Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Bioresource Technology 88 (2003) 153–156
BIORESOURCE TECHNOLOGY

Using tea waste as a new casing material in mushroom (*Agaricus bisporus* (L.) Sing.) cultivation

Coşkun Gülser [a,*], Aysun Pekşen [b]

[a] *Department of Soil Science, Faculty of Agriculture, Ondokuz Mayis University, Samsun 55139, Turkey*
[b] *Department of Horticulture, Faculty of Agriculture, Ondokuz Mayis University, Samsun 55139, Turkey*

Received 28 May 2002; received in revised form 16 October 2002; accepted 21 October 2002

Abstract

In this study, the possibility of using tea production waste as a new casing material in mushroom (*Agaricus bisporus*) cultivation was investigated. Some physical and chemical characteristics of tea waste, fermented tea waste and a mixture of tea waste with peat were compared with that of peat casing, as were their effects on yield. The highest yield was obtained from peat casing. Using tea production waste alone as a casing was not acceptable for assured yield when it was compared with peat. But, a mixture of tea production waste with peat in 1:1 (v:v) ratio increased the yield. There was no significant difference between the mushroom yields of tea production waste + peat and peat casing materials at the end of 30 and 40 days. High salt content, organic and inorganic compounds in casing materials caused reduction of yields. However, a high iron content in casing material gave a significant positive correlation with total yield at 40 days.

Keywords: *Agaricus bisporus*; Mushroom; Casing; Tea waste; Yield

1. Introduction

Casing soil has an important role in the cultivation of *Agaricus bisporus*. Peat is commonly used and recommended as a good casing in mushroom cultivation, even though several different casing materials instead of peat have been examined by many investigators (Noble and Gaze, 1995; Labuschagne et al., 1995; Levenon et al., 1986). Locally available casing media is a very important factor to obtain a maximum and assured yield in the mushroom cultivation.

The required physical and chemical properties of a good casing should be high porosity and water holding capacity (WHC), 7.2–8.2 pH, 2.5–3.5% active lime, and 0.7–0.8% total nitrogen (Couvy, 1974), low content of soluble inorganic and organic nutrients, and free of disease and pests. In the study of the effects of some characteristics of casing on mushroom yield, optimum values for casing were found by Gierzsynski (1974) as 180–200% WHC, 78% porosity, more than 12% airable capacity, 7.3–7.5 pH, 47% organic matter, 1.22% total N and about 21:1 ratio of C:N.

Mushroom cultivation has recently become very popular in the Black Sea Region of Turkey. But, one of the most important problems in mushroom cultivation is to obtain a suitable casing material. Tea plants are commonly grown in the Eastern Black Sea Region of Turkey. Therefore, there is much tea production waste in this region. This waste material might be reused as a new casing in mushroom cultivation.

The objective of this study was to investigate the possibility of using tea production waste as a casing material in mushroom cultivation. Some physical and chemical characteristics of tea waste, fermented tea waste and mixture of tea waste with peat casing were compared, including their effects on yields.

2. Methods

Compost was supplied by Mupa Mushroom Cooperative, İzmit in Turkey. The fungus used in this study, commercial Somycel 512 spawn (*A. bisporus* (L.) Sing.), was obtained as infected within the compost by the same producer. Tea manufacture waste was supplied from the

* Corresponding author.

0960-8524/03/$ - see front matter
PII: S0960-8524(02)00279-1

tea processing plant in Rize, Turkey. The following casing materials were investigated:

1. Tea manufacture waste (TW): It contains dried straw and fiber of tea leaves after manufacturing process.
2. Fermented tea waste (FTW): Tea manufacture waste was moistened to about 70% only at the beginning and mixed every two days interval over a month, in a room at 25 ± 5 °C.
3. Mixture of tea manufacture waste and peat in 1:1 (v:v) ratio (TW + P).
4. Peat as a standard casing material (P).

In order to adjust the pH level to neutral, gypsum was added to all the casing materials. To sterilize all the casing materials, 2% formaline was sprayed and aired after two days.

