Methane production from tomatoes wastes via co-fermentation

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Abstract

Biogas generation via anaerobic fermentation is one of the methods of producing biomass energy in other words renewable energy. This research was carried out to determine the methane production from cattle manure with different tomato greenhouse wastes which are mixtured at different ratios (15, 30, 45, 60, 75, and 90%). The experiments conducted in a through flow laboratory biogas units for 15 days retention times, fermentation process continuing under 37 ±1 ºC. The laboratory biogas units, which have total 18 litres, net 15 litres fermentation volume, were mixed automatically for 1 minute every 29 minutes at 30 revolutions per minutes. Organic loading rate was chosen 4.67 g.VS/l.d. Firstly, fresh greenhouse tomato wastes are sun dried. Later this dried materials are granulated by branch shredder and waste disposal machine. The mixtures were obtained adding 15, 30, 45, 60, 75 and 90% tomato greenhouse waste into the cattle manure, and also only cattle manure used to make comparison. According to the results, the highest methane production was obtained from the mixture of 70% cattle manure and 30% tomato greenhouse with 0.143 l/g.VS.d

Keywords: Biogas, tomato greenhouse waste, cattle manure. Cofermentation

1. Introduction

The population is rising on the Earth day by day. So, world energy consumption and demand is increasing naturally. When developing technology is comforting human life and rising standard of living, energy consumption is increasing this situation as parallel. We know that, Earth fossil energy resources are not unlimited. Besides increase of CO_2 emission born of using fossil energy sources causes global warming and climate change which effects human life negatively. When scientists are researching for using fossil resources more efficiently, on the other hand researching about using and universalizing of renewable, clean, environmental friendly, alternative energy sources. One of this is biogas technology.

Biogas is gas mixture and obtained disintegration of organic materials on anaerobic conditions. 1 m^3 biogas has 5000-5500 kcal energy according to methane rate. Biogas is uncoloured, odourless, weak from air, density rate according to air 83%, octane number 110, a gas mixture. First biogas plants constructed on underground, small, simple system, using animal manure and unheated for rural areas. Today biogas plants developed by the time and they can use many kind of organic materials for industrial scale. Subject of waste management legislated and selling of electricity which is obtained from biogas, is given incentive bonus, increased this development

Nowadays, one of the most important problem of the world is environmental pollution. One of the most important factor of environmental pollution is energy usage and production. Especially biogas technology can help reducing of CO_2 emission born of using fossil energy resources. Increase of biogas plant is reduced demanding of fossil energy resources. More intensive using of natural resources for energy production, such as vegetable and animal waste, will help to reduce environmental pollution.

2. Materials and Methods

The aim of this study determination of biogas production from mixtures of tomato greenhouse wastes and cattle manure.

Antalya is centre of greenhouse tomato producing of Türkiye and greenhouse tomato is most important export item for Antalya. According to greenhouse areas of Türkiye at the years of 2009, Antalya has 36% of greenhouse areas. In addition, 83% of glass greenhouses, 51% of plastic greenhouses, 23% of high tunnel and 4% of low tunnel in Turkey are in Antalya [1]. Knowledge about greenhouse areas are shown table 1. 1 811 310 tons tomatoes are produced in Antalya from 14 390 ha greenhouse areas in 2009. This knowledge shows us, greenhouse production is extensive in Antalya. This extensive greenhouse production is produced abundant of agricultural organic wastes. There is no positive application for recovery of agricultural organic wastes. Only there is a regular garbage storage area for greenhouse wastes in Kumluca.

Table 1 Türkiye and Antalya greenhouse areas at the years of 2009 [1].

	Greenhouse Glass (da)	Greenhouse Plastic (da)	High Tunnel (da)	Low Tunnel (da)	Total
Antalya	6 907.8	11 311.5	1 787.3	655.3	20 661.9
Türkiye	8 293.2	22 018.6	7 704.6	18 701.6	56 718.0
Rate (%)	83	51	23	4	36

Kürklü at al. had researched for determination amount of greenhouse wastes in Antalya. According to the results, 111 480.99 tons dry organic matter is produced from tomato greenhouse wates in a year [2].

Tomato greenhouse wastes cannot recovery any methods in Türkiye. Especially if agricultural organic wastes cannot be used by another way, this wastes are serious environmental problem. Tomato greenhouse wastes can use for neither animal feeding nor another aim. This wastes are generally burned or thrown in environment haphazardly.

Tomato production finishes in greenhouses at the end of June or middle of July. Farmers are dried tomato plant under sun. Aim of this sun drying process is either reducing weight and volume of tomato plant or facilitating of unpick plants.

