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Short Communication

Effect of the physical properties of *Lentinula edodes* bedlogs on fruiting body production*1

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Fruiting of *Lentinula edodes* was induced by soaking the bedlogs in water. It appeared that each bedlog had its own optimum water content for fruiting, and the value was affected by the extent of wood decay. A high content of free water, more than 20%, together with a high content of air volume, 32 - 43%, resulted in good fruiting. As less decayed young bedlogs have high contents of wood substance, it is difficult to obtain high contents of both free water and air volume. This is one reason why less decayed bedlogs produce less fruiting.

Key Words——air volume; free water content; fruiting induction; *Lentinula edodes*; shiitake.

Shiitake, *Lentinula edodes* (Berk.) Pegler, is the most commercially important mushroom grown on wood. Although many studies on the biological nature of this fungus have been presented, information regarding the fruiting mechanism on logs is insufficient. Nutritional conditions (Tokimoto et al., 1977, 1982; Fukuda et al., 1987; Matsumoto et al., 1990; Yoshida et al., 1987; Matsumoto and Tokimoto, 1992), mycelium quantity (Tokimoto and Fukuda, 1981), primordium number (Komatsu and Tokimoto, 1982), the rate of wood decay (Tokimoto et al., 1980), and enzyme activities (Ishikawa et al., 1983; Tokimoto et al., 1987; Tokimoto and Fukuda, 1997) in bedlogs have been studied in relation to fruiting. Low temperature (Ohira et al., 1982) and electrical stimulation (Kaneko et al., 1987; Meguro et al., 1988) are effective for the induction of fruiting body development. However, the role of the physical properties of bedlogs in fruiting remains largely unknown. This study focuses on the free water content and air volume of bedlogs and discusses their role in fruiting body development.

Materials and Methods

Preparation of bedlogs Three strains of *L. edodes*, TMI-563 (low-medium temperature type, fruiting in late autumn to spring in Japan), and TMI-655 and TMI-1164 (medium-high temperature type, fruiting in all seasons, with watering and maintenance at 10–20°C), were used. Logs of *Quercus serrata* Thumb. (8–12 cm in diam, 100 cm long) were inoculated with the stick type of *Lentinula* spawns, using a common method, in March. These logs were placed under trees in the shade required for use in this study.

Induction of fruiting The bedlogs were soaked in tap water for 1–24 h, then placed in a conditioned room controlled at 12°C (in TMI-563) or 20°C (in TMI-655, TMI-1164) with 80–90% RH, to develop fruiting bodies. To aid water absorption, partial bedlogs were cut at both ends (10 mm wide) with a saw or notched in the bark (six points per log) with a hatchet prior to soaking. Mature fruiting bodies were harvested, and the number and weight were measured.

Determination of the physical properties of bedlogs The difference of bedlog weights before and after the soaking revealed the amount of water absorbed into the logs. After the soaking, two blocks of wood (2 cm tangential, 2 cm radial, 4 cm longitudinal) were taken from the surface of the sapwood of every log, ca. 20 cm from each longitudinal end. These fresh blocks were weighed, then dried at 100°C to constant weight. The physical properties of the wood blocks were calculated using the following formulae, where the moisture content at the fiber saturation point, specific gravity of wood substance, and specific gravity of bound water were set at 28% (in dry base), 1.5, and 1.1, respectively (Ringyoshikenjo, 1958).

Volume of wood substance in fresh condition (WS)
$=\text{Dry weight} / 1.5 + \text{Dry weight} \times (0.28 / 1.1)$
Volume of free water (FWa)
$=\text{Fresh weight (g)} - \{\text{Dry weight} + \text{Dry weight} \times 0.28\}$
Air volume (AV)
$=\text{Volume in fresh condition} - (\text{WS} + \text{FWa})$

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Results and Discussion

Fruiting body development was induced by soaking the bedlogs in water, and the amount of water absorbed into logs affected fruiting body yield. In TMI-655 and TMI-1164 bedlogs treated in September, soaking for 5 h resulted in much more fruiting than soaking for 1 h or 24 h (Table 1). Similar results were obtained with TMI-563 bedlogs treated in December (Table 2). Old bedlogs, 45 mo after inoculation, produced more fruiting bodies when water absorption was increased (more than 1.7 kg/10,000 cm^3) by cutting ends or notching bark, but little harvest was obtained without these treatments, when a small amount of water, 0.55 kg, was absorbed. In contrast, young bedlogs, 21 mo after inoculation, produced a relatively small amount of fruiting bodies when more water was absorbed.

