TWO MEDIA FOR THE RAPID GROWTH OF PLEUROTUS SPECIES

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ABSTRACT

A growth medium composed of ground sorghum grains was found to be suitable for the vegetative growth of edible *Pleurotus* species. A partially defined medium based on components of sorghum grains was also found to be superior to other media commonly used for vegetative growth of *Pleurotus spp.*

INTRODUCTION

The mushroom *Pleurotus ostreatus* (Jacq. ex Fr.) Kummer has been used both for the commercial production of fruiting bodies (Zadrazil, 1978) and as a model in studies of lignin biodegradation (Hiroi and Eriksson, 1976). The mushroom *Pleurotus cystidiosus* (O. K Miller) is gaining popularity in Taiwan as a commercial strain for the production of fruiting bodies (Jong and Peng, 1975).

A major problem encountered in research of these two organisms is their relatively slow growth on common mycological media. Eger (1978) has used a specially prepared malt medium to overcome this problem whereas Zadrazil (1978) suggested a rich medium based on malt extract, soybean flour peptone and yeast extract for the growth of all *Pleurotus* species. In this article we show the use of a sorghum medium and a synthetic nutrient medium for rapid growth of these two species.

MATERIALS AND METHODS

Pleurotus ostreatus (Jacq. ex Fr.) Kummer strain 3004 obtained from Somycel Ltd., France (Oyster mushroom) and *P. cystidiosus* (O. K. Miller) obtained from Dr. Peng of the Taiwan Agricultural Research Institute, Taiwan (abalone mushroom) were used as test organisms. Cultures were maintained on malt extract agar slants at 4°C and transferred to fresh medium every 3 months. All experiments were carried out in 9 cm diameter Petri dishes at 30°C. Mycelial discs (0.5 cm diam.) cut from the growing edge of a colony were used for inoculum. The following growth media were used: a) Homogenized grain medium. Thirty gm samples of grain were milled, suspended in 1 litre distilled water, supplemented with 1% agar (difco) and autoclaved. Grains used were wheat, barley, rye, panicum, oat, corn, setaria, vidan, sorghum, bean or chickpea. b) Undefined media (g/l): 1) malt extract medium (difco) 12. 2) commercial *Agaricus* compost medium. 3) Compost extract medium (water extract of 30 g compost in 1 litre of distilled water). 4) General organic medium: soybean flour 65, starch 6.5, carboxymethyl cellulose 10, lignin 6.5 (Indulin A. T. Westavco chemicals), $CaCl_2.2H_2O$ 0.15, NaCl 0.15, $CoCl_2$ 0.05, $CuSO_4.5H_2O$ 0.05, $MgSO_4.7H_2O$ 0.03, $MnSO_4$ 0.085, KH_2PO_4 0.05, $ZnSO_4$ 0.03, vitamin A 0.1, vitamin B 0.06, biotin 5×10^{-4}, distilled water 650. All media were supplemented with 2% agar. c) Synthetic media (g/l): 1) Maltose 23.4; glucose 8.7; sucrose 0.8; dextrin 6.75; KCl 0.2; $MgSO_4.7H_2O$ 0.2; $CaCl_2.2H_2O$ 0.2; $FeSO_4.7H_2O$ 0.001; $NaHPO_4.2H_2O$ 0.06; biotin 5×10^{-6}; thiamine 2×10^{-4}; ethyl acetate 0.01 ml; agar 20 (Hayes, 1979). 2) Casein hydrolysate medium, casein hydrolysate 65; starch 165; carboxymethyl cellulose 10; lignin 6.5; and minerals as above. Biotin, thiamine or vitamins were sterilized separately by filtration through a milipore 0.45 μ filter and added aseptically to the autoclaved media.

