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Full Length Research Paper

Agaricus bisporus cultivation using locally obtainable casing materials and various composting recipes. Part I: Composting formulations based on wheat straw and locally obtainable casing materials

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Three compost formulas; wheat straw based and using different activator materials such as wheat brain, chicken manure, and pigeon manure were used for *Agaricus bisporus* cultivation. Locally available casing materials such as peat of Bolu, peat of Agacbasi, peat of Caykara, and their mixture (80:20; v:v) with perlite were used. Temperature degrees of all of compost formulas were measured during composting at various depth in order to determine the compostability level. Results showed that inner compost temparature increased until the 8th and 9th day of composting for formula I, formula II, and formula III composts, respectively. The maximum inner compost temperature degrees were measured for all compost formulas at the second turning stage of composting. The highest mushroom yield (1707.2 g) was recorded by wheat straw mixed with pigeon manure with the peat of Caykara and perlite mixture as casing material.

Keywords: Composting, *Agaricus bisporus*, compost temperature, peat of Bolu, peat of Agacbasi, peat of Caykara.

INTRODUCTION

Since ancient times, mushrooms have been consumed by humans not only as a part of the normal diet but also as a delicacy because they have a highly desirable taste and aroma (Kurbanoglu and Algur, 2002). Fruit bodies of the basidiomycete fungus *Agaricus bisporus* are produced in large quantities for human consumption on specific compost covered with a casing layer (De Groot et al., 1998). Compost for the production of the white button mushrooms, *A. bisporus*, is produced from wheat straw, straw-bedded horse manure, chicken manure and gypsum (Straatsma et al., 2000).

The preparation of mushroom compost has for many years been divided into distinct phases, phase I during which raw material are mixed, wetted and stacked with considerable dry matter losses. Phase II, which includes pasteurization and conditioning treatment to produce a selective and pathogen free substrate (Randle and Hayes, 1972; Ross and Harris, 1983; Bech, 1973).

Due to scarcity of horse manure, many efforts have been made by scientists to develop its alternative based on vegetable origin named as “synthetic compost”. Synhetic compost formulations remained standard for several years and scientist have recommended various formulations from different parts of the world depending upon their availability (Shandilya, 1979; Tewari and Sohi, 1976; Lambert, 1929; Sinden and Hauser, 1953).

The casing layer is an essential part of the total substrate in the artifical culture of *A. bisporus*. Although many different materials may adequately function as a casing layer, peat is commonly used and recommended as a good casing in mushroom cultivation (Gülser and

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Table 1. Wheat straw based compost formulas.

Formula	Ingredients	Fresh weight (kg)	Moisture content (%)	Dry weight (kg)	Nitrogen (%)	Nitrogen (kg)
I	Wheat straw	460.0	15.0	400.0	0.5	2.00
	Wheat bran	137.0	17.0	113.0	2.4	2.71
	Ammonium nitrate	17.1	0.0	17.10	26.0	4.94
	Urea	10.1	0.0	10.10	44.0	4.84
	Mollasses	24.0	50.0	16.0	1.3	0.20
	Gypsum	24.0	0.0	24.0	0.0	0.0
	TOTAL			**580.2**		**14.69**
II	Wheat straw	460.0	15.0	400.0	0.5	2.00
	Chicken manure	82.5	20.0	113.0	1.7	1.92
	Ammonium nitrate	20.0	0.0	20.0	26	5.20
	Urea	12.0	0.0	12.0	44	5.20
	Mollasses	24.0	50.0	16.0	1.3	0.20
	Gypsum	24.0	0.0	24.0	0.0	0.0
	TOTAL			**585.00**		**14.32**
III	Wheat straw	460.0	15.0	400.0	0.5	2.00
	Pigeon manure	133.0	18.0	113.0	3.5	3.95
	Ammonium nitrate	15.0	0.0	15.0	26	3.90
	Urea	10.0	0.0	10.0	44	4.40
	Mollasses	24.0	50.0	16.0	1.3	0.20
	Gypsum	24.0	0.0	24.0	0.0	0.0
	TOTAL			**578.00**		**14.45**

Peksen, 2003).

The aim of the this study was to determine the individual and mutual effects of controlled compost temperature, and of locally available casing materials with the addition of perlite, and of different raw materials based wheat straw on cultivation of *A. bisporus*.

MATERIALS AND METHODS

Three compost formulas based wheat straw are given in Table 1. Peat of Bolu, peat of Agacbasi, and peat of Caykara were supplied from Bolu district, Agacbasi district (Trabzon), and Caykara district (Trabzon), in Turkey, respectively. Composting was carried out within two phases (Shandilya, 1982).

