The Effect of Temperature on the biogas Production from Olive Pomace

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Abstract :

The effect of temperature on the biogas production from olive pomace only, a mixture of olive pomace and poultry dropping at different temperatures were investigated. The results indicated that the highest production was achieved at the mesophilic temperature ($40C^o$) and the thermophilic temperature ($60C^o$). The production of biogas from olive pomace was enhanced when mixed with poultry dropping. At $60C^o$ the rate of biogas production is faster than at the $40C^o$. It is concluded that the digestion of olive pomace together with other wastes such as poultry dropping, is a sustainable and environmentally attractive method to treat wastes and thus convert them from a burden to society to useful resource.

Introduction:

Animal and agricultural wastes constitute a high proportion of biomass and their utilization and recycling is important for economical and environmental aspects.

Anaerobic digestion one of the most widely used processes for treating these wastes and represents an attractive method for treating organic wastes for biogas production as alternative energy sources [1,2,3,4].

Biogas is a type of a bio-fuel, produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manures and energy crops. The brake down of organic materials usually occurs in three temperature ranges: the psychrophilic (12-30C^{o}), mesophilic (25-40C^{o}) and thermophilic (45-60C^{o}). But anaerobic digestion is mainly taking place at either mesophilic, or thermophilic temperature [5,6].

Several studies on effect of temperature on biogas production have reported previously that a higher digestion rate and improved solids settling and destruction of pathogens is more efficient in the thermophilic temperatures [7].

Though, very few studies have examined the effect of temperature on the generation of biogas from lignocellulosic material such as olive pomace (olive oil wastes). Organic olive pomace in addition to animal wastes can be used as source of fermentable organic matter in biomass technologies for biogas production [8,9,10]. Other benefits of co-digesting multiple waste streams include the improvement of nutrient balance for bacterial and digestion [11].

This study focuses on the effect of temperature on biogas production from olive pomace as feedstock, in order to determine which region of operating temperature will suit generation of biogas.

Methane can be produced very efficiently by co-digesting olive oil wastewater with other organic wastes [12,13]. And as a result a blind of olive pomace and poultry dropping was also investigated for biogas production under the various temperature regimes.

Anaerobic digestion is a biological process which occurs in the absence of oxygen. It helps in the breakdown of the organic matter and the stabilization of these materials, by conversion into CH_4 and CO_2 gases and a nearly stable residue. The digestion of the organic materials by microorganisms produces biogas. Biogas typically consists of 50-65% (volume) methane and 35-50% (volume) CO_2.

The process of anaerobic digestion involves hydrolysis, acidogenesis, acetogenesis and methanogesis reactions.

Hydrolysis: Complex organic materials are broken down by enzymes to soluble products (hydrolytic fermentative bacteria).

Acidogenesis: generation of intermediary products such as short chain fatty acids, hydrogen producing and acetogenic bacteria).

Acetogensis: acetate production (hydrogen-producing, hydrogen consuming acetogenic bacteria).

Methanogenisis: CH_4 production (methane forming bacteria).

Material and methods

At every temperature considered two set-ups were designed to examine the effect of temperature:

Setup 1 300g of olive pomace only mixed with water in ratio 1:1 (w/v)

Setup 2 300g of mixture of olive pomace and poultry droppings in ratio 3:2 and water was added in ratio 1:1 (w/v).

Figure 1 illustrates the experimental anaerobic digester used in both set-ups. 1000ml conical flask with approximately 600 ml working volumes served as digesters placed in a water bath with a temperature adjuster dial. The conical flask (digester) was seal with a rubber cork with one end of a tube inserted in it. Measuring cylinder and a water bath were filled with diluted sodium hydroxide solution, As CO_2 rapidly dissolved in the solution and the remaining gas can be assumed to be methane. A measuring cylinder was then inverted into the water and held in place using a clamp and tripod stand. The other end of the tube was then inserted into the measuring cylinder. The conical flasks were shaken at intervals and the volume of biogas produced was collected by down-ward displacement of water, read and record daily from the measuring cylinders. Samples were withdrawn every five days intervals and analyzed for total solids and total volatile solids using standard methods for wastewater analysis [14].

