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IMPROVEMENT OF ORGANIC FERTILIZER AND THE QUALITY OF BIOGAS PRODUCED FROM POULTRY DROPPINGS

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ABSTRACT

Laboratory experiments were executed in batch-operating digesters at mesophilic conditions (40 ºC) to optimize biogas production from poultry droppings at different adding times of agrotain (Urease enzyme inhibitor). A comparative analysis of biogas yield and chemical composition of the influent and effluent slurries as organic fertilizer for the different treatments were also carried out. Biogas composition (Methane, carbon dioxide and hydrogen sulfide) of biogas were found. Influent and effluent enumeration of total fecal *califorms* and *Salmonella* was evaluated. Biogas production from treatment 3 was 37.7, 15.2 and 44.9 % higher than that of treatments 1, 2 and 4, respectively. The fermentation process efficiency for the four different treatments was 47.8, 64.0, 72.8 and 45.7%, respectively. Absence of total and fecal *coliform* and *Salmonella* of all effluent slurries of the different treatments was noticed. The digested treatments under study have the potential of being soil conditioners.
Keywords: Biomass, Biogas, Anaerobic digestion, Agrotain, Poultry droppings, Organic fertilizer.

INTRODUCTION

Energy conversation, coupled with concern for management of livestock wastes. Converting organic materials, such as animal wastes, to an easily utilized forms of energy can be accomplished by several methods. The process with the greatest potential is anaerobic fermentation. Anaerobic digestion is a two-part process and each part is performed by a specific group of organisms. The first part is the breakdown of complex organic matter (manure) into simple organic compounds by acid-forming bacteria. The second group of microorganisms, the methane-formers, breaks down the acids into methane and carbon dioxide. In a properly functioning digester, the two groups of bacteria must be in balance so that the methane-formers just use the acids produced by the acid-formers (Hansen, 2007). In today's energy demanding life style, there is a need for exploring and exploiting new sources of energy which are renewable as well as eco-friendly. In rural areas of developing countries various cellulosic biomass (animal wastes, agricultural residues) are available in plenty which have a very good potential to cater for the energy demand, especially in the domestic sector (Kashyap et al., 2003). Biogas technology offers a very attractive route to utilize certain categories for meeting partial energy needs. In fact proper functioning of biogas system can provide multiple benefits to the users and the community resulting in resource conservation and environmental protection. Biogas is a product of anaerobic degradation of organic substrates, which is one of the processes used for treatment of wastes and stabilization of sludges. It is carried out by a consortium of microorganisms and depends on various factors like pH, temperatures, Hydraulic retention time (HRT), C/N ratio, (Yadvika et al., 2004). Low pH inhibits the methanogenic bacteria and gas generation and is often the result of overloading. A successful pH range for anaerobic digestion is 6.0 – 8.0. low pH may be remedied by dilution or by addition of lime. Biogas contains about 60 to 70 % methane, 30 to 40 % carbon dioxide, and other gases, including ammonia, hydrogen sulfide and other noxious gases. It is also saturated with water vapor (Hansen, 2007). Biogas can be utilized directly combustion by the aid of methane burners, this will produce thermal energy or combustion in an engine to produce thermal energy and mechanically drive an engine-generator set.

The biogas manure (organic fertilizer) is devoid of pathogens, parasites and weed seeds as compared with traditional manure prepared from other organic manures (EL-Shimi and Badawi, 1993). It can be more effective by 30 % than raw manure in crop production, since it has tremendous nitrogen content in the form of ammonical nitrogen. Anaerobic digestion makes the effluent slurry sterile and C:N ratio is lowered to 12:1 which is ideal for higher yields (Gosch and Datta, 1977; Chawla, 1986; Jeyabal et al., 1992; Laksman et al., 1993; Singh et al., 1996; Jeyabal and Kuppuswamy, 1997). Mathers and Stewart (1984) and Juiliana (1991) stated that fertilization with slurry increased the organic matter and phosphorus in the soil. Hydraulic conductivity has been increased, whereas, bulk density decreased.

The main feed for biogas plants is cattle feces which is not available in sufficient quantity within the proximity of the biogas plants (Kalia and Kanwar, 1990). Anaerobic digestion of cattle slurry with the present technology has no economical value when considered only as a source of energy. To cope with this problem, it is becoming essential to evaluate the biogas yield potential of other available organic wastes (Parsons, 1986). EL-Hadidi and AL-Turki (2007) reported that, poultry dropping is one of such organic wastes which could be used in the biogas digester to increase the energy production from biogas plants and the fermented poultry droppings may be used as an organic fertilizer. They found that, adding agrotain to poultry droppings improve the fermentation process efficiency by inhibiting the activity of urease enzyme which catalyzes the decomposition of urea to ammonia.

