Improvement of VFA production from food waste using biological pretreatments

Yen-Keong Cheah[1], C. Vidal-Antich[1], J. Dosta[1,2], J. Mata-Álvarez[1,2]

[1]Department of Chemical Engineering, University of Barcelona, Barcelona, Catalonia, 08028, Spain
[2]Water Research Institute, University of Barcelona, Catalonia, 08001, Spain.
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Presenting author email: jdosta@ub.edu

Abstract
Urban organic wastes shall be treated properly after disposal due to their large proportion in municipal solid waste. Energy and resource recovery of these types of waste are currently of special interest since these streams are considered full of valuable organic compounds and sources of bioenergy. This study explores the effects of biological pretreatments based on mature compost and waste activated sludge addition to acidogenic fermentation of food waste (FW) for volatile fatty acids (VFA) production. Laboratory-scale experiments were carried out in discontinuous assays of 200 mL effective volume and in semi-continuous fermenters of 4.5 L working under several operating conditions. Discontinuous assays at pH 6 demonstrated a rapid increment of VFA production in the first two days of experiment while changing to pH 7, relatively large increment was observed after 4th day of experiment. For long-term effect observation, semi-continuous fermenters treating FW with an addition of 2.5% w/w mature compost provided reliable results reaching 10.60 ± 0.95 gVFA/L (pH 6) and 15.3 ± 2.1 gVFA/L (pH 7). Changing working pH from 6 to 7 in semi-continuous fermenters showed an increase of propionic acid composition, from 1.98 ± 0.50% to 7.69 ± 1.48%. On the other hand, the pre-treated WAS shown an increment of solubilisation ratio from 3% to 25% with 4h and 30 min of pre-treatment which result the optimal pre-treatment time. Moreover, the WAS pre-treated during 2h 30 min with FW allow the increment from 580 mg VFA/L to 6200 mg VFA/L in FW discontinuous assays after 8 days of discontinues assay. Besides, the VFA distribution was affected by different proportion of WAS with FW.

Keywords Food Waste, biological pre-treatments, acidogenic fermentation, mature compost, extracellular polymeric substances

1. Introduction

In 2013, the Water Environment Federation began using the term of water resource recovery facility (WRRF) instead of well-known Waste Water Treatment Plant (WWTP)[8]. This change was due to the redefinition on how used water is being treated since, within this context, it will not be considered as waste or burden for the society but as a stream full of resources to be recovered. Therefore, the used-water recovery sector enables to retrieve energy and materials such as biohydrogen, biogas, valuable organic compounds, phosphate and ammonia, among many others. The potential of energy in the used-water could lead to achieve positive-energy goal in WWTPs which means that this facility would become energy self-sufficient or even generate profits and will no longer depends on the financial support from Local Council. The Strass and Wolfgangsee-Ischl WWTPs in Vienna [14,19] are good examples to proof the feasibility of positive-energy goal for WWTPs. Other than the biogas produced from anaerobic digestion which leads to electricity generation, the Volatile Fatty Acids (VFA) are also one of the interesting resources that could be obtained from the material recovery of WWTP. The raising concern about climate change and sustainability have led to an increasing awareness of resource recovery [7] and, under this context, acidogenic fermentation by using urban organic wastes is gaining attention. Those urban organic wastes include biodegradable organic compounds generated in urban areas (RES URBIS Project, 2018), including sewage sludge (primary and secondary), Food Waste (FW) and Organic Fraction of Municipal Solid Waste (OFMSW), among others, and are under research to improve the VFA production via acidogenic fermentation. In 2012, approximately 90 million tons of FW was generated in all European countries [3]. This indicated that a huge quantity of VFA could have been recovered through anaerobic acidogenic fermentation, which is a process based on hydrolysis and acidogenic phases from the anaerobic digestion process. The former has been identified as the rate limiting step[10,12] and there are a number of existing pre-treatment methods to enhance hydrolysis step which are usually classified as physical, chemical and biological pre-treatments. Physical pre-treatments (thermal and mechanical) increase the disintegration of cell membranes or specific surface area which can provide better contact between substrate and microorganisms [2]. In chemical pre-treatments, the external addition of chemicals (acids, alkalis or organic solvents) will somehow increase the solubilisation of substrate [17]. Biological treatments include the use of enzymatic bacteria to break the lignin seal and make it more susceptible to microbial attack [18]. Biological pre-treatments are getting more

attention for acidogenic fermentation, since they do not require reagent additions and do not require high energy demands to be applied.

This paper focuses on the enhancement of VFA production from FW by using biological pre-treatments, namely by adding mature compost and pretreated waste activated sludge (WAS) to the FW. In addition, this study provides information about the solubilisation of substrate before and after undergoing the pretreatment.

2. Materials and Methods

2.1 Substrate and inoculum

Mature compost addition in acidogenic fermenters treating Food Waste was used to check its effect on VFA production and its composition and distribution. The FW was collected from university canteen every two weeks. Then it was shredded (Bosch, MMB66G5M) and mixed with deionized water in a proportion of 1:2 by volume, to obtain a concentrated feedstock for fermenters. The FW was stored in refrigerator chamber at 4 ºC until its usage. When the feedstock was needed for acidogenic fermentation, this substrate was mixed with deionized water to control the contents of total solids (TS) and volatile solids (VS) so that their values were within certain range during the experiments. The characterisation of FW collected in different periods is shown in Table 1(a) and 1(b). The mature compost used in the same acidogenic fermentation was collected from a full-scale mechanical-biological treatment (MBT) plant in the metropolitan area of Barcelona. In this MBT plant, tunnel composting is applied to decompose and stabilise anaerobically digested organic fraction of municipal solid waste (OFMSW). This mature compost came from a mixture of anaerobic digestate of source sorted OFMSW and vegetable waste fraction. Once it was collected, it was stored in a covered tank to preserve its original moisture content. Unlike FW, the mature compost was once and, therefore, its characteristics were constant throughout the experiments. The inoculum used was effluent of acidogenic fermenter treating FW at pH 6 and hydraulic retention time (HRT) of 3.5 days [5].

