National Autonomous University of Mexico
Master's and PhD Program in Engineering
Environmental engineering

TOWARDS TO ANAEROBIC CO-DIGESTION OF OFMSW BASED ON THE ANALYSIS OF CHEESE WHEY AND MEAT WASTE ON TWO TYPES OF SLUDGE

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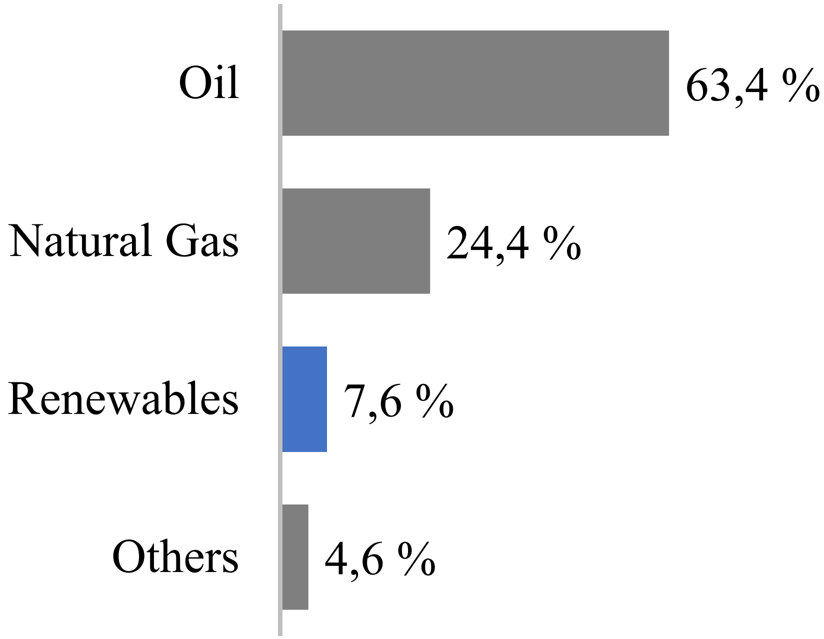
Outline

1. Background
2. Method
3. Results
4. Conclusions

1. Background

Supply and Demand of energy(*)

Fuels	Supply (PJ)	Demand (PJ)
México	8,624	5,128



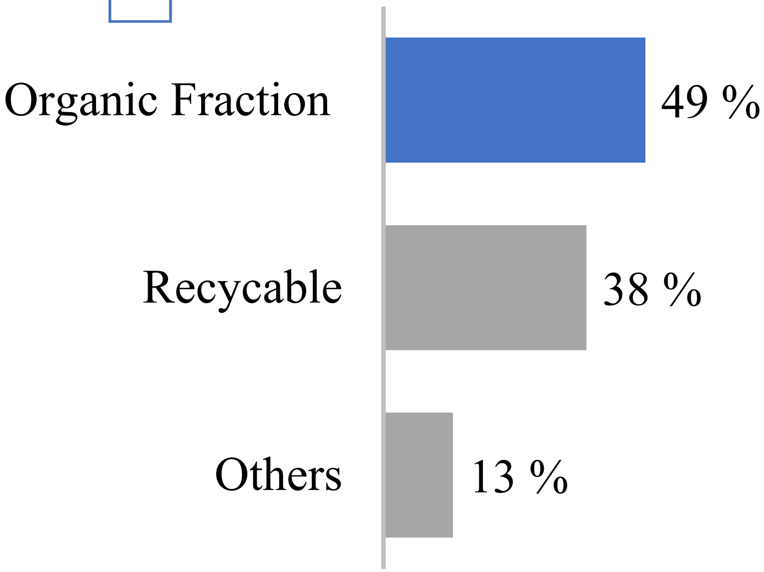
The Mexican Law for the Use of Renewable Energy and the Financing of Energy Transition (LAERFTE, 2008) establishes that, by 2024, participation of non-fossil sources in electricity generation will be 35% in Mexico.