From the data for each strain, significant regression equations were obtained:

TMI-655 bedlogs

17 mo old: $y=-59.1(x-2.34)^2+361$ ($n=60$, $P<0.01$)

TMI-1164 bedlogs

17 mo old: $y=-135(x-1.85)^2+584$ ($n=60$, $P<0.01$)

TMI-563 bedlogs

21 mo old: $y=-201(x-0.80)^2+140$ ($n=45$, $P<0.05$)

45 mo old: $y=-236(x-2.39)^2+244$ ($n=45$, $P<0.01$)

where y is the fruiting body yield in fresh weight (g/10,000 cm^3 wood), and x is the amount of water absorbed into the logs (kg/10,000cm^3 wood). These equations showed that each bedlog had its own optimum water content for fruiting body production.

These differences in the optimum amount of water absorption among strains and bedlogs of different ages are attributed to differences in the rate of wood decay. The ability of TMI-655 to decay wood was stronger than TMI-1164, resulting in ca. 34.6% vs 40.1% in the content of wood substances with bound water (Table 1). In TMI-563, the content of wood substances (with bound water) of the old bedlogs, ca. 29.5%, was lower than that of young bedlogs, 40.5% (Table 2). From this, we propose the general rule that more decayed logs require much more water.

Volume ratios of wood substance, free water content and air were calculated (Tables 1, 2). It appeared that the balance of free water content and air volume affected the fruiting yield. High free water content is necessary for good fruiting, and an appropriate air volume of 32–43% is also required, regardless of whether the fruiting temperatures is 12 or 20°C. It is likely that a small air volume lowers air permeability in logs and inhibits fruiting. Kishimoto et al. (1984) reported that the air volume for good mycelial growth was 8–40% in sapwood of *Quercus serrata* logs. Fruiting body development needs relatively higher air volume than mycelial growth.

As less decayed bedlogs had relatively high contents of wood substance, it is difficult to obtain a high free water content together with a high air volume. This is

Table 1. Physical properties and fruiting body yield in 17-mo-old bedlogs of *Lentinula edodes*.

Strain	Soaking period (h)	Absorbed water (kg) by soaking[a,b]	Volume (%) in sapwood after soaking[c]			Fruiting body yield (g)[a,b]
			Wood substance and bound water	Free water	Air	
TMI-1164	1	0.3	39.5	12.7	47.4	195
	5	1.1	40.1	20.2	39.7	614
	24	1.8	40.6	27.4	32.4	421
TMI-655	1	0.5	34.9	14.1	51.0	160
	5	1.3	34.5	22.1	43.1	392
	24	2.4	34.3	33.2	32.0	236

a) Per 10,000 cm^3 of wood. b) Mean of 20 bedlogs. c) Mean of 10 bedlogs.

Table 2. Physical properties and fruiting body yield in *Lentinula edodes* bedlogs, strain TMI-563.

Bedlog age (mo)	Treatment before soaking[a]	Absorbed water (kg) by soaking[b]	Volume (%) in sapwood after soaking[c]			Fruiting body yield (g)[b]
			Wood substance and bound water	Free water	Air	
21	Cut ends	0.81	40.5	20.5	39.0	111
	Notched bark	1.05	40.9	23.9	35.5	122
	None	0.58	40.1	17.3	42.3	151
45	Cut ends	1.95	29.7	32.8	37.7	242
	Notched bark	1.77	29.4	32.0	38.6	190
	None	0.55	29.4	17.8	52.8	68

a) See Materials and Methods. Soaked for 16 h. b) per 10,000 cm^3 of wood, mean of 15 bedlogs.
c) Mean of 10 bedlogs.

one reason why less decayed bedlogs tend to exhibit poor fruiting, although other conditions such as mycelium quantity (Tokimoto and Fukuda, 1981), primordium number (Komatsu and Tokimoto, 1982), and nutrient amount (Tokimoto et al., 1977; Matsumoto and Tokimoto, 1992) are also important.

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