On the other hand, solubilisation assays of waste activated sludge (WAS) at 55 ºC were performed to improve the hydrolysis of FW. To carry out these experiments, thickened WAS was collected from a municipal wastewater treatment plant (WWTP) of the Barcelona Metropolitan Area and stored in the refrigerator chamber at 4 ºC until its use.

Table 1(a). Characteristics of Food Waste from university canteen in corresponding collection period

Parameter	Units	FW1	FW2	FW3	FW4	FW5	FW6
Period	days	1-20	21-40	41-57	58-72	73-96	97-114
pH	-	4.33 ± 0.61	6.54 ± 0.34	6.62 ± 0.75	6.46 ± 0.79	6.65 ± 0.23	6.67 ± 0.42
Total Solids (TS)	% w/w	5.88 ± 1.63	7.31 ± 1.10	7.27 ± 0.35	6.57 ± 0.52	4.76 ± 0.38	4.45 ± 0.15
Volatile Solids (VS)	% w/w	5.51 ± 1.68	6.12 ± 0.75	5.71 ± 0.24	5.46 ± 0.43	3.83 ± 0.24	3.78 ± 0.26
VFA	g/L	1.08 ± 0.16	1.03 ± 0.08	1.21 ± 0.07	1.49 ± 0.18	0.98 ± 0.10	1.32 ± 0.13
Soluble COD (sCOD)	g/L	40.6 ± 5.6	37.0 ± 2.9	38.7 ± 4.3	32.3 ± 14.7	31.1 ± 0.7	45.4 ± 1.6
NH_4^+-N	mg NH_4^+-N/L	14.2 ± 3.9	34.1 ± 4.8	50.5 ± 1.3	26.7 ± 6.2	25.1 ± 7.1	13.0 ± 1.0

Table 1(b). Characteristics of Food Waste from university canteen in corresponding collection period

Parameter	Units	FW7	FW8	FW9	FW10	FW11
Period	days	115-132	133-145	146-155	156-180	181-198
pH	-	7.09 ± 0.40	6.11 ± 1.49	6.96 ± 1.15	5.73 ± 1.28	5.17 ± 0.85
Total Solids (TS)	% w/w	4.71 ± 0.42	7.03 ± 0.44	7.57 ± 0.96	6.39 ± 0.56	6.10 ± 1.23
Volatile Solids (VS)	% w/w	3.90 ± 0.28	6.40 ± 0.84	6.43 ± 1.03	5.79 ± 0.45	5.64 ± 1.18
Volatile Fatty Acids (VFA)	g/L	0.93 ± 0.14	0.95 ± 0.28	0.75 ± 0.15	0.72 ± 0.19	0.83 ± 0.11
Soluble COD (sCOD)	g/L	51.0 ± 4.7	51.8 ± 4.7	14.9 ± 3.4	35.7 ± 21.8	31.9 ± 5.4
NH_4^+-N	mg NH_4^+-N/L	27.4	32.2 ± 12.0	26.6 ± 6.9	79.5 ± 23.8	107 ± 10

2.2 Experimental set-up

The experimental set-up of mature compost experiments was in semi-continuous lab-scale reactors and in batch tests modifying mature composts doses. On the other hand, the solubilisation assays were carried out only in batch test assays.

2.2.1 Batch assays: FW with mature compost

Discontinuous assays were performed in serum bottles of 200 mL effective volume with different mature compost doses (0, 2.5, 3.5 and 4.5% w/w) to study the effects of mature compost on VFA production and distribution serum bottles were filled with inoculum and substrate according to their volatile solids content, to obtain a inoculum to substrate ratio (ISR) of 1:1 by weight. Corresponding mature compost doses (0, 2.5, 3.5 and 4.5% w/w) were then added. Blank samples were prepared as control, including pure inoculum, substrate and mature compost (three times the weight for 4.5% w/w and filling with deionized water). In different periods of time, two batches were carried out operating at pH 6 and pH 7 by using sodium bicarbonate ($NaHCO_3$) and hydrochloric acid (10M HCl) for pH adjustment. Before the bottles were sealed with stopper containing PTFE/Butyl septum, nitrogen gas was flushed through the headspace to remove residual air. These bottles were located inside an incubator (Memmert, Pass-through ovens UF750) working at mesophilic temperature (35ºC). 2.5 mL of sample were taken and centrifuged for VFA analysis where this operation was performed daily from day 0 to 7, and on day 10 to check the stability of VFA production. Every condition and blank samples were performed in duplicate for standard deviation calculation.

2.2.2. Batch assays: FW with WAS

On the other hand, solubilisation assays were performed in bottles of 1L capacity with 900 mL of effective volume. These bottles were kept in an incubator at 55ºC maintaining a constant temperature to determine the optimal contact time to activate WAS enzymes. Once the microorganisms release extracellular polymeric substances (EPS) that are contained in their own metabolic system resulting in autohydrolysis, acidogenic fermentation discontinuous assays with FW were performed in serum bottles of 200 mL effective volume at 35 ºC. These experiments were carried out with different VS contents of FW and activated WAS: i) 20 % VS of FW + 80 % VS of WAS, ii) 50 % VS of FW + 50 % VS of WAS and iii) 80 % VS of FW + 20 % VS of WAS. The bottles of 200 mL were maintained at mesophilic range (35 ºC) during the experiment.

2.2.3 Semi-continuous operation

For this study, 3 jacketed lab-scale reactors with an effective working volume of 4.5 L and mechanically stirred (using IKA-Werker, RW 16 basic functioning at approximately 150 rpm) were used as fermenters at mesophilic conditions working with FW. These fermenters were operated at HRT of 3.5 days and the equivalent quantity of substrate (FW) was fed manually once per day (fed-batch culture). During feeding and draw-off operations, minimum amount of nitrogen gas was flushed through headspace of fermenters to avoid entering air.

