



Physico-chemical properties of peat harvested for mushroom casing from three sites in Ireland

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Summary

The quality of peat determines many of the physical and chemical properties of the subsequent casing product used by mushroom growers, and this factor impacts considerably on the yield and quality of mushrooms produced. The aim of this investigation was to evaluate properties of peat harvested from three sites that are used by casing producers from the midlands and the northern part of Ireland. The production sites were sampled during 2006 and 2007 to evaluate physical and chemical properties from a vertical strip of approximately 1 m width that descended from the upper bog surface to a depth of up to 3 m. Samples from the sites were analysed for pH, conductivity, dry matter, ash, total soluble polyphenol, carbon content, water absorption, bulk density, water retention and 11 minerals. Changes in these characteristics from the surface to the bottom of the cut profiles were broadly similar, and key differences between the sites are discussed. Peat from these sites is currently used to produce high-quality casing soil for the mushroom industry.

Key index words: peat, casing for mushroom production, physical and chemical parameters.

Introduction

The high proportion of peat-based growing media used in Ireland, the United Kingdom and Germany reflects the presence of peat bogs that have large reserves of high-quality peat. By contrast, France and The Netherlands, which have minimal peat reserves, use a wider range of raw materials to manufacture growing media (Anon., 2004). Currently, peat is less expensive than most other substrates used in horticulture, which has hindered the uptake of alternative products, as customers have been unwilling to pay more for the plants or mushrooms that are produced using peat substrate (Anon., 2004).

Casing soil is prepared by mixing peat with a neutralising agent, such as lime or sugar-beet lime, and is used to cover a composted substrate colonised with *Agaricus bisporus* mycelium. The casing layer (*ca.* 7 cm thick) has an important function in promoting the development of mushrooms and quality of the produce (Sharma *et al.*, 1996). Annually, the United Kingdom mushroom industry uses approximately 90,000 tonnes m³ acc. to EN 12580 is the preferred unit for expressing the quantity (volume) of growing media throughout Europe and elsewhere. This would be the preferred unit in this paper too. of peat for casing production (Anon., 2004), with 89,686 and 28,267 tonnes used in the Republic of Ireland and Northern Ireland, respectively (Kilpatrick, 2007). With pressure from environmental groups and multiple retailers, allied with an increasingly broad interpretation of 'organic' production, the horticultural industry has investigated the potential of

using peat substitutes in mushroom casing (Noble & Dobrovin-Pennington, 2001). In the United Kingdom, peat substitution for mushroom casing accounts for approximately 10% of total casing production. The poor commercial uptake of alternative casing materials is due to the increased costs compared to peat casing and the associated reduction in mushroom quality and yield (Pryce, 1999; Anon., 2004).

In Ireland, *ca.* 14% of the total peatland area has been exploited for agriculture and forestry, with significant environmental repercussions (Leinonen, *et al.*, 1997; McGovern, *et al.*, 2000). Within the Republic of Ireland, there has been a 92% loss of raised bogs and an 82% loss of blanket bogs (Anon., 1996). Large areas of drained peat-bogs in the Irish midlands are industrially exploited by Bord na Mona (Irish Peat Board) for energy and horticultural use (Leinonen, *et al.*, 1997). In Northern Ireland, there have also been extensive losses, with only 12% (167,580 ha) of peatlands remaining, and of this, only a small proportion remain intact (Anon., 2005). With the continuous depletion of natural peat resources, peat will become more expensive in the next decade and alternatives will become more financially competitive.

Previous studies on peat were mostly focused on understanding environmental changes over thousands of years (Tomlinson, 2005; Bindler 2006), but there is a need to evaluate characteristics of peat from a casing-soil-quality point of view. A comprehensive understanding of the physical and chemical properties of peat found within a



production site could assist in more effective and efficient use of the raw material to create high quality casings, as well as helping future developments of peat-substituted casings.

Three drained production sites that were used by casing producers during 2006 and 2007 were selected on the basis of size, casing-soil production volume and access to growers in the Republic of Ireland and Northern Ireland. The aim of this investigation was to evaluate physical and chemical properties of peat harvested from these sites.

Materials and Methods

Sites

Peat profile samples were obtained from three production sites (A, B and C). The site details including latitude, longitude, geology, bog type, current status and approximate area, are listed in Table 1. The locations of sites are illustrated in Figure 1. The three producers, who operate the sites, manufacture a range of blended peat casings using surface-milled, dry peat and vertically excavated, dark, wet peat. A large proportion of the blended casing product is exported to growers in Europe and other countries throughout the world.