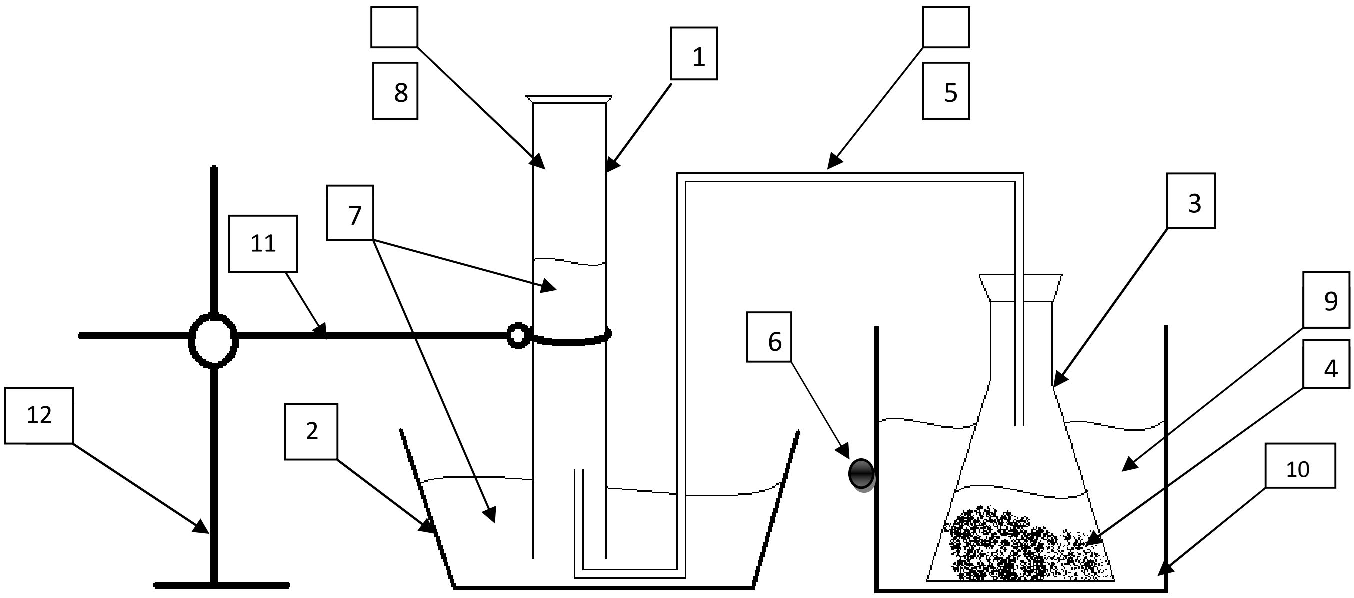

Figure 1: Diagram of Experimental setup

1- Measuring cylinder (Gas receiver), 2- Water bath, 3- Digester, 4- Digester feed, 5- Tube, 6- temperature adjuster dial, 7- Dilute sodium hydroxide solution, 8- Biogas, 9- Water, 10- Water bath, 11- Clamp, 12- Tripod stand.

Results and discussions

Figure 2 shows the daily biogas production generated from olive pomace substrate at 25C^{o}, 40C^{o} and 60C^{o}. The volume of the biogas produced from the olive pomace clearly illustrates the temperature effect. At 25C^{o}(psychrophilic condition) we note that the production of biogas is very low and slow, this is as a result of the fact that the rate of organic matter conversion into biogas is minimized, since the activity of microorganisms is limited. The consequence is to require very large residence time in the digester. Whereas, at the 40C^{o} and 60C^{o}, the biogas production was higher than at the 25C^{o}.

This is due to the fact that, the majority of methanogens (microorganisms that forms methane from organic matter) belongs to the mesophilic. They grow quickly in the 40C^{o} and exhibit high degrees of conversion of organic matter into biogas. The stability and growth conditions in the digester at mesophilic conditions make the process more balanced, more resistant to chemicals that inhibit digestion (e.g. ammonia) (5), and capable of treating efficiently a great variety of different types of biomass and waste.

