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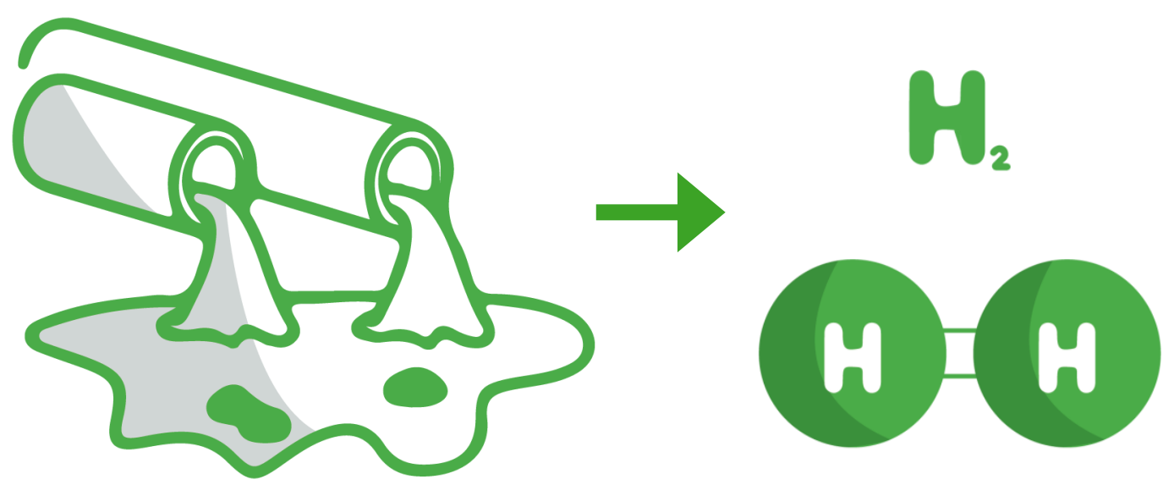

Wastewater2Hydrogen

Biotechnological Hydrogen Production from Industrial Wastewater

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Introduction

Global hydrogen production is currently still based almost exclusively on fossil resources. A sustainable hydrogen industry must be based on sustainable, renewable energy sources and resources. Waste water with a high organic load - such as that produced in biorefinery processes (e.g. starch production) - is an ideal resource for the fermentative production of biohydrogen (Chaubey et al., 2013). As waste water has to be treated anyway before being released to the environment, fermentative processes can reduce the organic load while saving H_2 production costs. A particularly promising approach for this is dark fermentation by means of a mixed culture. Here a pre-treatment of the waste water takes place while no expensive sterile technology is necessary in the fermentation process (Moreno-Andrade et al, 2015). As hydrogen is a side product of acidification (acetate and butyrate formation), biohydrogen production can also serve as a pre-acidification for industrial biogas plants (compare Figure 1).