RESULTS AND DISCUSSION

Pleurotus mushrooms are notorious for their slow growth rate as compared to other basidiomycetes on agar media (Chet and Henis, 1975). The effect of individual nutrients such as amino acids, N-sources, C-sources, sugars, vitamins and various grain straws on the growth of *P. ostreatus* and *P. florida* has been investigated (Koch, 1958; Eger, 1965, 1970; Voltz, 1972; Poppe, 1973; Eger, et al., 1974; Hashimoto and Takahashi, 1974; Kurtzman, 1974; Zadrazil, 1978). So far, no medium which allows rapid growth has been suggested, and most recent studies use the traditional mycological media (malt extract, PDA, etc.). In this work it was demonstrated that *Pleurotus* spp. grew at the highest rate on homogenized sorghum grain medium (Table 1). On this medium mycelium grew quickly and abundantly at a constant rate

Table 1. Growth of *P. ostreatus* and *P. cystidiosus* on various media

Medium Type	Component	Growth after 8 days (mm)[a] *P. ostreatus*	*P. cystidiosus*	Remarks
Homogenized grain	wheat	60	30	
	barley	55	25	
	rye	58	25	luxurient
	panicum	62	27	myceliabl growth
	oat	50	20	
	corn	60	26	
	setaria	57	25	
	vidan	80	44	
	sorghum (s)	85	45	
	s + 0.3% compost	85	45	
	s + 0.5% compost	85[b]	45	
	s + 1.0% compost	85[b]	45	
	s + 3.0% compost	85[b]	45	
	s + biotin	77	43	
	s + thiamine	85[b]	45	
	s + thiamine & biotin	85[b]	45[b]	
	bean	50	19	
	chickpea	48	18	
Undefined	malt extract	37	31	very sparse
	Agaricus compost	85[b]	44	mycelial growth
	compost extract	75	30	
	general organic	59	45	luxurient mycelial growth
Synth-etic	synthetic	24	32	scanty growth
	casein hydrolysate	22	15	

a: mean of 10 replicates
b: growth after 7 days.

(10.6 mm/day as compared to 4.6 mm/day on malt extract medium) and reached the edge of the Petri dish in 8 days. Addition of biotin, thiamine or *Agaricus* compost to the sorghum medium (10 μg/1, 10 μg/ml and 5-30 g/l respectively) shortened the time required by the fungus to reach the plate's edge to 7 days. When the *Pleurotus* fungi were grown on *Agaricus* compost or on water extract of this compost, although hyphae spread relatively rapidly, the mycelium was scarcely visible to the naked eye. The same type of growth was obtained on a synthetic medium but the rate of growth was slower. When the common malt extract medium was compared to the general organic medium developed, based on the chemical components of the sorghum grain and having approximately the same nutritional value, it became clear that the two fungi preferred it. Growth rate was similar to that obtained on wheat, corn or panicum grain medium for *P. ostreatus* and equal to the sorghum medium when *P. cystidiosus* was tested.

The growth rates of *P. ostreatus* and *P. cystidiosus* on sorghum medium, malt extract medium, general organic medium and synthetic medium are shown in Figure 1A and B, from which it may be seen that the growth rate for these fungi is higher on sorghum and general organic than on any other medium.

It appears that these two media may prove useful in areas of research that require a rapid growth of mycelium such as evaluation of spawn quality for mushroom production and in nutritional studies.

