LOW COST NON-THERMAL PLASMA TREATMENT OF DISTILLERY WASTEWATER FOR LACTIC ACID FERMENTATION

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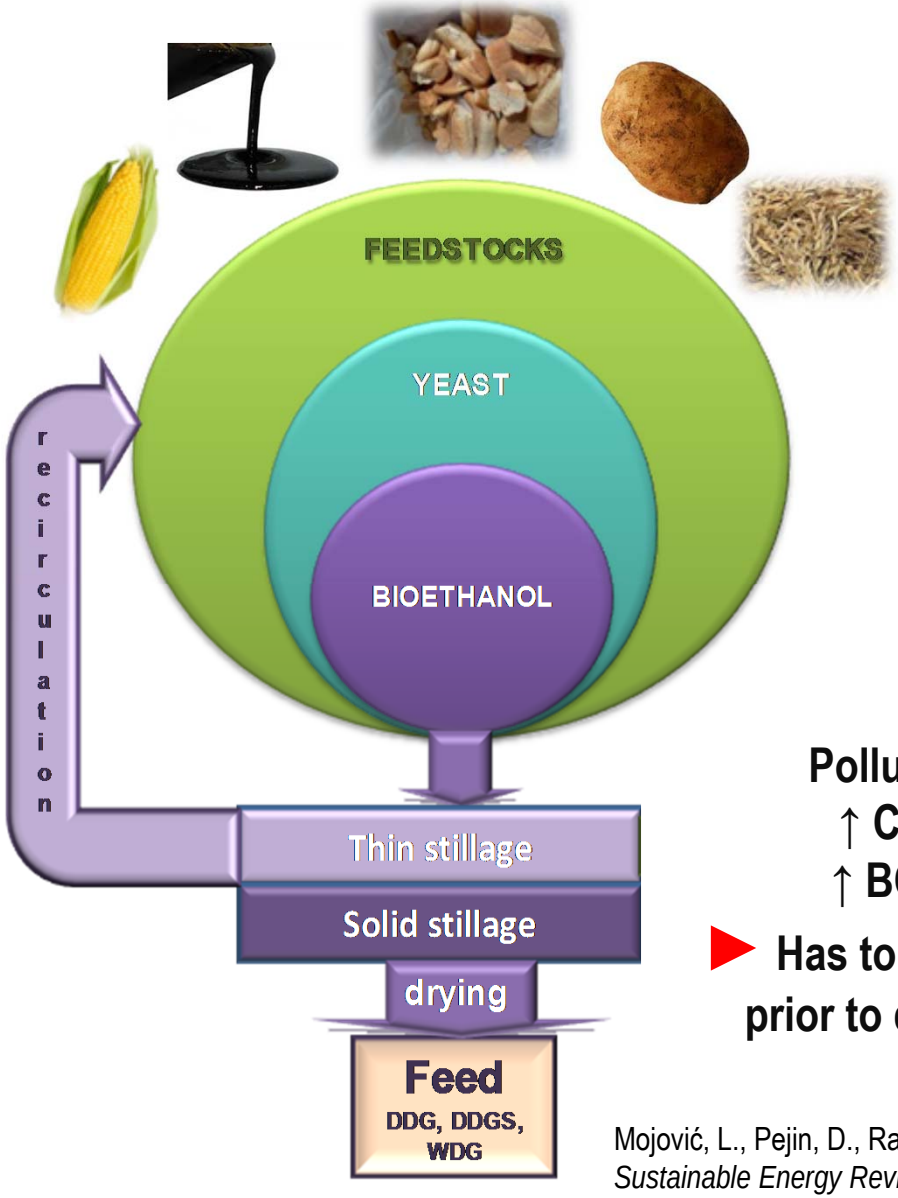
Distillery wastewater from bioethanol production - stillage



