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Full Length Research Paper

An investigation on pin head formation time of *Agaricus bisporus* on wheat straw and waste tea leaves based composts using some locally available peat materials and secondary casing materials

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This study was designed to determine pin head formation time of *Agaricus bisporus* on wheat straw and waste tea leaves based composts. Locally available peat materials such as peat of Bolu (PB), peat of Agacbasi (PA), peat of Caykara (PC), and their mixture (80:20; v:v) with piece of mosaic (PM), perlite (P), and sand (S) were used as secondary casing materials. Also, some activator materials such as wheat bran, chicken manure, and pigeon manure were used for *A. bisporus* cultivation. For wheat straw based composts, the fastest pin head formation times were observed with a mixture of PA with PM casing material on wheat straw and chicken manure based compost and with PA casing material on wheat straw and pigeon manure based compost. For waste tea leaves based composts, the fastest pin head formation times were obtained with a mixture of PA with PM and PC with PM on waste tea leaves and chicken manure based compost. Generally, when peat materials were used in combination with each other, the period of pin head formation times shortened compared to their individual use. A mixture of forest soil with sand (80 + 20; in volume) gave the worst results in terms of pin head formation times for both composts. In secondary casing materials, PM gave the best results in terms of pin head formation time for both composts.

Key words: Pin head formation time, wheat straw, waste tea leaves, peat, secondary casing materials, activator materials.

INTRODUCTION

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). Commercially available compost is selective for growth of *A. bisporus* mycelium (Gerrits, 1988). Compost for cultivation of the white button mushrooms, *A. bisporus*, is prepared from a mixture of organic materials subjected to a composting process making it selective for growth of *A. bisporus* (Colak, 2004; Holtz and Scheisler, 1986; Lambert, 1941; Kachroo et al., 1979). For the production of *A. bisporus*, the compost is generally 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; and phase II includes pasteurization and conditioning treatment to produce a selective and pathogen free substrate (Randle and Hayes, 1972; Ross and Harris, 1983; Bech, 1973).

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

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Table 1. Wheat straw based composts.

Formula Number	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	137,00	17,00	113,00	2,40	2,71
	Ammonium nitrate	17,10	0,00	17,10	26,00	4,94
	Urea	10,10	0,00	10,10	44,00	4,84
	Mollasses	24,00	50,00	16,00	1,30	0,20
	Gypsum	24,00	0,00	24,00	0,00	0,00
	TOTAL			**580.2**		**14.69**
II	Wheat straw	460,00	15,00	400,00	0,50	2,00
	Chicken manure	82,50	20,00	113,00	1,70	1,92
	Ammonium nitrate	20,00	0,00	20,00	26,00	5,20
	Urea	12,00	0,00	12,00	44,00	5,20
	Mollasses	24,00	50,00	16,00	1,30	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	133,00	18,00	113,00	3,50	3,95
	Ammonium nitrate	15,00	0,00	15,00	26,00	3,90
	Urea	10,00	0,00	10,00	44,00	4,40
	Mollasses	24,00	50,00	16,00	1,30	0,20
	Gypsum	24,00	0,00	24,00	0,00	0,00
	TOTAL			**578.00**		**14.45**

as a good casing in mushroom cultivation (Gülser and Peksen, 2003) because of its unique water holding and structural properties which are widely accepted as ideal for the purposes of casing. But, there are no available sources of peat in many mushroom-growing areas (Vedie, 1995). This has led to considerable research into possible peat alternatives for casing (Poppe, 2000).

This study was aimed to determine pin head formation time of *A. bisporus* on using some locally available peat materials and their combination with some secondary casing materials such as perlite, sand, and piece of mosaic. Composts were prepared from wheat straw and waste tea leaves and using wheat bran, chicken manure, and pigeon manure as activator material.

MATERIALS AND METHODS

Compost

Two composts; wheat straw and waste tea leaves using wheat bran, chicken manure, and pigeon manure as activator materials were studied. Composts used in this study are given in Tables 1 and 2. The composting of substrates was processed using method of Shandilya (1982). The total outdoor composting process (phase I) took 17 - 21 days and 21 - 25 days for wheat straw and waste tea leaves based composts, respectively. The phase II was processed indoor for 7 days. Nitrogen (N) content of the composts formulas was adjusted to 2.5%. Nitrogen contents of compost formulas were determined following equation:

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

Casing soil

Locally available casing materials such as Peat of Bolu (PB), peat of Agacbasi (PA), and peat of Caykara (PC) were used as primary casing materials. Peat of Bolu, peat of Agacbasi, and peat of Caykara were supplied from Bolu district, Agacbasi district (Surmene-Trabzon) and Caykara district (Trabzon) in Turkey, respectively. Forest soil (FS) was used as casing material, supplied from Meryemana-Trabzon district, in Turkey. Also, some secondary casing materials such as perlite (P), sand (S), and piece of mosaic (PM) with mixture of peat (20:80; v: v) in volume were used.

