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HORSE MANURE GRANULES IN THE ASPECT OF USE AS FERTILIZER IN SMALL ECOLOGICAL FARMS

Summary

The paper presents tests on the pressure agglomeration process of horse manure with the addition of chopped barley straw in order to produce fertilizer granules for fertilizing small crops as part of home grown organic vegetable growing. The granulation process was carried out on a laboratory pelletizer. The experiment was carried out with the dry matter content of chopped barley straw in relation to the total dry mass of the mixture containing a straw and a horse manure, amounting to 0; 16,6; 32,7%. Middle relative humidity of the raw material was 15,2; 23,6; 30,4%. The influence of addition of a chopped barley straw and substrate relative humidity on the selected properties of the obtained granulate was determined.
***Key words**: ecological farm, granulate, horse manure, chopped barley straw*

GRANULAT Z OBORNIKA KOŃSKIEGO W ASPEKCIE WYKORZYSTANIA GO JAKO NAWOZU W MAŁYCH GOSPODARSTWACH EKOLOGICZNYCH

Streszczenie

Opisano badania procesu aglomeracji ciśnieniowej obornika końskiego z dodatkiem sieczki słomy jęczmiennej w celu wytworzenia granulatu nawozowego do nawożenia małych upraw w ramach przydomowej ekologicznej uprawy warzyw. Proces granulacji przeprowadzono w granulatorze laboratoryjnym. Doświadczenie wykonano przy zawartości suchej masy sieczki słomy jęczmiennej w stosunku do całkowitej suchej masy mieszaniny zawierającej słomę i koński nawóz, wynoszącej 0; 16,6; 32,7%. Średnia wilgotność względna surowca wynosiła: 15,2; 23,6; 30,4%. Określono wpływ dodatku zawartości sieczki słomy jęczmiennej i wilgotności względnej substratu na wybrane właściwości otrzymanego granulatu.
***Słowa kluczowe**: rolnictwo ekologiczne, granulat, koński nawóz, sieczka słomy jęczmiennej*

1. Introduction

About 5 million horses live in stables in Europe. The animals produce a large amount of waste, which usually contains about 60% of solids and 40% of liquids. The waste from the stable consists of a mixture of faeces, urine and bedding material. It is estimated that approximately 20 m^3 of bedding material is used per horse [9, 10]. Horse owners have problems with the management of horse manure, especially since horses are usually kept for recreational purposes [7]. A part of the horse manure is intended for the production of biogas, a part - for the production of champignon-growing base, and a part - for landfill or incineration. It is estimated that currently the largest amount of horse manure is used as a fertilizer in agriculture and horticulture, [4]. The greatest possible amount of management of horse manure as a natural fertilizer should be sought in organic farms. In order to be able to use horse manure as a fertilizer, it is important to manage it properly, including the choice of bedding material, as well as its storage and further processing [5].

The conversion of horse manure to a more useful form, for example a pellet, would make it possible to use it in a wider scope as a fertilizer, especially where a large amount of the manure is not consumed. It could be used as an ecological fertilizer on small farms, in backyard vegetable gardens and on lawns. The possibility of selling horse manure in the form of granules instead of throwing it on the trash would improve also the economy of raising the horses.

The pellets form of horse manure also enables to be used as an energy source for combustion in heating boilers. For many stables, the energy content of the annual volume of waste produced from the stable would easily cover the need for heating the stables and the demand for hot water for over a year. Owners of horse studs are interested in burning litter with horse manure for energy production, despite the fact that horse manure has an extremely low energy value, problems with the emission of harmful emissions during combustion and therefore it requires the use of appropriate boilers and methods for its combustion [1-3, 6-8].

Granulate made of biomass, regardless of the purpose for which it was created (nutritional, fertilizing, energy), must have appropriate physical properties, ensuring its durability. During transport and storage, it is exposed to stresses causing cracking and abrasion. If the granulate is made from horse manure, which can contain both straw and horse manure, it is required not only a forming the material in the form of granules but to do it so in order to provide the granulate with adequate strength.

2. The aim of the research

The aim of the research was to determine the effect of straw content in the substrate for the production of granules, including horse manure and straw and the moisture of the substrate, on the physical properties of the granulate such as: hardness, resistance to gravity dropping and specific density.

