# Production of biogas from the waste of some restaurants of Tikrit University in order to produce thermal energy

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**Article History**: *Received: 11 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 10 May 2021*

**Abstract:** In this research, a study was undertaken to convert the waste of some Tikrit University restaurants into the energy that can be used in the production of electrical or thermal energy in addition to the disposal of that waste, which is a major problem facing the University of Tikrit. Therefore, the mechanism for disposing of these wastes was studied and converted into another form that can be used, where a system designed to dispose of these wastes. Where the best ratios of mixing were calculated to produce the largest amount of gas, as it was noted that the volume of biogas had increased to its highest value (3170 milliliters), and specifically when the water mixing ratio to wastes increased to (35%) and the highest value of the resulting biogas was On the 35th day of the system's operating time. After that, those wastes are used as organic compounds that are used as plant fertilizers that contain compounds rich in useful components for plants during cultivation. This research will include a presentation of the most important results obtained from the designed system. Also, this paper will discuss the most important practical results that have been measured in an experimental way in detail.

**Keywords:** Renewable energies, Waste energy, Biogas energies, Biomass, Solid waste density.

## 1. Introduction

Domestic solid waste can pose a threat to humans and the environment if it is not handled and disposed of in a sound manner and on sound environmental grounds. Household solid waste has organic materials that are biodegradable, which results in substances hazardous to human health such as hydrocarbons such as dioxin, which causes lung cancer, anxiety, depression, stress, redness and irritation of the eyes, in addition to other explosive and combustible gases such as methane gas, Not to mention the insects that live on these wastes and the diseases that it transmits to humans and animals [1,2,3].

Solid waste is the cause of at least 22 human diseases, as mentioned in one of the bulletins issued by the World Health Organization [4]. Disease germs and microbes are transmitted from solid waste to humans by several means, the most important of which are flies and mice. Whereas, flies multiply rapidly, as scientists estimated that one pair of flies, , if they lived on litter from March to September, they could descend 191 billion flies, if the appropriate conditions for growth and reproduction were provided, and each fly could carry 6 million microbes and transmit to humans any diseases, the most important of which are Trachoma and Dysentery [5,6].

Waste is the largest source of methane emission to the gaseous atmosphere, and $CH_4$ is the main factor in climate change and has a multiplier effect, as it is about 21 times greater than the impact of $CO_2$, and that any project to produce biogas from landfills can extract an amount of 85% Of the gas generated inside the landfill, and small dumpsites with a capacity of generating 5 megawatts [7].

## 2. Research Methodology (experimental part)

In this research, the waste was collected from restaurants and the waste was separated into two parts. One part is used, and it contains food residues and the other part is thrown because it contains plastic and metal materials that impede energy production. Then the waste was cut into small pieces using an electrical cutting machine and proportions were mixed, it is known from the wastes with water and in three percentages depending on water and wastes, and in varying proportions between water and wastes. Then the mixture was placed inside the system (inside the tank) and then the closure was sealed, and after the gas valve was closed to prevent its leakage. After a period that ranged from fifteen to seventeen days, a slight increase in pressure was observed, which indicates that there was a reaction inside the system that led to the production of gas slightly, and after a period of 35 days we notice a significant increase in gas, which led to the production of biogas inside the tank and this reaction continued smoothly and this is due to the increase in the amount of food available to the living. The microstructure represented by organic materials in addition to the increase in the activity and multiplication of the number of microorganisms, and thus increase of the resulting biogas, that meaning the production of biogas increases with time, and after a period of more than 45 days of fermentation. Stability of the gas ratio, which indicates the completion of the reaction, which indicates that the bacteria producing biogas, began to consume food, which led to a decrease in the number of microorganisms, and thus a decrease in the resulting biogas. The relationship of humidity and temperature with the amount of energy produced was also highlighted, as the positive relationship between increasing the temperature to a reasonable extent and increasing the resulting biogas was observed due to the increase in the production of bacteria that cause an increase in the production of biogas. The humidity ratios of the two restaurants were also studied. It was found that the general average for the moisture content of the waste for the two restaurants is equal to (24.8%). Finally, it was concluded that the volume of waste for Tikrit University restaurants reaches very high values that may cause an environmental disaster if not handled properly in addition to that some of these wastes, especially plastic and nylon, may remain for a period of more than 500 years to be dissolved and this is a dangerous matter. And through our study to use of wastes in energy production, it is possible to make use of wastes after energy production in using them to form organic fertilizer that can be used in fertilizing crops, which is what we will work on in the future. In conclusion, we can say this method is a method for the aerobic biological treatment to produce thermal and electrical energy, which is the best environmentally and economically appropriate method compared to the combustion process or gases resulting from the combustion of gases or fuels.

