Universidad Central "Marta Abreu" de Las Villas (UCLV).

Título: **Studies of some physical-mechanical and chemical property in organic waste to use for biogas production in Cuba.**

Authors: ***Dr. C. Carlos M. Martínez Hernández [1];***
Dr. Hans Oechsner [2];
MSc. Mathieu Brulé [3];
Prof. Elena Marañon Maison [4]

[1] Universidad Central de las Villas. Cuba.
[2] Universidad de Hohenheim. Germany.
[3] Universidad de Hohenheim. Germany.
[4] Universidad de Oviedo. Spain.

UCLV, 2013

INTRODUCTION (I)

- In accordance with the document Technological Attendance (2008), the determination of physical-mechanical and chemical properties in agricultural or animal biomass waste allows to know the maximum potential of biogas of a residual or mixture of residuals following the procedure of the norm VDI 4630 (2006).

- Each organic waste has a specific potential and remarkable differences exist according to its composition.

- The maximum biogas potential is determined experimentally by means of a batch laboratory scale biodegradation test under anaerobic controlled conditions.

INTRODUCTION (II)

Agro-industrial organic waste that can be found in Cuba:

- ✓ Agricultural waste of producer cooperatives (surpluses, low quality, etc).
- ✓ Cattle waste (pig slurry, bovine and chicken manure, etc.).
- ✓ Food industry waste of animal origin (slaughterhouses and meat industries, milky industries, fish and remains of the transformation of sea products, etc.).
- ✓ Food waste of vegetable origin (surpluses and wastes of the production of fruits and juices, remains coming from canning, used oil, vines, etc.).

INTRODUCTION (III)

Agro-industrial organic waste that can be found in Cuba (cont.) :

- ✓ Fatty muds from food industry.
- ✓ Waste from food distribution (past best-before date, returned or not complying with regulations).
- ✓ Waste from biofuel plants (and other from bioetanol plants or biodiesel).

INTRODUCTION (IV)

Background in co-digestion (cont.)

- Co-digestion is not a common practice in Cuba.
- Biogas plants use only cattle or pig manure in mono fermentation.
- Co-digestion of these manure with agricultural waste has not been implemented to date. Hence the importance of developing this methodology.
- References for this work:
  - German norm VDI 4630 (2006)
  - Works developed by investigators of the Universities of Hohenheim and Rostock, Germany
  - Works published by the author in previous years (Martínez et al., 2009 a; Martínez et al., 2008; Martínez et al., 2009 b; Martínez et al., 2011 and Martínez et al., 2012).

OBJECTIVES

Main objetive:

- To determine physical-mechanical and chemical properties of the agricultural and canteen organic waste generated in Cuba.

Specific objetive:

- To study the behavior of the biomass studied under Cuban condition in order to know which one is the best for producing biogas.

MATERIALS AND METHODS (I)

This work was carried out in the Central University of Las Villas, but some research was made at the University of Hohenheim, Germany.

The results have been obtained during the period 2009-2012 within the framework of collaboration projects between both Universities.

MATERIALS AND METHODS (II)

Biomass characterization:

- It was carried out according the VDI 4630 (2006) Standard.
- Biomass from different origins (agricultural, canteen) was characterized in order to know its potential for biogas production.
- Physical, mechanical and chemical properties were determined.
- The characterization gives important data to be considered in the manipulation an use of the biomass in biogas facilities.

MATERIALS AND METHODS (III)

The investigated agricultural waste were: sorghum 49V-96, sorghum-R-132, sunflower JE-94, yucca, corn, malanga shell, sweet potato shell, potato, and peanut shell. White bread was considered as canteen waste.

Once selected the biomass, the following characterization was performed:

1. Determination of humidity and dry matter, according to the NC74-22:1985 Standard.
2. Determination of the ash content according to the NC74-30:1985 Standard.
3. Ground and sieved of these biomass in fractions of smaller size of particles to 1 mm.
4. Determination of the carbon/nitrogen ratio.

MATERIALS AND METHODS (IV)

5. Evolution of the pH of the different biomass combinations and caw manure.
6. Evaluation of the specific methane yield for the selected biomass.
7. Evaluation of the innocuousness of the treated effluents.

MATERIALS AND METHODS (V)

UCLV, 2013

Starting from these input data, software was elaborated according the VDI4630 (2006) Standard.

The following parameters were calculated:

- Biodegradability rate.
- Maximum methane potential (m^3/kg oTS).
- Composition of the biogas generated (% CH_4, % CO_2, % H_2S).




MATERIALS AND METHODS (VI)

In each case the investigation protocol consisted on placing three controls and nine replicates of the investigated samples.

The above-mentioned research has been carried out with the collaboration of the University of Hohenheim, Germany (researchers and equipment from the biogas laboratories).




