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CULTIVATION OF THE EDIBLE MUSHROOM *VOLVARIELLA VOLVACEA* ON THREE DIFFERENT COMPOSTS IN HONG KONG*

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CULTIVO DEL HONGO COMESTIBLE *VOLVARIELLA VOLVACEA* EN TRES DIFERENTES SUBSTRATOS EN HONG KONG

SUMMARY

The edible mushroom *Volvariella volvacea* was cultivated on three different composts: a) cotton waste plus lime, b) paddy straw with lime, and c) paddy straw, cotton waste and lime. The first compost was the best substrate, because of an earlier pinhead appearance, and a higher and stable mushroom production. The biological efficiency on this substrate was 42.6±4.93%. Paddy straw gave poor and unstable mushroom production. The compost of paddy straw and cotton waste was stable but with lower biological efficiency if compared with cotton waste.

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RESUMEN

Se cultivó el hongo comestible *Volvariella volvacea* en tres diferentes substratos: a) bagazo de algodón con cal, b) paja de arroz con cal y c) paja de arroz, bagazo de algodón y cal. El primero de ellos resultó ser el mejor, ya que el hongo comestible se desarrolló rápidamente y se obtuvo una producción alta y estable, alcanzando una eficiencia biológica de 42.6± 4.93%. El substrato formado a base de paja de arroz y cal tuvo una producción baja e inestable y el substrato con paja de arroz, bagazo de algodón y cal presentó una producción de hongos estable, pero con una menor eficiencia biológica, en comparación con la obtenida a partir de bagazo de algodón con cal.

INTRODUCTION

Volvariella volvacea (Bull. ex Fr.) Singer is an edible mushroom which had been traditionally cultivated on paddy straw in Southeast Asia, even since the 18th. Century in some provinces of China (Chang, 1977). This mushroom is now cultivated in Indonesia, Singapore, Malaysia, Thailand, Philippines, China, Taiwan, India, and Sri Lanka, among others (Chang, 1979; 1982), reaching a total world production of about 49,000 tons (Delcaire, 1981). Many substrates have been used to cultivate *V. volvacea* and other species of the genus, such as banana leaves, sawdust and oil-palm bunch. However, nowadays, it is widely cultivated on cotton waste because better and stable yield, and earlier fruiting and harvesting is obtained (Chang, 1978a). This change has been specially observed in Hongo Kong, where cotton waste has practically replaced paddy straw as substrate for mushroom cultivation, as it can be observed in the succesfull mushroom commercial farms of figures 1 and 2.

V. volvacea is an Asiatic mushroom, however it is very close with the American edible species *V. bakeri* (Murr.) Shaffer, as was discussed by San Antonio *et al.* (1984). Singer (1975) considered both species in the same stirps of *V. volvacea*. On the other hand, *V. bakeri* is very common in Mexico in subtropical and tropical regions (Guzmán, 1977) growing in wild on agricultural wastes and it is now in study by the Senior author (see Martínez-Carrera *et al.*, 1984).

MATERIALS AND METHODS

a) Strain and spawn elaboration

The strain T-l of *Volvariella volvacea* from the Dept. of Biology at the Chinese Univ. of Hong Kong, was used in all experiments. The spawn was elaborated with cotton waste and lime. A mixture of 97% of cotton waste and 3% lime was composted during one day. Then 200 gr. of substrate was transfered into a polypropylene plastic bags of 30 x 15 cm. After that, bags were sterilized in the autoclave at 121°C during 45 minutes, then cooled, and inoculated with small pieces of previously colonized cotton waste. The inoculated bags were kept at 32°C during two weeks.

b) Compost preparation

Three different compost treatments were prepared as it can be observed in the table I. Each one of them was supplied with ten beds of 3.43 Kg (dry weight) at random in the mushroom house.

Compost 1. The cotton waste was mixed with lime (3%) in a mixing machine, then water was added to bring the moisture content more or less to 70%. It was put into a square wooden frame and compacted to be sure of full soaking with water. After that, the wooden frame was raised and the pile covered with a plastic sheet to keep temperature and moisture, and to favour fermentation.

