PhD DISSERTATION PROJECTS

**Sourdough Fermentation As a Tool to Increase the Nutritional properties of Leavened Baked Goods**

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This PhD thesis research project aims to develop a functional sourdough bread with low gluten, improved nutritional, and biochemical properties using a consortium of probiotic strains. The in vitro study of digestion of the low gluten sourdough bread will also be conducted on validated digestion model. This study is expected to shed light on the potential nutritional benefits of sourdough bread made with specific probiotic strains and may have implications for dietary recommendations for gluten sensitive populations.

La fermentazione del lievito madre come strumento per aumentare le proprietá nutrizionali dei prodotti lievitati da forno

Il progetto di ricerca di tesi di dottorato ha lo scopo di sviluppare un pane funzionale a lievitazione naturale con basso contenuto di glutine, migliori proprietà nutrizionali e biochimiche utilizzando un consorzio di ceppi probiotici. Lo studio *in vitro* della digestione del pane a lievitazione naturale a basso contenuto di glutine sarà condotto anche su un modello di digestione validato. Questo studio dovrebbe far luce sui potenziali benefici nutrizionali del pane a lievitazione naturale prodotto con specifici ceppi probiotici e, potrebbe avere implicazioni per le raccomandazioni dietetiche per le popolazioni O sensibili al glutine

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

Cereal fermentation is one of the oldest biotechnological processes, dating back to ancient Egypt, where both beer and bread were produced by the help of yeasts and lactic acid bacteria (LAB). Initially, spontaneous fermentation was used just to activate the naturally occurring microbes in milled grains. In the more recent past, the use of sourdough has already been more systematic, sustainable, and effective tool for ensuring hygiene, rheology, sensory and shelf-life features, and improving the functional/nutritional value of many animal- and plant-based foods and beverages (Gobbetti et al., 2019).

The focus of sourdough research was mostly directed on the technological effects of sourdough on baked goods such as how it affects taste, texture, and shelf life, as well as the microbial interactions involved in the process. However, in recent years scientific research has also moved towards the functional and /nutritional features of sourdough fermentation. Sourdough fermentation boasts a plethora of health benefits. It has been reported to lower the glycemic index, enhance its fiber availability, and release bioactive compounds that are beneficial for human health. Furthermore, released organic acids can aid digestion, reduce inflammation, and improve mineral absorption (Gobbetti et al., 2019). Furthermore, the microbial metabolism of *Lactobacillus* spp. harboring the sourdough produces nutritionally bioactive compounds, such as amino acid derivatives and potentially prebiotic substances. Scientists are keen to explore the potential of developing new products that can assist in managing chronic ailments such as high cholesterol, heart disease, autoimmune disorders, and diabetes (Canesin and Cazarin, 2021).

Sourdough *Lactobacillus spp.* enhance the activity of cereal proteases, allowing gluten to break down more easily. As a result, amino acids accumulate, which can be further broken down by specific intracellular peptidases found in lactobacilli. Proteases in the fermentation process can extensively degrade proteins in sourdough, creating new products that are safe for individuals with gluten intolerance. Thus, proteolysis performed by LAB proteases has been suggested as a new tool for food processing for celiac persons (Siepmann et al., 2018).

# **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) **Optimization of sourdough process**

To optimize the sourdough process, we will employ various propagation techniques at different fermentation times. This will involve conducting microbial and biochemical analyses to effectively achieve our objective.

A2) **Enzymatic treatment of sourdough**

The sourdough will also be treated with commercial protease enzymeto identify its effect on protein, texture, and sensory properties.

A3) **Characterization of the optimized functional sourdough and bread**

Once the sourdough process has been optimized, we will proceed to prepare sourdough bread. Both the sourdough itself and the resulting sourdough bread will undergo characterization to assess their biochemical, and nutritional properties, respectively.

A4) ***In vitro* digestion study**

To investigate the effects of low gluten sourdough bread on the digestive tract (including the oral cavity, stomach, and small intestine), a validated in vitro digestion model will be employed. This model will be utilized to assess the optimal operating conditions for the digestion process. The evaluation will focus on examining the impact of low gluten sourdough bread on the digestive tract, with the aim of identifying potential health benefits specifically for individuals with gluten intolerance or sensitivity.

A5) **Writing and Editing**

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) | ***Optimization of sourdough process*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Preparation and propagation at different fermentation time |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) LAB persistence experiment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | ***Enzymatic treatment*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Microbial characterization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) biochemical characterization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A3) | ***Characterization of the optimized functional sourdough and bread*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Biochemical Characterization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Nutritional Characterization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A4) | ***Invitro digestion*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | ***Thesis and Paper Preparation*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

# **3. Selected References**

Canesin, M.R., and C.B.B.J.C.O.i.F.S. Cazarin. 2021. Nutritional quality and nutrient bioaccessibility in sourdough bread. 40:81-86.

Gobbetti, M., M. De Angelis, R. Di Cagno, M. Calasso, G. Archetti, and C.G.J.I.j.o.f.m. Rizzello. 2019. Novel insights on the functional/nutritional features of the sourdough fermentation. 302:103-113.

Siepmann, F.B., V. Ripari, N. Waszczynskyj, M.R.J.F. Spier, and B. Technology. 2018. Overview of sourdough technology: From production to marketing. 11:242-270.