Improvement of Quality and Nutritional Value of Foods Using Natural Compounds and Mild Biotechnologies

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This PhD thesis project is aimed at developing biotechnological approaches to reformulate food products through new ingredients and recalibrate processes, especially heat treatments, also through emerging mild technologies. This goal is designed to innovate traditional foods into products with enhanced quality and safety features, prolonged shelf life, improved nutritional value, organoleptic characteristics and functional features, while reducing water and energy consumption.

Miglioramento della qualità e del valore nutrizionale degli alimenti mediante l’uso di composti naturali e processi biotecnologici “mild”

Questo progetto di tesi di dottorato è finalizzato allo sviluppo di approcci biotecnologici per riformulare i prodotti alimentari attraverso nuovi ingredienti e ricalibrare i processi, in particolare quelli termici, anche attraverso tecnologie emergenti. Questo obiettivo è pensato nell’ottica di ottenere alimenti con caratteristiche di maggiore qualità e sicurezza, prolungata conservabilità, migliore valore nutrizionale, caratteristiche organolettiche e funzionali rispetto a quelli tradizionali di riferimento, riducendo al contempo il consumo di acqua ed energia associato ai processi produttivi.

# **1. State-of-the-Art**

Food and nutrition security and transitions to sustainable food systems are currently major topics for the agri-food sector. The increase in global population, which is projected to reach over 9 billion by 2050, in combination with climate changes, pose a serious threat to food security as arable land becomes increasingly limited. On the other hand, approximately 1.3 billion tons of food is reported to be yearly lost or wasted globally along the supply chain, i.e. through agricultural practices, postharvest handling and storage, processing, distribution and during food preparation. This results in over one-third of the food produced worldwide, while over 870 million people still suffer hungry (FAO, 2016).

In this context food processing and technology have a key role in transforming raw materials into safe foods with extended shelf life, desired nutritional properties, high quality and improved functional properties. For these goals, food industry continuously faces the need to innovate and advance the technologies currently used. This is to meet the global demands of increasing food security and assuring sustainability, while responding to the consumers changing dietary choices and request for safe, high quality and healthy foods resembling natural and fresh-like products (Tian *et al*., 2016).

The need to guarantee an adequate shelf life to foods often relies on heat treatments, which can partially impair their nutritional value, or debated preservatives which are negatively perceived by consumers. Natural alternatives can be based on ingredients derived from plants, e.g essential oils or plant extracts, through green biotechnologies also through their recovery from agri-food byproducts. It is in fact widely reported that they are characterized by bioactivities, e.g. antioxidant and antimicrobial ones, which make them valuable alternatives to traditional preservatives (Tongnuanchan and Benjakul, 2014). Moreover, bioprotective and tailored starter cultures can be used assure shelf life and safety and, eventually, to enrich foods with relevant functional and nutritional compounds, or reduce the content of antinutritional ones. Also, literature reports good synergistic action with emerging non-thermal technologies, e.g. cold plasma, high pressure, pulsed electric fields, or mild heat processes which can be a sustainable approach to innovate food processing to preserve food safety, functional, nutritional and sensory properties.

This PhD thesis project will be addressed to the development of biotechnological approaches to reformulate food products through new ingredients and recalibrate processes, especially heat treatments. This goal is aimed at innovating traditional foods into products with enhanced quality and safety features, prolonged shelf life, improved nutritional value, organoleptic characteristics and functional features.

# **2. PhD Thesis Objectives and Milestones**

Within the overall objective mentioned above, this PhD thesis project can be subdivided into the following activities according to the Gantt diagram given in Table 1:

A1) **Review of the scientific literature** in the field of food processing waste and by-products as a source of bioactives, and emerging non thermal technologies as alternatives to heat treatments, sanitizers and chemical preservatives in relation to different food products.

A2) **Functional characterization of the by-products:** different by-products (e.g. citrus paste, olive pomace, residues from fish, fruit and vegetable processing) will be selected and tested for some bioactivities, e.g. antioxidant, prebiotic towards some commercial probiotic bacteria, antimicrobial/antifungal against foodborne pathogenic (e.g. *L. monocytogenes, E. coli, S.* Enteritidis, *S. aureus*) and spoilage microorganisms (e.g. *Enterobacteriaceae, Pseudomonas* spp*.,* *Bacillus* spp., yeasts and moulds). The evaluation will be done in model systems (liquid in microtiter plates, solid in Petri dishes) at different pH conditions, water activity, temperature conditions and microbial inoculum level.

A3) **Screening and selection of LAB and yeasts species** Lactic acid bacteria and yeasts newly isolated and from the Microbial Culture Collection of the University of Bologna will be screened for pro-technological and functional properties. Each strain will be inoculated in synthetic media, and the ability to produce e.g. bacteriocin, phenyllactic acid, γ-aminobutyric acid, exopolysaccharides, aroma compounds will be assessed. Growth ability and acidification when using by-products as substrate will be also evaluated.

A4) **By-products valorisation through microbial fermentation**: strains of the most promising yeasts and lactic acid bacteria will be used to ferment the by-products in order to enhance their bioactivities and use them as functional food ingredients.

A5) **Definition of experimental design** toreformulate selected food products and recalibrate the processes by exploiting the most promising biotechnological solutions outlined by the previous activities. Also the interactive effects with non-thermal treatments, e.g. cold plasma, high pressure, will be assessed to obtain foods with enhanced quality and safety features, prolonged shelf life, improved nutritional and functional features.

A5) **Writing and Editing** of the PhD thesis, scientific papers and oral and/or poster communications.

***Table 1***Gantt diagram for this PhD thesis project.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Activity Months | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| A1) | ***Literature review and working plan*** |   |   |   |  |   |   |   |  |   |   |   |  |   |   |  |  |  |  |   |   |  |  |  |  |
| A2)  | ***By-products characterisation*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A3) | ***Screening and selection of LAB and yeasts strains*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |   |   |  |  |  |  |
| A4) | ***By-products valorisation through microbial fermentation*** |   |  |   |   |   |   |  |   |   |   |   |   |  |   |  |  |  |  |   |   |   |   |   |  |
| A4) | ***Food reformulation and process recalibration*** |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
| A5) | ***Thesis and Paper Preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |   |   |   |   |   |   |

# **3. Selected References**

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