

## Cultural Characteristics of Veiled Lady Mushroom, *Dictyophora* spp.

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This study was carried out to obtain the basic data for artificial culture of veiled lady mushroom (*Dictyophora* spp). The optimal conditions for the mycelial growth were 25°C and pH 5.0 for all isolates except the optimal temperature of 30°C for *D. echinovolvata* ASI 32002 and *Phallus rugulosus*. The optimal medium for *Dictyophora* spp. was PBA (potato bamboo sawdust extract agar) medium. The strain ASI 32002, *D. echinovolvata*, grew faster than *D. indusiata* ASI 32003 and *Phallus rugulosus* ASI 25007 on the medium. Carbon sources such as glucose, maltose and inuline were favorable for stimulating a mycelial growth of the two strains of ASI 32002 and ASI 32003. Asparagine and glutamine appeared to be favorable to the strain ASI 32002 and ASI 32003, where as alanine, one of nitrogen source also favorable to the strain ASI 32002. The optimum C/N ratio of the two isolates of ASI 32002 and ASI 32003 was about 25 : 1 when 2% glucose as carbon source was mixed with the basal medium. While, in the case of 4% as carbon source, the optimum C/N ratio was about 30 : 1.

**KEYWORD:** Artificial cultivation, *Dictyophora* spp., PBA medium, Veiled lady mushroom

*Dictyophora* species, one of the high quality cooking mushrooms belongs to Phallaceae, Phallales, Gasteromycetidae of Basidiomycetes, and it has been called bamboo sprouts, or veiled lady mushroom as common name. Also, there are many local names such as Jukson, Juksang, bamboo ginseng, net mushroom, and helmet mushroom, respectively. Moreover it is known as queen of mushroom or flower of fungi (Li, 1986; Sun, 1991).

Although wild mushrooms have been used as small scale in the past, people are preferable for mushrooms due to either healthy or functional food. Thus, artificial cultivation methods for several edible mushrooms were developed to meet consumers' growing demand. Nowadays, mushroom cultivation became not only a high income source for farmers but also appeared to be a popular healthy food for people.

Since seven species of the mushrooms including *Dictyophora indusiata* has been record throughout world, only one species two form, *D. indusiata* and *D. indusiata* f. *lutea* was reported in Korea. With regard to functional characters, this mushroom had a tonic effect for maintaining healthy lung, liver, brain, kidney and bright eye (Sun, 1991).

Recently, dictyophorine isolated from this mushroom is known to have an effect for synthesizing nerve growth factor (NGF) (Kawagishi *et al.*, 1997). And also antitumor effect was newly reported as a functional ability (Mizuno, 1995). Therefore, artificial production method of the mushroom is required to solve an increasing demand.

In Korea, no studies on artificial cultivation of mushroom have been report at present, although many researches on cultivation of *D. indusiata* (Huang *et al.*, 1994; Jia and Liu,

1992; Jin *et al.*, 1986; Yang and Jong, 1987; Yuan, 1996; Zhou and Qiao, 1989; Zhou *et al.*, 1994), and *D. duplicata* (Luo, 1994; Tong *et al.*, 1992), *D. rubro-volvata* (Fan *et al.*, 1987; Huang and Cao, 1993), *D. echinovolvata* (Hua *et al.*, 1990; Hui *et al.*, 1988) were reported in China.

Therefore, this study was undertaken to find out cultural characteristics of the mushroom to obtain the basic data for applying artificial cultivation method.

### Materials and Methods

#### Cultures

Eleven strains of *Dictyophora* spp. including preservation strain in the Division of Applied Microbiology, NIAST, were used for this experiment in addition to one check isolate belonging to the same family *Phallus rugulosus* ASI 25007. After these strains were cultured on PBA (potato bamboo sawdust extract agar) medium at 25°C for 30 days, the strains were kept at 4°C incubator.

