

BIOMETHANIZATION OF "ALPERUJO" (TWO PHASE OLIVE MILL WASTE) WITH CATTLE MANURE: INOCULUM ADAPTATION

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ABSTRACT

In this study, the starting up procedure of anaerobic reactors for two phase olive mill waste (2POMW) and cattle manure (CM) co-digestion at mesophilic temperature (35°C) was carried out. The mixed waste (2POMW and CM; 60:40 w/w) with an optimal C/N (25), and as inoculum, the waste water treatment plant digester in the 20% of total reactor volume, was introduced in a stirred tank reactor (4L). This reactor was operated in batch with a total solid content of 10%. Due to the non-existence of an available adapted inoculum, the reactor was re-inoculated with mesophilic effluent of a reactor of pulp beet in order to eliminated de propionic acid accumulated. After three months, with increase in the production of biogas, accompanied by a progressive decline in parameters such as total acidity and propionic acid concentration, indicates the start up of the reactor.

For evaluate the process evolution, biogas production and composition, chemical oxygen demand, pH, dissolved organic carbon and volatile fatty acid were measured periodically. In the next stage, begins a stepped reduction of the HRT in a continuous operation feeding the reactor with the same mixture of both wastes (60/40, w/w). The final objective this study is the optimization of biogas generation.

Keywords: Anaerobic co-digestion; Start up procedure; Two-phase olive mill waste; Cattle manure; Propionic acid; Mesophilic temperature.

INTRODUCTION

Approximately 90 million tonnes of cattle manure (CM) are collected annually in Spain. Further, the most Spanish olive oil mills operate with the use of a two-phase centrifugation system for oil separation, which generates a semisolid waste, the two-phase olive mill waste (2POMW) called "alperujo". The main organic matter constituents are lignin, hemicellulose and cellulose. Other important organic components are fats, hydrosoluble carbohydrates and proteins. It has a low N concentration, which gives a high C/N ratio. Cattle manure is a combination of feces and manure, bedding material,

wasted feed, and water. This is a waste with a high N organic concentration, which implies a low C/N ratio.

The main advantage of co-digestion is to harness the synergy of mixtures, and compensate weaknesses of each of the separate substrates. Among the benefits of co-digestion anaerobic includes among others, improves balance nutrients, achieving an optimum C / N ratio, the dilution or metabolism of potential toxic components such the ammonium or high concentration of volatile fatty acids, particularly the propionic acid that have a significant inhibitory effect on methanogenic bacteria growth (Wang et al., 2009).

There are studies related with anaerobic digestion of cattle manure (Mackie & Bryant, 1995) and alperujo (Borja et al., 2002) separately, but there is no reference about its co-digestion. In the anaerobic process there is several factor than inhibit the process

In this study, the starting up procedure of a mesophilic anaerobic reactor and obtaining an adapted inoculum for co-digestion of alperujo and livestock farming, cattle manure, was examined.

METHODS

Equipment: The experiments were carried out in a glass anaerobic reactor of four litres of effective volume. The reactor content is mixed through mechanical overhead stirrer at 15 r.p.m. The reactor temperature was maintained at $35 \pm 1^\circ\text{C}$ by circulating water through the water jacket. The production of biogas was collected for subsequent quantification and composition in Tedlar bag of 40 litres.

Inoculum and substrates: The reactor was inoculated initially with anaerobic mesophilic sludge from waste water treatment plant digester. The characteristics of this inoculum were: total solids (TS), 17.63 g/kg; volatile solids (VS), 10.22 g/kg and a pH of 7.8.

The use of effluent from a mesophilic reactor of pulp beet was also used as a source of inoculum due to its adaptation to degrade volatile fatty acids and specifically propionic acid. Its main characteristics were: TS, 59.79 g/kg; VS, 47.62 g/kg; Total volatile fatty acids (TVFA), 128.76 mg/l (principally acetic acid, 101.44 mg/l, and propionic acid, 22.15 mg/l) and a pH of 7.6.

Fresh 2POMW were collected from an olive oil mill located in Olvera (Cádiz-Spain) and CM was obtained from a livestock farming of El Puerto de Santa Maria (Cádiz-Spain). Both wastes were preserved and kept frozen (-4°C), the main characteristic are shown in the Table 1.

The following parameters were determined: total solids (TS), volatile solids (VS), chemical oxygen demand (COD), pH, dissolved organic carbon (DOC), volatile fatty acids (VFA), biogas production and composition. All analyses were carried out according to the recommendations of the Standard Methods

(APHA, AWWA, WPCF, 1989), the biogas composition and volatile fatty acids were determined with gas chromatography.