3. Material and research methods

The research material was composed of a mixture of chopped barley straw and horse manure. The barley straw has been shredded into chaff by means of the H111 univer-

sal shredder. Horse manure was subjected to the process of drying in the open air for about 7 days. From horse manure and chopped barley straw, 9 mixtures were formed containing respectively: 0; 25; 50% of the chopped barley straw in relation to the mass of the fertilizer. 200 g of horse manure was used in each trial. 40, 60, 90 ml of water were added to the resulting mixtures. Prepared samples were sealed in hermetic plastic bags and stored for 72 hours to let the liquid enter into the structure of the ingredients.

Laboratory granulator, equipped with a flat die with a hole diameter of 6 mm, was used to thicken the mixture of straw and horse manure (granulation).

The relative humidity of the tested samples was determined in accordance with the standard PN-EN ISO 18134-1:2015-11 and calculated according to the formula (1):

$$M_{ad} = \frac{(m_2 - m_3)}{m_2 - m_1} \cdot 100\% \quad (1)$$

where:
M_{ad} – relative humidity [%],
m_1 – mass of an empty dish [g],
m_2 – mass of a dish with the sample before drying [g],
m_3 – mass of a dish with the sample after drying [g].

Determinations of relative humidity for the mixed horse manure group with the addition of chopped barley straw were made by a gravimetric method in accordance with the standard PN-ISO 6540. The research involved the use of an electric laboratory dryer Alpina with natural air circulation. The samples were dried at 105°C. The value of relative humidity was 4,4% for barley straw, and 6,9% for horse manure. Recalculated, after determining the relative humidity of the substrate components, the dry matter content of straw and fertilizer in the total dry mass of the substrate for the production of granules and the resulting moisture content of the material prepared for implementation is shown in Table 1. Since it was considered that the individual humidity of the individual samples for the same amount of water added in value are close to each other, the average relative humidity was determined for each substrate of additional water.

Determination of the specific density of granules resulting from horse manure with chopped barley straw was made on the basis of the standard (PN-EN ISO 188472016-11), measuring with a caliper the height and diameter of 10 pellets with the accuracy of ± 0,02 mm and determining their mass by laboratory weight with accuracy of ± 0,001 g. The specific gravity of the agglomerate was calculated as the ratio of the mass of pellets to the sum of their volumes. The pellets volume was measured based on formula (2):

$$V_p = \frac{D_{em}{}^2 \cdot \Pi \cdot L}{4}, \quad (2)$$

where:
V_p – volume of pellets [cm^3],
L - length [cm],
D_{em} - average diameter value for 10 measurements [cm].

A density was determined based on the formula (3):

$$\rho = \frac{m}{V_p}, \quad (3)$$

where:
ρ – density of pellets [$g \cdot m^{-3}$],
m – mass of a sample [g],
V_p – volume of pellets [cm^3].

4. Research results

The pellets after drying in a granulator were dried in a laboratory dryer in order to achieve a complete loss of moisture.

The measurement of pellet hardness was made using a Kahl durometer. Measurements were made in 30 replications from one sample. The results obtained from the measurement of granular hardness using the Kahl method were analyzed by variance analysis to determine the significance of the effect of substrate composition and substrate relative humidity on hardness of pellets. The analysis of variance showed the significance of the effect of chopped barley straw content in pellet tests on granulate hardness (at the significance level of $p < 0,05$).

Table 1. Indicators of a mixture of horse manure with chopped barley straw
Tab. 1. Wskaźniki mieszaniny nawozu końskiego z sieczką słomy jęczmiennej

Item	Content				Additional water	Moisture content	Average moisture content
	Horse manure	Barley straw	Manure (d.m.)	Straw (d.m.)			
	g	g	%	%	ml	%	%
1.	200	0	100,0	0,0	30	16,8	15,2
2.	200	50	80,4	19,6	30	15,1	
3.	200	100	67,3	32,7	30	13,8	
4.	200	0	100,0	0,0	60	26,4	23,6
5.	200	50	80,4	19,6	60	23,3	
6.	200	100	67,3	32,7	60	21,0	
7.	200	0	100,0	0,0	90	34,0	30,4
8.	200	50	80,4	19,6	90	30,0	
9.	200	100	67,3	32,7	90	27,1	

Source: own work / Źródło: opracowanie własne

Fig. 1 presents the results of the hardness of the tested pellet samples depending on the content of the chopped barley straw.

