PRODUCTION OF BIOGAS FROM CITRUS WASTE

ITALY

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ABSTRACT

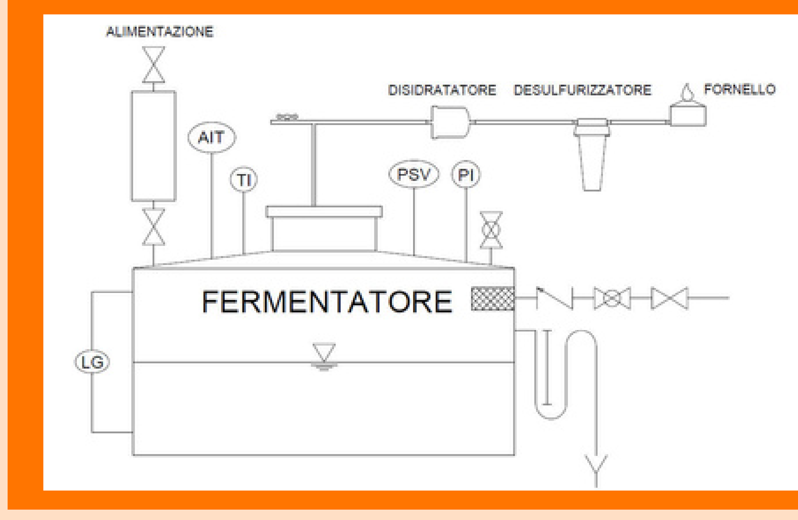
The idea for this research project stems from the concept of producing biogas from the fermentation of "citrus pomace", a by-product of the citrus industry, with the subsequent addition of another organic vegetable waste to increase the biogas yield. The advantages of using citrus waste are:
1. Reuse of highly polluting waste when dispersed in the environment.
2. The high carbohydrate content significantly enhances the fermentation process.
The biogas produced contains low levels of H2S and CO2.

INTRODUCTION

"The biomass of “citrus pomace” can undergo anaerobic digestion, as evidenced by the fermentation reaction, which can be approximately described by the following equation:

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$

It should be noted that this reaction also generates unwanted byproducts, such as H2S and water. These are subsequently removed using a desulfurizer and a dehydrator. The methane produced can be utilized for domestic heating purposes through combustion. As with other fossil fuels, the combustion of biogas results in the production of CO_2 (carbon dioxide). However, the carbon present in biogas is extracted from the atmosphere through the photosynthesis process by plants, thereby closing the carbon cycle within a relatively short period (one to three years). Furthermore, the generation of biogas from generic biomass also serves to diminish methane and nitrous oxide (N2O) emissions, which are produced by the storage of untreated animal manure utilized as fertilizer or by the decomposition of solid residues in landfills. It is crucial to acknowledge that methane possesses a greenhouse gas potential that is 23 times greater than that of carbon dioxide and 296 times that of nitrous oxide. Consequently, the generation of biogas represents an effective strategy for mitigating the greenhouse effect and reducing costs through the utilization of biomass.



MATERIALS, METHODS, AND EXPERIMENTS

Materials

- Fermenter; pressure gauge; desulfurizer (containing Fe2O3 which removes gaseous hydrogen sulfide according to the reaction: $Fe_2O_3 + 3H_2S \rightarrow Fe_2S_3 + 3H_2O$); dehydrator containing silica gel;
- Citrus pomace and water

Methods

The Calculation of biogas yield i as follows:
By applying the ideal gas law equation PV=nRT and rearranging it with simple algebraic steps, we obtain the following relation for biogas
Applying the ideal gas law equation PV=nRT and rearranging it with simple algebraic steps, we obtain for biogas the relation:
$d = P\frac{MM}{RT}$ where:

- d is density;
- MM is the average molecular mass of biogas;
- P and T are pressure (in atm) and absolute temperature, respectively;
- R is the universal gas constant = 0.082 L atm mol-1 K-1

Subsequently, from the relation d = M/V we obtain Mbiogas= d x V, from which:
d = (1,02 atm x 27,2 g/mol) / 0,082 l atm mol-1 k-1 x 298 k=1,1 g/l, which, in turn yields:
Massbiogas= 1,1 g/l x 1400 l = 1,54 Kg (the pressure value was provided by the pressure gauge).
The percentage yield η of biogas was obtained from the stoichiometric relation:
η = Massbiogas (kg)/Massfeed (kg) x 100 = 1,5 /14 x 100 =10,7%

CHARGE	BAR PRESSURE	TEMPERATURE (K)	YIELD % biogas
Pure Citrus Pomace	1,01	298	10,7
Citrus Pomace plus	1,30	298	13,0

RESULTS AND DISCUSSION

Two fermentations were conducted to ascertain the biogas yield from known quantities of pomace and water, varying the composition of the incoming charge. The first utilized only raw pomace, while the second incorporated a modest amount of compost and digestate from the initial process. To facilitate the calculations, approximations were made. In particular, it was assumed that the biogas was composed of 60% methane and 40% carbon dioxide (with an average molecular mass of 272 uma), a mean temperature of 25°C (298 K) was considered, and the biogas was treated as an ideal gas. The results of the two fermentations between different matrices demonstrate a notable increase in biogas yield. This observation was further validated in the second fermentation with compost, resulting in an increase in yield from 10.7% to 13.0%.

CONCLUSIONS

The soluble and insoluble carbohydrates present in citrus processing waste make this biomass an excellent candidate for anaerobic digestion. However, the main challenge with this biomass is its seasonal availability and the high risk of rapid acidification in the early stages (due to the presence of citric, malic, and isocitric acids), reaching a pH of about 3, which could impact the overall process. Furthermore, the presence of D-limonene in the peels may have an inhibitory effect on various bacterial strains that are essential for the entire biotransformation process. It would be advisable to use such waste after aeration and drying treatment to remove the high water and limonene content. However, this solution is not a long-term fix, as pomace tends to ferment quickly.

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