Development of High Nutritional Quality Food Ingredients from Avocado Production Wastes and By-products

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Considering the significant increase in tropical fruit production in Sicily, this PhD thesis project aims to develop high nutritional quality food ingredients from the wastes and by-products of avocado production. Defatted pulps, peels, leaves, and seeds will be used to produce flours, through different drying technologies, and their chemical, nutritional, and sensory quality and consumer acceptability will be evaluated. The flour obtained will be proposed as a food ingredient in meat and baked products.

Sviluppo di ingredienti alimentari di elevata qualità nutrizionale da scarti della produzione di avocado

Considerato il significativo aumento della produzione di frutta tropicale in Sicilia, questo progetto di tesi di dottorato mira a sviluppare ingredienti alimentari di elevata qualità nutrizionale da scarti e sottoprodotti della filiera di produzione dell’avocado. A tal fine le polpe disoleate, le bucce, le foglie e i semi di avocado verranno utilizzati per la produzione di farine attraverso differenti tecnologie di essiccamento e ne verranno valutate le caratteristiche chimiche, nutrizionali, sensoriali e l’accettabilità del consumatore. Le farine saranno, quindi, proposte per il loro utilizzo quali ingredienti in prodotti carnei e da forno.

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

Avocado (*Persea americana* Mill.) is a tropical fruit native to Mexico and Central America, but nowadays widely produced and consumed worldwide. The market for processed avocados is projected to reach US $ 2.70 billion by 2024 with an increase of about 25% in the last five years (Nyakang’i *et al.,* 2023). The increased request for avocado, as raw and processed, leads to large amounts of by-products like seeds, peels, and defatted pulps which account for approximately 30% of fruit weight, which must be disposed of. At the same time, avocado by-products are rich sources of carbohydrates (seed 27.5-82%, peel 43-81%), lipids (seed 0.5-15%; peel 2-11.4%), proteins (seed 0.14-9%; peel 0.17-8%), vitamins such as ascorbic acid, vitamin E, polyphenols, and carotenoids whose amount greatly varies according to the variety and production area. Moreover, since avocado trees are subjected to frequent pruning practices a big amount of biomass (branches and leaves) results (one-five tons per cultivated hectare) (Tesfaye *et al.,* 2022). Otherwise, it is well known that the avocado leaves are rich in bioactive compounds, especially polyphenols, and in fact, the indigenous populations of central America used them to prepare teas or infusions against different diseases, such as neurodegenerative and cardiovascular diseases, cancer, etc. (Jimenez *et al.,* 2021).

***Table 1***Amount\* of bioactive compounds in avocado fruits and leaves.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class of substances** | **Pulps** | **Seeds** | **Peels** | **Leaves** |
| Total phenolic content (mg GAE/100g DW) | 60-535 | 7.73-38.98 | 246-535 | 1.70 – 2.40 |
| Total flavonoid content (mg QE/100g DW) | 49.5-396 | 47.9 | 44.3-243 | 552 |
| Total carotenoids content (mg/100g DW) | 0.3-1.2 | 0.07-0.9 | 0.89-2.6 | 0.3 |
| Antioxidant activity (DPPH μM TE/g DW) | 0.8-8.3 | 128-240 | 39-189 | 57.8-110 |

\* (Jimenez *et al.,* 2021); GAE: gallic acid equivalent; QE: quercetin equivalent; DW: dry weight.

Due to the climatic changes, avocado production is largely increasing in the Mediterranean area with the Hass variety the most appreciated and cultivated in Sicily for its intense taste and creamy pulp (Nyakang’i *et al.,* 2023); even if other varieties are cultivated, too such as Bacon, Fuerte, and Reed; the varieties distinguish each other not only for the sensory features but also for the amount of bioactive compounds. As regards the avocado varieties cultivated in Sicily, to the best of our knowledge, no information is reported in the literature on the fruit composition. Here, as happens in the countries of origin, the large quantity of waste and by-products represents one of the main problems of avocado production (Salazar-Lopez *et al.,* 2020; Araújo *et al.,* 2018). Considering the composition and the amount of bioactive compounds in leaves, peels, and seeds (Jimenez *et al.,* 2021), they are a promising material to produce innovative ingredients for functional foods; in the context of a circular economy, converting them into value-added goods could be a solution to improve the economic and environmental sustainability of the avocado production.

# **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) **Characterization of avocado by-products and wastes** through proximate composition, including total dietary fiber (A1.1) and bioactive compounds (A1.2).

A2) **Production of flours.** Defatted pulps, seeds, peels, and leaves will be dried through different drying green technologies and milled to obtain flours.

A3) **Chemical, technological, and sensory characterization of the flours** through physical and chemical analyses (A3.1), technological (water absorption solubility, hydrophobicity, emulsifying and foam, water and oil absorption capacity, viscosity, and gelatinization) (A3.2) and sensory analysis (color and texture profile), and consumer acceptability (hedonic test, CATA test, survival analysis, preference maps) (A3.3).

A4) **Nutritional evaluation and probiotic activity of the flours** through protein digestibility, glycemic index, and microbial survival studies.

A5) **Application of the flours** in baked goods and/or meat products.

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) | ***Characterization of avocado by-products and waste*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
|  | 1)Proximate composition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2)Bioactive compounds |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | ***Production of flours*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |   |   |  |  |  |  |
| A3) | ***Chemical, technological, and sensory characterization of the flours*** |   |  |   |   |   |   |  |   |   |   |   |   |  |   |  |  |  |  |   |   |   |   |   |  |
|  | 1)Physical and chemical analyses |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2)Technological analyses |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 3)Sensory analysis |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A4) | ***Nutritional evaluation and probiotic activity of the flours*** |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
| A5) | ***Application of flours*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A6) | ***Thesis and Paper Preparation*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

# **3. Selected References**

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