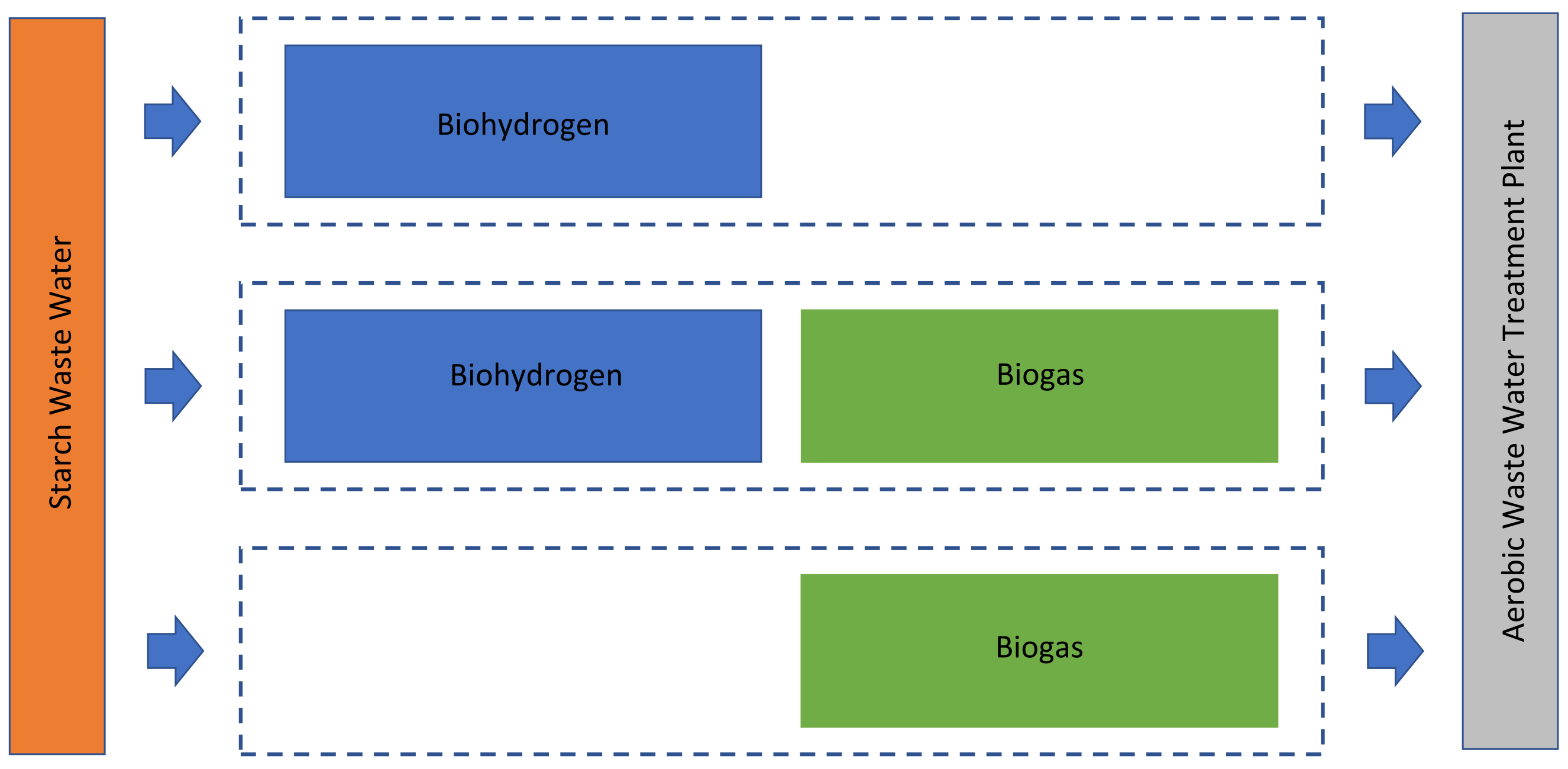

Figure 1: Possibilities for waste water treatment

Material and methods

In laboratory tests, dark fermentation is examined for different parameter variations. Experiments are focusing on the selection of suitable starch waste water as a substrate while examining associated optimal operating parameters. As a reference, biohydrogen production is compared to biogas production, or the combination of both processes.

Results shown in the following are examined in 116 mL serum flasks as shown in Figure 2. All experiments were conducted in triplicate as anaerobic batch fermentations using mixed microbial consortia. The first experiments aiming to learn more about the process and handling, were done with synthetic media according to Myoung-Joo Lee et al. (2012). Analysis were done by GC, HPLC as well as standard analysis regarding biogas.

The **aim** of the experiments is to determine the preferred option in terms of biohydrogen production and its position in relation to the optimal total energy yield (Figure 1). Finally, the most promising process will be up-scaled.

Figure 2: 116 mL serum flasks

Microbial pathways

As seen in Figure 3 by Huang et al. (2018), there are multiple pathways where H_2 results as a side-product. While producing acetate being the path yielding most ATP and therefore preferred, products can switch due to the mixed consortia and/or the current predominate chemical equilibrium.

