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Evaluation of casing materials made from spent mushroom substrate and coconut fibre pith for use in production of *Agaricus bisporus* (Lange) Imbach

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Abstract

The agronomic performance of different proportions of mixtures of coconut fibre (CF) pith and spent mushroom substrate (SMS) was studied for their use as casing material in mushroom cultivation. After chemical and biological characterisation of the casing substrates qualitative and quantitative production parameters were evaluated in a cycle of *Agaricus* production. An increase in the proportion of SMS reduced the number of carpophores and overall yield; while the first flush was delayed, mushroom size tended to increase and the mushrooms had a higher dry matter content and a better texture, although their colour was worse. Combinations of CF pith and SMS of 4:1 and 3:2 (v/v) gave biological efficiencies of 92.9 and 82.6 kg 100 kg^{-1} compost, respectively. These values compare well with that obtained from the commercial casings used as a control. The high electrical conductivity of the mixture containing the highest proportion of SMS would limit its use. However, the results indicate the viability of reusing SMS as an ingredient of casing material for mushroom cultivation. This alternative could be considered to partially replace the organic substrates normally used for mushroom cultivation, with the double advantage of decreasing cost and reducing the environmental impact of waste disposal.

Additional key words: alternative casing, compost reuse, mushroom cultivation.

Resumen

Evaluación de sustratos de cobertura basados en compost agotado y fibra de coco en la producción de *Agaricus bisporus* (Lange) Imbach.

Se describe en el presente trabajo el estudio del comportamiento agronómico proporcionado en cultivo de champiñón por sustratos de cobertura basados en mezclas de fibra de coco (CF) y compost agotado (SMS) en diferentes proporciones. Para ello, tras la caracterización física, química y biológica de los sustratos de cobertura, se evaluaron los parámetros de producción cualitativos y cuantitativos en un ciclo de cultivo de *Agaricus bisporus*. Se observó que al aumentar la proporción de SMS en las mezclas disminuyó el número de carpóforos cosechados y el rendimiento total, a la vez que se vio retrasada la cosecha de la primera florada, aunque tiende a aumentar el tamaño de los champiñones cosechados, que presentan mayor contenido en materia seca, mejor textura y peor coloración. Combinaciones de CF y SMS 4:1 y 3:2 (v/v) proporcionaron, respectivamente, eficiencias biológicas de 92,9 y 82,6 kg/100 kg compost, comparables a las proporcionadas por las coberturas empleadas como testigo. Aunque la elevada conductividad eléctrica de las mezclas con alta proporción de SMS suponen una limitación a su empleo, los resultados obtenidos muestran la viabilidad de la reintroducción del SMS de champiñón en nuevos ciclos de cultivo empleándolo como ingrediente de mezclas de cobertura. Esta aplicación constituye una alternativa a considerar en la producción comercial para reemplazar parcialmente a los sustratos orgánicos empleados habitualmente para este fin, con la doble ventaja de disminuir los costes de elaboración y el impacto ambiental.

Palabras clave adicionales: cultivo de champiñón, materiales de cobertura alternativos, reutilización del compost.

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Abbreviations used: BE (biological efficiency), CF (coconut fibre), CIES (Centro de Investigación, Experimentación y Servicios del Champiñón), EC (electrical conductivity), MAPA (Ministerio de Agricultura, Pesca y Alimentación), MS (mineral soil), MSC (Ministerio de Sanidad y Consumo), N (nitrogen), SL (spent lime), SMS (spent mushroom substrate), SP (Sphagnum peat), WHC (water holding capacity).

Introduction

In commercial mushroom cultivation casing is used to cover the compost, usually after the substrate is colonized by mushroom mycelium to encourage fructification. Many materials, alone or in combination, have been used as casing both commercially and experimentally, although only very few have been shown to be of practical application. The effect of the material on quality and yield, its availability and price are determining factors when choosing a particular casing material. Sphagnum peat moss is a common component of casing materials in North America and Europe. In addition to peat moss, natural materials of mineral origin, such as soil, gravel and tuffeau stone, calcium carbonate in different forms and spent *Agaricus bisporus* compost are the most common (Pardo *et al*., 1999). Casings used in Castilla-La Mancha (Spain), an area which produces about 45% of the total Spanish mushroom crop, are mainly based on mineral soils of different origins (arable layer, sub-soil), to which peat is normally added as a bulking agent and to improve the water holding capacity (WHC) (Pardo *et al*., 1999). However, problems associated with structural variability, low porosity and low WHC of mineral soils, the depletion of peat reserves and alterations of ecosystems emphasize the need for new alternative casing materials. Among the alternatives is coconut fibre (CF) pith which has been used successfully when incorporated as an ingredient in other casing substrates (Pardo, 1999; Pardo *et al*., 2002).