### 1.1 The physical properties of the waste

This paper included studying the physical properties of solid wastes and calculating the density, moisture content and components of the waste, as follows.

#### 1.1.1 Solid waste density

In this part of research, the density of solid waste was calculated and as show in Figure (1), which shows the general average of household wastes density for two restaurants studied at Tikrit University for three periods, which was obtained from the analysis of the samples for this study of excrement, which amounted to (172.5) kg / m3.

As the density values depend directly on the proportions of the waste components as well as on the difference in moisture contents. From the same figure, it is possible to notice the change in the density of solid waste for the two restaurants at the University of Tikrit, which is the subject of the study, as it appears that the highest value among the values is in the student center cafeteria and the second value was lower in the College of Agriculture restaurant, due to the increase in the percentage of organic materials in the student center restaurant and its decrease in the College of Agriculture restaurant, where the density value increases with the increase in the percentage of nutrients and decreases with its decrease Figure (2) also shows the variation in density values during the three periods of waste collection operations and within the study period. It is clear that the highest value of density was in the third period of the collection process (170) kg / m3, and the lowest value was in the second period (150) kg / m3. The reason for this increase is due to the difference in moisture content and also because the second period of collection was at end of the first academic course, i.e., the number of students in the university is small and there is no high turnout for restaurants, as well as the effect of climate on density.

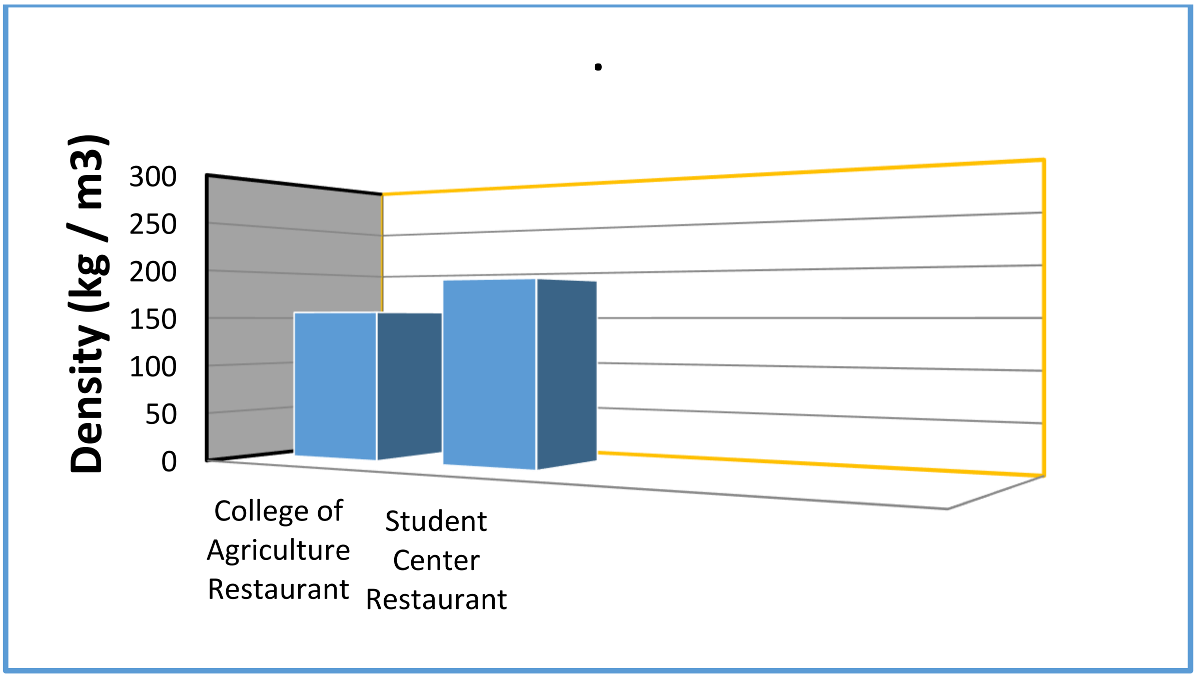



Figure (1) the average of  density of household wastes for two restaurants studied

