**Study of Innovative and Sustainable Approaches for the Mitigation of Contamination with Mineral Oils in Vegetable Oils and Fats**

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As the standard of living improves, concerns over food safety and potential contaminants will continue to be an important health issue. The aim of this PhD research project is to study the sustainable approaches for the mitigation of contamination with mineral oils in vegetable oils and fats. These compounds are associated with risks to human health especially as carcinogenic factors. To this purpose, methods capable of detecting carcinogenic hydrocarbons in selected mineral oils will be studied and optimised, then applied to assess the decontamination properties of conventional and innovative adsorbents.

**Studio di approcci innovativi e sostenibili per la mitigazione della contaminazione da oli minerali in oli e grassi vegetali**

Con il miglioramento del tenore di vita, le preoccupazioni per la sicurezza alimentare e i potenziali contaminanti continueranno a essere un importante problema sanitario. L'obiettivo di questo progetto di ricerca di dottorato è di studiare approcci sostenibili per la mitigazione della contaminazione da oli minerali negli oli e nei grassi vegetali. Questi composti sono associati a rischi per la salute umana in quanto cancerogeni. A tal fine, verranno studiati e ottimizzati metodi in grado di rilevare gli idrocarburi minerali cancerogeni selezionati, per poi essere applicati per valutare le proprietà decontaminanti di adsorbenti convenzionali e innovativi.

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

Nowadays, food safety is a concern matter, especially when regarding the possible presence of genotoxic and carcinogenic compounds in food. Mineral oils mainly consist of saturated hydrocarbons (MOSH) able to bio-accumulate in human tissue and organs, and aromatic hydrocarbons (MOAH). MOAH contamination has become of public interest due to its harmful effects on human health. Polycyclic aromatic compounds with >3 rings non alkylated or of low alkylation degree are of high concern due to their recognized genotoxic and carcinogenic properties (EFSA, 2012; Jaén et al., 2022). Mineral oil hydrocarbon (MOH) contamination in foods such as vegetables oils and fats may occur at any stage of material production (Purcaro et al., 2016).

Partial MOH mitigation can be achieved by increasing the temperature during the deodorization step, but this can lead to the other side to the formation of other contaminants. It is well known that some absorbents such as activated carbons (ACs) used during the bleaching step of edible oils may play an important role in retaining parent polycyclic aromatic hydrocarbons (PAHs) (Torres et al., 2021), but their effectiveness against the most relevant genotoxic and carcinogenic fraction of MOH has not been evaluated to date. AC is a popular choice among all owing to its good adsorption capacity, active free valences, high surface area, porous structure, surface reactivity, inertness, and thermal stability (Soni et al., 2020). Furthermore, mesoporous silica nanoparticles (SiO2 NPs) can be used also as adsorbent. SiO2 NPs are the most used nowadays as adsorbent material for their attractive properties like stability, low toxicity, and the ability to be functionalized with various molecules and polymers. It also has various applications as an additive for rubber and plastic production (Ali 2016; Sadegh et al., 2017). Biological decontamination by microorganism has been widely described in aqueous environment (Kajla et al., 2021), but scarcely studied and applied on vegetable oils.

Several protocols for isolating the targeted MOAH (>3 rings and low degree of alkylation) from the oil matrix prior to analytical determination will be carried out. A set of protocols using online HPLC-GC-FID, GC-MS, GC×GC-FID/MS will be optimized and applied for determining selected polycyclic aromatic compounds (alkylated and not alkylated) chosen as model molecules, and for group-type separation of the MOAH. The developed protocols will be then applied to test decontamination properties of conventional adsorbent (bleaching earths and ACs) used for oil bleaching. New adsorbent materials such as SiO2 NPs will be also studied, characterized, and optimized, which can be in terms of enhancing the shape, size, pores, and crystallinity properties to facilitate the decontamination efficacy against the targeted compounds. The surface area and the porosity of the synthesized NPs could be determined by nitrogen (N2) gas adsorption-desorption analysis, while NPs properties by X-ray diffraction (XRD) for crystallinity, morphological studies, and size by field emission scanning electron microscopy (FESEM). Finally, biological decontamination using bio-surfactants able to solubilize these hydrophobic contaminants in an aqueous environment, favouring decontamination processes by microorganisms, could be tested. The most promising decontamination process will be scaled-up at Unigrà srl company.

**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) **Developing new protocols** for isolating and detecting genotoxic carcinogenic PAHs and MOAH (>3 rings and little alkylation) from edible oils.

A2) **Studying physicochemical properties and evaluating the behaviour** of adsorbent materials such as ACs, and SiO2 NPs for removing contaminations.

A3) **Spending six months undertaking research abroad** in collaboration with other research teams. The main goal could be: 1) improve the analytical methodology, and/or 2) deepen the study on adsorbent properties, and/or 3) evaluate biological decontamination by microorganisms.

A4) **Spending six months at Unigrà srl** to scale-up the most promising decontamination method.

A5) **Data processing.**

A6) **Writing and Editing of the PhD thesis**, scientific papers and oral and/or poster communication.

***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** |
| *Literature review* |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A1) | ***Developing new protocols for detection*** |   |   |   |  |   |   |   |  |   |   |   |  |   |   |   |  |   |   |
|  | 1) Protocol comparison |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |
|  | 2) Protocol optimization |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |
| A2) | ***Adsorbent characterization, optimization, and testing*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |
|  | 1) Adsorbent properties |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |  |  |  |
|  | 2) Adsorbent optimization and testing |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |   |  |   |
| A3) | ***Undertaking research abroad*** |   |  |   |   |   |   |  |   |   |   |   |   |  |   |  |  |  |  |
| A4) | ***Process scale-up at Unigrà srl*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | ***Data processing*** |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |
| A6) | ***Thesis and paper preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |

**3. Selected References**

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