#### Cultural characteristics

After solid spawns of the 12 strains of the fungi (Table 1) were inoculated on sawdust medium in test tube (30 mm diameter) for 30 days at 25°C, mycelial growth was measured.

#### Screening of favorable culture medium

Twelve different culture media were used to investigate a favorable growth of *Dictyophora* spp. (Table 2). After media were autoclaved for 20 minutes at 121°C (15 psi pressure), 20 ml of each agar solution was aseptically poured into a petri-dish. After inoculation of the strains, the cultures were

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**Table 1.** The list of species of *Dictyophora* species used in this study

Scientific name	Isolate	Collection year	Source
<i>D. indusiata</i>	ASI 32001	1997	Bosung, Korea
<i>D. indusiata</i>	ASI 32003	1997	China, Private
<i>D. indusiata</i>	ASI 32005	1998	Damyang, Korea
<i>D. indusiata</i>	ASI 32006	1998	Bosung, Korea
<i>D. indusiata</i>	ASI 32011	1999	ATCC 60890, U.S.A.
<i>D. indusiata</i> f. <i>lutea</i>	ASI 32009	1997	Cheongyang, Korea
<i>D. echinovolvata</i>	ASI 32002	1997	China, Private
<i>D. echinovolvata</i>	ASI 32007	1998	China, Private
<i>D. echinovolvata</i>	ASI 32008	1998	China, Private
<i>D. echinovolvata</i>	ASI 32010	1999	China, Private
<i>Phallus rugulosus</i>	ASI 32004	1998	Gwangyang, Korea
<i>Phallus rugulosus</i>	ASI 25007	1997	Gongjoo, Korea

incubated for 14 days at 25°C. After 14 days incubation the mycelial growth and density were observed.

#### Screening of favorable nutrients for liquid culture

**Carbon source:** To screen favorable carbon sources for stimulating mycelial growth of *Dictyophora* spp., the basal medium used was composed of modified GA medium (glucose 20 g, ammonium tartrate 1.0 g,  $\text{KH}_2\text{PO}_4$  1.0 g,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  0.5 g, ferrous citrate 5 mg,  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  4.4 mg,  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$  5 mg,  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  55.5 mg, thiamine HCl 10 mg, nicotinic acid 10 mg and distilled water 1000 ml) (Lee, 1997). The basal medium was adjusted to pH 6.0 before high-pressure sterilization. With the basal medium containing glucose, each carbon source was added to the basal medium at concentration of 0.2 M per 1 l. All the other processes including the inoculation and measurement of mycelial growth of the

fungus were performed by the standard methods of NIAST (RDA, 1997).

**Nitrogen source:** Except for the addition of 2% glucose as carbon source per 1000 ml of the medium, the basal medium was same as the above. Based on each molecular weight of 12 different nitrogen sources including aniline, each nitrogen source was added to the basal medium at concentration of 0.02 M. All the other processes including the incubation and measurement of mycelial growth were conducted by the standard methods of NIAST (RDA, 1997).

**C/N ratio:** The basal medium which D-glucose as carbon source was mixed at a rate of 2 and 4% (w/v) were added with glutamine and alanine as nitrogen source. Finally, the ratios of glutamine and alanine versus glucose in each basal medium were adjusted to C/N ratio of 10:1, 15:1, 20:1, 25:1 and 30:1, respectively. The basal media were adjusted to pH 6.0, autoclaved for 20 min. at 121°C (15 psi pressure), and poured into petri-dish. Measurement of mycelial dry weight of the fungus was performed by the standard method of NIAST (RDA, 1997).

#### Measurement of optimal temperature and pH

**Temperatures:** To investigate the optimal temperature for stimulating a favorable growth of *Dictyophora* spp. PBA medium was used. A 5 mm diameter plug of an inoculum was inoculated on PBA medium and incubated for 14 days at 15°C, 20°C, 25°C, 30°C and 35°C, respectively. Mycelial growth of the fungus was measured according to standard method.