Spent *Agaricus* and *Pleurotus* substrate is currently used mainly as a component of amendments and growing substrates, but not in sufficient quantities to solve the problem of its accumulation in mushroom production areas, where it is a potential pollution risk. This is because during field weathering of SMS, leachate caused by rain percolates into the underlying soils and poses a risk of groundwater pollution. The mushroom growing sector in Spain generates about 5 x 10^5 Mg of spent compost, while the EU, as a whole, produces more than 3.5 x 10^6 Mg. Among possible uses bioremediation (purification of air, purification of water, purification of soil, purification of substrates contaminated with pesticides), crop production (greenhouse and field crops) and as a general soil amendment (in nurseries and for landscaping), food for animals and fish, pest control, biofuel or vermiculture, as a casing material for growing *Agaricus* spp. and as substrate for growing other species (Rinker, 2002).

Various casing mixtures based on spent mushroom substrate (SMS) through *Agaricus* spp. cultivation have been tried both commercially and experimentally with varying degrees of success. Successful mixtures have included a mixture of soil, ground tuff and 2-yr old spent compost (Sinden, 1971); a 4:1:1 mixture of 1-yr old spent compost with sand and slaked lime (Mantel, 1973); a mixture of 2-yr old spent compost and ground limestone (Brosius, 1981) and 2:1 and 3:1 mixtures of farm yard manure with 2-yr old spent mushroom compost (Singh *et al*., 2000; Bhatt and Singh, 2002; Dhar *et al*., 2003). However, high concentrations of soluble salts are a serious drawback, so salts must be leached from the spent compost substrate. Flegg (1961) showed, experimentally, that fruiting of *Agaricus bisporus* was related to the electrical conductivity of the casing layer. He concluded that the mushroom response was related to the osmotic pressure and, therefore, moisture stress in the casing layer. In each successful usage the spent material was aged with the salts having been leached out through normal rainfall. Another possibility, which this study considers, is to lower the final electrical conductivity of the casing material by mixing it with other substrates. In this work, we analyse the agronomic performance of casings made with various proportions of CF pith and spent mushroom compost.

Material and methods

Physical, chemical and biological analysis

To determine the physical, chemical and biological characters of the composts and casing soil, the following measurements were taken: moisture content (MAPA, 1994), pH (Ansorena, 1994; AENOR, 2001a), electrical conductivity (AENOR, 2001b), total N content (MAPA, 1994), organic matter and ash (MAPA, 1994; Ansorena, 1994), C:N ratio, crude fibre (MSC, 1985a), crude fat (MSC, 1985b), particle real density (AENOR, 2001c), bulk density, total porosity and water-holding capacity (Ansorena, 1994; AENOR, 2001c), carbonates and active lime (MAPA, 1994), pathogenic nematodes (Nombela and Bello, 1983), mites (Brady, 1969; Krantz, 1986) and *Trichoderma* spp. (Tello *et al*., 1991).

Compost and spawn used

A pasteurised wheat straw and poultry manure-based commercial compost, obtained from a commercial producer (Compost Villacasa, Casasimarro, Spain), was used as the base material for *Agaricus bisporus* cultivation. The analytical characteristics after phase II of the composting process were as follows: moisture, 639 g kg^{-1}; organic matter, 726.4 g kg^{-1}; total nitrogen, 19.8 g kg^{-1}; C:N ratio, 21.3; pH, 7.86; ash content, 273.6 g kg^{-1}; crude fibre, 347.4 g kg^{-1} and crude fat, 6.1 g kg^{-1}. All observed values were in the range considered optimal for mushroom cultivation (Pardo, 1993; Hearne, 1994). After phase II of the composting process the substrate was inoculated at 10 g kg^{-1} of fresh compost using Fungisem H-25 (Micelios Fungisem, S.A., Autol, Spain) mushroom mycelium (commercial smooth white hybrid strain).

