

MIMAGAS - Combination of physicochemical pre-treatments of biomass to maximise biogas production



Renewable energy need

Development of sustainable and carbon-neutral energy routes



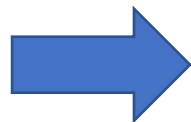
Biogas from biomass
feedstock and agro-wastes

Anaerobic digestion (AD) of organic matter as an ecological process for agricultural sector



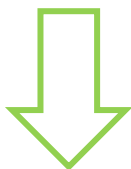
Fibrous matter
pre-treatment

Lignocellulosic biomass conversion strongly depends on its accessibility to microorganisms due to fibrous structure (manure)



Development of a pre-treatment protocol that combines weak organic acids addition, mild grinding and mild thermal hydrolysis

Chemical agent



Weak organic acids to attack
lignocellulosic fibers



Cheese whey

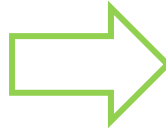
- Less toxic
- Less corrosive (equipment)
- Safe and cheap

- Widespread
- Abundant effluent 1'300'000 t/y in Switzerland
- Alternative use (45% to pigs)

Mechanical action



Manure size-reduction to
increase surface areas

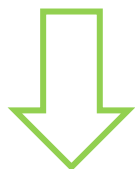


Meat grinder

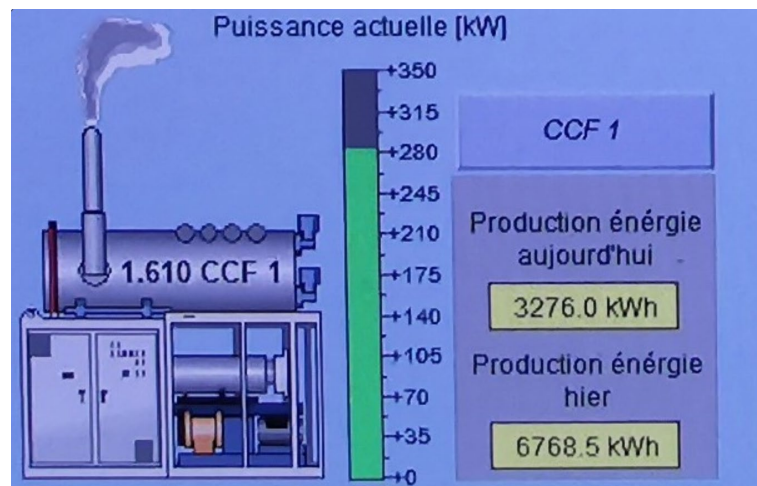
- Low energy consumption
- No technology development
- Simple and easy maintenance

- Meat – Manure similarities
- Endless screw (feeding machines)
- Scaling-up

Thermal treatment



Mild temperatures
to weaken cellulose
structure



Heat surplus from CHP

- Low energy consumption
- Work @ atmospheric pressure
- Simple and easy to integrate

- Few biogas upgrading agro-plants
- AD heating systems
- Minimal consumption (1-2% heat production increase)

Objectives

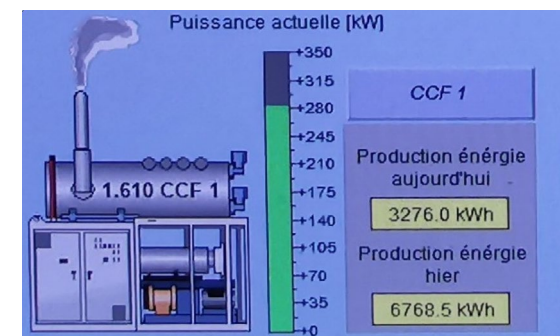
Chemical agent

+

Mechanical action

+

Thermal treatment



Objective 1: Exploratory study on the combined action of different types of pre-treatments

