Innovative technologies to design novel and functional foods from agro-food wastes

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This PhD thesis research project aims to bioprocess agro-food wastes to obtain health-promoting bioactive compounds and organic acids through fermentation and extraction processes, supported by bioaccessibility assessment and eventually improvement techniques for the design of novel and functional foods.

Tecnologie innovative per la realizzazione di novel foods e alimenti funzionali da scarti di produzione di varie filiere agroalimentari.

Questo progetto di ricerca per la tesi di dottorato mira a biotrasformare gli scarti della filiera agroalimentare per ottenere composti bioattivi che promuovono la salute e acidi organici attraverso processi di fermentazione ed estrazione, supportati da tecniche di valutazione ed eventualmente miglioramento della bioaccessibilità per la progettazione di novel food.

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

The agro-food industry produces a huge volume of different wastes such as coffee, nuts, beer, tomato, marine waste etc. with relevant disposal costs and environmental impact. Therefore, reintroducing wastes back into the food and non-food supply chain based on a sustainable circular economy approach belongs to the challenges of recent years. Some biotechnological and chemical techniques have been proposed as methods for waste recovery.

Among these, fermentation processes have long been recognized for their potential to transform and enhance the quality of certain food matrices through microbial metabolism. Submerged fermentation (SmF) and solid-state fermentation (SSF) are two techniques used for cultivating microorganisms in a liquid media or solid media with little to no presence of water (Subramaniyam & Vimala, 2012). Both SmF and SSF have demonstrated to produce chemical compounds of industrial interest, although the latter has received greater interest due to its better efficiency in terms of cost and production. Several food matrices have been “optimized” by increasing nutritional quality or used as fermentation substrates producing chemical compounds of industrial interest such as ethanol, enzymes, organic acid, secondary metabolites etc. (Martins et al., 2011). However, some microorganisms could produce toxic compounds (e.g. mycotoxins) motivating the need to apply mitigation techniques in order to ensure product safety (Zhang et al., 2021).

Instead, some modern (and green) extraction techniques have made it possible to obtain extracts with higher specificity and yields (Lefebvre et al., 2021). Therefore, the application of some green techniques could improve the fate of fermented products. Furthermore, in vitro digestion models and encapsulation processes enable the estimation and enhancement of the bioaccessibility of some compounds. Consequently, this PhD research project aims to apply the aforementioned techniques in designing functional and novel foods, namely any food (and food ingredient) that was not consumed in significant quantities prior to 15 May 1997, as defined by Regulation (EU) 2015/2283.

# **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 2:

A1) **Literature review** to identify the wastes and microorganisms of potential interest.

A2) **Characterization of agro-food waste** to determine the chemical profile **and screening of microorganisms** able to grow on the matrix.

A3) **Tuning of fermentation and chemical analysis** to assess the production of wanted (and unwanted) molecules.

A3) **Yields optimization** to higher production and recovery of the compounds with a low environmental and economic impact on industrial scale.

A5) **Product development** by selecting the formulation that provides better benefits.

A6) **Writing and Editing** of the PhD thesis, scientific papers and oral and/or poster communications.

***Table 2***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*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Wastes selection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Microorganisms selection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | ***Waste and microorganism analysis*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
|  | 1) Chemical waste characterization |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
|  | 2) Screening of the microorganism |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
| A3) | ***Tuning process*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |   |   |  |  |  |  |
|  | 1) Fermentation trials |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |  |  |  |   |   |  |  |  |  |
|  | 2) Chemical analysis |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |   |  |   |   |   |  |  |  |  |
| A4) | ***Yields optimization*** |   |  |   |   |   |   |  |   |   |   |  |  |  |  |  |  |  |  |   |   |   |   |   |  |
|  | 1) Process optimization |   |  |   |   |   |  |  |   |   |   |   |  |  |   |  |  |  |  |   |   |   |   |  |  |
|  | 2) Chemical extraction |   |  |   |  |  |   |  |   |   |  |  |   |  |   |  |  |  |  |   |   |  |  |   |  |
| A5) | ***Product development*** |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
|  | 1) post-intake behaviour |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
|  | 2) formulation |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
| A6) | ***Thesis and Paper Preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |   |   |   |   |   |   |

# **3. Selected References**

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*Regulation (EU) 2015/2283 of the European Parliament and of the Council on novel foods, amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001 (2013/0435 (COD). OJ L 327, 11.12.2015, p. 1–22.*

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