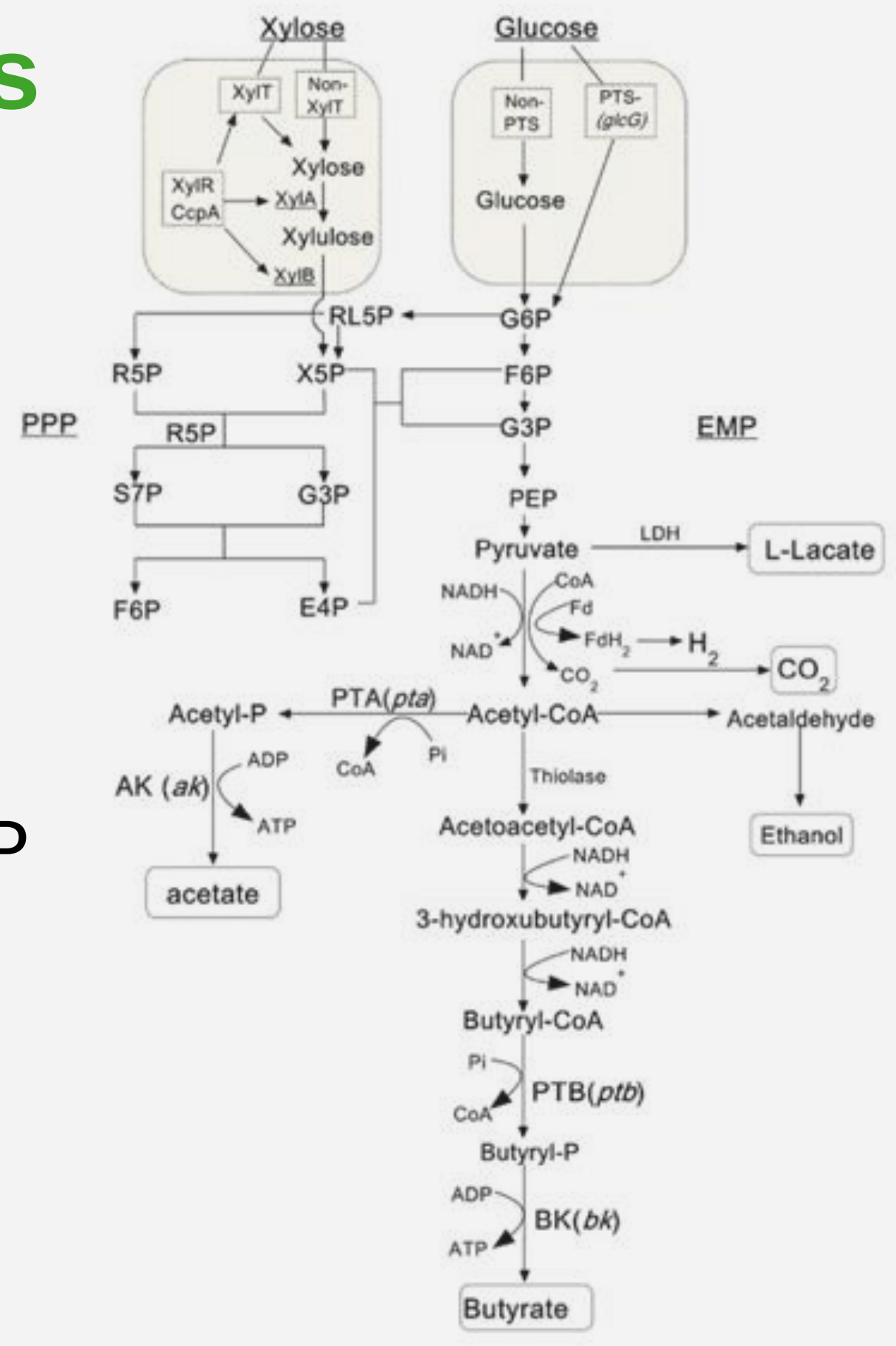

Figure 3: H_2 pathways (Huang et al., 2018)

First results

Corresponding to the pathways referred to in the box above, fatty acid pattern was found in liquid samples of serum flasks while H_2 production (compare Figure 4). It can be seen that the inoculated mixed consortia can only produce acids and therefore H_2 until a saturation is reached and production is inhibited. While converting glucose to fatty acids and CO_2 a productivity of 2.21 ± 0.75 mol H_2 per mol glucose was reached.