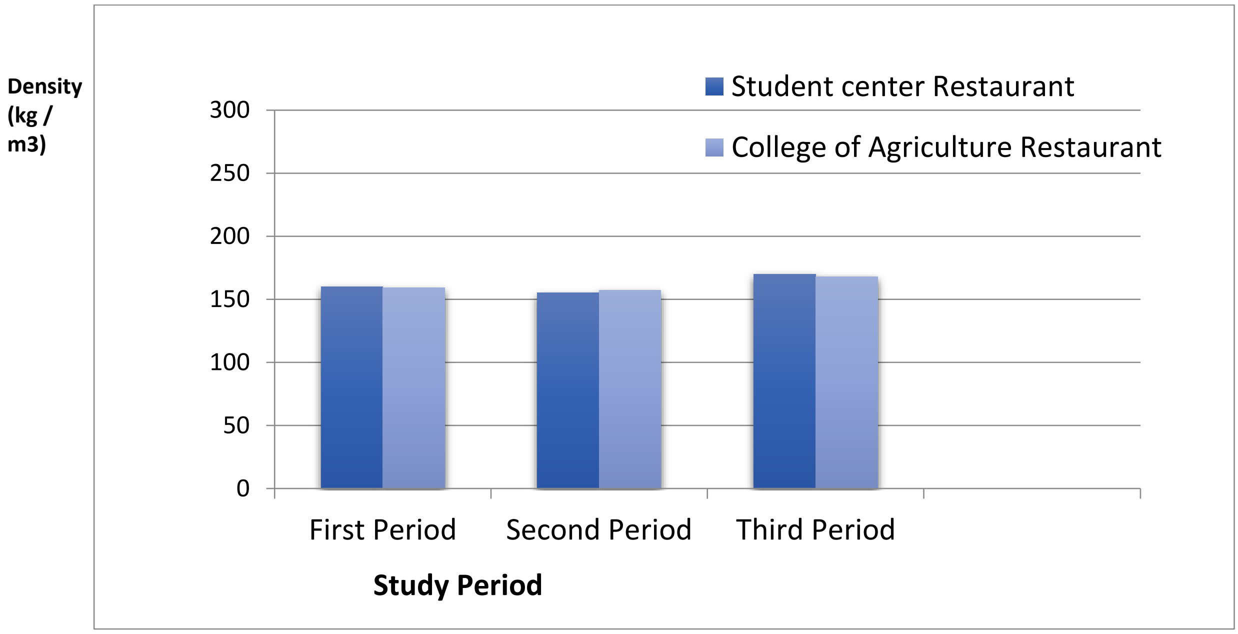



Figure (2) the waste density for each of two restaurants during three collection periods

**Moisture Content**

In this part of  research, the relationship between the moisture content of the waste in each of the two studied restaurants (Student Center Restaurant and College of Agriculture Restaurant) was studied during the study period, the results of which are shown in Figure (3), where it was found that the general rate of moisture content of waste for the two restaurants is equal to (24.8%). This value is close to the value (27.419%) obtained by researcher (Qarah Ghuli, 2011)[8], for the general average moisture content value of household solid waste in her study of Tikrit. Also, the value (28.88%) is considered compatible with the results of the ideal values for the approximate analysis of the moisture content of the waste ranging from (15-40)%.

