178th OMICS Group Conference

FEASIBILITY OF BIOFUELS PRODUCTION: COMBINING H_2-CH_4 AND LIPID PRODUCTION FROM FOOD WASTES USING MIXED ANAEROBIC MICROFLORA

X. Gómez, C. Fernández, EJ. Martínez, J. Fierro, F. González-Ándres

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Instituto de Medio Ambiente, Recursos Naturales y Biodiversidad

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OMICS Group Conferences
Accelerating Scientific Discovery

5th World Congress on Biotechnology

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- **IRENA**
- **Food waste valorisation**
- **Digestion and fermentation**
- **Coupling H_2-CH_4 production**
- **Feasibility of lipid production from the process**


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The research Group of Chemical Engineering, Environmental and Bioprocess (located at IRENA) has dedicated its activity to the valorisation of waste

In the last ten years our research work has focus on:

Energy recovery from organic waste: anaerobic digestion and pyrolysis.

Wastewater treatment by MEC and MFC.

Production of bio-fertilizers.

Hydrogen production from biological fermentation of organic waste

Development of prototypes for energy recovery

FOOD WASTES VALORISATION

- **Food wastes: food losses – food processing wastes**

Edible food
Discarded in different stages of the food supply chain

- Production
- Postharvest
- Handling
- Processing
- Distribution
- Consumption

utilization and disposal of food waste should yield benefits to the industry, society, and environment

FOOD WASTES VALORISATION

Extracting high added-value products

Phenols and carotenoids
Pectin
Insoluble fibres
Proteins

Pre-treatments
Molecule separation
Extraction
Isolation and Purification
Product formation

Biofuels-production

H_2 – CH_4 – lipid production

CHEESE WHEY VALORISATION

Cheese whey (CW) is a by-product from cheese factories that represents between 85 and 90% of the total volume of processed milk.

Lactose is the main component (4.5–5%), but other substances are also present:

proteins (0.6–0.8%),
lipids (0.4–0.5%)
and salts (0.7%)

↓

Proteins concentrates
Saccharide mixtures

Whey treatment

- Skimming for casein fines and whey cream removal
- Protein concentration by membrane filtration
- separation of glycoproteins in liquid form (heat coagulation, cooling, precipitation and centrifugation)
- Lactose recovery: time-temperature depended crystallisation by adding seed crystals

Animal feeding

Biofuels-production

H_2 – CH_4 – lipid production

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FOOD WASTES FERMENTATION

REFERENCIA PROYECTO: IPT-2012-0144-120000

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

ANAEROBIC DIGESTION

FERMENTATIVE H_2 PRODUCTION

Single stage process

Two-stage: Evaluating hydrolysis and H_2 production

Stream Recycling

Comapitol

Fertilizantes y abonos Ecológicos

Combustibles Abonos Piensos Toledo

BIOMASA PENINSULAR

CHEESE WHEY FERMENTATION

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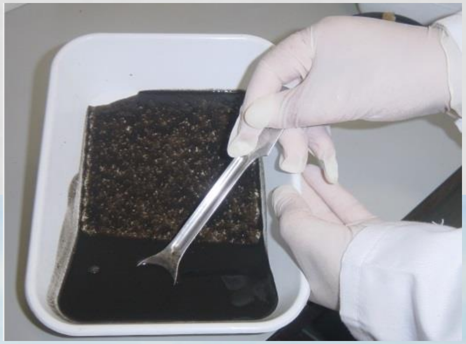
ANAEROBIC DIGESTION
FERMENTATIVE H_2 PRODUCTION

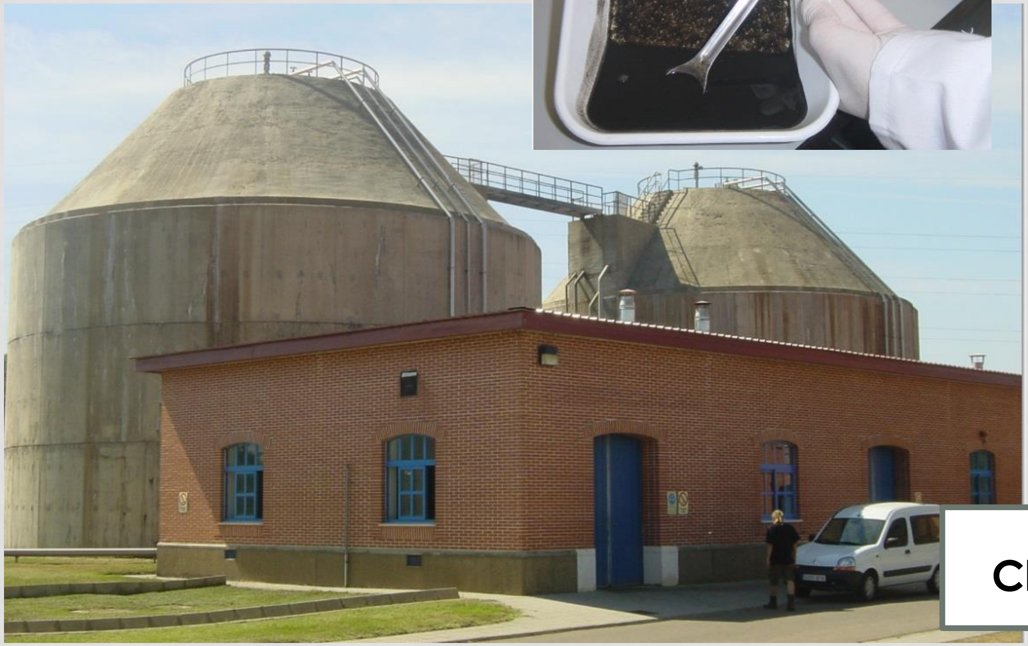
Single stage process
Two-stage: Evaluating hydrolysis and H_2 production
VFA accumulation
Membrane separation for effluent clarification