(*) Prospectivas del Sector Energético, Secretaría de Energía. 2016

1. Background

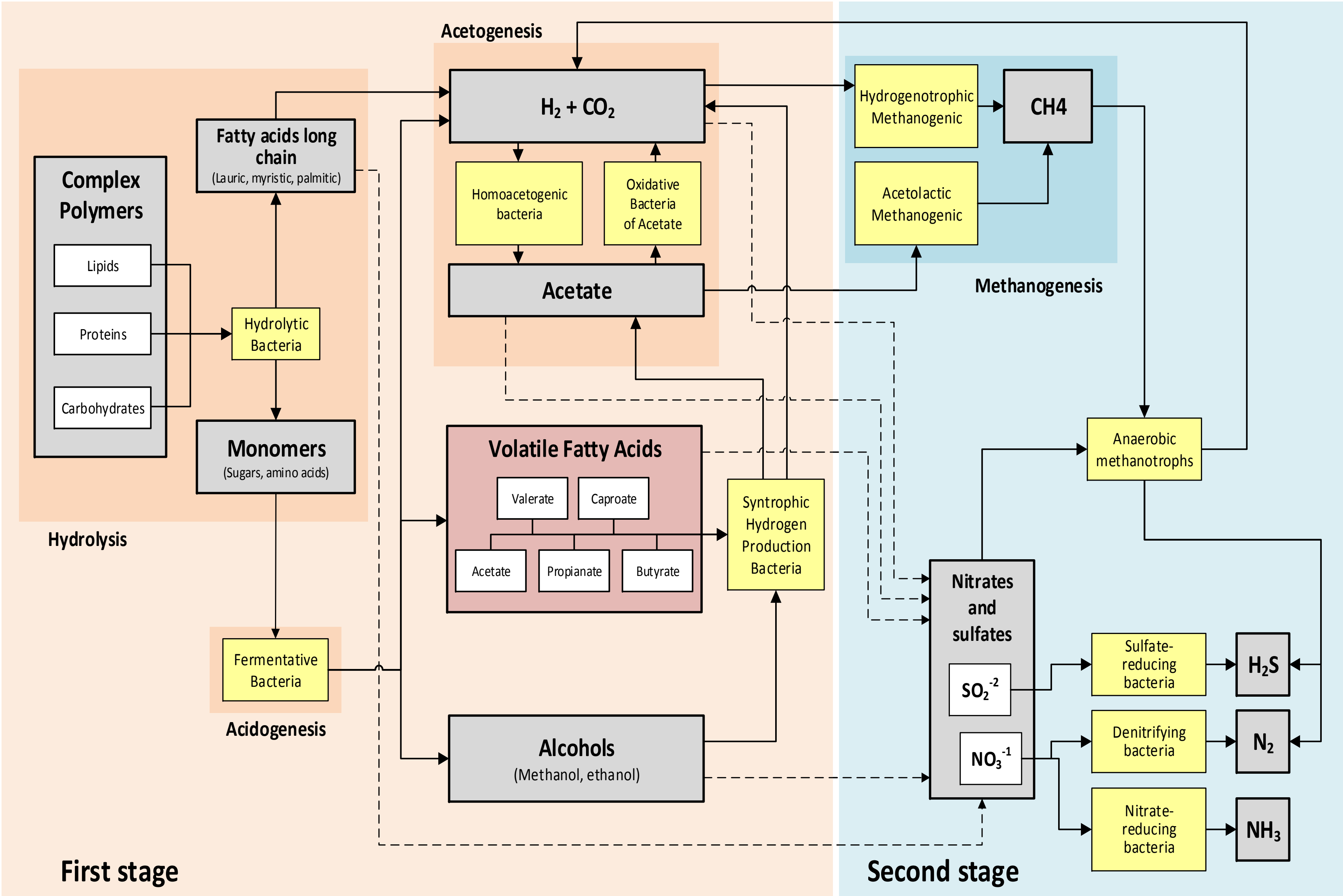
Current situation.

Mexico City → 117,500 t/d (2015) → 128,000 t/d (2020)



- OFMSW: 75%
- Treatment through **anaerobic digestion**, energy production.
- The characteristics of the substrate condition the production of biogas

Reference: Prepared based on Diagnostico básico para la gestión integral de residuos SEMARNAT, 2014.

