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Introduction

The accumulation of plastic waste in the environment has become a global concern, as improper disposal and the slow natural degradation of plastics cause significant environmental problems. Polyolefins such as polystyrene and polyethylene are highly resistant to biodegradation because they are very stable polymers with a high molecular weight and a hydrophobic character. In recent years, several studies have explored the unusual ability of some microorganisms and insects to consume and biodegrade various types of polymers into low molecular weight, simple and non-toxic molecules that are eventually excreted as frass. [1,2] This study aims to evaluate the degradation ability of two species of Coleopterans Tenebrionidae larvae, *Tenebrio Molitor* and *Zophobas Morio*, used for polystyrene and low-density polyethylene biodegradation tests. The degradation of polyolefins treated with hydrogen peroxide and subjected to microwave irradiation was also studied. The mass change of the larvae and the survival rate were measured periodically, while the frass collected after 15 and 30 days was analyzed by different analyses, such as spectroscopy (FTIR), spectrometry (molecular weight and polydispersity), thermal analysis (TGA) and microscopy (scanning electron microscopy observations).

Materials



Polystyrene (PS)



Tenebrio Molitor (TM)
Zophobas Morio (ZM)



Low Density Polyethylene (LDPE)

Feeding tests

Groups of *T. Molitor* and *Z. Morio* larvae (30 as a group) were reared on Polystyrene or Low-density Polyethylene (~0.4 g) in a polypropylene plastic container. As a control, other groups of larvae (30 as a group) were reared on a normal diet of wheat bran and fruits.

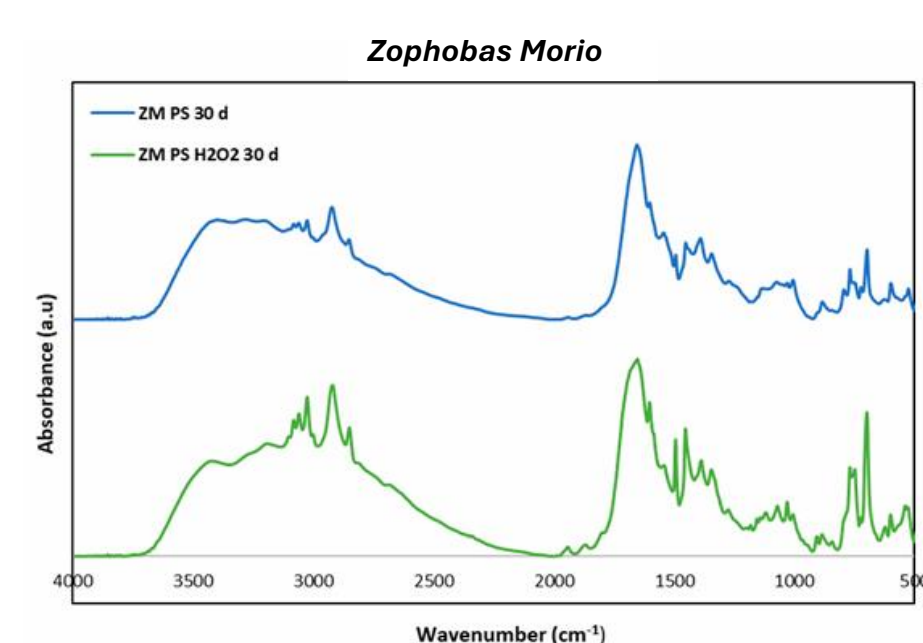
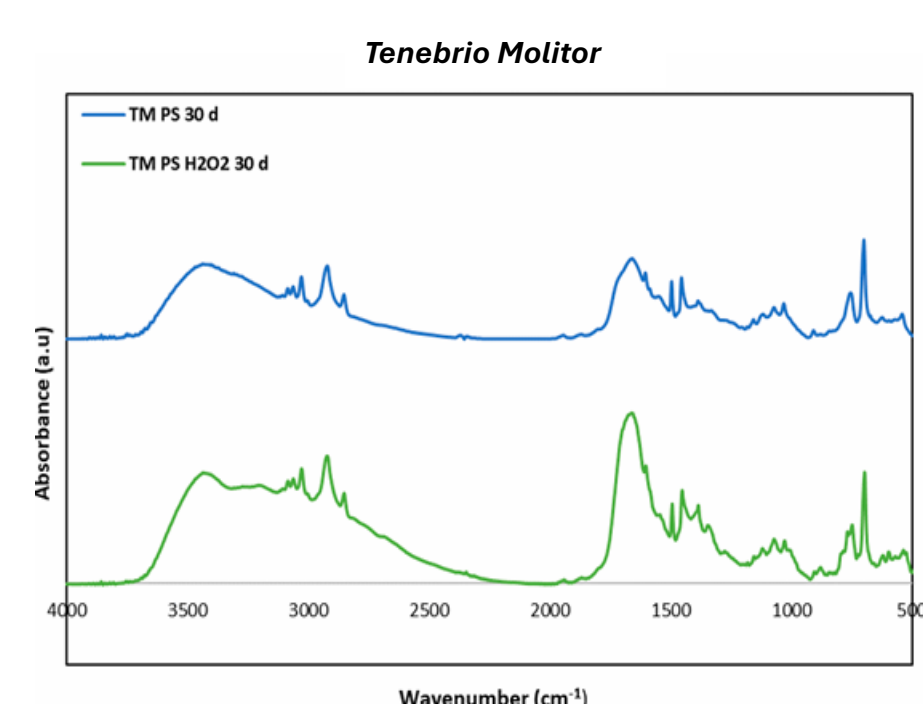
For microwave oxidation, a block of material was placed in a beaker with hydrogen peroxide H₂O₂ for 5 min and then microwaved into a commercial microwave oven at 800 Watt for 3 min, which caused the initial breakage of the polymer chains.

