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STUDIES ON NUTRITIONAL AND PHYSIOLOGICAL REQUIREMENTS OF WILD EDIBLE MUSHROOM *MORCHELLA DELICIOSA* FR. CHOSEN FROM NORTH WESTERN HIMALAYAS

Dr. Renu Rana
Associate Professor, Department of Botany,RKMV, Shimla.

Abstract
Morchella, the true morels, is a genus of edible sac fungi closely related to anatomically simpler cup fungi in the order Pezizales (division Ascomycota). This distinctive fungus have a honeycomb appearance, due to the network of ridges with pits composing their cap. Morels are sought by thousands of enthusiasts every spring for their supreme taste and the thrill of the hunt, and are highly prized by gourmet cooks, particularly in French cuisine. Morel mushrooms possess important nutritional and medicinal properties that can play key roles in optimizing the health. Major factors relevant for growing mycelium in laboratory are nutrients, temperature, pH and light and dark conditions. The impact of these factors on the growth and production of Morchella deliciosa was investigated under laboratory conditions. The aim of the Morchella deliciosa investigation was to determine optimal conditions for the development of the fungus. The results showed Yeastal Potato Dextrose Agar medium as best solid medium, Glucose-Asparagine as best liquid medium, optimal temperature was 25°C, whereas the highest weight of the mycelial dry mass was recorded at pH value 6.0 under dark conditions.

Keywords Used: True Morels, Cup Fungi, Honeycomb, Development, French Cuisine and Morchella Deliciosa.

Introduction

Mushrooms have been consumed since ages as a delicacy. Earlier these were collected from natural habitats and cooked either fresh or after drying. With time, cultivation techniques have been worked out for 25-30 edible species out of the 2000 naturally occurring edible mushrooms. Still, there are many more species which are consumed by local inhabitants which are yet to be cultivated.

Before cultivation is taken up of any mushroom it is essential to bring the mushroom into pure culture and to study its nutritional requirements. The present study was undertaken on cultural characteristics of edible mushroom i.e. *Morchella deliciosa*

We are still dependent upon forests for the supply of most of the wild edible mushrooms because they have not been artificially and commercially cultivated till date. The reason being little information about their nutritional requirements and entering of some of the mushrooms into mycorrhizal association with forest trees..Hence it was considered worthwhile to investigate the nutritional requirements of these wild edible mushroom..The information is recorded on the following parameters*:* **Growth of mycelium on different solid and liquid media; Recording the effect of temperature; pH and light and darkness**

Materials and Methods

Morchella deliciosa was brought into culture. For raising culture, the sporophores of mushroom were wiped gently with sterile cotton moistened with 70% ethanol. Bits of tissues were cut aseptically from the region of rapid cell division and planted in the centre of culture tubes containing sterilized potato-dextrose agar medium..After incubating for 10 days at 22^0 C± 2^0 C the actively growing mycelium was transferred to potato-dextrose slants for sub culturing. Throughout the study the culture was maintained on potato-dextrose agar fortified with yeast at 5^0C and was frequently sub cultured.

i) Composition of media

In order to study the effect of different solid and liquid media on growth, ten solid media of the same composition as given by Tuite (1969) were tried. In case of solid media, inoculations were done in petriplates, whereas inoculations were done in 100 ml conical flasks in case of liquid media, 20 ml of the liquid medium in each flask. Three replicates of each medium were taken for the purpose of study.

ii) Sterilization

All glassware was sterilized in an oven at 180± 5^0C for 90 minutes. The media were autoclaved at 15 lb pressure per sq. inch (1.0545kg /cm^2) for 20 minutes. The inoculation needle and cork borer were initially dipped in ethyl alcohol and then flame sterilized.

iii) Inoculum

Inoculum used during the course of all physiological studies consisted of 5 mm diameter discs cut with the help of pre-sterilized cork borer. Ten days old cultures raised on PDA were used.

iv) Incubation period

Pertiplates containing the basal medium and inoculums were incubated for ten days at 22 ± 2^0 C in order to raise the culture for further studies.

v) Recording of growth

On solid media, the vegetative growth was recorded by taking the average linear growth of mycelia colony in two directions at right angles, till the petriplates were completely colonized. In the liquid media studies, the mycelia mats were filtered through Whatman No. I filter paper discs of 7.5 cm diameter. These filter papers were previously oven dried at 70 ± 5°C for 3 consecutive days (until constant weight) and weighed, after keeping in moisture free desiccators. After filtration the mycelia mat was again oven dried as above and weighed to record the final dry weight of the same. Throughout the experimentation, three replicates of each treatment were kept and the average was used as a quantitative measure for comparing the growth under different treatments.

vi) Effect of temperature on growth

In this experiment the best solid and liquid medium, out of the 10 tried, were selected for the experiment. The flasks containing basal medium and inoculums were incubated at different temperatures viz. 5, 10, 15, 20, 25, 30, 35 and 40^0C, in separate incubators for studying the optimal temperature requirement.

vii) Effect of Hydrogen ion concentration (pH) on growth

In order to study the effect of pH, inoculation was done in different media with pH adjusted at 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, and 8.5, respectively. The pH of basal medium was adjusted with the help of sodium citrate and sodium phosphate buffers.

viii) Effect of light and darkness on growth

The flasks with best basal liquid medium, with optimum temperature and pH, were given the light and dark treatment. For dark conditions flasks were wrapped with black paper so that no light could enter inside.

