Innovation and Food Safety aspects

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Who I am

Ass. Prof. In Food Science and Technology
Since 2003 @ University of Teramo (previously @ Univ. Udine)

Coordinator Master Degree in Food Science and Technology (international)

Vice-Rector of Internationalisation and Joint Study programmes of University of Teramo

President of ISEKI-Food Association

Research expertise

- Food quality and processing
- New product design and formulation
- Physical properties of foods
- Mobility, water state, quality and stability of food matrices

Outline

1. Innovation aspects in food processing and products
2. Novel Foods
3. Genetically Modified Organisms
4. Nanotechnology

1. Innovation in food processing and products

Innovation in the food sector: drivers

- ***Advancements in science and technology***
  - Identifcation and detection of new foodborne pathogens a
  - Evaluation of presence and concentration of contaminants and undesired chemicals, at nano level.
  - New applied sciences (nanomaterials)
- ***Societal and economic changes***
  - Globalisation (population, food, cultures)
  - Change of the importance of the quality attributes as response of modern consumers' expectations.
    - Increased relevance of healthy, sensory and convenience aspects (nutritional value and food safety: intrinsic aspects).

1. Innovation in food processing and products

Innovation in the food sector: drivers

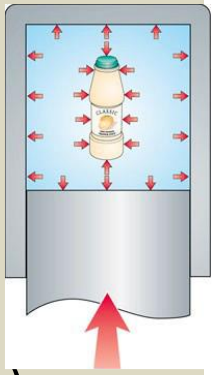
- ***Critical points of conventional products (e.g. thermal processes)***
  - Main degradation of food nutrients
  - Change quality properties (e.g. textural and physical characteristics of food products)
  - Reduced consumer acceptability.

1. Innovation in food processing and products

Innovative technologies

Novel methods that can improve overall quality, retain freshness of processed foods, while achieving the same safety and nutritional value.

- Non-thermal technologies like
  - High hydrostatic Pressure (HHP),
  - Pulsed Electric Fields (PEF),
  - Ultrasound (US)
  - Cold plasma (CP)
- Thermal microwaves (non-conventional heat treatments)



Additional benefits:

- environmentally friendly
- sustainable food manufacturing (low energy requirements, reduced water use.

1. Innovation in food processing and products

Commercialised HP products (examples)

1. Innovation in food processing and products

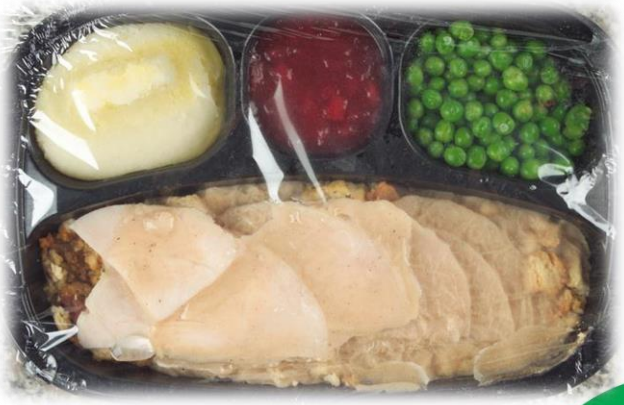
Innovative technologies, uses and safety issues

- Researches on innovative technologies are ongoing:
- Few processes have found application (HP)
    - Limits:
        - high costs (plants and equipment, e.g. HHP)
        - not uniformity of the treatment (e.g. microwaves): need of plant and equipment development and process optimisation.
        - Lack of scientific and objective equivalence of lethal effects on pathogenic microorganism in respect to the conventional ones (hindering use for pasteurisation and sterilisation purposes).

1. Innovation in food processing and products

Innovative technologies, uses and safety issues

Objective equivalence: **only microwave-based thermal treatments** are approved for industrial pasteurization and sterilization by the FDA and in Europe manufacturers willing to apply innovative technologies for sanitisation (pasteurisation/sterilisation) purposes require to obtain official approval by EFSA according to the “novel products” regulation.



2. Novel Foods

General definition

“Food or a food ingredient that has not been traditionally used as a food.

- Varies declinations depending on global location or area of interest.

2. Novel Foods

WHY?

