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MECHANICAL PROPERTIES OF PELLET FROM CHICKEN MANURE MIXED WITH CHOPPED RYE STRAW

Summary

The addition of straw to chicken manure can influences on humidity, ammonia emission and concentration of phosphorus of the obtaining mixture. This material can be used as a raw material to production of fertilizer pellet or energetic pellet. Because hardness is the most important feature of granulate, research related to the hardness of pellet made from a mixture of chicken manure and rye straw were done. The share of manure in pellet amounted to from 26 to 80%. An influence was found of increased manure contents on the increase in pellet hardness.
***Key words**: pellet, biomass, chicken manure, mechanical strength*

WŁAŚCIWOŚCI MECHANICZNE PELETU Z POMIOTU KURZEGO ZMIESZANEGO Z SIECZKĄ SŁOMY ŻYTNIEJ

Streszczenie

Dodatek słomy do pomiotu kurzego może wpływać na wilgotność, emisję amoniaku i stężenie fosforu w otrzymanej mieszaninie. Materiał ten może być stosowany jako surowiec do produkcji granulowanego nawozu lub peletu energetycznego. Ponieważ twardość jest najistotniejszą cechą granulatu, przeprowadzono badania dotyczące twardości granulek z mieszaniny kurzego nawozu i słomy żytniej. Udział pomiotu kurzego w pelecie wynosił od 26 do 80%. Stwierdzono wpływ zwiększanej zawartości pomiotu kurzego w mieszaninie na wzrost twardości wykonanego z niej granulatu
***Słowa kluczowe**: pelet, biomasa, pomiot kurzy, wytrzymałość mechaniczna*

1. Introduction

Animal manure including chicken manure constitutes a "natural" by-product of animal production. The composition of manure is dependent on such factors as the weight and age of the bird, the feed used and the quantity of water given to birds. Manure consists mainly of bird droppings, small quantities of feathers and feed leftovers spilled during feeding [13]. The composition and usefulness of poultry droppings depend on the quality and type as well as the quantity of the carbon source used (these may be agricultural crop residues, waste from the food industry processing plants) [9]. Manure constitutes a rich source of the basic mineral ingredients of fertilizers, such as nitrogen, phosphorus and potassium [4]. Table 1 presents the average chemical composition of poultry droppings.

Poultry manure can be used to directly fertilize plants, or it can be used in the form of compost or slurry. Composts made from chicken manure can be used as a fertilizer and as a factor that improves the physical and biological properties of soil in the production of a substrate for the cultivation of mushrooms or as a feed for ruminants [1]. Furthermore, it can be added to raw materials in the production of bio-gas. As manures include relatively high phosphorus contents which, as a result of soil erosion and leaching to surface waters, may also have a negative environmental impact, the quantity of compost used as a fertilizer is limited. A high concentration of farms over a limited area frequently causes an additional problem. As a result, the use of manures as fertilizers in local cultivation may appear to be impossible without a deterioration of the condition of underground and surface waters. However, the negative environmental impact of manure is smaller than in the case of using traditional mineral fertilizers. Part-drying is the most favourable method of manure use.

Several fundamental problems connected with the noxious environmental impact of droppings of this type are eliminated in this manner. Drying of the fertilizer has an influence above all on a reduction in the emissions of harmful ammonia additives through an inhibition of the occurring chemical reactions [12].

Table 1. Share of nutrients [kg/t] and dry substance percentage contents in various types of poultry droppings [7, 14]
Tab. 1. Udział składników odżywczych [kg/t] a także zawartość procentowa suchej masy w różnych rodzajach odchodów drobiowych [7, 14]

Type of droppings	Humidity [%]	N [kg/t]	P [kg/t]	K [kg/t]
Fresh manure	75	13.1	4.5	3.6
Stored manure	63.9	10.9	5,9	7.2
Slurry	92	10	5.4	3.2

Granulation of poultry manure is one of the forms of its preparation. The specific weight of granulates from natural fertilizers, which is considerably smaller than in the case of their natural forms (ca. 10 times), is their advantage. It permits more convenient ways of storage, transport and distribution. Granulation of organic fertilizers enables their precise dosing in the field through the use of spreaders for mineral fertilizers for this purpose instead of dung spreaders. Furthermore, fertilizing granules can also be used as a source of energy in heating boilers [6]. The physical properties of pellet from chicken manure depend chiefly on its humidity [5].

Straw is a valuable source of organic substance that soil humus is produced from. When used as a fertilizer, it is also a source of the following minerals supplied to soil: nitrogen, phosphorus, potassium, magnesium, calcium and micro-elements. It may play an important role in the regulation of the C:N ratio in soil [10].

The pellet form is one of the methods of straw preparation and storage. Granulated straw reduces its volume, and hence it is easier for transport and storage [11]. Mobile or semi-mobile pelleting machines or stationary lines for pelleting can be used for this purpose [15]. In this form, it is used as a feed and litter for animals, and it can also constitute energy material. Granulate from straw, similarly as non-granulated straw, can be also spilled in the field as an organic fertilizer. By granulating straw with chicken manure, a valuable organic fertilizer can be produced.