Manure contains compounds, such as proteins and urea, which upon degradation release ammonia, a potent inhibitor of aceticlastic methanogens (Heinrichs et al., 1990). Angeldaki and Ahring (1994) reported that urease enzyme catalyzes the decomposition of urea to ammonium and carbamate ions by its active site that contains two nickel (II) atoms. To inhibit the effect of urease enzyme, chemical inhibitor (Agrotain) was used. Philombios (2001) reported that, Agrotain (nBTPT) is a new generation nitrogen fertilizer additive that stops N volatilization losses up to 14 days by inhibiting the activity of the urease enzyme.

The main objective of this work is to compare biogas yield, biogas composition, anaerobic fermentation efficiency and biogas fertilizer composition from poultry droppings at different adding times of agrotain.

MATERIALS AND METHODS

In batch digesters, four Florence flasks, each with a volume of five litres were used as fermenters in the biogas laboratory of the Food Sci.&Human Nutrition Dept., College of Agriculture and Veterinary Medicine, Qassim University, Kingdom of Saudi Arabia (Fig. 1). The fermenters were fed with diluted poultry droppings and set to operate at the thermophilic temperature (40 ºC) and a hydraulic retention time (HRT) of 43 days. The fermenter contents were manually stirred for 5 to 8 minutes twice a day. The poultry droppings were produced from the poultry farm, College of Agriculture and Veterinary Medicine, Qassim University. Agrotain (0.1 ml agrotain/kg slurry concentrate) was added to the slurry of all ferementers at the beginning and during the digestion period. The addition of agrotain to the different treatments is shown in table (1). Table (2) shows the chemical analysis of poultry feed. Laboratory system of the anaerobic digestion process used is shown in the schematic diagram (Fig. 2).

The poultry droppings were analysed using APHA (1989) for Total solid (TS). They were diluted with distilled water to a concentration of 9%. Then the amount of water required to adjust the total solid fraction in the digester was calculated using the following equation (Lo et al., 1981).

$$Y = x\,[(TS_{man} - TS_{dig}) / TS_{dig}] \qquad (1)$$

Where:

Y = Dilution water required, kg.
X = Amount of raw material, kg.
TS_{man} = Total solids fraction of raw material, %
TS_{dig} = Total solids of slurry (Influent), %.

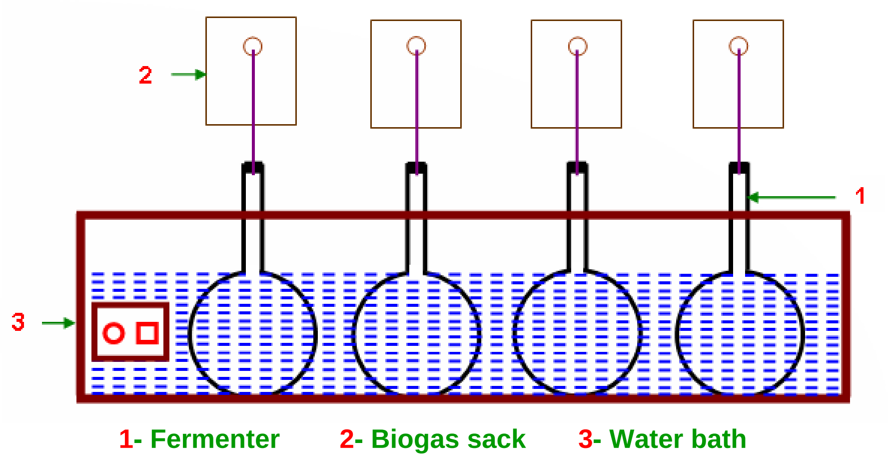

Fig. (1): Laboratory biogas plant.

Table (1): Addition of agrotain to the different experimental treatments.

Time, week	Treatment 1 (T1)	Treatment 2 (T2)	Treatment 3 (T3)	Treatment 4 (T4)
1	√	√	√	
2			√	
3		√	√	
4			√	
5		√	√	
6			√	

√ : adding agrotain (0.1 ml /kg)

The influent and effluent for the four different treatments were chemically analysed according to A.O.A.C. (1984), while BOD (Biochemical oxygen demand) test was followed up by manometric respirometer supplied with a BOD incubator maintained at 20 ºC (BODTRAK, hach tester). The following equation was used to determine the efficiency of fermentation process according to Abdel-Maged (2003)

$FPE=100(BOD_{in} – BOD_{Eff}) / BOD_{in}$ ……………………………...…….. (2)

Where:

FPE= Fermentation Process efficiency, %

BOD_{in}= BOD influent, mg l^{-1}

BOD_{Eff})= BOD effluent, mg l^{-1}

Table (2): Chemical analysis of poultry feed.