MATERIAL & METHODS

Inoculum: WWTP of city of León

Digesters: WAS and primary sludge





Parameters	Units	Inoculum
TS	(g L^{-1})	18.3 ± 0.1
VS	(g L^{-1})	9.1 ± 0.1
COD	(g L^{-1})	25.6 ± 4.6
Alkalinity	(g L^{-1})	1.8 ± 0.2
KN	(g L^{-1})	1.3 ± 0.1
TP	(g L^{-1})	0.5 ± 0.1
NH_4^+	(mg L^{-1})	578 ± 21
K^+	(mg L^{-1})	19.1 ± 5.2
Na^+	(mg L^{-1})	49.8 ± 9.1

Chemical characteristics of inoculum

MATERIAL & METHODS

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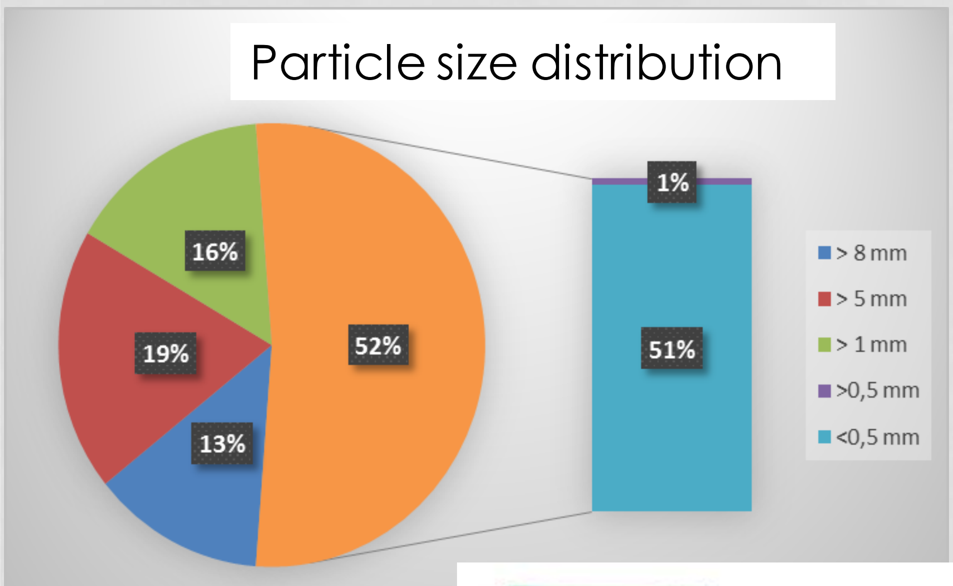
Substrate

Food wastes: Obtained from food processing industry elaborating salads and fresh packed fruits.



Parameters	Units	Food wastes
TS	(g kg^{-1})	123.7 ± 2.2
VS	(g kg^{-1})	115.1 ± 2.7
COD	(g Kg^{-1})	163.8 ± 7.6
Organic matter	(%)	86.4 ± 4.0
N	(%)	1.5 ± 0.1
Carbohydrates	(%)	44.5 ± 2.2
Cellulose	(%)	16.7 ± 0.8
Hemicellulose	(%)	19.2 ± 1.2
Ash	(%)	7.1 ± 0.4

JWCE Muffin Monster

Chemical characteristics of Food Wastes

MATERIAL & METHODS

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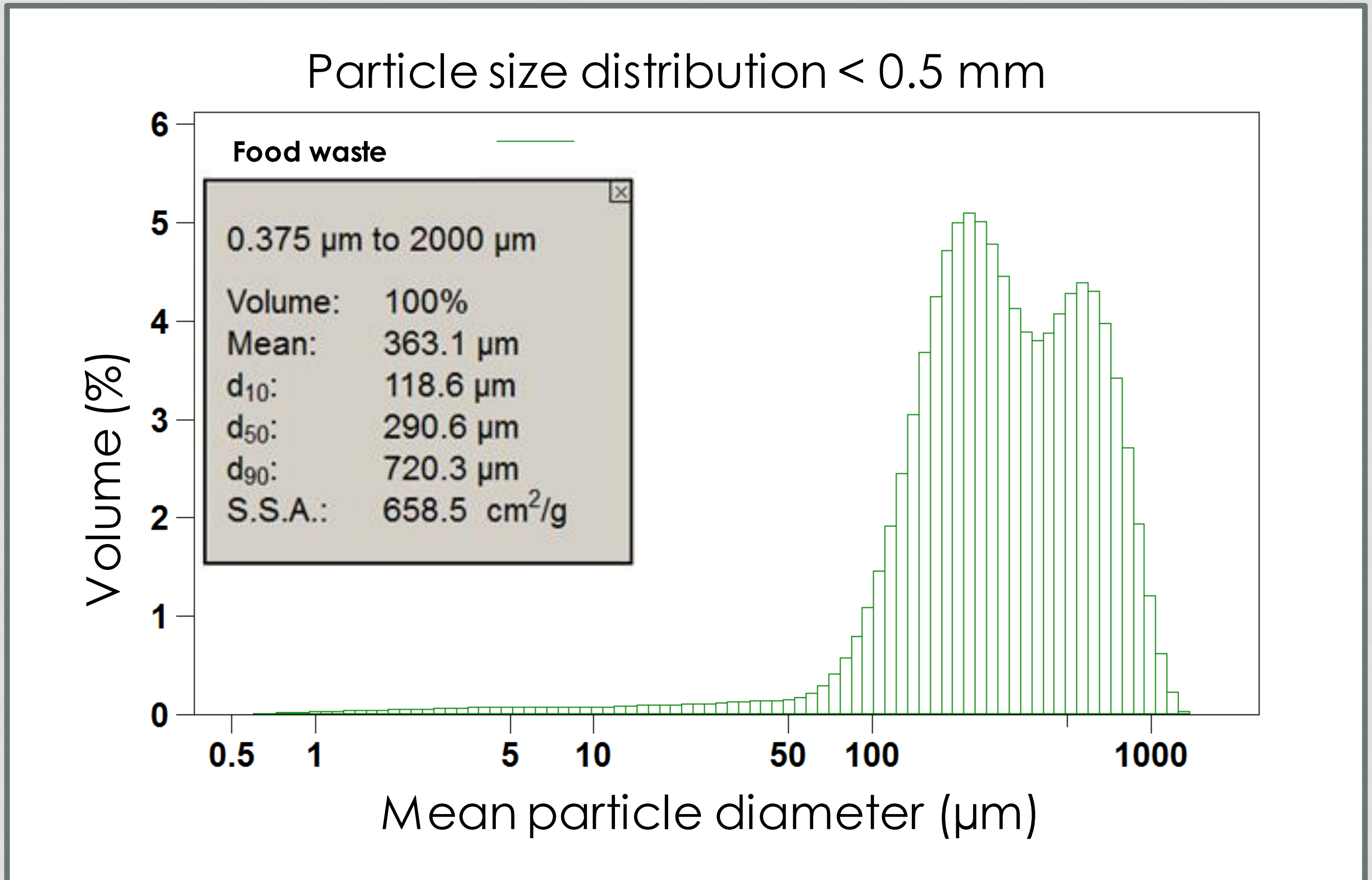


