Low-Dosage Enzymatic Decomposition of OFMSW for Sugar Recovery and Ethanol Production

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Low-dosage enzymatic decomposition of OFMSW for sugar recovery and ethanol production

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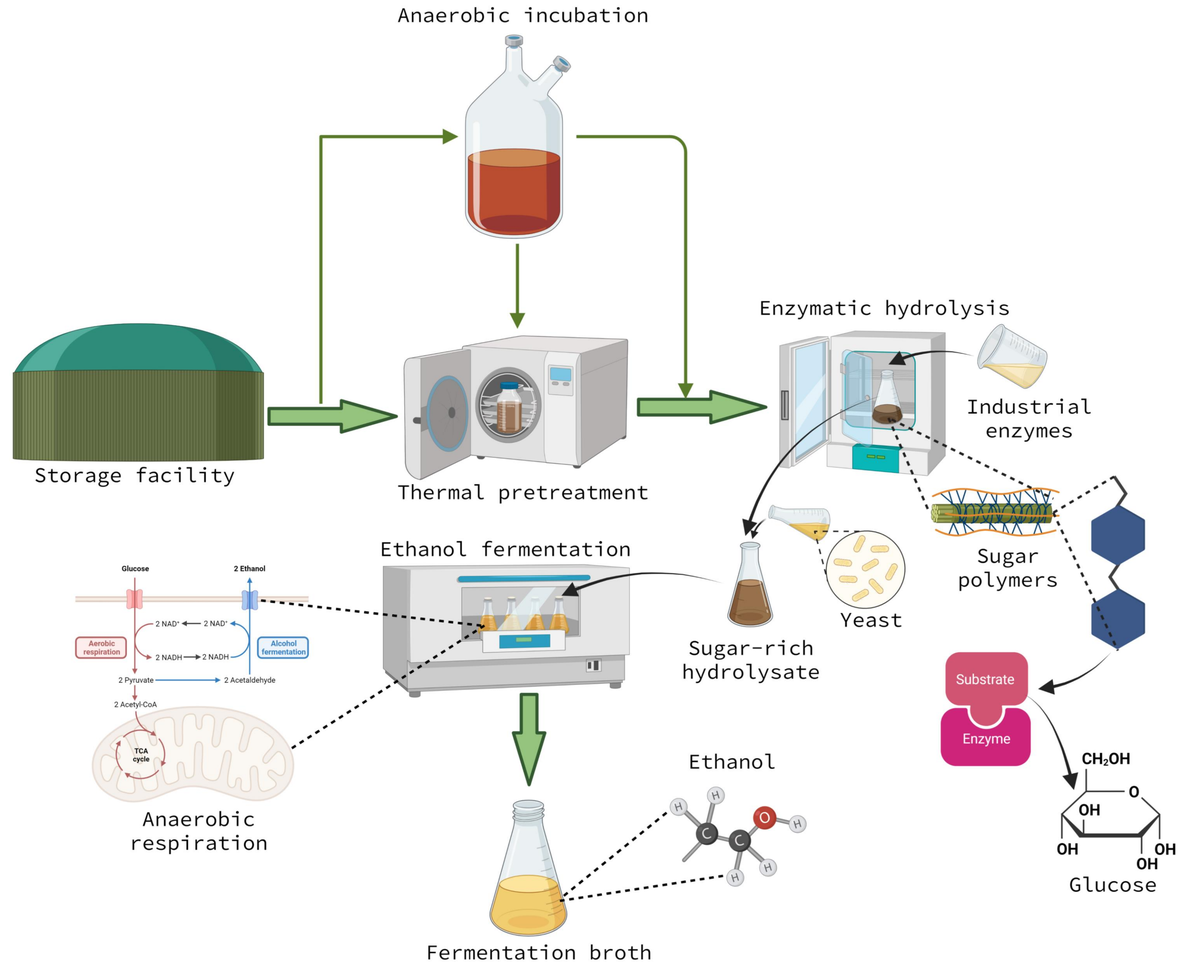
BACKGROUND

Saccharification of the organic fraction of municipal solid waste (OFMSW) is challenging due to its complexity and heterogeneous character. Nevertheless, OFMSW could be an **excellent second-generation feedstock** due to its high sugar, fat, and protein content (Tab. 1). These compounds have the potential to be converted into **green energy**, such as **biofuels and biogas**, as well as **bulk biochemicals**, which would contribute to the **green transition**. However, a significant challenge in this process is optimizing multiple technological applications. This typically involves using mechanical, physical, and biological processes to extract sugars, which can then be further converted into biofuels and/or bulk chemicals by fermentation.