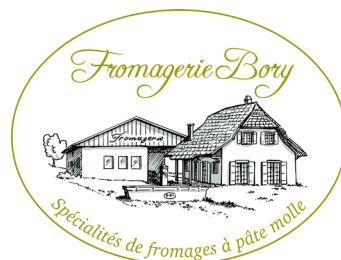
- Acid concentration in whey (fermentation)
- Size of the meat grinder grid
- Reaction temperature
- Reaction time

Procedures and methodology

Whey fermentation to increase the total acidity concentration



hard cheese



soft cheese



organic cheese



hard cheese



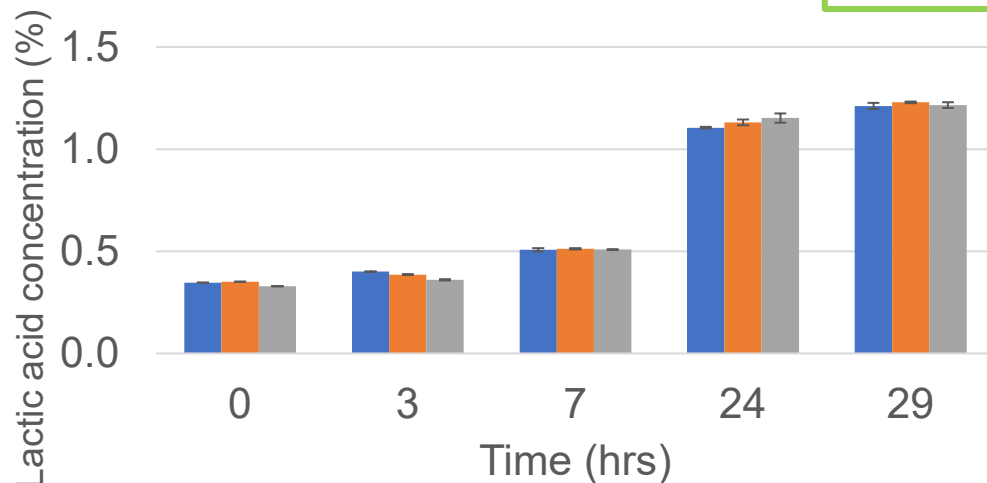
- Different cheese production processes
- Temperature variation
- LAB addition / boosting test
- Storage simulation