Casings

Mushroom crops were cultivated using various blends of CF and SMS (Table 1). Two controls, representing commercial practice, were used. The first control is widely used in Castilla-La Mancha and was a 4:1 (v/v) mixture of mineral soil and CF pith. The second was a soilless mixture and is similar to that used in the Netherlands and other countries. This commercial-like product was a mixture of sphagnum blond peat (Latagro, Company Olaines Kudra, Latvia) and factory waste lime (beet-sugar manufacture) in a 2:1 (v/v) proportion. Both casings have previously given good agronomic performance (Pardo, 1999; Pardo *et al*., 2002, 2004, 2008). The experimental casings used CF pith and spent mushroom compost as base material, in proportions 5:0, 4:1, 3:2, 2:3, 1:4 and 0:5 (v/v). Calcium carbonate was added to the mixtures at 100 g L^{-1}. Before preparing the mixtures, the spent compost used was treated thermally at 70ºC for 12h before the growing sheds were emptied. It was then matured for two months following the method of Lohr *et al*. (1984).

Experimental design

The experimental design was a randomised complete block design with six replicates. Replicates corresponding to six blocks were placed at three levels on both sides of the cropping chamber. A total of 48 trays were used in the experiment. The experimental trays (16 L in volume, 870 cm^2 in area) were filled with 6 kg of pressed compost (450 kg m^{-3}). The casing volume was 2.6 L $tray^{-1}$, giving a depth of 3 cm.

Growth cycle management

The mushroom growth cycle was carried out in a 20 m^3 experimental walk-in growth chamber. The chamber could be humidified heated and cooled with internal air circulation and outside ventilation. In the chamber the temperature, relative humidity and carbon dioxide levels were controlled automatically.

The production cycle was carried out using growth chamber conditions recommended for the selected mushroom strain (CIES, 2007). The compost was incubated for 16 d at about 27ºC and 95-98% relative humidity with at least 2000 ppm carbon dioxide (CO_2). After the spawn run period, experimental trays were top-dressed with casing materials. Immediately after casing, the casing materials were drenched with a disinfectant (formalin, 18 mL m^{-2}). Two days later, casings were irrigated with an insecticide (diflubenzuron 25%, 3.6 g m^{-2}). On day 4 after casing, trays were irrigated again with a fungicide (prochloraz 46%, 0.62 g m^{-2}). The environ-

Table 1. Composition of casing materials

Casing	Identification	Composition
1	Control MS+CF	Mineral soil + coconut fibre pith 4:1 (v/v)
2	Control SP+SL	*Sphagnum* peat + Spent lime 2:1 (v/v)
3	CF-SMS 5:0	Coconut fibre pith (+100 g L^{-1} $CaCO_3$)
4	CF-SMS 4:1	Coconut fibre pith + Spent mushroom substrate 4:1 (v/v) (+100 g L^{-1} $CaCO_3$)
5	CF-SMS 3:2	Coconut fibre pith + Spent mushroom substrate 3:2 (v/v) (+100 g L^{-1} $CaCO_3$)
6	CF-SMS 2:3	Coconut fibre pith + Spent mushroom substrate 2:3 (v/v) (+100 g L^{-1} $CaCO_3$)
7	CF-SMS 1:4	Coconut fibre pith + Spent mushroom substrate 1:4 (v/v) (+100 g L^{-1} $CaCO_3$)
8	CF-SMS 0:5	Spent mushroom substrate (+ 100 g L^{-1} $CaCO_3$)

mental conditions were a compost temperature of about 26ºC, a high relative humidity, and a high CO_2 concentration. Casings were ruffled deeply after 7 d of case run, and chambers were ventilated 9 d after casing to stimulate primordia formation. Pining was initiated and CO_2 was lowered to about 1000 ppm, relative humidity to about 90%, substrate temperature to about 20ºC and the air temperature to about 18ºC. Conditions then remained similar until crop termination. The total growth cycle from spawning was 60 d and four flushes of mushrooms were harvested.

Casings were moistened to between 70% and 80% of their water-holding capacity by regular and uniform watering, with between 0.5 L m^{-2} and 1.5 L m^{-2}, depending on necessity, according to usual mushroom cultivation techniques (Wuest, 1982).

Harvesting, production and commercial quality parameters

Mushrooms were harvested daily at their optimal commercial development stage corresponding to morphogenetic stages 2, 3 and 4, according to the classification of Hammond and Nichols (1976).

To assess production parameters, the weight before stipe trimming and the total number of mushrooms picked from each tray, was recorded each day. Total mushroom production was separated into two groups according to size: large mushrooms (≥ 40 mm) and medium mushrooms (15-40 mm). Yield is expressed as kg per cultivated area; and biological efficiency, a practical estimate of the ability of mushrooms to convert substrate into fruiting bodies, was calculated by dividing the total fresh weight of mushrooms harvested from a crop (several flushes) by total air-dry weight of substrate and expressing the fraction as kg/100 kg compost.