The main objective of this study is to enhance the understanding of **enzymatic hydrolysis and heat pretreatment** as effective methods for **converting OFMSW into fermentable sugars** in order to ultimately **improve the yield** of subsequent fermentation procedures

Table 1. The compositional characteristics of OFMSW

OFMSW	Dry Matter (%)	pH	Sugars (g/100g DM)	Protein (g/100g DM)	Lipids (g/100g DM)	Organic acids (g/L)	Ethanol (g/L)
March batch	12.7	4,23	46.5±1.0	19.3±0.5	17.7±0.2	22.5±0.8	13.5±0.50
October batch	14.3	4.02	42.8±2.1	19.1±0.7	17.9±0.5	38.0±5.3	12.4±0.05



RESULTS

The compositional analysis revealed that OFMSW is high in **sugars, protein, and lipids** but also in **organic acids and ethanol** (Tab. 1). Thermal pretreatment effectively promoted the solubilization of starch in OFMSW. The amount of solubilized starch increased progressively up to **130℃ for 4 hours of reaction time**, resulting in **the solubilization of 5.3 g of starch** from the total starch content of 14.7 g per 100 g dry matter of OFMSW. This corresponds to a **starch gelatinization rate of 36%** (Fig. 1). Further research revealed that the most optimal conditions are **100℃ for 4 hours** based on higher total sugar content and low concentration of furfural and HMF. Enzymatic hydrolysis showed that thermal pretreatment at **100℃ for 4 hours** increased the **saccharification yield from 4 to 11%** compared to untreated OFMSW (Fig. 2). The lowest tested dosage, 1 FPU Ctec3 + 0.5 U AMG, yielded the highest difference with **51% of sugar recovery**. Anaerobic incubation did not improve saccharification. Ethanol fermentation of sugar-rich hydrolysates resulted in **28.5 g of ethanol/100 g DM of OFMSW**, successfully converting most C6 sugars into ethanol (Fig. 3).