Compost 2. The preparation of this compost was the same as for Compost 1, but using the paddy straw (about 6 cm in lenght) mixed with lime (3%) in a mixing machine, then water was added to bring the moisture content more or less to 80%.

Compost 3. A mixture of paddy straw (48.5%), cotton waste (48.5%) and lime (3%) was done by a mixing machine. Then water was added to reach about 70% of moisture content. Likewise, it was compacted into a square wooden frame, completely soaked with water, and piled up. After take the square wooden frame out, the pile was covered with a plastic sheet for suitable fermentation.

Three days later after piling, a turning was necessary to have an homogenous fermentation of the material of every compost.

c) Mushroom cultivation

After a period of four days of composting, the composts were removed and then placed into the mushroom house. The beds were prepared putting more or less 3.43 Kg. of substrate for every compost. The area covered by each bed is given in table II. Each compost was supplied with 10 replicates randomly distributed on the shelves.

The pasteurization of the substrate was carried out by steaming, keeping the temperature at 62°C during 2.5 hours, then dropped to 52°C. This last temperature was maintained for another 5.5 hours with ventilation.

After pasteurization, the temperature was allowed to drop gradually to 34°C with 100% of relative humidity. Then the substrate of the different composts were evenly spawned at an spawning ratio of 3%. Previously, the hands were partially sterilized with 70% alcohol to prevent contamination. After spawning, the beds were covered with plastic sheets to prevent substrate dehydratation.

For plenty mycelial growth a temperature of 30-32°C and a relative humidity of 90-95°C were maintained. After four days of spawning, the plastic sheets were removed from the beds, ventilation of 2 hours, and light ing of about 8 hours was permited. When pinheads began to appear, the temperature during this reproductive stage was of 27-30°C with a relative humidity of 80-90%. These factors were kept until the second flush was produced.

The characteristicas such as pH, moisture content, and size and weight of each compost treatments are presented in table II.

RESULTS

In compost 1, formed with 97% cotton waste and 3% of lime, produced pinheads of the first flush of fruiting bodies 6 days after spawning in two beds, and after 7 days in the rest eight beds. The mushroom production of each bed was between 3.76 - 5.48 Kg/m^2. Pinheads from the second flush of fruiting bodies were produced 16 days after spawning for three beds and 17 days for the rest of the seven beds. In the second flush the production of

each bed was between 0.51 - 0.93 Kg/m^2. The total amount for the first and second flush was between 4.70 - 6.20 Kg/m^2 (table III).

In compost 2, formed with 97% of paddy straw and 3% of lime, pinhead appearance was very variable: one bed at 7, three beds at 8, and the rest six beds at 9 days after spawning respectively. The mushroom production was between 0.47 - 0.93 Kg/m^2. Pinheads of the second flush began to appear for two beds at 18, for three beds at 19, and for five beds at 20 days after spawning respectively. The mushroom production for this flush was between 0.16 - 0.25 Kg/m^2. The total amount for the first and second flush was between 0.72-1.04 Kg/m^2 (table III).

In compost 3, formed with 48.5 % of cotton waste, 48.5% of paddy straw and 3% of lime, the first pinhead appearance was uniform at 7 days after spawning for all beds, giving a mushroom production between 1.66 - 2.45 Kg/m^2. The second flush pinhead appearance was produced 16 days and 17 days after spawning for two beds and eight beds respectively, reaching a total amount between 2.02 - 2.69 Kg/m^2, for the first and second flush (table III).

The average yield of ten beds for the three different compost treatments is given in table IV.

DISCUSSION

The results showed that cotton waste plus pime is the best substrate compared with the others, because it gives an earlier pinhead appearance and higher and stable mushroom production, as it has been clearly pointed out by Chang (1978 a). The average yield of ten beds and its biological efficiency for the first and second flush were 5.24±0.60 Kg/m^2 and 42.6±4.93% respectively (table IV). The biological efficiency was very similar to that reported by Hu *et al.* in the 1973 in Taiwan (according to Chang, 1978 b).

The mushroom production of compost 2, formed with paddy straw and lime, was particularly low, unstable, and pinhead formation took place later than that for the other two composts. The average yield of ten beds and its biological efficiency were 0.94±0.12 Kg/m^2 and 15.3±1.95% respectively (table IV).

