Food Safety and Product Design

Strategic Pillars:

PILLAR I

Food Design Thinking

Human-centered approach to food product creation, integrating empathy, ideation, and prototyping to solve complex food system challenges without avoiding food culture and traditions.

PILLAR II

Innovation & Safety

- Main ingredients & additives
- Technological adjuvants
- Bioprocessing

PILLAR III

Food Control & Analysis

- Instrumental analysis
- Multi-omic approaches
- Data fusion

Goal: Creative food products and solutions through food science and food safety culture

Università degli Studi di Ferrara

University of Ferrara
Department of Chemical, Pharmaceutical and Agricultural Sciences

Food Safety (reactive) Culture

not a management tool

Food Safety performances

food science

teamwork organization

sociological factors

risk mitigation

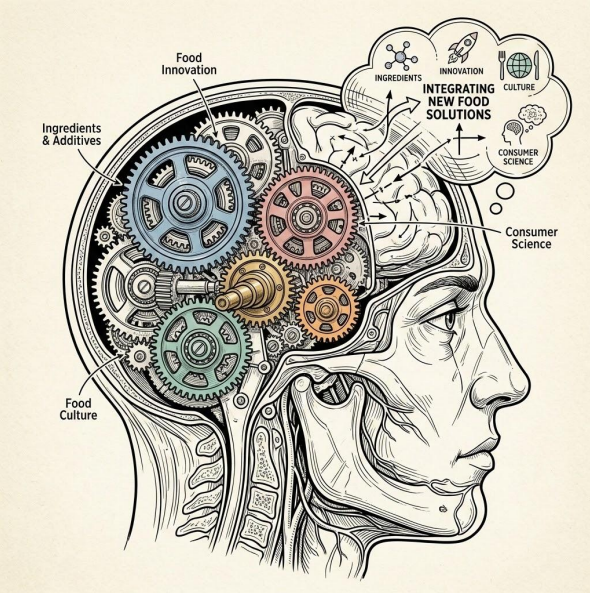
innovative functional foods

economic impact

Comprehensive solutions

Food Design Thinking

a problem solving approach that uses creative, collaborative and user-centered methods to tackle complex and ambiguous challenges



1. Empathy & Insight (definition)



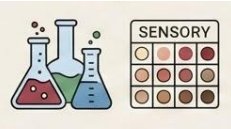
user needs,
food culture,
social context

2. Ideation & Conceptualization



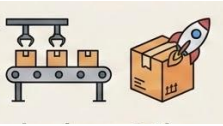
creative thinking:
new ideas,
product concepts &
recipe formulations

3. Development & Prototyping



testing and execution:
adjusting formulations,
sensory analysis,
stability, improvements

4. Implementation & Scale-up



industrial production,
packaging design,
market strategy

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Design thinking: An effective strategy to evolve food safety culture?

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Cultural heritage and food tradition - the medieval city of Ferrara



the marvelous House of Este banquet (1529)



Cristoforo di Messisbugo the Este court carver (1515-1548)



the moated Este castle

Cultural heritage and food tradition - the medieval city of Ferrara





the new book where he described how to prepare almost every kind of food







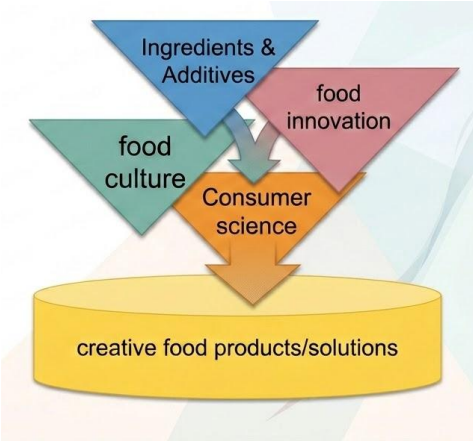
sturgeon
caviar





"Banquets. Compositions of food and how to prepare the table"

MSc Food Safety and Food Risk Management
Curriculum of Food Safety and Product Design



teaching courses:

Innovation in food additives

Omic sciences for food safety
- Fundamentals of advanced omic technologies
- Metabolomic assessment of food product safety