Particle size analysis was carried out using a Laser Diffraction particle Size Analyser LS 13 320 Beckmann Coulter. Samples were previously diluted in tap water for analysis. 10 measurements were performed for each sample

MATERIAL & METHODS

Substrate

Cheese whey: Obtained from Cheese processing factory (Zamora (Spain))

The CW liquid effluent was obtained after treatment with a membrane separation unit designed to recover proteins, thereby resulting in a liquid waste stream with poor nitrogen content

Parameters	Units	CW
TS	(g L^{-1})	33.1 ± 0.1
VS	(g kg^{-1})	30.1 ± 0.1
COD	(g Kg^{-1})	38.4 ± 1.4
Alkalinity	(mg L^{-1})	370 ± 10
KN	(g L^{-1})	0.4 ± 0.1
NH_4^+	(mg L^{-1})	26 ± 2.2
K^+	(mg L^{-1})	639 ± 30
Na^+	(mg L^{-1})	167 ± 10
Cl^-	(mg L^{-1})	487 ± 20

Chemical characteristics of CW

MATERIAL & METHODS

Digestion and fermentation: Batch

Experiments were carried out in Erlenmeyer flasks of 250 mL

Substrate – Inoculum ratio: Controlled based on desired process performance.

Tap water was added when needed to complete a 250 mL volume

Replicates: measuring gas production and composition.

Control: Batch reactor containing only inoculum was used as blank.

Temperature: 34°C, this being controlled by a water bath. Agitation was provided by means of magnetic stirrers.

MATERIAL & METHODS

Digestion under mesophilic conditions
3 L volume reactor

Analytical techniques

Kjeldahl nitrogen, TS, VS, COD, alkalinity, ammonium, and pH

Biogas composition and VFA (Varian CP 3800 GC)

Thermal analysis
FTIR spectroscopy
NMR

Soxhlet method

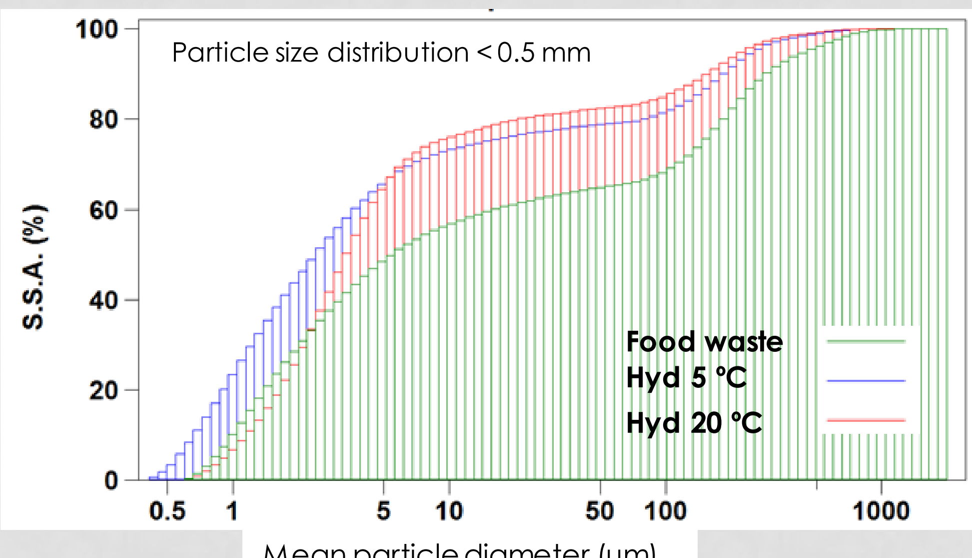
Digestion under thermophilic conditions
5 L volume reactor

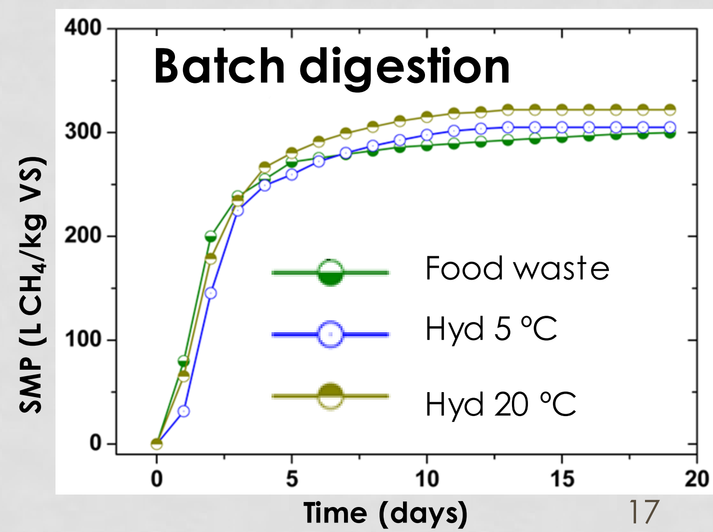
RESULTS

Hydrolysis of vegetable wastes (3 d period) at 20 and 5 °C.