RESULTS AND DISCUSSION (I)

The highest specific methane yield was obtained with the sunflower JE-94 biomass (0.393 m^3/kg oTS), meanwhile the lower value was achieved with the peanut shell biomass (0.095 m^3/kg oTS).

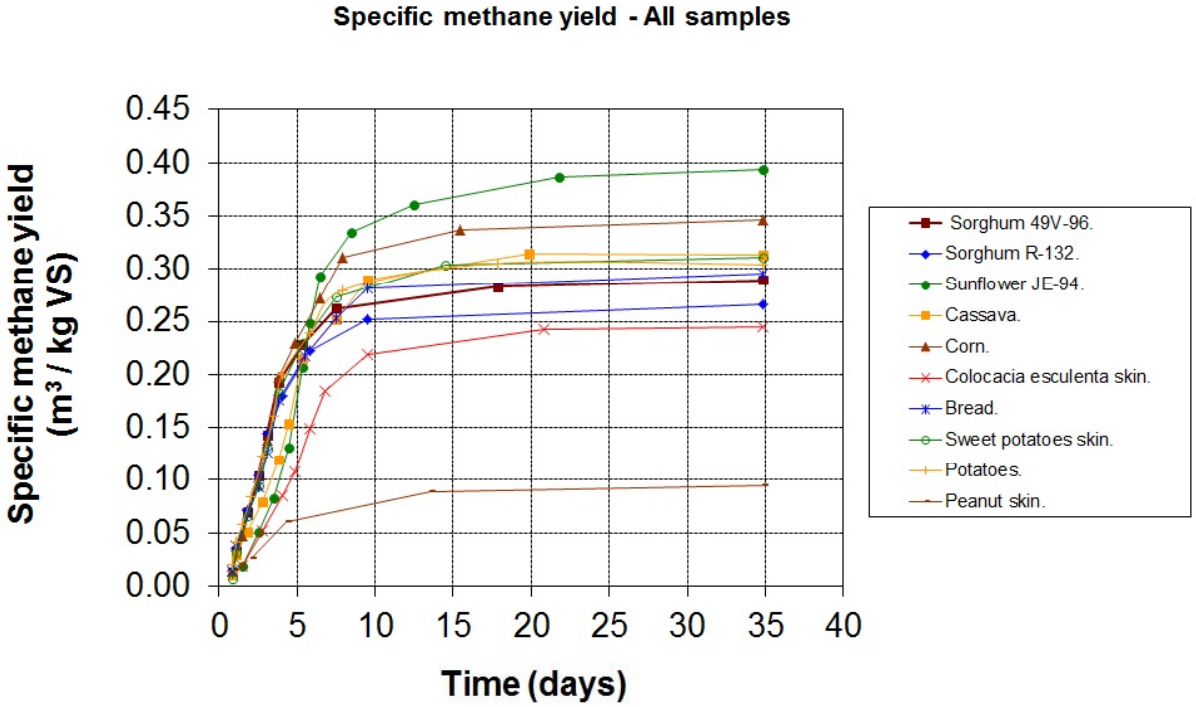


Fig.1. Methane specific yield from different samples

UCLV, 2013

RESULTS AND DISCUSSION (II)

Chart 1. Determination of TS and oTS in the substrates.

	Number	Repetition			Mean		Standard desviation	
Test			TS (%)	oTS (%)	TS (%)	oTS (%)	TS (%)	oTS (%)
Inoculum (caw manure)	1	1	3.68	44.67	3.40	53.44	0.60	0.89
	2	2	3.28	53.11				
	3	3	3.25	53.78				
Sorghum V-49-96	4	1	87.60	97.03	87.60	97.06	0.02	0.05
	5	2	87.58	97.12				
	6	3	87.61	97.03				
Sorghum 132-R	7	1	85.83	97.64	85.83	97.56	0.05	0.08
	8	2	85.79	97.53				
	9	3	85.87	97.49				
Sunflower JE-94	10	1	91.76	95.88	91.73	95.92	0.03	0.05
	11	2	91.70	95.98				
	12	3	91.75	95.91				
Cassava	13	1	89.33	97.98	89.34	98.00	0.07	0.10
	14	2	89.41	97.92				
	15	3	89.29	98.12				
Corn	16	1	87.18	98.37	87.20	98.34	0.05	0.02
	17	2	87.24	98.33				
	18	3	87.17	98.34				

RESULTS AND DISCUSSION (III)

