MANUFACTURING AND APPLICATION STUDIES OF SCOTS PINE BARK PELLETS

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Abstract
This paper describes the use of Scots pine (*Pinus sylvestris* L) bark humus and fine fractions for animal litter pellet manufacture, and the efficacy of various additives in improving absorbency. In Latvia is no researge about litter pellet manufacture of pine bark, and possibilities of increasing water absorbency; in internationals research papers there is also no information about the possibilities of improving water absorbency of pine bark pellets with various additives. The additives tested were fresh and fallen leaves, tree needles, dried hogweed and sawdust. Pellets were manufactured with a ZLSP200B granulator at Adazi city, Latvia, in 2014. The results indicated that production of small diameter pine bark pellets could be problematic. Absorbency of the pellets was tested both by rinsing and soaking the pellets, and results were compared to woodchip particle litter pellets. It was found that the best absorbency was achieved with adding up to 30% sawdust, which increased pellet absorbency both by rinsing and soaking. The results indicate that it is possible to manufacture pellets using Scots pine (*Pinus sylvestris* L.) bark humus and fine fraction with good absorbency which can be disposed of in sewerage systems.
Key words: bark pellets, animal litter, absorbency, renewable resources.

Introduction

The study aims to establish a practical use of litter pellets from pine bark fine fraction and humus. There are no pellet quality indicators or guidelines in the regulatory framework for pellets used as animal litter. In Latvia there are no studies about bark pellets, and no research about obtaining bark pellets for litter. There are only general animal welfare requirements - pellets must produce dust, they have to be absorbent, cannot be toxic, or contain compounds harmful to the environment, animals or humans. Used pellets must be easily disposed of. In practice, naturally dry or dried plant biomass - straw, leaves, peat etc. is used for pellet production. To prevent dust, raw plant material can be used.

It is possible to purchase the animal litter sawdust pellets with grass and soft deciduous tree leaf additives, in pet store chains. To investigate the possibilities of to using pine bark pellets as litter, we conducted an experiment on the possibilities of using pine bark for pellet production, manufactured pellet water absorbency, and determined the chemical composition of pine bark. The possibilities of using bark humus and fine fractions as additives to various plant raw materials (tree leaves, needles) was examined. Pine bark is environmentally toxic (Anas et al., 1987), as shown by long-term use of pine bark for mulching. Analysis of the utilised pine bark indicates that it does not contain hazardous substances in dangerous concentrations. Mainly pine bark conteins cellulose, heksozanes and lignin (more than 80%), and it also contains pentazones, pentazones, suberines, sterols, sugars and acids (Громова et al., 1977; 1978) that could not cause harm to animal and human health (Васильева, 1990). Chemical compounds in pine bark are not volatile, and are not released at a temperature of 105 °C; solubility of bark compounds in water, acetone or ethanol is not higher than 8%, solubility in alkaline aqueous solution – not higher than 45% (Корбукова, 1995). Solubility of individual compounds in animal urine has not been investigated in the scientific literature. In addition, in Latvia wood biomass is not contaminated with pesticides and heavy metals, because it is not allowed to use chemical products and fertilizers in forest areas.

Materials and Methods

For pellet production, pine bark mulch fractions and pine bark humus were utilized, which are not suitable for commercial mulch product because of their high flow ability. Pellet size fractionation was performed using a calibrated sieve set (3.15, 20.00, 1.00 and 0.500mm). Moisture content was determined using a Precisia XM 120 moisture analyzer. Ash content of the raw materials was calculated by determining the mass of dry sample, incineration at 500 °C, and then determination of residual ash mass (Table 1)

Studies were conducted in Latvia, Adazi and Salaspils cities in 2014. Pellets were manufactured using a ZLSP200B granulator with an interchangeable matrix. Hole diameters of 8, 6 and 4 mm were used (Ruiz Celma et al., 2012). Water was added during the pellet formation to ensure solid pellet creation (Relova et al., 2009). For determination of moisture content, pellets were placed into closed polyethylene bags prior to cooling, to ensure that the existing moisture content was not altered. Cooled pellets were packed into ventilated bags for further analyses. In order to improve the pellet properties, raw bark materials were added in various proportions (Tore et al., 2011), as well as other plant material additives, which were crushed in an M2 extruder type crusher.

Table 1

Scots pine (*Pinus sylvestris* L) bark humus and fine fraction structure with and without additives

Sample	Moisture, g kg^{-1}	Ash content, g kg^{-1}	Granulometry composition, mm				
			>3.15	3.15-2.00	2.00-1.00	1.00-0.500	<0.500
Bark	206	23	25.4	34.6	24.4	10.9	4.7
Humus	349	339	7.9	25.4	38.2	23.3	5.2
Bark and humus (ratio 1:1)	241	183	14.3	35.2	36.7	9.4	4.3
Bark with sawdust additive (10%)	202	21	38.7	30.1	20.2	6.2	4.9
Bark and humus with sawdust additive (10%)	246	180	20.8	33.9	32.5	10.0	2.8

The absorbency of the manufactured pellets was determined within 24 hours, taking a pre-determined mass of pellets and soaking them in water at a room temperature. After 24 hours, pellets were placed in a sieve, allowing excess water to drain, and reweighed. The increase in mass was the amount of water absorbed by the pellets in 24 hours.