After composting process, the compost was spawned with 30 g mycelium (Type Horst U1) per kg then filled into plastic bags as 7 kg wet weight basis. During spawn run the temperature of the inlet air is automatically regulated by a cooling surface in the recirculation canal such that the compost temperature is maintained at 24-25°C with a minimum supply of fresh air. Spawning room arranged to 25°C temperature, and 90% relaaative humidity without ventilation (Hayes and Shandilya, 1977). After 18 days of mycelial growth, a 3 cm layer casing material covered over the compost. Peat of Bolu, peat of Agacbasi (Trabzon), and peat of Caykara (Surmene-Trabzon) mixed with perlite as 80 to 20 volume bases used as casing materials. Before casing, chalk was added to give a pH of 7.5-8. After 7 days, the temperature was lowered to 16°C, with ventilation, for pin head production. Watering after casing was done as suggested for commercial growth (Randle, 1984; Shandilya, 1986). After pin head development, following picking periods of mushroom along with four flushes the yield data were recorded for 60 days below follow equation:

$$\text{Yield} = \frac{\text{Fresh mushroom weight}}{\text{Fresh compost weight}} \times 100$$

Percentage nitrogen (N) content of the composts formulas was arranged to 2.5%. Nitrogen contents of compost formulas were determined following formula:

$$\text{Percentage N at start} = \frac{\text{Nitrogen (kg)} \times 100}{\text{Dry weight (kg)}} \cong 2.5$$

Inner compost temperatures were measured during composting

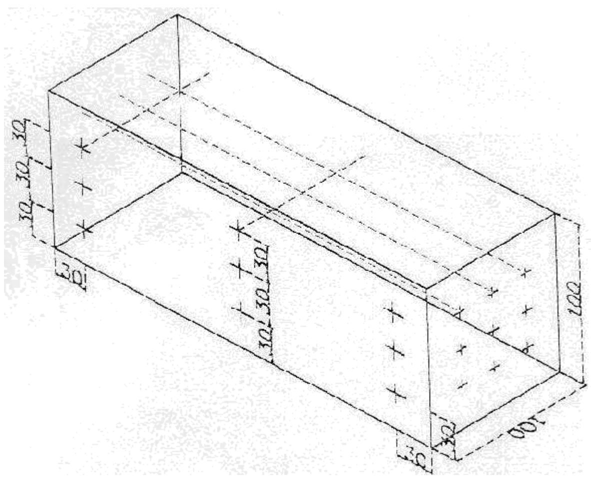

Figure 1. Measuring points of inner compost temperature.

process along the lengthwise, 30 cm from the points of compost pile three height as 30 cm, 60 cm, and 90 cm were marked. Also, three heights were determined just in the middle of compost alongs the length wise for temperature measurements which were made everyday at 24 h intervals (Figure 1).

Evaluation of test results

Test results were evaluated by a computerized statistical program composed of analysis of variance and following Duncan tests at the 95% confidence level. Statistical evaluations were made on homogeneity groups (HG), of which different letters reflected statistical significance.

RESULTS AND DISCUSSION

Inner compost temperature degrees

The inner temperature degrees of the compost formulas such as formula I, formula II, and formula III are given in Table 2, Table 3, and Table 4, respectively. According to results, the highest temperature degrees of all compost formulas were measured at the second turning stage. It can be probably due to addition of mollasses at the 6^{th} day of composting. Increased temperature at this stage is an indicator for a rapid and exotermic microbial activity within compost layers that might be critical stage for decomposition of carbohydrates for necessary to produce a selective substrate environment for mushroom growing (Colak, 2004). These results are consistent with the previous findings reported by earlier researchers (Baysal 1999; Yalinkilic et al., 1994). Inner temperature degrees of the composts raised to a peak level at the 1^{st} and 2^{nd} turning stages followed by a gradual decrease observed.