Mushroom cultivation

Composts were spawned with 30 g mycelium (Type Horst U1) per kg. It was 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 was arranged to 25°C temperature, and 90% relative humidity without ventilation (Hayes and Shandilya, 1977). After mycelia growth, a 3 cm layer casing material was covered over the compost. 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 pinhead production. The data concerning pin head formation time of *A. bisporus* was recorded as

Table 2. Waste tea leaves based composts.

Formula Number	Ingredients	Fresh weight (kg)	Moisture content (%)	Dry weight (kg)	Nitrogen	Nitrogen (kg)
I	Waste tea leaves	448.0	12.0	400.0	2.3	9.20
	Wheat bran	132,00	17,00	113,00	2,40	2,71
	Ammonium nitrate	3.67	0.0	3.67	26	0.95
	Urea	2,17	0,00	2,17	44,00	0,95
	Mollasses	24,00	50,00	16,00	1,30	0,20
	Gypsum	24,00	0,00	24,00	0,00	0,00
	TOTAL			**559,80**		**14,01**
II	Waste tea leaves	448,00	12,00	400,00	2,30	9,20
	Chicken manure	135,00	20,00	113,00	1,70	1,92
	Ammonium nitrate	5,00	0,00	5,00	26,00	1,30
	Urea	3,00	0,00	3,00	44,00	1,32
	Mollasses	24,00	50,00	16,00	1,30	0,20
	Gypsum	24,00	0,00	24,00	0,00	0,00
	TOTAL			**561.00**		**13.94**
III	Waste tea leaves	448,00	12,00	400,00	2,30	9,20
	Pigeon manure	134,00	18,00	113,00	3,50	3,95
	Ammonium nitrate	1,00	0,00	15,00	26,00	0,26
	Urea	0,60	0,00	10,00	44,00	0,26
	Mollasses	24,00	50,00	16,00	1,30	0,20
	Gypsum	24,00	0,00	24,00	0,00	0,00
	TOTAL			**578,00**		**13,87**

days after casing. Watering after casing was done as suggested for commercial growth (Randle, 1984; Shandilya, 1986).

RESULTS AND DISCUSSION

Pin head formation time of *A. bisporus* on wheat straw based composts

Time periods of pin head formation of *A. bisporus* on wheat straw and wheat bran based compost are given in Table 3. A mixture of PB with PC (50 + 50; in volume) yielded the most suitable casing material with average of 12.75 days. A mixture of FS with S (80 + 20; in volume) gave the worst result in terms of pin head formation time (21.00 days). When peat materials were used in combination with each other, the period of pin head formation time shortened. The most suitable casing material group in terms of pin head formation time was group II. The worst results with regards to the period of pin head formation time were produced by group VI casing materials.

Time periods of pin head formation of *A. bisporus* on wheat straw and chicken manure based compost are given in Table 4. The most rapid pin head formation time was 12.25 days with a mixture of PA with PM (80:20; in volume). The latest pin head formation time was 20 days with a mixture of FS with PM (80:20; in volume). The most suitable casing material groups in terms of pin head formation time were group IV, group III, and group V, respectively. The worst results with regards to the period of pin head formation time were produced by group VI casing materials.

Time periods of pin head formation of *A. bisporus* on wheat straw and pigeon manure based compost are given in Table 5. The fastest pin head formation time was 12.25 days with PA. The latest pin head formation time was 23.50 days with FS. When peat materials were used in combination with each other, the period of pin head formation time shortened. The most suitable casing material group in terms of pin head formation time was group II. The worst results with regards to the period of pin head formation time were produced by group VI casing materials.