Chart 1 (cont.). Determination of TS and oTS in the substrates

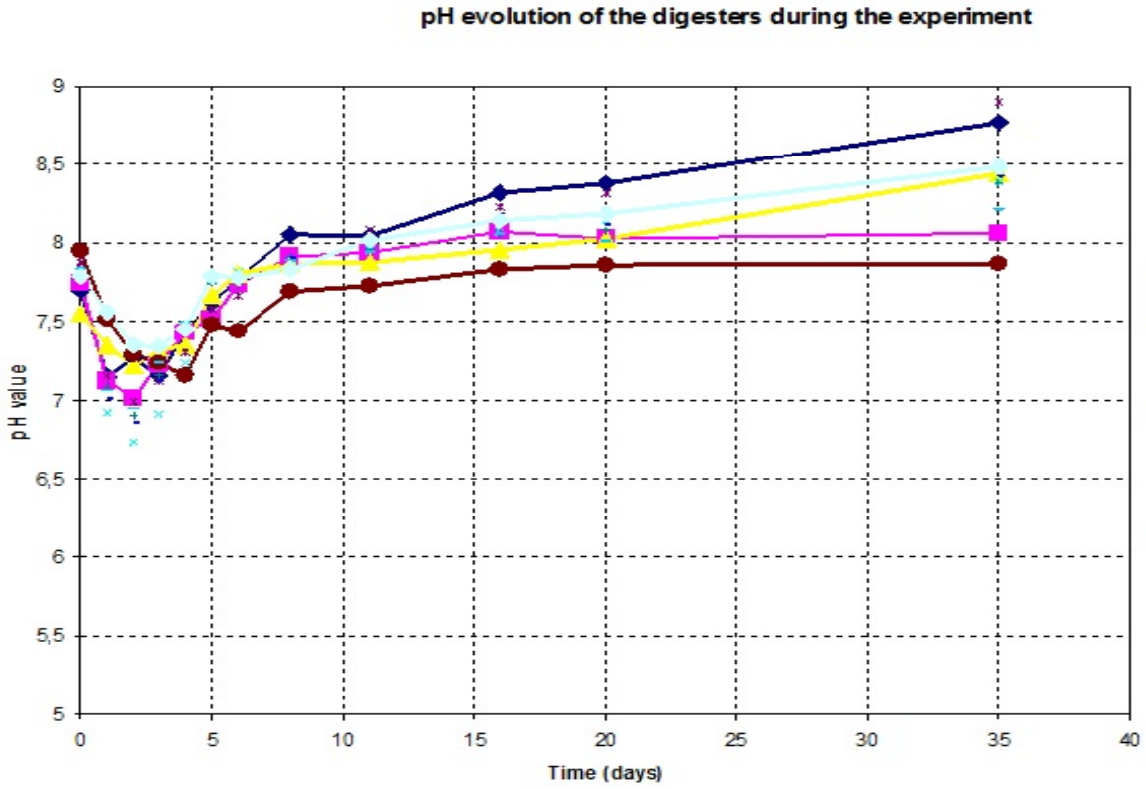
	Number	Repetition			Mean		Standard deviation	
Test			TS(%)	oTS(%)	TS(%)	oTS(%)	TS(%)	oTS(%)
Colocacia esculenta skin	19	1	90.92	89.04	90.64	89.28	0.29	0.23
	20	2	90.61	89.42				
	21	3	90.40	89.38				
Bread	22	1	87.56	97.76	87.51	97.43	0.10	0.41
	23	2	87.56	96.99				
	24	3	87.41	97.54				
Sweet potato skin	25	1	93.66	93.04	92.74	92.89	0.87	0.19
	26	2	92.42	92.69				
	27	3	92.15	92.93				
Potatoes	28	1	105.25	94.20	105.36	93.76	0.18	0.41
	29	2	105.26	93.60				
	30	3	105.58	93.49				
Peanut skin	31	1	93.99	94.74	93.88	94.78	0.11	0.12
	32	2	93.85	94.91				
	33	3	93.80	94.69				

RESULTS AND DISCUSSION (IV)

Chart 3. Biogas and methane yields obtained in the biodegradability tests.

No	Valuated substrate.	Corrected gas amount (mL)	Corrected methane amount (mL)	Corrected methane amount (% Volumen)	Specific Gas yields (m^3/kg oTS)	Specific Methane yields (m^3 CH_4/kg oTS)	Mean value	Standard deviation (%)
17	Sunflower JE-94.a	248	144	58	0.671	0.389	0.393	1.3
18	Sunflower JE-94.b	244	147	60	0.660	0.397		
20	Cassava .a	255	110	43	0.711	0.306	0.313	3.3
21	Cassava .b	249	115	46	0.693	0.321		
23	Corn.a	254	122	48	0.719	0.347	0.346	0.1
24	Corn.b	253	122	48	0.716	0.346		
26	Colocacia esculenta skin .a	164	75	46	0.508	0.232	0.245	7.3
27	Colocacia esculenta skin .b	171	83	49	0.530	0.257		
29	Bread .a	230	102	45	0.658	0.293	0.295	1.0
30	Bread .b	226	104	46	0.648	0.298		
32	Sweet potato skin .a	232	115	49	0.671	0.331	0.311	9.0
33	Sweet potato skin .b	227	101	45	0.655	0.291		
35	Potatoes.a	227	111	49	0.636	0.311	0.304	3.0
36	Potatoes .b	231	106	46	0.646	0.298		
38	Peanut skin .a	60	33	55	0.173	0.096	0.095	1.3
39	Peanut skin .b	59	32	55	0.172	0.094		

RESULTS AND DISCUSSION (V)



Sorghum V49 96
Sorghum R.132
Sunflower JE 94
Cassava
Corn
Colocacia esculenta skin
Bread
Sweet potatoes skin
Peanut skin
Potatoes

Fig.2. pH evolution in the substrates.

