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Management of Waste from the Dairy Industry for Energy Purposes †

Paweł Cwalina *, Sławomir Obidziński, Małgorzata Kowczyk-Sadowy, Małgorzata Krasowska and Gabriel Siegień

Department of Agri-Food Engineering and Environmental Management, Bialystok University of Technology, Wiejska 45E Street, 15-351 Bialystok, Poland

* Correspondence: p.cwalina@pb.edu.pl; Tel.: +48-571-434-469

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Abstract: This paper presents research that contributed to the development of guidelines for technology related to the management of dairy industry waste for energy purposes, used as an additive in the process of pelleting with wood sawdust. During the tests, the most advantageous material (composition and moisture of the mixture), process and construction parameters from the point of view of energy consumption of the process, and the quality of the obtained pellets were determined. The obtained results showed that increasing the content of post-flotation dairy sewage sludge in the mixture with sawdust increase its susceptibility to granulation, which reduces the energy consumption of the process and has a positive effect on the kinetic strength and density of the obtained granulate. The obtained values of the heat of combustion and the calorific value prove that the addition of post-flotation dairy sewage sludge only slightly reduces the energy values of the produced pellets.

Keywords: waste; dairy sludge; pellets; granulation

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1. Introduction

In the agriculture and the agri-food industry in Poland, more than 10 million tonnes of waste is generated annually, most of which is subject to management, but the problem of inappropriate waste management is becoming increasingly apparent [1].

The uncontrolled decomposition of waste from agriculture and the agri-food industry (PRS) increases the number of pollutants, including hazardous compounds and substances. For this reason, it becomes necessary to create new, rational processing systems from the agri-food industry and agriculture [2].

One of the ways to manage the waste of plant origin is its processing in pressure agglomeration into granules or briquettes, which is confirmed by numerous scientific works [3–6].

The basic raw material for the production of pellets is sawdust [7]. This is because, before the wood cutting process, the debris is removed by removing the bark and washing the logs. Which makes sawdust an ideal raw material for the production of pellets [8].

In the case of pellets or briquettes, other waste materials are used increasingly frequently, e.g., waste from the fruit and vegetable industry.

According to Wandrasz [9,10], the composition of fuels created in the process of pressure agglomeration may include waste from the processing of oilseeds, walnut husk, and rapeseed pomace.

The aim of this study was to attempt to develop a technology of management for energy purposes of waste from the dairy industry, used as an additive in the process of pelleting with wood sawdust. As part of the work, the most advantageous material (composition and moisture of the mixture), process and construction parameters from the

point of view of energy consumption of the process, and the quality of the obtained pellets were determined.

2. Materials and Methods

The basic raw material used for the research was sawdust from the BSH DBROWSCY SP. J., to which we added post-flotation dairy sewage sludge from the treatment plant operating in the MLEKOVITA plant in Wysokie Mazowieckie.

The research was divided into two stages. In the first stage, the physical and chemical properties of the tested materials were examined, including humidity, sawdust sieve analysis, and sawdust bulk density. In the second stage, the pelleting process of wood sawdust mixtures with the addition of 10, 15, and 20% of floating dairy sewage sludge was carried out, and the properties of the obtained granulate were determined, including kinetic strength, physical and isolated density, as well as its combustion heat and calorific value (Table 1).

Table 1. Methods.

Parameter	Methodology
Granulate bulk density	PN-EN ISO 17828:2016-02
The kinetic strength of the granules	PN-EN ISO 17831-1:2016-02
Physical density	With the use of a caliper and an AS 220/C/2 laboratory balance by RADWAG
Humidity	PN-76/R-64752
Particle size distribution	PN-89/R-64798
Combustion heat/calorific value	KL-12Mn calorimeter

3. Results

Based on the conducted research, it was found that the raw material (sawdust), which was used during the research, was characterized by a humidity of 10.87%, while post-flotation sewage sludge was characterized by a humidity of 83.58%. Such a low moisture content of sawdust prevented them from being pelleted and us to obtain granules of the desired quality. The solution to this problem is to add an additive with high moisture content to the sawdust, which is post-flotation sewage sludge.

The study of the grain size distribution of sawdust allowed us to state that the largest percentage in this raw material was the fraction of 1.00 mm (35.94%). The 2.00 mm fraction (20.96%), the 0.50 mm fraction (16.56%), and the 4.0 mm fraction (9.64%) had a slightly smaller share. The smallest percentage, 0.016%, was the non-screen fraction with a size <0.063 mm.

Table 2 shows the effect of the content of post-flotation dairy sewage sludge in the mixture with sawdust on the course of the granulation process (demand of the granulator for the power recorded in the process of granulation of the mixture) as well as the physical and bulk density and the kinetic strength of the granulate.

Table 2. Influence of the content of post-flotation sewage sludge on the granulation process.