Enzymes and biocatalysis in food development

Nanotechnological approaches in food safety

→ 2026/2027

Student free choice courses → 2025/2026

Curriculum of Food Safety and Product Design

<u>Mandatory Courses</u> (24 ECTs)

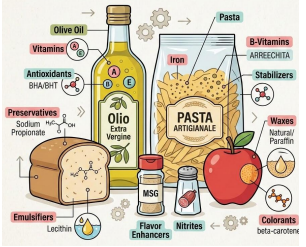
Teachers:

Prof. Paola TEDESCHI (food science and technology)

Prof. Maddalena SGUIZZATO (pharmaceutical technology)

Prof. Lindomar Alberto LERIN (chemistry and biotechnology of fermentation)

Prof. Martina CATANI (analytical chemistry)
Prof. Nicola MARCHETTI (food chemistry)



Innovation in food additives - 6 ECTs

Course Overview: the course explores the different classes of the food additives and their new uses in food product development, together with the regulation process and the main analytical methods employed in their molecular analysis

TOPICS:

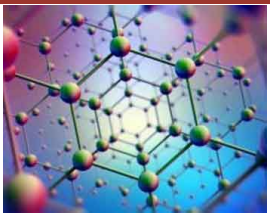
Introduction to Food additives: category of food additives; importance of food additives in food processing and preservation; safety of food additives

Food additives regulation: guidance to submission of food additive evaluation; re-evaluation of already authorised food additives; risk assessment related to food additives and food processing

Categories of food additives: antioxidants, sweeteners, flavouring, nutritive, emulsifiers, bulking, pH-control, hydrocolloids, antifoam and release agents, flour improvers and raising agents, chelating agents, enzymes

Techniques of analysis for food additives

Case studies on food additives and their safety issues



Nanotechnological approaches in food safety - 6 ECTs

Course Overview: The course aims to provide students with the basic knowledge about the design, production and quality control of nanotechnological formulations, their application in food processing, packaging and safety. Evaluation of the toxicological aspects of nanomaterials in food, the related safety concerns and regulatory laws.

TOPICS:

Nanotechnologies applied to food processing: nanoemulsions; nanoencapsulation; mixed nanoparticle delivery systems; natural Carriers

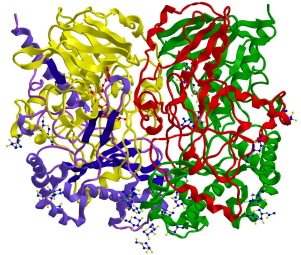
Nanotechnology for Food Packaging: active food packaging systems; smart/intelligent food packaging systems

Mechanism of Nanoparticle Activity: antimicrobial properties; synergistic antimicrobial effects;

Applications in Nutraceutical Delivery and Bioavailability

Toxicological Aspects of Nanomaterials in Food

Safety Concerns and Regulatory Laws



Enzymes and biocatalysis in food development -

6 ECTs (including 1 ECT practical activities)

Course Overview: Enzymes and biocatalysis drive sustainable, eco-friendly food development. By accelerating specific biochemical reactions at mild temperatures, these biological catalysts allow the industry to create cleaner, highly functional, and nutritious foods—ranging from plant-based meat alternatives to extended shelf-life bakery items and innovative food additives (i.e., texturizing, sweetening, flavor enhancement, shelf-life and waste reduction).

TOPICS:

INTRODUCTION: enzyme kinetics, enzyme families and catalytic mechanisms, enzymes immobilization.

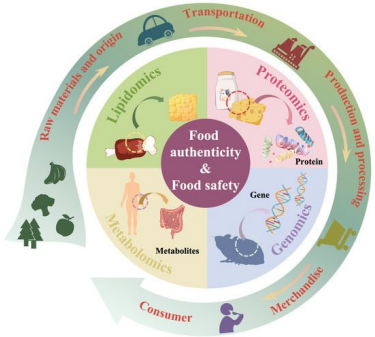
THE APPLICATION OF ENZYMES IN FOOD PRESERVATION: lytic enzymes, oxidative enzymes, transferases.

APPLICATION OF ENZYMES IN THE DETECTION OF FOOD CONTAMINANTS: enzymatic assay, enzyme-linked immunosorbent assay (ELISA), nucleic acid detection technology (PCR).