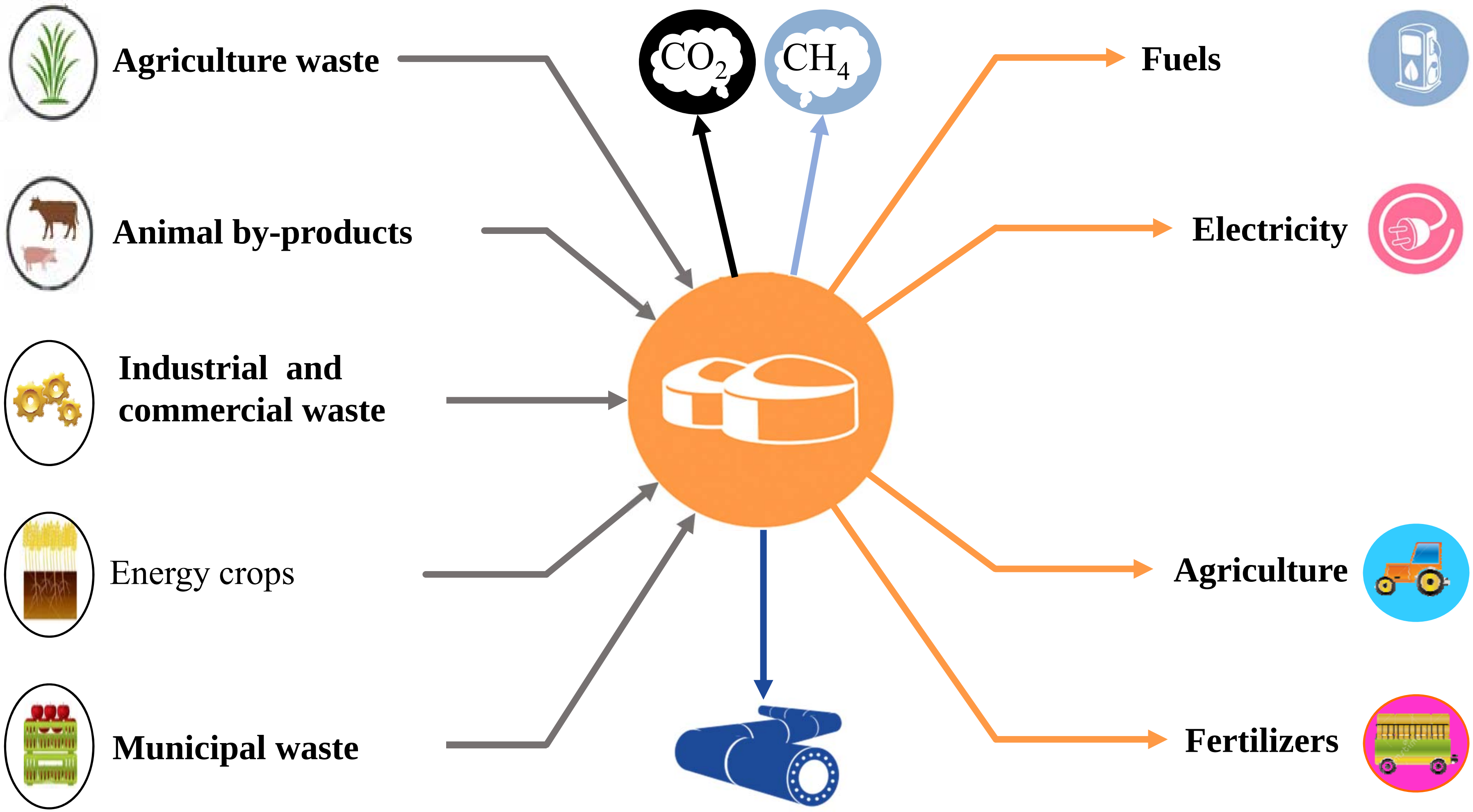


Acetogenesis
$H_2 + CO_2$
Homoacetogenic bacteria
Oxidative Bacteria of Acetate
Acetate
Hydrogenotrophic Methanogenic
CH4
Acetolactic Methanogenic
Methanogenesis
Complex Polymers
Lipids
Proteins
Carbohydrates
Fatty acids long chain
(Lauric, myristic, palmitic)
Hydrolytic Bacteria
Monomers
(Sugars, amino acids)
Hydrolysis
Volatile Fatty Acids
Valerate
Caproate
Acetate
Propianate
Butyrate
Syntrophic Hydrogen Production Bacteria
Anaerobic methanotrophs
Fermentative Bacteria
Acidogenesis
Alcohols
(Methanol, ethanol)
Nitrates and sulfates
SO_2^{-2}
NO_3^{-1}
Sulfate-reducing bacteria
Denitrifying bacteria
Nitrate-reducing bacteria
H_2S
N_2
NH_3
First stage
Second stage