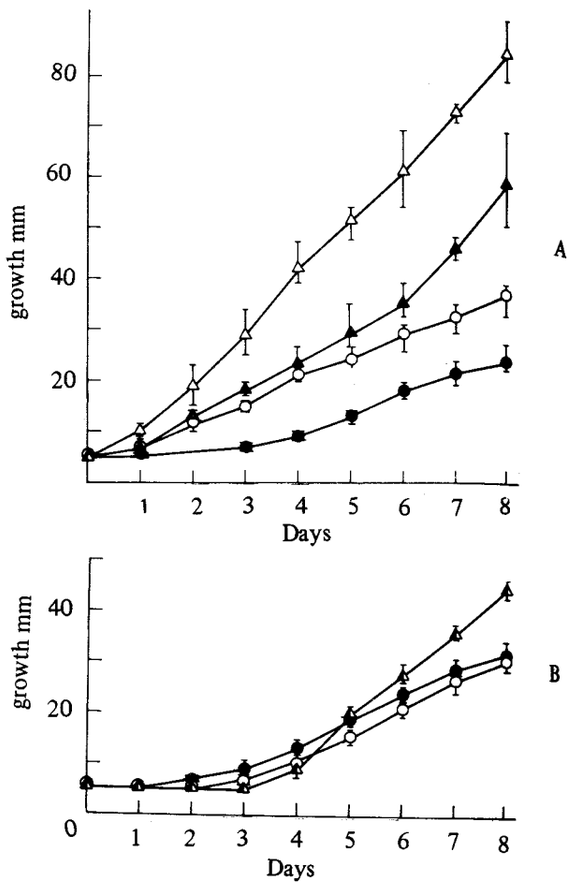

Fig. 1. Growth rates of *Pleurotus ostreatus* (A) and P. cystidiosus (B) on sorghum medium (△ – △), general organic medium (▲ – ▲), malt extract medium (o – o) and synthetic medium (● – ●) respectively.

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CONSUMPTION OF EDIBLE MUSHROOMS IN HONG KONG

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INTRODUCTION

The edible mushrooms are considered as a healthy food because the mineral content of mushrooms is higher than meat or fish and almost twice that of any other vegetables. Furthermore, the protein content of fresh mushroom is about twice that of vegetables and four times that of oranges. All the mushroom proteins contain all nine amino acids essential for man, and they are especially rich in lysine and leucine, which are lacking in most staple cereal foods. Mushrooms are devoid of starch and low in calories and carbohydrates, so mushrooms are an ideal food for diabetics and for anyone not wishing to put on weight.

The Hong Kong Government has much analytical information about crops, poultry, livestock and fish but little on mushroom. In other countries, for example, West Germany, U. S. A. and Canada, there is information on local per capita consumption of mushroom but this is not available in Hong Kong. Since it seems to be true that in the future mushroom will become one of the palatable and nutritious vegetables in the world, a preliminary survey of the consumption and economic of mushrooms in Hong Kong is important. In this paper, the consumption of

Table 1. The most common edible mushroom in Hong Kong

Types	Common name	Scientific name
Fresh	Straw mushroom	*Volvariella volvacea*
	White mushroom	*Agaricus bisporus*
Dried	Shiitake	*Lentinus edodes*
	White jelly fungus, silver ear	*Tremella fuciformis*
	Jew's ear, Wood ear	*Auricularia* spp.
Canned	Straw mushroom	*Volvariella volvacea*
	White mushroom	*Agaricus bisporus*
	Oyster mushroom	*Pleurotus* spp.

fresh mushroom, dried mushroom and canned mushroom in Hong Kong (Table 1) is discussed.

The fact-finding techniques used are by interviewing with imports, exports firms, fruit and vegetable buying agents and Hong Kong Trade Development Council, and by investigating documents provided by various Government departments, such as Agriculture and Fisheries, Census and Statistics and Trade Industry and Customs Departments.

FRESH MUSHROOM

The supply of fresh mushroom is mainly from Mainland China and local source. About 99% of the fresh mushroom consumed is straw mushroom and only 15 is white mushroom.

A. Fresh straw mushroom

Straw mushroom is the major mushroom cultivated in Hong Kong. There are about 40 mushroom farms. They all produce straw mushroom and only 2 farms also cultivate white mushroom.

The genral housewives seem to prefer the straw grown mushroom and thus the price of local straw mushroom, which is grown on cotton waste, does not increase much despite of the ever increasing labour and material costs.

However, even with these problems, the development of mushroom cultivation in Hong Kong has been gradually increasing during the past six years (Table 2).

Table 2. Development of straw mushroom cultivation in Hong Kong

	1974	1979	Percent increased in 6 years
Number of farm	13	40	207.7
Growing area	7,440 m^2	27,900 m^2	275.0
Local production	110 T	611 T	455.5

Source: Ho (1980).

Mainland China is the largest importer of fresh straw mushroom. It supplied about 78% of the total local demand in 1974 but the supplies gradually dropped to 53% in 1979 (Table 3). This is due to the rapid development of the local mushroom industry. The cheapest wholesale price of 1 kg straw mushroom is about HK$5 but the highest one may reach HK$9. The average price is about HK$7 per kg.

Fresh mushroom imports from Taiwan and Thailand gradually have decreased from 14.3% in 1973 to 1.1% in 1979 (Table 3). It is because the fresh mushrooms are transported by air. This results in higher costs and bad quality. Thus, it is difficult for Taiwan and Thailand to compete with the local suppliers and Mainland China. The average wholesale price of the fresh mushroom from Taiwan and Thailand is about HK$7 per kg.