**pH:** Modified GA (glucose 20 g, asparagine 2 g,  $\text{KH}_2\text{PO}_4$  1 g,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  0.5 g, ferrous citrate 5 mg,  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  4.4 mg,  $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$  5 mg,  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  55.5 mg, thia-

**Table 2.** Composition (g/l) of culture media for the *Dictyophora* species

	PDA	PPA	PMA	PBA	BMA	CDA	YMA	MCM	HA	MEA	Lilly	Czapek-Dox
potato	200	200	200	200								
dextrose	20	20	20	10	20	10	10	20	20			30
peptone		1	1	1	1	1	5			5		
malt extract			7	7	7	7	3			20		
bamboo sawdust				20	20							
dry compost						40						
maltose											10	
DL-asparagine											2	
yeast extract							3	2	2			
$\text{KH}_2\text{PO}_4$		1	1	1	1	1		0.4			1	1
$\text{K}_2\text{HPO}_4$								1				
$\text{MgSO}_4$		0.5	0.5	0.5	0.5	0.5		0.5			0.5	0.5
$\text{NaNO}_3$												2
KCl												0.5
$\text{FeSO}_4$												0.01
agar	20	20	20	20	20	20	20	20	20	20	20	20

\*PDA (potato dextrose agar), PPA (potato peptone agar), PMA (potato malt extract agar), PBA (potato bamboo extract agar), BMA (bamboo malt extract agar), CDA (compost dextrose agar), YMA (yeast malt extract agar), MCM (mushroom complete media), HA (Hamada media), MEA (malt extract agar).

mine HCl 10 mg. nicotinic acid 10 mg and distilled water 1000 ml) medium was used to screen pH level suitable for a favorable growth of *Dictyophora* spp. After 5 mm diameter plug of an inoculum was removed with cork borer from 14 days old cultures of *Dictyophora* spp. grown on PBA medium, the plug placed in the center of each agar plate of sterile modified GA medium adjusted to the range of pH 2.0~7.0 with 1 N NaOH or HCl, and incubated for 14 days at 25°C.

## Results and Discussion

### Screening of favorable culture medium

Mycelial growth of the strains of *Dictyophora* spp. was compared by using pine bamboo sawdust medium after filled up in 30 mm diameter test tube (Table 3). *D. echinovolvata* showed the fastest growth-rate compared to other strains used, and *Phallus rugulosus*, *D. indusiata* and *D. indusiata* f. *lutea* were next, respectively.

In order to select effective materials for mass culturing of the veiled lady mushroom, five natural nutrients such as bamboo sawdust, pine leaf, onion and potato bamboo sawdust sugar medium were investigated as a basic experiment. PBA showed the fastest in mycelial growth compared to other media and compact mycelial density as well (Table 4). Among twelve different culture media used, it was found that PBA medium was best medium with regard to mycelial growth and colony density (Table 5).

Furthermore, PBA medium was better than PPA used by Son (1991) and ATCC-1070 medium recommended by ATCC, although speedy mycelial growth of the mushroom was shown on bamboo extract PMA medium in comparison with PDA, MEA, YMA and MCM. On the other hand, *Dictyophora*

**Table 3.** Comparison of mycelium growth for the different species of *Dictyophora* species cultured in test tube<sup>1)</sup> with the pine bamboo sawdust at 25°C for 30 days

Species	Strain	Mycelial growth length (mm)
<i>D. indusiata</i>	ASI 32001	37.3 d <sup>2)</sup>
	ASI 32003	33.7 e
	ASI 32005	32.3 e
	ASI 32006	31.3 e
	ASI 32011	31.7 e
<i>D. echinovolvata</i>	ASI 32002	56.3 a
	ASI 32007	51.7 b
	ASI 32008	56.7 a
	ASI 32010	52.3 b
<i>D. indusiata</i> f. <i>lutea</i>	ASI 32009	10.7 f
<i>Phallus rugulosus</i>	ASI 32004	45.0 c
	ASI 25007	45.7 c

<sup>1)</sup>φ30 mm test tube, filled with pine sawdust and bamboo sawdust + rice bran (7 : 1 : 2 ratio) solid medium with moisture of 65% incubated at 25°C for 30 days.