1. Background

Substrates for Anaerobic Digestion

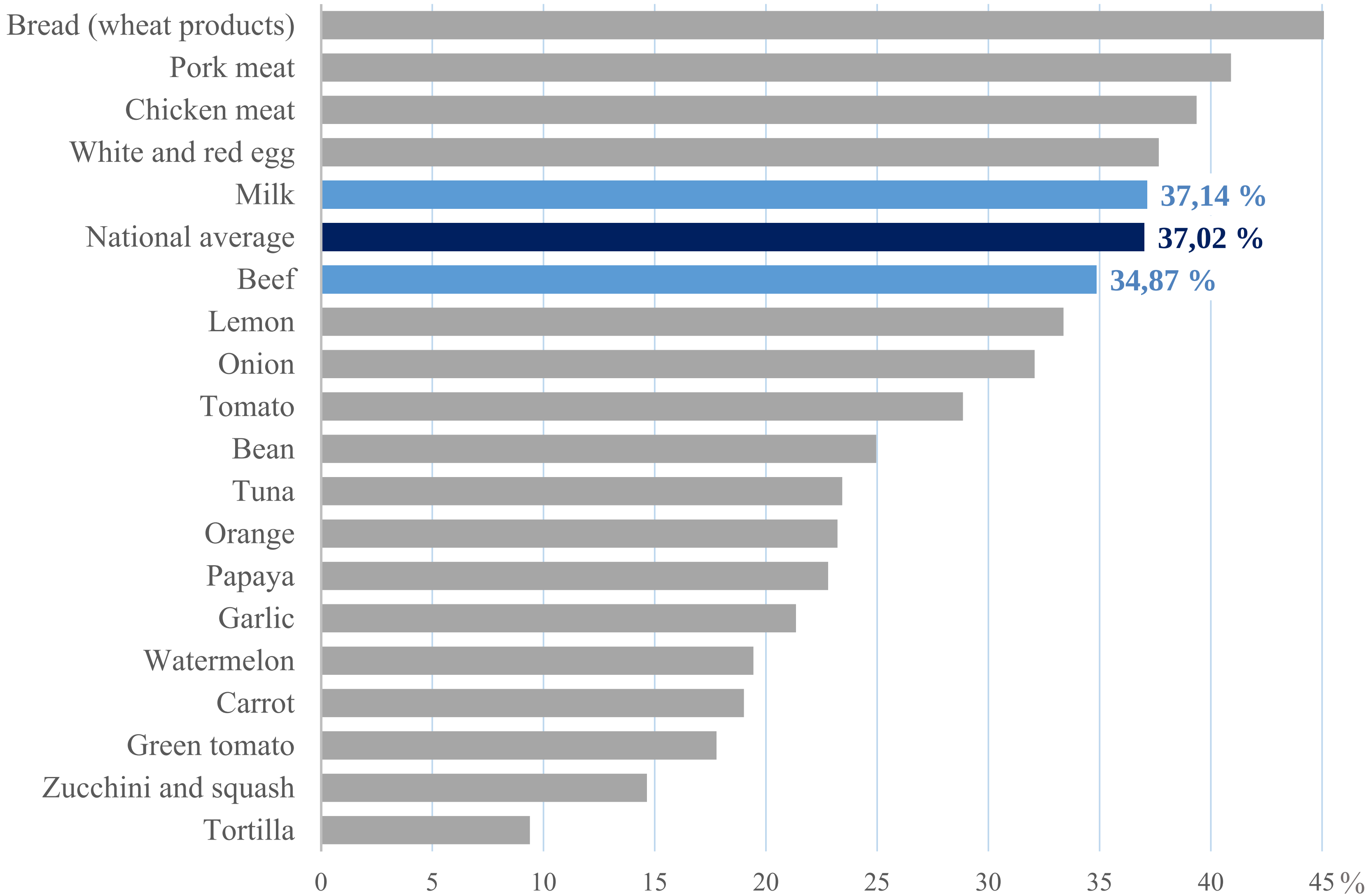
Tendency to flexibilize the production of biogas according to the energy demand



Reference: Prepared based on Bechamp, 2010; EUR-Lex. 2015.