Ingredient	Value
Crude protein, %	19.0
Crude fat, %	3.5
Crude fiber, %	3.0
Calcium, %	4.0
Phosphorus, %	0.65

Enumeration of total and *fecal coliforms* was executed according to Feng *et al.,* (2001), while *Salmonella* was isolated using the protocol of Andrews and Hammack (2001).

The outlet biogas was collected in aluminum sacks and measured using a Ritter gas meter at atmospheric pressure and room temperature according to CET (1997). The gas volume was re-calculated for STP as stated by Gosch et al., (1983) using the following equation:

$V_{tr} = V_f [273.15 (P_1 – P_2 – P_3)] / (T \times 1013)$ …………………..(3)

Where:

V_{tr} = Volume of dry gas under standard conditions, Litre.

V_f = Volume of wet gas at pressure P and temperature T, Litre.

P_1 = Air pressure at temperature T, millibar.

P_2 = Pressure of wet gas at temperature T, millibar.

P_3 = Saturation steam pressure of water at temperature T, millibar.

T = Temperature of wet gas, ºK.

Gas analysis was carried out for composition every 5 days during the biomethanation of different treaments. The methane content (%) was determined using GA 2000 gas analyzer manufactured by Geotechnical Insr., England.

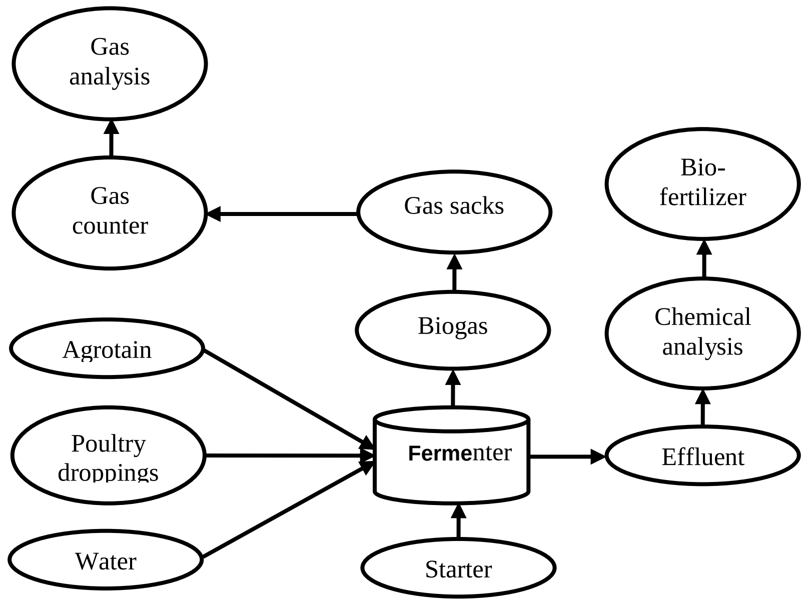

Fig. (2): Schematic diagram of laboratory biogas system.

RESULTS AND DISCUSSION

The plotted results shown in Fig. (3) revealed that the biogas production rate for the four different treatments 1, 2, 3 and 4 was 6.0, 7.17, 8.26 and 5.7 liters per liter of effluent, respectively. This means that biogas produced from treatment 3 was 37.7%, 15.2% and 44.9% higher than that produced from treatments 1, 2 and 4, respectively. This variation in biogas production rates may be due to the different agrotain concentrations of fermented slurry, which improved the biogas yield by reducing the ammonia generation. Statistically analysis (t-test) indicated that there were significant differences among the treatments 1 – 3 and 3 – 4, while there were no significant differences among the other treatments.

The results also showed that the hydraulic retention time (HRT) of 43 days was suitable for anaerobic fermentation of different treatments. Accordingly, the mean values of biogas production rates during this study were 0.15, 0.18, 0.21 and 0.14 liters per liter of effluent for treatments 1, 2, 3, and 4, respectively.

As shown in Fig. (4) the methane content in the biogas yield varied between minimum values of 11, 25, 28 and 9 % to maximum values of 66, 70, 73 and 64 % for treatments 1, 2, 3 and 4, respectively. This pattern indicates that only CO_2 rather than CH_4 occurred during the first week of fermentation. On the second week after the O_2 in the digester was consumed anaerobic conditions prevailed and combustible gas generation started. These results are in agreement with that reported by EL-Hadidi and AL-Turki (2007).