- Innovative technologies
- Globalisation (higher availability of raw materials from countries different that conventional)
- New raw materials (insects, algae)

2. Novel Foods

- **Definitions and regulations**

Some countries (e.g. European ones), have adopted specific definitions and regulations, others no.

- **General bases of official regulation systems**, where exists, are generally based on a safety assessment review model and require notification and approval before a novel food reaches the market.
- **Lists of approved novel foods** are typically maintained by regulators and are made publicly available.
    - **EU**: Regulation (EU) 2051/2283 of 25 November 2015
    - **US** no formal regulations for “novel foods”
    - **Chine** similar regulation system to the European one that, takes into account the specific local habits and cultural history where novel foods and health food are linked as certain materials can be used for both food and medicine.

2. Novel Foods

SAFETY CONCERNS

- Microbial aspects (microbiota, contamination, matrix aspects upon stabilisation processes applications)
- Nutritional value
- Potential allergenicity.
- Bioavailability (nanomaterials)

2. Novel Foods in Europe

EU Definition:
“any food that was not used for human consumption to a significant degree within the Union before 15 May 1997”

2. Novel Foods in Europe

They include

- Foods with a new or intentionally modified molecular structure; foods from cell culture or tissue culture derived from animals, plants, microorganisms, fungi, or algae
- Food from microorganisms, fungi, or algae
- Food from material of mineral origin
- Whole insects and their parts
- Plants obtained by non-traditional propagating practices with significant changes in the composition or structure of the food, affecting its nutritional value, metabolism, or level of undesirable substances.
- Foods consisting of engineered nanomaterials, micelles or liposomes.
- Foods “exotic” or “imported”, without a history of use in Europe, but they are currently used in other parts of the world (“novel imported foods”).

2. Novel Foods in Europe

Examples of novel foods are

- agriculture products from non-EU countries (e.g., chia and quinoa seeds),
- newly produced nutrients (e.g., synthetic zeaxanthin),
- synthetic minerals (zeolites),
- extracts from existing food (rapeseed protein).

2. Novel Foods in Europe

(cont.)

- **Foods processed with emerging, innovative technologies.** For them, the regulation specifies that a food should be considered a novel food when it results from a production process "*not used for food production within the European Union before May 15,1997, if that process results in significant changes in the composition or structure of a food, affecting its nutritional value, metabolism, or level of undesirable substances*".

2. Novel Foods

NOVEL FOODS in EUROPE: procedures (1)

For market or use in food for human consumption a novel food has to be included in a **European Union list** of authorized products (https://ec.europa.eu/food/safety/novel_food/catalogue_en).

- **Authorisation by the European Food Safety Authority (**EFSA) according to procedures and minimum requirements including
  - description of the novel food,
  - production process,
  - compositional data, specification,
  - proposed uses and use levels, anticipated intake .
  - In addition: history of use and/or its source, absorption, distribution, metabolism, excretion, nutritional information, toxicological information, and allergenicity.
  - toxicological data (toxicokinetics: absorption, distribution, metabolism, and excretion—ADME) relevant to assess safety, nutritional and toxicological impact of the novel food).

2. Novel Foods

NOVEL FOODS in EUROPE: procedures (2)

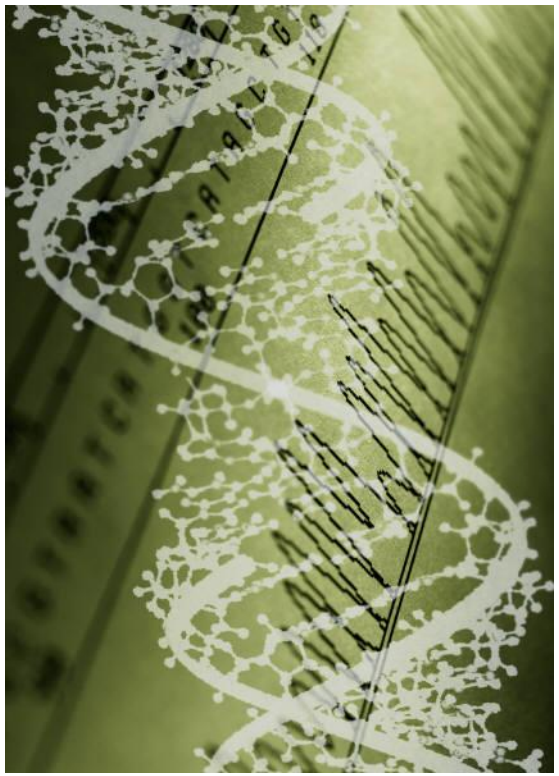
Simplified procedure for manufacturers to introduce novel food ingredients to market in the EU, known as the “substantial equivalence” procedure.