Sampling period and methods

Site A was sampled once on 18th August 2006, and sites B and C were samples three times (16-17th August 2006, 14th August 2007 and 13th November 2007). Samples were taken at 0.5 m intervals from a vertical strip of approximately 1m width that descended from the surface to an accessible depth of up to 3 m. The protocols for sampling and storage of samples have been reported by Baxter *et al.*, (2008). In total, 46 samples were collected and stored under refrigeration (5°C) in rigid, sealed boxes to preserve structural integrity.

Physical and chemical analyses

Each sample was analysed in 3 replicates. The pH, (EN 13037 would be the recommended method) electrical conductivity (EC or G) (EN 13038 would be the recommended method) and water retention were determined using recommended methods (BS 4516; Anon., 1990) (EN 13041 would be the recommended method). Laboratory compacted bulk density and dry matter content measurements were made using the recommended method (BS EN 13040; Anon., 2000). Fresh representative sub-samples (approx. 2 litres) were dried to constant weight at 105°C for ash determinations (EN 13039 would be the recommended method).

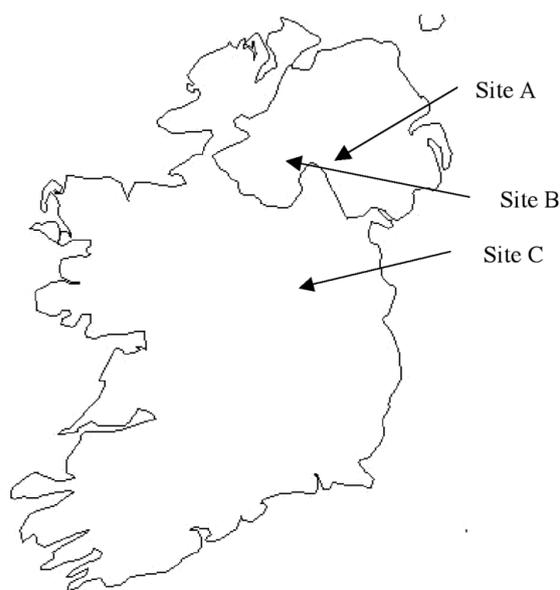


Figure 1. Map Showing the three sites.

The dried material was then milled to be able to pass through a 0.5 mm mesh screen. The samples were combusted at 500°C for 16 h or to constant weight. Water absorption capacity was conducted according to I.S. 400 (Anon., 1989). The protocols for measuring other parameters such as total soluble polyphenol, carbon and minerals have been previously reported (Sharma *et al.*, 1996).

Results

Three peat production sites were surveyed during 2006 and 2007 – August 2006, August 2007 and November 2007. Sites B and C were sampled on all three occasions whereas sampling of Site A had to be abandoned in 2007 due to poor drainage and hazardous site conditions. During the sampling periods, dominant vegetation and relevant site details were recorded (Table 1). Site A vegetation was dominated by birch woodland, common heather, grasses, sedges and mosses, sporadic rhododendron and pine, with an underlying geology of Lough Neagh clays and limestone-shale. Site B vegetation was dominated by birch, willow, heathers, grasses, bog cotton, sedges and mosses, with an underlying geology of marine limestone and shale. Site C vegetation was dominated by birch, willow, heathers, grasses, bog cotton, sedges and mosses, with an underlying geology of limestone (Geological Survey of Ireland, Dublin).

Table 1. Comparison of the three sites for latitude, longitude, geology, bog type, status, estimated area (ha) and dominant vegetation.

Site	Latitude	Longitude	Geology	Bog type	Status	Area	Dominant vegetation
A	54° 27' 58 N	6° 37' 17 W	Clay & limestone	Raised	Active	7.5 ha	Birch, heathers, grasses sedges, mosses, sporadic rhododendron and pine
B	54° 21' 35 N	7° 23' 53 W	Marine limestone and shale	Raised	Active	25 ha	Birch, willow, heathers, grasses, bog cotton, sedges and mosses.
C	53° 40' 49 N	7° 23' 49 W	Limestone	Raised	Active	125 ha	Birch, willow, heathers, grasses, bog cotton, sedges and mosses



The measured values for pH, electrical conductivity (EC or G), dry matter (DM), ash, total water soluble polyphenol (TSP), carbon content, bulk density, water absorption and water retention are listed in Table 2. Acidity of the samples declined from surface to bottom layers for the three sites, showing increased pH from 3.6-4.5 to 5.13-5.4 at the 3 m layer (Table 2). EC or G, DM and ash content of the samples were reduced from surface to 1.0 m layer considerably and at lower layers the measured values of the parameters increased indicating the influence of anaerobic conditions (Goodwin and Zeikus, 1987). The changes in the concentrations of polyphenol and carbon content were variable and did not show trends (Table 2). The physical parameters, such as sample bulk density, water absorption and water retention, showed an increase in measured values from surface level to 1.0 m of sampling depth, but at lower depths the samples showed reductions in the three properties (Table 2), indicating again influence of anaerobic conditions (Goodwin and Zeikus, 1987).