1 L of bioethanol produced

20 L of stillage are remaining!

Stillage composition	
Dry matter (%)	12.79 ± 0.31
Protein (g/L)	63.91 ± 2.81
Reducing sugar (g/L)	11.19 ± 0.83
Free –amino nitrogen (mg/L)	295.6 ± 1.5
Ash (g/L)	31.2 ± 0.1

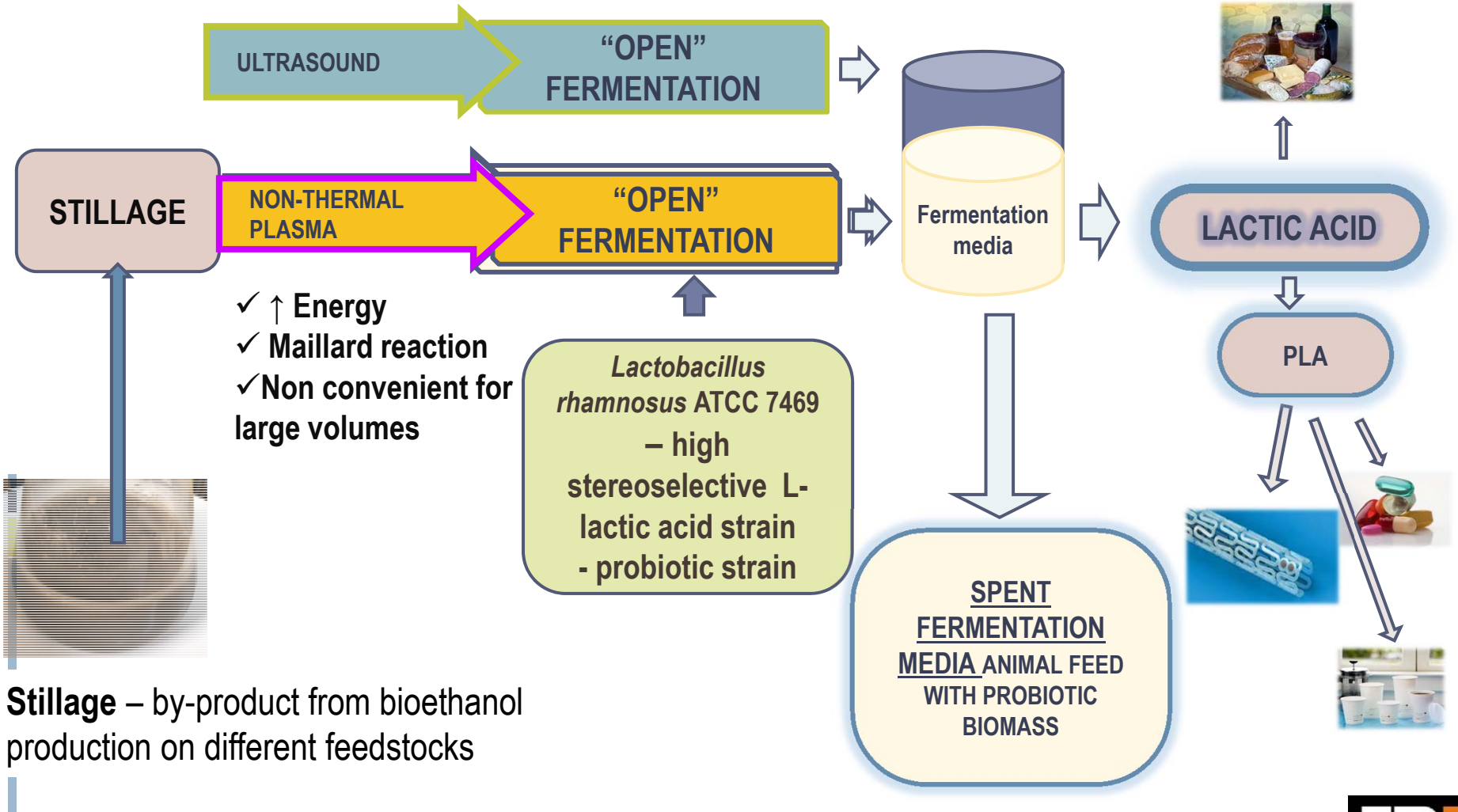
Pollution:
↑ COD
↑ BOD_5

Has to be treated prior to disposal

Stillage microbiota – susceptibility to contamination ...