It applies when an ingredient was deemed by a scientific committee to be similar to another ingredient already authorized as a novel food.

3. Genetically Modified Foods

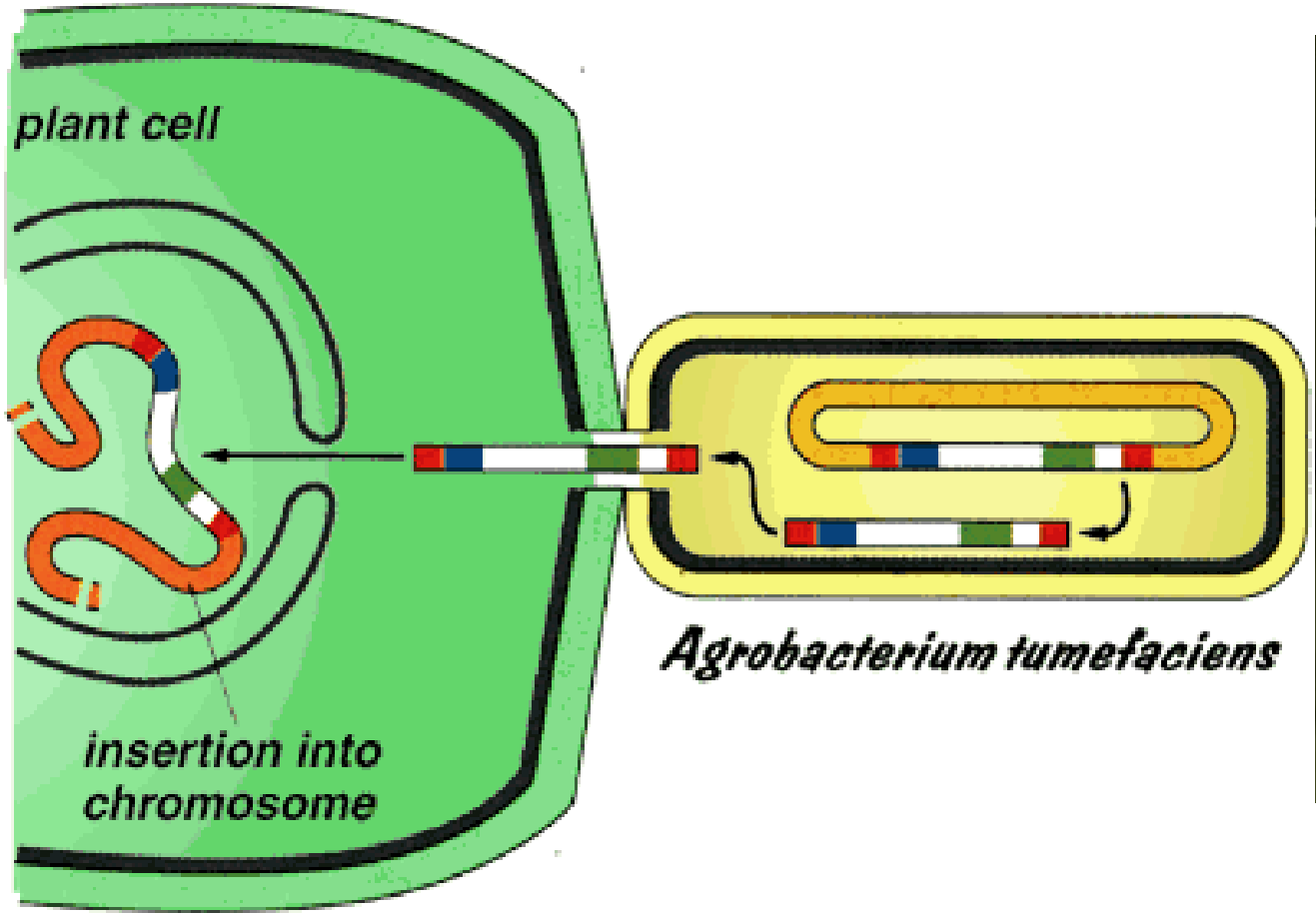
Genetically Modified Foods (GMOs)
= derived from organisms whose genetic material (DNA) has been modified by genetic engineering techniques to an extent that does not occur naturally.