At the beginning of experiment, to analyse the long-term effect of biological pre-treatment using mature compost on the acidogenic fermenter, two fermenters were working with addition of mature compost at different doses while one fermenter operated only with FW (reference reactor). At this moment, all fermenters were working at HRT of 3.5 days and pH 6, $NaHCO_3$ was used to increase alkalinity of fermentation broth and to adjust pH to the pre-set value.

Later, in addition to study the effects of biological pre-treatment, pH and HRT were taken into consideration. To evaluate the performance of fermenter at different pH conditions, two fermenters were working at pH 6 and pH 7 respectively to treat the same substrate: FW and 2.5% mature compost. Further changes were made to observe the VFA production by extending HRT from 3.5 to 5 days. The whole experiment was carried out under mesophilic conditions (35ºC). Samples were taken daily on weekdays for continuous assessment of VFA, and other characterisations were analysed once per week.

2.3 Analytical methods

The analysis of soluble COD, Total Solids (TS), Volatile Solids (VS), Total Soluble Solids (TsS), Volatile Soluble Solids (VsS), Total Kjeldahl Nitrogen (TKN) and ammonium ($N\text{-}NH_4^+$) were performed in accordance to the Standard Methods for the Examination of Water and Wastewater (APHA, 2012). For total ammonium nitrogen (TAN) concentration determination, sample was centrifuged at 4,000 rpm for 15 minutes, the supernatant was filtered through 0.45µm pore size regenerated cellulose syringe filter. Proper dilution factor was applied to have it in between 1-100 ppm which was determined using high performance ammonium ion selective electrode (Thermo Scientific, Orion 9512HPBNWP). The pH was determined by pressurized gel-electrolyte electrode of Mettler Toledo (HA405-DPA-SC-S8/225). The VFA concentration of filtered sample acidified with 85% phosphoric acid was determined by gas chromatography (Shimadzu GC 2010 plus) equipped with a capillary column (Nukol™, 15 m x 0.53 mm x 0.5 µm) and flame ionization detector (FID). The initial temperature of capillary column was 80 ºC and it heated by 10ºC per minute until 110ºC. Then the temperature is increased 15 ºC per minute to 145 ºC and, finally, 20ºC per minute to 190 ºC. The temperature was 280 ºC and 300 ºC to the injector and detector respectively. The carrier gas was helium, the fuel gas was hydrogen and the

oxidizing gas was synthetic air. Hence, acetic, propionic, isobutyric, butyric, isovaleric, valeric, isocaproic, caproic and heptanoic acids were detected by the programmed method for this gas chromatograph.

3. Results and discussion

3.1. Acidogenic fermentation of FW and mature compost at pH 6

Discontinuous batch to figure out the possible improvement on acidogenic fermentation of FW was carried out by adding mature compost with different doses from 2.5% to 4.5% w/w. Figure 1 shows the VFA production of this batch working at pH 6. The results showed that in short-term period (10th day), increment of 10.2%, 8.8% and 5.8% was observed when 2.5%, 3.5% and 4.5% w/w of mature compost was added respectively. Within one day, the batch containing at least inoculum and FW increased to reach a steady VFA concentration which then only small changes can be observed. This could be related to the easily fermentable organic material of fresh FW. The VFA concentration of the batch containing only inoculum was decreasing continuously showing a net consumption of VFA, starting with 7.11 gVFA/L and finishing with 6.02 gVFA/L. Obviously, bottles containing only FW and mature compost could have inherent bacteria, however, these bacteria did not contribute much to the formation of VFA in acidogenic fermentation. Analysing the VFA distribution between acidogenic fermentation of FW with and without addition of mature compost, in this batch, there was not a clear difference, every individual VFA changed in a similar way. A bigger change in VFA composition can be seen from day 0 to day 1, this was where the most VFA were produced and they reached stable conditions afterwards. From Figure 2, it can be clearly seen that acetic acid was the most VFA produced followed by hexanoic and butyric acids with 46.2-46.9%, 27.6-27.7% and 19.9-20.2%, respectively.

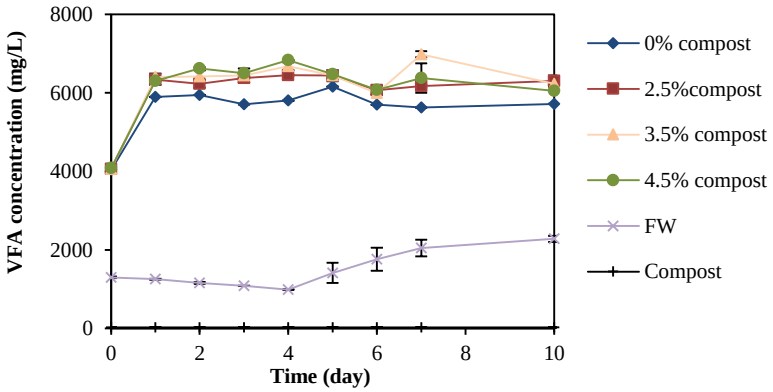

Fig. 1 Progress of VFA production in batch of acidogenic fermentation of FW at 35 ºC and pH 6