The compost 3, formed with cotton waste, paddy straw and lime, was more stable and little bit higher than compost 2 in mushroom production, but it was not better than cotton waste. Pinhead appearance was produced 7 days later after spawning. The average yield of ten beds and its biological efficiency were 2.31±0.22 Kg/m^2 and 31.4±2.95% respectively (table IV). These results are little higher than those obtained by Tzeng in 1974 in a similar experiment in Taiwan (according to Chang, 1978 b).

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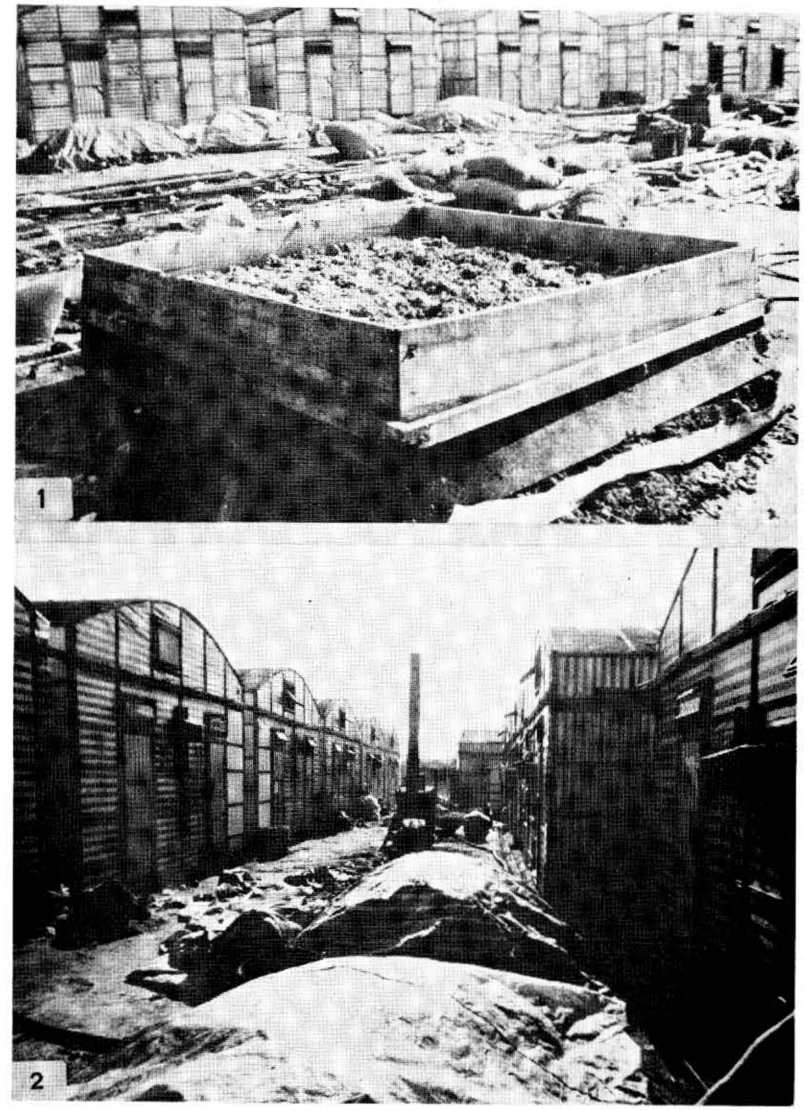
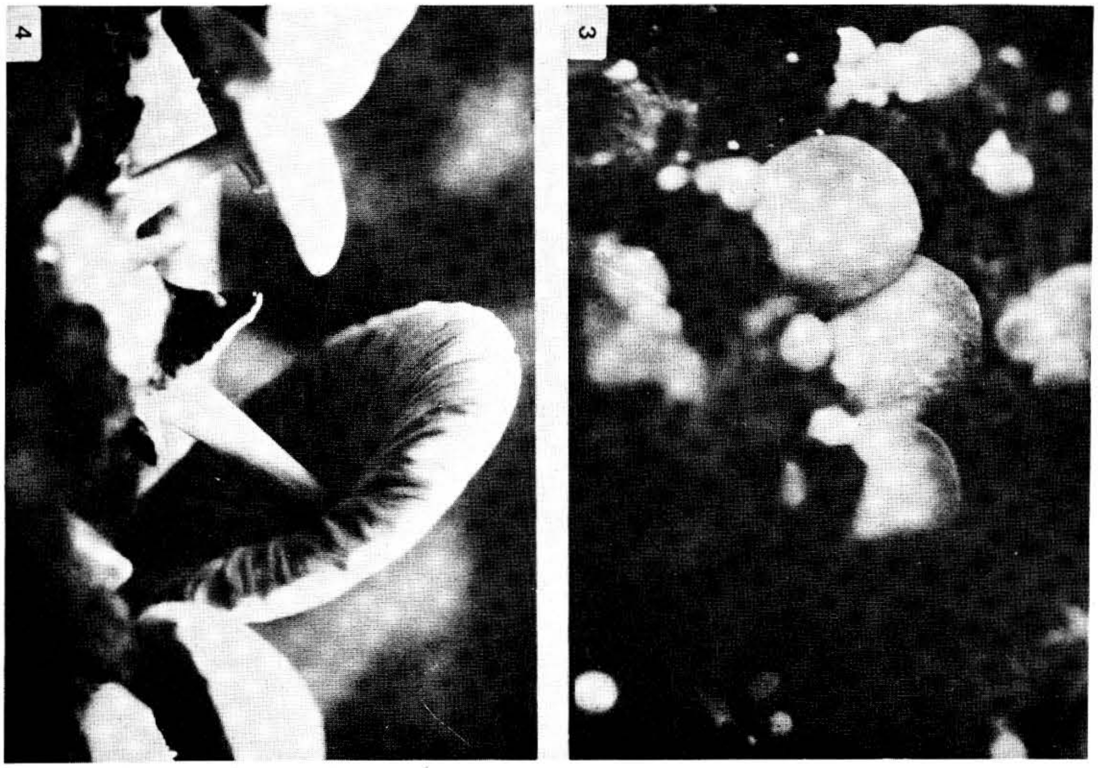
Table I. Composition of 3 compost treatments used in this experiment.