<sup>2)</sup>The letter is significantly different at p=0.05 level by Duncan's multiple range test.

**Table 4.** Selection of optimal medium of mycelial growth of *Dictyophora* species

Substrates	<i>D. echinovolvata</i> ASI 32002		<i>D. indusiata</i> ASI 32003	
	Mycelial growth (mm/14 days)	Mycelial density <sup>1)</sup>	Mycelial growth (mm/14 days)	Mycelial density <sup>1)</sup>
Bamboo sawdust <sup>2)</sup>	65.7 b <sup>7)</sup>	MC	35.0 b <sup>7)</sup>	MC
Bamboo leaf <sup>3)</sup>	60.7 c	C	39.0 a	MC
Pine leaf <sup>4)</sup>	64.0 b	C	30.0 c	C
Onion <sup>5)</sup>	53.3 d	MC	35.7 b	L
Potato + bamboo sawdust <sup>6)</sup>	69.7 a	DC	38.3 a	C
PDA(Control)	20.3 e	DC	17.0 d	DC

<sup>1)</sup>Mycelial density : Loose (L), Moderately compact (MC), Compact (C), Densely compact (DC).

<sup>2-6)</sup>Additive for the treatments (g/l).

<sup>2-4)</sup>sugar 10, malt ext. 7.

<sup>5)</sup>sugar 30, peptone 3.

<sup>6)</sup>bamboo sawdust 20 g, potato 200 g, sugar 10 g, malt ext. 7 g.

<sup>7)</sup>The letter is significantly different at p=0.05 level by Duncan's multiple range test.

spp. appeared a poor growth on YMA medium, regardless of two different species of the mushroom. The mycelial growth of 12 different culture media was observed in the range of 5.0~69.0 mm for 14 days. In general, *D. echinovolvata* showed faster mycelial growth than *D. indusiata*. The mycelial density of *Dictyophora* spp. on PBA medium was rather inferior to those of PDA and MEA.

### Effect of nutritional sources

**Carbon sources:** To screen favorable carbon sources capable of stimulating mycelial growth of *Dictyophora* spp. the basal medium was used with modified GA medium that is composed of glucose 20 g, asparagine 2 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, ferrous citrate 5 mg, ZnSO<sub>4</sub> · 7H<sub>2</sub>O 4.4 mg, MnSO<sub>4</sub> · 4H<sub>2</sub>O 5 mg, CaCl<sub>2</sub> · 2H<sub>2</sub>O 55.5 mg, thiamine HCl 10 mg, nicotinic acid 10 mg and distilled water 1,000 ml, and pH was adjusted at 5.0. Among 15 carbon sources, 9 carbon sources were favorable to the mycelial growth of two strains of *Dictyophora* spp compared with control (Table 6). Mycelial growth of *D. echinovolvata* was most favorable on the medium which were supplemented with glucose, mannose and maltose, and recorded colony diameter 32.3~20.3 mm while, in the case of *D. indusiata*, glucose, maltose and mannose and were favorable for the mycelial growth.

**Nitrogen sources:** Among 12 nitrogen sources including alanine, it showed that alanine appeared to stimulate a mycelial growth of *D. echinovolvata*, whereas, in the case of *D. indusiata*, good mycelial growth was resulted in asparagine, aspartic acid and glutamine (Table 7).

