2nd INTERNATIONAL CONFERENCE on Sustainable Solid Waste Management

Feather waste recycle for Biogas production

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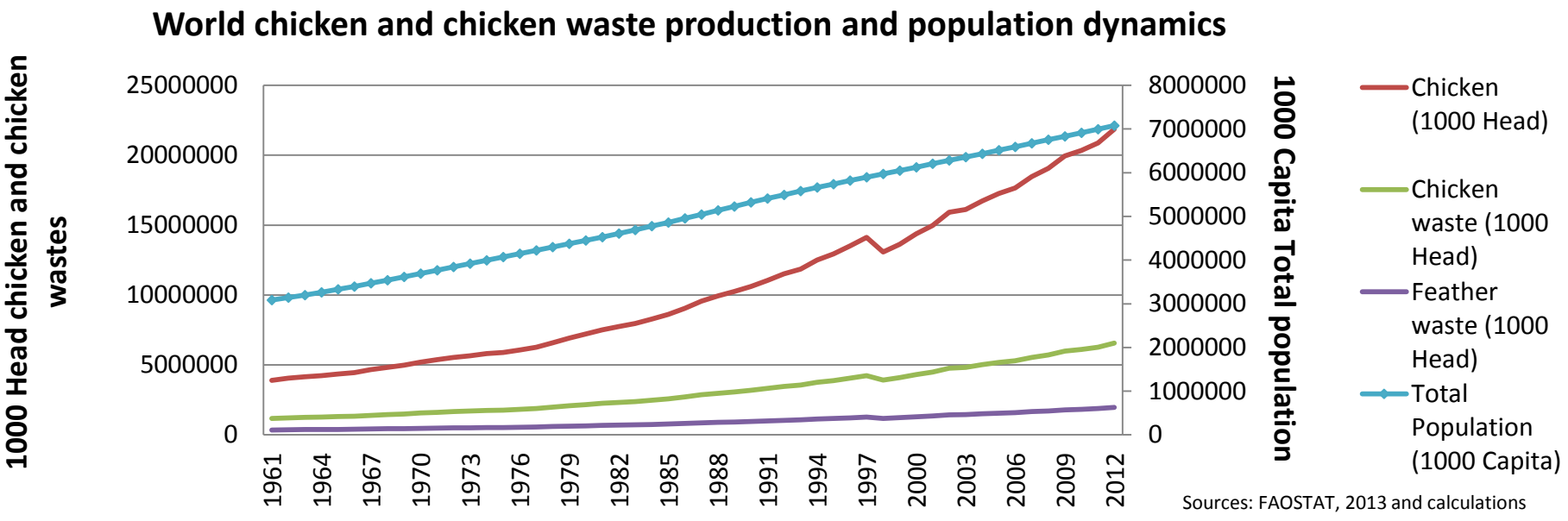
Problems



- Modified constitutional law (1576/2007/EK decree, European Parliament)

  => disable the feather utilization as feedstuff and depose to the landfill,

  => innovative developments and methods are needed
- Feather waste recycling with anaerobic digestion
- Keratin-content of feather (90%) can be difficulty degraded

Objectives

- to determine the efficiency of enzymatic pre-treatment of chicken feather waste
- to apply pre-treated feather as raw material for biogas production
- to optimize the most effective treatment ratios
- and methane potential of feather waste

Materials and methods

I. Pre-treatment of feather waste

1. Preparation and analysing of slaughterhouse chicken feather:

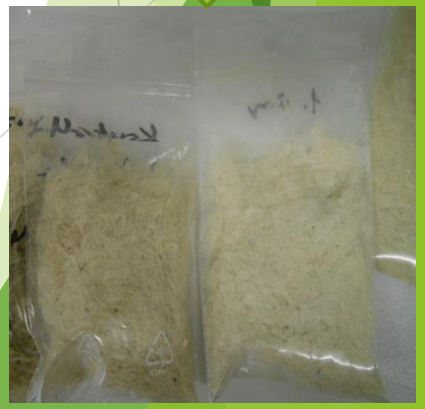
A, Autoclaving (100°C, 30 min) => bacterial pre-treatment

B, Autoclaving and drying (80°C, 10 h) (DM, oDM content) and grinding (2-5 mm sieve) => C-, N-content analysing.