Mushroom production used bags ($38 \times 50 \times 20$ cm), each containing 10 kg spawned compost. Experiments were conducted in a completely randomized design with six treatments and five replicates. The bags were incubated at 23 ± 2 °C. After the spawn run was complete, casing was done as 4 cm in depth for each material. The temperature in the cropping room was adjusted to 16 ± 5 °C, relative humidity was maintained around 80–85%. Ventilation was provided to induce fruit body formation when the mycelium reached the surface of the casing layer. Daily yield expressed in $kg\,m^{-2}$ was recorded for each treatment during the 40 day period. Experimental data were statistically analyzed according to Steel and Tore (1980).

Some physical and chemical properties of the casing materials were determined as follows: ash, organic C and organic matter content, which was calculated through the differences between the dry matter and the ash content, were determined according to Kacar (1994); pH and salt content in saturation extract by using pH and EC meter respectively (Black, 1965); $CaCO_3$ content with a Scheibler Calcimeter (Çağlar, 1958); total Ca, Mg, Na, K, Fe, Mn, Zn and Cu content in ash using an atomic absorption spectrophotometer; total nitrogen content by a Kjeldahl Method (Kacar, 1994) and bulk density using a cylinder method (Black, 1965). To determine the WHC, casing material was dried for 24 h at 105 °C and then submerged in water and left for 12 h (Labuschagne et al., 1995). WHC was calculated from the following equation:

$$\mathrm{WHC} = (\text{wet mass} \times 100)/\text{dry mass}.$$

3. Results

Higher cumulative yields during all the growing periods were found with the peat (P) casing used alone (Fig. 1). Except the yields of 10 day, FTW application had lower cumulative yields for 20, 30 and 40 day growing periods. The highest cumulative yield (17.41 $kg\,m^{-2}$) at 40 day was obtained from the peat casing. For the cumulative yields at 10 and 20 day growing periods, there were statistically significant differences ($P < 0.01$) between the peat casing and the other casing materials. However, there was no significant difference between the yields of P and TW + P casing at 30 and 40 day periods.

Some physical and chemical properties of different applications of tea waste and of the peat casing material are given in Table 1. pH, $CaCO_3$, bulk density and moisture content values were almost identical for all the casing materials investigated. WHC values varied from 530% to 840%. In this study, salt contents of TW, FTW and TW + P casing were higher than that of P casing. A significant negative correlation ($r = -0.847^{**}$) was determined between salt content and cumulative yield during 40 day period. organic C, organic matter and total nitrogen contents of P casing were lower than those of the other casing materials (Table 1). organic C and total nitrogen content of casing materials gave significant negative correlations with 40 day cumulative yield ($r = -0.931^{**}$ and -0.629^{*}, respectively).

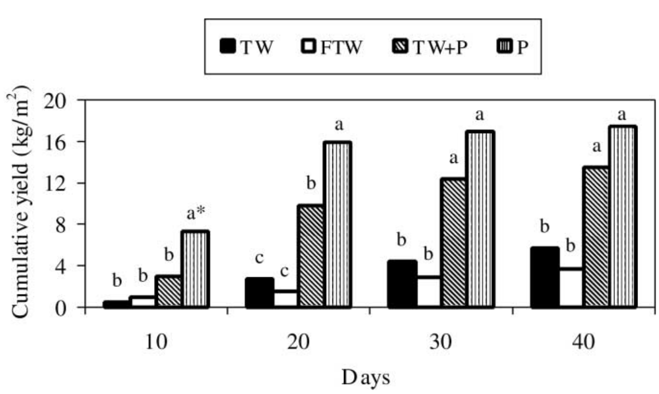

Fig. 1. Effects of different casing materials on cumulative mushroom yield (∗ there is no significant difference between the same letters statistically at 1% level).

Table 1
Some physical and chemical properties of the casing materials

Casing material[a]	pH	Moist (%)	WHC (%)	BD ($g\,cm^{-3}$)	$CaCO_3$ (%)	Salt (%)	Ash (%)	OM (%)	OC (%)	N (%)	C:N
TW	7.2	70	814	0.214	0.64	0.90	12.12	87.87	50.96	2.22	22.95
FTW	7.1	78	840	0.286	0.32	0.69	19.46	80.53	46.71	1.18	39.58
TW + P	7.0	69	623	0.264	0.82	0.55	34.09	65.90	38.22	1.25	30.58
P (control)	7.0	68	530	0.341	0.69	0.28	53.33	46.65	27.05	0.54	50.11

WHC: water holding capacity; BD: bulk density; OM: organic matter; OC: organic carbon.
[a] See methods.

