncorrelated principal components. Clustering aims at partitioning objects into a small number of groups that are as homogenous as possible.

Synthesize the data using Principal Component Analysis and Display the data onto a map;
Partition the data into groups using Clustering techniques and Characterize the groups thus formed.

Methods will be illustrated on various case studies. Beyond direct applications in food areas, this course is the first step to grasping the use of statistics in a scientific context. A special attention is paid to a balance between (1) Methodological aspects, (2) Practical applications and (3) Communication aspects with the interpretation of the results.
To go further in Data Science, the aim of this second course is to provide advanced techniques for the analysis of specific data encountered in chemometrics (Omics, spectral, imaging ...) and to conduct a multivariate data analysis.

Emphasis will be given on supervised methods where the aim is to explain or predict one or several response variables. In the scope of chemometrics, the data flood generated by modern analytical techniques requires dedicated analysis techniques, which can handle a great number of variables, often highly correlated together. Among these techniques, a focus will be done on the Partial Least Squares Regression, the chemometrics Swiss knife, to explain a set of response variables with highly correlated variables.

**Contents**

**Introduction to Chemometrics**

We begin by introducing Chemometrics and depicting the nature of data ranging from Omics, spectral data and imaging. Then we give an overview of the main data analysis techniques in chemometrics with a particular focus on supervised techniques.

**Explain one or several variables with the Partial Least Squares (PLS) regression**

This part is devoted to the presentation of PLS regression. We present how PLS regression operates a mixed strategy between Principal Component Analysis and Multiple Regression in order to provide simultaneously interpretable models and graphical displays. We present the main R stream programming to process data with PLS.

**Process hyperspectral images by chemometrics**

This part covers the main stream to process hyperspectral images by applying PCA and clustering.

Methods will be illustrated on various case studies involving analytical data. A special attention is paid to a balance between (1) Methodological aspects, (2) Practical applications in the R language and (3) Decision and validation models.

Evaluation will be done on the basis of a project related to a case study.