B. Fresh white mushroom

Besides local sources, Mainland China and Taiwan supply the local demand of fresh white mushroom. The local farms constantly produce 75 kg per day with the retail price about HK$30 per kg in 1980.

The amount of fresh white mushroom imported by sea from Mainland China is around 3,000 to 5,000 kg per year, and the price is about HK$7-10 per kg. Those from Taiwan are imported by air and it costs HK$7-9 per kg.

Table 3. Supply of fresh mushroom in Hong Kong (1974-1979)

Place		1974	1975	1976	1977	1978	1979
Local	Quantity (x 1000 kg)	110	140	170	180	210	611
	Percentage	8.0	10.1	12.1	12.7	15.2	45.7
	Value (million HK$)	0.74	0.94	1.07	1.21	1.41	4.10
Mainland China	Quantity (x 1000 kg)	1,080	1,050	1,100	1,130	970	711
	Percentage	77.7	76.1	78.0	79.6	70.2	53.2
	Value (million HK$)	7.26	7.06	6.90	7.60	6.52	4.92
Others: Taiwan & Thailand	Quantity (x 1000 kg)	200	190	140	110	120	15
	Percentage	14.3	13.8	9.9	7.7	14.6	1.1
	Value	1.34	1.28	0.88	0.74	0.81	0.10
	Total quantity	1,390	1,380	1,410	1,420	1,300	1,337
	Total value	9.34	9.28	8.85	9.55	8.74	9.12

Source: Agriculture and Fisheries Department, Hong Kong.

C. Local consumption of fresh mushroom in Hong Kong

In 1979, local production of fresh mushroom supplied 45.7% of the total demands while in 1974 it was only 8% (Table 3). Nevertheless, there is still much room for future development of straw mushroom cultivation in Hong Kong.

DRIED MUSHROOM

Shiitake, white jelly fungus and Jew's ear are the most commonly consumed dried mushroom in Hong Kong.

Japan, South Korea and Mainland China are the major importers of Shiitake, and Japan is the largest importer.

The white jelly fungus and Jew's ear are imported from Mainland China and Taiwan.

All the dried mushrooms are transported by ship or container. It is because the dried mushroom can be preserved for a long period and the cost of transportation is lower.

In 1979, Japan supplied about 85% of the local demand of the dried mushroom while South Korea, Mainland China and Singapore together only supplied about 15%. About 110 tons dried mushroom imported from Japan and Mainland China into Hong Kong are for re-export to U. S. A. and ECC. Therefore, the local consumption of dried mushroom can be calculated by subtracting the re-export by imports (Table 4). The local consumption of dried mushroom was about 1,700 tons (dry weight) in 1979.

The equivalent weight of dried mushroom can be worked out by multiplying the dried weight with the conversion factor "7" (Delcaire, 1978).

Although this formula applies mainly to the conversion of Shiitake, it is assumed here that this also holds for all other dried mushrooms because of the limited available information and the dried Shiitake is the most commonly consumed dried mushroom in Hong Kong.

Table 4. Local consumption of dried mushroom (1974-1979)

year	total	dry weight	equivalent fresh weight
1974	Quantity*	1,799.2	12,594.40
	Value**	109.9	
1975	Quantity*	1,763.9	12,347.30
	Value**	100.1	
1976	Quantity*	1,374.9	9,624.30
	Value**	104.4	
1977	Quantity*	1,311.0	9,177.00
	Value**	121.8	
1978	Quantity*	1,793.0	12,551.00
	Value**	180.4	
1979	Quantity*	1,733.0	12,131.00
	Value**	176.7	

* unit in 1,000 kg
** unit in million HK$.

Soruce: Hong Kong Trade Statistics: Imports (1974-1978), Trade Industry and Customs Department, Hong Kong.

CANNED MUSHROOM

There are three main types of canned mushrooms consumed in Hong Kong. They are straw mushroom, white mushroom and oyster mushroom.

A. Export

Hong Kong also sells some canned mushrooms to other countries such as U. S. A., West Germany and ECC and the U. S. A. is the major importer. Some salted mushrooms which are imported from other countries (for example, Mainland China) are canned in Hong Kong. This is why there are canned mushrooms for export.