Compost No.	Composition (%)		
	cotton waste	straw	lime
1	97		3
2		97	3
3	48.5	48.5	3



. Figs. 1-2.- Mushroom comercial farm to cultivate *Volvariella volvacea* using cotton waste in Hong Kong. 1: a general view and cotton waste composting on a wooden frame. 2: Mushroom houses and a local-made steam boiler (Photos by Martínez–Carrera).



Figs. 3-4.- 3: Pinhead appearance and button stage of *Volvariella volvacea* growing on cotton waste. 4: Completely developed fruiting body of *Volvariella volvacea* growing on cotton waste after two weeks (Photos by Martínez–Carrera).

Table II. Moisture contents, pH, size and weight of each bed of the 3 compost treatments of this study

Compost No.	moisture content	pH		each replicate		
	before filling	before pasteurization	after pasteurization	area (m^2)	dry weight (Kg)	Kg/m^2
1	66 %	7.8	7.2	0.279	3.43	12.29
2	76 %	7.8	7.2	0.557	3.43	6.16
3	72 %	7.5	7.0	0.465	3.43	7.38

Table III. Yield of *Volvariella volvacea* from each bed of 3 different compost treatment (fresh weight: Kg)

							lst. flush			2nd. flush				lst. & 2nd. flush			
1	2	Days after spawning					Yield				Yield						
		6	7	8	9	Total days	Total Weight (Kg)	Kg/m²	BE %	Total days	Total Weight (Kg)	Kg/m²	BE %	Total days	Total wt (Kg)	Kg/m²	BE %
A	1	P-1				12	1.48	5.30	43.1	7	0.20	0.72	5.8	19	1.68	6.02	49.0
	2	P-1				12	1.53	5.48	44.6	7	0.20	0.72	5.8	19	1.73	6.20	50.4
	3		P-1			12	1.19	4.27	34.7	8	0.22	0.79	6.4	20	1.41	5.05	41.1
	4		P-1			12	1.47	5.27	42.8	8	0.26	0.93	7.6	20	1.73	6.20	50.4
	5		P-1			12	1.11	3.98	32.4	8	0.23	0.82	6.7	20	1.34	4.80	39.1
	6		P-1			13	1.14	4.09	33.2	7	0.17	0.61	5.0	20	1.31	4.70	38.2
	7		P-1			13	1.17	4.19	34.1	7	0.17	0.61	5.0	20	1.34	4.80	39.1
	8		P-1			12	1.05	3.76	30.6	8	0.25	0.90	7.3	20	1.30	4.70	37.9
	9		P-1			12	1.14	4.08	33.2	8	0.20	0.72	5.8	20	1.34	4.80	39.1
	10		P-1			12	1.30	4.66	37.9	8	0.14	0.51	4.1	20	1.44	5.16	42.0
