

USEFULNESS OF THE BAKERY INDUSTRY WASTE FOR BIOGAS PRODUCTION

Summary

The article presents the results of laboratory tests of the suitability of the baking industry waste such as wheat roll, wheat bread and a donut, as a substrate for biogas production. The study used the eudiometric stand, located at Chemical Analysis Laboratory of the Institute of Engineering Biosystems UP in Poznań. The experiment was conducted in accordance with DIN 38 414 S8. It was found that the wastes containing breads waste showed good performance in case of periodic mixing and reduced process temperature. Waste based on stale bread can be successfully used for methane fermentation process.

Key words: biogas, bakery waste, bakery industry

PRZYDATNOŚĆ ODPADÓW Z PRZEMYSŁU PIEKARNICZEGO DO PRODUKCJI BIOGAZU

Streszczenie

Zaprezentowano wyniki laboratoryjnych badań przydatności odpadów z przemysłu piekarniczego, takich jak bułka pszenna, chleb pszenny oraz pączek, jako substratu do produkcji biogazu. Do badań wykorzystano stanowisko eudiometryczne, znajdujące się w Laboratorium Analiz Chemicznych w Instytucie Inżynierii Biostystemów UP w Poznaniu. Doświadczenie przeprowadzono zgodnie z normą DIN 38 414 S8. Stwierdzono, że odpady złożone z pieczywa odpadowego wykazały dobre parametry produktywności w sytuacji okresowego mieszania i obniżonej temperatury procesu. Odpad na bazie czerstwego pieczywa można z powodzeniem wykorzystać do procesu fermentacji metanowej.

Słowa kluczowe: biogaz, odpady piekarnicze, przemysł piekarniczy

1. Introduction

All available analytical sources indicate a high probability of the energy crisis, the observed differences are only the date of its occurrence and are expected over the next 15-25 years [6, 11, 12]. Therefore the share of Renewable Energy Sources in the total energy balance in Poland is growing. This is because of regulations aimed at protecting the environment. Green policy of the European Union makes so that renewable energy systems were of interest to individual customers, but also institutional investors. Directive of the European Parliament 2009/28/EC is a tool to implement the energy policy of the European Union under the common name "3x20" and sets ambitious targets for Poland in 2020, at least 15% of primary energy from RES in total energy consumption [9, 10].

Biogas produced by the anaerobic digestion of agricultural biogas plants is an important renewable energy carrier. Generating power in biogas could solve the problems of storage and disposal of many groups of waste from agriculture and agri-food industry. This would allow not only the rational management of waste, in accordance with the principles of environmental protection and sustainable development, but also the use of the energy contained in the waste. Bio-energy management system (recovery) is the best possible solution.

Baking industry is one of the most important sectors of the food industry in Poland. Currently there are approx. 9700 bakeries. Bread production is 1650000 tons in total in 2012 according to Central Statistical Office [4]. Each bakery producing bread and cakes is a manufacturer of wastes. As a result of the production activity in bakeries wastes are produced, such as raw materials and products unsuitable for consumption or processing, and unfit for use fats. Moreover

paper and cardboard, plastics, wood, metals and food packages remain unfit for consumption. Classification of waste is based on the Regulation of the Minister of the Environment of 27 September 2001. According to it, the waste are divided into groups according to the source of origin. Those produced in bakery are primarily the non-hazardous waste. These include materials unsuitable for consumption or processing (02 06 01). Cakes, flour confectionery and vegetables are the remains of foods wastes. Cabbage, mushrooms, onions, and unsuitable for use fats wastes (02 06 80). Waste cooking oil. In addition, paper and cardboard (15 01 01) - contaminated packaging, paper, cardboard and cardboard (including their cuttings). Besides food products overdue or unsuitable for human consumption (16 03 80) - mainly bread phrases or phrases fewer other bakery products. The way to reduce the amount of waste and its negative impact on the environment is to follow the appropriate technological regime baking. Besides affects the appropriate organization of the selective removal of waste production and transfer them to the economic use or disposal.

There is no information about research on the production of biogas from waste baking industry in laboratory conditions and the impact on the performance of biogas and methane in the literature. Therefore, the objective is to check whether there is a possibility to produce the energy from unused waste.

