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DISSERTATION SUMMARY

Biohydrogen production from keratin-containing animal wastes

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Meat processing industry produces many kinds of keratinous waste materials (animal feather, wool, hair), which are degraded very slowly in nature, therefore, it is regarded as hazardous waste according EU directives. Decomposition methods like incineration or chemical treatments are employed (Onifade et al. 1998), although these procedures are rather expensive or environment-polluting. In contrast, biotechnology offers environmentally sound and cheap or even economical biodegrading methods. Recently, a two stage fermentation system was constructed to convert keratin-containing biowaste into a useful product, biohydrogen (Balint et al. 2005). A keratin-degrading Bacillus strain was isolated and tested in waste decomposition experiments (Perei et al. 2000). During the biodegradation process keratin-containing material was converted into a fermentation product which was rich in amino acids and peptides. This mixture could be subsequently used as major nutrient source for an anaerobic hyperthermophilic achaeon, Thermococcus litoralis, which produced hydrogen gas as a physiological byproduct.

The conceptual setup of the two-stage fermentation system

Several keratinaceous wastes (chicken feather meal, goose feather meal, pig hair) were digested by Bacillus licheniformis KK1 and the fermentation product - supplemented with essential minerals - was subsequently used as nutrient for T. litoralis. Cell propagation, nutrient uptake and biohydrogen production were followed. The archaeon was found to utilize all three fermentation broths for biohydrogen production similarly to bacto-peptone, the standard peptidic growth substrate for T. litoralis in medium 623 (DSMZ). Besides T. litoralis two microbes (the gram negative E coli and the gram positive Caldicellusiruptor saccharolyticus) capable to produce hydrogen were examined but neither of them could utilize the keratin hydrolysate for biohydrogen production.

Optimization of the keratin-degradation step

Feather meal degradation was subsequently optimised for the hydrogen production step and the optimal feather digestion time was investigated in few pH controlled experiments performed in a 700 ml batch fermenter. Protein concentration of the cell-free fermentation broth was followed during fermentation and was found to increase significantly; 64% of the applied feather meal was solubilised within 60 hours. The picture of the samples taken from the fermenter and analysed on polyacrylamide gel confirmed that the feather materials were converted into small-sized soluble peptide fragments.

Scale-up of the hydrogen producing step

Hydrogen production studies were performed in a 7 l fermenter at 85°C, pH=6,5, under nitrogen. Cell growth, consumption of alkali (used to maintain pH), nutrient uptake and biohydrogen production was monitored. All the followed parameters indicated substantial metabolic activity of the hydrogen producing cells in the first 30 hours of fermentation. During this period 50% of the available peptides in the fermentation broth was utilized. Hydrogen production yield was found significantly higher than the earlier yields of small-volume pilot experiments.

Conclusion

Work presented here demonstrates the feasibility of biohydrogen generation from keratin-rich biowaste. Using the developed two-stage fermentation system it is possible to utilize animal feather, wool, hair and other protein-rich biowastes for biological hydrogen production.

References

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