Observations

Growth of mycelium of *Morchella deliciosa* on different solid media

Ten solid media were tried for the growth (Plate-II) of mycelium of *Morchella deliciosa*. The circular growth in petriplates was recorded after ten days of incubation at temperature (25 ± .5°C). The mean colony diameter of mycelium (± standard deviation) in different solid media is numerically and graphically presented in Table 1 and Fig. 1, respectively.

Analysis through one-way ANOVA with Tukey's multiple comparison test revealed that difference of colony diameter means of mycelium between Potato Dextrose Agar medium and Pridham Yeast Malt Dextrose medium; Glucose Yeast Asparagine and Maize Grain Extract and Wheat Grain Extract and Horse Gram Extract was non-significant (HSD: 0.00; F-value: 33075..055; $P \leq 0.10$). Whereas, the comparison of means observed in rest of solid media pairs revealed very significant differences (HSD: 0.000; F-value: 33075.055; $P \leq 0.001$) (Table 1.1).

It is concluded from the results of ten solid media that Yeastal Potato Dextrose Agar Medium showed maximum colony diameter of mycelium of *Morchella deliciosa*. The mean colony diameter of Yeastal Potato Dextrose Agar was significantly more than all other media tested.

Thus, Yeastal Potato Dextrose Agar medium was selected as best solid medium for the mycelial growth of *Morchella deliciosa*.

Growth of mycelium of *Morchella deliciosa* in different liquid media

Five liquid media were tried for the growth of mycelium of *Morchella deliciosa* in terms of weight (mg). The weight of mycelium was measured after ten days of incubation at ambient temperature (25 ± .5°C). The mean mycelial weight mg (± standard deviation) in different liquid media is numerically and graphically presented in Table 2 and Fig. 2, respectively.

Analysis through one-way ANOVA with Tukey's multiple comparison test revealed that the difference of means mycelial weight in all the pairs of liquid media showed very significant differences (HSD: 0.000; F-value: 4721.676; $P \leq 0.001$) while no pairs of media revealed non-significant differences between means of mycelial weight (mg) (Table 2.1).

Results of five liquid media revealed that Glucose-Asparagine showed maximum mycelial weight whereas, Asthana and Hawker's Solution allowed minimum growth. The mean mycelial weight in Glucose-Asparagine was significantly more than all other liquid media tested. Thus, Glucose-Asparagine was selected as the best medium for the growth of *Morchella deliciosa*.

Effect of temperature

To record the effect of different temperatures on the mycelial growth of *Morchella deliciosa*, pure culture of was inoculated in the flasks containing Glucose-Asparagine medium and was incubated at temperature ranging from 5-40^{o}C in separate incubators. The mean mycelial weight (± standard) deviation at different temperatures is numerically and graphically presented in Table 3 and Fig. 3, respectively.

Analysis through one-way ANOVA with Tukey's multiple comparison test to compare the means of mycelium weight revealed that the difference was non-significant between 5^{0}C and 40^{0}C temperature pair and 15^{0}C and 35^{0}C (HSD: 0.00; F-value: 14345.231; P ≤ 0.10). Whereas, rest of the pairs of temperatures showed very significant differences in the means of mycelial growth (HSD: 0.000; F-value: 14345. 231; P≤0.001) (Table 3.1).

Results revealed that maximum and minimum mycelial growth was recorded at 25^{o}C and 10^{o}C, respectively. The mycelial growth ceased completely at 5^{o}C and 40^{o}C. The mean mycelial growth at 25^{o}C was significantly more than at all other temperatures studied.

Thus, 25^{o}C was considered as the optimum temperature for growing *Morchella deliciosa* .

Effect of Hydrogen ion concentration (pH)

To record the effect of different pH values on the mycelial growth of *Morchella deliciosa*, the pH of the liquid basal medium in the flasks was adjusted in the range of 3.5-8.5 accordingly with the help of pH meter and inoculated and incubated at a temperature 25 ± .2^{o}C. The mean mycelial weight (± standard deviation) at different pH values is numerically and graphically presented in Table 4 and Fig. 4, respectively.