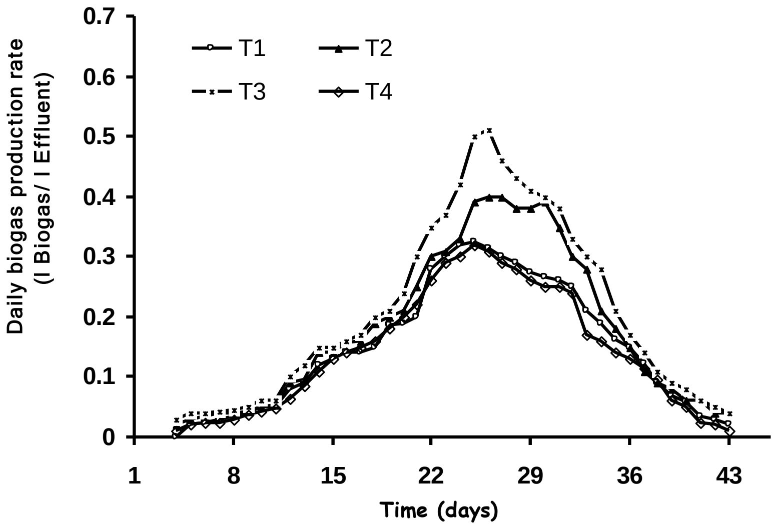

Fig. (3) Effect of different treatments on daily biogas production.

Total and fecal *Coliforms* and *Salmonella* in influent and effluent of different treatments are listed in Table (3). It indicated an absence of total and fecal *coliform* and *Salmonella* of all effluent slurries for the four different treatments. This implies that any pathogenic or non-pathogenic bacteria presents in the waste are killed as a result of high temperature and due to gases produced by anaerobic fermentation. It is evidenced that the effluent of different treatments has the potential of a good organic fertilizer in soils.

As shown in Fig. (5), the BOD value of the influent was1850 mg/l. The results revealed that the BOD value of the effluent of treatment 4 was 3.9, 33.7 and 49.9% higher than that for treatments 1, 2 and 3, respectively. These results also indicated that the BOD value of the effluents varied according to the effect of agrotain on ammonia production. Fig. (6), illustrates the fermentation process efficiency of the different treatments. It was found to be 47.8, 64.0, 72.8 and 45.7% for treatments 1, 2, 3 and 4, respectively. This indicates that the weekly addition of agrotain to treatment 3 improved the fermentation process efficiency of poultry droppings by inhibiting the activity of urease enzyme which catalyzes the decomposition of urea to ammonia.

Table (3): Levels of total and fecal *Coliforms* and *Salmonella* in different treatments.

		Total Coliforms*	Fecal Coliforms*	Salmonella
Influent		0.83×10^9	1.5×10^4	Present
Effluent	Treatment 1	Nil	Nil	Absent
	Treatment 2	Nil	Nil	Absent
	Treatment 3	Nil	Nil	Absent
	Treatment 4	Nil	Nil	Absent

***Determined by most proble number (MPN)**

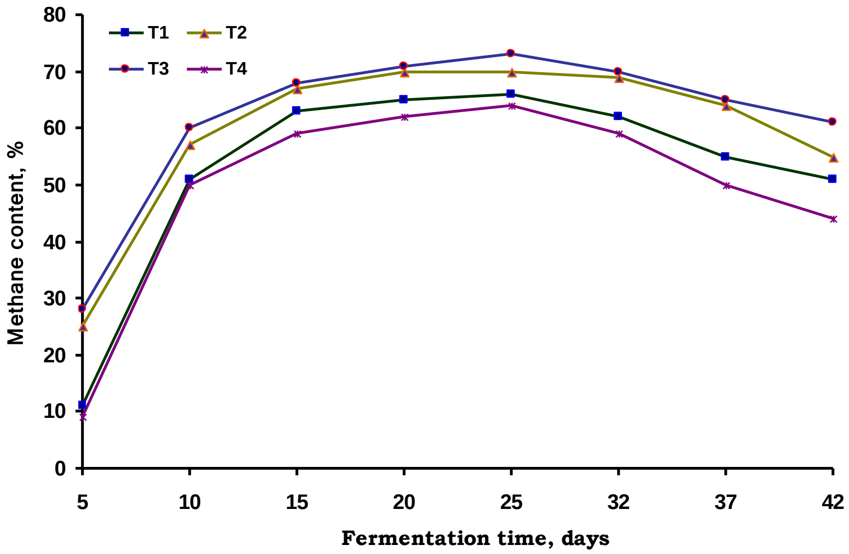

Fig. (4): Effect of different treatments on methane content.