Sediment Content [%]	Power Requirement of the Granulator [kW]	Quality of Pellet		
		Kinetic Strength [%]	Physical Density [kg/m^3]	Bulk Density [kg/m^3]
0	4.19	95.07	1301.05	618.04
10	3.92	98.30	1224.74	545.23
15	3.54	98.95	1216.78	526.48
20	2.87	96.85	1186.70	430.55

On the basis of the conducted research, it was found that the mixtures with the addition of post-flotation dairy sewage sludge were characterized by increased susceptibility to granulation, which reduced the energy consumption of the granulation process of mixtures with its participation from 4.19 kW (compare to the sawdust granulation) to 2.87 kW (with 20% addition of sludge) and had a positive effect on the kinetic strength and density of the obtained granulate. Increasing the content of post-flotation dairy sewage sludge in the mixture with sawdust from 10 to 15% increased the kinetic strength of the granulate from 98.30% to 98.95%. Further increase in the post-flotation additive of dairy sewage sludge from 15 to 20% resulted in a slight decrease in the kinetic strength of the granulate from 98.95 to 96.85%.

Increasing the content of post-flotation dairy sewage sludge in a mixture with sawdust from 10 to 20% caused a decrease in granulate density from the value of 1224.74 kg/m^3 to 1186.70 kg/m^3. Along with the increase in the content of sludge addition, the bulk density of the granules slightly decreased in relation to the granules obtained alone.

The obtained values of the heat of combustion and the calorific value prove that the addition of post-flotation dairy sewage sludge only slightly reduces the energy values of the produced pellets. For example, the addition of 10% of post-flotation dairy sewage sludge to sawdust caused a decrease in the heat of combustion by approx. 0.698 MJ/kg (approx. 3.46%) from the value of 20.199 to 19.500 MJ/kg and a decrease in the calorific value by approx. 0.685 MJ/kg (3.7%) from the value of 18.541 to 17.856 MJ/kg.

4. Summary

On the basis of the conducted tests, the properties of the raw materials used in the tests, i.e., sawdust used in the BSH DBROWSCY SP. J. and post-flotation dairy sewage sludge) and the properties of the obtained granulate were determined (physical density, bulk density, and kinetic strength of the granulate, as well as the heat of combustion and its calorific value). The conducted research on the granulation process allowed us to determine that the mixtures with the addition of post-flotation dairy sewage sludge were characterized by increased susceptibility to granulation, which reduced the energy consumption of the granulation process of mixtures due to its participation and had a positive effect on the kinetic strength and density of the obtained granulate.

A positive aspect of the use of post-flotation dairy sewage sludge is the possibility of managing large amounts of post-production waste, which is often not used and left lying in company yards, which is why the plant is often forced to utilize them. The possibility of managing the post-flotation waste of the dairy industry by using it for the production of pellets is in line with the EU policy on waste management.

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References

1. Daniel, Z.; Juliszewski, T.; Kowalczyk, Z.; Malinowski, M.; Sobol, Z.; Wrona, P. Metoda szczegółowej klasyfikacji odpadów z sektora rolniczego i rolno-spożywczego. *Infrastrukt. Ekol. Teren. Wiej.* **2012**, *2*, 141–152.
2. Arvanitoyannis, I.S.; Kassaveti, A.; Ladas, D. Food waste treatment methodologies. In *Waste Management for the Food Industries*; Arvanitoyannis, I.S., Ed.; Series: Food Science and Technology; Academic Press: Cambridge, MA, USA, 2008; pp. 345–410.
3. Hejft, R. *Ciśnieniowa Aglomeracja Materiałów Roślinnych*; Biblioteka Problemów Eksploatacji; Politechnika Białostocka: Białystok, Poland; Instytut Technologii Eksploatacji: Radom, Poland, 2002; ISBN 8372042519.
4. Skonecki, S.; Laskowski, J. Influence of chamber diameter and moisture content of wheat straw on compaction parameters. *Acta Agroph.* **2012**, *19*, 415–424.
5. Skonecki, S.; Potręć, M. Wpływ wilgotności na ciśnieniowe zagęszczanie biomasy roślinnej. *Zesz. Probl. Postępów Nauk. Rol.* **2010**, *546*, 341–346.
6. Skonecki, S.; Kulig, R.; Łysiak, G. Models of pressure compaction and their application for wheat meal. *Int. Agrophys.* **2014**, *28*, 125–130. [CrossRef]
7. Križan, P.; Matú, M.; Soos, L.; Beniak, J. Behavior of Beech Sawdust during Densification into a Solid Biofuel. *Energies* **2015**, *8*, 6382–6398. [CrossRef]
8. Gilbert, P.; Ryu, C.; Sharifi, V.; Swithenbank, J. Effect of process parameters on pelletisation of herbaceous crops. *Fuel* **2009**, *88*, 1491–1497. [CrossRef]
9. Wandrasz, J.W.; Wandrasz, A. *Formed Fuels*; Seidel-Przywecki Press: Warsaw, Poland, 2006.
10. Wandrasz, J.W. Wykorzystanie palnych substancji organicznych w formowaniu wybranych paliw. *Przegląd Komunal.* **2007**, *192*, 69.