This thesis presents work that was done within the Swedish Centre for Resource Recovery (SCRR). Research and education performed within SCRR identifies new and improved methods to convert residuals into value-added products. SCRR covers technical, environmental and social aspects of sustainable resource recovery.

The application of anaerobic digestion, from waste streams that currently have no use, can be utilized for bioenergy production. Due to the high protein and fat content, slaughterhouse waste has a high potential for biogas production. However, potential inhibitory compounds can be formed during its degradation making the process prone to failure. One of the ways to overcome these problems is co-digestion with carbohydrate-rich co-substrates *i.e.*, a mixture of agro-wastes.

In this study, four different waste fractions, *i.e.*, solid cattle slaughterhouse waste (SB), manure (M), various crops (VC), and the organic fraction of municipal solid waste (MSW) were investigated in mono-digestion and co-digestion processes. Different mixture ratios were prepared, and the methane yield ($Y_{CH4}$), the specific methanogenic activity (SMA), and a kinetic parameter ($k_0$) were determined using the batch digestion assays at thermophilic conditions (55°C). The SB had a lower degradation rate and lower SMA compared with those of the other samples. In order to investigate the effect of the temperature, a selected mixture ratio was also digested at mesophilic conditions (37°C), which resulted in a decrease in $Y_{CH4}$ and in the kinetic parameters, by up to 57% compared to those obtained at the thermophilic conditions. During the next part of the work, a four-factor mixture design was applied aiming to obtain possible synergetic or antagonistic effects. Mixing all four of the substrates resulted in a 31% increase in the $Y_{CH4}$ compared to the expected yield calculated on the basis of the methane potential of the individual fractions clearly demonstrating a synergistic effect. Nevertheless, antagonistic interactions were also observed for certain mixtures.

The impact of the mixture interactions, obtained in the batch operation mode, was also evaluated under semi-continuous co-digestion. Digestion of the SB as the sole substrate failed at an organic loading rate of 0.9 gVS $L^{-1}d^{-1}$, while stable performance with higher loadings was observed for mixtures that displayed synergy earlier during the batch experiments. The combination that showed the antagonistic effects resulted in unstable operation and poor representation of methanogens. It was proved that synergetic or antagonistic effects observed in the batch mode could be correlated to the process performance, as well as to the development of the microbial community structure during the semi-continuous operation.

In the last part of the work, the response of the methanogenic biomass to the consecutive feeding applied in the batch assays was evaluated regarding process parameters such as $Y_{CH4}$, SMA, and degradation kinetics. The objective was to examine whether there is a possibility to correlate these findings to the expected process performance during the long-term operation. Digestion of the SB alone showed a total inhibition after the second feeding, which is in correlation with the failure observed during the semi-continuous mode. Furthermore, enhanced SMA was observed after the second feeding in those mixtures that showed synergy in the previous batch assays as well as a good process performance during the semi-continuous operation.

Keywords: Slaughterhouse waste, Agro-Waste, Co-digestion, Synergistic effects, methanogenic community structure

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## Mixture interactions in co-digestion

UNIVERSITY OF BORÅS