The size of the mushrooms, expressed as the unit weight in g, was calculated from the yield and number of mushrooms harvested. A second estimate of size, expressed as cap diameter in mm, was determined from previously established non-lineal regression curves based on mushroom diameter and weight corresponding to the three first flushes (Pardo, 1999). Earliness or days to first harvest was expressed as the number of days between casing and harvesting of the first flush.

On the peak day of each of the first three flushes, the dry matter, colour and texture were determined in mushrooms of uniform size and at the same stage of development. For the overall evaluation of these parameters weighted means were calculated for the relative yield of each of the first three flushes.

The mushroom surface colour was determined using a Minolta Chroma Meter CR-300, with CIE Standard Illuminant D_{65} as a light source. Before measurement, the instrument was calibrated with a standard white plate (Calibration Plate CR-A43; L*=96.12, a*=-0.11, b*=+2.66). Twenty measurements were taken in each of the first three flushes for each tray. There were four measurements on the cap surface of five disease-free mushrooms of uniform size. The first measurement was taken in the centre of the cap and the other three between 1 and 2 cm from the first, depending on the size of the mushrooms. L* (brightness), b* (yellow-blue chromaticity coordinate) and ΔE* (degree of overall colour change in comparison to colour values of an ideal sporophore) absolute values were used to describe mushroom colour (Pardo, 1999).

Dry matter was determined by measuring weight loss after oven drying for 72 h at 105ºC (Lau, 1982).

To evaluate the mechanical properties of the mushrooms in terms of their texture (firmness), puncture tests were performed immediately after harvest using a TA-XT Plus texture analyser (Stable Micro Systems, Godalming, UK). For this, mushroom stems were cut perpendicularly at the level of the veil and texture was measured in the centre of the cap using a 6 mm diameter stainless steel cylindrical test needle at a constant velocity of 2 mm s^{-1}.

Statistical analysis

Data were analyzed using the Statgraphics Plus v. 4.1 (Statistical Graphics Corp., Princeton, NJ, USA) package with the Tukey-HSD to separate means (p = 0.05).

Results

The physical, chemical and biological characteristics of the different casings assayed are shown in Table 2. The overall mean moisture content of all casings at application was 525 g kg^{-1}. As the proportion of spent compost in the mixtures rose, this value fell, but in all cases it was higher than in the mineral soil-based control. The explanation for this lies in the higher WHC of the CF pith. With regards to pH, there was little difference with a mean of 8.15. Casing electrical conductivity increased with increased SMS and was 3140 mS

Table 2. Physical and chemical characteristics of the casing materials used

	1 Control MS+CF	2 Control SP+SL	3 CF-SMS 5:0	4 CF-SMS 4:1	5 CF-SMS 3:2	6 CF-SMS 2:3	7 CF-SMS 1:4	8 CF-SMS 0:5	Mean
Moisture (g kg^{-1})	237	571	730	651	602	548	461	401	525
pH (1:5, v/v)	8.62	8.18	8.86	8.04	7.86	7.84	7.84	7.95	8.15
Electrical conductivity (µS cm^{-1})	234	825	437	1112	1842	2290	2680	3140	1570
Bulk density (fresh) (g cm^{-3})	0.861	0.560	0.441	0.502	0.579	0.597	0.581	0.608	0.591
Bulk density (dry) (g cm^{-3})	0.657	0.240	0.119	0.175	0.230	0.270	0.313	0.364	0.296
Particle real density (g cm^{-3})	2.531	2.255	2.046	2.132	2.184	2.202	2.243	2.257	2.231
Total pore space (mL L^{-1})	740	894	942	918	895	877	860	839	871
Water-holding capacity (kg kg^{-1})	0.61	3.00	5.45	4.05	2.50	2.04	1.65	1.46	2.60
Total nitrogen (g kg^{-1})	0.5	4.0	2.6	4.9	6.3	7.8	8.0	8.0	5.0
Ash (g kg^{-1})	933.7	753.0	583.9	657.9	699.0	713.7	744.2	754.5	730.0
Organic matter (g kg^{-1})	66.3	247.0	416.1	342.1	301.0	286.3	255.8	245.5	270.0
C:N	76.9	35.8	92.8	40.5	27.7	21.3	18.5	17.8	41.4
Active lime (g kg^{-1})	214	262	294	261	249	172	186	154	224
Total carbonates (g kg^{-1})	604	592	498	514	503	495	473	464	518