Some canned mushrooms imported from Mainland China and Taiwan are re-exported to other countries, for example, U. S. A., West Germany and ECC. The amount was about 6,000 tons in 1979.

B. Import

The canned oyster mushroom is mainly imported from Taiwan but recently some is imported from Mainland China. Canned white mushroom is mainly imported from Mainland China and Taiwan. Only a small amount comes from France and Spain. the expartriates in Hong Kong like to eat the canned white mushroom. Those canned straw mushrooms from Mainland China and Taiwan are used by restaurants and homes.

All the canned mushrooms are transported by ship or container. About 80% of the canned mushrooms is supplied by Mainland China. Taiwan, the second largest importer, supplies only 20% of the local demand of canned mushroom (Table 5). The total local consumption of different kinds of canned mushroom is about 5,300 tons equivalent fresh weight. If it is assumed that each can cost HK$3, the total value of canned mushrooms is about 42 million Hong Kong dollars.

The equivalent fresh weight of canned mushrooms is calculated by dividing the net drained weight by 0.6. This is because it is estimated that 1 kg fresh weight gives 600 g net drained weight (Delcaire, 1978).

TOTAL PER CAPITA CONSUMPTION OF EDIBLE MUSHROOMS

The details of calculation is given in Table 6. Adding the consumption of fresh, dried and canned mushrooms gives the total mushroom consumed per year. The total amount is 18,764 tons in equivalent fresh weight. With a population of 4.9 million in 1979[1], it gives the total per capita consumption of edible mushrooms of 3.8 kg per year.

[1]The data is obtained from "Hong Kong in Figures, 1980 Edition" published by Census and Statistics Department, Hong Kong.

Table 5. Local consumption of different kinds of canned mushroom (1979)

Imported from	Straw Mushroom*	White Mushroom*	Oyster Mushroom*	Total*	Total**
China	1,400.0	1,000.0	–	2,400.0	4,000.0
Taiwan	386.4	331.2	55.2	772.8	1,288.0
France & others	–	4.7	–	4.7	7.8

* unit in 1000 kg of net drained weight.
** unit in 1000 kg of equivalent fresh weight.

Source: The data were estimated from different sources.

Table 6. Calculation of the total per capita consumption of edible mushrooms in Hong Kong (1979)*

Consumption per year (x 1000 kg)	Equivalent fresh weight
Fresh mushroom	1,337
Dried mushroom	12,131
Canned mushroom	5,296
Total mushroom	18,764
Total per capita (x 1 kg)	3.8

* Population in 1979 = 4.9 millions

Table 7. Local consumption of fresh, dried and canned mushroom in equivalent fresh weight in 1979

	Quantity x 1000 kg	%	Value (million HK$)
Fresh mushroom	1,337	7	9
Dried mushroom	12,131	65	177
Canned mushroom	5,296	28	42
Total	18,764	100	228

Table 7 shows the local consumption of fresh, dried and canned mushrooms in 1979. It is important to note that the dried mushroom (mainly *Lentinus* mushroom) valued up to 177 million Hong Kong dollars.

CONCLUSION AND DISCUSSION

The four major mushrooms consumed in Hong Kong are (1) the canned and fresh white mushroom *(Agaricus bisporus)*, Taiwan (canned); (2) the dried Shiitake *(Lentinus edodes)* from Japan and South Korea; (3) the fresh straw mushroom *(Volvariella volvacea)* from Mainland China and local sources while the canned one from Mainland China and Taiwan; (4) canned oyster mushroom (*Pleurotus* spp.) from both Taiwan and Mainland China.

In 1979, the total per capita consumption of mushroom in Hong Kong is 3.8 kg equivalent fresh weight per year, of which 7% is fresh, 65% is dried and 28% is canned mushrooms. Fresh straw mushroom and dried Shiitake are more favoured by the people of Hong Kong. Local production of fresh straw mushroom now supplies 45.6% of the total local demands while in 1974 is was only 8%.

As people become wealthier, their consumption of mushroom will increase. The per capita consumption of *Agaricus* mushroom increased by 3 to 5 times in West Germany, Canada,