# Use of Biochemical Methane Potential (BMP) Assays for predicting biogas production from co-digestion of food waste and compostable bags

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**Abstract.** Biodegradable plastics have been introduced to the market to substitute petro-based plastics to alleviate plastic pollution. Biochemical methane potential tests were carried out on food wastes (FW), with or without pre-treatment, compostable bag and a mixture of food waste and compostable bag (CB) to examine the anaerobic biodegradability of those materials. Anaerobic tests were carried out in mesophilic (35ºC) conditions. The aim of this work is to study the residuality of compostable bags in anaerobic digestion. At the end of the process, a dry mass of 26 % and 28 % was recorded for compostable bag and co-digestion of compostable bag and food waste respectively.

The CB added to the feed did not have a negative effect on reactor performance, but seemed to have higher biogas production. Moreover, co-digestion with CB improved biogas production by 0.8-1 times. The best VS removal efficiency of approximately 68% was achieved for FW & CB substrate. Therefore, when the compostable bag was used as a combination of substrate with food residues it produced larger amounts of biogas than samples containing only food residues. This result highlights the fact that the compostable bag does not adversely affect the process.

**Keywords:** biogas, compostable bags, anaerobic digestion

## 1. Introduction

With more than 8 Mt of plastics released into the global environment each year, the majority of which ends up in the sea, plastics' contamination has become the largest worldwide environmental problem. Pollution of the marine environment by plastics is one of the most severe environmental threats humanity has to cope with (Calabro and Grosso, 2018), since around 7.8-8.2 million tonnes of discarded plastics enter the oceans every year (Thakur et al., 2018).

The emergence of bio-plastic arises due to the environmental considerations on the non-biodegradable plastic. The origin of bioplastic (biodegradable plastic) are cellulose, starch, sugar etc., which are primarily renewable in nature (Meeks et al., 2015). No doubt, biodegradable plastics are environment-friendly but they also came with some limitations like high manufacturing cost and low mechanical tendency (Jain and Tiwari, 2015; Thakur et al., 2017). A feasible way to minimize cost is to blend them with natural bio-materials such cellulose (Thakur et al., 2018) or bio-waste collected from Hospitality Units (Maragkaki et al., 2021).

In Greece, since 01.01.2018, non-biodegradable lightweight plastic carrier bags are banned and Imposition of an environmental tax. Biodegradable and compostable bags are excluded from the imposition of the environmental tax. Therefore compostable bags are increasingly used in Greece.

For anarobic degradation, the rate of conversion of the substance to biogas has to be at least 50 % of the theoritical value over a maximun period of two months.

Despite the sufficient knowledge on the aerobic degradation of biopolymers (Meeks et al., 2015) research on their anaerobic degradability is still limited (Batori et al., 2018).

The objective of this paper was to study the anaerobic degradation of compostable bags designed to substitute petro-based conventional plastics under anaerobic conditions found in typical full-scale anaerobic units. Therefore the aim of this work was to study the residuality of compostable bags in anaerobic digestion.

## 2. Experimental setup and methods

### *2.1. Raw materials, substrates and inoculum*

Food waste (FW) used in the present study was collected from the students' restaurant at the Hellenic Mediterannean University, Heraklion. The FW composition was 80% raw-fresh food (vegetables), 10% fruits and 10% salads (on a wet-weight basis). FW was homogenized using a mechanical mixer (approximately 4.0 mm). FW dried at a temperature of 105 ºC. Regarding the compostable bag (CB) is made of MaterBi designed for delivering organics to household waste collection systems and is compliant with the EN 13432 norm. The compostable bag was pre-treated mechanically. Mechanical pre-treatment consisted of shredding so that to reach particles with a final dimension of 1 x 1 cm. Inoculum was obtained from the anaerobic digester of the sewage treatment plant (STP) of the city of Heraklion, Greece (population about 200,000). The mean composition of raw FW, CB and inoculum is summarized in Table 1.

**Table 1.** Characteristics of materials and inoculum used in batch experiment

| Parameter | Inoculum | FW | CB |
|---|---|---|---|
| pH | 7.1 ± 0.0 | 4.1 ± 0.0 | - |
| VS (g/kg) | 20.4± 5.4 | 242.7± 5 | 968.8± 5.5 |
| N (%) | 0.1± 0,0 | 2.5± 0,0 | 0.1± 0,0 |
| TOC (g/kg) | 433.1± 4.9 | 634.1± 24.1 | 692± 92 |

*2.2. Methane potential experiment*

Batch experiments were carried out in triplicate at mesophilic conditions (35 ºC) to determine the methane potential of fresh food wastes (FW), with or without pre-treatment, compostable bag and a mixture of food waste and compostable bag (CB). CB was added in order to examine the anaerobic biodegradability of those materials. They were carried out using a method based on Angelidaki & Sanders, 2004. One inoculum to substrate ratio (ISR) was examined 1:2 (VS). The experiments were conducted in 120 ml serum bottle reactors. The reactors were flushed with a gas mixture of nitrogen and carbon dioxide (70% and 30% respectively) immediately after the addition of inoculum and substrates to remove air and achieve anaerobic conditions. Serum bottles were then sealed with rubber septa and aluminum crimp caps. Biogas production and content was measured in each bottle at regular time intervals for a period of more than 4 months (about 135 days). The characteristics of the mixed substrate are summarized in Table 2.

