Sustainable recovery of high value-added compounds from secondary raw materials of the milling industry

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The aim of this industrial PhD project is to valorise milling by-products from a nutritional and technological point of view. In particular, new products will be produced with technologically advanced methods starting from milling secondary raw materials in the innovative plant of Casillo Next Gen Food Srl, Corato (BA). These products will be nutritionally characterised, analysed for their rheological and technological properties and evaluated as possible ingredients for functional foods.

Recupero sostenibile di composti ad alto valore aggiunto da materie prime secondarie dell’industria molitoria

L’obiettivo di questo dottorato di ricerca industriale è capire come i sottoprodotti dell’industria molitoria possano essere valorizzati dal punto di vista nutrizionale e tecnologico. Nello specifico, nell’impianto innovativo di Casillo Next Gen Food Srl, Corato (BA), dagli scarti della molitura verranno realizzati nuovi prodotti con procedure tecnologicamente avanzate. Questi prodotti saranno caratterizzati dal punto di vista nutrizionale e tecnologico e valutati come possibili ingredienti per la formulazione di alimenti funzionali.

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

Wheat grains are morphologically divided in three parts: endosperm, germ and bran. The endosperm accounts for 80-85 % of the kernel and is mainly constituted by starch. The germ makes up 2-3% of the kernel and is rich in lipids and vitamins. The wheat bran, made by the outer layers of the grains, provides protection to the whole kernel and is characterized by a high content of fibre and proteins. The milling operations aim is to remove the external layers of the grains and to collect the endosperm, to produce flour and semolina. Wheat germ, although particularly rich in micronutrients such as vitamins E and B, is generally excluded from the final products because oxidation of the lipids could affect the shelf life of the flour. Technological aspects, like the rheological behaviour of pasta and bakery products are also affected by the addition of dietary fibre above a certain amount, because of the interfering effect of non-gluten proteins that modify the consistency of dough gluten matrix (Hemdane et. al, 2016; Aravind et. al, 2012). However, considering that 20-25 % of the wheat kernel is constituted by bran and germ, a considerable amount of by-product is produced yearly by the milling industry and mostly used as feed in the livestock sector. After overcoming some technological problems, wheat by-products could gain a higher profile, especially given the benefits they can bring to human nutrition and in relation to the "zero waste" concept of agri-food promoted by the Farm to-Fork strategy of the European Green Deal (EU, 2020). The high fibre content of wheat bran helps to control postprandial glycaemic index, obesity and the incidence of type 2 diabetes (Prückler et. al, 2014), and also has prebiotic effects and promotes enteric equilibrium (Aravind et. al, 2012). However, not only fibre brings benefits for human health, but the whole set of bioactive/antioxidant compounds it contains (cellulose, lignin, arabinoxylans, polyphenols, etc.). The subsequent actions of separation and extraction of fibre and wheat germ components could allow to produce ingredients that mixed with flour or semolina could lead to obtain functional and non-functional foods. Reducing the particle size by micronization makes these products more suitable for transformation and incorporation into food. Moreover, the air classification process is able to change the distribution of nutrients by concentrating certain molecules in the fine and coarse fractions. In addition, purification of proteins and arabinoxylans (from bran and germ) through chemical or enzymatic methods can yield valuable isolates for further food applications. The aim of this PhD project is to follow the entire milling process in order to extract and to recover secondary raw materials, verify their properties (chemical, nutritional, functional, rheological) and apply physical enrichment/separation techniques to obtain innovative ingredients for the production of sustainable, healthy food.

# **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** for the continuous updating of knowledge on the specific topic.

A2) **Determination of chemical composition of secondary raw materials** from milling industry. The analysis is meant to verify the health-promoting properties of the starting material before technological transformation.

A3) **Micronization and air-classification of secondary raw materials.** (A3.1) Operative setting of lab-scale micronization and turboseparation trials to produce fine and coarse fractions. (A3.2) Scale up of micronization and air-classification at industrial scale.

A4) **Characterization of the fractions obtained from air-classification.** (A4.1) Particle size analysis through laser diffractometry techniques. (A4.2) Evaluation of the presence of specific micronutrients (markers) attributable to the presence of bran or germ.

A5) **Rheological and technological evaluation of flours** from turboseparation system, also in mixtures with normal flour/semolina. (A5.1) Rheological properties analysis. (A5.2) Production on pilot plants, and then scale up to an industrial plant, of innovative food products (bread, pasta, etc.) and evaluation for their sensory, nutritional and technological attributes.

A6) **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  | **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** | **22** | **24** | **26** | **28** | **30** | **32** | **34** | **36** |
| A1) | ***Bibliographic research*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | ***Determination of chemical composition of secondary raw materials*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |
| A3) | ***Micronization and air-classification of secondary raw materials*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |
|  | 1) Lab scale |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Industrial scale |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |   |  |   |
| A4) | ***Characterization of the fractions obtained from air-classification*** |   |  |   |   |   |   |  |   |   |   |   |   |  |   |  |  |  |  |
|  | 1) Laser diffraction analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Markers analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | ***Rheological and technological evaluation of flours*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Rheological analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Formulation, production and evaluation of innovative products |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A6) | ***Thesis and Paper Preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |

# **3. Selected References**

Aravind N, Sissons M, Egan N, Fellows C (2012) Effect of insoluble dietary fibre addition on technological, sensory, and structural properties of durum wheat spaghetti. *Food Chem* **130**:299–309

European Commission. Farm to Fork Strategy—For a Fair, Healthy and Environmentally-Friendly Food System. (2020) Available online: https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy\_en

Hemdane S, Jacobs PJ, Dornez E, Verspreet J, Delcour JA, Courtin CM (2016) Wheat (Triticum aestivum L.) Bran in Bread Making: A Critical Review. *Compr Rev Food Sci Food Saf* **15**:28-42

Prückler M, Siebenhandl-Ehn S, Apprich S, Höltinger S, Haas C, Schmid E, Kneifel W (2014) Wheat bran-based biorefinery 1: Composition of wheat bran and strategies of functionalization. LWT - *Food Sci Technol* **56**: 211-221