2. The objective of the paper

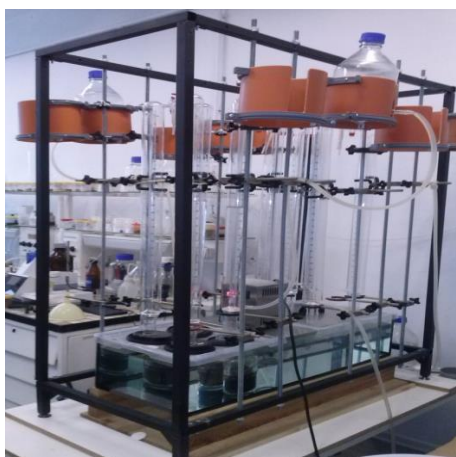
The aim of the study was to analyze the possibilities of using the baking industry waste such as wheat bread, stale wheat bread, donut with jam, as a substrate for biogas production.

The scope of work included the basic physico-chemical studies of the substrate, ie. the dry matter (%), organic dry

matter (DM%), pH. The scope of the research was to investigate the biogas (its volume and chemical composition) and the development of biogas productivity characteristics of the substrates used.

3. Material and research methods

The study used the eudiometric stand located at Analysis Laboratory at the Institute of Chemical Engineering, University of Life Sciences Biostystems in Poznan. Workplace consisted of 10 biodigesters, three of which were used to test bakery waste. The study used three substrates: wheat roll, wheat bread and jam donut. The first stage of the study consisted in the fragmentation of substrates (rolls and bread) which was carried out using manual grater. Donut was pre-shredded first using kitchen knife, and then mechanically blender. The second component of the mixture was pig slurry.



Source: Own work / Źródło: opracowanie własne

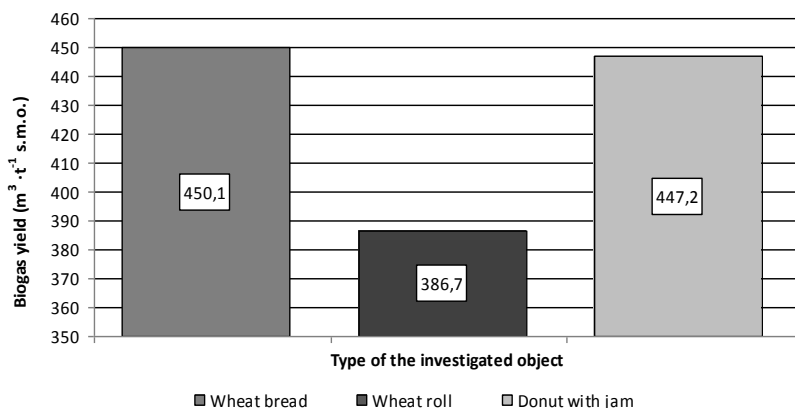
Fig. 1. Test equipment – eudiometers set
Rys. 1. Aparatura badawcza – zestaw eudiometrów

The experiment was conducted in accordance with DIN 38414 S 8 [2]. Biodigesters were placed in water bath, which allowed constant 33°C temperature in chamber, and so was the lower limit of the mesophilic fermentation phase. The water has been heated by an specialist electric heater, and the temperature distribution has been provided by the stirrer. In order to reduce water loss by evaporation tank has been covered with a plastic cover with special

openings through which bioreactors has been put on. The space between the neck of the bioreactor, and the cover was covered with a rubber gasket. Readings of produced biogas were performed with daily frequency. The analysis of greenhouse gas components (CH₄, CO₂, O₂, NH₃, H₂S) was performed by the microprocessor system monitoring the recordings MSMR - 4 Alter Bio Company SA. Before the test, bakery waste biogas yield parameters determined by dry weight (measured by drying PN-75 C-04616/01) [7], pH (measured by electrometric PN-90 C-04540/01) [8], conductivity (BS EN 27888: 1999). The fermentation process was carried out for 43 days. Fermentation of the above-mentioned substrates was conducted on a test stand (Fig. 1) consisting of a set of eudiometers immersed in a water bath (water temperature 33°C).