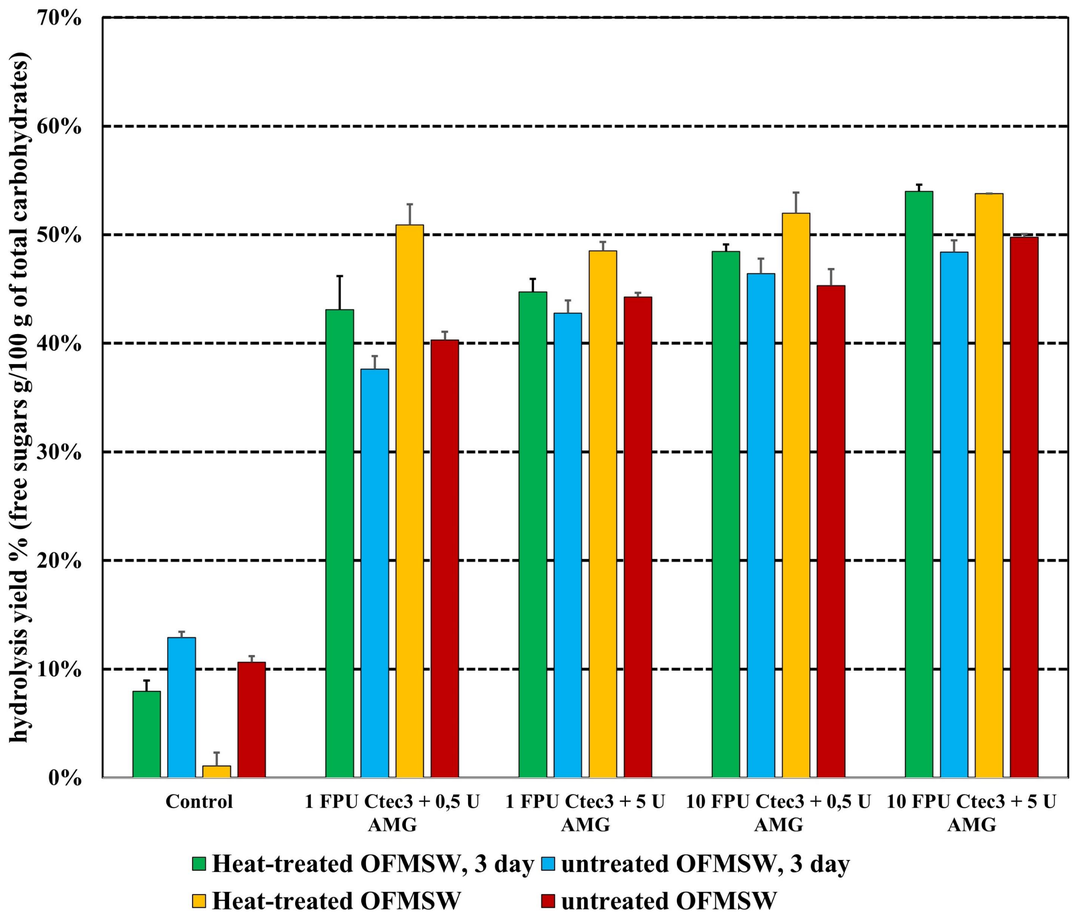


Figure 2. Enzymatic hydrolysis of untreated, heat-pretreated, and anaerobically incubated samples of OFMSW at vying enzymatic dosage

CONCLUSION

In conclusion, the findings suggest that thermal pretreatment at 100℃ for 4 hours, followed by low-dosage enzymatic hydrolysis and fermentation, can effectively convert OFMSW into valuable products, such as ethanol, by maximizing saccharification yield and minimizing sugar degradation and contamination risks.

EXPERIMENTAL SET UP

The OFMSW was collected at Holsted municipality, South Denmark, and provided by Ragn-Sells Denmark A/S. **Thermal pretreatments** were performed from **70℃ to 160℃** for a period of **1, 2,3, and 4 hours** in water and oil baths. **Anaerobic incubation** was conducted for three days at 20℃. **Enzymatic hydrolysis** was conducted with **Cellic® CTec3** (Novozymes A/S) as a source of **cellulases and hemicellulases** and **AMG® 300 L BrewQ** (Novozymes A/S) as a source of **glucoamylase**. The hydrolytic effect of varying dosages on pretreated OFMSW was investigated. Reaction conditions were 100 g of mass with 10% dry matter incubated for 24 hours at 50℃ with 150 RPM. **Ethanol fermentation** was made with *Saccharomyces cerevisiae* (De Danske Spritfabrikker A/S) at 32℃ with 130 RPM for 96 hours in a shaking incubator. **Iodometry** was used to analyze **starch solubilization.** For analysis of **sugars**, **organic acids,** and **ethanol** HPLC (1260 Infinity II, Agilent Technologies) was used with (Bio-Rad Aminex HPX-87H Column, Rio-Rad Laboratories Inc.) and a refractive index detector. The HPLC analysis of **furfural** and **HMF** was performed by (InfinityLab Poroshell 120 EC-C18, Agilent Technologies, Inc.), using a diode array as a detector.