B	1		P-1			12	0.35	0.63	10.2	9	0.11	0.20	3.2	21	0.46	0.83	13.4
	2			P-1		13	0.36	0.65	10.5	8	0.11	0.20	3.2	21	0.47	0.84	13.7
	3			P-1		13	0.49	0.88	14.3	8	0.09	0.16	2.6	21	0.58	1.04	16.9
	4				P-1	15	0.43	0.77	12.5	7	0.14	0.25	4.1	22	0.57	1.02	16.6
	5				P-1	14	0.52	0.93	15.2	8	0.11	0.20	3.2	22	0.63	1.13	18.4
	6				P-1	14	0.26	0.47	7.6	7	0.14	0.25	4.1	21	0.40	0.72	11.7
	7			P-1		12	0.43	0.77	12.5	9	0.14	0.25	4.1	21	0.57	1.02	16.6
	8				P-1	14	0.46	0.83	13.4	8	0.11	0.20	3.2	22	0.57	1.02	16.6
	9				P-1	14	0.43	0.77	12.5	8	0.09	0.16	2.6	22	0.52	0.93	15.2
	10				P-1	14	0.39	0.70	11.4	8	0.09	0.16	2.6	22	0.48	0.86	14.0
C	1		P-1			12	0.86	1.85	25.1	8	0.14	0.30	4.1	20	1.00	2.15	29.2
	2		P-1			11	0.97	2.09	28.3	9	0.18	0.39	5.2	20	1.15	2.47	33.5
	3		P-1			11	0.92	1.98	26.8	8	0.15	0.32	4.4	19	1.07	2.30	31.2
	4		P-1			12	0.86	1.85	25.1	8	0.17	0.37	5.0	20	1.03	2.22	30.0
	5		P-1			12	0.81	1.74	23.6	8	0.14	0.30	4.1	20	0.95	2.04	27.7
	6		P-1			12	1.14	2.45	33.2	8	0.11	0.24	3.2	20	1.25	2.69	36.4
	7		P-1			12	1.00	2.15	29.2	8	0.09	0.19	2.6	20	1.09	2.34	31.8
	8		P-1			12	1.11	2.39	32.4	8	0.12	0.26	3.5	20	1.23	2.65	35.9
	9		P-1			12	0.90	1.94	26.2	8	0.15	0.32	4.4	20	1.05	2.26	30.6
	10		P-1			12	0.77	1.66	22.4	8	017	0.37	5.0	20	0.94	2.02	27.4

1 = Compost treatment, A: 97% cotton waste and 3% lime; B: 97 % paddy straw and 3% lime, and C: 48.5 % paddy straw and 3% lime

P-1 = Pinhead appearance of lst. flush

2 = No. of bed.

Tabla IV. The average yield for the 3 compost treatment used in the present study (Mean ± standard deviation)

Compost	lst. flush		2nd. flush		lst. + 2nd. flush	
No.	Kg/m²	BE(%)	Kg/m²	BE(%)	Kg/m²	BE(%)
1	4.51 ± 0.59	36.7 ± 4.83	0.73 ± 0.13	6.0 ± 1.03	5.24 ± 0.60	42.6 ± 4.93
2	0.74 ± 0.13	12.0 ± 2.08	0.20 ± 0.03	3.3 ± 0.59	0.94 ± 0.12	15.3 ± 1.95
3	2.01 ± 0.25	27.2 ± 3.38	0.31 ± 0.06	4.2 ± 0.80	2.31 ± 0.22	31.4 ± 2.95

BE = Biological Efficiency

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