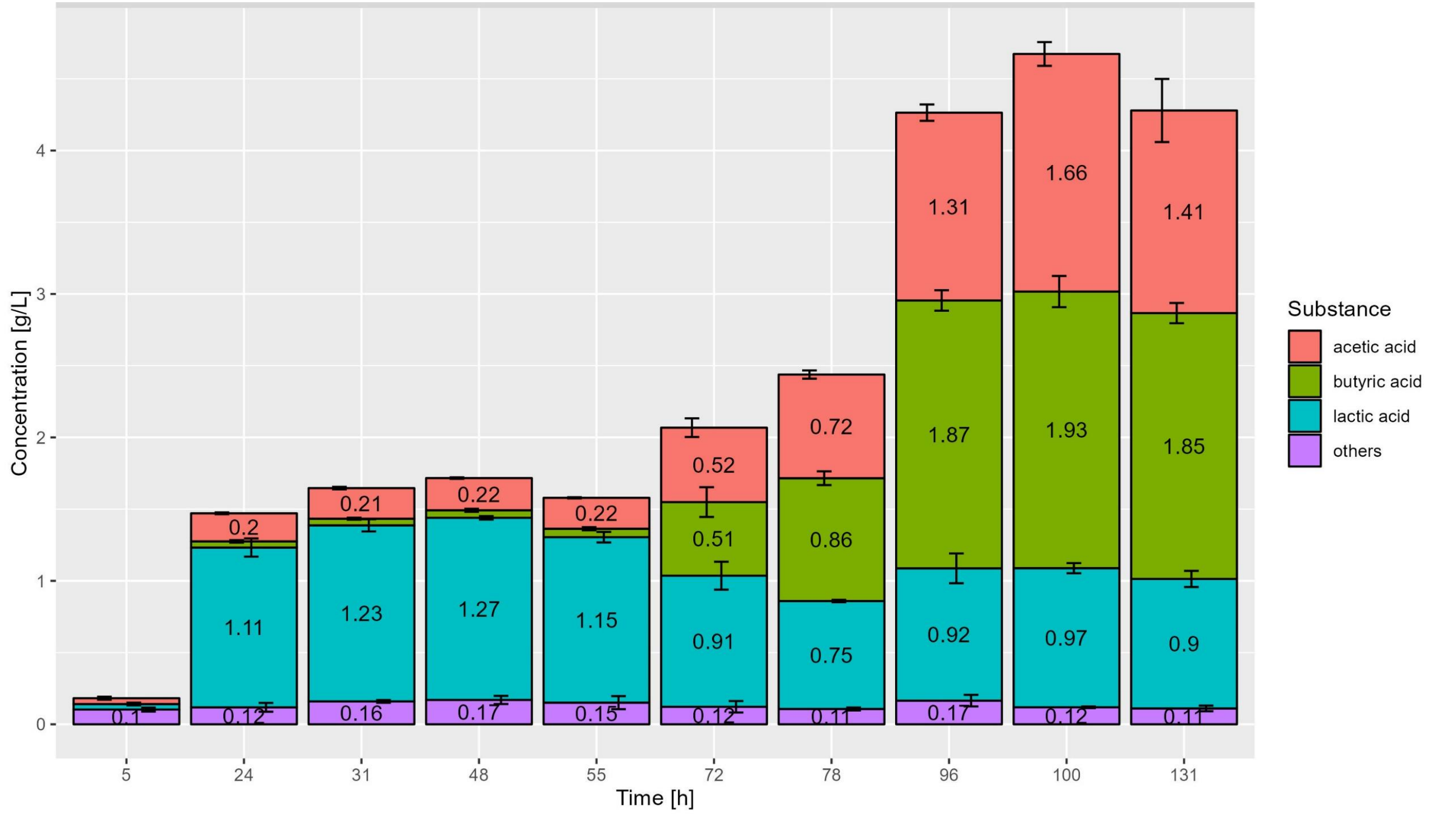

Figure 4: Fatty acids found while H_2 production

Outlook

Learning from those first results, the production of H_2 will be optimized using synthetic media. At the same time experiments are running, using waste water from AGRANA starch production plant. Combining those findings and upscaling the cultivation is the aim in the next months of this COMET funded project.

References

Rashmi, C., Satanand, S., Olusola, O. J. and Sudip, M., 2013. A review on development of industrial processes and emerging techniques for production of hydrogen from renewable and sustainable sources. Renewable and Sustainable Energy Reviews 23, 2013: 443 - 462.

Huang, J., Tang, W., Zhu, S. and Du, M., 2018. Biosynthesis of butyric acid by Clostridium tyrobutyricum. Preparative Biochemistry & Biotechnology Volume 48 (5), 2018: 427 - 434.

Moreno-Andrade, I., Moreno, G., Kumar, G. and Buitrón, G., 2015. Biohydrogen production from industrial wastewaters. Water Science and Technology 71 (1), 2015: 105 - 110.

Myoung-Joo, L., Tae-Hyeong, K., Booki, M. and Sun-Jin, H., 2012. Sodium (Na^+) concentration effects on metabolic pathway and estimation of ATP use in dark fermentation hydrogen production through stoichiometric analysis. Journal of Environmental Management 108, 2012: 22 - 26.

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