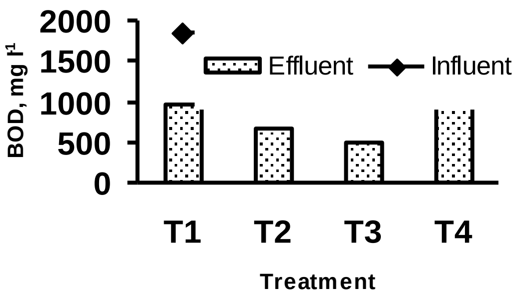

Fig. (5): Effect of different treatments on BOD status.

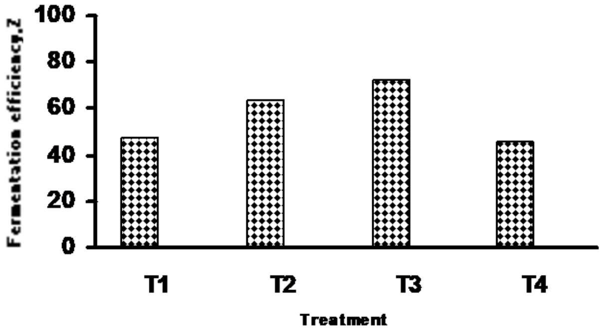

Fig. (6): Effect of different treatments on fermentation process efficiency

Table (4) shows the obtained data from chemical analysis. It is evidenced that the effluent slurry of the different treatments could be used as a good organic fertilizer. The effluent slurry of treatment 3 has the highest concentration of nitrogen (3.62%), potassium (0.67%) and phosphorus (1.29%) as compared with the other treatments. It is clear that the effluent of treatment 2 has the most suitable C/N ratio, which is ideal for the mineralization of organic material. This implies that the effluent of different treatments have the potential of being a good organic fertilizer for sandy soils.

Table (4): Chemical composition of the treatments studied.

Constituent	Influent	Treatment 1	Treatment 2	Treatment 3	Treatment 4
N, %	2.73	2.86	3.49	3.62	3.40
C, %	29.30	30.20	29.85	29.00	30.65
C/N Ratio	11:1	11:1	9:1	8:1	9:1
K, %	0.56	0.62	0.64	0.67	0.60
P, %	1.12	1.20	1.24	1.29	1.18

CONCLUSION

The obtained results can be summarized and listed in the following points:

1-The poultry droppings may be used as an organic fertilizer and non-traditional energy source by mixing in suitable well formulated concentrations with agrotain in an anaerobic digestion process.

2-Biogas production increased moderately with the increase of agrotain adding times (weekly).

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تحسين إنتاج السماد العضوي والغاز الحيوي من مخلفات الدواجن

أحمد بن إبراهيم التركي و ياسر مختار الحديدي

كلية الزراعة والطب البيطري – جامعة القصيم – المملكة العربية السعودية.

تم إجراء هذه البحث بمختبر أبحاث الغاز الحيوي بكلية الزراعة والطب البيطري – جامعة القصيم بهدف دراسة تأثير استخدام مثبطات اليوريا (الأجروتين) على إنتاج السماد العضوي والغاز الحيوي من مخلفات الدواجن وذلك بإضافة الأجروتين بتركيز 1 ملليجرام/كجم محلول متخمر من زرق الدواجن على فترات مختلفة كالتالي:

المعاملة (1): إضافة الأجروتين في بداية الأسبوع الأول.

المعاملة (2):إضافة الأجروتين في بداية التجربة ثم كل 2 أسبوع.

المعاملة (3):إضافة الأجروتين في بداية التجربة ثم أسبوعيا.

المعاملة (4):عدم إضافة الأجروتين.

أوضحت أهم النتائج التي تم الحصول عليها الأتي:

- زيادة الغاز الحيوي الناتج من المعاملة (3) بمقدار 7ر37% ، 2ر15% ، 9ر44% عن الغاز الحيوي الناتج من المعاملات (1) ، (2) ، (4) على التوالي.
- أقل قيمة لمحتوى الميثان في الغاز الحيوي الناتج كانت 11% ، 25% ، 28% ، 9% بينما أعلى قيمة كانت66 % ، 70% ، 73% ، 64% للمعاملات (1) ، (2) ، (3) ، (4) على التوالي.
- أوضح التحليل الكيميائي لنواتج التخمر اللاهوائى في المعاملات المختلفة أنها غنية في عناصرها الغذائية الكبرى، كما أوضحت الفحوص الميكروبية أن هذه النواتج خالية من مسببات الأمراض مما قد يشجع على استخدامها كسماد عضوي للتربة الرملية .