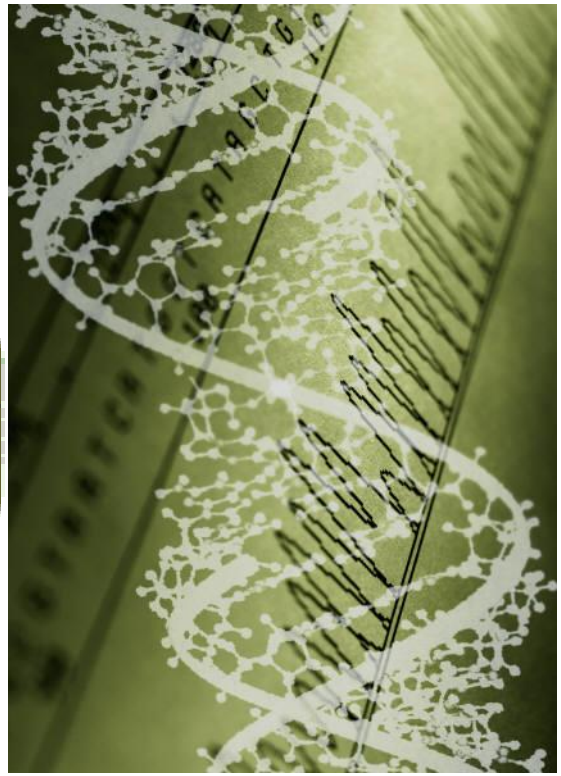
= introduction of a gene from a different organism or its removal from the organisms via recombinant-DNA technology in modern plant breeding and biotechnological food production systems.
The resulting organism is said to be 'Genetically modified (GM)', 'Genetically engineered' or 'Transgenic'.



3. Genetically Modified Foods

Genetically Modified Foods (GMOs)





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Some of the benefits obtained by genetic engineering could be achieved by conventional breeding programs. However, while genetic modification permits the expression of the target gene(s) alone, most of the traditional breeding techniques are aimed to change as many genes as possible in the plant genotype with a broader effect and impact on the process efficiency and food quality changes.

3. Genetically Modified Foods

Genetically Modified Foods (GMOs)

The majority of the currently available GMOs are obtained from plants,
Ongoing experiments will lead to introduce in the market as “future foods” also those derived from GM microorganisms or GM animals.

Salmon DNA altered so fish grow to maturity in half the time - Transgenic Livestock

3. Genetically Modified Foods

Genetically Modified Foods (GMOs): why?

- To produce crops with innovative performances with advantages in the agrifood sector with improved agronomic traits and yield (no direct benefit for consumers):
  - Resistance to plant diseases, environmental stresses (drought, low temperature), increased tolerance of herbicides and insecticide (soybeans, corn, cotton and canola). These modifications have

3. Genetically Modified Foods

Genetically Modified Foods (GMOs): why?

- (In the future) to obtain GMOs
  - specific sensory quality properties, higher nutritional value (e.g. rice with increased iron and vitamins to alleviate chronic malnutrition)
  - better health attributes
  - increased resistance to spoilage (e.g. sweet potato resistant to a virus that could destroy most of the African harvest), to improve efficiency of food production and human health (e.g. bananas that produce human vaccines against diseases (e.g.hepatitis B), fish that mature more quickly, fruit and nut trees that yield years earlier and plants that produce new plastics with peculiar properties.

3. Genetically Modified Foods

Genetically Modified Foods (GMOs): safety

Since the early stage of the development of biotechnology to produce GMOs main safety issues have been perceived by the consumers including:

- impact of the processes applied to the genetic modification
- risks related to the new proteins safety and allegenicity
- impact of the gene transfer to gut microflora
- role of the GM food in the “conventional” food diet
- influence of food processing.