There was no mycelial growth on the medium which were

**Table 5.** Effect of various media on mycelial growth of *Dictyophora* species

Culture medium	<i>D. echinovolvata</i> ASI 32002		<i>D. indusiata</i> ASI 32003	
	Mycelial growth (mm/14 days)	Mycelial density <sup>1)</sup>	Mycelial growth (mm/14 days)	Mycelial density <sup>1)</sup>
	PPA <sup>2)</sup>	50.3 c <sup>3)</sup>	C	20.3 e <sup>3)</sup>
CDA	17.3 f	DC	8.0 g	DC
PMA	15.7 fg	DC	12.3 f	C
BMA	65.7 a	C	30.8 a	MC
PBA	69.0 a	DC	26.7 b	DC
MEA	50.7 c	DC	26.0 bc	C
HA	53.3 bc	C	25.3 bc	DC
YMA	12.7 g	MC	9.0 fg	MC
MCM	43.0 d	C	18.3 de	MC
Lilly	43.0 d	MC	22.3 cd	MC
Czapek	57.3 b	L	5.0 g	L
PDA(Control)	38.3 e	DC	17.3 de	DC

<sup>1)</sup>Mycelial density : Loose (L), Moderately compact (MC), Compact (C), Densely compact (DC).

<sup>2)</sup>PPA (potato 200 g, sugar 20 g, peptone 1 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, agar 20 g), CDA (dry compost 40 g, sugar 10 g, malt extract 7 g, peptone 1 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, agar 20 g), PMA (potato 200 g, sugar 20 g, malt extract 7 g, peptone 1 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, agar 20 g), BMA (bamboo sawdust 20 g, sugar 20 g, malt extract 7 g, peptone 1 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, agar 20 g), PBA (potato 200 g, bamboo sawdust 20 g, sugar 10 g, malt extract 7 g, peptone 1 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, agar 20 g), MEA (malt extract 20 g, peptone 5 g, agar 20 g), HA (sugar 20 g, yeast extract 2 g, agar 20 g), YMA (yeast extract 3 g, malt extract 3 g, peptone 5 g, sugar 10 g, agar 20 g), MCM (sugar 20 g, yeast extract 2 g, KH<sub>2</sub>PO<sub>4</sub> 0.4 g, K<sub>2</sub>HPO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, agar 20 g), Lilly (maltose 10 g, DL-asparagine 2 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g, Agar 20 g), Czapek-Dox (sugar 30 g, NaNO<sub>3</sub> 2 g, K<sub>2</sub>HPO<sub>4</sub> 1 g, MgSO<sub>4</sub> · 7H<sub>2</sub>O 0.5 g, KCl 0.5 g, FeSO<sub>4</sub> 0.01 g, agar 20 g), PDA (potato 200 g, sugar 20 g, agar 20 g).

<sup>3)</sup>The letter is significantly different at p = 0.05 level by Duncan's multiple range test.

supplemented with nitrogen source such as lysine, arginine, isoleucine. Generally, it was confirmed that most of 12 nitrogen sources didn't have a distinct effect on favorable growth of the mushroom (Table 7).

**Optimum C/N ratio:** Optimum C/N ratio suitable for a favorable growth of *D. echinovolvata* and *D. indusiata* was observed on the GA culture medium which were adjusted to ratio of glucose to each one of alanine and glutamine. On the culture medium which were mixed 2% and 4% of glucose as carbon source and them adjusted to the C/N ratio as 10 : 1, 15 : 1, 20 : 1, 25 : 1, 30 : 1, respectively. In the case of 2% in carbon concentration, the most favorable C/N ratio was 25 : 1 with the two species as 28.7 mg and 28.5 mg as mycelial dry weight. On the other hand in case of lower C/N ratio, mycelial growth was rather poor.

#### Optimal temperature

Among *Dictyophora* spp. cultured on PBA medium at dif-

**Table 6.** Effect of carbon sources on the mycelial growth of *Dictyophora* species

Carbon source	Dry weight (mg/100 ml/30 days)	
	<i>D. echinovolvata</i> ASI32002	<i>D. indusiata</i> ASI 32003
	arabinose	4.0 f <sup>2)</sup>
fructose	11.3 def	9.5 cdef
galactose	T <sup>3)</sup>	4.0 ef
mannose	22.3 bc	25.0 ab
xylose	4.0 f	17.0 bcd
lactose	7.5 ef	12.3 cdef
maltose	20.3 bcd	20.3 abc
sucrose	14.7 cde	13.7 bcdef
dextrin	13.0 cdef	16.3 bcde
glycerine	5.0 ef	5.3 def
inuline	15.0 cde	16.7 bcd
mannitol	5.3 ef	20.0 abc
starch	32.3 a	14.3 bcdef
Control <sup>1)</sup>	29.0 ab	30.0 a

Each carbon source was added in the basal medium at the concentration of 0.2 M.