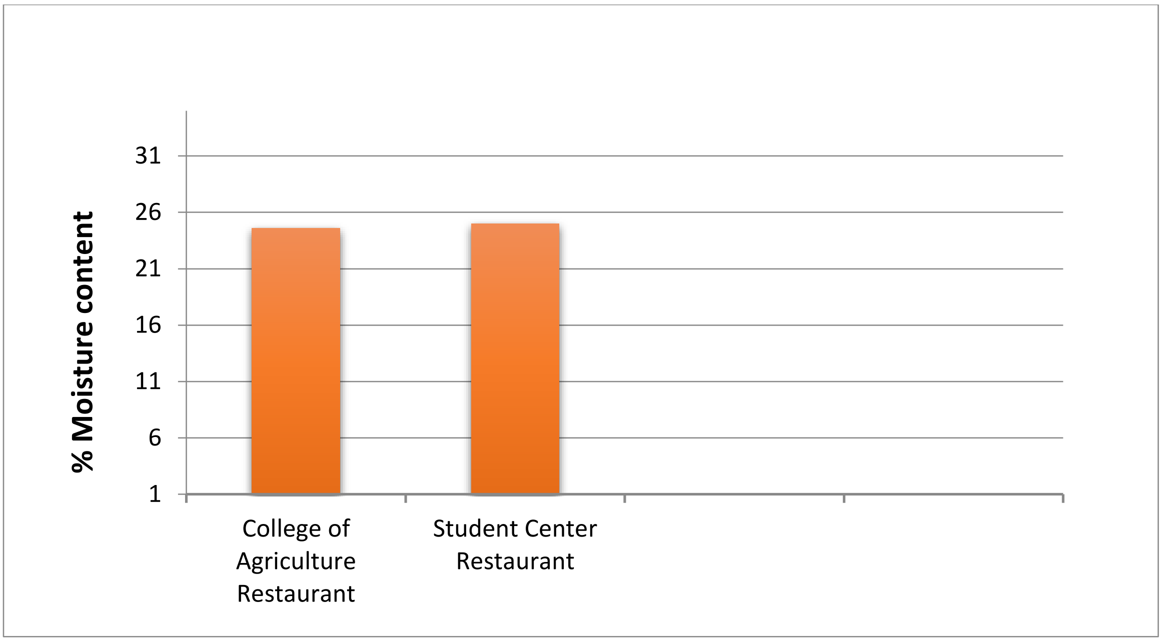



Figure (3) the moisture content of the waste in each of two studied restaurants

Figure (3) also shows the moisture content of wastes in each of two studied restaurants, as it was found that the highest value of the moisture content for household solid waste reached (25%) in the student center cafeteria and it was in the College of Agriculture restaurant (24.6%). This difference in results is attributed to that The amount of moisture content increases with the percentage of food waste. Whereas, in times of high temperatures, the highest value of moisture content, and the lowest value is at low temperatures and the same explanation explains the differences in the results, which considers the organic materials containing high materials of liquids, which increases the moisture content, as the difference between the percentage of humidity during the three periods of waste collection, which is shown in Figure (4), and the proportions are very close, and there is no significant difference due to the close time period of the collection process, as well as there is no variation in the climate as the percentage of gas production increases with climate changes.

