Pigmented wheat as a valuable raw material to produce cereal-based foods with high nutritional value and rich in bioactive compounds

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This PhD thesis project aims to enhance the bioactive potential of pigmented durum and soft wheat varieties through anthocyanin-rich flours production. Appropriate recombination of pigmented wheat milling fractions will allow the production of flours enriched in bioactive compounds useful to obtain innovative functional foods, such as fresh or dry pasta and bakery products that meet the nutritional, sensory, and health needs of consumers.

**Il frumento pigmentato quale preziosa materia prima per la produzione di alimenti a base di cereali ad alto valore nutrizionale e ricchi di composti bioattivi**

Questo progetto di tesi di dottorato mira a valorizzare il potenziale bioattivo di varietà di frumento duro e tenero pigmentato attraverso la produzione di sfarinati ricchi in antociani. Mediante opportune ricombinazioni di frazioni di macinazione si produrranno sfarinati ricchi di composti bioattivi utili all’ottenimento di alimenti funzionali innovativi, come pasta fresca o secca e prodotti da forno, in grado di soddisfare il consumatore sotto il profilo nutrizionale, sensoriale ed eventualmente salutistico.

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

Anthocyanins are a class of polyphenols responsible for the red, purple, orange, and blue colors of many fruits, vegetables, flowers, and other plants. Scientific research is evaluating the use of anthocyanins in producing foods that may positively affect health (Gupta et al., 2021). Anthocyanins are also found in a few pigmented wheat varieties as polyhydroxylated and methoxylated heterosides derived from the flavylium ion or 2-phenilbenzopyrilium(Figure 1).

***Figure 1*** *Flavylium cation with two aromatic rings (****A*** *and* ***B****) and an oxygenated heterocycle (****C****)*

In pigmented wheat, anthocyanins are localized in the outer layer of the caryopsis, where they preserve the integrity of the plant cells. Scientific literature reports that this class of compounds is not only responsible for the pigmentation of plants but can also exert various protective effects. These properties include antioxidant and anti-inflammatory activities, prevention of heart disease, anti-ageing effects, and improving gut health (Zhu, 2018). Based on the notion that cereal-based products can be suitable systems for delivering bioactive compounds (Ficco et al., 2014), the combination of bioactive molecules, such as anthocyanins, with one of the world's most consumed cereals, such as wheat, makes the latter an ideal raw material from which to derive various functional foods. To date, there is limited evidence on the formulation of anthocyanin-enriched products from pigmented wheat, such as cookies (Pasqualone et al., 2015), bread (Bartl et al., 2015), and dry or fresh pasta (Ficco et al., 2016), and furthermore, these studies still reveal some limitations and highlight the sensitivity of anthocyanins to different process parameters like temperature, light, humidity, and pH. Starting from these issues, this project aims to overcome the limitations by characterizing all fractions obtained by milling pigmented wheat varieties through their chemical and technological properties and anthocyanins content. In this way, it will be possible to identify the most suitable recombination to obtain an enriched flour useful to produce innovative grain-based functional foods with significant nutritional, technological, and health potential through bioactive compounds.

# **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) **Bibliographic research:** analysis of scientific literature and publications (1-36 months).

A2) **Screening and** **characterization of pigmented grains:** Screening of durum and soft wheat varieties with high anthocyanin content (A2.1) (4-8 months) on which analysis to determine the proximate composition, anthocyanin content, and other parameters used for their exhaustive characterization will be conducted (A2.2) (6-12 months).

A3) **Grain milling and chemical characterization of milling fractions:** pigmented wheat fractions will be produced using pilot milling plants (A3.1) (12-16 months), and will be evaluated for nutritional composition, along with anthocyanin content (A3.2), to obtain the necessary information for recombination (12-16 months).

A4) **Anthocyanin profile evaluation of milling fractions by chromatographic and spectrophotometric methods:** the individual fractions anthocyanin profile will be evaluated by means of different analytical procedures (A4.1) (12-18 months).

A5) **Milling fractions recombination and flours rheological assessment:** proper recombination of milling fractions to obtain anthocyanin-enriched flours on which the main compositional and rheological parameters (Chopin's alveograph, Brabender's farinograph and micro-viscoamilograph, and Falling number) (A5.1) will be evaluated to identify their potential technological implications (18-20 months).

A6) C**ereal-based anthocyanin-rich foods production**: use of enriched flour to produce innovative functional foods with balanced rheological and health outcomes related to anthocyanins. The innovative products will be characterized by considering nutritional, sensory, and health features (22-36 months).

A7) **Writing and Editing** of the PhD thesis, scientific papers, and oral and/or poster communications (1-36 months).

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  Months Activity | **12** | **14** | **16** | **18** | **20** | **22** | **24** | **26** | **28** | **30** | **32** | **34** | **36** |
| **A1)** | ***Bibliographic research*** |  |  |   |   |  |  |  |  |   |  |  |  |   |
| **A2)** | ***Screening and characterization of pigmented grains***  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Screening and sampling |  |  |  |   |  |  |  |  |  |  |  |  |  |
|  | 2) Chemical and technological evaluation |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A3)** | ***Grain milling and chemical characterization of milling fractions*** |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Milling with plant pilot |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Fraction’s chemical analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A4)** | ***Anthocyanin profile evaluation of milling fractions*** |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Chromatographic and spectrophotometric method identification |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A5)** | ***Milling fractions recombination and flours rheological assessment*** |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Rheological assessment of flour |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A6)** | ***Cereal-based anthocyanin-rich foods production*** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **A7)** | ***Thesis and Paper Preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |

**3. Selected References**

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