MS: mineral soil; CF: coconut fibre pith; SP: sphagnum peat; SL: spent lime; SMS: spent mushroom substrate

cm^{-1} in the casing based exclusively on this product. As the proportion of spent compost rose, bulk density increased, as did the real density although to a lesser extent. As a consequence, porosity decreased. Casing WHC was also negatively affected by increased proportions of SMS. However, values observed for the last two parameters were always higher than those in the mineral soil-based control, which had a porosity of 740 mL L^{-1} and WHC of 0.61 kg kg^{-1}. Both parameters are of special interest for the qualities sought in casing material. High porosity facilitates gas exchange, while a high WHC contributes to the moisture content of the microclimate where fruiting occurs and, along with the compost, ensures an adequate water supply for carpophore development. An increased proportion of SMS was accompanied by increased total nitrogen and ash giving a lower carbon:nitrogen ratio and a lower active lime content. Mites, nematodes and *Trichoderma* spp. counts were negative in all assayed casings. All of these characteristics are shown in Table 2.

The ratio of CF pith to SMS significantly affected the number of mushrooms harvested unit surface area^{-1} (Table 3). The lowest figure of 950 mushrooms m^{-2} was from casing 8 which was exclusively SMS. However, the same casing gave the biggest mushrooms (unit weight and diameter). Mushroom yields were affected by type of casing mixture (Table 3). In all cases the highest yields were obtained from the first and second flushes with values gradually falling thereafter. The lowest total yield was from casing 8, which was exclusively SMS (14.16 kg m^{-2}), followed by casing 7, CF pith and SMS 1:4 (v/v) (16.71 kg m^{-2}), both values were significantly lower than those from the other casings. Generally, biological efficiency was high, and three of the casings assayed and the controls had values of more than 80 kg 100 kg^{-1} of compost. The lowest values for this were from casings 7 and 8 (highest SMS contents) at 67.1 and 56.9 kg 100 kg^{-1} compost, respectively. With the same casings there was a significant delayed in the date of the first flush, while casing 4 (4:1 mixture of CF pith and SMS) gave the earliest at 18.5 d between casing and first flush.

The commercial class size, mushroom colour, dry matter and the pileus firmness was influenced by casing mixture (Table 4). Separating production based on commercial category, the lower yield from casing 8 (exclusively SMS) was due to a reduction in medium sized mushrooms. This size was about 70% of the production with most casings. An exception was the control casing based on mineral soil and the casing based on a 1:4 mixture (v/v) of CF pith and SMS, and the casing based exclusively on SMS, in which medium and large size mushrooms tended to be equally balanced. Mushroom diameter at harvest with casing 8 was

Table 3. Mean values of mushroom quantitative production parameters[1]

Casing	Number of mushrooms m^{-2}	Unit weight (g mushroom^{-1})	Mushroom yield (kg m^{-2})					Biological efficiency (kg 100 kg^{-1} compost)	Earliness (days from casing)
			1st flush	2nd flush	3rd flush	4th flush	Total		
1-Control MS+CF	1594 ab	15.0	9.64 a	7.30	4.58 a	2.21 ab	23.72 a	95.3 a	19.9 bc
2-Control SP+SL	1799 a	12.5	9.68 a	7.07	3.45 abc	2.10 ab	22.30 ab	89.6 ab	19.7 c
3-CF-SMS 5:0	1707 a	13.5	7.63 ab	8.90	3.50 ab	3.06 a	23.08 ab	92.7 ab	20.1 bc
4-CF-SMS 4:1	1740 a	13.5	9.16 a	8.12	3.35 abc	2.50 ab	23.13 ab	92.9 ab	18.5 d
5-CF-SMS 3:2	1615 ab	12.9	7.34 abc	7.47	3.18 bc	2.58 ab	20.57 bc	82.6 bc	19.2 cd
6-CF-SMS 2:3	1496 ab	12.2	6.02 bcd	7.72	2.66 bc	1.62 bc	18.03 cd	72.4 cd	20.1 bc
7-CF-SMS 1:4	1236 bc	14.0	4.94 cd	7.67	2.41 bc	1.70 bc	16.71 de	67.1 de	21.0 b
8-CF-SMS 0:5	950 c	15.5	4.43 d	7.09	2.11 c	0.54 c	14.16 e	56.9 e	23.8 a
Mean	1517	13.6	7.35	7.67	3.15	2.04	20.21	81.2	20.3