Used tomato greenhouse wastes are obtained from Akdeniz University Faculty of Agriculture demonstration glass greenhouses. Firstly, unpicked tomato plants are cleaned from strings. Later tomato plants are dried by sun in greenhouse or out of greenhouse. All parts of the tomato plants except root is used. Dried materials are granulated by branch shredder and waste disposal machine. According to laboratory analyses of tomato greenhouse waste, dried matter rate is 91.84%, organic dried matter rate is 81.1%. This material diluted by tap water and adjusted organic dry matter rate of 7%.

Dairy cattle manure is used in this experiments. It is obtained from a cow house in Yeniköy village. Each cattle is fed by 10-15 kg straw and 10 kg prepared stock fodder daily. Cattle manure is filled into 50 kg plastic barrel and carried to laboratory area. This manure is conserved horizontal cap refrigerator at +5 ºC condition for unfermentation. Before cattle manure diluted with tap water which is pH 7.1, it is total solid matter is determinated. Before every loading, material is mixed by electrical mixer for homogenize.

Experimental set is consist of 8 biogas reactor which has 15 litres fermentation volume (figure 1). Each biogas reactor consist of fermentation room, hot water pocket for heating, mechanical mixer, inlet and outlet pipe, wet gasometer and gas stabilizer. Biogas reactors, central water heating system and wet gasometers are emplaced on a big table and platform. Hot water is heated one center and distributed each hot water pocket of biogas reactor.

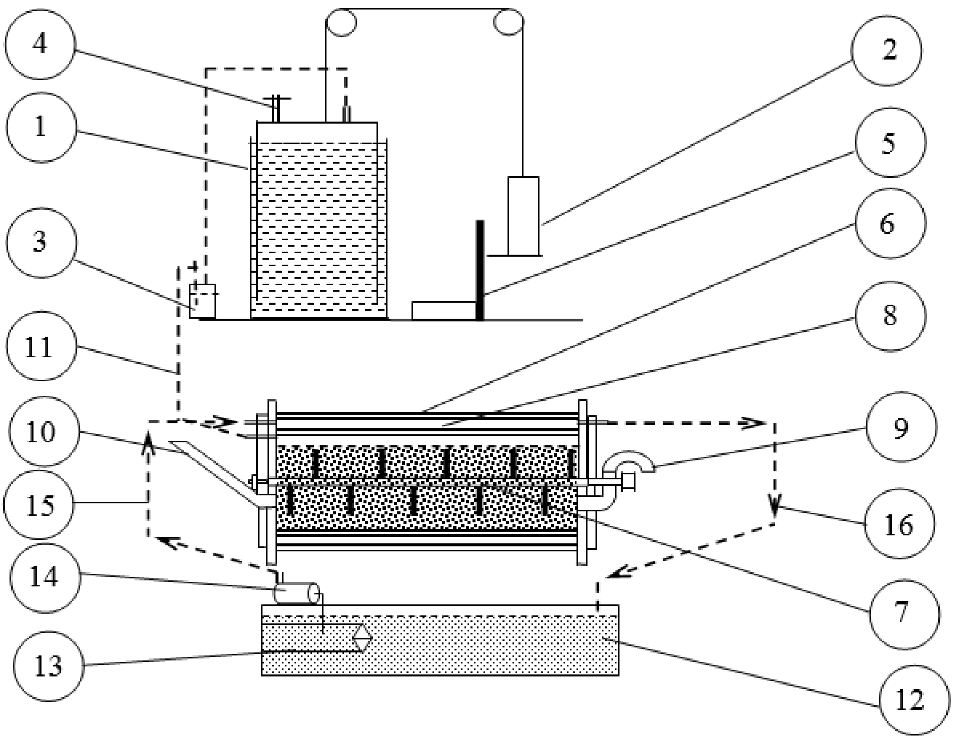

Figure1: Laboratory biogas reactor; 1- Wet gasometer, 2-Contrary weight, 3- Water trap, 4- Biogas discharge faucet, 5- Measurement scale, 6- Reactor external wall, 7- Mechanical mixer , 8-Water pocket, 9- Outlet pipe, 10- Inlet pipe, 11- Biogas line, 12- Hot water storage, 13- Heater resistance, 14-Hot water pump, 15- Hot water inflow line, 16- Hot water come back line

Material is mixed by toed type mechanic mixer which is made stainless steel. Mixers are emplaced in the middle of the reactor horizontally. This mixers connected each other by chain and actuated by an electric engine. Mixer speed is 30 min^{-1}. Electric engine is controlled by timer. Therewith mixers are turned on 1 minute per 29 minutes. Duty of mixer is inhibition of sedimentation.

The experiments conducted for 15 days retention times, fermentation process continuing under mesophilic condition at 37±1 ^oC. Each biogas reactor is filled with fresh mixture every day. Prepared mixtures contain approximately 70 gram organic dry matter. This means 4.66 gram/liter filled per volume of biogas reactor. Biogas production, methane rate, pH, dry and organic dry matter are determinated and filled fresh mixture periodically every day.