The Ba, Mg and Mn concentrations differed considerably between layers, showing a reduction from surface to bottom layers (Table 3). Similarly, the concentrations of Al, Fe, Ca, P, Pb and Zn showed a decreasing trend from the surface to the deeper layers (2.5 or 3 m) for the three sites but for Site C the concentration increased at the bottom layer indicating possibility of soil contamination (Table 3). Concentrations of other minerals, such as Cu and Na appeared to remain unchanged during the sampling period.

Discussion

Many factors, including geochemical, hydrological and physical processes, influence and contribute to the variations in the properties of peat samples from the three

sites (Proctor and Maltby, 1998; Krackler *et al.*, 2002; Jauhainen *et al.*, 2004). The range of characteristics reported in this study reflects this variation and the diversity of material available to the mushroom casing industry in the Republic of Ireland and Northern Ireland (Baxter *et al.*, 2008). Currently, casing producers blend different types of peat removed from the acrotelm and catotelm with surface-milled, dry peat to tailor a final product with specific physical and chemical properties for a range of growing systems. Furthermore the addition of limestone or sugar beet lime, during the preparation of mushroom casing to neutralise acidity, has a significant influence on the chemical and physical properties of peat including the formation of non-water soluble calcium carbonate-polyphenol complexes (Sharma *et al.*, 1996). The formation of this complex is dependent on the length of time and concentration of available calcium and carbonate ions formed to react with humic and fulvic acids in the peat.

Due to the presence of a sphagnum-rich layer, mean water retention and water absorption values recorded maximum values at 1.0m depth, whilst parameters such as EC (or G), dry matter and ash, recorded their lowest values at the same depth. The presence of this layer was consistent at all three sites. The physical properties of this layer would appear to be of greatest benefit to casing producers who strive to produce casings with high water absorption and retention properties.

The Fe and Ca concentrations in sites B and C were highest at 3 m level indicating a slow but significant diffusion of the two cations from the underlying layer. This observation is likely to be related to the underlying geology, such as limestone deposits or rock structure at the bottom of the peat bogs (Cruickshank, 1997). Site A showed a

Table 2. Comparison of pH, electrical conductivity (Ec, $\mu\text{S cm}^{-1}$), dry matter (DM, %), ash (%), total water soluble polyphenol (TSP, %), carbon (%), bulk density (g/litre), water absorption (%) and water retention (%) of peat samples taken from three sites at increasing depths. Water absorption and retention figures are based on dried material. Measured parameters for sites B and C - mean values of three sampling dates; site A - mean value of one sampling date only.

Site	Sampling Depth	pH	Ec	DM	Ash	TSP	Carbon	Bulk Density	Water Absorption	Water Retention
A	Surface	3.60	35.17	13.00	3.57	0.67	55.93	517.37	1572.10	1050.00
A	0.5 m	3.74	26.80	9.20	1.56	0.91	57.10	548.83	2553.63	1280.20
A	1.0 m	4.29	15.57	6.20	1.42	---	57.18	684.04	3777.03	1575.02
A	1.5 m	4.55	16.53	8.60	1.84	1.35	56.93	801.58	2416.07	1117.77
A	2.0 m	4.83	23.77	11.30	3.51	1.13	55.96	766.77	1424.14	869.92
A	2.5 m	5.13	23.60	10.30	4.70	3.17	55.28	658.06	2019.39	1045.45
B	Surface	4.54	27.23	15.08	5.37	2.04	54.89	552.06	1285.97	890.97
B	0.5 m	4.57	23.40	11.21	1.31	0.65	57.24	658.39	1773.72	1005.80
B	1.0 m	4.96	19.34	10.37	0.69	2.35	57.60	653.83	2062.63	1070.94
B	1.5 m	5.07	21.58	10.80	1.41	1.01	57.18	696.76	1930.39	1015.34
B	2.0 m	5.13	23.99	12.45	8.83	0.86	52.88	682.59	1419.25	885.85
B	2.5 m	4.97	56.37	13.54	15.72	0.56	48.88	662.39	1045.32	831.77
B	3.0 m	5.15	29.77	14.30	5.17	0.59	55.04	574.02	1126.71	977.89
C	Surface	4.36	29.86	16.90	1.84	0.65	56.93	448.56	1624.28	987.95
C	0.5 m	4.49	20.37	09.40	0.98	1.07	57.43	552.03	2504.34	1347.64
C	1.0 m	4.62	18.16	08.50	1.06	0.95	57.39	598.51	2721.60	1462.13
C	1.5 m	4.75	18.37	09.30	1.12	1.30	57.35	600.26	2735.92	1311.4
C	2.0 m	4.76	21.68	11.50	1.67	0.78	57.03	642.98	1644.21	952.3
C	2.5 m	5.10	21.19	11.90	3.47	0.73	55.99	617.64	1391.37	1010.0
C	3.0 m	5.39	26.44	12.70	6.59	0.64	54.18	608.20	1356.56	983.6