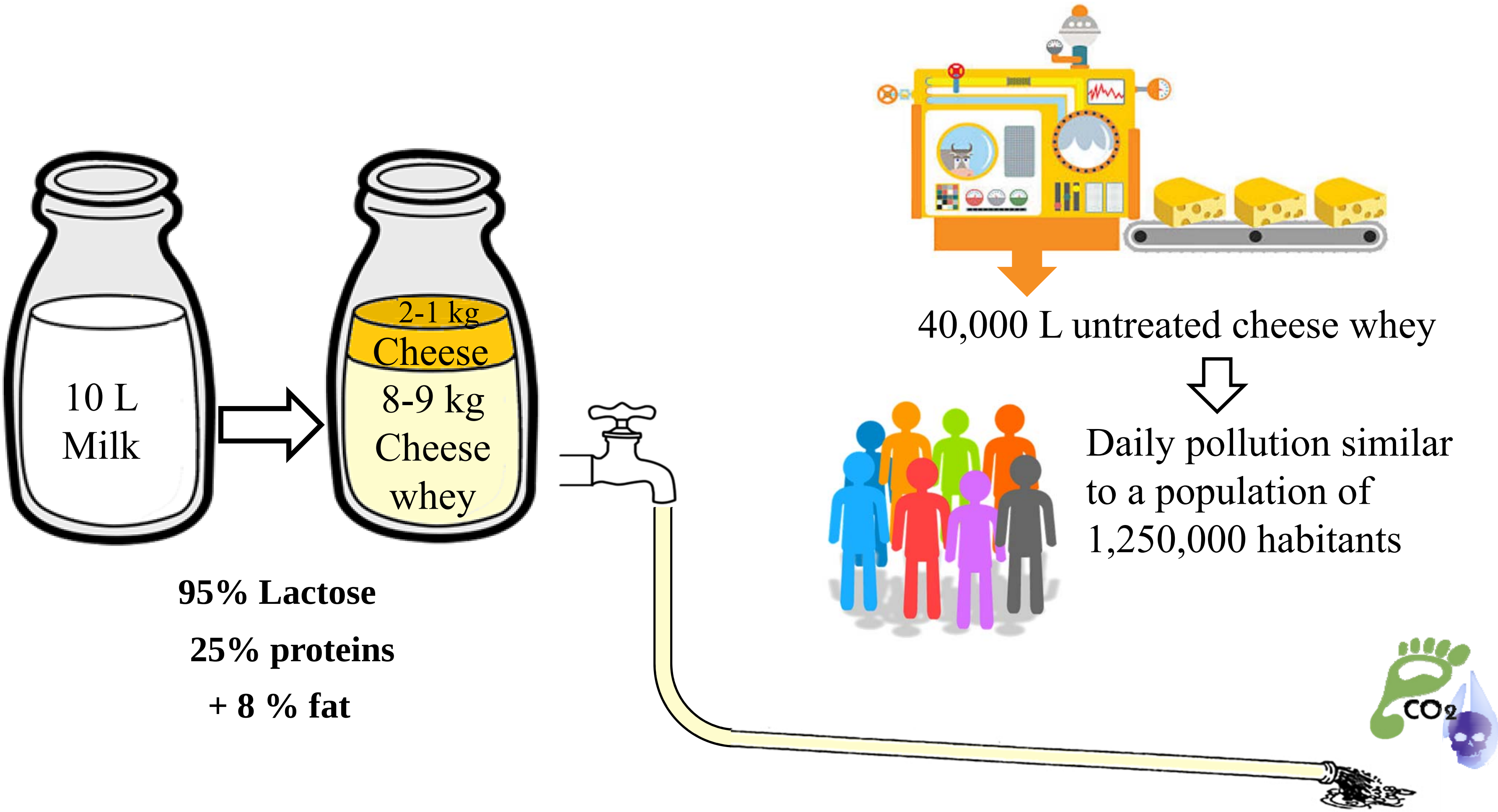
1. Background

Food waste by type in Mexico



Reference: Prepared based on SEDESOL, 2014.

1. Background

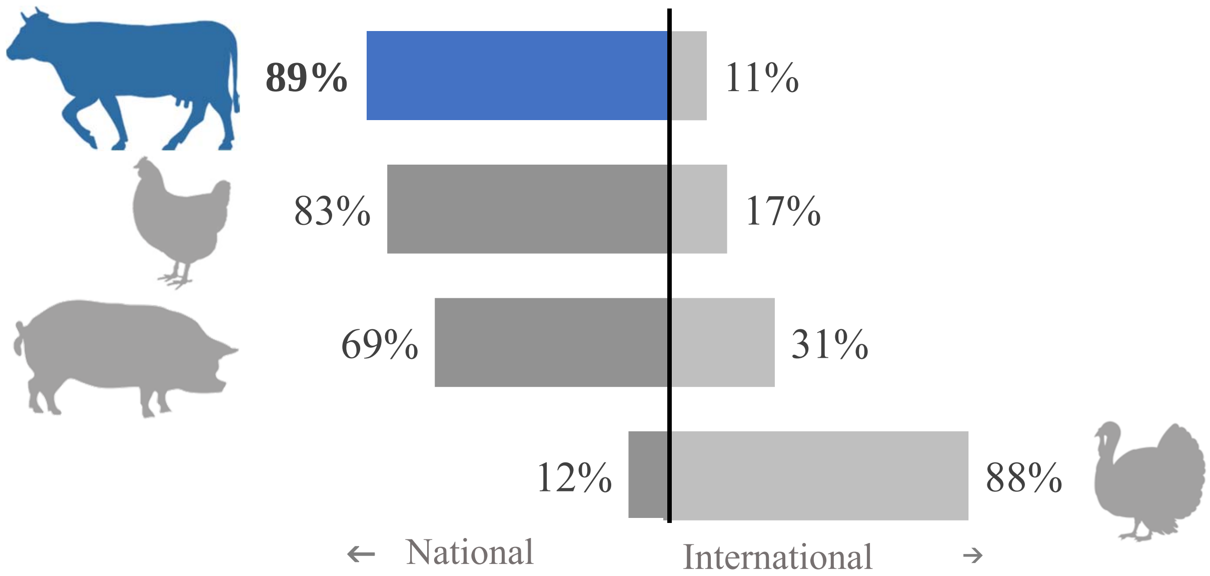


In Mexico, 47% is discharged to sewer system
The CW produced has a pH of 5 to 5.8.

1. Background

Waste from the meat industry

National Consumption by origin



In Mexico **403,257 tones** of beef are wasted.
A **34.8%** of national food waste