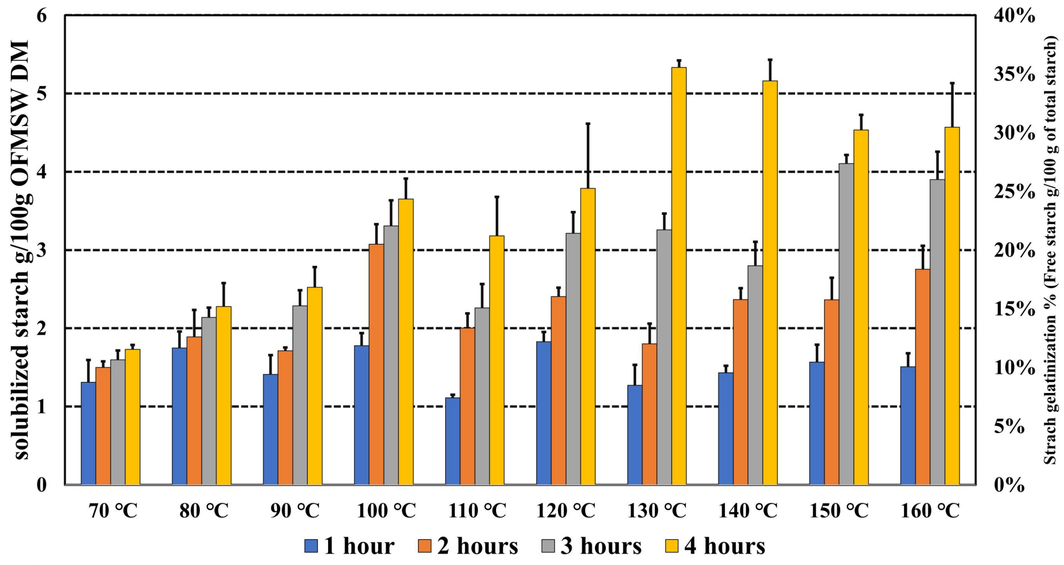


Figure 1. Investigation of starch gelatinization in thermally pretreated OFMSW

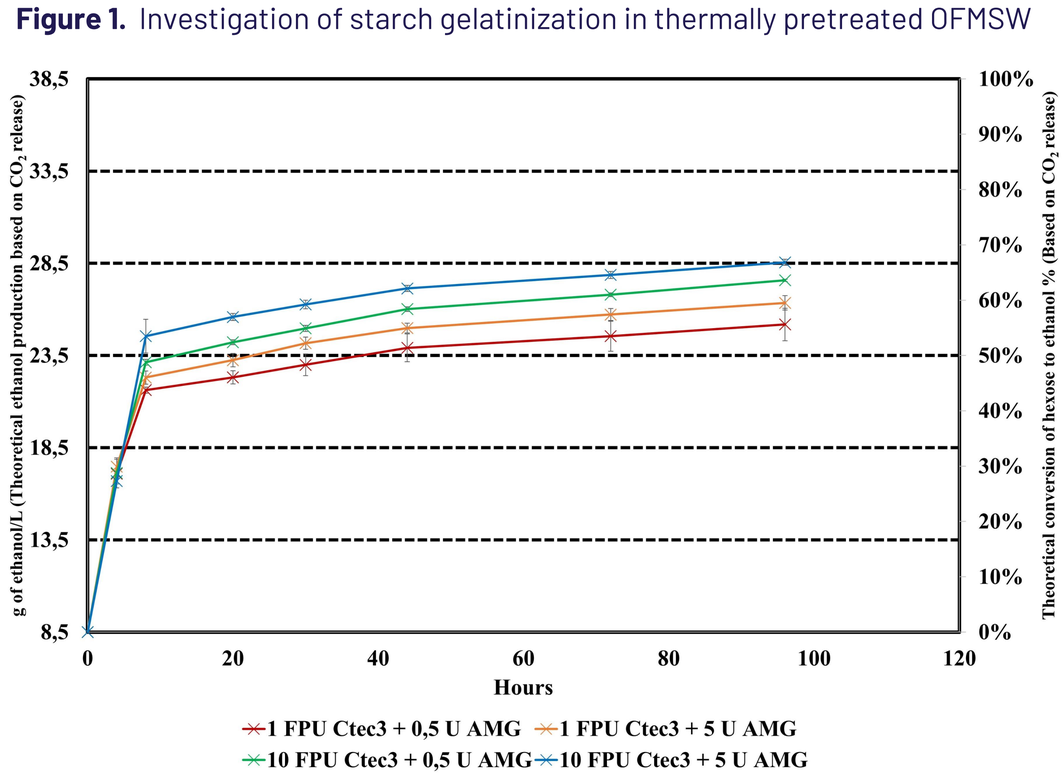


Figure 3. Ethanol fermentation of sugar-rich hydrolysates

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