The evolution of the pH in all the substrate analyzed in the co-digestion of different waste with cattle manure fulfills within the recommended security values (6 at 8) with the exception of the substrate sorghum V49-96, yucca, sunflower JE-94, which reached higher values at the end of the process. But as the substrates have already been degraded from the point of view of their methane production, this fact does not constitute a limitation in the process.

RESULTS AND DISCUSSION (VI)

Chart 4. Results of the microbiological analysis

Samples No.	1	1	2	2	3	3
Variable	Influent	Eflluents	Influent	Eflluents	Influent	Eflluents
Fecal coliform	≥ 1600	≥ 1600	≥ 1600	≥ 1600	≥ 1600	≥ 1600
Total coliform	≥ 1600	≥ 1600	≥ 1600	≥ 1600	≥ 1600	≥ 1600
Pseudomonas aeruginosas	$2*10^9$	$8*10^8$	$8.5*10^9$	$1.12*10^{10}$	$5*10^8$	$2.3*10^9$

The values obtained are above the limit values in the Cuban Standard (NC-27:1999); therefore these effluents should be treated before being used as bio fertilizer or disposed of (according to Cuban Standard NC-27:1999).

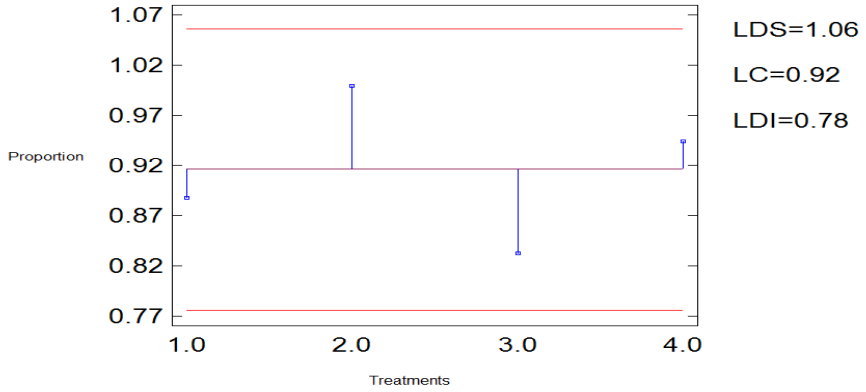
RESULTS AND DISCUSSION (VII)

Chart 5. Results of the germination test using white beans BAT–482.

Samples	Treatments	Proportion	Germination seeds
18	1 (zero samples)	0.888	16
18	2	0.999	18
18	3	0.833	15
18	4	0.914	17

In the replicate tests with the control, 88.88% germination was achieved.

In the replicated test with the effluents 92.59% germination was achieved



The germination of the seeds was 3.7% higher when using the treated effluents with respect to the control.

UCLV, 2013

Fig.3. Graph of analysis of proportion with decision limits of 95 %.

CONCLUSIONS (I)

- The biomasses with higher specific methane yield are the sunflower JE-94 (0.393 m^3 CH_4/kg oTS) and the corn (0.346 m^3 CH_4/kg oTS). Being the biomasses peanut shell (0.095 m^3/Kg oTS) and inoculum (bovine manure), the ones with lower values.
- The pH during the anaerobic process oscillates between 6.0 and 8.0 with the exceptions of the sorghum V49-96, yucca, and sunflower JE-94, which finish the cycle at pH above 8. However when this happens, the substrates have already been degraded. Therefore the high pH values do not constitute a limitation for the anaerobic process.
- The values obtained in the microbiological analysis are above the limit values in the Cuban Standard (NC-27:1999); therefore these effluents should be treated before being used as bio fertilizer or disposed of (according to Cuban Standard NC-27:1999).

CONCLUSIONS (II):

- The results referred to the germination of seeds using the effluents showed an increase of 3.7% with respect to the control values.
- These results show the possibility of using the effluents from the digesters as bio fertilizers.

UCLV, 2013

RECOMMENDATIONS

- To evaluate mixtures of (caw + pig) manure in co-digestion with biomasses of agricultural and industrial origin.
- To evaluate other waste (from agriculture and cantine).

UCLV, 2013

Thank you so much.