Also, a smaller proportion of methanogenic bacteria are thermophilic, meaning that attached perfectly to higher temperatures. As a result, at 60C^{o} all bacteria consume organic substrates with higher rates and grow faster, and as a result, the production of biogas will be high and the residence time is short. This is will illustrated in figure 2, were the production of biogas ceased by the tenth day.

The thermophilic methanogenic bacteria are extremely sensitive to changes in anaerobic digestion to such an extent that even a small changes of the operating parameters can impact negatively on their activity, for example, a change in a temperature greater than 1-2C^{o} have a significant reduction in the amount of produced biogas (6). Moreover, the variety of materials that can be processed in anaerobic thermophilic conditions is lower than the mesophilic, mainly because of the chemical composition and the stronger influence of some digestion inhibitors in the process.

Figure 4 shows the biogas production from a mixture of olive pomace and poultry dropping. Again the production of biogas at the psychrophilic condition (25C°) is low, whereas the highest production obtained in the mesophilic condition (40C°) and for the thermophilic condition (60C°) the production rate again high in the first ten days.

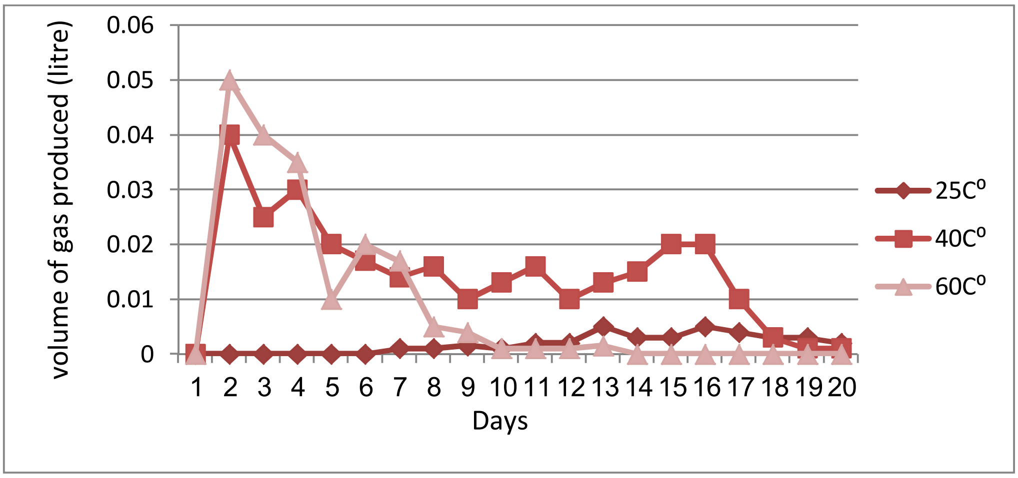

Figure 2: Daily biogas yield of olive pomace at different temperature.