3. Genetically Modified Foods

Genetically Modified Foods (GMOs): safety assessment

- ***Harmonized evaluation strategies have been defined since the early stages of the introduction of modern genetic engineering procedures in food production systems***

- **Developed guidelines** by several organisations (e.g. International Food Biotechnology Council-IFBC, Organisation for Economic Cooperation and Development-OECD, Food and Agriculture Organization of the United Nations-FAO, World Health Organization-WHO, International Life Sciences Institute-ILSI), taken as reference by most of the countries worldwide for the official regulations for GM foods approval and production.

3. Genetically Modified Foods

3.5.3. Genetically Modified Foods (GMOs): safety assessment

The concept of “substantial equivalence”: core concept of the safety evaluation framework for GM foods based on the idea that existing foods can serve as a reference for comparing the properties of a GM food with the appropriate counterpart.

Based on the genetic modification, three main categories of genetically modified plant or food could be identified

(i) GM substantially equivalent;
(ii) substantially equivalent except for the inserted trait;
(iii) not equivalent at all.

3. Genetically Modified Foods

Genetically Modified Foods (GMOs): safety assessment

The safety evaluation includes

- compositional analysis of key components, nutrients and natural toxicants
- evaluation of the phenotypic and agronomic characteristics of the genetically modified plant.

In general, national regulations on GMOs are harmonised on the evaluation procedures of their safety assessment despite some differences exist among countries and geographical areas (eg. Australia, Europe, US, Canada).

3. Genetically Modified Foods

3.5.3. Genetically Modified Foods (GMOs): legislation in EU

Based on "**precautionary principle"** that requires the definition of measures to prevent adverse effects on human health and the environment due to the intentional release of GMOs into the environment or the marketing/import of GMOs or products made from GMOs into the EU.

It is based on the following aspects:
- High standards safety assessment before any GMO is placed on the market
harmonised procedures for risk assessment and efficient, time-limited and transparent authorisation of GMOs.
- Clear labelling of GMOs placed on the market to allow an informed choice of consumers and end-users.
- traceability of GMOs when placed on the market

3. Genetically Modified Foods

Genetically Modified Foods (GMOs): legislation in EU

- **Reference**: Regulation (EC) 1829/2003 on genetically modified food and feed complemented by the Regulation (EC) 1830/2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and the Directive 2009/41/EC on contained use of genetically modified micro-organisms.

In 2015 the EC has issued a new regulation that allows member states freedom to restrict of prohibit use of authorised GMOs.

- Market possible only for authorised GMOs, foods or feeds made from GMOs according to the results of strict evaluation procedures and safety assessment.
- Authorizations granted for a ten-year period by the EC through a centralized procedure chaired by the EFSA that performes the risk assessments.

4. Nanomaterials

Nanoscience and nanotechnology
= study and application of extremely small things (nanomaterials) engineered at an a nano-size (molecular and atomic scales) and exert special properties and can be used for applications in various sciences and manufacturing fields (chemistry, biology, physics, materials science, and engineering).

Applications of nanomaterials in the food sector:
- packaging materials and other materials intended for food contact and used for food containers or tools (e.g. pans).
- Ingredients for foods and feeds (to deliver nutritional and health components)
- Nanoencapsulated ingredients and biocomponents
- Biosensors to detect quality and safety indices during processing and storage.
- Other applications including chemicals, pesticisers and fertilisers.

4. Nanomaterials

Agriculture:

- Nanocapsules for delivery of pesticides, fertilizers and agrochemicals
- Nanomaterials for detection of animal and plant pathogens
- Nanomaterials for identity preservation and tracking and tracing

Food and feed:

- Nanocapsules to improve dispersion, bioavailability of nutrients
- Nanomaterials and nano-encapsulated as colour and flavour enhancers
- Nanotubes and nanoparticles as gelation and viscousifying agents
- Nanoparticles for selective binding and removal of chemicals and pathogens from food