Mojović, L., Pejin, D., Rakin, M., Pejin, J., Nikolić, S., & Djukić-Vuković, A. (2012). *Renewable and Sustainable Energy Reviews*, *16*(8), 6040-6047.

AIM: Opportunities for application of non-thermal plasma in LA biorefinery processes



Stillage – by-product from bioethanol production on different feedstocks

Non-thermal or cold plasmas: ●lower pressures ●lower temperatures ●less energy intensive

Non-thermal plasma generates:

- **reactive species**
- **UV radiation**
- **electroporation of cells to lower extent**

Superoxide anion $O_2^{-\bullet}$

Hydrogen peroxide H_2O_2

Hydroxyl radical $^{\bullet}OH$

Nitric oxide NO

Peroxynitrite $ONOO^-$

Dinitrogen trioxide N_2O_3

Secondary generated active species

Media subjected to plasma treatment

→ "etching" surfaces

→ ↓ pH value of media (H_3O^+)

Applications:

- To inactivate undesired microbiota in substrate?

In stillage microbiota:

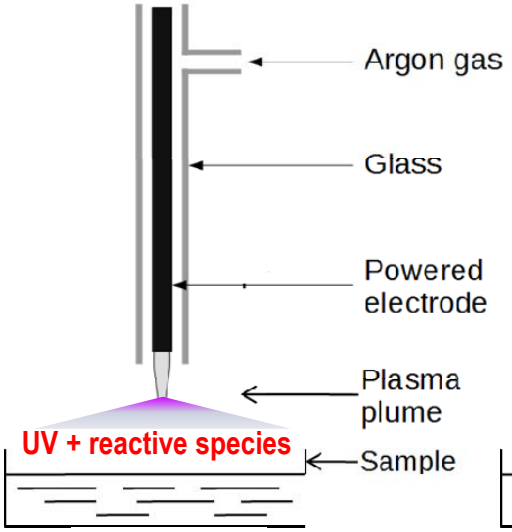
Gram (+) bacteria – lactic acid bacteria - desired

Gram (-) bacteria – undesired

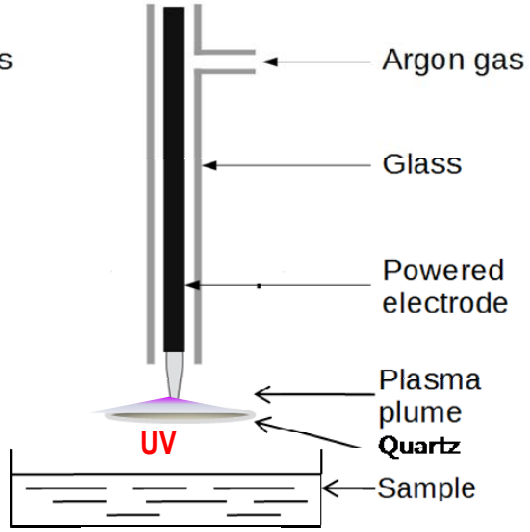
Materials and methods

Non-thermal plasma

Non-thermal plasma



Non-thermal plasma generated UV



- Plasma needle operating at 25 kHz in ambient air.
- Argon was used as a feed gas (2 slm flow rate) in order to reduce the breakdown voltage through Penning ionization.
- The operating power was 2 W.
- The distance between the jet and substrate was 1 cm.

