Lena Vasylenko, Berlin, Kirsten Loewe and Jens Wegener, Göttingen

Applicability of Agricultural By-products from the Mushroom Industry for Fuelling

Industrial production of mushrooms on artificial culture mediums is very energy-intensive. Energy is used for room climate control, where mushrooms are cultured, for cooling harvested mushrooms and for sterilizing the rooms at the end of a culture period [1]. Due to high energy prices for conventional energy production, utilizing by-products from mushroom cultivation for energetic purposes speaks for itself.

Lena Vasylenko, Landwirtschaftlich-Gärtnerische Fakultät, Institut für Gartenbauwissenschaften, Humboldt Universität zu Berlin, Lentzeallee 75, 14195 Berlin.
Kirsten Loewe, Fakultät Ressourcenmanagement, Fachgebiet Nachhaltige Energie- und Umwelttechnik NEUTec, HAWK Hochschule für angewandte Wissenschaft und Kunst Hildesheim, Holzminden, Göttingen, Rudolf-Diesel-Str. 12, 37075 Göttingen.
Dr. Jens Wegener, Department für Nutzpflanzenwissenschaften – Abteilung Agrartechnik, Georg-August Universität Göttingen, Gutenbergstraße 37, 37075 Göttingen; e-mail: *jwegene1@gwdg.de*

Keywords

Mushrooms substrates, pellets, combustion, industrial mushroom production

Based on the substrate used, artificial culture mediums for mushroom production can be divided into three groups:

- Compost based substrates (e.g. for white mushrooms *Agaricus bisporus*)
- Straw based substrates (e.g. for oyster mushrooms *Pleurotus ostreatus*)
- Sawdust based substrates (e.g. for Shii-take mushrooms *Lentinula edodes*)

Residues of mushroom industry are presently used as fertilizer, mainly because of their high content of organic material and of nitrogen compounds [2, 3]. In the following, the application of used sawdust based substrates as basis for a renewable fuel is analyzed. Particularly the heating value, physical structure and chemical composition make these substrates apparently for pelleting and fuel combustion [4].

Material und Methods

For analyzing the characteristics, a sawdust based culture medium from the production of Shii-take mushrooms was selected. The substrate is composed of 79% sawdust, 20% corn grist and 1% calcium chloride ($CaCl_2$). The dry matter content of the substrate is about 40% [5]. The material is formed into round blocks with a size of 23 cm and a diameter of 15 cm (*Fig. 1*). The weight of these blocks is about 2 kg. As a general rule, the maturing period of mushrooms is between 120 and 150 days. In contrast, the age of analyzed blocks is between 60 and 240 days, since the production of blocks is continuously throughout the year, whereas the production of mushrooms varies with the seasons. For this reason, the substrate blocks can be older than the maturing period.

For determining the physical characteristics of sawdust substrates a categorization of size was made by sieving the material. The following screens were used: 4.0 mm; 1.0 mm; 0.63 mm; 0.20 mm; 0.063 mm. For pre-

Table 1: Results from screening a used mushroom substrate on basis of sawdust

Sieve diameter [mm]	substrates mass [g]	contingent [%]
4.0	0.00	0.00
1.0	35.14	62.91
0.63	10.59	18.96
0.2	8.61	15.41
0.063	1.02	1.83
dust	0.5	0.90
Sum	55.86	100.00

Fig. 1: With Shii-take mushrooms interspersed substrates blocks on the basis of saw dust

paration of screening, the substrate was dehumidified over night at 105 °C, so that at the time of screening the dry matter content was about 100%. Screening was made in quantities of 56.0 g for 20 minutes per sample.

For determining the calorific value of the sawdust substrate, the dehumidified samples were grounded to a particle size of < 1 mm in a centrifugal mill (Retsch, type 3 M 100) and were pressed into pills with a mass of 0.5 to 0.6 g. Analysis was made in a bomb-calorimeter (IKA, type C 7000), according to regulations of CEN/TS 14918:2005 and repeated twice. Aside other substrates like pure sawdust, hemp straw, wheat straw, corn grist, colza cake, sunflower bowls and rape bowls were analyzed.

Results

Analyzing the particle size distribution no particles bigger than 4 mm could be found (*Table 1*). In the range between 1 and 4 mm of the samples, the main components were found with 63%. Particle sizes of 0.63 to 1 mm have had a contingent of about 19 %, 0.2-0.63 mm a contingent of about 15 % and between 0.063-0.2 mm only a contingent of 2%. Particle sizes smaller than 0.063 mm have had a fraction of almost 1 %.

The result of calorimetric analyses is that used sawdust based substrate has a gross and net calorific value comparable to other agricultural and forestry products like pure sawdust, hemp straw, wheat straw, corn grist, colza cake, sunflower bowls and rape bowls (*Table 2*). This means that the maturing period of mushrooms has almost no or only an insignificant effect on the measured values.

Discussion

Based on the results presented, used mushroom substrates based on sawdust can be used for energetic purposes. Biological processes during mushroom production within the period of 120 to 150 days have, based on this analysis, no essential effect on the calorific value of the substrates. Because of the physical characteristics like particle size and calorific value, sawdust based substrates can be used for pelleting and fuel combustion. Therefore further analyses of burning characteristics have to be made. An essential disadvantage of mushroom substrates is the relative low dry matter content of 40%. Only if competitive drying possibilities are available, an energetic utilization seems to be useful.

Table 2: Results from calorimetric analyses of mushroom culture mediums after various retention times, compared with other agricultural products

Sample	TS [%]	Average value Ho [J/g]	Net calorific value at constant pressure	
			$q_{p,net,d}$ [kJ/kg$_{TS}$]	$q_{p,net,m}$ [kJ/kg$_{FM}$]
Substrate after				
60 days	40	18612	17261	5439
90 days	40	18720	17369	5482
120 days	40	18695	17344	5472
240 days	40	18228	16878	5285
Sawdust	86	19438	18088	15214
Hemp straw	91	18986	17614	15809
Wheat straw	90,5	17738	16366	14579
Corn grist	84	18519	17168	14031
Colza cake	91,5	21914	20575	18619
Sunflower bowls	87,2	20682	19067	16314
Rape bowls	90,4	21222	19607	17931

TS: dry matter content, FM: raw material, Ho: gross calorific value, $q_{p,net}$: net calorific value at constant pressure, $_d$: dry - relating to TS
$_m$: moist – relating to FM

Literature

Books are marked by •

[1] • *Carlile, M.J., and S.C. Watkinson*: The Fungi. Academic Press, 1994

[2] • *Hobson, P.N., and A. Robertson*: Waste treatment in agriculture. Applied Science Publishers, Barking, England, 1977

[3] *Bisaria, R., P. Vasudevan and V.S. Bisaria*: Utilization of spent agro-residues from mushroom cultivation for biogas production. Applied Microbiology and biotechnology 33 (1990), pp. 607-609

[4] • *Sjöström, E.*: Wood Chemistry: Fundamentals and Applications. Academic Press, 1993

[5] • *Sarkanen, K.V., and C.H. Ludwig*: Lignins: Occurence, Formation, Structure, and Reactions. Wiley Intersci., New York, 1971