All containers were maintained in the climatic chamber under controlled conditions, for a period of 30 days.

Characterizations

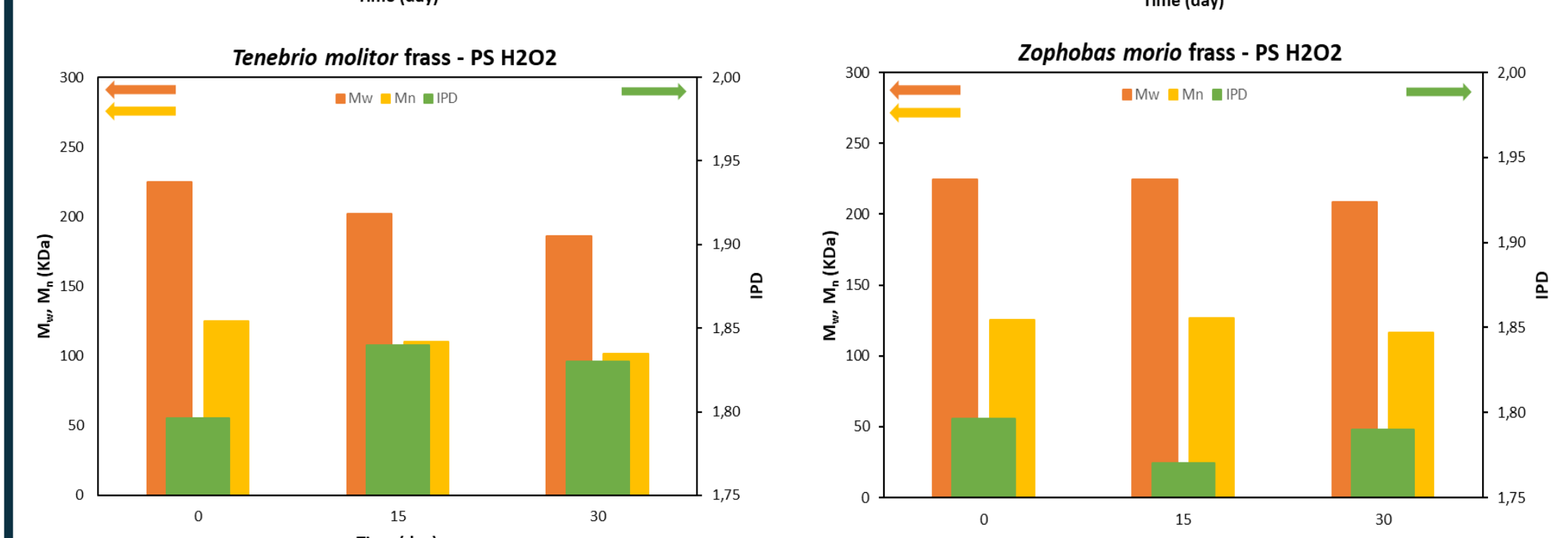
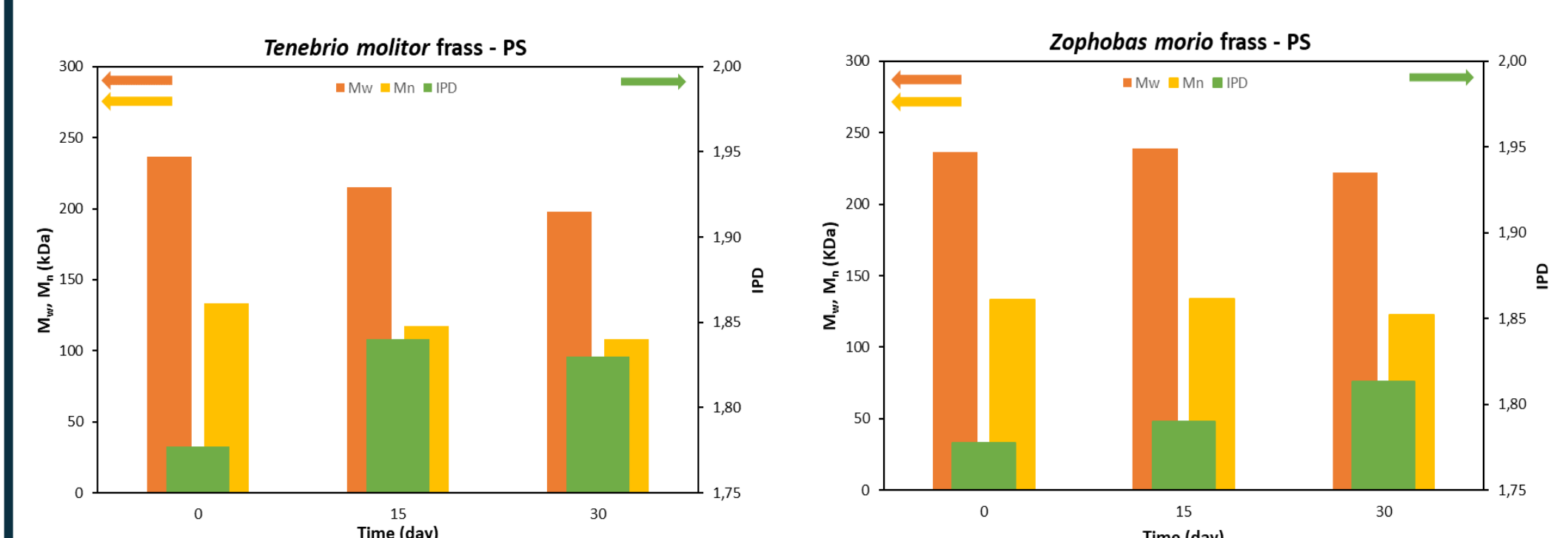
- Weight Variation (NW) and Survival Rate (%)
- Size-Exclusion Chromatography (SEC)
- Spectroscopy analysis (FTIR-ATR)
- Thermogravimetric analysis (TGA)
- Morphological analysis (SEM)