High-power ultrasound

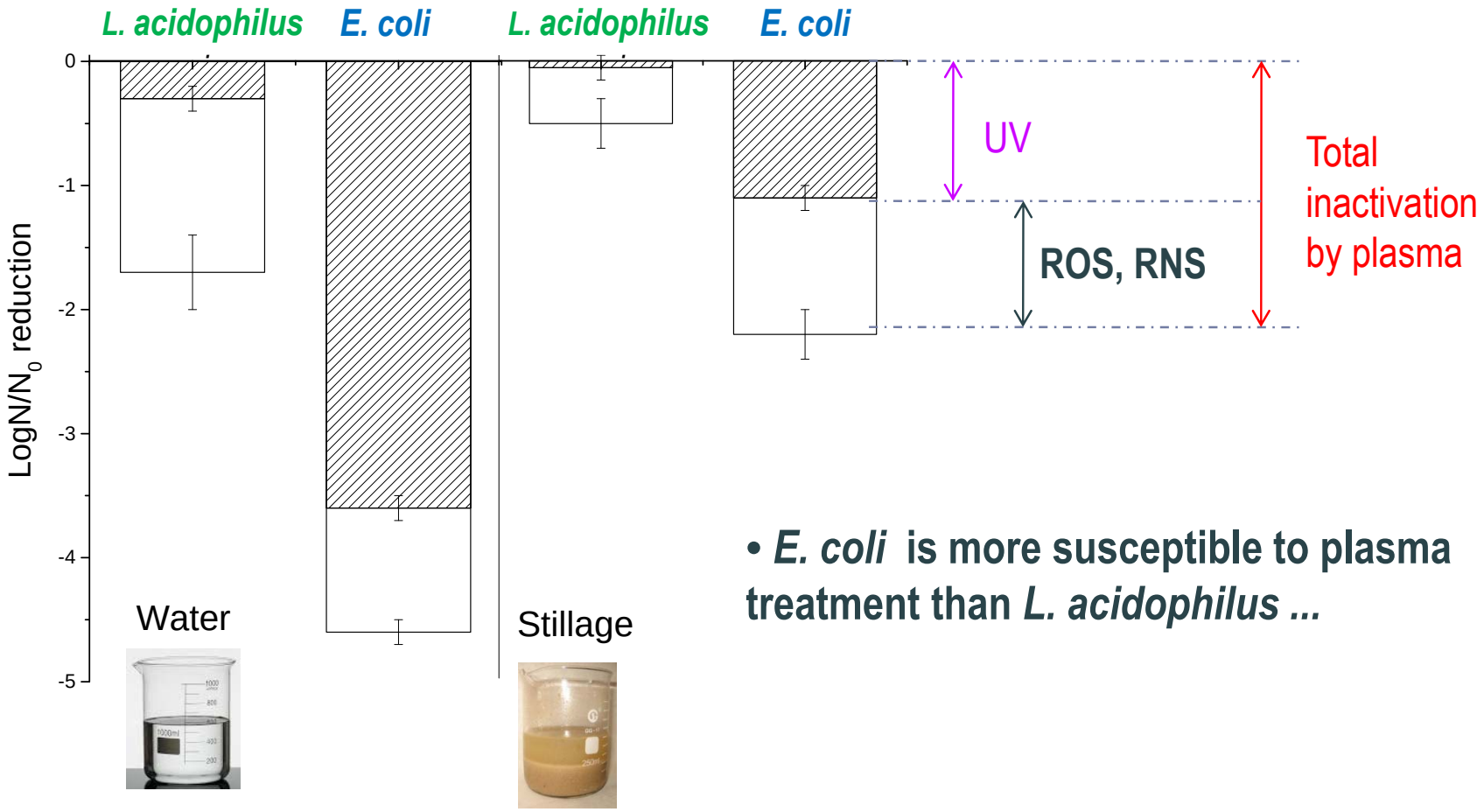
Ultrasound sonotrode (TT 13 mm , Bandelin, Germany), 20 kHz, 200 W
Volume of sample 60 ml

Results

Two model microorganisms treated by non-thermal plasma in sterilized water and stillage:

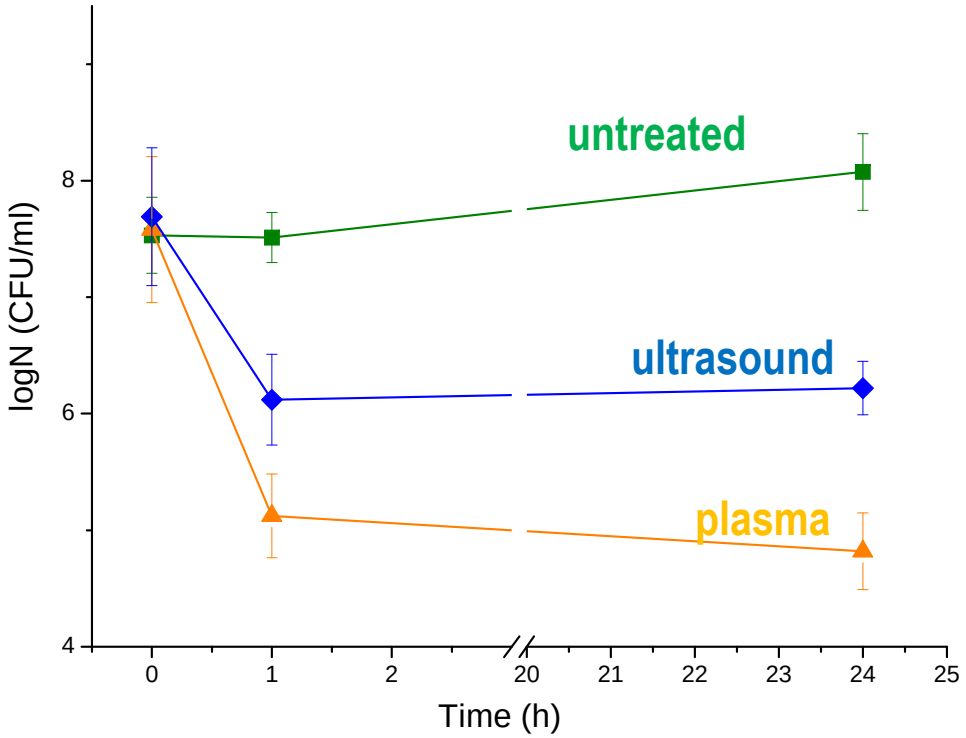
***Lactobacillus acidophilus* – Gram (+) bacteria – representative of LAB**

***Escherichia coli* – Gram (-) bacteria**



- ***E. coli*** **is more susceptible to plasma treatment than *L. acidophilus* ...**