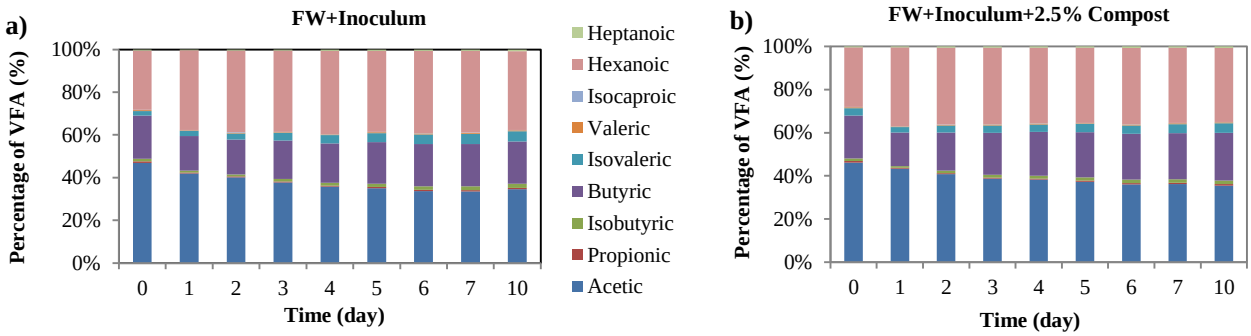

Fig. 2 Individual VFA distribution in batch treating FW with 0% (a) and 2.5% (b) mature compost at pH 6

To study the effects in long-term, three semi-continuous reactors were put into operation. Figure 3 shows the profile of VFA concentration in three different fermenters and percentage of mature compost addition in the influent. The fermenter with FW only was considered as reference. When 2.5% w/w of mature compost was mixed with FW as feeding, an increase of VFA production from the reference fermenter can be observed. The VFA yield reached its maximum 0.33 gVFA/gVS one week after start adding 2.5% w/w of mature compost, operating at an average of 13.6 ± 9.0%. This results were consistent with the study of Fdez.-Güelfo et al. (2011) who tested the biological pretreatment of OFMSW using

mature compost and reported that 2.5 % v/v was enough to increase the soluble chemical oxygen demand (sCOD) by roughly 50%, which was the indicator of solubilisation yield in that study. In the other acidogenic fermenter fed with FW and 3.5 % w/w of mature compost, the production of VFA could merely grow an average of 12.4 ± 8.1% than the reference fermenter. Therefore, it yielded similar results than the fermenter working with 2.5% w/w mature compost. To further understand the relation between percentage of mature compost and VFA production, percentage of mature compost in the feeding was decreased from 3.5 to 1.5% w/w. Even though the percentage of mature compost was lowered, the VFA production seemed to not be affected, yielding a total VFA concentration close to fermenter with 2.5% w/w mature compost. Mature compost contained hydrolytic bacteria which reacted to hydrolyse complex organic compounds. In both long-term and short-term periods, with the presence of these bacteria, VFA production could be limitedly boosted up in the beginning and maintained its dominance during the experiment, without considering the quantity of doses. Generally, higher solubilisation expressed in terms of sCOD was detected in the fermenters working with added mature compost. This might due to that mature compost consists of a variety of microorganisms, aerobic and anaerobic, with hydrolytic enzymes whose are capable to solubilize difficult biodegradable organic matter [6].

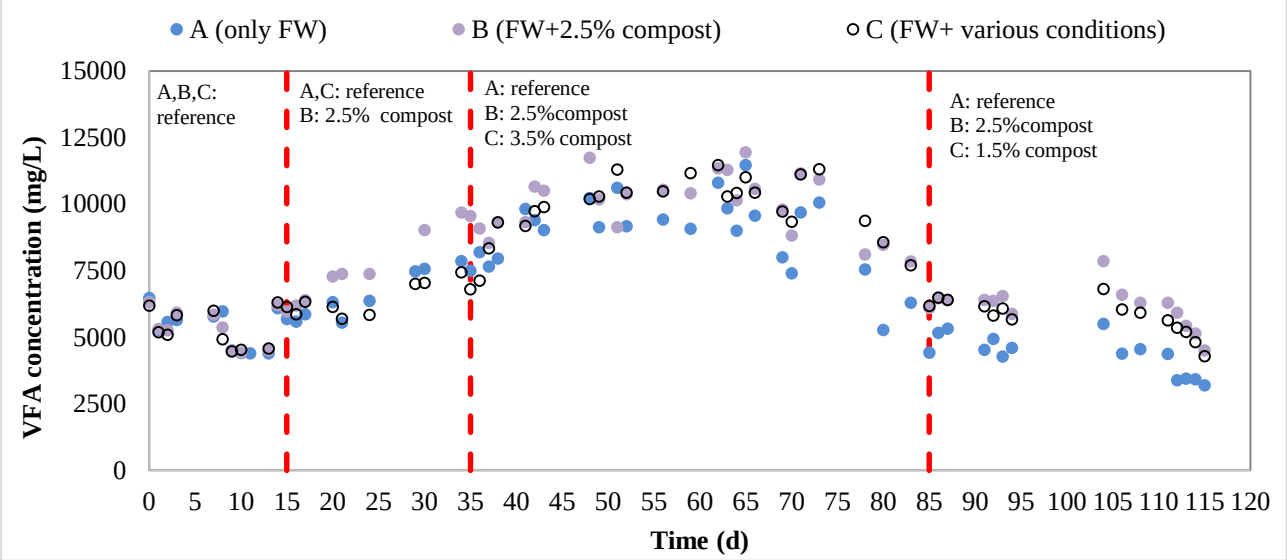

Fig. 3 VFA concentration in acidogenic fermentation of FW with different percentage of mature compost (temperature 35ºC, pH near 6, HRT 3.5 days)

3.2. Acidogenic fermentation of FW and mature compost at pH 7

Figure 4 shows the profile of VFA concentration of batch treating FW under 35ºC and pH 7. From the results of batch assays, VFA concentration increased slowly from day 0 to day 4. After being at steady stage for 4 consecutive days, more VFA started to be produced after day 4 and reached their maximum VFA concentration at day 7. In this batch test, the bottles containing 0% mature compost were following the VFA production of those containing mature compost ranging from 2.5% to 4.5% and their difference was relatively small. As shown in Figure 5, the distribution of individual VFA of fermentation broth treating FW with 0% and 2.5% mature compost was practically the same, having acetic acid as predominance product followed by hexanoic and butyric acids. Working under neutral pH, up to 7.4% propionic acid was produced when 2.5% mature compost was added and 6.6% propionic acid when there was not presence of mature compost. These results confirmed a different metabolic path in the production of VFA when pH was raised from 6 to 7.