Wet gasometer is used for determination of produced biogas amount. Methane rate is measured by a digital gas analyser. The digital gas analyser brand is "Gas Data PCO_2". This analyser can measure oxygen until 21% (with 0.1 precision) and carbon dioxide until 100% (with 0.01 precision). Biogas consists of carbon dioxide and methane. We determinated carbon dioxide rate of biogas and remainder of biogas is accepted as methane rate.

3.Results and Discussion

Biogas materials are loaded every day at the same time. The production became stabilization and then the data is recorded. When system becomes unstable during the experiments, this datum did not add the estimation.

Maximum biogas production is obtained from the mixture of 30% greenhouse tomato waste and 70% of cattle manure as 19.925 l/d. Minimum biogas production is obtained from the mixture of 90% greenhouse tomato waste and 10% cattle manure as 4.918 l/d. The highest methane rate is 52% which is obtained from the mixture of 15% greenhouse tomato waste and 85% cattle manure. The lowest methane rate is 22% and obtained from the mixture of 90% greenhouse tomato waste and 10% cattle manure. Biogas productions and methane rates are shown figure 2.

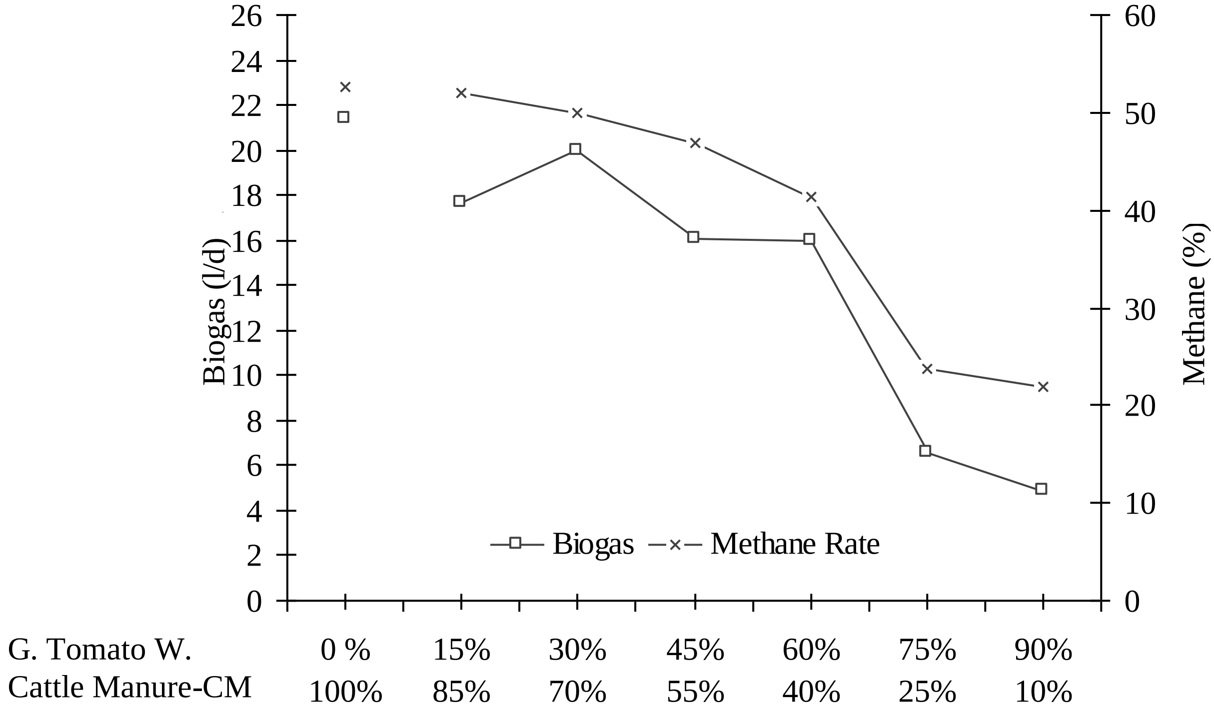

Figure 2. Biogas productions and methane rates

The highest methane yield is obtained from 30% greenhouse tomato waste and 70 % cattle manure, as 0.143 l/g VS.d. Minimum methane yield obtained from mixture of 90% greenhouse tomato waste and 10 % cattle manure as 0.015 l/g VS.d. Firstly methane yield rose when we add the greenhouse tomato waste, but later methane yield decreased rapidly.

When we looked the pH values; pH values had decreased when greenhouse tomato waste rate rose. Experiment results are shown table 2.

