Practical Approach to ImproveBiogas Produced from Poultry Manure

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Abstract**—***Poultry Manure (PM) produced in Egypt in huge amount and considered as an environmental problem. Poultry waste can, however, be fermented anaerobically to produce biogas, but its great majority of nitrogen that affects the efficiency and methane ratio of generated biogas. So, the aim of this work to enhance the methane ratio in biogas produced from Poultry Manure using the Dried Bread (DB). 100:0, 25:75, 50:50, 75:25 and 0:100% ratios of DB:PM mixtures has been studied. Biogas yield, C/N ratio, pH, and methane content were studied. The initial pH was 6.43±0.01, 6.85+0.31 6.87±0.56, 6.89±0.23, and 6.95±0.35 respectively; and finally, it was 7.9±0.50, 8.20±0.03, 8.51±0.34, 8.64±0.21 and 8.86+0.25 respectively. While the produced biogas from 100 gm from each mixture was 1180, 1050, 943, 890 and 785 mL respectively with regression coefficient = 0.983. From the obtained results the biogas with high methane content (56%) was produced from mixture of 3:1 DB: PM. The study conclude that Dried Bread can be used to enhance the properties of poultry manure for best biogas quality.*)

Keywords— poultry manure, dried bread, biogas, methane, anaerobic fermentation

I. INTRODUCTION

Currently, approximately 81% of global energy demand is met with fossil fuels [1]. Employing traditional fossil fuel-based energy solutions to meet this ever-growing demand will result in continued escalation of greenhouse gas (GHG) emissions and global warming[2]. While, poultry farms consume a huge quantity of liquefied petroleum gas (LPG) cylinders for heating purpose [3]. Poultry Manure origins a serious environmental problematic where it pollutes soil, water and air (caused by the emission of CH4 gas, NH3 and CO_2). Anaerobic fermentation was used worldwide to produce biogas from different biomass feedstock [4]. Biogas is mainly composed of 50 to 70 % methane (CH_4), 30 to 40 % carbon dioxide (CO_2) and traces such as H_2S, N_2, NH3 and CO [5]. Biogas is about 20 percent lighter than air and has an ignition temperature in the range of 650° to 750° C. The calorific value of biogas is about 6 DBh /m^3 (20 mega joules) - this corresponds to about half a liter of diesel oil [6]. but its great majority of nitrogen that affects the efficiency and methane ratio of generated biogas. Overproduction of bread resulting biowastes bush us to maximize their utilization for green energy production [7]. Breads wastes are an interesting substrate for biogas production [8]. Huge amount produced every day in Egypt as a waste after normal meal. For economical and health purpose, it should be excluded from any other wastes due to sanitary-epidemiological reasons [9]. Different physical and chemical changes happen for bread during storage, containing changes in taste, moisture or starch content, normally called choking, which disturb sensory properties negatively [7]. Wastes from bakery products can be used for biogas production [10]. So, the aim of this study is to improve the quality the biogas produced from poultry manure using the dried bread as available feedstock from daily consumption.

II. MATERIAL AND METHOD

A. Sample Collection and Preparation

Dried bread and poultry manure were used as substrate for the generation of biogas. Fresh poultry manure (2.5Kg), Fresh bread (2.5Kg) were collected. The collected poultry manure and fresh bread were allowed to dry, then it was ground [3], [11].

B. Feedstock Composition

The experiments were carried out five times, each of them with a different feed stock. Dried bread, 75:25, 50:50, 25:75 % (DB: PM) respectively and poultry manure were used as feedstock. Water was added to each experiment at a percentage of 1:1. The initial pH of the digesters was between 6.43±0.01 and 6.95 ±0.35.

The temperature was controlled at 38^0C during all the incubation time by located the digester in the incubator (Mesophiles operating condition) [12].