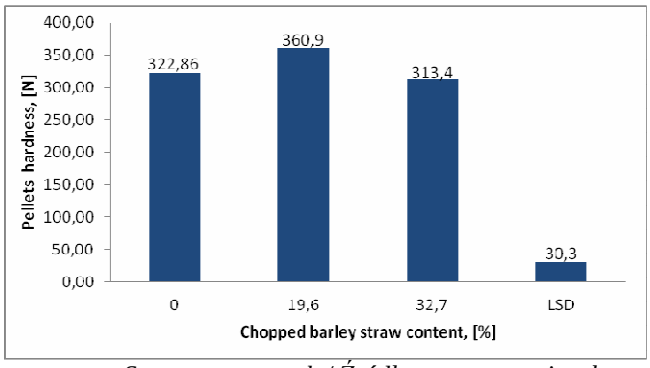

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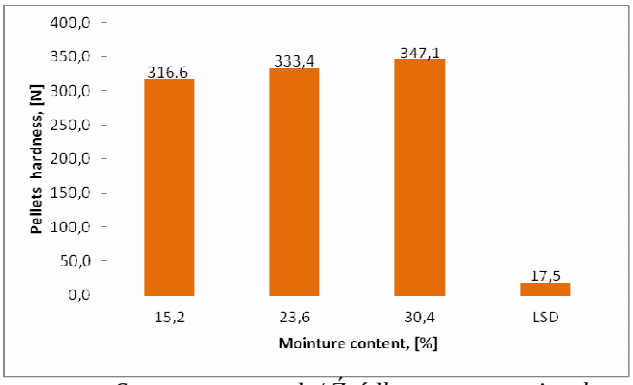
Fig. 1. Influence of dry matter content of chopped barley straw in relation to the total weight of dry matter of the substrate from horse manure on the hardness of produced LSD (Lower Significant Difference) pellet = 30,3 N

Rys. 1. Wpływ zawartości suchej masy sieczki słomy jęczmiennej w stosunku do całej wagi suchej masy substratu z nawozu końskiego na twardość wytworzonego peletu LSD (Lower Significant Difference) = 30,3 N

On the basis of the obtained results, a significant influence of the addition of barley straw in a mixture with horse manure fertilizer on the hardness of the granulate made from the mixture was found. The addition of 19,6% barley straw to the substrate of horse manure caused a significant increase in the hardness of the obtained granulate, while a larger addition of 32,7% in the total mass caused a significant decrease in the hardness of the obtained granulate.

The test results of the effect of substrate relative humidity on the hardness of pellets are presented in the graph, in Fig. 2.



Source: own work / Źródło: opracowanie własne

Fig. 2. Effect of relative humidity of a mixture of horse manure with the addition of chopped barley straw on the hardness of the produced pellet

Rys. 2. Wpływ wilgotności względnej mieszaniny nawozu końskiego z dodatkiem sieczki słomy jęczmiennej na twardość wytworzonego peletu

The increase in substrate moisture caused the increase in hardness of the obtained granulate. The analysis of variance performed showed the significance of the influence of water content in pellets samples on granulate hardness (at the significance level of p <0,05). Since the calculated minimum significant difference in the hardness of the LSD pellet groups was 17,5, a significant difference between the hardnesses occurred only between a relative humidity of 15,2% and a relative humidity of 30,3%.

Total impact of chopped barley straw content and material moisture on granulate hardness. could be observed in Fig. 3.

Changes in the value of the pellets resistance coefficient to gravity dropping Wz depending on the content of barley straw in the substrate are shown in Fig. 4. The pellets resistance coefficient to gravity dropping decreases with the content of chopped barley straw. The results show that in all cases the value of the pellets resistance coefficient to gravity dropping is over 90%. The highest value of the coefficient was obtained in the absence of the addition of chopped barley straw.

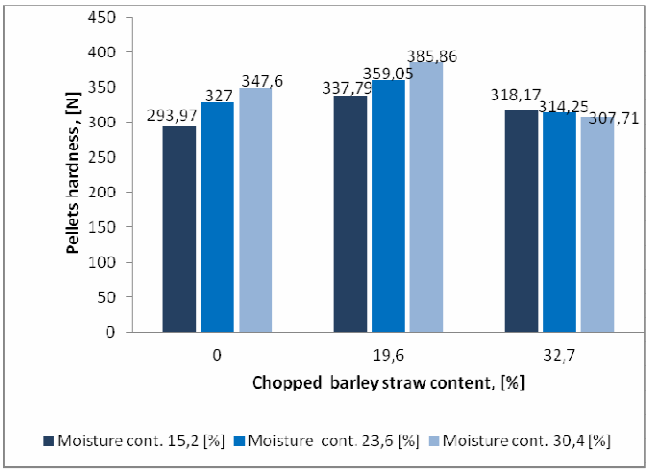


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Fig. 3. Influence of dry matter content of the chopped barley straw in relation to the total mass of dry matter of substrate from horse manure and moisture of the substrate on average hardness of produced pellets