Biogas production values are tested by Duncan Test for establishing differences between mixture groups. According to Duncan test (5% significant); 6 mixtures are separated into 5 groups. According to this separation, there is no differences statistically (5% significant) between 45% greenhouse tomato waste + 55% cattle manure mixture and 60% greenhouse tomato waste + 40 % cattle manure mixture. There are statistical differences amongst them.

Table 2. The experiment results

Mixtures	%100 CM	%15 TGW +%85 CM	%30 TGW +%70 CM	%45 TGW + %55 CM	%60 TGW + %40 CM	%75 TGW + %25 CM	%90 TGW + %10 CM
Biogas production (l/d)	21.425	17.663	19.925	16.030	15.937	6.559	4.918
Methane rate (%)	52.638	52.000	50.029	46.915	41.447	23.781	22.000
Methane yield (l/g VS.d)	0.162	0.132	0.143	0.108	0.095	0.022	0.015
Methane production (l/l.d)	0.752	0.612	0.665	0.501	0.440	0.104	0.072
Loading rate (g VS/l.d)	4.627	4.633	4.639	4.644	4.650	4.656	4.662
pH (inlet)	6.587	6.439	6.297	6.162	6.050	5.934	5.821
pH (outlet)	7.092	7.159	7.214	7.180	7.174	6.922	7.028

TGW= Tomato Greenhouse Waste, CM= Cattle Manure

There is no a lot of experimental studies about biogas production from agricultural or vegetal material. Because this agricultural wastes had evaluated by different ways as composting, green fertilizer or biomass. But the best way is biogas technology for evaluation of organic wastes. Scientists are researching about evaluation of organic wastes by biogas technology .

Hashimoto used milled straw and manure mixture in experiments. When straw rate exceeds 40% at 35 ºC and 75% at 55 ºC, biogas production starts to decrease [3].

Park researched biogas production from some mixtures in Korea at rural biogas plants. The highest biogas production is obtained from hen manure with profitless pasture and pork manure with profitless pasture mixtures [4]..

Callaghan at al used cattle manure, hen manure, fruit wastes and vegetable wastes. The cattle manure is added into wet fruit-vegetable wastes at 20, 30, 40 and 50% rate. According to experimental results, when fruit-vegetable rate increases, methane yield increases too [5].

Weiland researched co-materials which are obtained from agricultural wastes. The highest methane production is obtained from animal beet and its greens [6].

Al-Masri used goat manure, sheep manure and olive residuum. When olive residuum rate rises, biogas production and methane yield decrease [7].

Sözer and Yaldiz have investigated the effects of olive residues and sunflower oil to gas production by mixing with cattle manure. The analysis was performed at the temperature of 37 ° C and retention times of 15, 20 and 25 days. The dry matter contents were in the series (pure cattle manure, 20% cattle manure + 80% Olivienrest, 10% cattel manure+ 90% Olivienrest and 10% cattle manure + 90% Olivienrest and sunflower oil) of 5:52%; 6:59%; 6.88% and 15:54% set. Methane production decreased in all trial variants based on pure cattle manure [8].

Hartmann and Ahring determinated biogas production from cattle manure with municipal solid waste. According to the results, 0.36-0.46 l CH_4/g VS is produced from only municipal solid waste, 0.34-0.35 l CH_4/g VS from mixture of cattle manure with municipal solid waste [9].

Umetsu at al. researched cofermentaion of cattle manure with sugarbeet on thermophilic condition. It is determinated that, biogas production rises when sugar beet is added [10].

İsçi and Demirer used cotton waste on batch experiments. 1 gram cotton stipe, cotton seed shell, cotton oil cake produced 65, 86 and 78 millilitres methane, respectively [11].

Gómez at al. researched cofermentaion of primary sludge with fruit-vegetable waste. Biogas production rises when fruit-vegetable waste added inside of primary sludge [12].

4. Conclusions

Biogas production and methane yield decreased when high rate vegetal materials added. Chemical material adding, different digester type using or different pre applications can use for improvement biogas production. Some vegetal wastes belong to only produced country or growing climate, so these countries had developed special systems for evaluating organic wastes. If vegetal wastes cannot be evaluated by any way, biogas technology is an alternative for recovery of vegetal wastes. The important thing is the least damage for environment and recovery of vegetal material to nature. In this way environmental pollution could be reduced, then energy and fertilizer could be produced.

Some developed countries and EU had legislated about inhibition of environment pollution. Laws put into practise for protecting of all nature sources. It is necessary recovery of organic wastes for natural balance. Biogas technology is the best alternative for evaluation of organic wastes, inhibition of environment pollution and energy production as nature friendly. If we want to have more clean green world and country, we have to either recover organic wastes or universalize environmentalist technology like biogas technology.

Acknowledgements

This paper was made possible by funding from the Research Fund of Akdeniz University, Antalya, Turkey

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