C. Experimental set up (Digester configuration)

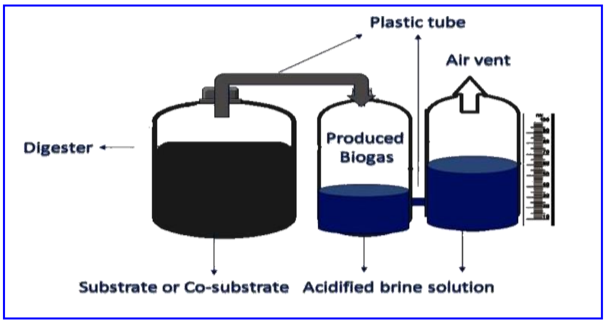

Figure 1 Digester configuration

D. Anaerobic digesters

Anaerobic digesters were commonly built-in bench-scale trials where biogas is formed out of the degradation of organic matter in 2L digester with proper working volume. The three plastic reactors were arranged in such a way that the first one contained substrate, the middle one contained acidified brine solution and the last one was for the brine solution collection which expelled out from the second reactor. distilled water

A supersaturated solution from NaCl was prepared to prevent the dissolution of biogas in the water. Next, 3 drops of H_2SO_4 were added to acidify the brine solution. All the three reactors were interconnected with each other using plastic tube with 1 cm diameter. The connection tube from first reactor to the second was fitted just above the slurry in the first reactor to help gas collection. While first reactor to the reactor which contained the brine solution to displace a volume of the brine solution equal the volume of produced biogas. The lids of all reactors were sealed tightly using super glue to prevent the oxygen entry and biogas loss.

E. Determination of pH

The pH of each sample was measured directly before and after AD by using digital pH meter (HANNA HI 8314).

F. Measuring Carbon: Nitrogen (C/N) ratio

The C: N ratio of feed stocks employed here was considering by total carbon and total nitrogen, it was measured using a LECO analyzer. Samples are combusted at 3000°C in an oxygen atmosphere to produce carbon dioxide and nitrogen gas. A non-dispersive infrared detection cell is used to determine the portion of CO_2 present in the sample. A thermal conductivity cell determines the concentration of nitrogen gas. Utilizing the concentrations of CO_2 and N_2 within the sample, total carbon and total nitrogen can be calculated [13].

G. Measuring the amount of produced biogas

The amount of gas produced was measured by water displacement method using supersaturated NaCl solution [3]. The daily gas production was recorded for different experiments until the gas production ceases [14].

H. Measuring percentage of methane content

High percentage of methane content indicates high quality of biogas [15]. Gas composition was measured from gas sample by Clarus 580 Perkin Elmer gas chromatograph according to Eftaxias et al. (2020) [16].

III. RESULT AND DISCUSSIONS

A. Co-digestion of Poultry manure with Dried Bread

1) pH

The pH is well-thought-out a main parameter for evaluating the quality and efficiency of the digester. Ideal biogas production is produced when the value of pH of the substrate before anaerobic digestion is between 6 and 7 (e.g., Marchaim, 1992).

Table 1 Initial and final pH values for anaerobic digestion of different feedstock ratios of DB and PM

Experiment	pH	
	Initial	Final
E1(100% DB)	6.43±0.01	7.9±0.50
E2(75% DB+25%PM)	6.86±0.32	8.20±0.03
E3(50% DB+50%PM)	6.88±0.56	8.51±0.34
E4(25% DB+75%PM)	6.89±0.23	8.64±0.21
E5(100%PM)	6.95+0.35	8.86+0.25

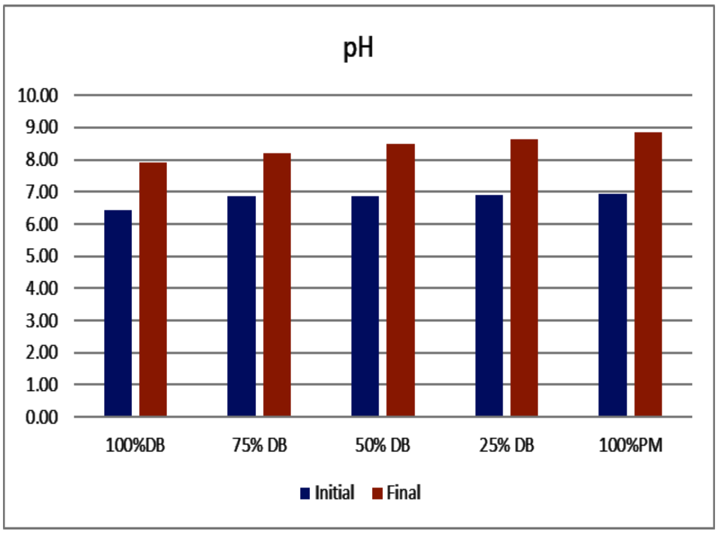

Figure 2 Initial and final pH values for anaerobic digestion of different feedstock ratios of DB and PM.

