End-of-life of biodegradable plastic supports through anaerobic digestion: a case study of coffee capsules

Révélateur de solutions durables

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INTRODUCTION

A biodegradable plastic, produced from renewable resources (bio-based plastics) or non-renewable resources (fossil fuel-based plastics), as defined by Iwata (2015), is a material that is degraded to carbon dioxide and water by the action of naturally occurring microorganisms. Anaerobic digestion (AD) appears to be a promising valorisation route for biodegradable plastics such as coffee capsules, although there has been a lack of information to date in the literature. This study investigated AD of three biodegradable coffee capsules under both mesophilic (37 °C) and thermophilic (57 °C) conditions.

MATERIALS & METHODS

Launay®, Beanarella®, and Tintoretto® coffee capsules were selected for this study. All of the capsules were separated from the coffee and opercula. The coffee capsules were then successively ground using a cutting mill (SM100 Restch, Haan, Germany) and a centrifugal mill (*ZM200 Retsch, Haan, Germany*) to obtain a particle size of 0.75 mm. Total Solids content (TS) and Volatile Solids content (VS) were determined by the APHA standard method (APHA, 2005). Elemental analysis (C,H,N,S determination) was carried out using an Elemental Vario Macro Cube. The degradation test was performed using the biochemical methane potential (BMP) method described in Monlau *et al*. (2012) at 37 °C (mesophilic inoculum) or 57 °C (thermophilic inoculum). The maximum theoretical methane potential was estimated with different methods (Li *et al.,* 2013, Frigon *et al.*, 2010).

	Beanarella®	Launay ®	Tintoretto®
Capsule mass (g)	5.83	2.26	3.75
Opercule mass (g)	0.11	0.10	0.27
Coffee mass (g)	6.97	5.40	6.75
Capsule relative mass	45.15%	29.08%	34.85%
Capsules			
Plastic benchmark	**Ecovio ®**	**Vegemat ®**	**Mater-bi ®**
TS (% raw mass)	99.82% (±0.003%)	99.65% (±0.019%)	99.85% (±0.003%)
VS (organic content % TS)	70.73% (±0.124%)	94.42 (±0.043%)	98.60% (±0.007%)
Ash (%TS)	29.27%	5.58%	1.4%
C [%TS]	37.73%	49.65%	53.97%
H [%TS]	4.42%	5.79%	6.05%
N [%TS]	0.00%	0.04%	0.00%
S [%TS]	0.11%	0.44%	0.15%
Maximum theoretical methane potential NL $CH_4.g^{-1}$ VS	0.532	0.522	0.534

Table 1: Physico-chemical characteristics of the three capsules investigated in this study.

RESULTS

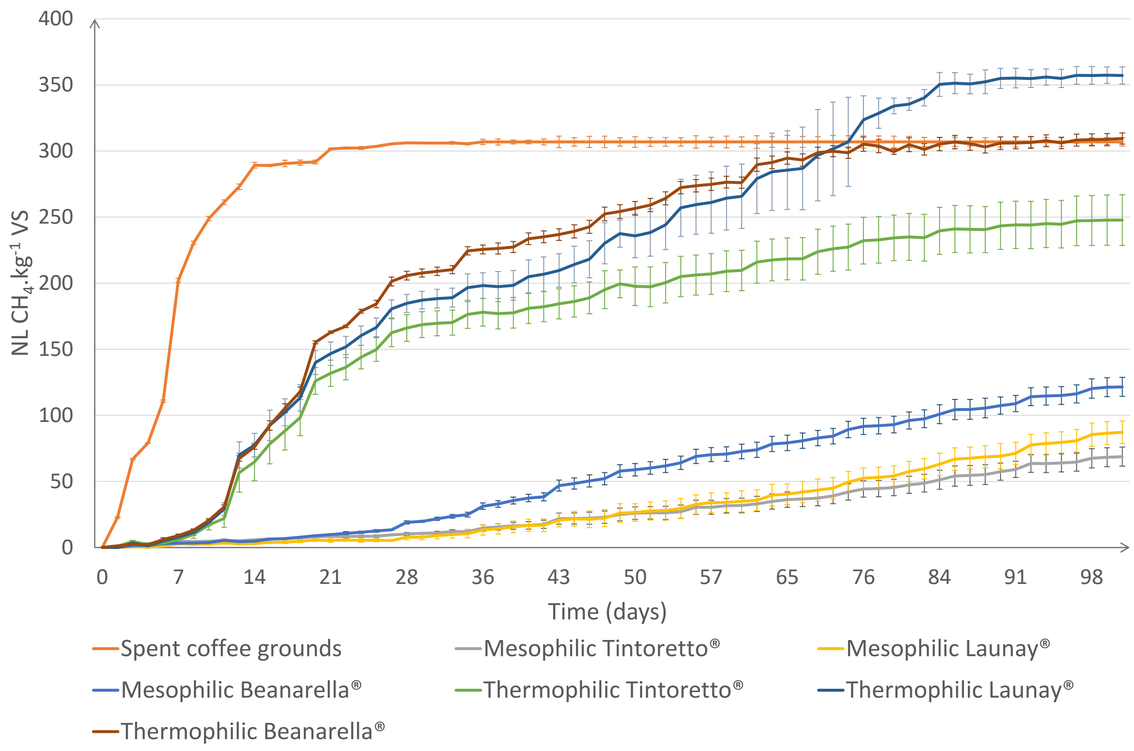

Figure 1: Methane potential NL $CH_4.kg^{-1}VS$ of different substrates under mesophilic and thermophilic conditions

- The volatile solid content (Table 1) varied significantly between the different capsules (from 71% to 98%). Approximately 30% of the Beanarella® capsule was composed of ash.
- Despite some substantial differences in the C,H,N,S ratios, there was only a slight change in the maximum theoretical methane potential (Table 1).
- Spent coffee grounds had similar methane potentials under thermophilic and mesophilic conditions (310 NL $CH_4.kg^{-1}$ VS).
- All of the capsules exhibited a higher methane potential under thermophilic versus mesophilic conditions (Figure 1).
- Three phases can be recognized for the spent coffee grounds and for the capsules under thermophilic conditions: first a lag phase, then a production phase and finally a stationary phase was reached.
- The low degradation under mesophilic conditions precluded us from observing the above phases (Figure 1).
- The percentage of the maximum theoretical methane production of the Beanarella®, Launay®, and Tintoretto® capsules after 100 days reached, respectively, 58.1%, 68.6%, and 46.5% under thermophilic conditions and 22.8%, 16.7%, and 12.9% under mesophilic conditions.

CONCLUSIONS

A **low degradation rate** was noted under **mesophilic AD** (methane conversion less than 25% of the theoretical value in 100 days).**Thermophilic AD** led to a better degradation of the coffee capsules (between **46.5 and 68.6%** of the theoretical value in 100 days). The time to reach the maximum methane production was longer for the capsules than for spend coffee grounds, limiting a possible AD of the whole capsule. An inoculum acclimation or a plastic pretreatment may enable a faster degradation.

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