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Ultrasonic pretreatment of kitchen waste during thermophilic anaerobic digestion-A pilot study

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Research purpose and background

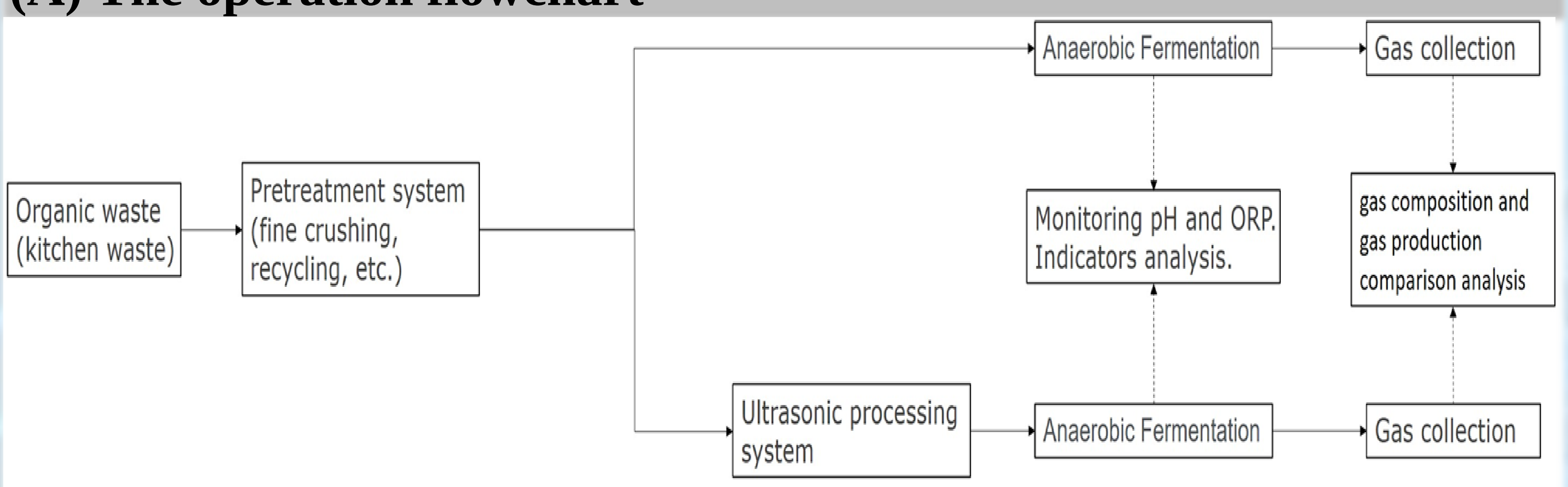
At present, fate of Taiwan's kitchen waste is mainly used as pig feed (72%) and composting (28%). Major concern of the former is the spread of the African swine fever. Many developing and developed countries have banned the application of kitchen waste as pig feed. The main problem of the latter is the odor of the traditional composting plant causing resident‘s complaints.

Kitchen waste is rich in organic matter and should be used beneficially. Anaerobic fermentation technology can be applied to achieve waste recycling, waste reduction, and reduce the burden of the incinerators. Currently the focus of anaerobic technology is to maximize methane production (Chowdhury et al., 2017). Improvement of anaerobic digestion by ultrasound (US) technology has been widely used in sludge treatment of wastewater plants (Cesaro et al., 2010) and has been tested for large-scale applications. However, due to the limited effect of this technology on different organic substrates, its popularity is limited. The aim of this study was to evaluate the effectiveness of ultrasound enhancement in biodegradability of different types of kitchen waste and to assess the impact of feed matrix composition on organic waste transformation into biogas for bioenergy.

Materials and methods

In this study, two kinds of kitchen waste were used, they are raw kitchen waste and cooked kitchen waste, with the former usually contains high cellulose contents. Characteristics of raw and cooked kitchen wastes are shown in Table 1. The operation was to use a parallel process which contained two identical two-phase digestion systems and maintained at a thermophilic temperature (55°C). The only difference in the two processes is whether it has been subjected to ultrasonic pretreatment or not. Technical information of the ultrasonic unit is shown in Table 2.