Table 2
Some inorganic elements in the casing materials

Casing material[a]	Ca (%)	K (%)	Na (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
TW	0.959	0.511	0.017	0.040	999.0	1255.5	301.4	10.76
FTW	1.417	0.322	0.028	0.043	939.4	736.8	175.0	9.27
TW + P	1.246	0.248	0.026	0.027	1728.6	220.4	199.5	10.59
P (control)	1.122	0.043	0.019	0.016	1631.7	210.7	277.4	11.52

[a] See methods.

Total K, Mg and Mn contents of the P casing were lower than those of the other casing materials (Table 2). Total K, Mg and Mn contents gave significant negative correlations with the cumulative yield over 40 days ($r = -0.847^{**}$, -0.832^{**} and -0.806^{**}, respectively). However, Fe content of P casing was higher than that of TW and FTW. Fe content of casing showed the significant positive correlation with yield in 40 day ($r = 0.909^{**}$). Fe and Mn contents between TW + P and P casing were found to be identical.

4. Discussion

According to the results, neither TW nor FTW can be used alone as a casing material. Even though using tea waste alone as a casing did not give a higher mushroom yield compared with the yield of peat casing, a mixture of tea waste with peat in 1:1 (v:v) ratio provided a higher cumulative yield than TW and FTW. There was no significant difference between the yields of TW + P and P casing at the end of 30 and 40 day. Therefore, a mixture of TW and P in 1:1 ratio can be used profitably as a new casing material in mushroom cultivation.

It has been noted that a good casing should have a high WHC and high porosity (Vijay et al., 1988). A positive relationship between air filled porosity and mushroom yield was obtained by Rainey et al. (1986). In the present study, the highest cumulative yield was obtained from the peat casing alone which had a low WHC. In the study by Labuschagne et al. (1995), WHC of the different casing materials varied from 207% to 887%. Although they found a significant variation in the WHC of the different casing materials, the yields were not significantly different. In another study by Noble and Gaze (1995), no relationships were found between the bulk density, air filled porosity and water retention of a peat-based casing material and mushroom yield or dry matter content. These results indicate that having a high WHC in casing materials is not enough to obtain a higher yield in mushroom cultivation.

Besides WHC and porosity, inorganic and organic matter contents of casing also have important effects on mushroom yield. According to Hayes (1981), a good casing soil should have low availability of soluble inorganic ions and of organic nutrients. TW + P casing material decreased the salt content (Table 1) and increased 30 and 40 day cumulative yields (Fig. 1) to values which were not significantly different from cumulative yields of P casing. This indicates that decreasing salt content of casing increases mushroom yield. Generally, a low salt content in casing is desired in mushroom cultivation (Erkel, 1980).

The total nitrogen content in casings is usually required to be between 0.7% and 0.8% in mushroom cultivation (Couvy, 1974; Boztok, 1990). The lower the organic C and total N contents in P and TW + P than in TW and FTW (Table 1), the greater was the increase in cumulative yield in P and TW + P casings (Fig. 1). It shows that higher organic C and total N contents of casing decrease mushroom yield.

In mushroom cultivation, using a casing material which has a high Mg content causes a half percent decrease in yield and a delay in mushroom growth (Flegg and Wood, 1985). In this study, the salt effects of Mg and K may have caused a decrease in yield, because mixing TW with P decreased total Mg and K contents (Table 2) and increased cumulative yields (Fig. 1). Total

Fe ion concentration (Fe^{2+} and Fe^{3+}) in casing had a positive effect on mushroom yield (Hayes, 1972). It is suggested that, 200 ppm iron sulfate should be added into compost for an earlier harvest of mushrooms (Kaul and Kachroo, 1976; Boztok, 1978). Fe and Mn contents were identical between TW + P and P casing materials (Table 2) while cumulative yield of TW + P casing was not significantly different from the yield of P casing in 30 and 40 day growing periods. A high iron content in casing gave a significant positive correlation with cumulative yield at 40 days while high organic and inorganic compounds in casings caused lower yields.