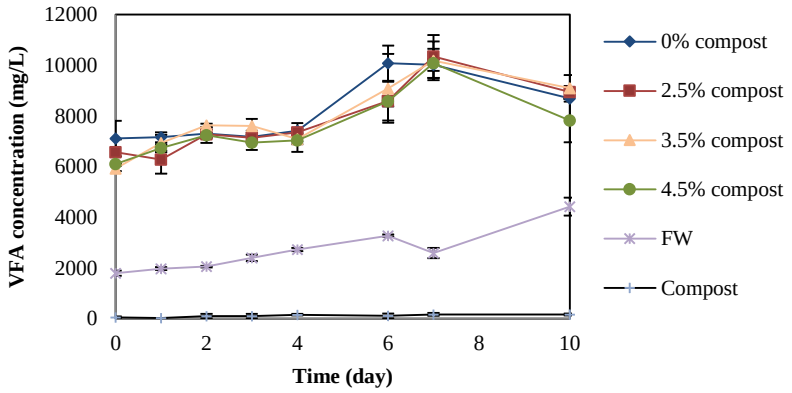

Fig. 4 Progress of VFA production in batch of acidogenic fermentation of FW at 35 ºC and pH 7

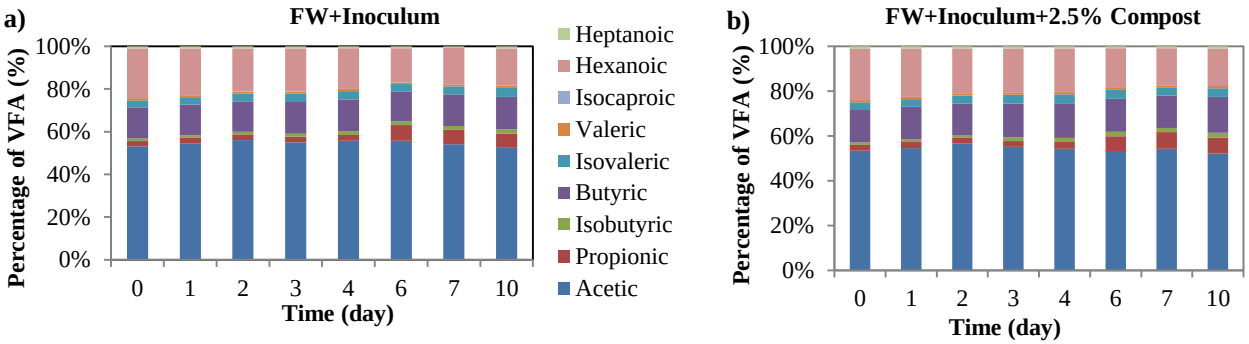

Fig. 5 Individual VFA distribution in batch treating FW with 0% (a) and 2.5% (b) mature compost at pH 7

Several changes were applied to fermenters and their results were compared with the reference fermenter. As shown in Figure 6, after changing to pH 7, there was not lag phase as the bacteria responded quickly and total VFA concentration started to increase 5 days later. It seems like a stepwise increment from 120 to 125 day and from 129 to 135 day. A large gap between fermenters working at pH 6 (A and B) and pH 7 (C) can be noted by the end of the first operation period. A 200% improvement was recorded at this moment. Based on the results of batch experiments, there were possibilities to increase VFA production when working at longer HRT. At longer HRT, more time was given to bacteria to undergo decomposition of long chain organic molecules, especially the time-consuming hydrolysis step due to its lower reaction rate. A small increment during second operation period proved this hypothesis. It could be possible to achieve higher VFA production, however, risk of interference of methanogenic activities should be taken into account [9]. At pH 7 and HRT of 5 days, the effect of mature compost on VFA production was not so significant. Comparing fermenter B (without mature compost) and C (with 2.5% mature compost) which were working under same conditions of pH and HRT, after having an adaptation period of 10 days, their differences in VFA concentration narrowed from 3,170 mgVFA/L to 1,423 mgVFA/L. The fermenter containing mature compost was still producing the most VFA, namely, VFA production of acetic, propionic and butyric acids at 48.7 ± 3.0%, 4.6 ± 0.9% and 18.4 ± 2.8%, respectively.

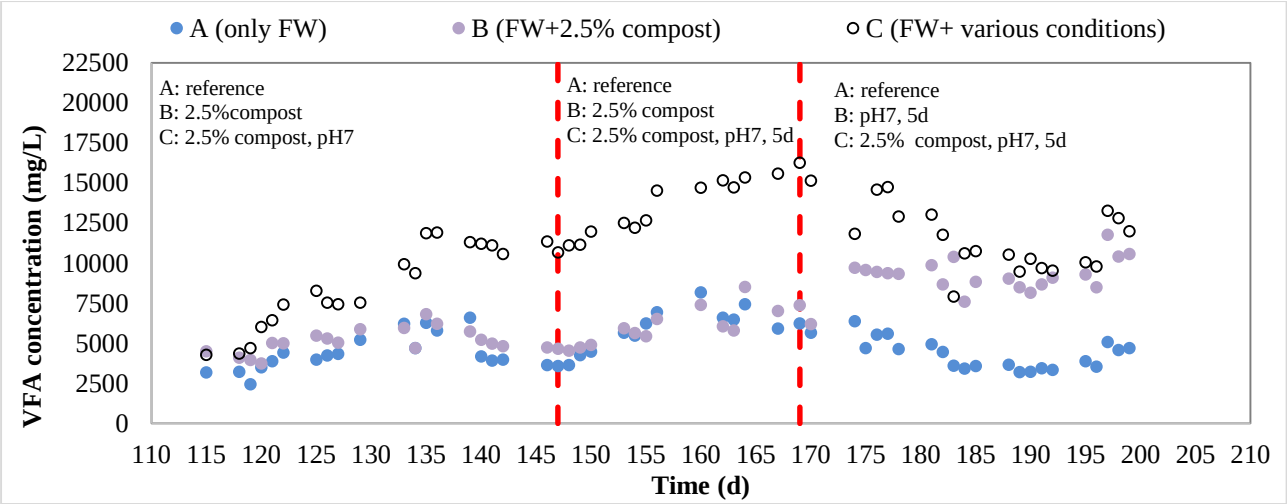

Fig. 6 VFA concentration in acidogenic fermentation of FW with different working pH, HRT and percentage of mature compost (temperature 35ºC)