<sup>1)</sup>Control contains glucose 20 g, asparagine 2 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g and distilled water 1,000 ml.

<sup>2)</sup>The letter is significantly different at p = 0.05 level by Duncan's multiple range test.

<sup>3)</sup>T : trace.

**Table 7.** Effect of nitrogen sources on the mycelial growth of *Dictyophora* species

Nitrogen source	Dry weight (mg/100 ml/30 days)	
	<i>D. echinovolvata</i> ASI 32002	<i>D. indusiata</i> ASI 32003
	Asparatic acid	14.0 b <sup>2)</sup>
Glutamic acid	11.0 b	11.7bcd
Glutamine	11.0 b	25.3a
Lysine	T <sup>3)</sup>	9.3cd
Arginine	T	T
Glycine	13.0 b	T
Alanine	22.7 a	7.7cd
Valline	11.7 b	17.0abcd
Isoleucine	9.7 b	12.7abcd
Serine	8.7 b	15.0abcd
Threonine	10.0 b	12.5abcd
Control <sup>1)</sup>	4.3 b	25.0ab

Each nitrogen source was added in the basal medium at the concentration of 0.02 M.

<sup>1)</sup>Control contains glucose 20 g, asparagine 2 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> 0.5 g and distilled water 1,000 ml.

<sup>2)</sup>The letter is significantly different at p = 0.05 level by Duncan's multiple range test.

<sup>3)</sup>T : trace.

ferent temperature for 14 days, mycelial growth was mostly favorable for the two species at 25°C, while, to *D. echinovolvata* ASI 32002 strain and *Phallus rugulosus* was 30°C. The reason that the strains of *D. echinovolvata* have differ-

**Table 8.** Mycelial growth of *Dictyophora* species at different C/N ratios in the basal medium<sup>1)</sup> (mg/100 ml/30 days)

C : N <sup>2)</sup>	Concentration of D-Glucose			
	<i>D. echinvolvata</i> ASI 32002		<i>D. indusiata</i> ASI 32003	
	2%	4%	2%	4%
10 : 1	20.0 e <sup>3)</sup>	13.3 f	19.0 bcd	18.7 bcd
15 : 1	20.3 de	18.7 ef	18.0 bcd	24.3 abcd
20 : 1	24.0 cde	26.7 bcd	13.0 d	19.7 bcd
25 : 1	28.7 bc	32.7 b	28.5 ab	15.0 cd
30 : 1	21.3 de	42.7 a	27.3 abc	33.7 a

<sup>1)</sup>Basal medium : glucose 20 g, asparagine 2 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> · 7H<sub>2</sub>O 0.5 g and distilled water 1,000 ml, pH 4.0.

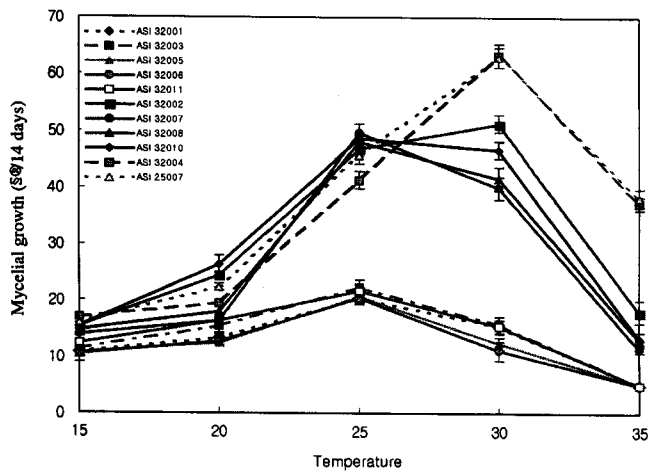
<sup>2)</sup>The ratio of alanine and glutamine versus D-glucose were adjusted to total ratio 10 : 1, 15 : 1, 20 : 1, 25 : 1, 30 : 1, respectively.