FTIR-ATR



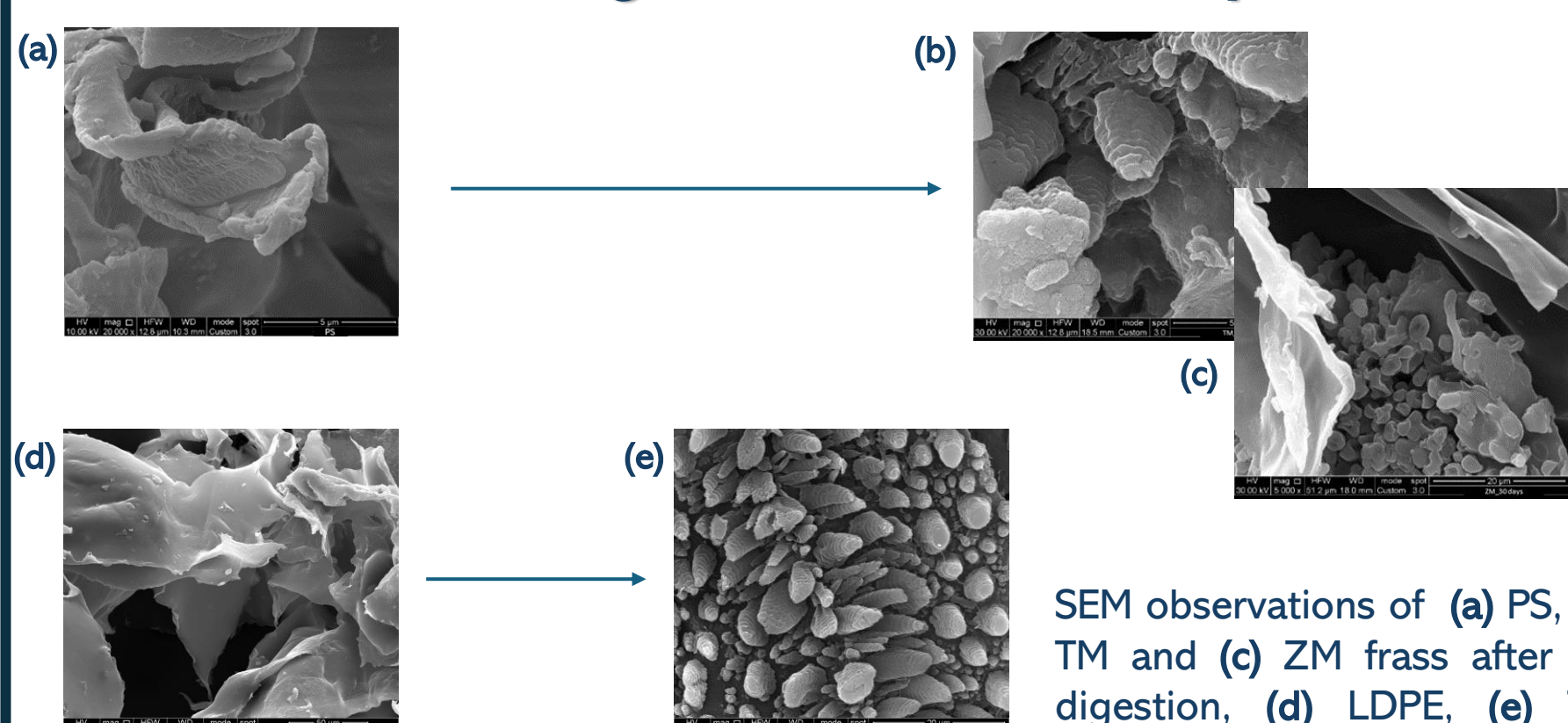
FTIR spectra of frass of TM and ZM feeding with PS and PS-H₂O₂ after 30 days.