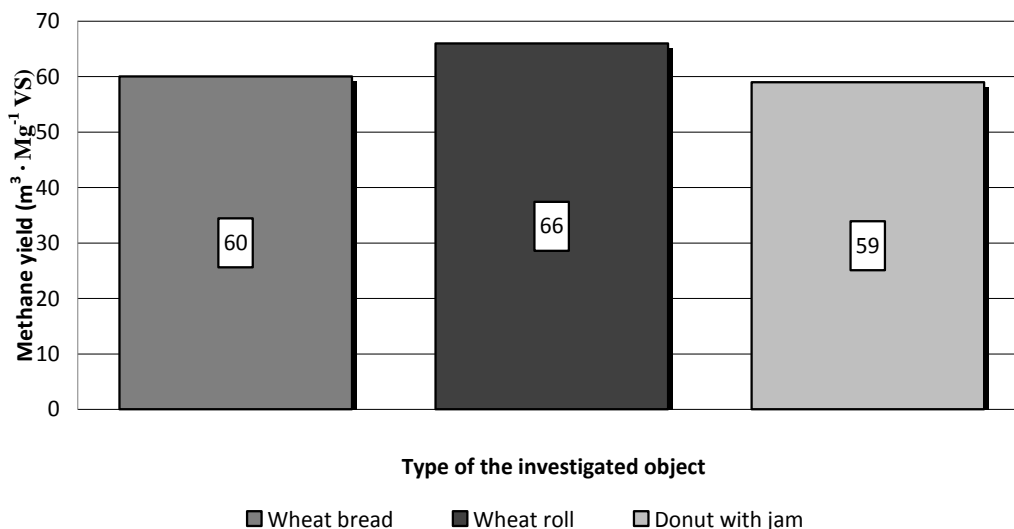
4. Research results and analysis

The test results showed the possibility of using waste of the substrate based on stale bread. It is a good substrate for chemical properties that can be successfully used in processings of methane fermentation. Probe substrates, due to their chemical composition are subject to the complete methane fermentation process for about 22-25 days. After this time a very large decrease of the production of biogas has been observed. The experiment was performed at low temperature to check what is the productivity of substrates at a time when the biogas plant is not able to retain the same high temperature (eg. at the time of failure). Waste from the baking industry has shown good performance of biogas productivity. The fastest process to go for a donut with jam, but the substrate was rapidly burned. This is caused by high carbohydrate content contained in the donut. The process was running slowest when using rolls waste. The reason for this was probably relatively smallest substrate concrete as well as the chemical composition. Stale bread was most effective and most sustainable in biogas production substrate. Waste rolls achieved production levels similar to animal waste (manure bovine) (average 386.7 m³ · t⁻¹ s.m.o.). Bread waste showed cumulative productivity on the level of leaf beet and bio-waste from households (450.1 m³ · t⁻¹ s.m.o.) Waste donut showed similar average productivity 447.2 m³ · t⁻¹ s.m.o. Satisfactory levels of concentration of methane in the produced biogas has been achieved. Biogas production is shown in Fig. 2.



Source: Own work / Źródło: opracowanie własne

Fig. 2. Biogas yield of waste wheat bread, wheat roll, donut with jam
Rys. 2. Wydajność biogazowa odpadów z chleba pszennego, bułki pszennej, pączka z dżemem



Source: Own work / Źródło: opracowanie własne

Fig. 3. Methan yield of waste wheat bread, wheat bread, donut with jam

Rys. 3. Wydajność metanowa z chleba pszennego, bułki pszennej, pączka z dżemem

The average concentration of methane is 59% for the rolls waste, 60% for stale bread and 66% for a donut with jam and is higher than in the silage products (50 to 55%), often used in biogas plants [13]. For about a week carbon dioxide gas was the most produced - over 50%. After this period, the production of methane has dominated, which has stabilized around day 14 and was over 60% for all substrates. However, the total share of methane in the biogas from studied waste bakery was low, since biogas contains from 55 to 80 percent of methane [3, 5]. The yield of methane is shown in Fig. 3.

5. Conclusions

Based on the research results and analysis carried out, the following conclusions have been formulated:

1. Waste from the baking (bread wheat, wheat roll, donut with jam) is a valuable substrate for methanation process.
2. Tested food waste (stale bread) in the chosen field of technological parameters (low temperature and mixing intensity) showed the ability to work independently in the digester.
3. In the course of performed experiments no signs of skin formation that inhibits the process of removing gas bubbles.

6. References

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