ENZYMES ACTIVITY AND FOOD PROCESSING: enzymes as marker of food quality, enzymatic time temperature indicators (TTIs)

ENZYMATIC SYNTHESIS OF FOOD ADDITIVES

Omic Sciences for food safety - 6 ECTs (including 1 ECT practical activities)



Course Overview: fundamental concepts of omics sciences - genomics, transcriptomics, proteomics, and metabolomics - with particular emphasis on their application in the food sector. Main strategies and techniques in omics sciences, for understanding experimental workflows, from sampling to data analysis.

TOPICS:

Module 1 - Fundamentals of advanced omic technologies - 3 ECTs (including 1 ECT practical activities)

Concept of omics sciences and "omics cascade"
Principles of separation science, particularly liquid chromatography and gas chromatography coupled with high-resolution mass spectrometry.
Focus on Proteomics and Metabolomics: definition, methods for protein extraction and analysis, targeted and untargeted approaches for protein analysis, lipidome and volatilome, methods for separating volatile and non-volatile metabolites, targeted and untargeted chromatographic approaches; statistical approaches for data analysis.

Module 2 - Metabolomic assessment of food product safety - 3 ECTs

Definition of foodomics and integration of omics technologies in the field of food and human nutrition.
Omic applications on specific food matrices and case studies

Curriculum of Food Safety and Product Design

<u>Student's Choice Courses</u>

Teachers:

Prof. Irene GUGEL (chemistry and biotechnology of fermentation)

Prof. Riccardo FONTANA (pharmaceutical chemistry)

Prof. Rita CORTESI (pharmaceutical technology)

Prof. Elena MAROCCHINO (geochemistry)

Prof. Fabio BARTOLINI (agricultural and food economics)
Prof. Maria RAIMONDO



Upcycling for safe and sustainable design of food ingredients

6 ECTs (including 1 ECT practical activities)

Course Overview: knowledge and skills necessary to design food ingredients in a safe and sustainable way through upcycling processes. The emphasis is on utilizing waste or by-products from food production and transforming them into valuable ingredients while adhering to safety and sustainability principles. The course will foster understanding of circular economy concepts, innovative processing techniques, regulatory considerations, and the environmental impact of upcycling in food production.

TOPICS:

Safe and Sustainable by Design: principles and core concepts; regulatory frameworks and international standards for food safety and sustainability.

Upcycling in the food industry: processes and technologies to recover and repurpose food waste and by-products.

Innovative design for functional food ingredients: case studies and practical applications of upcycled ingredients in the food industry.

Food safety and regulatory aspects: legal requirements; risk assessment and quality control.

Sustainability metrics and life cycle analysis (LCA): tools for assessing the environmental, social, and economic impact of upcycled ingredients.



Interaction between food products and human microbiota

6 ECTs (including 1 ECT practical activities)

Course Overview: role of human microbiota in health and disease and its relationship with the microbiological aspects of food safety. Topics include microbial ecology, molecular approaches to studying microbiota, foodborne pathogens, regulatory frameworks, and the influence of diet on microbiota composition.

TOPICS:

Microbiological Quality and Safety in Food Systems

Human Microbiota and Diet

(Molecular approaches; microbial ecology and oral microbiota; impact of diet on intestinal microbiota composition)

Human Microbiota and Health

(stability, disturbance, resistance, resilience of human microbiota and dysbiosis, impact of dietary carbohydrates on intestinal microbiota composition, understanding reactions catalyzed by intestinal microbiota on food molecules)

Relationship between Diet, Microbiota, and Human Health

(analysis of case studies, impact of artificial sweeteners on glucose intolerance, promotion of colitis and metabolic syndrome by food emulsifiers, relationship between fats and intestinal inflammation, cases of food safety issues)



Geochemical and isotopic fingerprints as tools for food traceability and food safety

6 ECTs (including 1 ECT practical activities)

Course Overview: basic geochemistry of waters, soils and plants from an elementary and isotopic point of view, detecting the elemental and isotopic signature for investigating the origin of foods and their authenticity, carbon and nitrogen cycles, storage of soil texture, seasonal changes and soil microbial communities, biogeochemical cycles and relationships with the geo - lithological environment, carbon exchanges between soil and atmosphere and the isotopic balance of organic matter pools to quantify the alterations due to changes in climate or land use and anthropogenic impact.