The pH of 100% Dried bread and 100% poultry manure before an aerobic digestion were 6.43, 6.95 respectively, these values are lower than treatments with two mixed substrates 75% DB+25% PM, 50% DB+50% PM, 25% DB+75% PM which have pH values 6.86, 6.88 and 6.89 respectively. There is no significant difference between substrates in pH before anaerobic digestion as shown in (**Table 1**) and (**Fig. 1**). Mixing of Dried Bread with poultry manure raised pH toward optimum level, which is recommended for anaerobic digestion and biogas production.

Table 2 C:N ratio, Methane percentage and biogas produced from anaerobic digestion process of different mixtures of DB and PM.

	Different ratios from (DB: PM) as feedstock				
	100% DB	75:25	50:50	25:75	100% PM
% C	33.9	32.7	32.3	31.5	34.4
% N	1.5	1.7	1.9	2.3	3.3
C: N	22.6 :1	19.2: 1	17.0: 1	13.7: 1	10.4: 1
CH_4 Content %	56.7	56	54.6	53.2	51.7
Qty of biogas (mL)	1180	1050	943	890	785

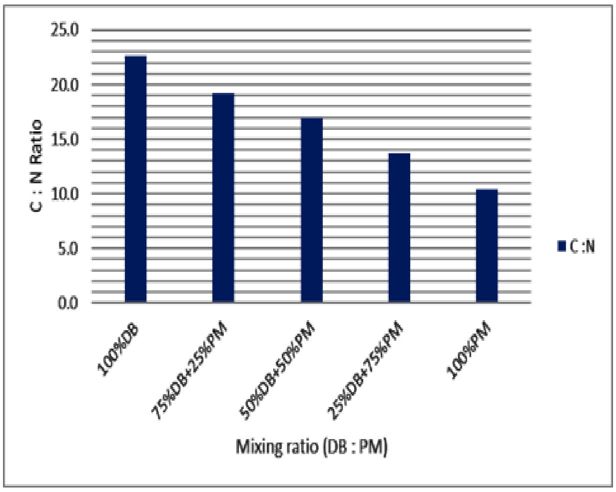

Figure 3 Carbon to nitrogen ratio for different mixtures DB and PM

2) Carbon Nitrogen ratio:

The mixing of several wastes for anaerobic digestion can utilize the nutrients and bacterial diversities that could provide buffering capacity and improved C/N ratio by decreasing the risk of ammonia inhibition to the digestion process as shown in (**Table 2**) and (**Fig. 3**).

By adjusting Carbon Nitrogen ratio in the substrate, the methane content in biogas increase. Carbon Nitrogen ratio of substrate with 100% Dried Bread is 22.6 :1 it is the best Carbon Nitrogen ratio. While substrate with 100% poultry manure is 10.4:1 which considered the low Carbon Nitrogen ratio as shown in (**Fig. 3**).

So, we made co-digestion of poultry manure with Dried Bread to increase carbon percentage and decrease nitrogen percentage in poultry manure wastes, the co-digestion occurred in a different proportion to just of Carbon Nitrogen ratio to obtain highest methane content in the biogas.

3) Amount of biogas produced:

In the first days the substrate with 100% Poultry manure and co-substrate 75% DB+ 25%PM produce highest amount of biogas compared to other treatments. That is due to the presence of microbes in the poultry manure and readily available organic nutrients that are easily digestible by microbes. large amount of native anaerobic microbes in the poultry manure than in others [11]. Thus, biogas production is a function of the feedstock's organic content and its biodegradability [12]. Substrate with 100% Dried Bread produce suitable amount of gas in the first days. Production of biogas decreases rapidly after the first days of measurement and eventually reached 9-0 ml on the 24th day of the experiment for all substrates as shown in (**Fig. 4**). This may be attributed to the depletion of the necessary nutrients from the digesters and the increase in ammonium concentration that resulted in an increased pH values to inhibit digestion [13].