2. Objective and scope of the research

The addition of straw to chicken manure reduces the relative humidity of the mixture comparing to the pure fertilizer. Can also reduce ammonia emission and dilute the concentration of phosphorus in the obtaining mixture. It is not known, how degree of reduction of chicken manure content in relation to the straw quantity will affect on the hardness of pellet made from this mixture.

The objective of the research was to assess the hardness of pellet produced by mixing chicken manure with chopped straw. The laboratory tests were aimed at a determination of the influence of chicken manure content in the mixture with chopped straw on the strength of pellet made from this raw material.

3. Research methodology

The raw materials used for the production of pellet were obtained from an organic farm (rye straw and chicken manure). Straw was ground with a hammer crusher H 111 with sieves with 3 mm holes. The humidity of straw and chicken manure was determined with a dry oven test by drying the samples in the temperature of 105°C in compliance with the PN-EN ISO 18134-1:2015-11 Standard [8]. The humidity of the raw material obtained after grinding was 45.0% (chicken manure) and 9.0% (chopped rye straw). Four mixtures of chopped straw with chicken manure were used in the research. The percentage composition and the calculated relative humidity of the mixtures are presented in Table 2. The material prepared was subject to the compaction process in a ZPL rotary pellet machine (Fig. 1).

Table 2. Characterization of the mixture (chicken manure and chopped straw) used in the production of pellet
Tab. 2. Charakterystyka mieszaniny (pomiotu kurzego i sieczki słomy) użytych do produkcji peletu

Sample no.	Composition of raw material [%]		Relative humidity [%]
	Poultry droppings	Chopped rye straw	
I	26.7	73.3	15.1
II	40.0	60.0	13.6
III	67.0	33.0	33.0
IV	80.0	20.0	45.4

Source: own work / Źródło: opracowanie własne

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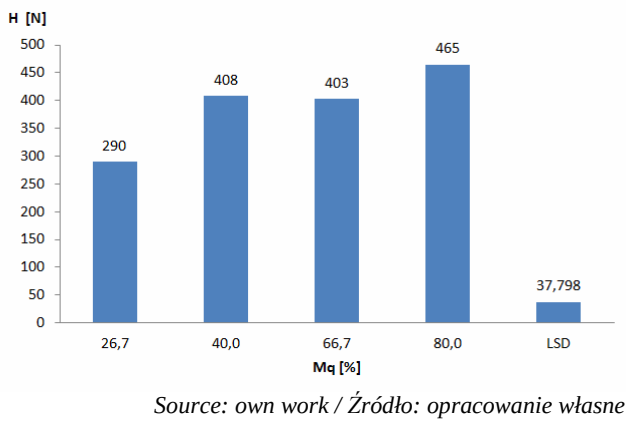
Fig. 1. ZPL rotary pellet machine
Rys. 1. Peleciarka talerzowa ZPL

A disc matrix with a 6 mm diameter holes was used to produce pellet. The strength of the granulate was assessed by measuring its compression resistance. The compression resistance of the pellet was determined by establishing the compression force which is required to crush it. The Kahl hardness tester was used for this purpose [2, 3]. The value of the compression force was determined for pellet dried to humidity equal to zero.

The assessment of the hardness of the granulates obtained was performed on pellet that had been dried with its relative humidity being equal to zero. For this purpose, an electric laboratory dryer with natural air circulation with temperature adjustment within the accuracy of 1°C was used. Drying the samples took place similarly as with the determination of the relative humidity of the raw material: in the temperature of 105°C. Drying was performed in the period of 9 hours while checking for any changes in the weight of the material every three hours. For each of the four groups of granulate, shear stress measurements with the use of the Kahl hardness tester were repeated 45 times.

4. Results

The average results of the mechanical strength of the groups of examined pellets are presented in Fig. 2.



Source: own work / Źródło: opracowanie własne

Fig. 2. Influence of the share of chicken manure on the hardness of produced pellet, H – pellet hardness, Mq – percentage share of chicken manure
Rys. 2. Wpływ udziału pomiotu kurzego na twardość wytworzonego peletu, H – twardość peletu, Mq – procentowy udział pomiotu kurzego

The analysis carried out of variance demonstrated the significance of the influence of chicken manure and straw contents in the samples of pellet on the hardness of the granulate (on significance level $p < 0,05$). The calculated smallest essential difference in the hardness of the groups of granulate NIR = 37,798 (the least significant difference – LSD).

A significance of differences for hardness values between granulates with manure contents: 26,7, 40 and 80% was found, while no significance was found of changes in hardness for granulate samples with the contents of 40 and 66,7%.

5. Conclusions

By analyzing the results of the experiment for the mixtures used in pelletisation with different percentage compositions of chicken manure and straw, it can be found that the hardness of granulate significantly increases together with greater contents of chicken manure and smaller contents of straw. A strong increase of hardness occurred at content of chicken manure between 26,7 and 40 and between 66,7 and 80%.

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