Composting was completed at 21, 19, and 17 days for formula I, formula II, and formula III, respectively. Inner temperature degrees of formula I compost was significantly higher than the other two compost formulas. Therefore, it was completed later than other compost formulas. The highest inner compost temperature degrees were measured 71.9, 72.3, and 70.5°C for formula I, formula II, and formula III, respectively. Baysal (1999) studied the inner compost temperature degrees of waste tea leaves based and mixed some activator materials such as wheat brain, chicken manure, and pigeon manure. The highest temperatures degrees were recorded 86.2, 70.3, and 77.2°C, respectively. Also, Colak (2004) reported that the highest compost temperature degrees of composts prepared from wheat straw based and used same activator materials such as wheat brain, chicken manure, and pigeon manure were 56.7, 59.8, and 54.5°C, respectively. In this study, composting process was completed between 40- 45°C for all compost formulas. This result is consistent with previous researchers' findings (Colak, 2004, Baysal, 1999; Yalinkilic et al., 1994). Ross and Harris (1982) reported that ammonia disappeared most rapidly in the range of 40 to 45°C from the compost. Ammonia is a respiration inhibitor and its complete release from the compost is critical at the end of the composting process (Flegg and Wood, 1985).

Effects of various compost formulas and casing materials on the mushroom yield

The mushroom yield values during a harvesting period of 60 days (4 flush) are given in Table 5. Generally, among the casing materials, peat mixed with perlite (80:20 in volume) gave the higher mushroom yield compared to sole peat casing materials. The highest mushroom yield (1707.2 g) was recorded by wheat straw mixed with pigeon manure with the peat of Caykara and perlite mixture as casing material. Baysal (1999) studied average mushroom yield values of waste tea leaves based compost formulas and mixed some casing materials. He reported that the best mushroom yield was obtained by waste tea leaves and pigeon manure compost mixture and using peat of Caykara and perlite mixture as casing material. In this study, peat of Caykara gave the higher mushroom yield compared to other peat casing materials. It may be due to some differences of the peat casing materials such as the total nitrogen, inorganic and organic matter contents, porosity, and salt content. Couvy (1974) reported that a good casing material should be of high porosity, pH 7.2-8.2, and should have 0.7 to 0.8% total nitrogen content.

Conclusion

In the present study, three types of composts formulas based wheat straw and different activator materials were used. Also, locally available casing materials such as peat of Bolu, peat of Agacbasi, and peat of Caykara and their mixture with perlite (80:20 volume basis) were used for cultivation of *A. bisporus.* Results showed that all the

Table 2. Inner temperature degrees of wheat straw mixed with wheat bran (Formula I).

Composting stage	Day	Daily temperature (°C)*	Temperatures of turning (°C)*
	1	$60.5 \pm 3.02d^{e}$	
	2	62.6 ± 2.28^{defg}	
I	3	69.7 ± 3.32^{op}	65.9 ± 4.22^{d}
	4	67.2 ± 3.06^{klm}	
	5	69.8 ± 1.90^{op}	
	6	68.4 ± 2.62^{nop}	
II	7	70.0 ± 2.32^{op}	
	8	69.4 ± 3.99^{op}	69.9 ± 1.47^{e}
	9	71.9 ± 2.39^{p}	
III	10	63.0 ± 3.31^{defg}	63.8 ± 1.130^{cd}
	11	64.6 ± 2.01^{fghi}	
IV	12	65.8 ± 1.84^{ijkl}	59.2 ± 2.12^{b}
	13	64.2 ± 1.55^{fghi}	
V	14	63.8 ± 1.67^{defgbc}	$64.0 \pm 0.35c^{d}$
	15	63.8 ± 1.67^{defgbc}	
VI	16	62.2 ± 1.34^{def}	60.7 ± 2.05^{c}
	17	59.3 ± 2.21^{cd}	
VII	18	55.3 ± 1.58^{bc}	54.5 ± 1.06^{b}
	19	53.8 ± 1.62^{b}	
VIII	20	47.2 ± 2.81^{a}	45.3 ± 2.61^{a}
	21	43.5 ± 2.30^{a}	

*Values are in Mean ± SD (standard deviation).
Similar letters within a column reflect statistical insignificance at the 95% confidence level.

Table 3. Inner temperature degrees of wheat straw mixed with chicken manure (Formula II).

Composting stage	Day	Daily temperature (°C)*	Temperatures of turning (°C)*
	1	63.1 ± 5.19^{cdef}	
	2	62.5 ± 13.6^{bdef}	
I	3	66.8 ± 2.99^{defg}	65.3 ± 2.32^{c}
	4	66.5 ± 3.17^{defg}	
	5	67.6 ± 2.64^{defg}	
	6	72.3 ± 2.85^{h}	
	7	72.3 ± 2.75^{hefg}	
II	8	68.7 ± 3.71^{efg}	70.6 ± 1.92^{d}
	9	69.3 ± 2.85^{fg}	
III	10	66.2 ± 2.21^{defg}	65.7 ± 0.70^{c}
	11	65.2 ± 3.08^{cdefg}	
IV	12	57.7 ± 3.13^{abc}	59.2 ± 2.12^{b}
	13	60.7 ± 1.82^{bcde}	
V	14	60.0 ± 2.02^{bcd}	58.5 ± 2.12^{b}
	15	57.0 ± 1.75^{abc}	
VI	16	54.9 ± 1.89^{ab}	53.3 ± 2.26^{a}
	17	51.7 ± 1.57^{a}	
VII	18	47.0 ± 2.2^{a}	45.0 ± 1.6^{a}
	19	43.0 ± 1.8^{a}	

*Values are in Mean ± SD (standard deviation).
Similar letters within a column reflect statistical insignificance at the 95% confidence level.