**Table 2.** Characteristics of the mixed substrate

| Parameter | Blank | FW | FWD | CB | FW & CB | FW & CB |
|---|---|---|---|---|---|---|
| pH | 7.7 | 7.5 | 7.4 | 7.8 | 7.6 | 7.4 |
| VS (g/kg) | 20.4 | 37.5 | 39.5 | 39.8 | 37.9 | 39.7 |
| COD (g/l) | 19.3 | 38.7 | 33.3 | 24.2 | 30.1 | 34.7 |

2.3. Analytical Methods

The pH was analyzed according to APHA (2005) using a pH-meter (model GLP21, Crison). COD were determined spectrophotometrically by use of standard test kits (Hach). TS and VS were measured gravimetrically according to APHA (2005).

## 3. Results & Discussion

Cumulative biogas production is presented in Figure 1. Values obtained for the maximum biogas production as expressed per VS added. Specifically, the maximum biogas production was 641 ml/g VS, 243 ml/g VS, 751 ml/g VS, 768 ml/g VS, 792 ml/g VS and 275 ml/g VS for FW, CB, FWD, FW & CB and FWD & CB respectively. The abovementioned findings shown that FWD & CB and FW & CB had no significant effect on maximum biogas production. More than 80% of produced biogas was collected during the first 70 days. The Cumulative biogas production was found to increase as the dried FW was added. Moreover, in all cases the addition of CB resulted in higher biogas production. The CB added to the feed did not have a negative effect on reactor performance, but seemed to have higher biogas production. Moreover, co-digestion with CB improved biogas production by 0.8-1 times. The best VS removal efficiency of approximately 68% was achieved for FW & CB substrate. Therefore, when the compostable bag was used as a combination of substrate with food residues it produced larger amounts of biogas than samples containing only food residues. This result highlights the fact that the compostable bag does not adversely affect the process. Regarding the mass loss of the compostable bag, it is observed that the largest decrease with 28.4 % was presented by the FW & CB sample while the CB sample had a slightly smaller decrease by 26.3 %. The smallest decrease with 19 % was presented by the sample FWD & CB.

## 4. Conclusions

The experiments carried out indicate that:

After anaerobic digestion the compostable bags were partially degraded (mass loss in 135 days was 19 %to 30 % in mesophilic conditions) so were fully recognizable in the digestate after the end of the digestion process. Nonetheless the CB added to the feed did not have a negative effect on reactor performance, but seemed to have higher biogas production and the best VS removal efficiency. Therefore, when the compostable bag was used as a combination of substrate with food residues it produced larger amounts of biogas than samples containing only food residues. This result highlights the fact that the compostable bag does not adversely affect the process.

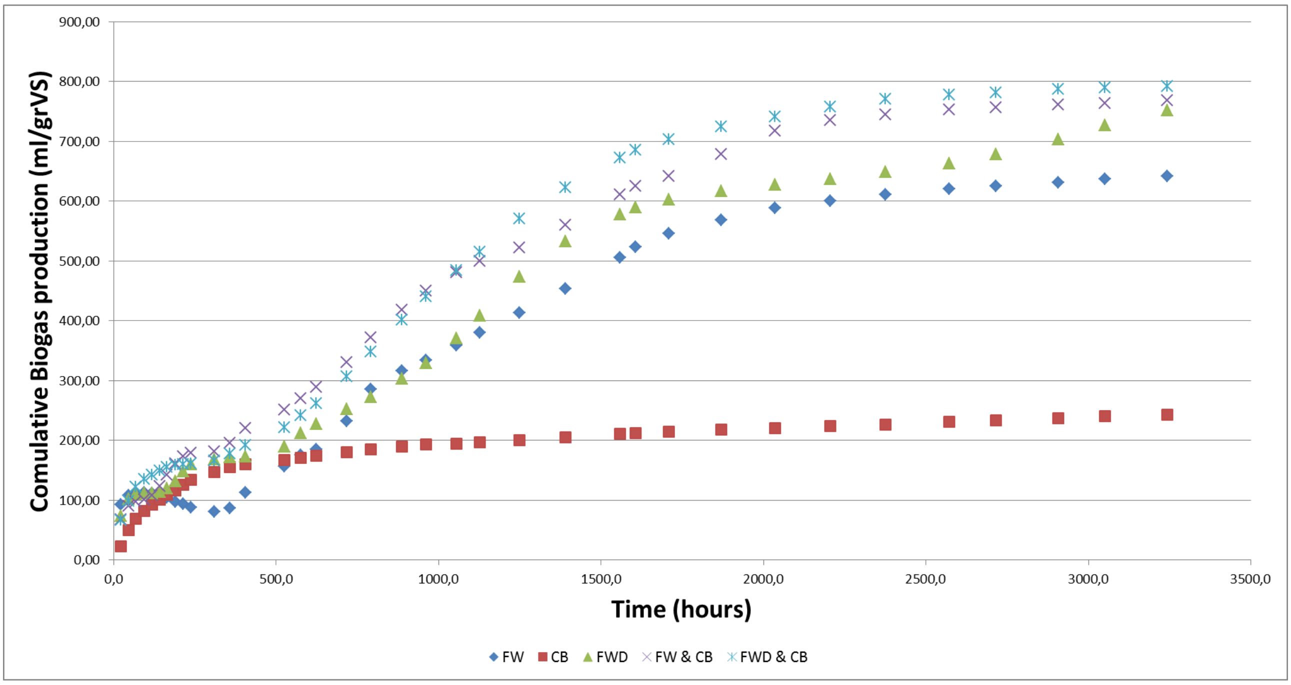


**Figure 1.** Cumulative biogas production for different substrate.

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