**Sensory and technological improvement of hemp seed flour. Strategies for food applications.**

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The first two activities of the PhD project are described: 1) characterization of two by-products of the hemp oil production process, namely hemp seed cake flour (HSCF) and hemp seed protein concentrate (HSPC); 2) use of the two by-products as fortifying ingredients in gluten-free baked goods.

**Miglioramento delle proprietà sensoriali e tecnologiche della farina di canapa. Strategie per il settore alimentare.**

Sono descritte le prime due attività del progetto di tesi di dottorato: 1) caratterizzazione della farina ottenuta dal pannello di canapa (HSCF) e del concentrato proteico di semi di canapa (HSPC), due sottoprodotti del processo di estrazione meccanica a freddo dell’olio di canapa; 2) utilizzo dei suddetti sottoprodotti come ingredienti alimentari per fortificare prodotti da forno senza glutine.

**Keywords**: hemp seed cake flour; hemp seed protein concentrate; hemp seed oil by-products; flour techno-functionality; volatile profile; gluten-free bakery products.

# **1. Introduction**

In accordance with the PhD thesis project, this poster reports the main results of the first two activities concerning:

(A1) the assessment of the nutritional and techno-functional properties, and of the volatile profile of two by-products of the hemp oil production process, namely hemp seed cake flour (HSCF) and hemp seed protein concentrate (HSPC); (A2) the development of gluten-free muffins fortified with different percentage (15%, 20%, 30%) of HSCF or HSPC and the evaluation of their nutritional, technological and functional quality.

# **2. Materials and Methods**

**2.1 Characterization of HSCF and HSPC**

The HSCF and HSPC were analyzed for their proximate composition. Moisture, ash, protein (N × 5.7), and fiber content were determined according to the official methods (Horwitz and Latimer, 2005). The total fat content was determined on hexane Soxhlet extracts. Carbohydrate content was calculated by difference. Folin-Ciocalteu assay was used for the total phenolic content (TPC) determination. Bulk density (BD), water holding capacity (WHC), oil absorption capacity (OAC), and swelling index (SW) of both HSCF and HSPC were assessed according to Okaka & Potter (1977). The volatile profile of the two by-products has been investigated by HS-SPME-GC-MS; for the HS-SPME extraction, 5 g of each sample was suspended in 15 mL of saturated sodium chloride solution in a 40 mL vial. Extraction was performed at 35 °C exposing a DVB/CAR/PDMS fiber, 50/30 μm film thickness (Supelco, Bellefonte, PA, USA), to the headspace of the sample for 30 min. The sample was maintained under continuous magnetic stirring and, before extraction, thermally balanced for 30 min. The extracted analytes were directly desorbed into the injector port of the GC/MS held at 260 °C. The GC-Ms analyses were performed as previously reported by Condurso et al. (2020).

**2.2. Development of fortified Gluten-free muffins and** **assessment of their nutritional, technological and sensory quality.**

Gluten-free muffins were prepared according to the method described by Shevkani *et al*. (2015) using rice flour, sunflowers oil, sugar, egg, milk, and baking powder. HSCF or HSPC were used as partial substitutes for rice flour in three different percentages, i.e. 15%, 20%, and 30%. Three muffin samples fortified with HSCF, three fortified with HSPC, and one control sample (CM) were produced on a laboratory scale and their technological quality has been assessed through texture profile analysis (TPA) (Martínez-Cervera *et al*., 2015), measurement of color based on the CIELab color system, and determination of cooking properties (moisture, volume, height, diameter, backing loss). CATA, hedonic, and acceptability tests, performed by a panel of 80 untrained judges, were used for the sensory quality evaluation.

# **3. Results and Discussion**

**3.1 Characterization of HSCF and HSPC**

The HSCF showed a statistically higher content of fat and fiber and a lower content of protein, carbs, and TPC (Table 1), than HSPC. HSCF had a higher OAC due to its higher amount of insoluble fiber, and lower WHC and SW values as a consequence of its lower protein and carb contents. The higher OAC of HSCF makes it more suitable than HSPC to be used in bakery products where oil is an important ingredient, whereas its lower value of WHC will result in a lower level of available moisture in the baked goods where the flour is used affecting their textural properties and accelerating the process of crumb firming.

***Table 1*** *Gross composition, total phenolic content (TPC) and techno-functional properties of hemp seed by-products.*

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | **Moisture†** | **Fat†** | **Protein†** | **Carbs†** | **Ash†** | **Fiber†** | **TPC§** | **BD**$ | **WHC†** | **OAC†** | **SW#** |
| HSCF | 10.14±1.1 | 9.6±1.0 | 26.1±2.1 | 5.1±0.3 | 0.05±0.0 | 46.3±4.1 | 7.21±0.8 | 0.60±0.00 | 204±2.8 | 56.0±0.0 | 1.39±0.02 |
| HSPC | 9.91±0.9 | 7.4±0.8 | 40.3±3.5 | 10.7±0.9 | 0.05±0.0 | 24.2±2.2 | 13.11±1.2 | 0.59±0.05 | 233±17.6 | 48.5±0.1 | 1.63±0.29 |
|  | ns | \* | \*\* | \*\* | ns | \*\* | \* | ns | \* | \* | \* |

 **†***= (g/100g) and;* **§***= mg gallic acid /100g; $=g/mL;* **#***=adimensional; ns=not statistically significant; \*= P<0,05; \*\*= P<0,01*

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| **Figure 1** *Volatile composition as class of substances (%) hemp seed by-products.* |

 The volatile profile of HSCF and HSPC was constituted mainly by alcohols, aldehydes, furanic compounds, and terpenoids (Figure 1); among volatiles compounds, 3-methyl-1-butanol (14.36 %), 1-hexanol (12.19%), hexanal (10.63%), 3-methyl-butanal (8.73%), and 2-pentyl-furan (8.33%) prevailed in HSCF, whereas 3-methyl-1-butanol (10.68%), hexanal (10.57%), 1-hexanol (8.17%), acetic acid (7.38%), and (Z)-2-heptenal (5.6%) were the main constituents of the HSPC volatile fraction. Most of the identified volatile compounds are plant secondary metabolites resulting from the different biosynthetic pathways occurring in plant tissue. Others, such as 2-alkylfurans, originate from oxidation of unsaturated fatty acid denoting unsuitable packaging and storage conditions of the flour.

**3.2. Development of fortified Gluten-free muffins and assessment of their nutritional, technological and sensory quality.**

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| **Figure 2** *TPA results of control and fortified gluten-free muffins.* |

 The moisture of the gluten-free muffins was higher than the control samples, especially for muffin samples fortified with HSPC as expected due to the higher WHC of HSPC than HSCF. The incorporation of HSCF and HSPC did not affect the baking loss, but improved the physical parameters (muffin volume, specific volume and height) of muffins except for sample with 30% of HSPC. Regarding crust color, fortified muffins showed lower values for L\* a\* b\* than the control sample: the higher was the percentage of fortifying flours, the greater the decrease of crust color parameters. Also crumb L\* and b\* values decreased with the increasing percentage of the HSCF or HSPC, whereas the a\* values increased, denoting a tendency to crumb browning. The hardness of HSCF muffins was always higher than the control, whereas in the case of HSPC muffins, the hardness increased at a 30% addition level; a similar trend was observed for the muffin gumminess and chewiness for both by-products (Figure 2).

The consumer’s acceptability of fortified samples was similar to the control samples, except for muffins fortified with 30% HSPC which was the least appreciated by the consumers. The results suggest that both HSCF and HSPC are suitable as fortifying ingredients for gluten-free muffins.

# **4. References**

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