Table 4. Inner temperature degrees of wheat straw mixed with pigeon manure (Formula III).

Composting stage	Day	Daily Temperature (°C)*	Temperatures of turning (°C)*
I	1	63.0 ± 4.98^{cdef}	63.4 ± 416^{cdefg}
	2	63.4 ± 416^{cdefg}	
	3	61.8 ± 7.02^{cde}	
	4	65.2 ± 2.97^{defg}	
	5	65.0 ± 2.81^{defg}	
II	6	70.5 ± 5.13^{i}	68.7 ± 1.47^{e}
	7	69.2 ± 6.23^{hi}	
	8	67.0 ± 2.27^{efg}	
	9	68.3 ± 2.43^{efg}	
III	10	56.9 ± 2.89^{b}	59.0 ± 3.04^{c}
	11	61.2 ± 3.67^{cde}	
IV	12	52.7 ± 3.07^{ab}	55.9 ± 4.59^{bc}
	13	59.2 ± 1.73^{bcd}	
V	14	53.3 ± 2.34^{ab}	52.1 ± 1.62^{b}
	15	51.0 ± 1.98^{ab}	
VII	16	48.9 ± 2.27^{a}	47.6 ± 1.83^{a}
	17	46.3 ± 2.81^{a}	

*Values are in Mean ± SD (standard deviation).
Similar letters within a column reflect statistical insignificance at the 95% confidence level.

Table 5. Mushroom yield values of *Agaricus bisporus* on different compost types and casing materials.

Compost Formulas	Casing materials	Mixture ratio (%, in volume)	Yield** Mean ± Sd***
Formula I*	Peat of Bolu	100	1253.2 ± 139.8^{e}
	Peat of Agacbasi	100	1351.2 ± 140.4^{e}
	Peat of Çaykara	100	1373.7 ± 86.1^{de}
	Peat of Bolu + perlite	(80:20)	1346.5 ± 89.5^{cde}
	Peat of Agacbasi +perlite	(80:20)	1468.2 ± 108.2^{cde}
	Peat of Caykara + perlite	(80:20)	1699.2 ± 106.5^{cde}
Formula II	Peat of Bolu	100	1427.2 ± 85.6^{cde}
	Peat of Agacbasi	100	1262.7 ± 138.7^{bcde}
	Peat of Çaykara	100	1467.2 ± 78.2^{bcd}
	Peat of Bolu + perlite	(80:20)	1162.0 ± 112.8^{abc}
	Peat of Agacbasi + perlite	(80:20)	1659.7 ± 186.4^{abc}
	Peat of Caykara + perlite	(80:20)	1403.2 ± 121.9^{abc}
Formula III	Peat of Bolu	100	1100.0 ± 131.6^{abc}
	Peat of Agacbasi	100	1363.2 ± 183.7^{abc}
	Peat of Çaykara	100	1501.7 ± 184.4^{abc}
	Peat of Bolu + perlite	(80:20)	1473.0 ± 118.7^{abc}
	Peat of Agacbasi + perlite	(80:20)	1337.7 ± 70.8^{ab}
	Peat of Caykara + perlite	(80:20)	1707.2 ± 355.8^{a}

Small letters given as superscript over yield values represent homogenity groups obtained by statistical analysis with similar letters within a column reflecting statistical insignificance at the 95% confidence level.
*Composts were filled into plastic bags as 7 kg weights basis.
**Results reflect observations of four plastic bags.
***Standard deviation.
****Homogenity groups

organic ingredients used in different formulations composted well with in 17-21 days of outdoor composting. Composting process was completed nearly between 40 - 45°C for all compost formulas. Inner temperature degrees of all compost formulas reached the highest level at the 2^{nd} turning stage, because of acceleration effect of mollasses in microbial activity. The highest mushroom yield was obtained by wheat straw mixed with pigeon manure with the peat of Caykara and perlite mixture as casing material.

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