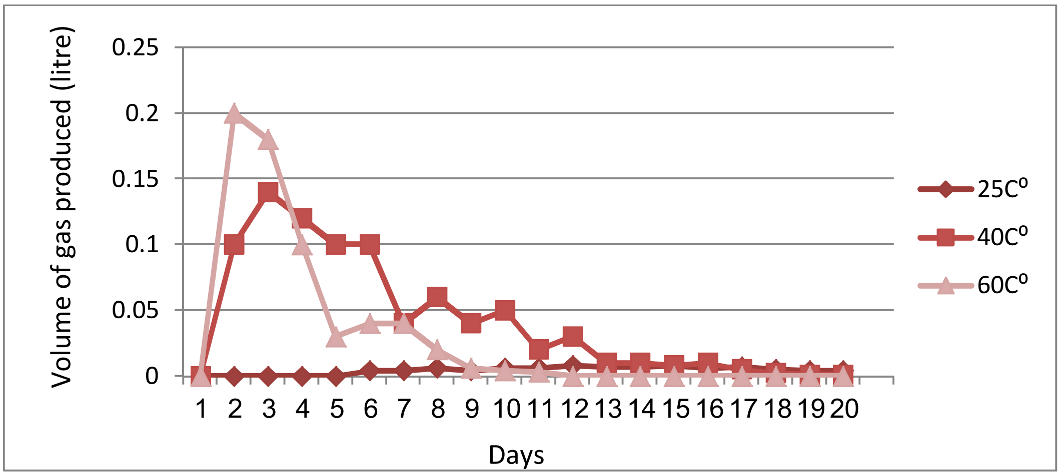

Figure 3: Daily biogas yield from mixture of olive pomace/poultry dropping at different temperature.

Figure 4; show the cumulative biogas production from olive pomace at different temperature. It is clear that the highest yield was at 40C°, followed by the 60C°, although for the first ten days the rate of production was higher at the 60C°, again this is because at the thermophilic conditions bacteria consume organic substrates with higher rates and grow faster, and as a result, the production of biogas will be high.

Figure 5 also show that the best yield of biogas was at 40C° and 60C°. And the mixing of olive pomace with poultry dropping increase the amount of biogas yield compared with olive pomace only, this could be attributed to the high amount of lignocellulosic materials and lignin in olive pomace with low digestibility (15) and also may be because the poultry droppings are much more watery than the olive pomace (16), an increase in water content increases the surface area for microbial action to take place.

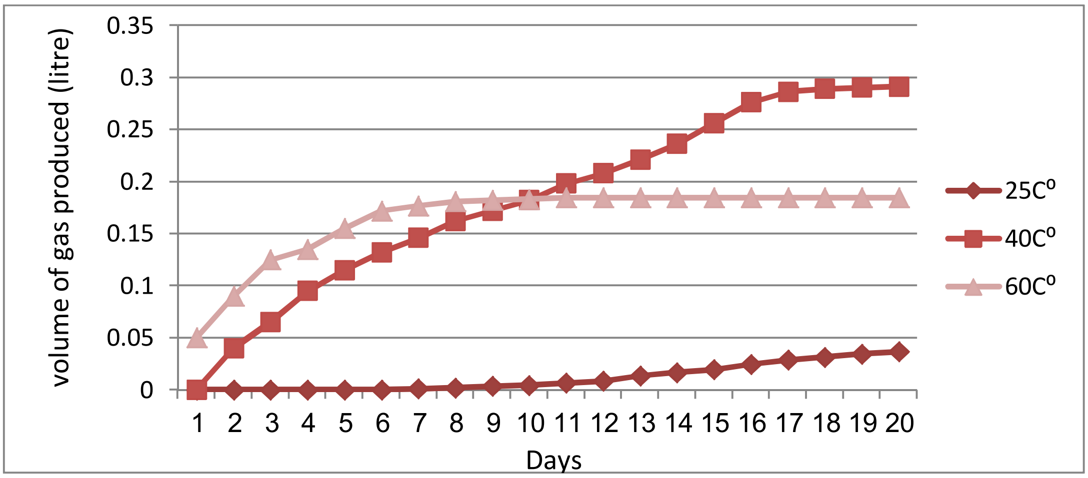

Figure 4: Accumulated biogas production from olive pomace at different temperature.