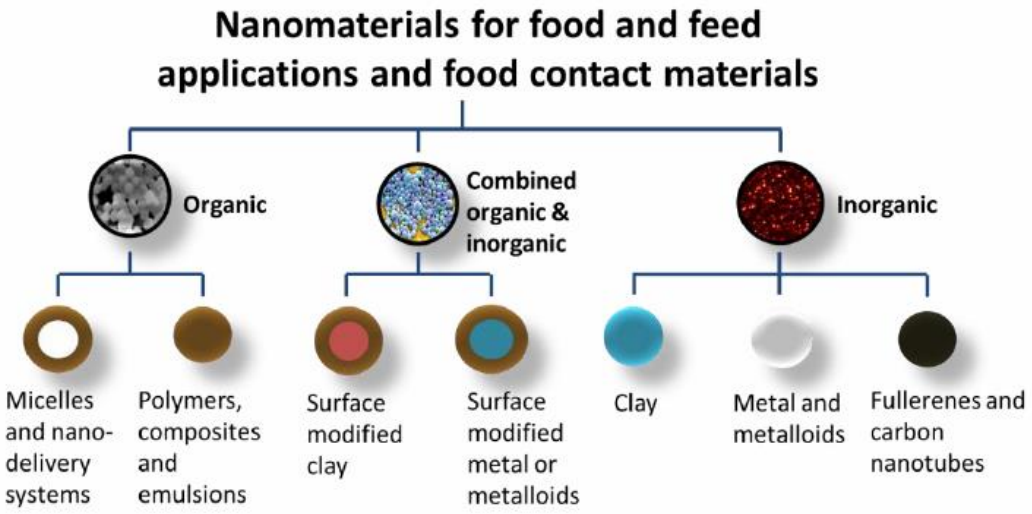
Food packaging:

- Nanoparticles to detect chemicals of foodborne pathogens
- Biodegradable nanosensors for temperature and moisture monitoring
- Nanoclays and nanofilms as barrier materials to prevent spoilage and oxygen absorption
- Nanoparticles for antimicrobial and antifungal surface coatings

4. Nanomaterials

Nanomaterials type (based on nature/origin):

- organic (es. nano-encapsules for vitamines, antioxidants, colourants, aromas, additives; organoclay –nano-layered materials with improved physical and mechanical properties
- inorganic (e.g. in packaging mayterials, Titanium and silicium dioxide)
- organic/inorganic mix (surface modified)



4. Nanomaterials

Nanomaterials: various forms and structures that allow them to achieve specific performances and technological functionalities

- **Main characteristic** (important for practical applications and health and environmental effects):
    - larger surface area (at equal mass and chemical composition than conventional materials), affecting:
        - chemical reactivity (higher)
        - ability to penetrate cells (higher).
- **Lack of instrumental and analytical techniques and tools** to determine presence and concentration of nanomaterials in foods and food packaging:
    - Difficulties to identify and characterise nanomaterials (especially when integrated in products), i.e. to measure particle size and size distribution.
        - Difficult to estimate and predict exposure

4. Nanomaterials

Currently used analytical methods to deteremine engineered nanomaterials (ENM) in food

- Light scattering,
- Microscopy
- Spectrometry
- Chromatography
- Size separation techniques
- Surface characterisation

✓No ”gold standard” method for identification of various ENM:s or NP:s properties
✓Not validated for ENM:s matricies

✓ **Validated** reference materials: SiO_2 (IRMM-304) and Au (NIST CRM 8011, 8012 and 8013)

✓**New reference** NP:s material: Ag in chicken meat, SiO_2 in tomato soup, C_{60} in edible oil, organic NP:s in beverage

4. Nanomaterials

Legislation

Nanomaterials intended for food use need to be regulated to guarantee safety of consumers and/or users.

In Europe: sector- or product- related legislation (cosmetics, novel foods, biocidal products, medical devices, chemicals) including also aspects on nanomaterials, the requirements for labelling and assessment of their safety.

4. Nanomaterials

Legislation: critical points

The novel and/or nanospecific properties and peculiar behaviour of nanomaterials as compared to “ordinary” materials arises some uncertainties.

<u>Specific actions have to be taken to address</u>

- safety of nanomaterials
- development of proper tools for assessment.

Several international regulations require hazard testing of nanomaterials before authorisation to be used in the food sector.

Notes and comments