	Mean µm	S.S.A. cm²/g
Food waste	91.1	659
Hydrolysis 5ºC	45.7	1312
Hydrolysis 20ºC	37.6	1596

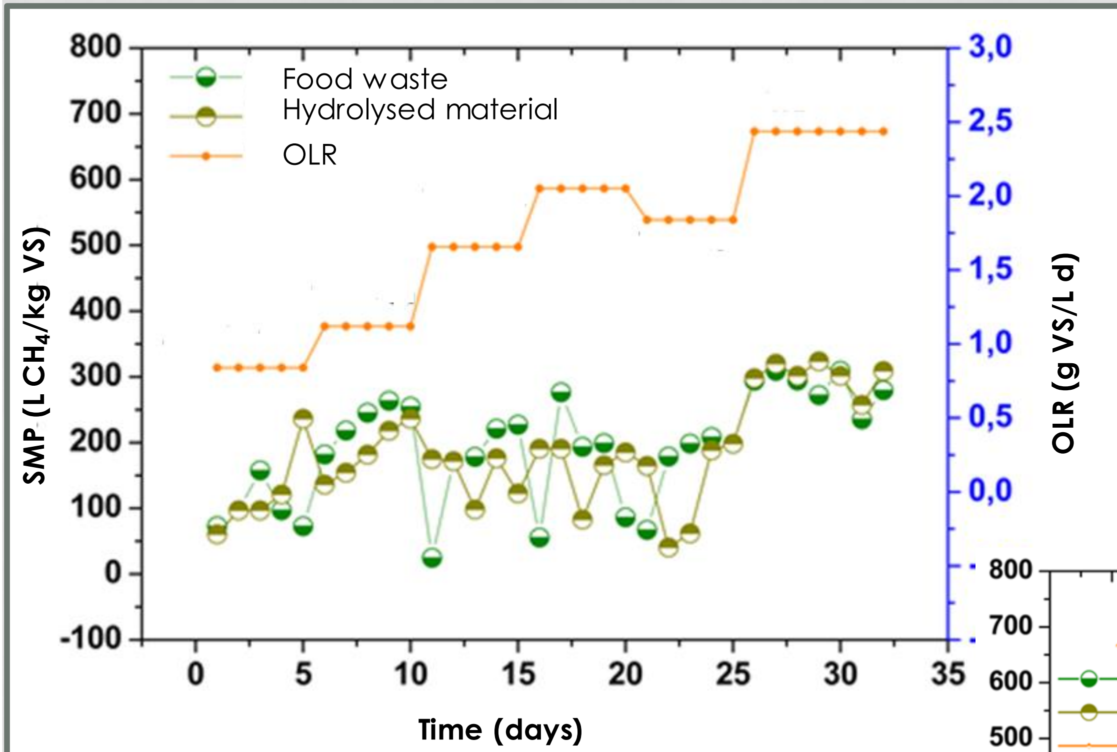
Hydrolysis		20°C	5°C
Gas production (mL)		272.5	140
Gas Composition	% CO_2	99.2	99.6
	% CH_4	0.8	0.4
COD soluble (g COD/L)		49.7	38.5
VFA			
Acetic (mg/L)		526	374
Butyric (mg/L)		65	69
Valeric(mg/L)		232	114