Raypa type autoclave

Grinder (WARING®, Snijders)

Elementar VARIO EL universal analyser



Materials and methods

I. Pre-treatment of feather waste

2. Feather hydrolysis:

- Inoculation *with Bacillus licheniformis KK1**: 4,55x10^6 cell/ml (10 ml) except of the control experiment
  - produce extracellular protease, incubation (42°C, 200 rpm) (Heidolph Unimax 1010)
  - pH optimum (7.2) setting with Tris-HCl
  - Medium: LB broth (MILLER et al. 1972)
- with 1:2 (w/v) feather: water ratio (0.67 kg whole feather: 1.33 l deionized water)
- in four 3 litre glass bottles for 5 days
- in a 45 l water bath (Memmert), triplicate.
- agitation (air pump) was controlled by flow meter (1.5 l/min air flow).

pH measuring: Hanna HI2550 multifunctional pH/ORP/temperature/EC/TDS/NaCl device

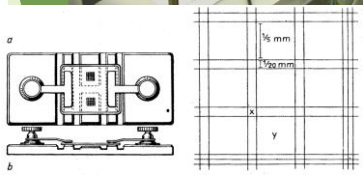
**isolated by Kovács et al., 2002; Perei et al., 2004; Bálint et al., 2005*

Materials and methods

I. Pre-treatment of feather waste

3. Analysis of feather degradation efficiency I.

- **Cell counting:** in Burker chamber with Alpha BIO-3CCD light microscope



- **Determination of the protein concentration with Bradford (1976) method:**
  - 4 samples per day until 5 days.
  - Bacteria culture was filtrate with centrifuge (10000 rev/min for 20 min)
  - Absorbance of solutions was measured photometrically with Sacoman Athelie Junior spectrophotometer (2 min and 1 hour) at 595 nm
  - Calibration curve: Standard: bovine serum albumin (BSA)

3. Analysis of feather degradation efficiency II.

- Keratin degradation rate (%) was calculated from protein content of raw chicken feather and protein concentration of liquid culture filtrate.

- Determination of chemical oxygen demands:
  - After centrifuge with PF-10 compact photometer (Macherey-Nagel) with 0–15,000 mg/l sCOD test solution at 620 nm after 148°C, 2h destruction.

- Solubilisation degree of feather (%) calculation was based on method described by Forgács et al. (2013).

Materials and methods

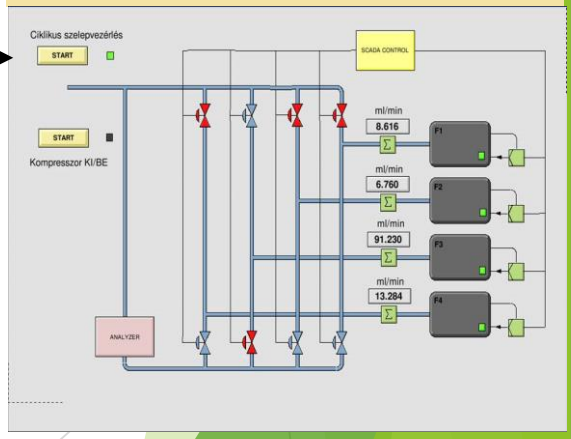
II. Biogas production

1. Biodegradation laboratory: Anaerobic digestion; Batch tests

Stainless steal digesters (6 l volume) (mixing, heating, pH controlling) in incubators

Biogas washing (gas-washer bottle), **and dewatering** (cryogenic instalment) **system**

Controlling system



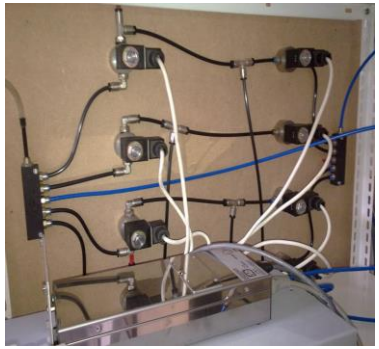
Biogas quality analysis

CH_4
CO_2

H_2S
NH_3

Biogas quantity analysis

Cyclic, doubled valve-system



Materials and methods

II. Biogas production

2. Batch digestion: raw materials and experiments:

Mesophilic conditions (38°C), 5 l volume, 30 days

Table 1. Experimental settings:

Digester	Corn silage (kg)	Mesophilic liquid digestate (kg)	Cattle slurry (kg)	Pre-treated feather (%)
1 (Control)	0.2	2.2	2.6	0
2	0.2	2.2	2.6	5
3	0.2	2.2	2.6	10
4	0.2	2.2	2.6	20

Results and discussion

I. Pre-treatment of chicken feather

Table 2. Quality parameters of feather samples:

Number of samples	Carbon-content (%)	Nitrogen-content (%)	DM%	oDM%
Mean±SD	51.61±1.78	14.09±0.995	39.13±0.49	93.35±4.11

The protein content of examined feather sample (nitrogen content*6.25) on average was 88.1±6.22% which was similar to results of Papadopoulos (1985) experiments (85-99%).

Table 3. Monitoring of growth of bacteria cells with Burker chamber:

Bacterial cell number ($x10^6$ cell/ml)	1. day	2. day	3. day	4. day	5. day
Infected experiments	4.55±0.00	11.2±0.58	23.7±1.11	52.32±1.33	**70.8±4.62**

Results and discussion

I. Pre-treatment of chicken feather

Determination of feather protein concentration

- Protein concentration of samples could be determined with comparison of absorbance values and calibration curve
- The dissolved protein concentration in our case was 0.19 mg/ml.

Table 4. Efficiency of feather pre-treatment:

Experiments and differences	Protein concentration changes (mg/ml)				
	1. day	2. day	3. day	4. day	5. day
Infected experiments	0.012±0.001	0.09±0.014	0.16±0.018	0.24±0.031	0.36±0.014
Control	0.00±0.0	0.00±0.0	0.008±0.002	0.013±0.003	0.026±0.012
Differences%	1.2	9.0	16.0	22.7	33.4

Table 5. Keratin degradation rate (%):

Experiments and differences	Keratin degradation rate (%)				
	1. day	2. day	3. day	4. day	5. day
Infected experiments	0.91±0.052	6.79±2.14	12.08±0.96	18.12±1.66	27.17±0.75
Control	0.00±0.0	0.00±0.0	0.60±0.10	0.98±0.16	1.96±0.64
Differences%	0.91	6.79	11.48	17.14	25.21

Pre-treated and control experiments

Determination of sCOD (g/l):

Control

- sCOD: 6.8±0.56 g/l
- Solubilisation degree(%):4.53%±0.37

Pre-treated feather

- sCOD: 106.15±3.18 g/l
- Solubilisation degree(%):70.77%±2.12

- **Solubilisation degree** (%): 66.23% difference was determined compared the control experiments

Results and discussion

II. Biogas production

Batch digestion experiments:

Table 6. Quality parameters of biogas raw materials:

Raw materials	Corn silage	Cattle slurry	Liquid digestate	Pre-treated feather
DM%	26.0±2.73	3.6±0.52	2.8±0.91	19.94±1.36
oDM %	93.0±3.35	82.7±3.89	72.4±4.02	96.4±2.31
C:N ratio	*27.6*	*13,0*	*18.0*	*1.47*
C-content	45.8±0.87	40.4±2.40	47.3±2.07	*15.09*
N-content	1.7±0.29	3.1±1.21	2.6±0.25	*10.26*

Table 7. Calculated average of DM% and oDM%:

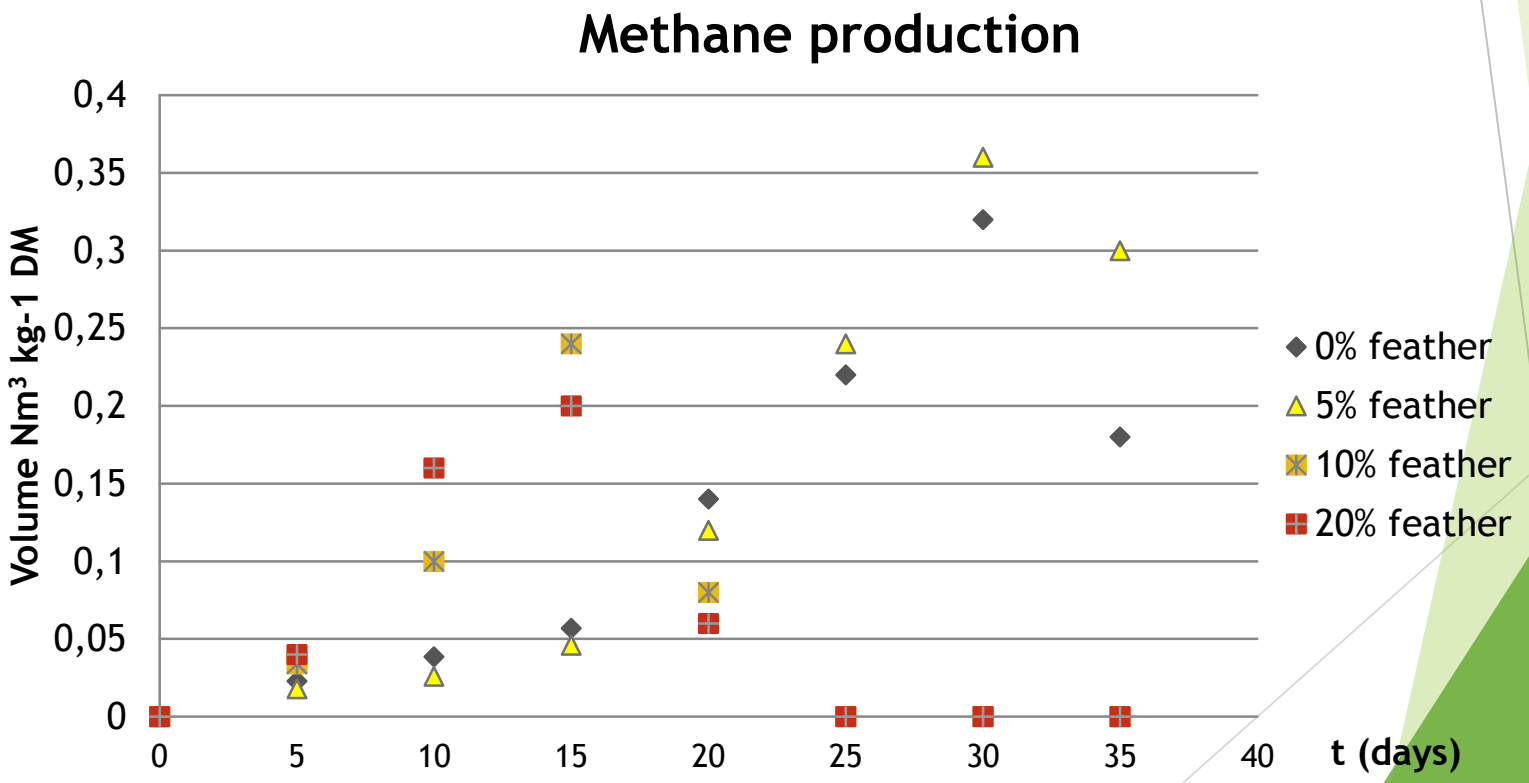
Digester number	1	2	3	4
Pre-hydrolysed feather%	0	5	10	20
DM%	3.9±0.5	3.7±0.6	3.6±0.4	3.4±0.5
oDM% in DM%	3.1±0.4	2.8±0.3	2.5±0.2	2.3±0.2

Results and discussion

II. Biogas production

Biogas production of biodegraded chicken feather:

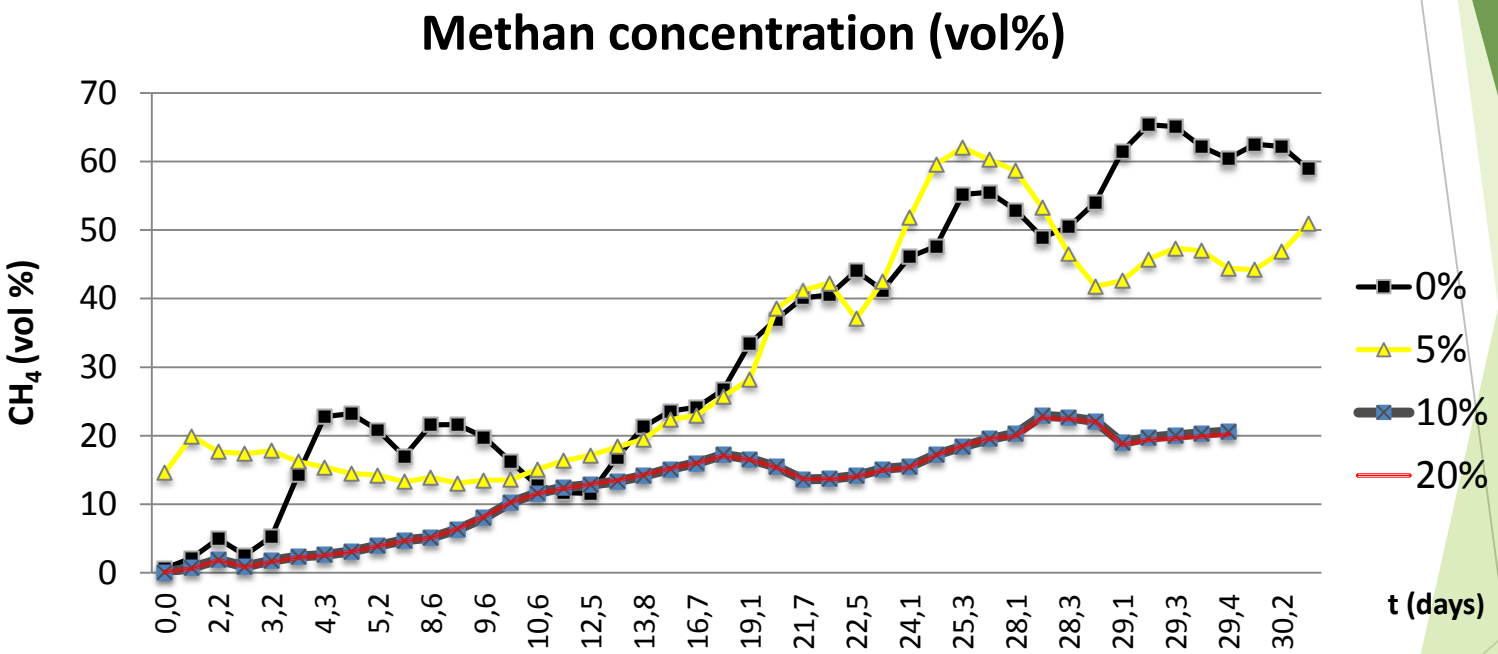
Methane production during co-digestion of different pre-treated feather ratios:



Results and discussion

II. Biogas production

Methane concentration (vol%) during co-digestion of different pre-treated feather ratios:



- The biogas quality in case of the poultry feather mixture rate of 5 showed better results and differed significantly from the rates of 10 and 20%.
- In case of treatments with a feather mixture rate of 5 methane concentrations around 60% stayed stabile.

Conclusion I.

Pre-treatment of feather waste:

- The protein concentration values and keratin degradation ratios (%) of infected and control experiments showed significant difference applying t-test and variance analysis (Tukey's test) (SD 0.1%).
- Solubilisation degree of feather (%) - calculated from sCOD - shows 66.23% difference compared the control experiments.

Positive effects on biogas production:

- In our case 5% pre-treated feather ratio result in a favourable biogas production, the highest methane yield was 0.36±0.13 Nm^3/kg DM,
- second was the control experiment (0.32±0.13 Nm^3/kg DM) after 30 days.
- Control, 5% experiments and 10, 20% experiments showed significant differences.

Conclusion II.

Negative effects on biogas production:

- The ratio, which is more than 10%, reduce the biogas yields significantly.
- Due to the amount of produced H_2S (ppm) the critical mixing ratio of feather proved to be 10% in laboratory environment.
- The production of the H_2S reached its maximal value (200 ppm) already on the 9^{th} day in case of the 10% treatment.
- Three treatments group could be selected in case of the highest ammonia concentrations (control and 5% and 10, 20%), which were detected after 20 days.
- Above 10% inhibitory effect was observed in case of produced ammonia.

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Nemzeti Kiválóság Program

ÚJ SZÉCHENYI TERV

Thank you for your kind attention!