Number of viable cells of stillage microbiota in time after different treatments

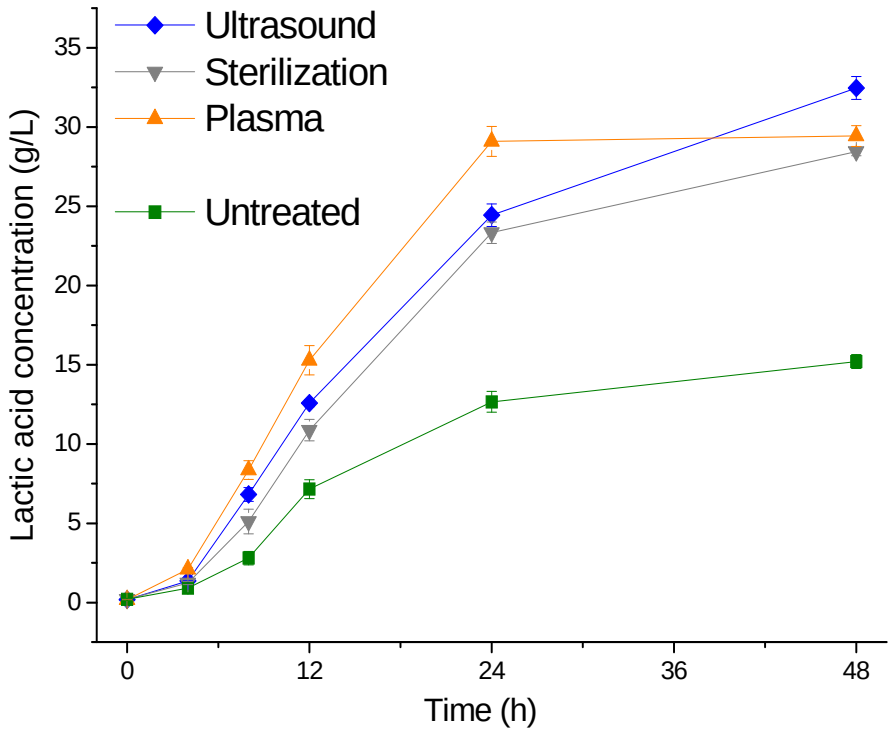


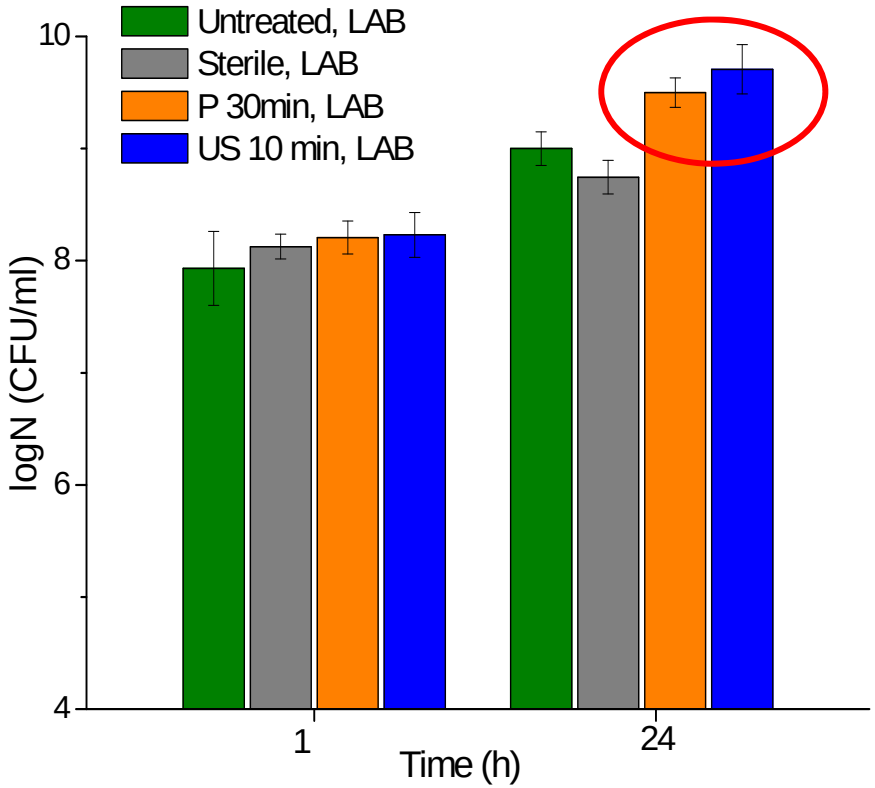
- 24h after treatment no significant increase in the number of bacteria
- 3 log unit lower number of viable cells than in untreated sample

Longer storage time for stillage
Versatility in utilization – for different revalorization strategies

