Exploring the biochemical methane potential of open market waste from Jordan and Tunisia for a future scale-up of anaerobic digestion in Amman and Sfax

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To face the increasing food demand and urbanization, it has been estimated that the agri-food sector generates approximately 140 million tons of biodegradable wastes yearly at the European Union (EU) level. As high portions of organic waste are still managed in an improper way, the traditional linear economy practices lead to the release of high CO_2 amounts, having unavoidable and negative consequences on global warming (Eriksson *et al.* 2015). The implementation of new sustainable bio-based technologies is needed to produce clean and renewable energy, as well as to recover resources from organic waste. Among the multiple strategies developed to valorize the energy content of organic feedstocks, anaerobic digestion (AD) is still the most widely applied process mainly due to its high efficiency, reliability and operational flexibility (Pavlas *et al.* 2020).

This study foresees the involvement of five institutions from five different countries of the Mediterranean area within an international project focused on more proper management of the organic waste produced from open markets in Amman (Jordan) and Sfax (Tunisia). In particular, the present research deals with the implementation of experiments aimed at evaluating the conversion into biomethane of the open market waste, being this mainly composed of fruit and vegetables and, thus, ax excellent substrate for AD. The experiments were carried out in Italy, Spain and Greece, while the Jordanian and Tunisian partners gathered and transferred information related to the variation of the waste composition on a yearly basis. The final goal of the experimental campaign is to transfer knowledge to the Jordanian and Tunisian partners on the optimal operating conditions of AD, for further implementation of the technology at a pilot scale in the next year.

Experimentally, the effect of the seasonal variation and particle size of the market waste on the biochemical methane potential (BMP) was investigated. Several sets of batch BMP assays were run using three seasonal waste compositions (winter, spring and summer). The selected fruits and vegetables per each composition were chopped until reaching a particle size of 10 mm, between 4 and 10 mm, and below 4 mm (Figure 1), following the indications of the Jordanian and Tunisian partners regarding the dimensions to be used in the pilot-scale digesters.

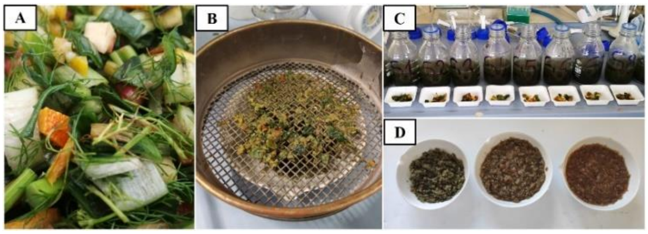

Figure 1. Photo of the synthetic winter waste chopped at a particle size of approximately 10 mm (A); sieving of the waste to obtain a particle size below 4 mm (B); bottles used for the BMP tests with the three different substrate compositions (C); photo of the three substrates with a particle size below 4 mm (winter, spring and summer compositions from left to right).

The variation of fruits and vegetables per season can be observed in Figure 2. Fruits and vegetables rich in sugars and carbohydrates prevail in the summer, while the fibre-rich vegetables are abundant in winter. Sewage sludge collected from wastewater treatment plants located nearby was used as inoculum. All batch experiments were performed with an inoculum/substrate ratio of 2 (g VS basis). The working volume was 200-250 or 400-500 mL in the bottles used (Figure 1). The alkalinity was adjusted to 3-3.5 g $CaCO_3$ L^{-1} by adding $NaHCO_3$. After inoculation, the bottles were purged with N_2-CO_2 mixture (80-20%) and placed in an incubator set at 37°C (Figure 3). The biogas produced was collected in NaOH traps, and the volume of methane was reported at STP (0°C and 1 atm). All conditions were tested in triplicates, and blank tests with the inoculum were run in parallel.

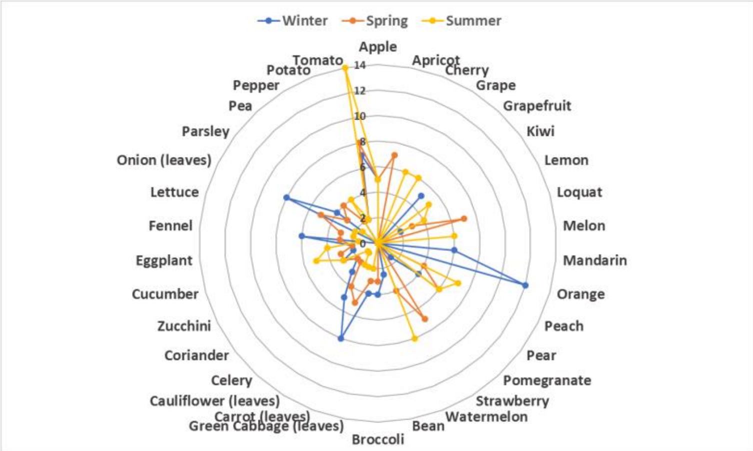

Figure 2. Percentage variation of typical fruit and vegetable wastes from the Mediterranean open markets.

Figure 4 shows the variation of the methane yield of the different waste mixtures that are representative for each season of the year. Both fractions of the wastes in summer (4-10mm and <4mm) have higher yields than the other mixtures. The whole samples (0-10 mm) do not seem to present any difference in the wastes for all seasons. The variation exhibited via the fractionation of the wastes is interesting since the results should not only be related to the particle size of the substrates but also to their components for each fraction. The lower size fraction contains mostly the juices from the wastes produced during cutting as well as pieces of leaves passing through the sieve, while the larger fraction contains the main body of the fruits and vegetables. Therefore, a qualitative difference in the volatile solids contained in the two fractions exist.

Figure 3: Batch tests in the 37°C incubator

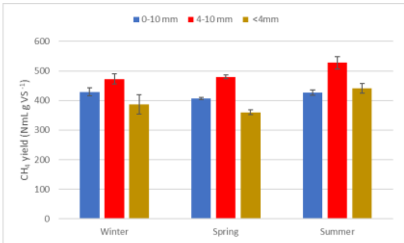

Figure 4: Overall methane yields of the open market wastes

The fractionation of the wastes has also an impact on the initial rate of methane production (Figure 5). The smallest size promotes the highest rate but, in the sequel, the largest size is the fraction that yields methane at a higher rate. This pattern is consistent in all three cases of the waste mixtures studied.

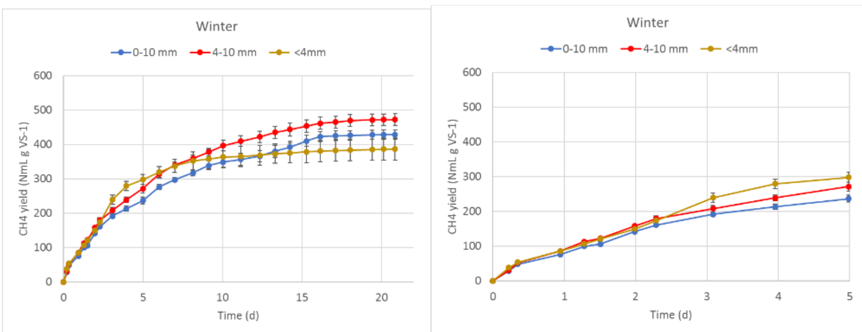

Figure 5. Effect of the fraction size on the initial and the final rate of methane production

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