PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVIII cycle, 2022-25)

Project draft

1.Field of interest

AGR13: biomass recovery, circular economy, bioeconomy

2.Project title

Characterization and valorization of vegetable oil waste

3.Tutor Fabrizio Adani – Gruppo Ricicla-DiSAA- University of Milano

- Eventually: co-tutor: Irene Rapone (ENI)

4.Relevance of the topic and state of the art:

According to the Renewable Energy Directive II (REDII), the use of palm oil will be gradually reduced from 2023 and should reach zero in 2030 from the production of biofuel/bioenergy. It will be thus necessary to find alternative feedstocks to produce biofuel. It becomes necessary an evaluation of different oleaginous seeds use to produce vegetable oils with low impact on food-and-feed chain and necessity of low input: interest in drought-resistant oil crops that can be cultivated on marginal lands and don't compete with food crops. The oil recovery is possible by mechanical pressing of seeds. The solid residue (panel), an extraction co-product, can be used for different purposes: as animal feed or fertilizer, or can be converted into biogas via anaerobic digestion or into biochar, which can improve the soil characteristics and is helpful to make the biofuels value chain carbon neutral. The identification of possible and valid ways for the solid residue valorization becomes fundamental both for the circular economy aspects and for the economy of the biofuel production process.

5.Layout of the project (draft)

5.1. Materials & Methods:

The panels will be analysed for what that concern:

Nutritional aspect in order to recovery them as feed.

2. biogas and/or biochar production exploring energy production

3. fertilizers properties exploring organic matter and nutrient recovery

Economical and environmental aspects will be considered as well to better evaluated panels recovery in a useful way.

In brief.

Proximate analysis of seeds and defatted panels: the moisture, ash , fat and protein contents will be determined using AACC method 44-19, 08-01, 30-20 and 46-12, respectively (AACC, **2000**). The neutral detergent fiber (NDF), cellulose, and lignin contents in the panel dry matter will be estimated using the fiber detergent method, determined according to protocols developed by Ankom Technology, based on Goering and Van Soest method. Mineral composition will determine using ICP-Mass Spectroscopy. Total phenolic (TP) and flavonoid content will be assayed and their antioxidant properties will be characterized. The quali-quantitative characterization of TP will perform on the extracts, achieved by adding to the dry sample a hydro-alcoholic mix. The quantity of TP content will determine by Folin-Ciocalteu method. The antiradical activity of the extract will assess with the DPPH radical scavenging Phenolic composition. The free and bound TP extracts are used for phenolic profiling with the HPLC system. Anti-nutritional factors will be analysed by using various methods, it depends on type of vegetable panel, according to Samtiya et al. (2020).

Potential biogas production will performed by batch approaches using standardized method. Biogas production kinetic will be performed as well. Result will be referred to both dry matter and wet weight. Biogas composition will be detected by GC.

Biochar will be produced by pilot scale furnace adopting process parameters allowing producing biochar having correct characteristics to be used as amendment and C sequestration agent.

Fertilizer properties of panels will be performed by analysing and characterization of organic matter and nutrient content. Nutrient speciation will be considered to better evaluate fertilizer properties.

5.2. Schedule and major steps (3 years):

1 year: the activity is focused on the solid residue characterization and valorization (animal feed or fertilizer or can be converted into biogas via anaerobic digestion or into biochar). The panels will be supplied by Eni and, initially, characterized in UNIMI laboratories. In this way, the student will become familiar with the analytic procedures. A second activity will be the identification of the most promising oil crops suitable to produce biofuels through bibliography research.

2 year: the PhD will involve a period of 6-18 months in the company and must be synergistic with respect to project activities coordinated by Eni. During these months of working alongside Eni employees, the achievement of a high degree of working autonomy and a continuous and fruitful exchange of skills will be required, to allow for an increase in knowledge on the agronomic issues of greatest interest to Eni. The activities will be carried out in Eni Renewable, New Energies and Material Science Research Center (Novara). The student will be involved in lab scale mechanical pressing test, solvent extraction tests and chemical-physical characterization of products (oil and panel). The panel characterization results will be helpful to identify the best valorization way for this product.

3 year: the PhD will be focused on economic aspects of different panel valorization ways (market, availability, costs), European and Italian regulations for the different uses (animal feed, fertilizers or for the production of biogas and biochar) and Life Cycle Assessment (LCA).

6. Available funds: Fabrizio Adani-UNIMI and RSE funds (> 100.000 €);

6. Literature:

Abbasi-Parizad P. et al. (2021) Recovery of phenolic compounds from agro-industrial by-products: Evaluating antiradical activities and immunomodulatory properties. Food and Bioproducts Processing 127:338–348

Kafuku G., et al. (2010) Croton megalocarpus oil: A feasible non-edible oil source for biodiesel production, Bioresource technology, 101 (2010) 7000–7004

Owade JO, et al. (2019). Utilization of croton seed as a possible animal feed: a review. Online J. Anim. Feed Res., 9(4): 178-186

Ramachandran S. (2007) Oil cakes and their biotechnological applications – A review Bioresource Technology, Vol 98, 10:2000-2009

Samtiya M. et al. (2020) Plant food anti-nutritional factors and their reduction strategies: an overviewFood Production, Processing and Nutrition 2:6 https://doi.org/10.1186/s43014-020-0020-5