Size-Exclusion Chromatography



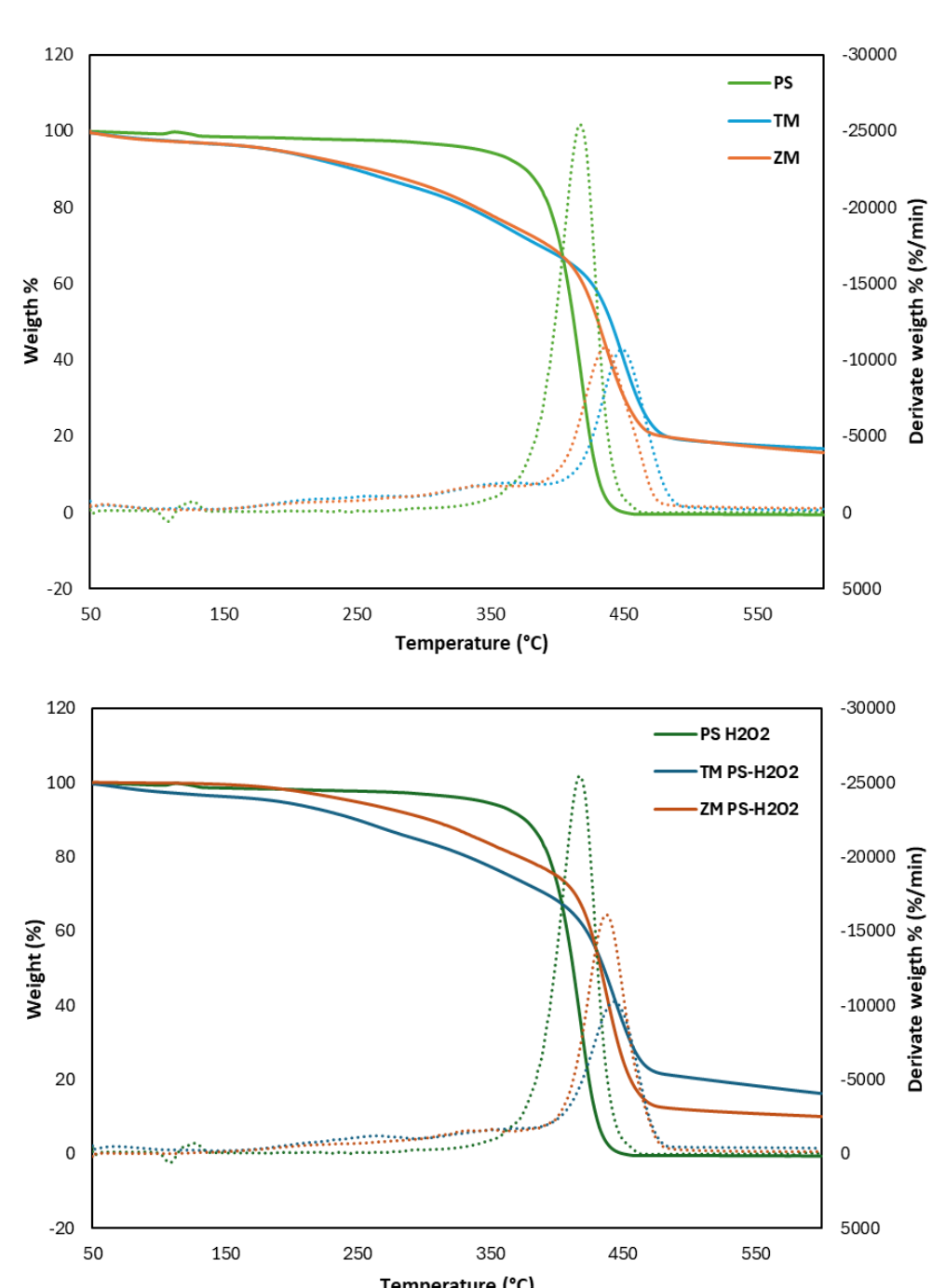
Data related to the changes of ponderal molecular weight (M_w), numerical molecular weight (M_n) and polydispersity index (IPD) of PS and PS-H₂O₂ (0 days), and frass of TM and ZM after 15 and 30 days.