TOPICS:
Food authentication techniques & technologies, authenticity vs traceability;

Food frauds in the global food system: case studies, tackling food fraud through technology;

Analytical Methodology in food authenticity and traceability;

Theory of Isotopes: nature and formation of Isotopes

Nontargeted fingerprinting approaches and future prospects



Designing functional foods for human health - 3 ECT

Course Overview: basic knowledge about the design, production and packaging of functional foods products and their EU regulation. In addition, the student will be provided with in-depth understanding and applying the biopharmaceutic principles and evaluating the technological aspects involving the functional food product, their release and packaging.

TOPICS:

Functional food international regulation, Health claims of functional food, Antinutritional factors

Preformulation, Conventional formulations (i.e. powder, granules, capsules, tablets, solutions, dispersions, gels, solutions, disperse systems)

Supramolecular systems (i.e. liposomes, cyclodextrins, microparticles)

Mixing and milling, Coating, Encapsulation, Desiccation, Lyophilization

Food labelling system



Consumer perception and attitudes - 3 ECT

Course Overview: Food psychology and customer's subjective views, feelings, and beliefs about food products.Beliefs, feelings, and intentions that influence how people interact with food products, shaping their buying choices. Consumer behavior and marketing strategies. Methods to measure consumer perception and attitude, including surveys, focus groups, and social monitoring.

TOPICS:

Introduction to consumer behaviour

Perception and attitudes

Motivation and social norms

Practical applications

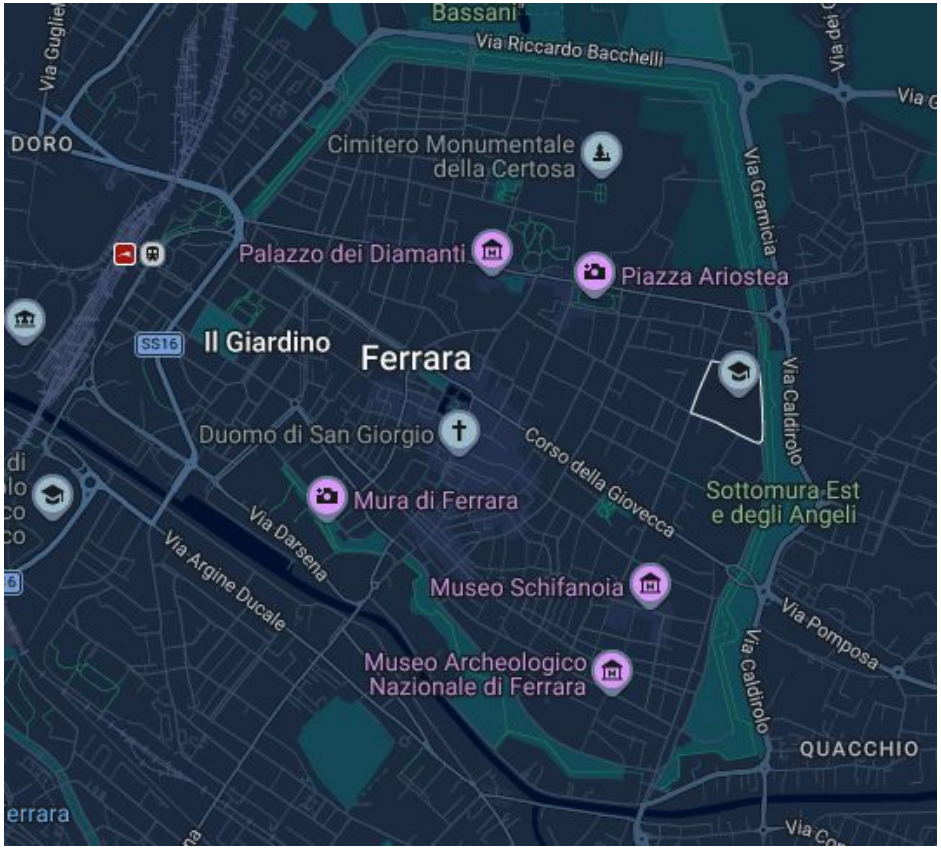












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