(A) The operation flowchart



(B) Side view of the mobile two-phase anaerobic digestion system

Table 1 Characteristics of raw and cooked kitchen wastes

Parameter	Raw kitchen waste	Cooked kitchen waste
SS (mg/L)	13,961	28,613
VSS (mg/L)	10,916	25,716
TCOD (mg/L)	31,864	47,862

Table 2 Specifications of the Ultrasonic unit

Ultrasonic parameter	Value
Frequency (kHz)	20
Material	Titanium alloy/ stainless steel
Probe diameter (cm)	5.0
Ultrasonic power (W)	500
Size (cm) (L×W×H)	120×110×200
Weight (kg)	165
Operating voltage (V)	220
Effective volume (L)	4.0

Results and discussion

(A) Substrate characteristics analysis

Because raw kitchen waste is mostly uncooked fruits and vegetables, a higher moisture content can be found in raw kitchen waste, with lower TS content, as shown in Table 3. Nevertheless, both substrates have high VS(%TS) contents (about 83%). One thing can be sure is that both raw and cooked kitchen waste are rich in organic matter, and are suitable for the use of anaerobic digestion for biogas production.

The average contribution to COD of the cooked kitchen waste is 1.44 g COD/g TS, and is higher than that of raw kitchen waste (0.97). Possible reason reason is that cooked kitchen waste contains carbohydrates, proteins, and oil during the preparation of meals.

Table 3 Average characteristics of the feedstocks and standard deviations

Kitchen waste	MC (%)	TS (%)	VS (%TS)	g COD/g TS
Raw	83.08±2.29(n=4)	16.92±2.29(n=4)	83.42±0.87(n=4)	0.97±0.23(n=4)
Cooked	74.33±1.49(n=4)	25.68±1.49(n=4)	83.99±5.83(n=4)	1.44±0.15(n=4)

(B) Raw kitchen waste for ultrasonic pretreatment test

The result of ultrasonic processing revealed a significant increase in gas production, from an average of 1,208 (L/d, w/o US) to 2,219 (L/d, w/US), as shown in Fig. 1. with more than 80% increase in the daily gas production. In the removal of SS, it was increased by more than 5% and the removal of VSS and TCOD are also increased by about 10%. It shows that raw kitchen waste is suitable for ultrasonic pretreatment.