3.3. Co-fermentation of pretreated WAS and FW

Furthermore, the enhancement of VFA production favouring the autohydrolysis pre-treating of WAS was studied. As shown by Carvajal et al. (2013), when treating the WAS at 55 ºC, the microorganisms release extracellular polymeric substances (EPS) that are contained in their own metabolic system resulting in autohydrolysis with high solubilisation of organic matter. The EPS consist of a complex high-molecular-weight mixture of proteins, humic acids, polysaccharides, glycoproteins, nucleic acids and phospholipids [11,15]. The EPS recovered is currently considered as potential resource and thus it plays an important role in paradigm shift from wastewater treatment to biorefinery [13,16]. Moreover, it is important the study of the pre-treatment of WAS and subsequent co-fermentation of FW and WAS improving the hydrolysis. Hence, preliminary assays were performed to analyse the maximization of solubilisation of pre-treated WAS at 55 ºC. First of all, the increasing of solubilisation (as VsS/VS %) was studied with WAS samples at 55 ºC in the incubator during 9h. As can be seen in Figure 7, the solubilisation ratio grew from 3% to 26% in this period due to EPS release. However, it is important to study the optimal contact time to activate these enzymes. Arias et al. (2018) did similar studies and showed that 8 h was the optimal time of WAS pre-treatment. In this study, 4h and 30 min were sufficient with 25% of solubilisation compared with 9h that obtain 26% of solubilisation. It is important to know that an increasing contact time would not entail a significant increase of substrate solubilisation, whereas it would increase the amount of energy needed for the pretreatment. Thus, three studies at different contact time were performed.

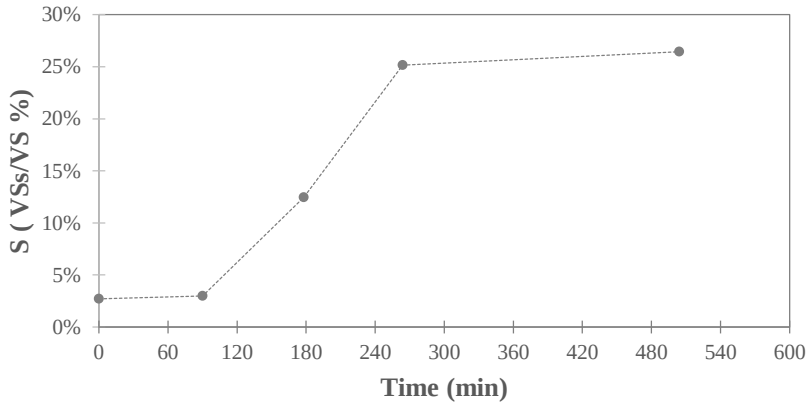

Fig. 7 Change of solubilisation of WAS under thermal pre-treatment at 55 ºC

First of all, an experiment with 4h pre-treated WAS with FW were carried out changing the VS proportion (50 % VS FW + 50 % VS WAS, 80 % VS FW + 20 % VS WAS) to test the effect at different ratio at mesophilic temperature (35 ºC). As shown in Figure 8, no synergies were found in any case probably due to enzyme inactivation of EPS. This inactivation could be due to a long pre-treatment time of WAS. Furthermore, the FW had an initial value of solubilisation higher than

WAS causing a false “dilution” effect in samples with mixture of pre-treated WAS and FW. Due to this, seems that samples with WAS had less solubilisation than FW.