The absorbency of the pellets was also determined by rinsing. Approximately 10 g of pellets were placed in a single layer on a sieve rinsed with 10mL water for approximately 15 s. Excess water was allowed to drain and pellets were reweighed. The increase in mass was the amount of water absorbed by the pellets during rinsing.

The feasibility of disposal of the pellets in sewerage systems was determined by placing water saturated pellets in a tube which conformed with the Construction Standard LBN 221-91. A known mass of saturated pellets was flushed with 5L of water. Pellets were collected at the other end of the tube and weighed. A large mass difference indicated sediment formation

Results and Discussion

The pine bark fine fraction and humus size fractionation was performed 5 times, and the sample average was calculated. Bark fine fraction and humus granulometric structure, moisture and ash content is shown in Table 1.

Various raw material mixtures were prepared in the laboratory using pine bark fine fraction and humus with addition of sawdust, pine needles, fallen leaves, fresh leaves and dried hogweed (*Heracleum Sosnowsky*) (Table 2). The mixtures were dried at the room temperature to 15% moisture content, which is approximately the moisture levels utilised in the pellet manufacturing.

Granulation is done using four, six and eight millimeter diameters. The six millimeter pellets were used for further analyses, as these were the most

Table 2

Additives and properties of bark pellets

Base	Additive	Additive content, g g^{-1}	Absorption by rinsing, mL g^{-1}	Absorbtion (24 hours), mL g^{-1}
Bark	-	0	0	0.326
Bark	leaves	0.05	0.030	0.646
Bark	needles	0.05	0.038	0.517
Bark	withered leaves	0.05	0.028	0.446
Bark	sawdust	0.05	0.029	0.555
Bark	sawdust	0.10	0.039	0.625
Bark	hogweed	0.05	0.029	0.502
Bark	humus	0.50	0.039	0.499
Humus	-	-	0.039	0.500
Bark and humus	sawdust	0.10	0.038	1.112
Bark and humus	sawdust	0.17	0.039	1.732
Bark and humus	sawdust	0.23	0.048	1.825
Bark and humus	sawdust	0.33	0.078	1.837
Bark and humus	sawdust	0.29	0.087	1.849
Bark and humus	sawdust	0.50	0.094	1.932
Commercial litter pellets	-	0	0.162	4.213

suitable for both pellet production and use. 8mm diameter pellet production was equally efficient as for 6mm pellets, but 4mm diameter pellet granulation was highly problematic, as the raw material obstructed matrix openings and the granulation process was halted after a few minutes. As a result, the production of 4mm pellets from the pine bark fine fraction and humus was not technically possible. The raw materials were hydrated according to thr requirement, to promote a better pellet formation. The manufactured pellet optimum moisture content ranged from 15% to 20% of dry mass. Pellets with lower moisture content were looser in form, but pellets with a higher moisture content often disintegrated during drying and cooling.

Water absorbency of pellets was determined by rinsing and soaking them for 24 hours (Table 2). As a comparison, commercial woodchip litter pellets also were tested

Increasing amounts of additives enhance pellet absorbency, with sawdust giving the largest increase of absorbency. The water absorbency of pine bark fine fraction and humus additives was similar, and as the proportion of these two additives in the raw materials obtained was similar, they could be used as additives in the pellet production in equal proportions. Pine bark humus contains a high amount of minerals (high ash content), which indicates the presence of soil and sand particulate matter, so it is not recommended to use only humus as an additive for pellet manufacture, as this would increase wear and tear on granulator mechanisms. To increase the pellet absorbency, we recommend addition of bark mixture (humus and fine fraction) in combination with sawdust, up to a proportion of 0.1 to 0.3 g g^{-1}. Increasing the amount of additives, only slightly improves pellet absorbency, and in addition, a high proportion of additives might reduce pellet mechanical strength, which can be significant during pellet drying and transportation (Monedero et al., 2015).

Flushing of water saturated pellets through a tube indicated that no particles were retained in the tube. Weight measurement results confirmed that pellets and their particles did not accumulate in the tube. During the experiment, 300 to 600 g of saturated pellets were inserted into the tube and rinsed with 5 L of water. Saturated pellets were utilized to exclude the effect of dry pellets, as only saturated pellets could be flushed into municipal sewer systems. The decrease in pellet mass during the flushing experiment did not exceed 10 g of the original mass and it can be assumed that the mass loss resulted because of small particles being rinsed through the sieve or water splashing from the surface of the sieve. Visual examination of the tube confirmed that there were no deposits, and we assume that pellets would be fully flushed through properly assembled sewer pipes.

Conclusions

1. Formation of pellets manufactured using pine bark additives can be problematic, but by utilizing raw materials with a moisture content of 15 - 20%, as well as additionally moistening them during the granulation process, it is possible to obtain mechanically strong pellets with a strong surface.
2. The water absorbency of the pellets manufactured in this study was lower than that of commercial litter pellets. An increase in water absorbency can be achieved by adding sawdust to the raw material mix. Addition of up to 30% sawdust improves the absorbency of pellets manufactured using pine bark fine fraction and humus and other fresh and dried plant material as additives.
3. Pellets manufactured with pine bark additives can be flushed in properly constructed sewerage systems without blocking or forming deposits in sewer pipes.

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