Activities and results – whey fermentation

Cheese factory Villars-Burquin

■ 38°C ■ 40°C ■ 44°C

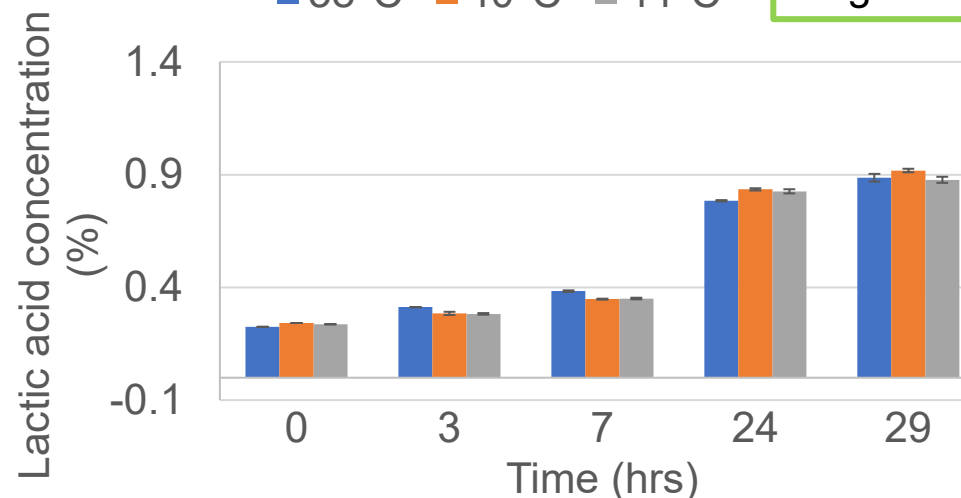
hard cheese



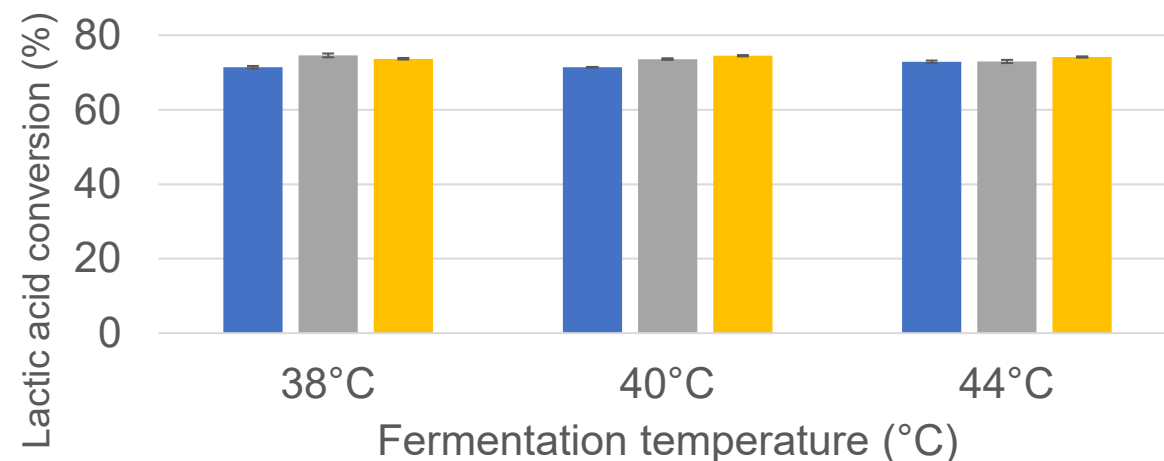
Cheese factory Pomy

■ 38°C ■ 40°C ■ 44°C

organic cheese



■ Villars-Burquin ■ Pomy ■ Gros de vaud



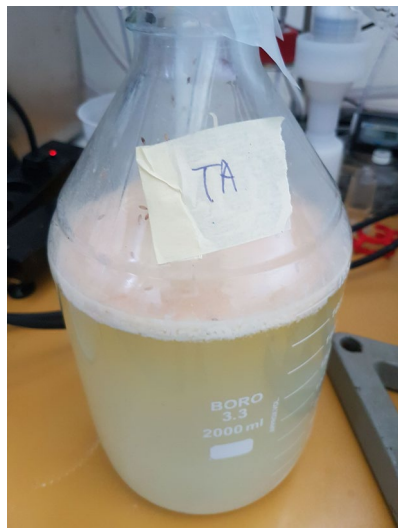
- No difference between conventional/organic farms
- No difference in terms of fermentation temperature
- Lactic acid conversion between 70-75%
- Aim: maximise acidity production

Activities and results - whey fermentation

LAB addition

Powder microorganisms

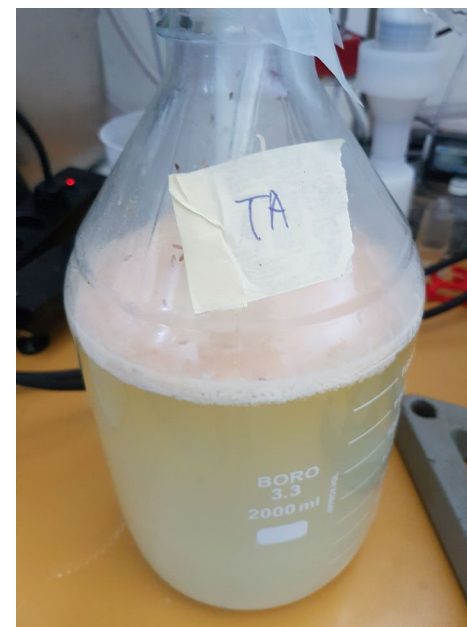
Fermented whey



No significant changes in fermentation reaction
– no boosting needed

Storage simulation

Room temperature between 22-25°C



Total acidity conversion of 80% in 30 days

Procedures and methodology

WP1: Exploratory study of combination of different types of pre-treatment

1. Milk whey **fermentation** to increase the total acidity concentration
2. Mixing of manure and liquid agent and its mechanical **grinding**
3. Mild **thermal** treatment of the grinded material