In secondary casing materials, PM gave the best results followed by perlite, and sand in terms of pin head formation time. Addition of a wetting agent to the peat contributes to the ease of drainage and reduces the surface tension, increasing media air porosity (Wilson, 1985). From our study, sand adversely affected the pin head formation time for all wheat straw based composts. The reason of this adverse effect may be due to the high ratio of sand in the mixture (Baysal, 1999; Toker et al., 2007).

Table 3. Pin head formation time of *Agaricus bisporus* on wheat straw and wheat bran based compost using locally available peat materials and secondary casing materials.

Casing groups	Casing material	Mixture Ratio* (%)	Pin head formation time (days)**		Pin head formation time (days)	
			Mean	Sd***	Mean	Sd
I	PB	100	17.25	0.5	16.13	2.95
	PA	100	14.25	0.50		
	PC	100	13.25	1.50		
	FS	100	19.75	1.25		
II	PB+PA	50+50	13.75	0.95	14.54	1.34
	PB+PC	50+50	12.75	0.50		
	PB+FS	50+50	16.25	0.50		
	PA+PC	50+50	14.25	0.95		
	PA+FS	50+50	16.00	0.81		
	PC+FS	50+50	14.25	0.50		
III	PB+P	80+20	17.50	0.50	17.08	1.42
	PB+S	80+20	18.25	0.95		
	PB+PM	80+20	15.50	0.57		
IV	PA+P	80+20	15.00	1.41	15.66	1.37
	PA+S	80+20	17.25	0.50		
	PA+PM	80+20	14.75	0.50		
V	PC+P	80+20	16.50	1.29	16.08	0.38
	PC+S	80+20	16.00	0.00		
	PC+PM	80+20	15.75	0.95		
VI	FS+P	80+20	19.25	0.50	19.75	1.09
	FS+S	80+20	21.0	1.41		
	FS+PM	80+20	18.50	1.73		

*In volume.
**Results reflect observations of four plastic bags and composts were filled into plastic bags as 7 kg weights basis.
***Standart deviation.

Pin head formation time of *A. bisporus* on waste tea leaves based composts

Time periods of pin head formation of *A. bisporus* on waste tea leaves and wheat bran based compost are given in Table 6. A mixture of PB with PA (50 + 50; in volume) gave the best result in terms of pin head formation time (14.00 days.). A mixture of FS with S (80 + 20; in volume) gave the worst result in terms of pin head formation time (21.75 days). When peat materials were used in combination with each other, the period of pin head formation time shortened. The most suitable casing material groups in terms of pin head formation time were group II and group IV. The worst results with regards to the period of pin head formation time were produced by group VI casing materials.

Time periods of pin head formation on waste tea leaves and chicken manure based compost are given in Table 7. The most rapid pin head formation time was 13.75 days with a mixture of PC with PM and PA with PM with equal average. The latest pin head formation time was 19.75 days with a mixture of FS with S (80:20; in volume). When peat materials were used in combination with each other, the period of pin head formation time shortened.

Table 4. Pin head formation time of *Agaricus bisporus* on wheat straw and chicken manure based compost using locally available peat materials and secondary casing materials.

Casing groups	Casing material	Mixture Ratio* (%)	Pin head formation time (days)**		Pin head formation time (days)	
			Mean	Sd***	Mean	Sd
I	PB	100	16.50	1.00	16.12	2.68
	PA	100	14.50	0.57		
	PC	100	13.75	0.95		
	FS	100	19.75	0.50		
II	PB+PA	50+50	14.25	0.95	15.20	1.69
	PB+PC	50+50	14.00	0.00		
	PB+FS	50+50	17.75	0.50		
	PA+PC	50+50	14.25	0.50		
	PA+FS	50+50	17.00	0.00		
	PC+FS	50+50	14.00	0.00		
III	PB+P	80+20	13.75	0.50	14.58	1.89
	PB+S	80+20	16.75	0.50		
	PB+PM	80+20	13.25	1.25		
IV	PA+P	80+20	13.75	0.95	14.16	2.15
	PA+S	80+20	16.50	0.57		
	PA+PM	80+20	12.25	0.50		
V	PC+P	80+20	14.00	1.41	14.91	1.01
	PC+S	80+20	16.00	1.41		
	PC+PM	80+20	14.75	0.50		
VI	FS+P	80+20	16.75	0.95	18.25	1.30
	FS+S	80+20	19.00	0.91		
	FS+PM	80+20	20.00	1.00		

*In volume.
**Results reflect observations of four plastic bags and composts were filled into plastic bags as 7kg weights basis. ***Standart deviation.