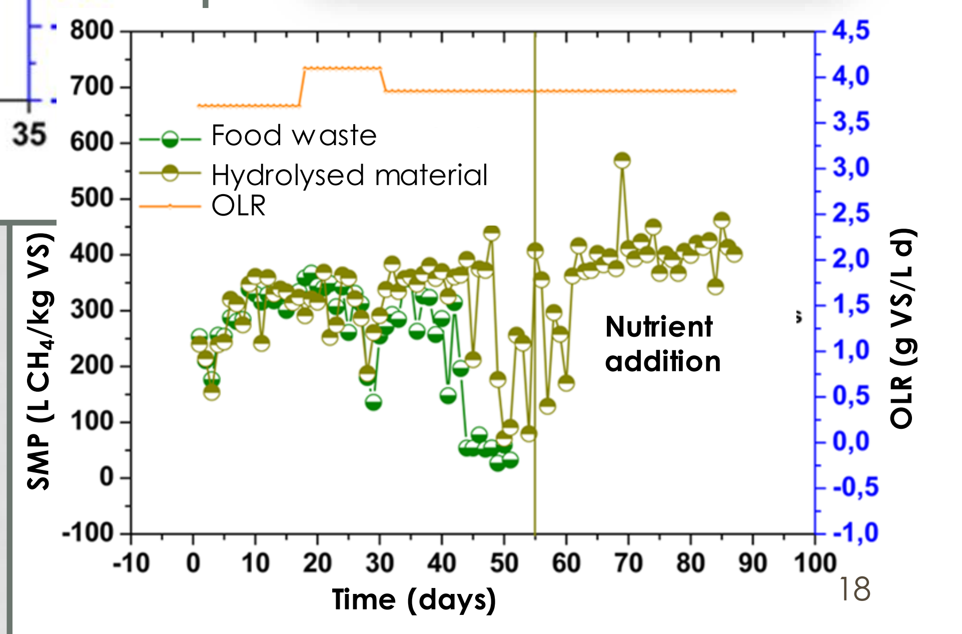


RESULTS

Digestion of vegetable wastes

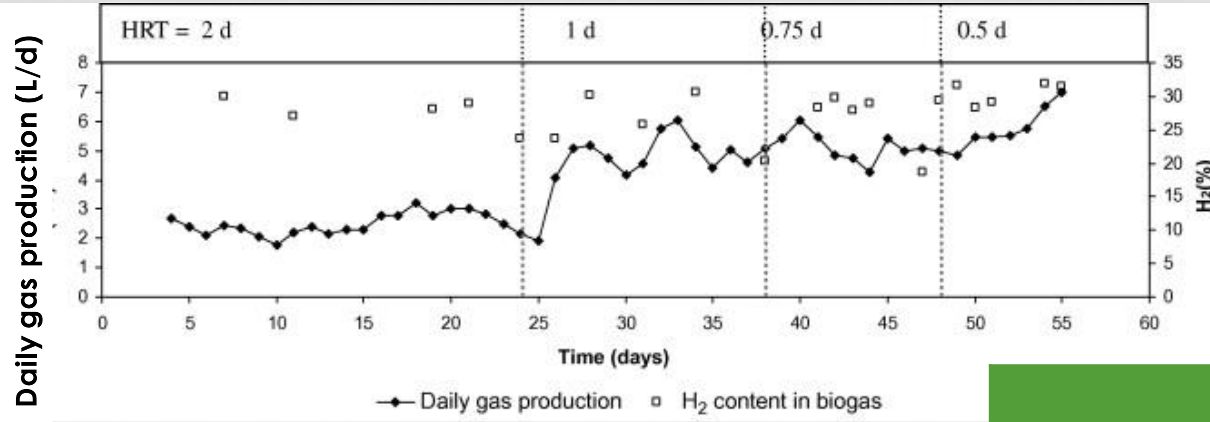


Parameters	Food Waste			Hydrolysed material		
HRT (d)	30			30		
OLR (g VS/L d)	3.68	4.09	3.84	3.68	4.09	3.84
Biogas (L)	5.4	5.9	3.8	5.3	6.1	6.5
CH_4 (%)	58	61	58	59	60	60
SMP (LCH_4/kg VS)	290	299	195	291	300	350
pH	7.4	7.2	7.1	7.4	7.3	7.1



RESULTS

Coupling H_2 – CH_4 Production

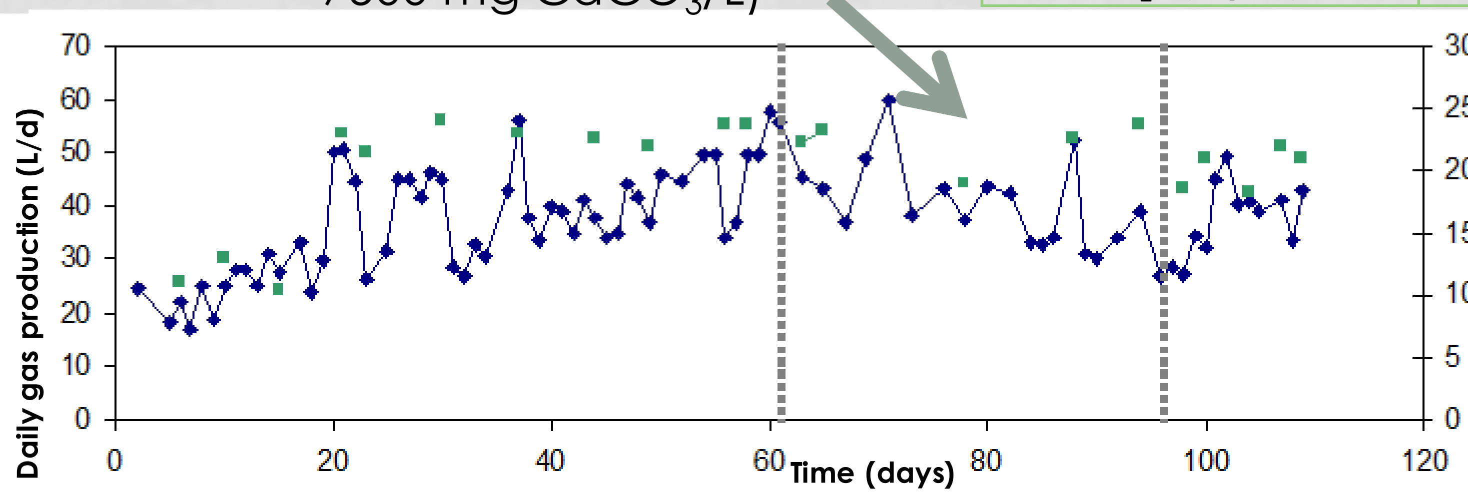


3 L reactor

V. Redondas , X. Gómez , S. García , C. Pevida , F. Rubiera , A. Morán , J.J. Pis. **Hydrogen production from food wastes and gas post-treatment by CO2 adsorption.** Waste Management, Volume 32, Issue 1, 2012, 60 - 66

H2 producing reactor				
HRT (d)	2	1	0.75	0.5
Daily gas production (L/d)	2.5	4.7	5.1	5.8
H2 production (L/ Lr d)	0.23	0.42	0.44	0.6
SH_2P (L/g VS)	20.6	18.5	14.5	13.1

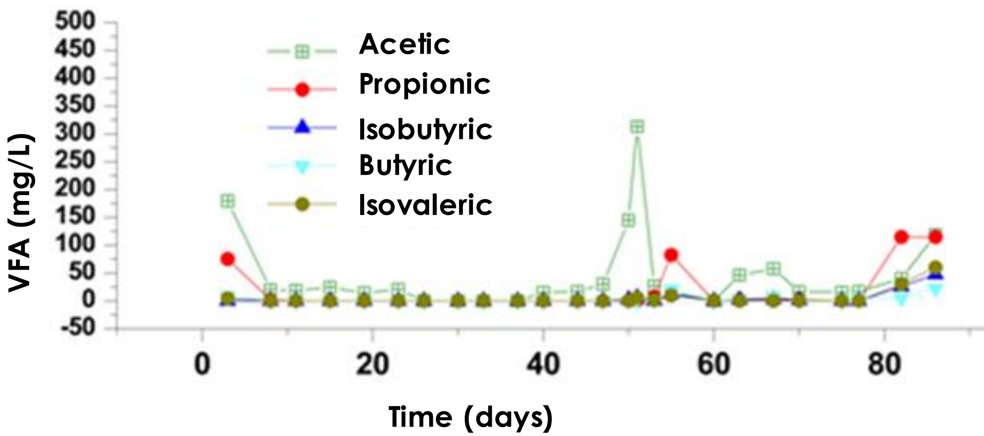
Supernatant recirculation (20% v/v)
7500 mg $CaCO_3$/L)