<sup>3)</sup>The dry weight (mg) was measured after 30 days in cultivation. The letter is significantly different at p=0.05 level by Duncan's multiple range test.

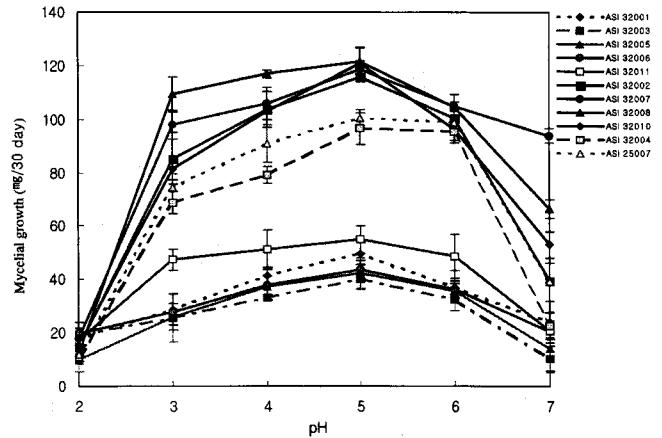
ent optimal temperature is supposed to be related with geographical distribution. Yang and Jong (1987) reported that the most favorable temperature for mycelial growth and fruiting body development of *D. indusiata* was 24°C. On the other hand, this result is consistent with Zeng's report (Zeng *et al.*, 1988) was 30 to 35°C. A favorable temperature of *D. echinvolvata* for mycelial growth and fruiting body formation.

**Optimal pH**

To screen pH level favorable for *Dictyophora* spp., the pH levels in the modified GA medium were adjusted to intervals of pH in the range of pH 2.0~7.0. The mycelial growth of the *Dictyophora* spp. was most favorable at pH 5.0.



**Fig. 1.** Mycelial growth of *Dictyophora* species strains cultured on PBA at different temperature for 14 days. PBA : Potato and bamboo sawdust extract medium, *D. indusiata* : ASI 32001, 32003, 32005, 32006 and 32011, *D. echinvolvata* : ASI 32002, 32007, 32008 and 32010, *Phallus rugulosus* : ASI 25007 and 32004.



**Fig. 2.** Mycelial growth of *Dictyophora* species strains cultured on modified GA medium at different pH levels for 30 days. Modified GA medium : glucose 20 g, asparagine 2 g, KH<sub>2</sub>PO<sub>4</sub> 1 g, MgSO<sub>4</sub> · 7H<sub>2</sub>O 0.5 g, ferrous citrate 5 mg, ZnSO<sub>4</sub> · 7H<sub>2</sub>O 4.4 mg, MnSO<sub>4</sub> · 4H<sub>2</sub>O 5 mg, CaCl<sub>2</sub> · 2H<sub>2</sub>O 55.5 mg, thiamine HCl 10 mg, nicotinic acid 10 mg and disilled water 1000 ml. *D. indusiata* : ASI 32001, 32003, 32005, 32006 and 32011, *D. echinvolvata* : ASI 32002, 32007, 32008 and 32010, *Phallus rugulosus* : ASI 25007 and 32004.

While there was no favorable for mycelial growth at pH 2.0 and 7.0 (Fig. 2). These results was similar with reports by Son (1991) and Yo (1997) that pH 5.5~6.0 for mycelial growth and pH 4.5~5.0 for fruiting body formation.