Scanning Electron Microscope

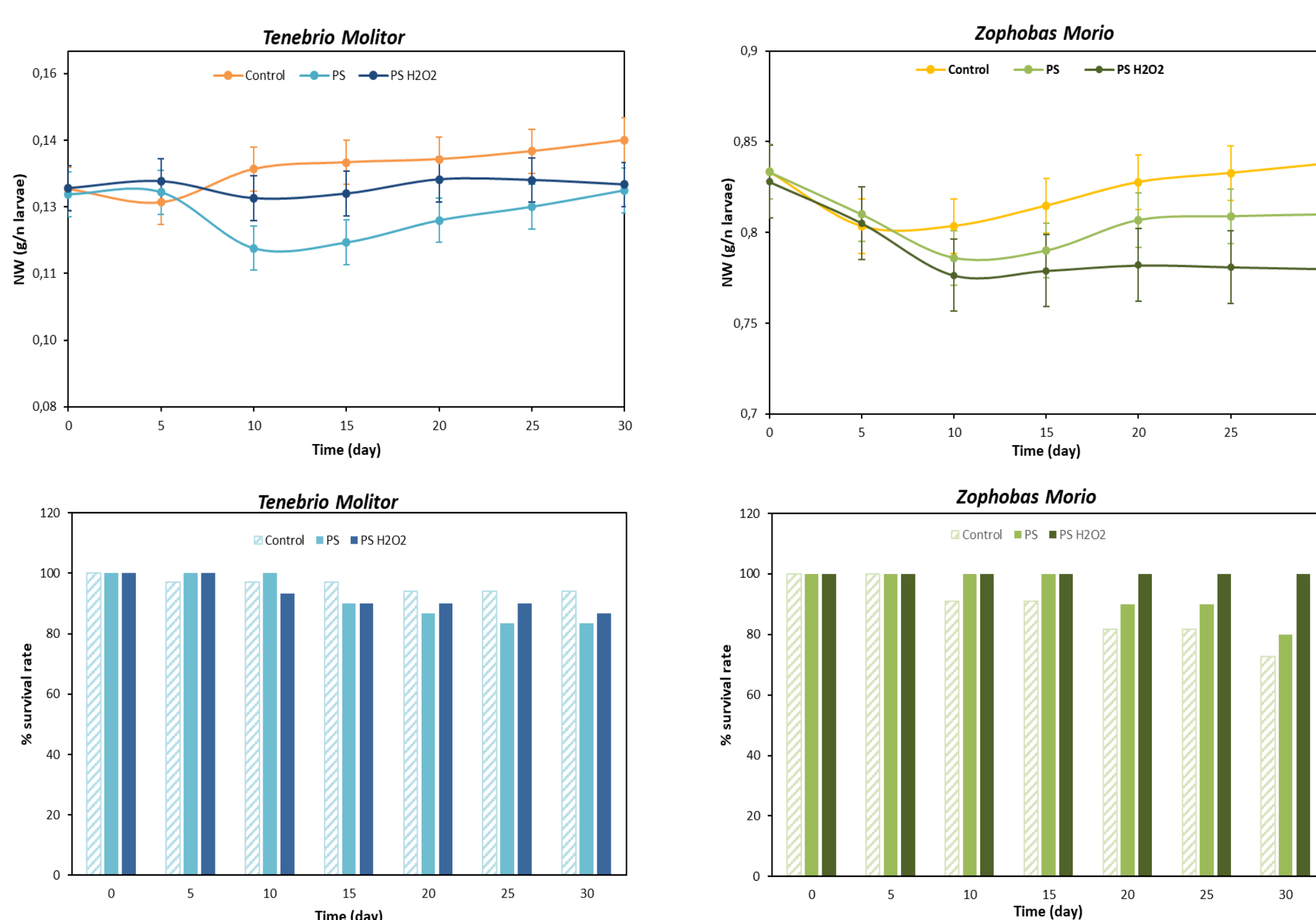


SEM observations of (a) PS, (b) TM and (c) ZM frass after PS digestion, (d) LDPE, (e) TM frass after LDPE digestion.

Thermogravimetric analysis



Weight Variation (NW) and Survival Rate (%)



Discussion and Conclusions

In this work, the biodegradation of PS and LDPE by *T. Molitor* and *Z. Morio* has been investigated, considering also pretreatment with H₂O₂ in order to facilitate the degradation. Different experimental diets were compared. The change of the larvae mass and the survival rate were monitored periodically and obtained results suggest that both *T. Molitor* and *Z. Morio* larvae are able to biodegrade the polymers, and their mass changes and survival rate are similar to that of larvae fed with bran. Although not strongly pronounced, SEC analysis shows that the M_w and M_n of the frass of both larvae decreased over 30 days, suggesting a reduction in chain weight and length. Further, the data coming from FTIR analysis support this thesis highlighting the changes in compositions after the digestion. Therefore, all these results highlight the ability of both larvae to survive using as fed plastic rather than bran.