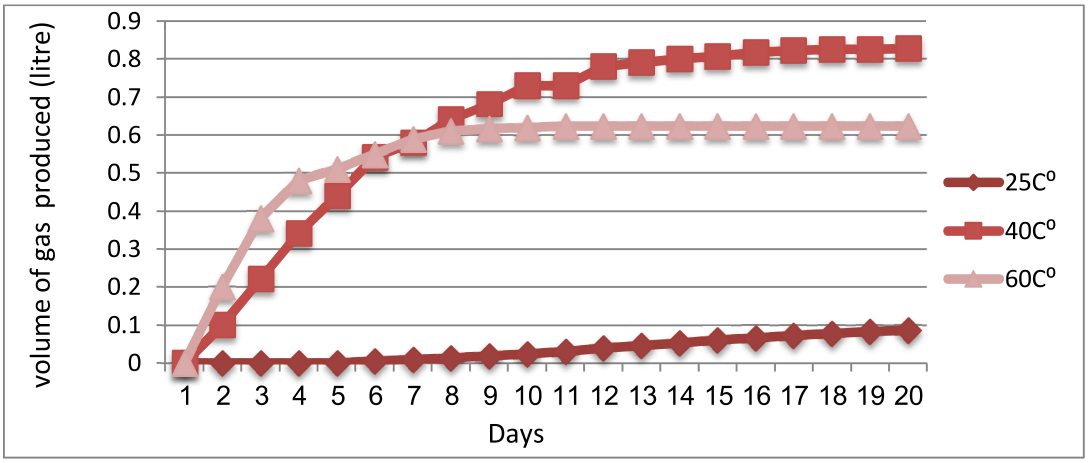

Figure 5: Accumulated biogas production from mixture of olive pomace/poultry dropping at different temperature

Figures 6-9 shows that the total solids and volatile solid contents decreased with time during the time of digestion, and this is clearer for the 40C° and 60C°. Temperature is observed to have an effect on the reduction of the total solids contents of the substrates. This is an indication that temperature has an effect on the generation of biogas as the reduction of the solid contents always results in biogas production and also the rate of the decrease of volatile solids is proportion to the rate of biogas production ((16,17).

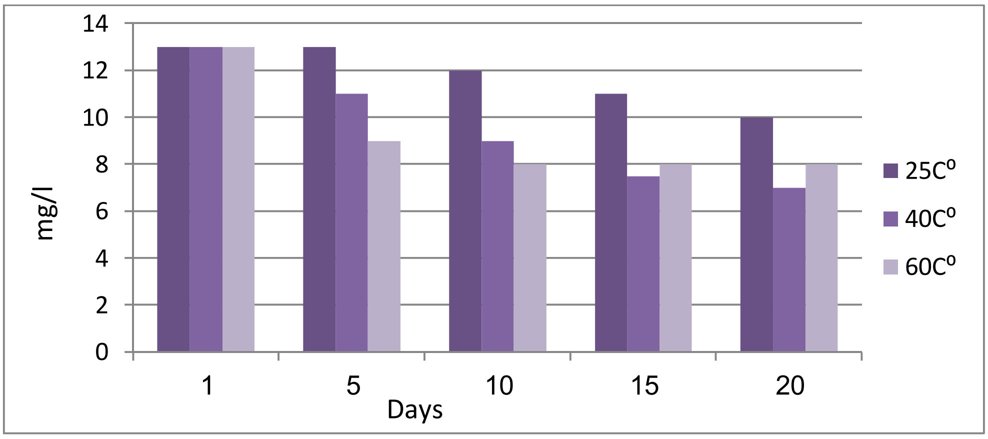

Figure 6: Total solid content mg/l of olive pomace at different temperature.

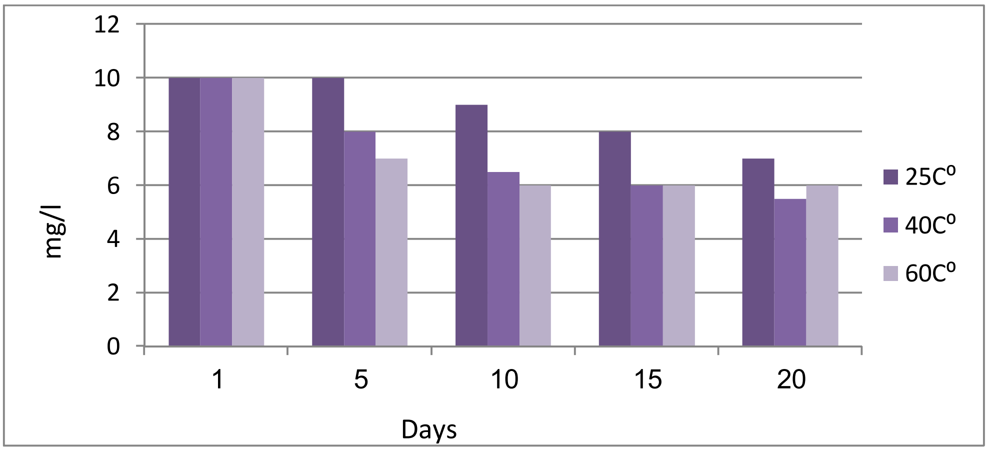

Figure 7: Total solid content mg/l of mixture of olive pomace/poultry dropping at different temperature.