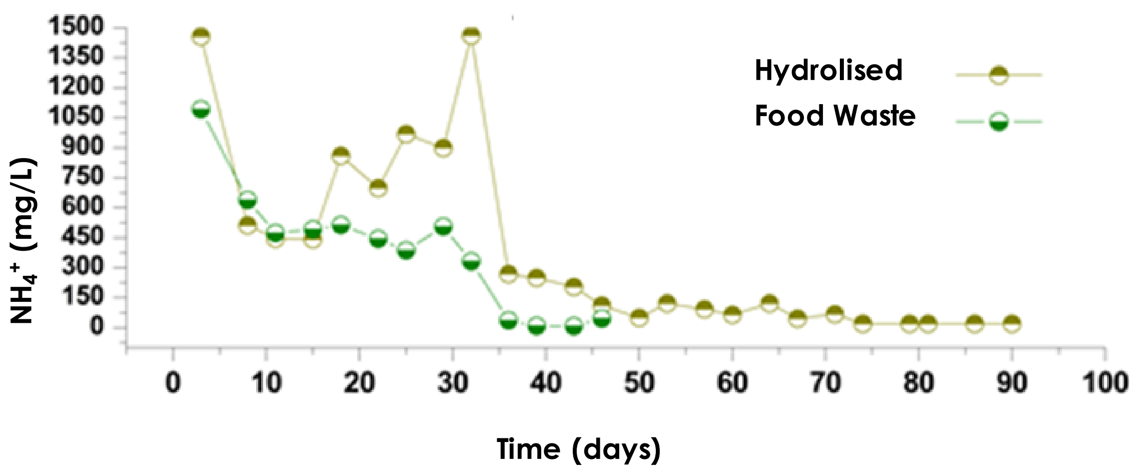


25 L reactor
HRT: 3 d

RESULTS

CH_4 Production





FEASIBILITY OF LIPID PRODUCTION

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Single cell oil production from low cost substrate

Food wastes
Municipal wastewater → Cryptococcus curvatus, Yarrowia lipolytica, and Rhodotorula glutinis

Biomass concentration: 0.58 – 1.5 g/L

Lipid content: 18,7 – 28.6%

Lipid Production by Culturing Oleaginous Yeast and Algae with Food Waste and Municipal Wastewater in an Integrated Process

Zhanyou Chi • Yubin Zheng • Anping Jiang • Shulin Chen

Appl Biochem Biotechnol (2011) 165:442–453
DOI 10.1007/s12010-011-9263-6

RESULTS

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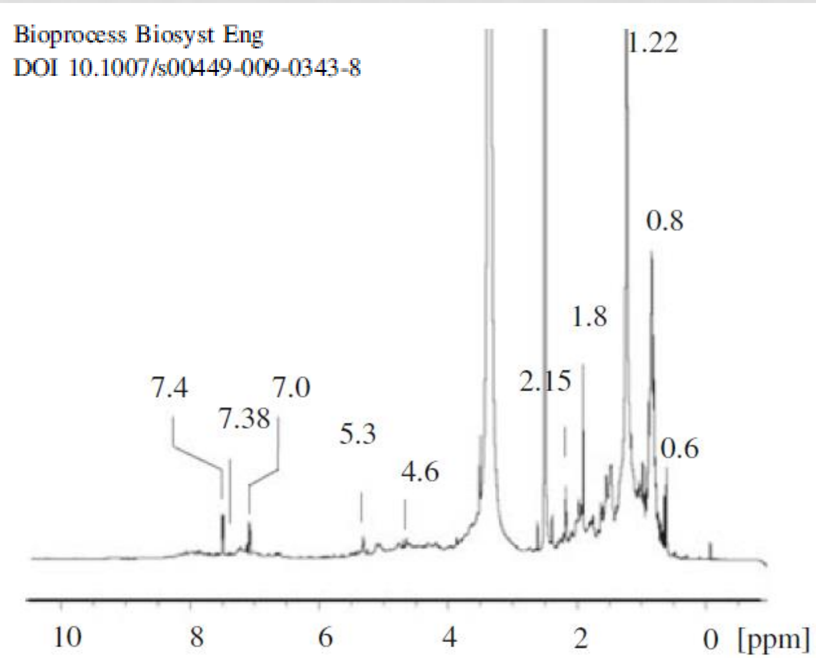
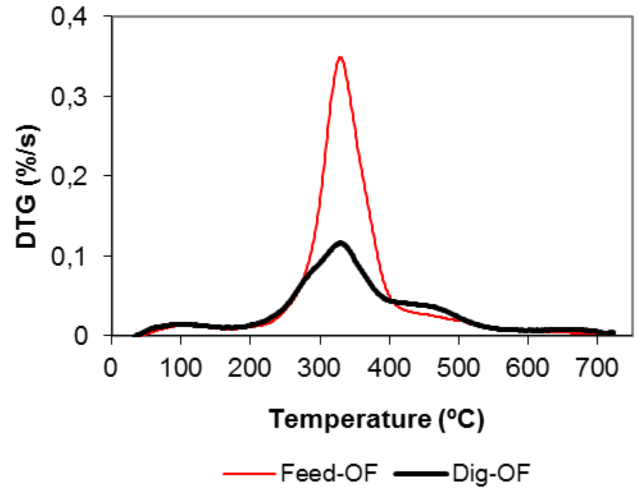
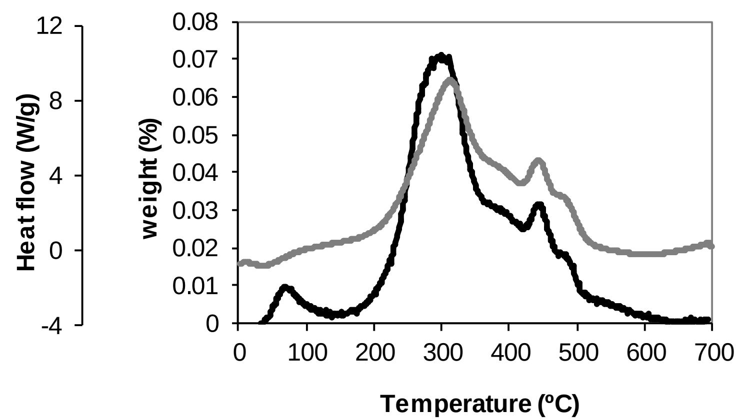