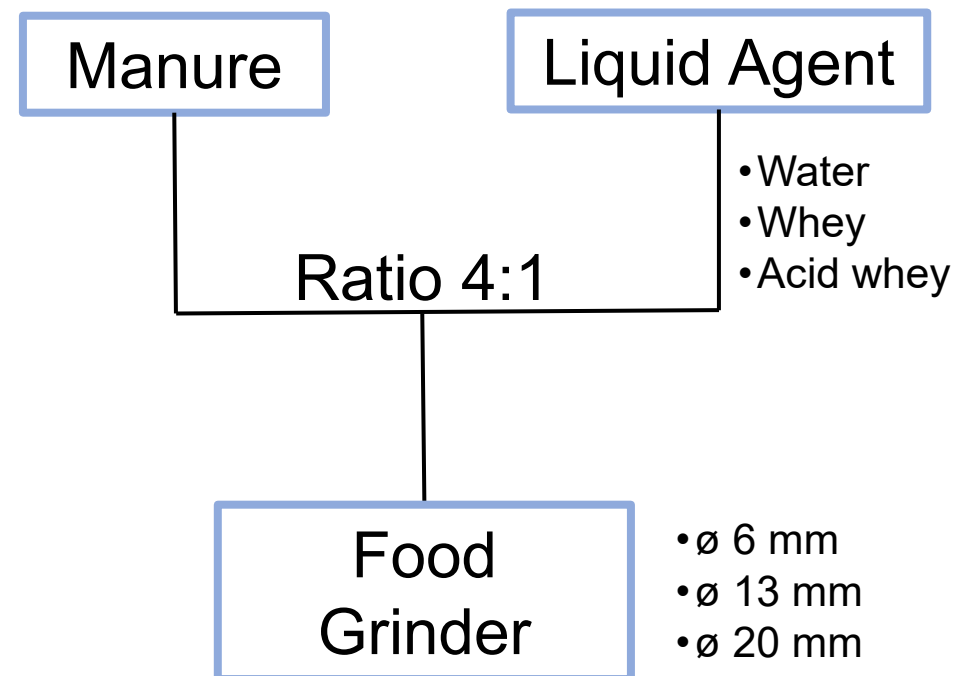
4. Analyses

Factors	level 1	level 2	level 3
Time (hours)	2	8	24
Temperature (°C)	20	40	80
Acid conc. (%)	0	whey	acid whey
Grid dimension (mm)	6	13	20

Taguchi L9 method
(four factors at three levels,
according to ISO/TR 12845:2010)

Run	Time	Temperature	Acid concentration	Grid dimension
1	2	20	0	6
2	2	40	whey	13
3	2	80	fermented whey	20
4	8	20	whey	20
5	8	40	fermented whey	6
6	8	80	0	13
7	24	20	fermented whey	13
8	24	40	0	20
9	24	80	whey	6