Table 1. Characteristics of the wastes used

	Unit	2POMW	CM
pH	-	5.41	7.84
TS	g/kg	315.00	182.95
VS	g/kg	282.74	143.91
DOC	g/kg	525.50	164.57
COD	g O ₂ /kg	142.16	43.20

RESULTS AND DISCUSSION

Initially the experimental reactor was operating in batch, using a mixed waste of 2POMW and CM (60:40 w/w) at mesophilic temperature (35°C). The mixture of waste was selected in based to the optimal C/N for the development of anaerobic processes (optimal relation C/N 25) (Flotats & Sarquella, 2008). The initial microbiote comes from mesophilic sewage sludge (20% total volume reactor) used as inoculum and cattle manure mixed with alperujo, in order to obtain a total solid content of 10% inside reactor. After a week, the reactor was re-inoculated with mesophilic effluent of a reactor of pulp beet (10% total volume reactor), in order to obtain populations of microorganisms adapted to the waste mixture. The reinoculations with the reactor effluent pulp beet were carried out between days 8, 55, 60 and 69. The pH reactor was maintained around 8 using a sodium bicarbonate solution.

Figure 1 illustrated the temporal evolution of methane productivity. After two weeks, there is a production of methane accompanied by consumption of volatile fatty acids accumulated, mainly acetic and butiric acids as shown in Figure 2. Propionic acid values remained constant around 1200 mg/l during this first stage of the start up, no degradation occurring. As a result of previous experiments, in which the accumulation of propionic acid causes long-term inhibition of methanogenic bacteria, and to avoid this phenomenom an inoculum from a pulp beet reactor was used due to its active biomass adapted to remove this acid.

The result of the reinoculations is a progressive decline in total acidity and the reduction of propionic acid concentration reaching concentrations below 40 mg/l. The degradation of accumulate propionic acid is indicative of the start up of the process, because a level over 900 mg/l has an inhibitory effect of the methanogenic population of anaerobic digestion (Wang et al., 2009). Then the reactor was fed with initial HRT of 40 d (day 97) with a mixed waste of 2POMW and CM (60:40 w/w). In this moment there is an increase of total acidity in the reactor, mainly acetic acid, as a result of the initial steps of anaerobic digestion (hydrolytic and acidogenic stages). Once the methanogenic microbiote are acclimated, there

is a significant increase in daily production of methane and the removal of accumulated acetic and propionic acids.

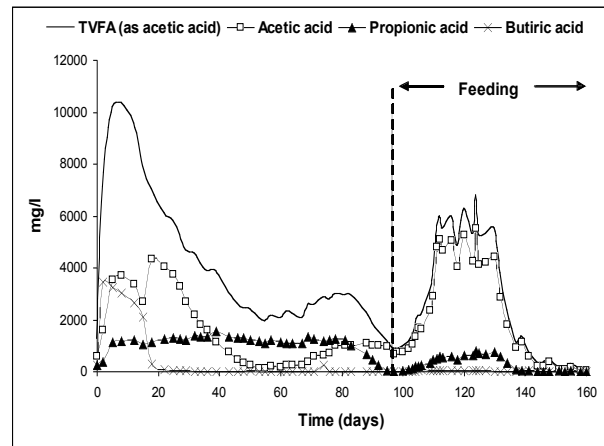
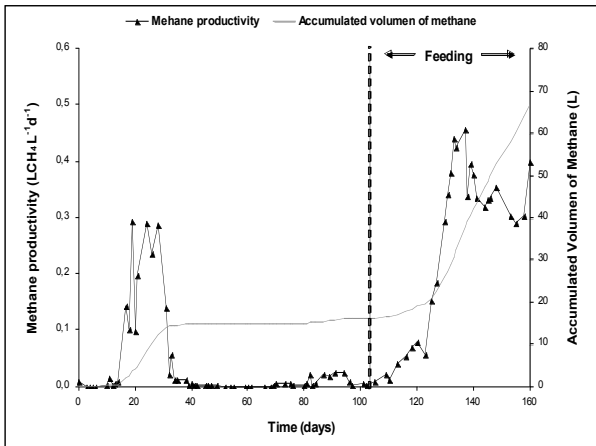


Figure 1. Evolution of methane productivity ($\text{LCH}_4 \cdot \text{L}^{-1} \cdot \text{d}^{-1}$) and accumulated volume of methane (L).

Figure 2. Evolution of TVFA and individual acids and accumulated volume of methane (mg/l).

CONCLUSIONS

Due to the complexity of the wastes and the need of an adapted inoculum, the startup time and stabilization of the anaerobic reactor is lengthy compared to other complex waste, reaching to 97 days. To ensure the stabilization of the process is necessary a sufficient degradation of the accumulated volatile fatty acids, in particular propionic acid, preventing the inhibition of methanogenic bacterial populations.

The use of a mixture 60:40 w/w of 2POMW and CM wastes in the co-digestion process is adequate as shown the stable operation in the stepped reduction of the HRT in a continuous operation feeding of the reactor.

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