Effect of treatments on growth of LA producing microorganisms and LA production

Lactobacillus rhamnosus ATCC 7469 – high L (+) LA strain



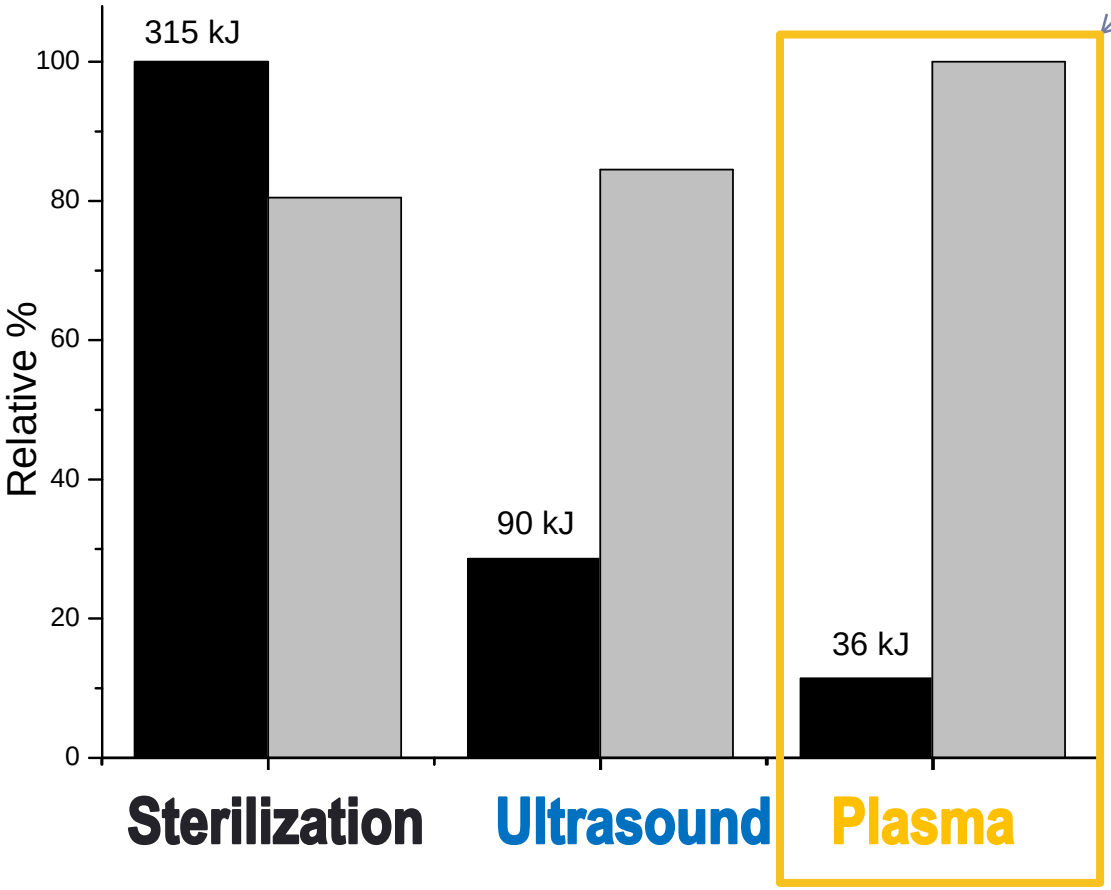


Stereoselectivity?

closed LAF - 97.2% of produced LA was L (+) isomer
Plasma treated, open LAF - 95.5% L (+) isomer

The growth of microorganisms was not affected by previous plasma treatment.

Estimate of required energy for different processes at laboratory level and mass of LA produced



Plasma treatment:

- Highest in LA production
- Lowest in energy consumption

Conclusions

- **Non-thermal plasma treatment could decrease the number of microorganisms in media and improve overall performance of LAF on stillage**
- **Plasma treatment has shown selectivity towards G (-) bacteria.**
- **Plasma treatment resulted in the highest LA productivity (20% higher than with ultrasound treatment) and lowest energy consumption - in “open” fermentation.**
- **Stereoselectivity of L(+) LA was maintained.**

ACKNOWLEDGMENT

This work presented here was funded by the Serbian Ministry of Education, Science and Technological development (TR 31017).

Thank you for your attention!

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