Analysis through one way ANOVA with Tukey's multiple comparision test revealed that the difference of means of mycelial growth was non- significant between pH 4.0 and pH 8.0 (HSD: 0.000; F-Value: 9919.869; P ≤ 0.10). Whereas, rest of the pairs of pH showed very significant difference in the means of mycelium weight (mg) (HSD: 0.000; F-value: 9919.869; P ≤ 0.001) (Table 4.1).

Conclusion derived from the results indicated that maximum and minimum mycelial growth was recorded at pH 6.0 and pH 3.5, respectively. The mean mycelial growth at pH 6.0 was significantly more than in all other pH values studied.

Thus, pH 6.0 was considered as the optimum pH for growing *Morchella deliciosa* in the cultures for further studies.

Effect of light and darkness

To record the effect of light and darkness on the growth of *Morchella deliciosa*, the flasks containing basal liquid medium (Glucose-Asparagine) adjusted at pH 6.0 were inoculated and incubated at 25 ± .2^{o}C in light and darkness (flasks wrapped in black paper). The mean mycelial weight (± standard deviation) (mg) in light and dark conditions is numerically and graphically presented in Table 5 and Fig.5, respectively.

It is clear from the results that maximum mycelial growth was supported by darkness.

Table 1:Colony diameter of *Morchella deliciosa* on different solid media

Sr. No.	Name of the medium	Colony diameter (cm) (mean ± SD)
1.	Potato Dextrose Agar (PDA)	8.45 ± .05
2.	Yeastal Potato Dextrose Agar (YPDA)	8.85 ± .086
3.	Pridham Yeast Malt Dextrose (PYMD)	8.38 ± .76
4.	Glucose Yeast Agar (GYA)	7.75 ± .05
5.	Malt Agar (MA)	6.83 ± .028
6.	Wheat Grain Extract (WGE)	6.07 ± .12
7.	Maize Grain Extract (MGE)	7.78 ± .076
8.	Horse Gram Extract (HGE)	6.13 ± .057
9.	Pea Extract (PE)	4.60 ± .05
10.	Czapek's Dox (CD)	3.63 ± .29

*** Incubation period of 10 days**

Table 2: Weight of mycelium (mg) of *Morchella deliciosa* in different liquid growth media

Sr. No.	Name of the medium	Weight of mycelium (mg) (mean ± SD)
1.	Glucose-Asparagine	114.85 ± .355
2.	Czapek's solution	97.40 ± .279
3.	Dimmick's solution	89.55 ± .873
4.	Richard's solution	71.37 ± .472
5.	Asthana and Hawker's solution	60.67 ± .510

*** Incubation period of 10 days.**

Table 1.1: Differences between the means and One-Way ANOVA with Tukey's Multiple Comparison Test for colony diameter (cm) of mycelium of *Morchella deliciosa* on different solid growth media

Sr. No.			1	2	3	4	5	6	7	8	9	10	HSD	F-value
	Growth Media		PDA	YPDA	PYMD	GYA	MA	WGE	MGE	HGE	PE	CD		
		Mean (cm)	8.450	8.850	8.383	7.750	6.833	6.062	7.783	6.133	4.600	3.633	.000	33075.055
1.	PDA	8.450	0.00	-.400***	.961	.700***	1.617***	2.383***	.667***	2.317***	3.850***	4.817***		
2.	YPDA	8.850		0.00	.467***	1.100***	2.017***	2.783***	1.067***	2.717***	4.250***	5.217***		
3.	PYMD	8.383			0.00	.633***	1.550***	2.317***	.600***	2.250***	3.783***	4.750***		
4.	GYA	7.750				0.00	.917***	1.683***	-.33 ^{NS}	1.617***	3.150***	4.117***		
5.	MA	6.833					0.00	.767***	-.950***	.700***	2.233**	3.200***		
6.	WGE	6.067						0.00	-1.171***	-0.67 ^{NS}	1.467***	2.433***		
7.	MGE	7.783							0.00	1.650***	3.183***	4.150***		
8.	HE	6.133								0.000	1.533***	2.500***		
9.	PE	4.600									0.00	-.967***		
10.	CD	3.633										0.00		

Table 2.1: Differences between the means and One-Way ANOVA with Tukey's Multiple Comparison Test for weight (mg) of mycelium of *Morchella deliciosa* in different liquid growth media

Sr. No.			1	2	3	4	5	HSD	F-value
	Liquid Growth Media		Glucose Asparagine	Czapek's Solution	Dimmick's Solution	Richard's Solution	Asthana and Hawker's Solution		
		Mean (mg)	114.85	97.40	89.55	71.37	60.67	0.00	4721.576
1	Glucose-Asparagine	114.85	0.00	17.45***	25.29***	43.48***	54.17***		
2	Czapek's Solution	97.40		0.00	7.84***	26.03***	36.72***		
3	Dimmick's Solution	89.53			0.00	18.18***	28.88***		
4	Richard's Solution	71.37				0.00	10.69***		
5	Asthana and Hawker's Solution	60.67					0.00		

*****P ≤ 0.001;** P ≤ 0.01; * P ≤ 0.05; NS: Non-Significant Difference at P ≤ 0.10;**
HSD: Honestly Significant Difference as revealed through Tukey's multiple comparison test.

