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Experimental Analysis on the Aerobic and Anaerobic Degradation of Paper-Based Boxes for Food Delivery

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Abstract

The organic fraction is generally the most relevant among the source-separated materials collected with municipal solid waste. In addition to food waste and garden waste, the amount of other material such as bioplastics and cellulosic fractions are not negligible, and on the rise. This study aims at evaluating the behaviour of compostable paper-based packaging when subjected to aerobic and anaerobic degradation conditions. Differently from the technical standard for compostability (EN 13432:2002), the tests were performed under conditions more similar to those found in industrial plants. In particular, four paper-based boxes for food delivery were tested: two corrugated cardboard boxes, one cartonboard box coupled with a film in polylactic acid (PLA) and a cartonboard box (with a lid) subjected to a barrier treatment. With regards to aerobic conditions, the European standard EN 14045:2003 was taken as reference. The anaerobic degradability of two out of the four boxes (one made exclusively of paper and the one with the PLA film) was firstly investigated through biochemical methane potential (BMP) tests. Then, semi-continuous co-digestion tests with food waste were also carried out on the box with the PLA film to verify the BMP test results under conditions more similar to the full-scale treatment plants. When subjected to composting, the four boxes exhibited different behaviours. After four weeks, the two boxes made exclusively of paper were completely disintegrated and indistinguishable from the compost. Analysing the box with the PLA film, limited variations in the structure of the inserted pieces were observed at the end of the first four weeks of testing. On the contrary, after eight weeks the average weight loss of the inserted pieces increased up to 75%. Finally, the box subjected to the barrier treatment showed an intact structure after four weeks, which was still distinguishable after eight weeks. Only after twelve weeks the level of degradation resulted comparable to that of the other boxes. The BMP test showed a good anaerobic degradability (>72%) of all the packaging, with no undigested residues after the tests. In particular, the box made exclusively of paper showed higher degradability and methane production compared to the one with the PLA film (+24%). These results are confirmed by the semi-continuous tests, in which the anaerobic degradability of the box with PLA (75%) resulted slightly higher than the one observed in the BMP tests (72%). Despite the

good degradability, due to the changed operating conditions, undigested PLA residues were observed in the extracted digestate. The outcomes of the study are in agreement with the characteristics of the tested boxes. The best results were obtained for the paper-only boxes, a material highly compatible with biological processes. As regards the box coated with PLA, the slower disintegration in the composting process and its lower anaerobic degradability in BMP tests are reasonably related to the presence of the bioplastic film. Similarly, the barrier treatment is potentially the cause of the slower disintegration in the composting process of the box characterised by this feature.

Keywords: composting, anaerobic degradation, packaging