A comparison of analytical techniques for evaluating food waste degradation by anaerobic digestion

X. Gómez · M. J. Cuetos · B. Tartakovsky · M. F. Martínez-Núñez · A. Morán





Lipid extraction
2.15%

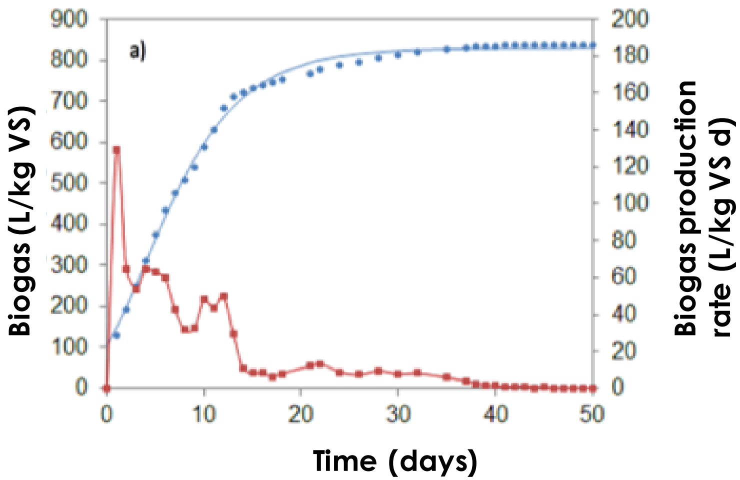
(Solid content: 23 g/L)