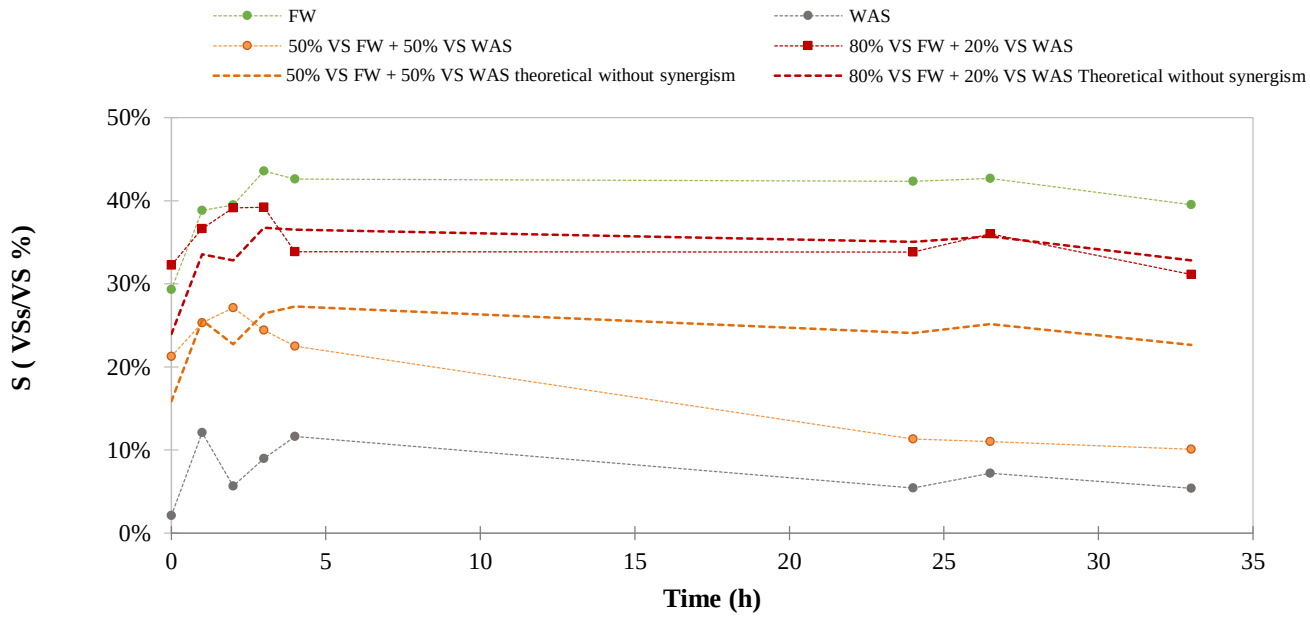

Fig. 8 Change of solubilisation of FW with WAS under thermal pre-treatment at 55 ºC during 4h (discontinuous curves are referred to the expected values of solubilisation if no synergism was observed)

Therefore, the contrary strategy was followed pre-treating WAS until the solubilisation ratio starts to increase to assure that microorganisms release EPS (1h 30 min at 55 ºC). In this case, no hydrolysis improvement of FW was observed probably due to a short time of WAS pre-treatment that may not have been enough to activate the enzymes as can be seen in Figure 9. Besides, the decreasing solubilisation in the samples with pre-treated WAS were found again due to the same effect as previous experiment. Therefore, the working methodology was changed to obtain better representative results not affected by high FW solubilisation initial values.

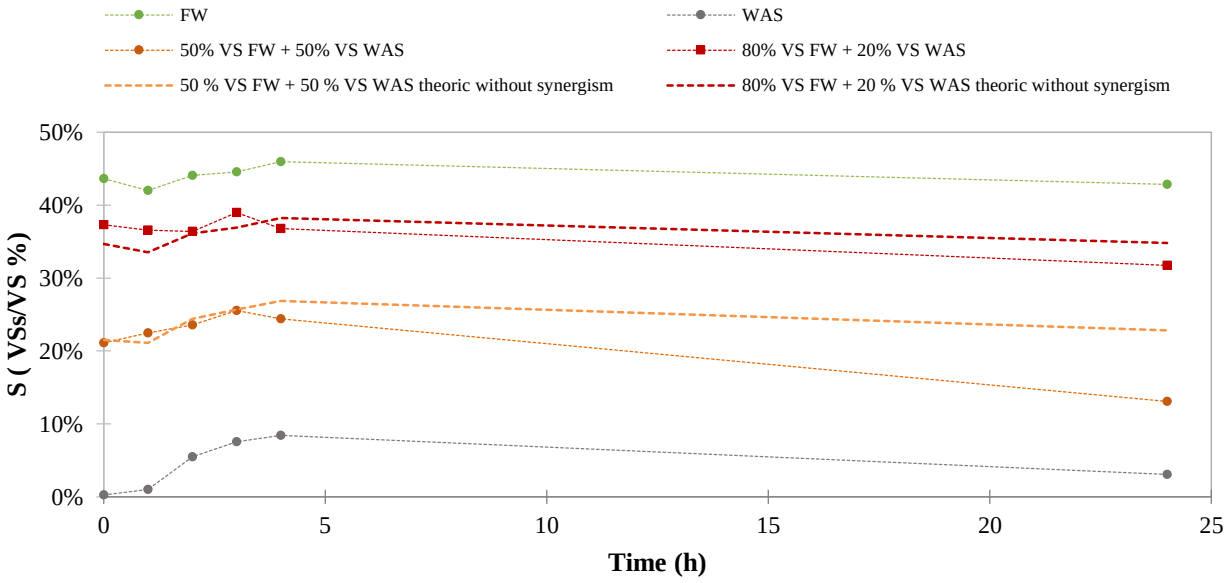

Fig. 9 Change of solubilisation of FW with WAS under thermal pre-treatment at 55 ºC during 1h 30 min (discontinuous curves are referred to the expected values of solubilisation if no synergism was observed)

Once the two extremes were checked pre-treating WAS (1h 30 min and 4h), it was decided to test the middle extreme pre-treating WAS during 2h 30 min. Then, the WAS was mixed with FW to do an acidogenic fermentation discontinuous assay analysing the VFA concentration to obtain more information than previous ones. Unlike the previous assays,

promising results were obtained with different content of FW and activated WAS changing the VS proportion: i) 20 % VS of FW + 80 % VS of WAS, ii) 50 % VS of FW + 50 % VS of WAS and iii) 80 % VS of FW + 20 % VS of WAS. The study was performed for 10 days analysing the VFA content and distribution showing an improvement in the total production as can be shown in Figure 10. An important improvement was obtained specially in 20 % VS of FW + 80 % VS of WAS and 50 % VS FW + 50 % VS WAS incrementing the total production from 580 mg VFA/L to 6090 and 6200 mg VFA/L respectively. These results seem to confirm the autohydrolysis effect of pre-treating WAS with more VFA production compared with the condition 80% VS FW + 20 % VS WAS, where minor production of VFA was obtained. Nevertheless, it is important to do more experiments testing the effect of FW and WAS separately to know the individual effect of each other.