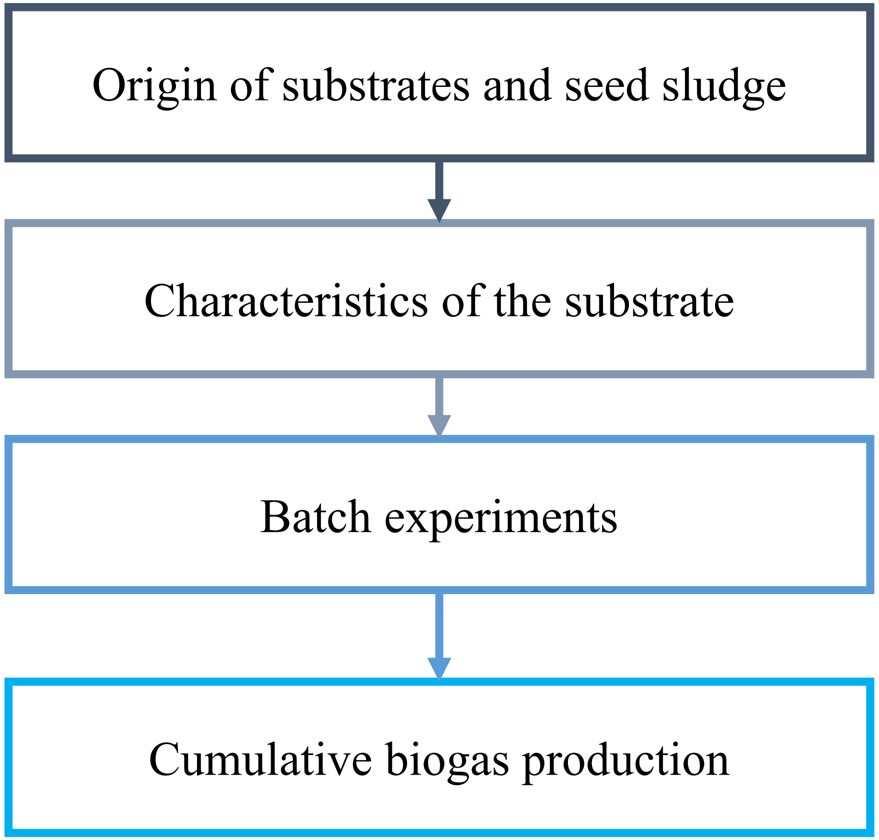
20% is discharged to rivers; 15% to landfills; And 3%, incinerated.

Reference: Prepared based on Consejo Mexicano de la Carne con datos del SIAP. AMEG. 2015

3. Aim

Assess anaerobic co-digestion of OFMSW based on the analysis of cheese whey (CW) and meat waste (MW) on two types of sludge to increase biogas production.

5. Method


Origin of substrates and seed sludge
Characteristics of the substrate
Batch experiments
Cumulative biogas production

5. Method

Origin of substrates and seed sludge

OFMSW

Cuautitlán Izcalli (65 kg)

MW

Santa Cruz Market (10 kg)

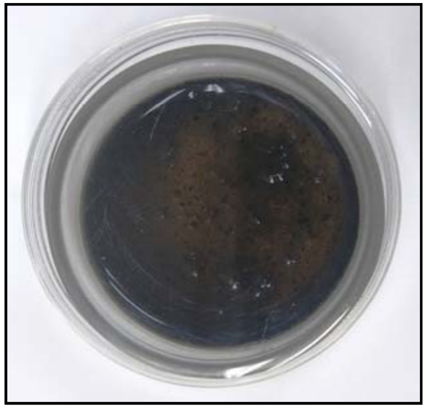
CW

Santa Rosa Farm (10 L)

Sludge

Granular (20 L)

Suspended (20 L)



5. Method

Reduced particle size

Characterization based on Standard Methods

5. Method

Batch experiments

I/S

Substrate
50 %

Inoculum
50 %

Analysis and experimental follow-up

Parameters	Initials/finals	Daily	Weekly
Solids (ST, SF, SV)	●		
COD	●		
Nitrogen	●		
Biogas (CO_2 and CH_4)		●	●
pH	●		

Suspended **Granular**

Operational conditions

Reactor Capacity: 500 mL

Working volume: 400 mL

Temperature: 35 ° C

Biogas quantification

Volume: increase in pressure

Composition: gas chromatography

Variable response: methane volume

6. Results

Parameter	Unit	OFMSW		CW		MW		Granular sludge		Suspended sludge	
pH		5.05	± 0.14	3.67	± 0.14	7.15	± 0.14	6.71	± 0.12	6.5	± 0.13
Humidity	%	86	± 0.14	94	± 0.14	50	± 0.14	92	± 0.15	90	± 0.16
COD	gO_2/kg	50	± 1.3	72	± 1.3	73	± 1.3	47	± 0.3	72	± 0.7
TS	g/kg	130	± 5.6	64	± 5.6	531	± 5.6	61	± 1.3	96	± 0.1
VS	g/kg	125	± 17	54	± 17	522	± 17	61	± 0.9	96	± 1.3
NH_4-N	g/kg	0.2	± 0.01	0.3	± 0.01	0.5	± 0.01	-	-	-	-
Nitrogen*	g/g	2	± 0.14	2	± 0.14	9	± 0.14	-	-	-	-
Carbon*	g/g	44	± 1.3	36	± 1.3	68	± 1.3	-	-	-	-
Hydrogen*	g/g	5	± 5.6	6	± 5.6	9	± 5.6	-	-	-	-
Carbohydrates	g/kg	118	± 17	18	± 17	4.1	± 17	-	-	-	-
Lipids	g/kg	39	± 0.14	1.6	± 0.14	72	± 0.14	-	-	-	-
Proteins	g/kg	34	± 0.14	11	± 0.14	155	± 0.14	-	-	-	-
Lignin	g/kg	30	± 1.3	-	-	-	-	-	-	-	-
Cellulose	g/kg	47	± 5.6	-	-	-	-	-	-	-	-
Hemicellulose	g/kg	12	± 17	-	-	-	-	-	-	-	-