Activities and results – Grinding tests



grid dimension	grinding energy
mm	kWh/ton
6	33
13	24
20	13

Activities and results – Hydrolysis tests



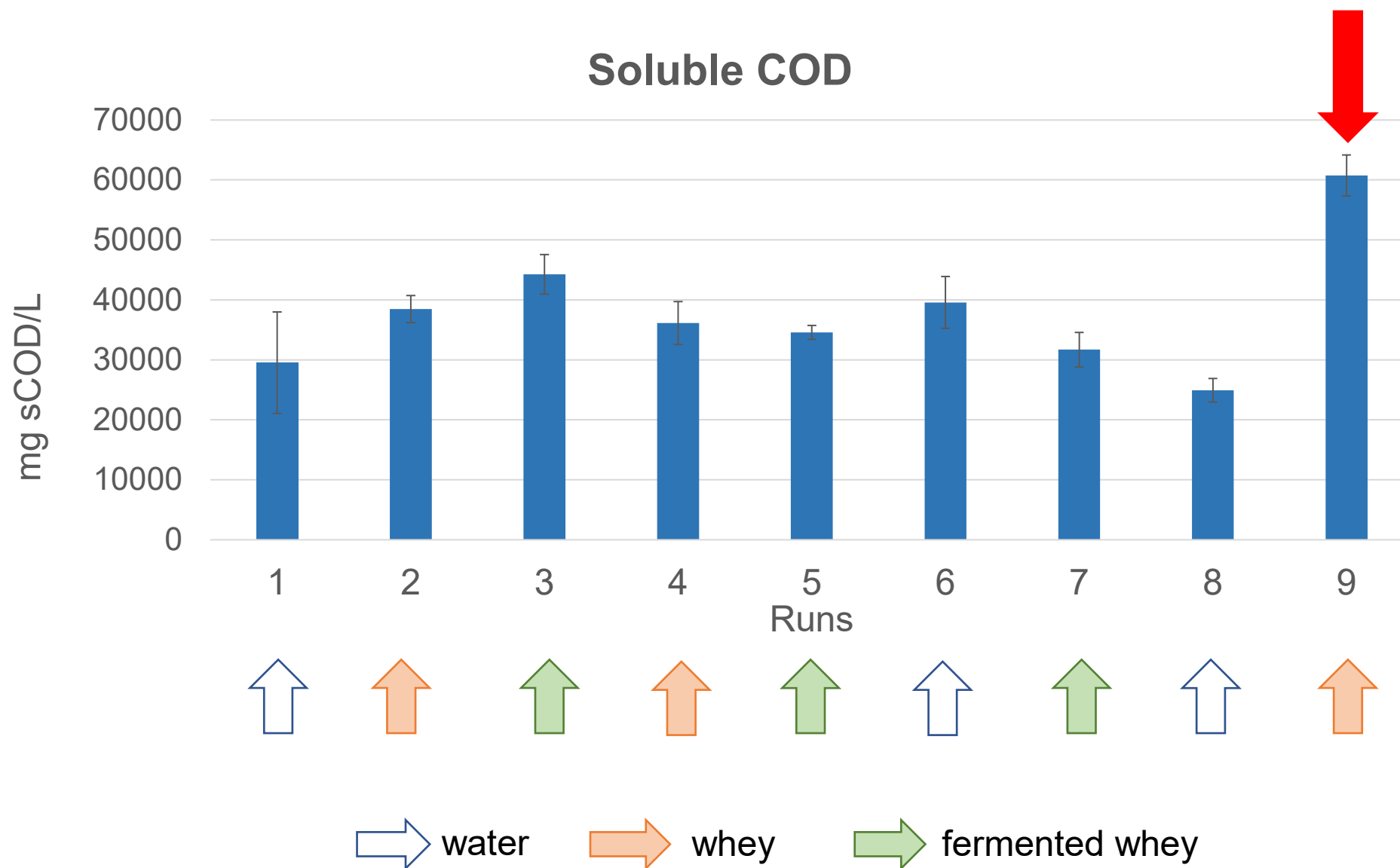
Grinded material

2L- bottles

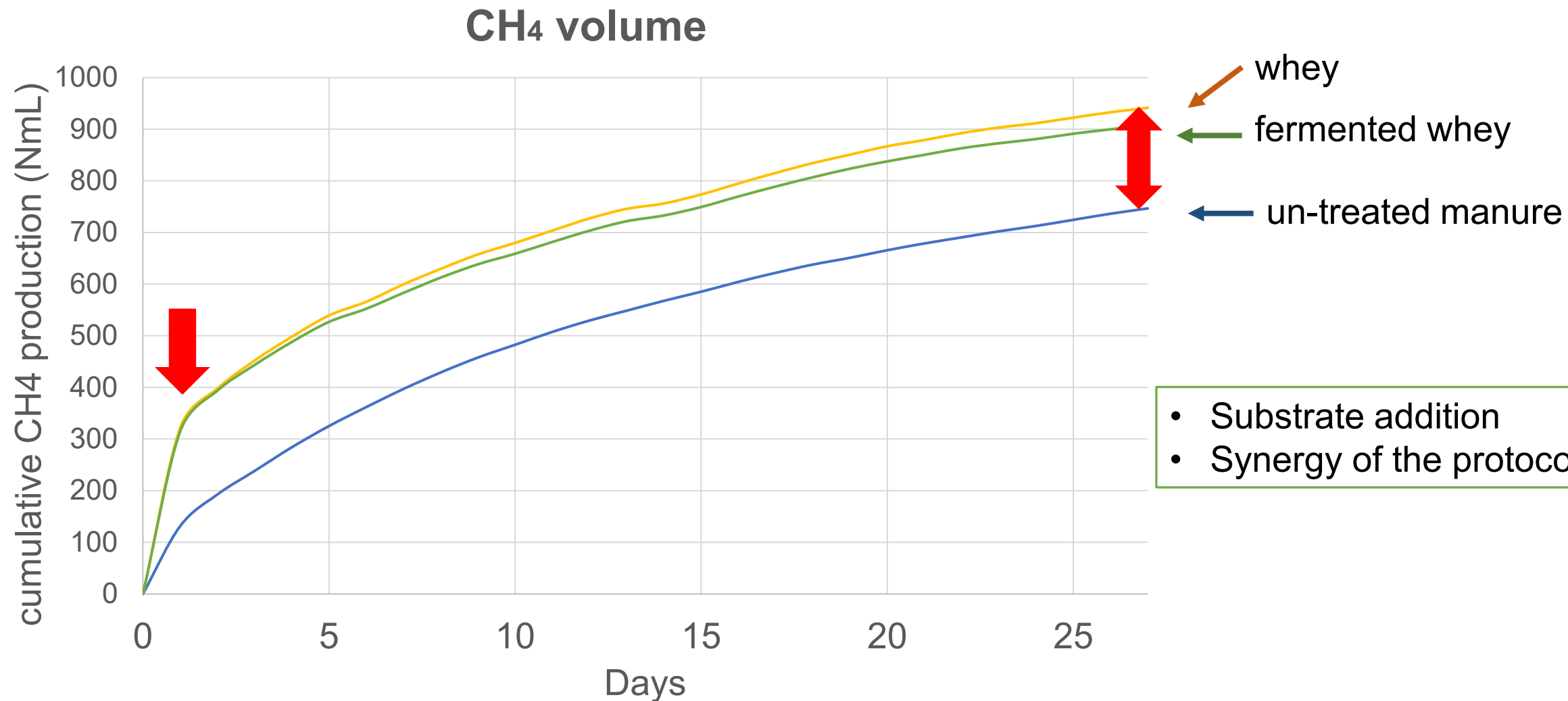
Reaction

- | | |
|-------|-------|
| •20°C | •2 h |
| •40°C | •8 h |
| •80°C | •24 h |

Analyses results



Analyses results



BMP results

Run	Time	Temperature	Acid concentration	Grid dimension	BMP yield % Synergy
3	2	80	fermented whey	20	33
5	8	40	fermented whey	6	23
9	24	80	whey	6	51

Inoculum: Agro AD sludge



Objective 2: *anaerobic digestion tests in 50-L reactors
Fed with un-treated manure and treated manure*



Conclusions

- Different pre-treatments combinations tested
- Presence of **acidity** increases BMP values (still open about simple whey or fermented)
- Grinding with **smaller** holes
- **Higher temperature** to increase sCOD values
- **Combination** of different pre-treatment gives a synergy to work at **mild conditions**

**HE^{VD}
IG**

**HAUTE ÉCOLE
D'INGÉNIERIE
ET DE GESTION
DU CANTON
DE VAUD**