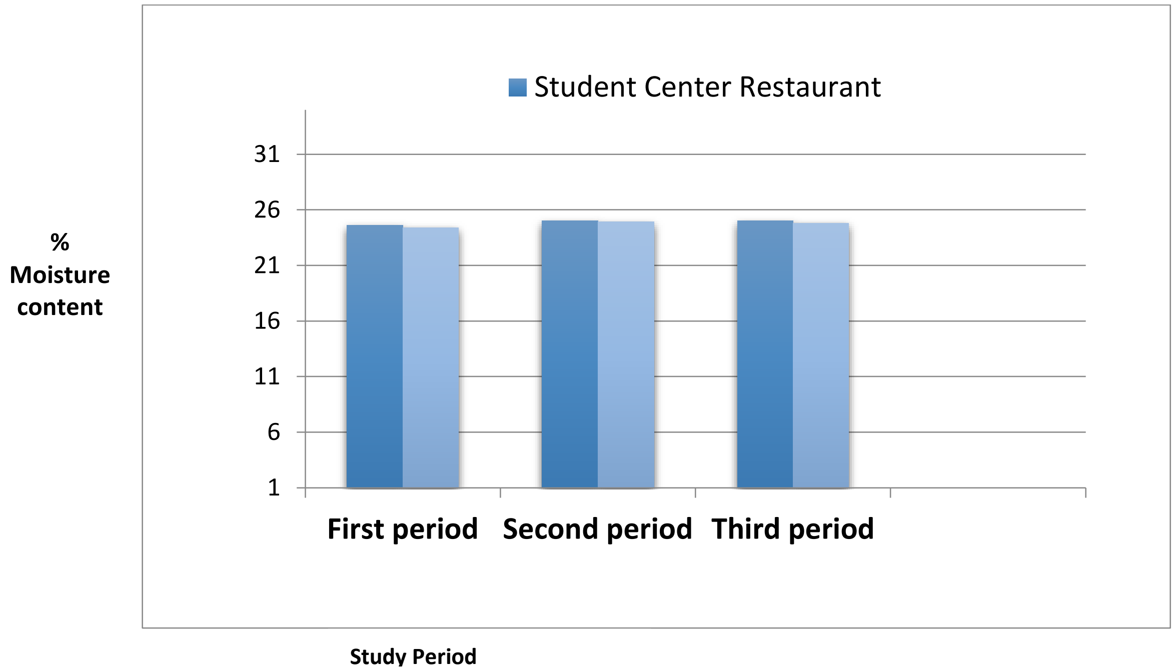
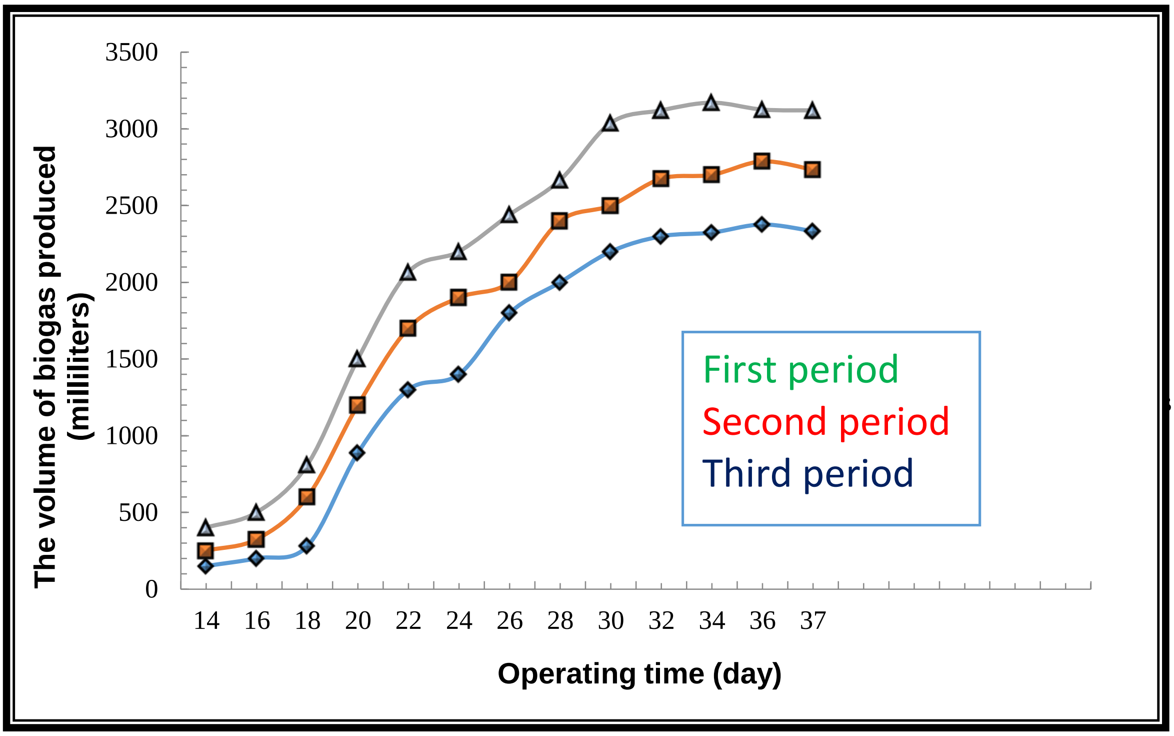



Figure (4) the moisture content of the waste for each of the three periods for each of two restaurants

### 1.1.3 Biogas production for the anaerobic biological system:

In this part, we show the relationship between the volume of biogas produced (milliliters) with the operating time, as it is clear from the results that the production of biogas increases with time. Figure (5) shows the relationship between biogas production and the operating time of the fermentation processes during the three periods. As can be seen from the above mentioned curve figure that the production of biogas began to appear on the seventeenth day of the treatment process for the first fermentation process. As for the second fermentation process, the gas began to appear on the fifteenth day. As for the third fermentation process, the gas began to appear on the sixteenth day, the first system with volumes (400 And 250, and 150 ml) for first, second and third fermentation, respectively. These small volumes indicate that the anaerobic biological treatment in its first stage is disintegration and decomposition (liquefaction). The biogas may be formed at this stage in very small proportions by micro-organisms with rapid growth potential. When highlighting Figure (5), it can be seen that the volume of the resulting biogas increases gradually over time for the three fermentation periods of the system, as the maximum value of the biogas volumes (3170 milliliters, 2788 milliliters and 2377 milliliters) was recorded for the first, second and third periods, respectively. The maximum values of the biogas volumes were recorded on days (thirty-fourth, thirty-fifth, and thirty-sixth) for the first, second and third reactions respectively of the anaerobic biological treatment time. This is attributed to the increase in the amount of food available to the micro-organisms represented by organic matter, in addition to the increased activity and multiplication of the numbers of micro-organisms.