6. Results

Seed sludge	Initial conditions	Reactor	21 days anaerobic monodigestion*		90 days anaerobic codigestion*	
			VFA ($g\ L^{-1}$)	Biogas production ($NL\ kgVS^{-1}$)	VFA ($g\ L^{-1}$)	Biogas production ($NL\ kgVS^{-1}$)
Granular	OFMSW+CW	R1	3.4	113	2.7	140
	OFMSW+MW	R2	7.9	132	1.0	383
	OFMSW	R3	1.0	45	0.7	115
Suspended	OFMSW+ CW	R4	9.7	81	3.9	107
	OFMSW+MW	R5	10.9	101	4.3	105
	OFMSW	R6	1.3	6.8	0.7	27

6. Results

Reactor	RT	pH	TS (g/ kg)	TS removed (%)	VS (g/ kg)	VS removed (%)	COD (gO2/kg)	COD removed (%)
R1	Initial	8.3	102	47.5	84	51.1	71	70.4
	Final	6.7	53.5		41		21	
R2	Initial	8.3	104	52.8	98	61.2	70	44.2
	Final	6.8	49		38		39	
R3	Initial	8.1	77	19.4	61	29.5	73	53.4
	Final	6.3	62		43		34	
R4	Initial	8.2	73	63.0	63	71.4	77	75.3
	Final	6	27		18		19	
R5	Initial	8.3	86	68.6	80	76.2	58	48.2
	Final	5.8	27		19		30	
R6	Initial	8	104	81.7	96	90.6	28	60.7
	Final	6.7	19		9		11	

6. Results

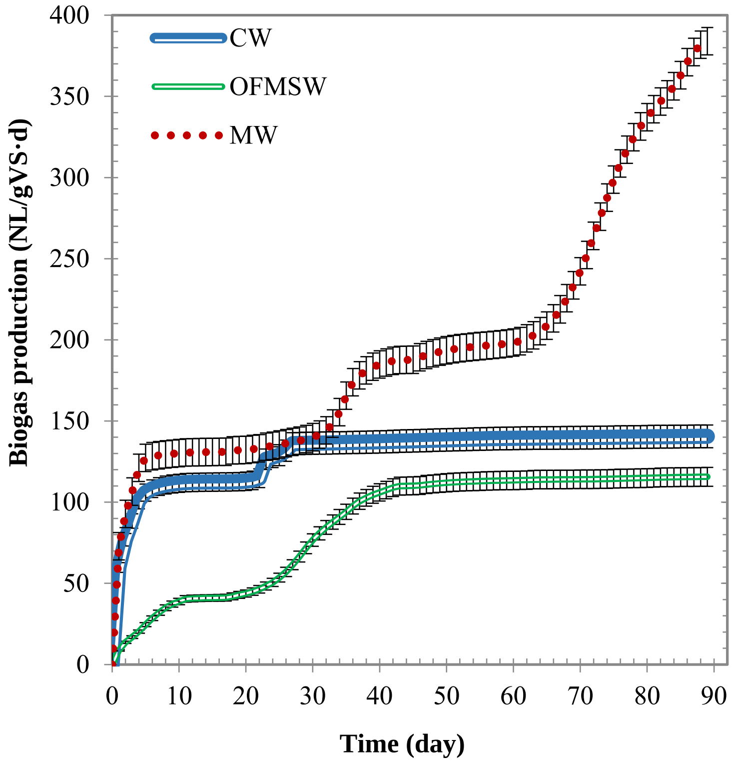


Figure 2. Daily variation of biogas production under BPM test at 35°C, granular sludge.