[1] Values followed by a different letter within a column are significantly different at 5% level according to Tukey's HSD test. MS: mineral soil; CF: coconut fibre pith; SP: sphagnum peat; SL: spent lime; SMS: spent mushroom substrate.

high (35.1 mm), as was their dry matter content (97.4 g kg^{-1}), which contributed to the high puncture force values observed (30.2 N) and compression energy (126.4 mJ). Casings 7 and 8 (high proportion of SMS) produced mushrooms which were less white. Luminosity (L*) was lowest at 92.41 with casing 8. The same casing, with the 1:4 (v/v) mixture of CF pith and SMS had the highest degree of yellowness (b*) and colour difference (ΔE*). The dingy colour of the mushrooms in these cases could be attributed to the longer time they needed to develop.

Discussion

The determining factor in the agronomic behaviour of mushrooms grown in the different casings seemed to be due to their respective electrical conductivity (EC) values. In a previous study with this type of material (Pardo *et al*., 2004), EC values of around 1600 mS cm^{-1} were observed to be a threshold above which a substantial yield reduction could be expected. This value was exceeded in this study by four casings with the highest SMS content and giving the worst agronomic perfor-

Table 4. Mean values of qualitative production parameters[1]

Casing	Commercial class (kg m^{-2})		Sporophore diameter (mm)	Colour			Dry matter (g kg^{-1})	Firmness	
	Large size (≥ 40 mm)	Medium size (< 40 mm)		L*	b*	ΔE*		Puncture force (N)	Compression energy (mJ)
1-Control MS+CF	9.70 a	14.02 a	34.7 ab	93.24 ab	8.747 d	9.81 c	73.2 d	19.8 c	89.4 b
2-Control SP+SL	6.74 ab	15.56 a	32.2 ab	93.80 a	9.196 cd	9.93 c	79.1 d	22.1 bc	97.1 ab
3-CF-SMS 5:0	7.99 ab	15.09 a	33.3 ab	92.92 b	9.153 d	10.46 bc	74.5 d	21.3 bc	86.3 b
4-CF-SMS 4:1	7.92 ab	15.22 a	33.3 ab	93.01 ab	10.194 bc	11.21 ab	77.1 d	21.2 bc	89.9 b
5-CF-SMS 3:2	6.37 ab	14.19 a	32.7 ab	93.83 a	9.406 cd	10.10 bc	87.0 c	23.1 bc	99.9 ab
6-CF-SMS 2:3	5.52 b	12.50 ab	31.9 b	93.80 a	9.781 cd	10.43 bc	90.1 bc	23.9 bc	88.9 b
7-CF-SMS 1:4	6.94 ab	9.78 bc	33.6 ab	93.38 a	11.246 a	11.95 a	96.1 ab	24.5 b	94.9 b
8-CF-SMS 0:5	6.60 ab	7.56 c	35.1 a	92.41 ab	11.088 ab	11.99 a	97.4 a	30.2 a	126.4 a
Mean	7.22	12.99	33.3	93.30	9.851	10.74	84.3	23.3	96.5

[1] Values followed by a different letter within a column are significantly different at 5% level according to Tukey's HSD test. MS: mineral soil; CF: coconut fibre pith; SP: sphagnum peat; SL: spent lime; SMS: spent mushroom substrate.

mance. Casings with a high soluble salt concentration reduced both the yield and the number of mushrooms produced, although they were larger (unit weight and diameter), with a higher proportion of large mushrooms of better texture and a higher dry matter content, although they were inferior in colour. The lower porosity and lower WHC also had a negative influence, although, given the results from the mineral soil based control these parameters seem to be irrelevant. Even though it had the lowest porosity and WHC values, the same control, with its low EC, produced excellent agronomic behaviour.

These results demonstrate the viability of reincorporating freshly aged SMS as an ingredient of casing mixtures in new cycles of mushroom cultivation. Besides the use of washing to reduce the EC of spent compost, there is the possibility of mixing it with other substrates with a low EC to increase its re-use potential. This would be an important alternative in commercial operations to partially replace CF pith and peat, especially in the light of growing problems associated with availability and cost. The material can be integrated using new formulations and methodologies with the added advantages of lowering production cost and decreasing the environmental impact of its ever-growing accumulation.

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