

Background

Acidogenic fermentation is an intermediate stage of anaerobic digestion, where volatile fatty acids (VFA) with a low carbon number ($C_2 - C_6$) are produced. VFA can be used as platform chemicals for “green” chemistry, e.g., for biodegradable solvents, bioplastics (i.e., polyhydroxyalkanoates) and biofuels, or as substrate for biological transformations (e.g. microbial fuel cells, biological nutrient removal)

Experimental conditions

Substrate	Apple pulp
Substrate : inoculum COD ratio	4:1
Initial concentration	55 gCODt/kg_ML
pH	5.2 - 5.5
Temperature	35 °C
Working volume	100 ml
Fermentation type	batch (in duplicates)
Duration	15 days
Inoculum	1: Wastewater activated sludge (pre-treated: pH 5.5, heating 70 °C for 1h) 2: Rumen juice (no pre-treatment)

COD(s,t): Chemical Oxygen Demand (soluble, total); ML: Mixed Liquor; FM: Fresh Matter; TS: Total Solids; VS: Volatile Solids; GC: Gas Chromatography; TCD: Thermal Conductivity Detector; FID: Flame Ionization Detector; PCR: Polymerase Chain Reaction; DGGE: Denaturing Gradient Gel Electrophoresis

Results

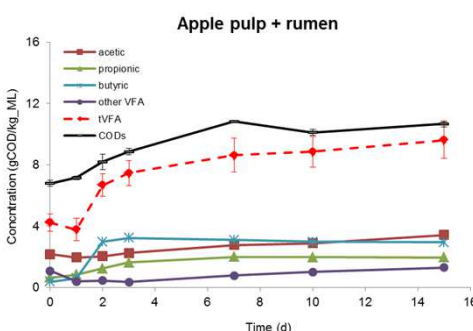
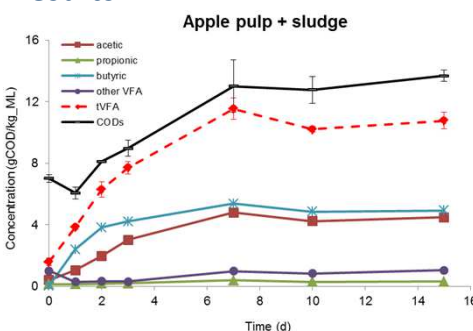


Fig. 1: Concentration of metabolites during acidogenesis of apple pulp (average of two reactors; tVFA: total VFA)

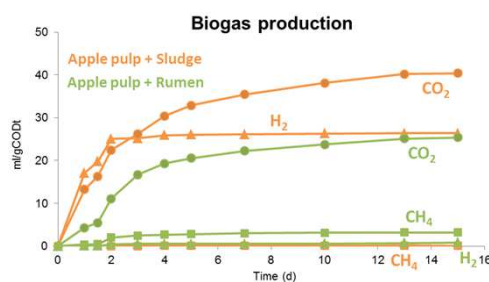


Fig. 2: Cumulated biogas production during acidogenesis of apple pulp

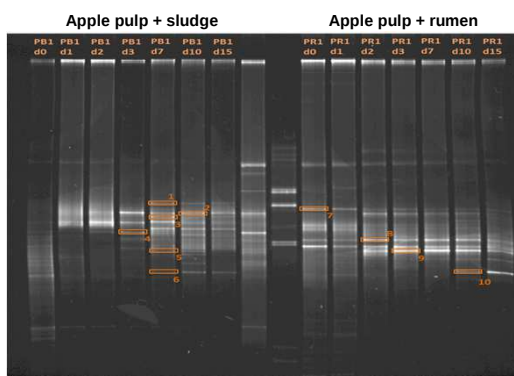


Fig. 3: DGGE gel for one reactor from each condition. Lanes correspond to different fermentation days. Bands represent different microorganisms.

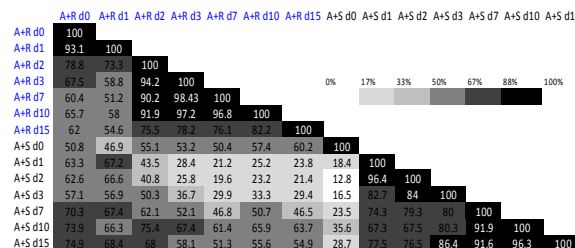


Figure 4: Matrix of similarity of microbial communities identified in Fig. 3 (A: Apple pulp; S: Sludge; R: rumen ; one reactor from each condition)

Table 2: Microorganisms identified in Fig.3 and activity known in literature

1. <i>Clostridium straminisolvans</i> (F)	Cellulose degradation
2. <i>Acetomicrobium flavidum</i> (B)	Acetic acid, ethanol, H ₂
3. <i>Clostridium thermocellum</i> (F)	Acetic acid, ethanol, lactic acid
4. <i>Bacterium NLAE</i>	n.i.
5. <i>Clostridium</i> sp. strain Z6 (F)	Often isolated in anaerobic reactors
6. <i>Ethanoligenes harbinense</i> (F)	Ethanol fermentation
7. <i>Aeromonas caviae</i> (P)	Ethanol, acetic, lactic acid
8. <i>Selenomonas ruminantium</i> (F)	Acetic, propionic, butyric, lactic acid
9. <i>Prevotella bryantii</i> (B)	Acetic, butyric acid
10. <i>Prevotella</i> sp. (B)	n.i.

F: Firmicutes; B: Bacteroidetes; P: Proteobacteria; n.i. non identified;
NLAE: National Laboratory for Agriculture and the Environment

Conclusions

- tVFA concentrations up to 11.5 and 9.6 gCOD/kg_ML with sludge and rumen juice as inoculum, respectively. Corresponding conversion yields : 21 and 18 % CODt , respectively
- Main metabolites (Fig.1-2)
 - A+S: Acetic, butyric acid, CO₂ and H₂, *no propionic acid*
 - A+R: Acetic, butyric, propionic acid, CO₂ and little CH₄, *no H₂*
- Similarities of microbiological profiles are mainly observed between neighbouring days of the same inoculum (Fig. 4)

Perspectives

In the long term, such combined information could permit the development of fermentation systems for targeted and selective production of VFA

Objectives

- To determine and compare the efficiency of acidogenic fermentation of apple pulp by two different microbial communities
- To identify bacterial species involved in acidogenic fermentation
- To investigate the relationship between the metabolic and the microbial profile of the fermentation

Analysis

Substrate & inoculum

COD, TS, VS

Gas

Biogas volume (manometric)

Biogas composition (GC-TCD)

Centrifuged mixed liquor

Supernatant → CODs, metabolite concentration (GC-FID)

Pellet → Microbiological analysis (PCR-DGGE, sequencing)

Table 1: Characterisation of substrate and inoculum

	COD (g_COD/g_FM)	TS (%_FM)	VS (%_TS)
Apple pulp	0.36	22.2	99.1
Sludge	0.019	2.33	43.0
Rumen juice	0.041	3.93	73.7