Also, its shows that the maximum value for biogas volumes was recorded for the first fermentation process (3170 milliliters). The reason for this is that the water mixing ratio for the first fermentation process (35%) is higher than the amount used for the third and second reactors (15% and 25%) respectively. A gradual decrease is observed in the values of the resulting biogas volumes for three periods in a simple way, and the reason for this is a decrease in the amount of food represented by the mass of organic matter and the speed of its consumption by microorganisms, and thus the activity and number of the micro-organisms responsible for the production of biogas will decrease as a result of their destruction due to the outlet of food necessary for their survival and reproduction.




The method of calculating the weight of the residual waste after the completion of the anaerobic biological treatment process was adopted directly, and the purpose of that is to compare it with the original weight of the excreta calculated at the start of the anaerobic biological treatment process, which was equal to (150 kg) for each fermentation process. Figure (6) illustrates the relationship between the mixing ratio of the wastes with the decrease in the weight of the waste % after the anaerobic treatment of three fermentation operations. It is clear from Figure (6), that the decrease in the weight of the waste after the anaerobic treatment of the first, second and third reactors is equal to (26.78, 34.85 and 38.14%) when mixing rates of solid waste (65, 75 and 85%) for the first, second and third reactors respectively. It follows from this that the highest decrease in the weight of the waste was recorded at the first reactor (38.14%) equivalent to (56.7 kg) when the mixing percentage of solids was (65%), while the lowest value for the decrease in the weight of household solid waste was observed at the third fermentation process (26.78%) equivalent to (39.7 kilograms) at a mixing rate of solid waste equal to (85%). Furthermore, it follows from this that the values of decrease in the weight of household solid waste increase when the rate of mixing of waste decreases, and the reason for this is that the increase in concentrations of waste causes obstruction and slowness in the activity of microorganisms on the decomposition of organic materials, and then a decrease in the speed of dissolution and hydration of the excreta, which increases the weight of solid waste, the decrease in the number of bacteria and the abundance of food [9, 10, 11].

It is evident that the highest decrease in the weight of household solid waste % in the reactors of the first and second system was recorded at the first fermentation period (38.14%), equivalent to (56.7 kg) at mixing ratio of solids (65%). The reason for this is that the decrease in solid organic waste concentrations causes an increase in the velocity and the activity of microorganisms and thus a decrease in the weight of solid waste after the completion of the anaerobic treatment process.