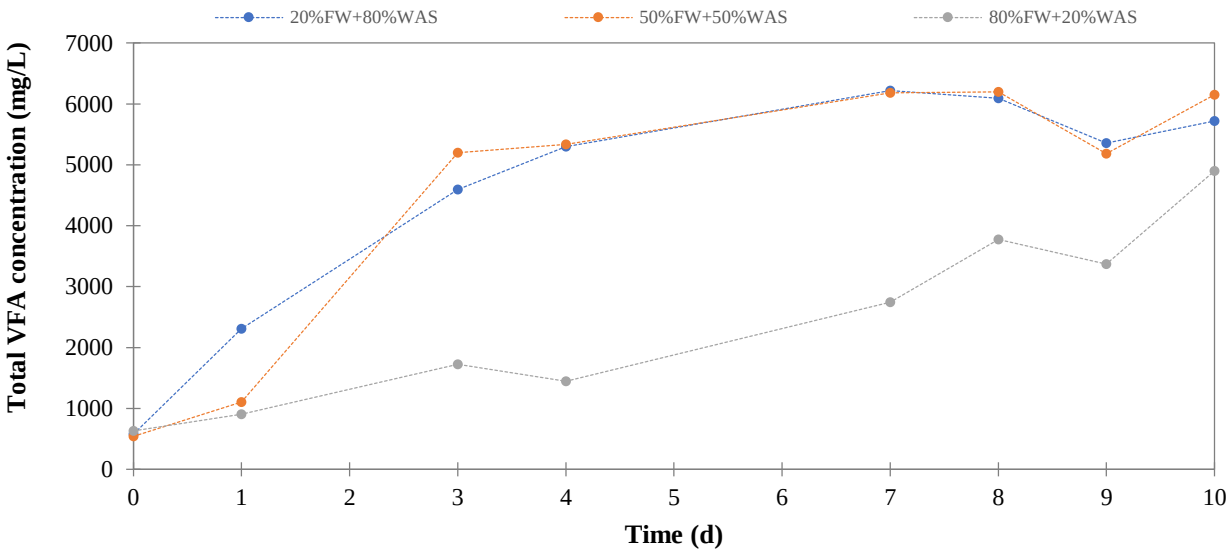

Fig. 10 Total VFA of discontinuous assay with 2h 30 min pre-treated WAS

The effect of different pre-treated WAS not only affect the VFA production but also the VFA distribution. In the three conditions, a stable VFA distribution was shown from 7 day until the end (Figure 11). In the case of 20%VS FW + 80%VS WAS, the distribution was dominated by acetic acid (50%), butyric acid (30%) and propionic acid (10%). The second condition (50%VS FW + 50%VS WAS) had a similar total VFA production but a different distribution with 30% acetic acid, 20% butyric acid, 17% propionic acid and 16% valeric acid being an interesting distribution due to balanced acids proportion. Finally, taking into account the VFA distribution of FW, the third condition showed an expected distribution with a huge quantity of acetic acid (95 %) due to acidic pH of FW (between 3.5-4.0). Moreover, the VFA distribution of this experiment was not been effected by the initial distribution of WAS which had 60% acetic acid, 22% propionic acid, 4% isobutyric acid, 6% isovaleric acid and 2% valeric acid, being a distribution very different than obtained in the these discontinuous assays. Hence, it is proved that pre-treated WAS effect the production and distribution of VFA, but more studies are needed to verify the effect.

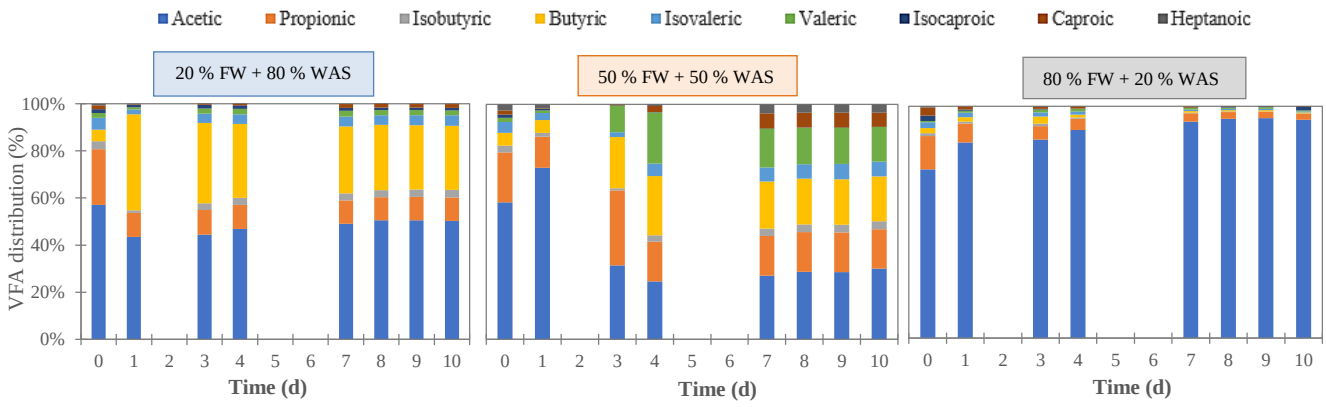

Fig. 11 VFA distribution in different conditions when co-fermenting FW and pretreated WAS

4. Conclusions

The biological pretreatment using mature compost was useful to enhance the hydrolysis and, as consequence, increase VFA production from Food Waste: (i) in short-term analysis, the addition of mature compost increased the VFA production from Food Waste only between 5.8% and 10.2% when working at pH 6; while working at pH 7, a considerable amount of propionic acid (763.7 mg VFA/L or equivalent to 7.4 %) was produced with addition of 2.5 % mature compost, (ii) in semi-continuous fermenters operated at pH 6, with 2.5% and 3.5% w/w of mature compost added to the FW, nearly 13.6 ± 9.0% and 12.4 ± 8.1% more on VFA concentration was obtained, respectively, similar to batch test, semi-continuous fermenters operated at pH 7 were able to increase the propionic acid production from 0.7 % to 30.5% (iii) the autohydrolysis pre-treatment of WAS at 55ºC promotes the solubilisation from 3% to 26%,(iv) 2h 30 min pre-treated WAS promotes higher increment of VFA in FW discontinuous assays and the VFA distribution is affected by pre-treated WAS.

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