Table 3. Comparison of mineral content of peat samples obtained from the three sites (A, B and C). Measured parameters for sites B and C - mean values of three sampling dates; site A - mean value of one sampling date only.

Site	Sampling Depth	Al ppm	Ba ppm	Cu ppm	Fe ppm	Ca ppm	Mg ppm	Mn ppm	Na ppm	P ppm	Pb ppm	Zn ppm
A	Surface	1138.6	14.3	14.2	794.0	1484.8	1136.7	4.4	329.1	300.3	54.0	12.9
A	0.5 m	340.5	2.9	2.6	199.2	1583.3	1895.5	3.2	447.3	120.3	5.0	3.5
A	1.0 m	182.1	1.8	2.9	206.1	1615.3	2402.3	4.7	488.6	138.6	3.0	3.4
A	1.5 m	222.9	5.7	2.8	723.4	4060.5	1545.1	28.5	493.9	210.6	2.3	4.9
A	2.0 m	181.8	28.3	4.1	2665.3	10858.5	1257.5	82.8	413.8	212.6	2.8	5.8
A	2.5 m	195.1	48.8	3.7	3941.6	15453.6	1039.8	94.0	380.3	180.1	1.8	4.3
B	Surface	763.5	6.9	4.6	740.5	4022.1	1549.9	5.6	682.9	225.5	29.0	7.2
B	0.5 m	398.2	3.0	4.5	226.7	1190.1	1665.9	2.5	633.1	158.3	7.4	3.4
B	1.0 m	125.9	2.4	3.4	142.6	1002.6	1585.7	1.6	612.0	148.6	2.2	3.1
B	1.5 m	086.8	13.8	4.1	513.1	2300.5	1501.7	4.2	669.3	181.6	2.5	4.3
B	2.0 m	087.6	32.4	6.1	908.5	3616.8	1123.8	8.8	657.1	288.9	5.6	5.8
B	2.5 m	201.5	72.2	6.8	2676.4	8226.0	1239.4	24.5	650.9	353.0	8.2	38.0
B	3.0 m	140.7	106.8	4.2	4413.8	15174.6	845.1	62.6	725.6	178.3	1.7	4.1
C	Surface	285.1	3.7	4.3	248.7	1738.1	1539.5	4.7	672.0	141.0	4.2	7.1
C	0.5 m	222.8	2.8	4.3	181.9	1066.5	2067.9	1.3	743.9	119.7	2.6	3.5
C	1.0 m	210.7	2.7	3.4	156.6	1163.5	2198.8	2.3	847.9	100.0	1.5	2.9
C	1.5 m	191.5	3.5	4.4	140.5	1939.9	1779.1	6.2	951.0	125.1	2.3	3.5
C	2.0 m	174.3	9.9	3.5	270.9	4654.6	928.0	31.4	793.7	171.0	1.7	2.6
C	2.5 m	167.1	23.0	3.8	836.4	10801.0	455.7	97.4	727.4	178.6	1.7	3.3
C	3.0 m	274.9	42.4	7.2	1594.3	18128.4	321.9	176.5	721.6	138.3	1.8	3.1

much lower pH at surface compared to the other two sites possibly due to differences in local micro-climate. Similar observations on the changes in mineral content of peat in Finland have been reported by Jauhiainen *et al.* (2004).

Malley *et al.*, (2007) have been involved in the application of Visible-Near Infrared Spectroscopy (Vis-NIRS) as a tool for the evaluation of fresh peat to determine moisture and carbon content of fresh peat from bogs in Canada. Recently, Baxter *et al.*, (2008) have reported that certain properties i.e. dry matter, ash content, water absorption, water retention and pH of peat and casing soil can be predicted using Vis-NIRS technology. The accuracy and reliability of the partial least squares regression models for evaluating peat and casing soils have been reported (Baxter *et al.*, 2008). The technique described above will be very helpful for rapid quality assessment of peat used by casing soil producers, and in turn, will promote effective and efficient use of peat reserves.

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