Based on the obtained basic data, the next study will be focused on investigating the possibility that *Dictyophora* spp. can produce a lot of its fruiting body on the culture medium. Sooner or later, it will be possible to develop a new culture medium suitable for mass production of *Dictyophora echinvolvata*.

**References**

Fan, C., Li, D. and Zhou, Z. 1987. Relation between growth and substrate in *Dictyophora rubrovalvata*. *Acta. Botanica Yunnanica* (China). **9**: 209-216.

Hua, S. L., Li, X. L. and Dong, J. Q. 1990. Cultivation of *Dictyophora echino-volvata*. *Zhongguo Shiyongjun Edible Fungi of China* **9**: 18-20.

曾德容, 胡仲賢, 周崇蓮. 1988. 一種喜高溫的美味竹蓐-棘托竹蓐. *中國食用菌* 1988. **4**: 5-6.

Huang, Y. and Cao, R. 1993. Biological characteristics of *Dictyophora rubrovalvata*. *Journal of Zhejiang Agricultural University* (China). **19**: 183-187.

黃義勇, 梁淑娃, 張嘉健, 陳衛東. 1994. 長裙竹蓐生理特性的研究. *食用菌* 1994.

Jia, S. and Liu, X. 1992. Cultivation of *Dictyophora indusiata* with raw wheat straw. *Edible Fungi* (China). **14**: 24.

陳可義, 王亦仁, 徐國山. 1986. 長裙竹蓐室外栽培研究簡報. *中國食用菌* 1986. **2**: 18.

- Kawagishi, H., Ishiyama, D., Mori, H., Sakamoto, H., Ishiguro, Y., Furukawa, S and Li, J. 1997. Dictyophorines A and B, two stimulators of NGF-synthesis from the mushroom *Dictyophora indusiata*. *Phytochemistry* **45**: 1203-1205.
- Mizuno, T. 1995. Special issue on mushrooms : the versatile fungus - food and medicinal properties. Chemistry, biochemistry, biotechnology, and utilization. *Food Reviews International*. **11**: 236.
- Lee, T. S. 1997. Genetic characteristics of *Lentinula edodes* strains and effect of sawdust culture by inoculation of the liquid spawn. Ph. D. thesis. Chungbook Univ. 48.
- 李國俊. 1986. 食用菌栽培技術. 延邊大. pp. 293-298.
- 羅 凡. 1994. 短裙竹蓀室外高產栽培技術. 食用菌 **1994**. **5**: 32.
- 孫榮信. 1991. 竹蓀栽培. 福建三明真菌研究所. p. 22.
- Tong, Y., Tan, W. and Wang, X. 1992. Cultivating technique of *Dictyophora duplicata* with other materials under trees. *Southwest China Journal of Agricultural Sciences* (China). **5**: 5562.
- Yang, Q. Y. and Jong, S. C. 1987. Artificial cultivation of the veiled lady mushroom, *Dictyophora indusiata*. *Cultivating Edible Fungi*. 437-442. (Developents in Crop Science 10. Amsterdam, Netherlands; Elsevier Science Publishers B.V.)
- 姚秋生. 1997. キヌガサタケの生物學的特性と栽培(第1回). 特産情報きのこ etc. **1997**. **1**: 57-60.
- 姚秋生. 1997. キヌガサタケの生物學的特性と栽培(第2回). 特産情報きのこ etc. **1997**. **3**: 35-37.
- Zeng, D., Hu, Z. and Zhou, C. 1988. A thermophilic delicious "Veiled Lady"-*Dictyophora echino-volvata* [China]. *Edible Fungi of China* (China) no. **4**: 5-6.
- Zhou, F. and Qiao, C. 1989. Research on fast cultivation of *Dictyophora indusiata*. *Edible Fungi of China* (China) no. **1**: 1718.
- Zhou, X., Yang, J. and Liu, D. 1994. High yield cultivation of *Dictyophora indusiata* (*Dictyophora indusiata* (Vent. expers.) Fisscher). *Journal of Hunan Agricultural College* (China) **20**: 156-160.