Highest biogas production was noticed in substrate with 100% Dried Bread due to presence of large carbon content in carbohydrates in the wastes like potatoes, rice. Highest biogas production of co-substrates is produced from mixture 75%

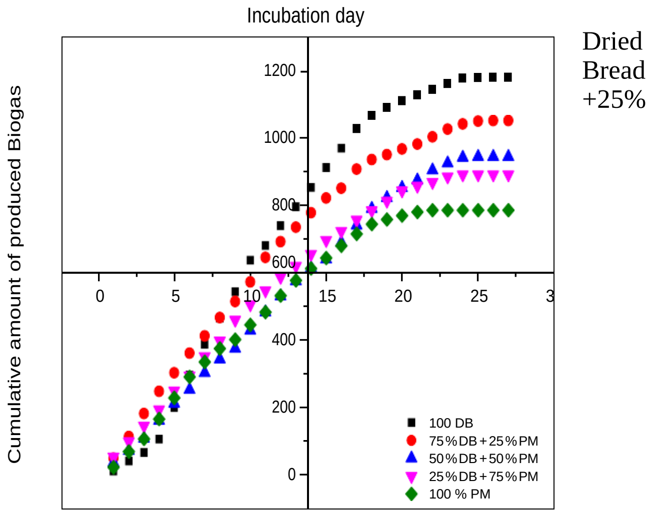

Figure 4 Cumulative amount of produced Biogas for different mixtures of DB and PM

Poultry manure due to high carbon content and low nitrogen content in Dried Bread and presence of microorganisms in both dried breads and poultry manure. Methane content in biogas, which is produced from anaerobic digestion, was measured and the results recorded, it has found that substrate with 100% Dried Bread produce highest methane content due to high carbon nitrogen ratio in it. While substrate with 100% Poultry Manure produce biogas with lowest methane content 51.7% due to high nitrogen ratio in poultry wastes. In addition, the co-substrate with highest percentage of methane content in produced biogas is treatment with 75% DB+25% PM that is because of high carbon nitrogen ratio in Dried Bread and presence of microorganisms in poultry manure.

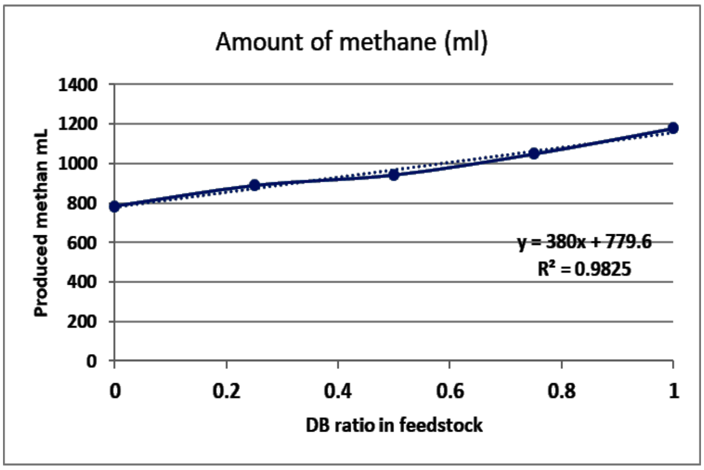

Figure 5 Volume of methane in produced Biogas (ml) vs DB ratio in the feedstock

Volume of methane in produced biogas is measured and recorded, the results indicate that the highest methane content is in 75% Dried Bread + 25% Poultry Manure, amount of methane raised from 785 ml in 100% PM to 943 ml in 50% DB+50% PM. Addition of Dried Bread by ratio 75% to poultry manure improves the amount of methane to 1050 ml which consider improvement with 33.7% comparing with usage of poultry manure without co-digestion (100% PM). As shown in (Fig. 5), it is found that dried bread significantly affects the biogas production from poultry manure.

IV. CONCLUSION

Global suffering from huge quantity of wastes and environmental problems pushing the decision makers to analyze the root cause of each environmental issue and to put a green solution in place to solve the environmental issues. Poultry manure waste and dried bread as a waste considered as an environmental issue, but with anerobic fermentation in our study it is presenting a promising solution to produce biogas. The benefits from our research are avoiding the high nitrogen content from poultry manure in case of use it for biogas production by making co-digestion with dried bread wastes to adjust the carbon to nitrogen ratio. From the gotten results it can be decided that the best ratio is 3:1 (Dried Bread to Poultry Manure) produced the highest percentage of methane content and high amount of biogas produced. So, it is recommended to use dried bread to enhance the biogas production from poultry manure.

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