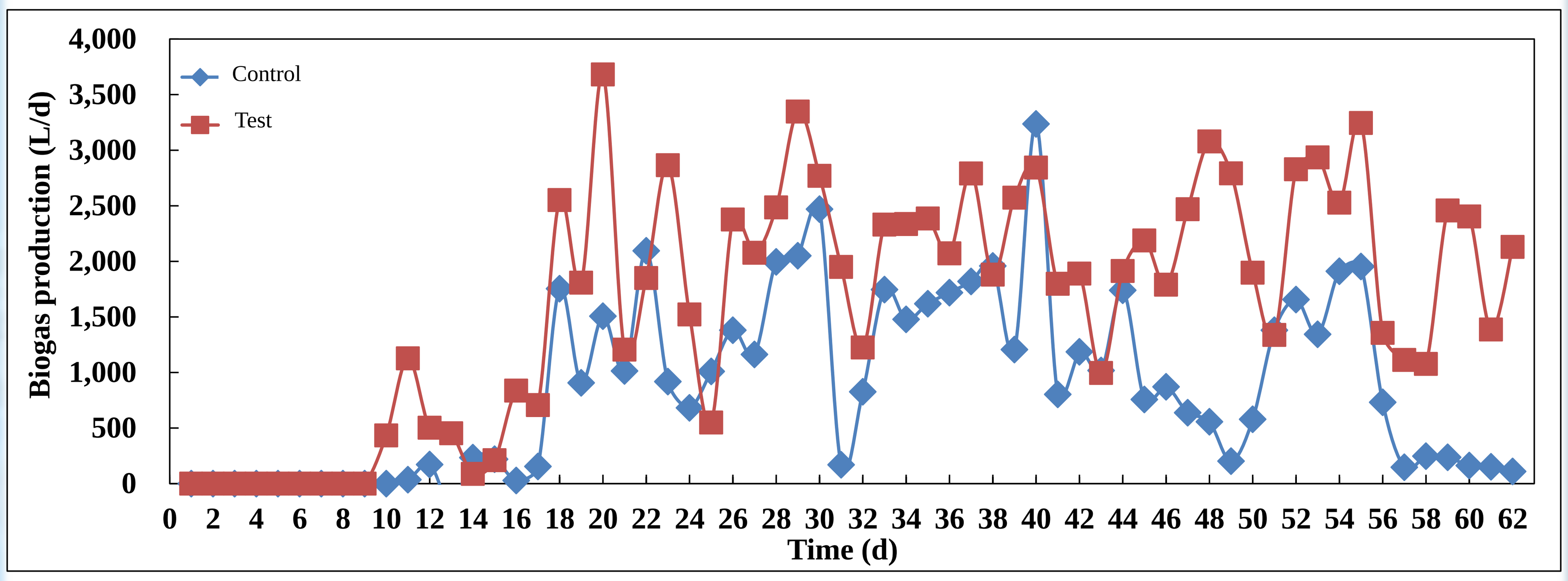


Fig. 1. Comparison of daily gas production for raw kitchen waste with and without ultrasonic pretreatment

(C) Cooked kitchen waste for ultrasonic pretreatment test

The results of ultrasonic processing for cooked kitchen waste showed that there was no significant increase in gas production, from an daily average of 2,718(L/d) to 2,780(L/d), as shown in Fig. 2. The control in the picture is a system without ultrasound pretreatment, and the results show that cooked kitchen waste is not suitable for ultrasonic pretreatment due to fast hydrolysis and can cause a sharp pH drop and subsequent system failure.

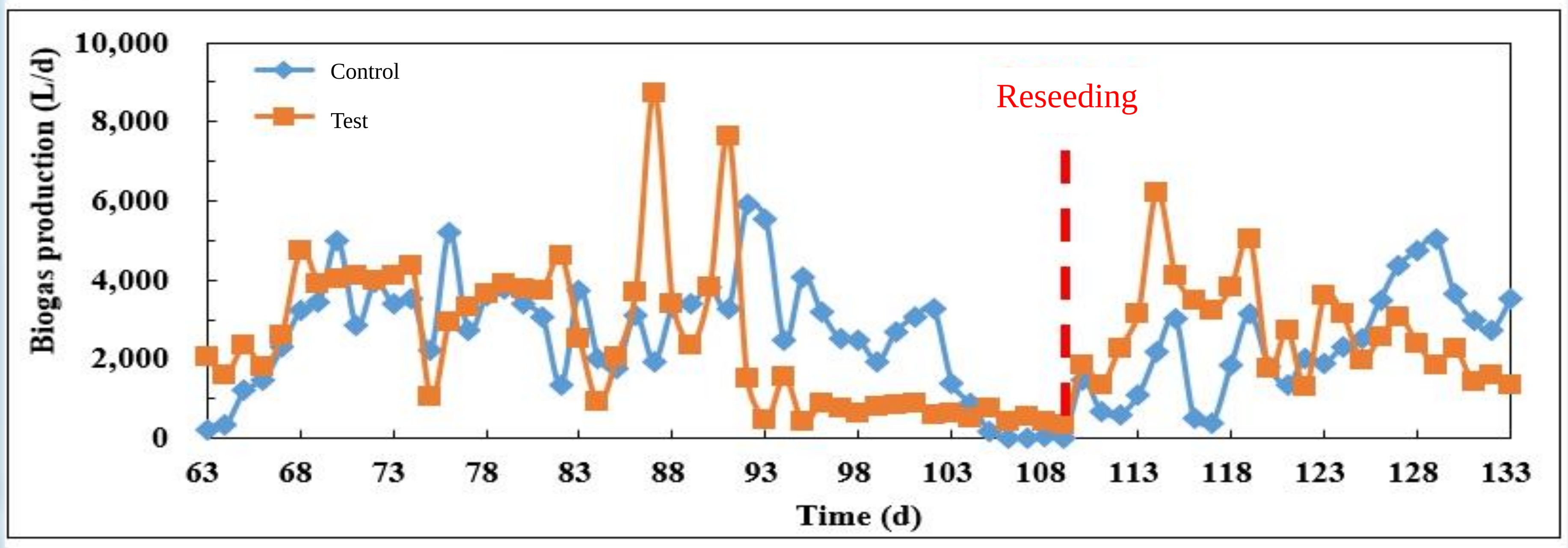


Fig. 2. Comparison of daily gas production for cooked kitchen waste with and without ultrasonic pretreatment

Conclusions

1. After ultrasonic pretreatment, biogas production of raw kitchen waste could be increased by more than 10%.
2. Cooked kitchen waste is ready to acidify, and if it is pretreated by ultrasound, it will lead to system instability and possible failure.

References

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