The most suitable casing material groups in terms of pin head formation time were group IV, group II, and group V respectively. The worst results with regards to the period of pin head formation time were produced by group VI casing materials.

Time periods of pin head formation on waste tea leaves and pigeon manure based compost are given in Table 8. The most rapid pin head formation time was 14.50 days on a mixture of PA with PM. The latest pin head formation time was 21.0 days on FS. Although when peat

Table 5. Pin head formation time of *Agaricus bisporus* on wheat straw and pigeon manure based compost using locally available peat materials and secondary casing materials.

Casing groups	Casing material	Mixture Ratio* (%)	Pin head formation time (days) **		Pin head formation time (days)	
			Mean	Sd***	Mean	Sd
I	PB	100	15.00	0.57	16.37	1.87
	PA	100	12.25	0.50		
	PC	100	14.25	0.50		
	FS	100	23.50	3.87		
II	PB+PA	50+50	14.25	0.50	14.62	2.24
	PB+PC	50+50	12.50	0.57		
	PB+FS	50+50	18.00	0.00		
	PA+PC	50+50	13.00	0.00		
	PA+FS	50+50	16.75	0.50		
	PC+FS	50+50	13.25	0.50		
III	PB+P	80+20	17.25	0.50	16.58	1.38
	PB+S	80+20	18.00	1.29		
	PB+PM	80+20	15.00	0.00		
IV	PA+P	80+20	15.00	0.00	15.58	0.52
	PA+S	80+20	16.00	0.81		
	PA+PM	80+20	14.75	0.50		
V	PC+P	80+20	15.25	0.50	15.50	1.14
	PC+S	80+20	16.75	0.50		
	PC+PM	80+20	14.50	1.29		
VI	FS+P	80+20	17.25	0.50	17.75	0.43
	FS+S	80+20	18.00	0.00		
	FS+PM	80+20	16.75	1.50		

*In volume.
** Results reflect observations of four plastic bags and composts were filled into plastic bags as 7 kg weights basis.
*** Standart deviation.

materials were used in combination with each other, the period of pin head formation time shortened. The most suitable casing material groups in terms of pin head formation time were group II and group IV followed by group III, group I, and group V, respectively. The worst results with regards to the period of pin head formation time were produced by group VI casing materials.

Generally, in secondary casing materials, while PM

Table 6. Pin head formation time of *Agaricus bisporus* on waste tea leaves and wheat bran based compost using locally available peat materials and secondary casing materials.

Casing groups	Casing material	Mixture Ratio* (%)	Pin head formation time (days) **		Pin head formation time (days)	
			Mean	Sd***	Mean	Sd
I	PB	100	19.75	1.25	17.75	2.92
	PA	100	15.50	1.91		
	PC	100	15.00	1.41		
	FS	100	20.75	1.89		
II	PB+PA	50+50	14.00	1.63	15.75	2.56
	PB+PC	50+50	14.25	0.95		
	PB+FS	50+50	20.50	0.57		
	PA+PC	50+50	15.00	0.81		
	PA+FS	50+50	16.25	0.95		
	PC+FS	50+50	15.50	1.29		
III	PB+P	80+20	18.50	1.95	18.50	1.14
	PB+S	80+20	19.50	1.00		
	PB+PM	80+20	16.75	0.50		
IV	PA+P	80+20	15.50	1.29	15.75	1.39
	PA+S	80+20	17.75	0.50		
	PA+PM	80+20	14.50	1.00		
V	PC+P	80+20	18.50	1.25	17.16	1.28
	PC+S	80+20	16.50	0.57		
	PC+PM	80+20	15.75	0.95		
VI	FS+P	80+20	20.00	0.81	20.08	1.63
	FS+S	80+20	21.75	2.21		
	FS+PM	80+20	18.50	1.00		

*In volume.
** Results reflect observations of four plastic bags and composts were filled into plastic bags as 7 kg weights basis.
***Standart deviation.

was found to be the most suitable secondary casing material, sand gave the worst results in terms of pin head formation time.

Conclusion

In this study, pin head formation time of *A. bisporus* on wheat straw and waste tea leaves based composts using some locally available peat materials with secondary casing materials were studied. Results showed that pin head formation time ranged from 12.25 to 23.75 days and from 13.75 to 21.75 days for wheat straw and waste tea leaves based composts, respectively. Generally, FS and a mixture of FS with S gave the worst results in terms of pin head formation time for both composts. In secondary casing materials, PM was found more suitable secondary

Table 7. Pin head formation time of *Agaricus bisporus* on waste tea leaves and chicken manure based compost using locally available peat materials and secondary casing materials.