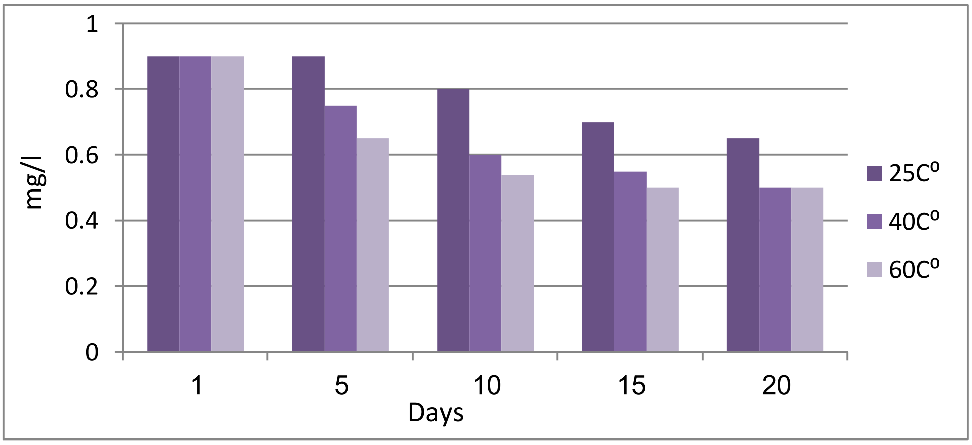

Figure 8: Total volatile solid content of olive pomace at different temperature

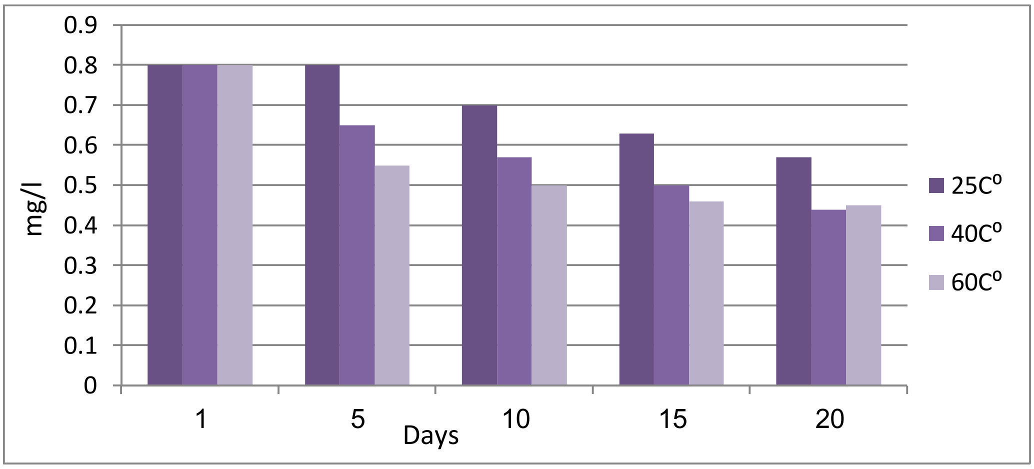

Figure 9: Total volatile solid content of mixture of olive pomace/poultry dropping at different temperature.

Conclusions

The study reveals that anaerobic digestion can occur in the mesophilic range (40C°) or in the thermophilic range (60C°). At 40C° total biogas production was the highest, however it take longer retention time. But at 60C° the rate of digestion and hence, the biogas production is higher in the first ten days, and as a result, the thermophilic conditions require less retention time than mesophilic condition. The addition of poultry dropping to the olive pomace increases the biogas production for all temperature ranges.

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