Anaerobic co-digestion of fruit and vegetable wastes for biogas production and digestate valorization

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Fruit and vegetable wastes (FVW) are mainly generated before consumption during agricultural production and distribution. In Tunisia, FVW started creating enormous waste disposal problems due to the negative effects of improper waste management. The disposal of these wastes in a municipal landfill site represents a loss of valuable biomass and also affects the overall economy of the country. Considering the high moisture and organic content of FVW, the anaerobic digestion (AD) can be an attractive option for energy generation as well as for reducing the disposal problem. In addition to the production of renewable energy, this biotechnology generates a by-product, the digestate, with interesting agronomic potential. The reutilization of digestate, as bio-fertilizers, is the key way to close the nutrient cycle (Przygocka-Cyna et al. 2021). Indeed, the application of digestates and the study of their agronomic potential are still unexplored.

Many studies have demonstrated the failure and dysfunction of anaerobic reactors during mono-digestion of FVW at high organic loading rate (Mlaik et al., 2021). The high concentration of rapid fermentescible organic matter lead to the accumulation of VFAs that causing inhibition of methanogenic phase. It was also stated that single step AD lead to process instability due to the rapid production and slow conversion of VFAs. These negative aspects can be reduced by the use of new reactor configuration with phase separation (solid-liquid). Bi-phasic reactor with leachate recirculation was demonstrated to enhance process stability and biogas production. This new configuration for solid waste treatment was proposed to solve the problems of accumulation of VFAs and to evaluate the state inside the reactor (Massaccesi et al., 2013). In the same way, the stability of reactor and the improvement of methane potential of FVW could be achieved by the co-digestion technology using a nitrogen-rich co-substrate. In this context, the aim of this work was to optimize the anaerobic co-digestion of FVW with locally available co-substrates. The agronomic characteristics of anaerobic digestates and their fertilizing effect on tomato plants were also evaluated

The determination of the methane potential of substrates during mono- and co-digestion tests showed a correlation between the biogas yield and the bio-accessibility as well as the complexity index of organic matter present in FVW. A high methane potential was obtained with the combination of FVW, poultry manure and olive mill wastewater. The optimal co-digestion experiment conducted in a bi-phasic reactor with leachate recirculation showed the stability of the anaerobic bio-system and an improvement of biogas yield during the co-digestion experiment (Figure 1).

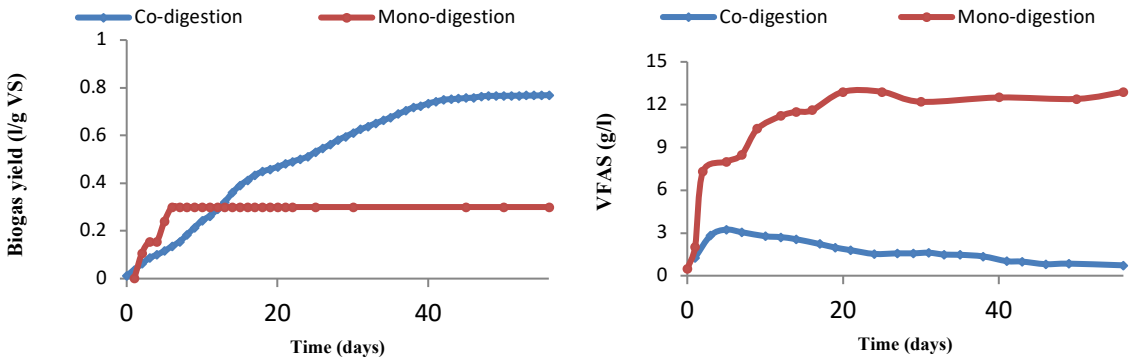

Figure 1. Evolution of methane yield and VFAs concentration during mono- and co-digestion experiments in the hybrid reactor.

The results of the physicochemical characterization of digestates showed their good agronomic quality. In fact, they were characterized by their stability, their richness in (nitrogen, phosphorus and other micro and macronutrients) and humic and fulvic acids and their low contamination by heavy metals in comparison to Tunisian standards. Tomato growth tests showed that the application of the digestate from the anaerobic co-digestion of organic wastes at a dilution of 20% for the fertigation of tomato plants gave the best results in terms of growth and quality parameters. According to results, anaerobic co-digestion of FVW could be a sustainable mode of waste management that reduce reliance on landfills and promote circular economy by generation of renewable energy and biofertilizer.

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