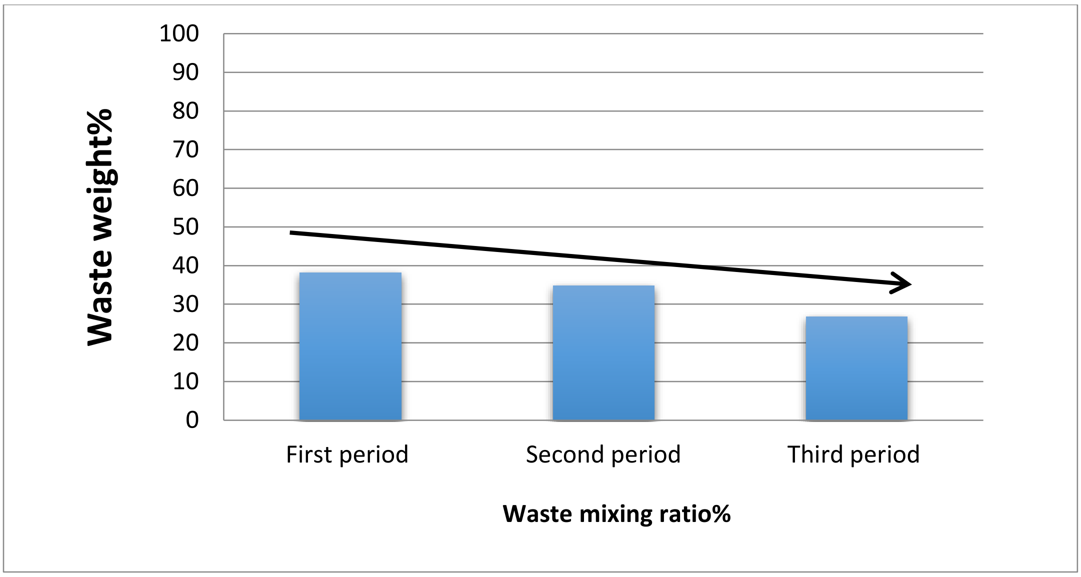



Figure (6) the relationship of the mixing ratio of wastes with decrease in weight after anaerobic treatment.

**1. Effect of blending ratio on biogas production:**

Figure (7) shows the relationship between biogas production and the mixing ratio of the additive into the waste, as it is evident that the amount of biogas increased with the increase in the mixing ratio of the additive to the waste. This leads ultimately to promote decomposition and digestion. This interpretation is consistent with that reported by the researchers (Reddy et al., 2006; Rabaey et al., 2005). It is evident from Figure (7) that volume of biogas increased to its highest value (3170 milliliters), specifically when the water mixing percentage of wastes increased to (35%).

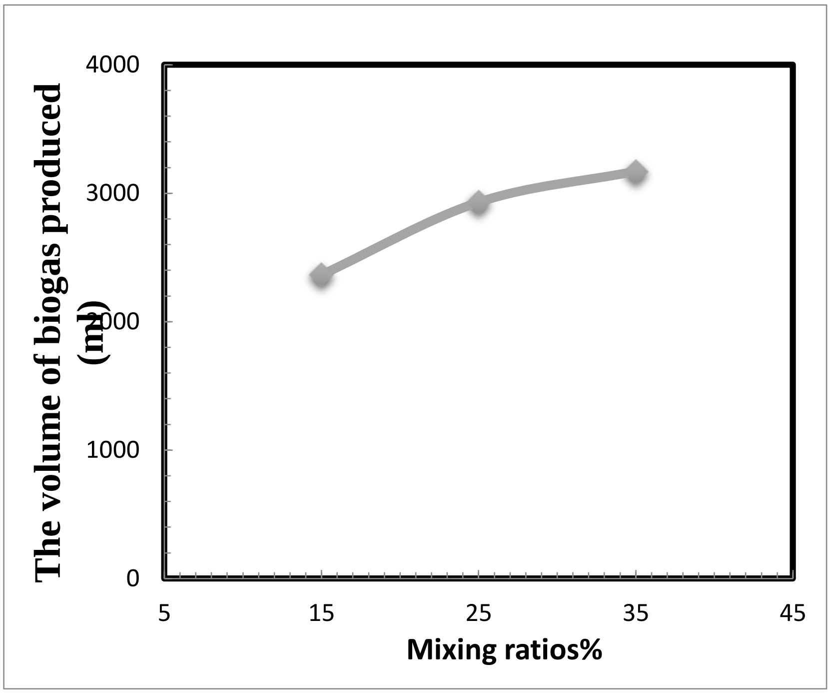



Figure (7) the relationship of biogas production with the mixing ratio of waste

**Conclusion**

The process of producing gas to produce energy through the internal reactions of the waste collected in particular from the restaurants of Tikrit University, especially the Student Center restaurant and the College of Agriculture restaurant, we conclude from a set of practical results that were investigated from practical experiments, which are as follows:

The highest value of the biogas produced was on the 35th day of the operating time of the system and the reason is due to the increase in the amount of food available to the micro-organisms represented by organic materials in addition to the increase in the activity and multiplication of the numbers of microorganisms. Also, the positive relationship between the mixing ratio and the biogas production process, as we noticed the increase in the biogas production process as the mixing ratios increased, as well as the decreasing waste value after the completion of anaerobic biological treatment. When the temperature increases to a reasonable extent, the biogas produced will increase due to the increase in the production of bacteria that cause the increase in the production of biogas. In addition, the anaerobic biological treatment method for the production of electrical energy is the environmentally and economically better method compared to the incineration process. Finally, fermented waste products can be used as an organic fertilizer rich in live bacteria and nitrogen.

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