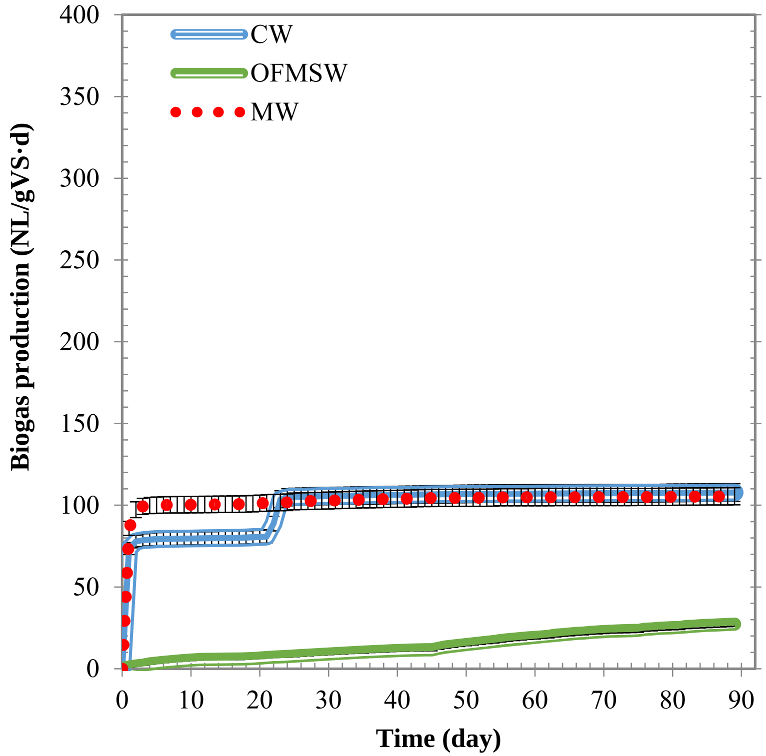


Figure 3. Process performance on suspended sludge and daily quantity of biogas production

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7. Conclusions

- The highest concentration of VFA at the end of the first stage (45-day) was R1, and thereafter due to the accumulation decreased the biogas production.
- At the end of co-digestion, (90-day) high biogas yield of 383 NL $kgVS^{-1}$ was observed at R2; co-digestion of mixtures of meat waste with OFMSW allows higher production of biogas.
- The highest production of biogas was from reactors operated with granular sludge.
- The conclusions of this study apply to lab-scale batch operations, therefore, a further improvement of the seeded sludge is deemed required to increase the rate of either CW or MW in codigestion with OFMSW.

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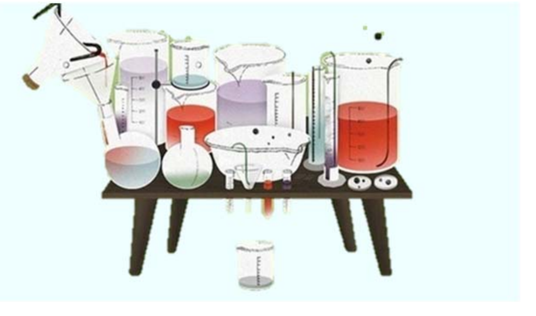
Thank you



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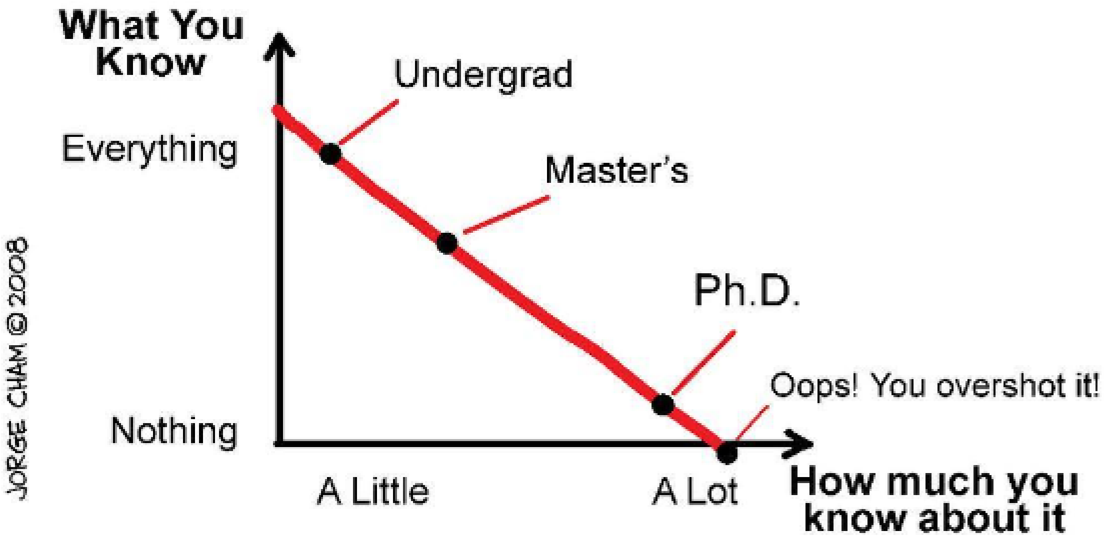
What You Know
Everything
Nothing
Undergrad
Master's
Ph.D.
Oops! You overshot it!
A Little
A Lot
How much you know about it
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ANATOMY OF A GROUP MEETING PRESENTATION
pulled all-nighter. finished slides 5 minutes before meeting started.
trying to come up with insightful question that will impress advisor.
first year. only person actually paying attention. has no clue what's going on.
relieved she doesn't have to explain why she hasn't done anything this week.
starving. thought there'd be food at meeting.
has written two proposals in his head since meeting started.
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