Rys. 3. Wpływ zawartości suchej masy sieczki słomy jęczmiennej w stosunku do całej wagi suchej masy substratu z nawozu końskiego i wilgotności tego substratu na średnie twardości wytworzonego peletu

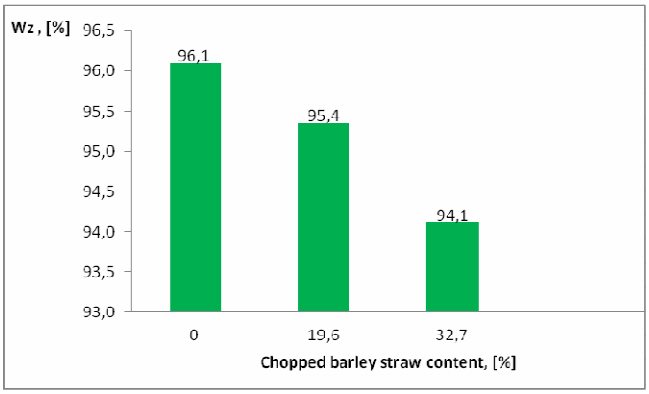

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Fig. 4. Value of the resistance coefficient to gravity dropping Wz, depending on the dry matter content of chopped barley straw in relation to the total mass of dry matter substrate from horse manure

Rys. 4. Wartość współczynnika odporności na zrzut grawitacyjny Wz w zależności od zawartości suchej masy sieczki słomy jęczmiennej w stosunku do całej wagi suchej masy substratu z nawozu końskiego

Together with the addition of chopped barley straw, the value of the coefficient decreases to the level of 94,1%, which occurs at 32,7% of the content of chopped barley straw in the total dry mass of pellets from horse manure. With increasing the humidity in the mixture, the specific density of the pellet decreases (Fig. 5). Increasing the moisture of the mixture of horse manure with the chopped barley straw 15,2 to 30,4% before the pelleting process reduces the density of the granulate.

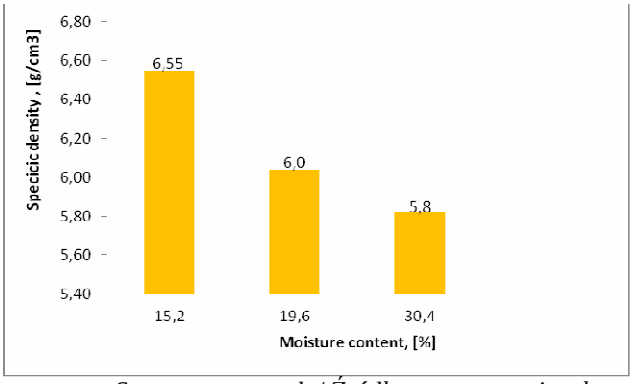

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Fig. 5. The value of the specific density of the pellets from the substrate of horse manure mixed with the chopped barley straw depending on the relative humidity of the substrate
Rys. 5. Wartość gęstości właściwej peletu z substratu nawozu końskiego zmieszanego z sieczką słomy jęczmiennej w zależności od wilgotności względnej substratu

5. Summary and conclusions

On the basis of the obtained test results it could be concluded that the use of the chopped barley straw for the horse manure and the relative humidity of the resulting mixture can affect the physical parameters of the granulate made from the mixture.

A significant effect of the content of the chopped barley straw on the hardness of the produced granulate from horse manure mixed with the chopped barley straw was found. The hardness of the granulate increased with the increased content of the chopped barley straw for horse manure up to 19,6% of its content in the total mass of dry granulate but the content of 32,7% of the chopped barley straw in the total mass of dry granulate affected the hardness of obtained pellets. Therefore, there is an optimal content of the chopped barley straw in a mixture with horse manure, where the granulate made from this mixture can achieve maximum hardness.

It was found that in the studied relative humidity scope of the raw material containing horse manure and barley straw, the hardness of the pellets made from the mixture significantly increased with increasing humidity.

The value of the pellets resistance coefficient to gravity dropping decreased with the addition of the chopped barley straw to the substrate.

The research also shows that the specific density of a pellet made of a mixture of horse manure and the chopped barley straw depends on the relative humidity of the mixture. As the humidity increases, the specific density of the granulate decreases.

6. References

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