Casing groups	Casing material	Mixture Ratio* (%)	Pin head formation time (days)**		Pin head formation time (days)	
			Mean	Sd***	Mean	Sd
I	PB	100	17.00	0.00	16.25	1.88
	PA	100	14.25	0.95		
	PC	100	15.25	0.50		
	FS	100	18.50	1.29		
II	PB+PA	50+50	14.25	0.50	15.58	1.89
	PB+PC	50+50	14.00	0.00		
	PB+FS	50+50	18.00	0.00		
	PA+PC	50+50	14.50	0.57		
	PA+FS	50+50	18.00	0.81		
	PC+FS	50+50	14.75	0.50		
III	PB+P	80+20	17.75	0.50	16.75	1.73
	PB+S	80+20	17.75	1.50		
	PB+PM	80+20	14.75	0.50		
IV	PA+P	80+20	15.00	0.00	15.17	1.50
	PA+S	80+20	16.75	0.50		
	PA+PM	80+20	13.75	0.50		
V	PC+P	80+20	16.50	0.57	15.33	1.42
	PC+S	80+20	15.75	0.50		
	PC+PM	80+20	13.75	1.50		
VI	FS+P	80+20	18.00	0.81	18.67	0.95
	FS+S	80+20	19.75	1.70		
	FS+PM	80+20	18.25	0.95		

*In volume.
**Results reflect observations of four plastic bags and composts were filled into plastic bags as 7kg weights basis. ***Standart deviation.

casing material followed by perlite, and sand respectively.

Synthetic 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). Our results showed that waste tea leaves based composts gave similar results compared to wheat straw based composts in terms of pin head formation time. Therefore, in terms of pin head formation time, waste tea leaves may be used as a new composting material for cultivation of *A. bisporus.* However, yield and nutritional values of *A. bisporus* should be investigated in more detail on cultivated waste tea leaves based composts.

One of the most important problems in mushroom cultivation is to obtain a suitable casing material. Locally available casing media is a very important factor to obtain a maximum and assured yield in the mushroom cultivation (Gulser and Peksen, 2003). However, there are no available sources of peat in many mushroom growing areas (Vedie, 1995). This has led to considerable research into possible peat alternatives for casing (Poppe, 2000). Our results showed that mixtures of peat

Table 8. Pin head formation time of *Agaricus bisporus* on waste tea leaves and pigeon manure based compost using locally available peat materials and secondary casing materials.

Casing groups	Casing material	Mixture Ratio* (%)	Pin head formation time (days)**		Pin head formation time (days)	
			Mean	Sd***	Mean	Sd
I	PB	100	18.00	0.00	17.56	2.56
	PA	100	16.00	0.81		
	PC	100	15.25	1.25		
	FS	100	21.00	1.41		
II	PB+PA	50+50	16.00	0.00	16.83	1.80
	PB+PC	50+50	15.50	0.57		
	PB+FS	50+50	20.00	0.81		
	PA+PC	50+50	15.75	0.95		
	PA+FS	50+50	18.00	1.41		
	PC+FS	50+50	15.75	0.50		
III	PB+P	80+20	18.00	0.81	17.50	1.32
	PB+S	80+20	18.50	0.57		
	PB+PM	80+20	16.00	1.15		
IV	PA+P	80+20	16.50	1.00	16.83	2.51
	PA+S	80+20	19.50	0.57		
	PA+PM	80+20	14.50	0.57		
V	PC+P	80+20	19.00	1.41	17.58	1.23
	PC+S	80+20	17.00	1.50		
	PC+PM	80+20	16.75	0.50		
VI	FS+P	80+20	20.25	0.75	20.00	0.43
	FS+S	80+20	20.25	0.95		
	FS+PM	80+20	19.50	0.57		

*In volume.
** Results reflect observations of four plastic bags and composts were filled into plastic bags as 7 kg weights basis.
***Standart deviation.

materials with some secondary casing materials such as piece of mosaic and perlite showed good results in terms of pin head formation time. We found that when peat materials were used in combination with each other, pin head formation time was shorter compared to their individual use for both composts.

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