5. Conclusion

These results showed that a mixture of tea waste and peat is a new and practicable casing material for the Black Sea Region of Turkey, where the peat casing is more expensive and hard to find when compared with the tea waste. To increase the yield and mushroom quality, different applications and mixing ratios of tea waste and peat should be investigated in more detail.

References

Black, C.A., 1965. Methods of Soil Analysis. Part I, American Soc. of Agron., No. 9.

Boztok, K., 1978. Mantar yetiştiriciliğinde örtü toprağına katılan sentetik materyalin ürünün kalite ve kantitesine etkileri üzerinde araştırmalar. Ege Üniversitesi, Ziraat Fakültesi Yayınları, 382.

Boztok, K., 1990. Mantar Üretim Tekniği. Ege Üniversitesi Ziraat Fakültesi Yayınları, No. 489, Ege Üniv. Basımevi, 168 s., Bornova, İzmir.

Couvy, J., 1974. Les facteurs de la fructification de l'*Agaricus bisporus*. Bulletin de La Federation Nationale des Syndcats Agricoles des Cultivateurus de Champignons 1, 653–657.

Çağlar, K.Ö., 1958. Toprak İlmi. Ankara Üniversitesi Yayınları, No. 10, Ankara.

Erkel, İ., 1980. Örtü materyali karışımlarının kullanılma olanakları. Türkiye II. Yemeklik Mantar Kongresi, 85-91, Yalova.

Flegg, P.B., Wood, D.A., 1985. Growing and fruiting. In: Flegg, P.B., Spencer, D.M., Wood, D.A. (Eds.), The Biology and Technology of the Cultivated Mushroom. John Wiley & Sons Ltd., pp. 141–178.

Gierzszynski, M., 1974. The effect of the physical and chemical properties of the casing layer on cropping in mushrooms. Hort. Abst. 45, 4200.

Hayes, W.A., 1972. Nutritional factors in relation to mushroom production. Mushroom Sci. 8, 663–674.

Hayes, W.A., 1981. Interrelated studies of physical, chemical and biological factors in casing soils and relationships with productivity in commercial culture of *Agaricus bisporus* Lange (Pilat). Mushroom Sci. 1 (2), 103–129.

Kacar, B., 1994. Bitki ve Toprağın Kimyasal Analizler: III, Toprak Analizleri, 149–165, Ankara Üniversitesi Zir. Fak. Eğit., Araşt. ve Geliştirme Vakfı Yay., No. 3, Ankara.

Kaul, T.N., Kachroo, J.L., 1976. Use of ferrous sulphate for stimulating fruit body formation at mushroom farms in Kashmir. Mushroom J., 43–214.

Labuschagne, P., Eicker, A., van Greuning, M., 1995. Casing mediums for *Agaricus bisporus* cultivation in South Africa: a preliminary report. In: Elliott, T.J. (Ed.), Mushroom Science XIV, Science and Cultivation of Edible Fungi, vol. 1. Balkema, Rotterdam, pp. 339–344.

Levenon, D., Motro, B., Dosoretz, C., Henis, Y., 1986. Differential utilization of nutrients present in the casing layer by *Agaricus bisporus*. Mushroom J., 151–159.

Noble, R., Gaze, R.H., 1995. Properties of casing peat types and additives and their influence on mushroom yield and quality. In: Elliott, T.J. (Ed.), Mushroom Science XIV, Science and Cultivation of Edible Fungi, vol. 1. Balkema, Rotterdam, pp. 305–312.

Rainey, P.B., Cole, A.L.J., Sanderson, F.R., 1986. Air filled pores an important component of the mushroom casing layer. In: Wuest, P.J., Royse, D.J., Beelman, R.B. (Eds.), Proc. Intl. Symp. Scientific & Tech. Aspects of Cultivating Edible Fungi. Elsevier, Amsterdam, pp. 501–514.

Steel, R.G.D., Tore, J.H., 1980. Principle and Procedures of Statistics. Mc Graw-Hill Company, New York.

Vijay, B., Saxena, S., Sohi, H.S., 1988. Studies on new casing media for *Agaricus bisporus* (L.) Sing. Science into Practice 3, 313–315.