Inoculum: 0.8%

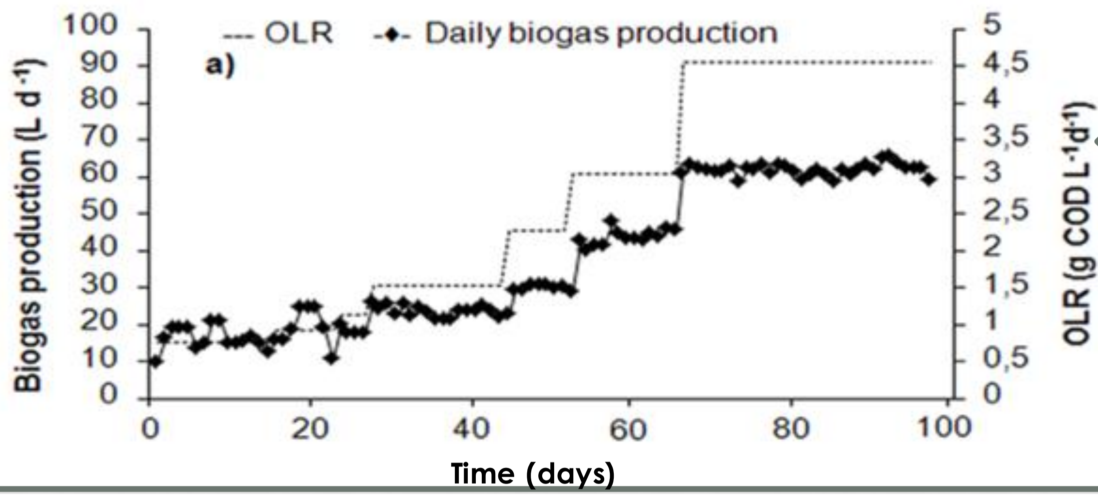
RESULTS: Thermophlic

CH$_4$ Production: Cheese whey

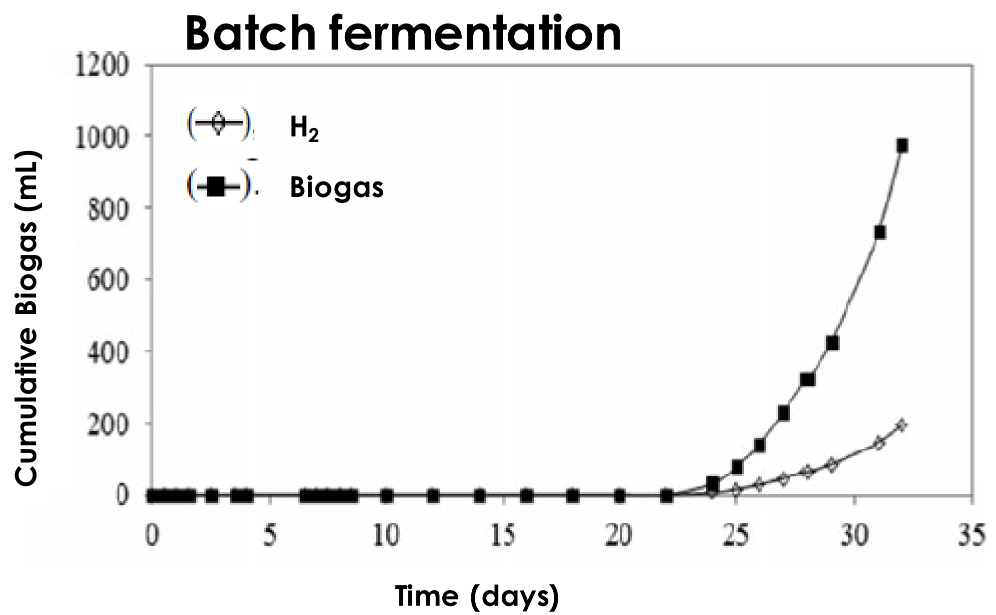
Batch digestion



5 L semi-continuous digestion

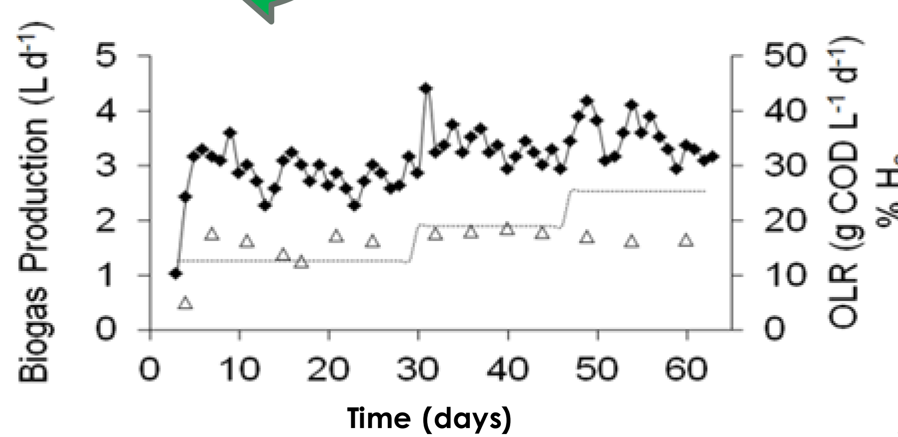


RESULTS: H_2 - mesophilic



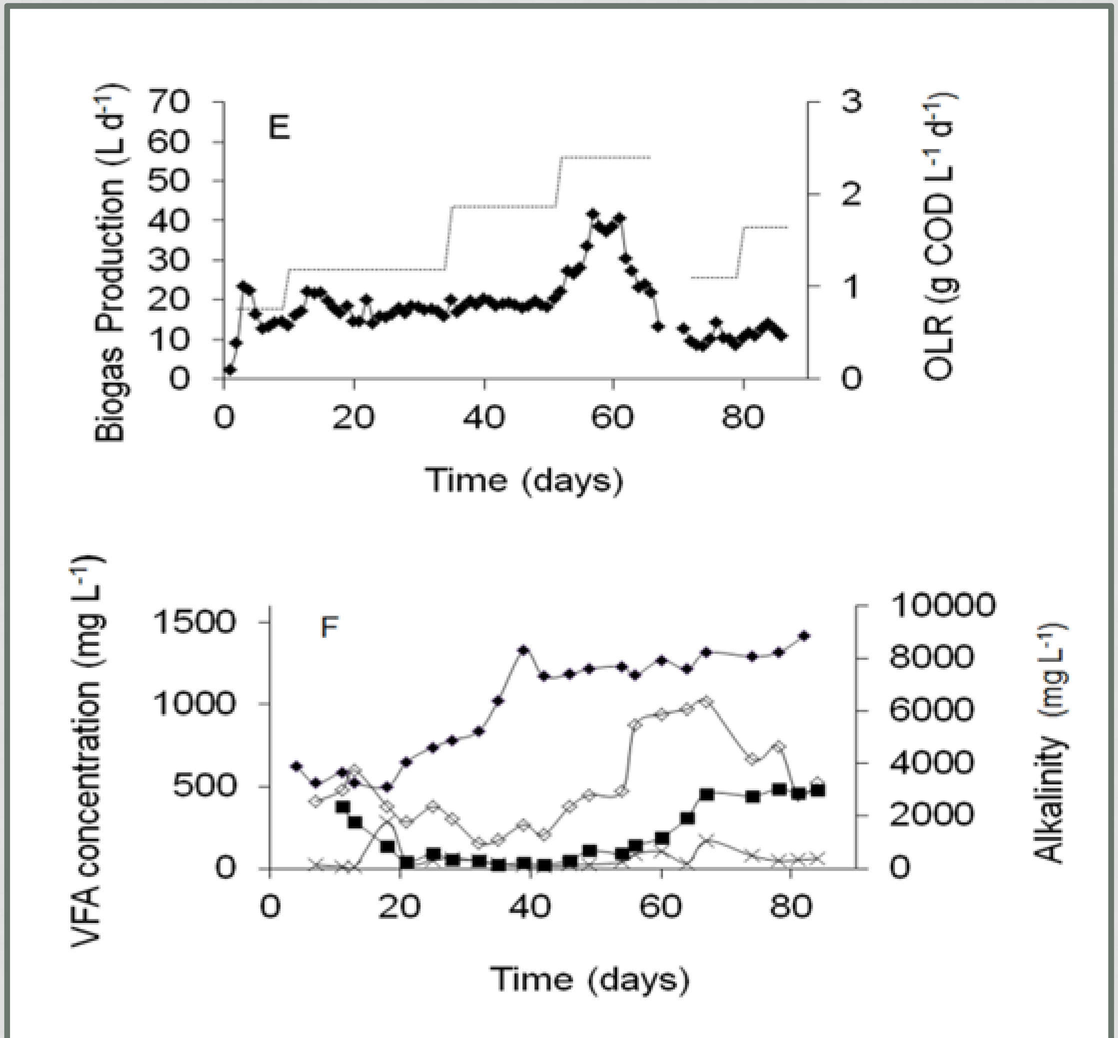
DGGE analysis: revealed that the genus *Clostridium* was dominant, *Clostridium acetobutyricum* (at 24 h) *Clostridium butyricum* (at 32 h)

3 L reactor
Mesophilic conditions



RESULTS

Coupling $H_2 – CH_4$ Production



Second Stage (25 L reactor)
Thermophilic conditions
Biomass accumulation

Lipid extraction

Single digestion
HRT 8.3 d: 1.61%

Second phase
HRT 16.7: 0.81%

CONCLUSIONS

Food waste (Fruit and vegetables) and cheese whey valorisation by means of fermentative processes was evaluated. Results indicated high methane potential from these wastes. The need of nutrient addition to keep steady operation becomes an economical burden to the process.

Exploring the alternative of increasing the amount of lipid extracted from digestates may be a novel option for producing polar lipids.

Further studies are needed to explore the characteristics of polar lipids obtained from anaerobic microflora and its industrial application

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