Table 3: Weight of mycelium (mg) of *Morchella deliciosa* at different temperatures

Sr. No.	Temperature (in ^{0}C)	Weight of mycelium (mg) (mean ± SD)
1.	5	0.00 ± .000
2.	10	15.83 ± .714
3.	15	27.33 ± .454
4.	20	55.97 ± .950
5.	25	117.50 ± .477
6.	30	76.33 ± .577
7.	35	28.80 ± .778
8.	40	0.00 ± .000

*** Incubation period of 10 days**

Table 4: Weight of mycelium (mg) of *Morchella deliciosa* at different pH values

Sr. No.	pH	Weight of mycelium (mg) (mean ± SD)
1.	3.5	25.56 ± .487
2.	4.0	29.25 ± .250
3.	4.5	41.41 ± .454
4.	5.0	60.59 ± .525
5.	5.5	85.30 ± .336
6.	6.0	109.11 ± .211
7.	6.5	70.59 ± .491
8.	7.0	52.21 ± .612
9.	7.5	40.23 ± .654
10.	8.0	28.68 ± .464
11.	8.5	51.48 ± .577

*** Incubation period of 10 days**

Table 3.1: Differences between the means and One-Way ANOVA with Tukey's Multiple Comparison Test for weight (mg) of mycelium of *Morchella deliciosa* at different temperatures

Sr. No.			1	2	3	4	5	6	7	8	HSD	F-value
	Temperature		5	10	15	20	25	30	35	40		
		Mean (mg)	.000	15.83	27.33	55.97	117.50	76.33	28.80	1.00	.000	14345.231
1	5	.000	-0.00	-15.83***	-27.33***	-55.97***	-117.50***	-76.33***	-28.80***	0.00 ^{NS}		
2	10	15.83		0.00	-11.50***	-40.13***	-101.67***	-60.50***	-12.97***	15.83***		
3	15	27.33			0.00	-28.63***	-90.17***	-49.00***	1.47 ^{NS}	27.33***		
4	20	55.97				0.00	-61.54***	-20.37***	27.16***	55.97***		
5	25	117.50					0.00	41.17***	88.70***	117.50***		
6	30	76.33						0.00	47.53***	76.33***		
7	35	28.80							0.00	28.80***		
8	40	0.00								0.00		

Table 4.1: Differences between the means and One-Way ANOVA with Tukey's Multiple Comparison Test for the weight of mycelium of *Morchella deliciosa* at different pH values

Sr. No.			1	2	3	4	5	6	7	8	9	10	11	HSD	F-value
	pH		3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5		
		Mean (mg)	25.26	29.05	41.41	60.59	85.30	109.11	70.59	52.21	40.23	28.68	51.48	.000	9919.869
1.	3.5	25.26	0.00	-3.69***	-15.86***	-35.04***	-59.74***	-88.55***	-45.03***	-26.65***	-14.67***	-3.13***	2.22***		
2.	4.0	29.05		0.00	-12.16***	-31.34***	-56.05***	-79.86***	-41.34***	-22.96***	-10.98***	.57 ^{NS}	5.92***		
3.	4.5	41.41			0.00	-19.18***	-43.89***	-67.69***	-29.17***	-10.79***	1.19 ^{NS}	12.73***	18.08***		

4.	**5.0**	60.59				0.00	-24.71***	-48.51***	-9.99***	8.39***	20.39***	31.91***	37.26***	
5.	**5.5**	85.30					0.00	-23.81***	14.71***	33.09***	45.07***	56.62***	61.97***	
6.	**6.0**	109.11						0.00	38.52***	56.90***	68.88***	80.42***	85.77***	
7.	**6.5**	70.59							0.00	18.38***	30.36***	41.90***	47.25***	
8.	**7.0**	52.21								0.00	11.98***	23.52***	28.87***	
9.	**7.5**	40.23									0.00	11.54***	16.89***	
10.	**8.0**	28.68										0.00	5.35***	
11.	**8.5**	51.48											0.00	

*****P ≤ 0.001; ** P ≤ 0.05; * P ≤ 0.10; NS: Non- Significant Difference at P ≤ 0.10;**
HSD: Honestly Significant Difference as revealed through Tukey's multiple comparison test.

Table 5: Weight of mycelium (mg) of *Morchella deliciosa* in best liquid medium (Glucose asparagine) in light and darkness

Sr. No.	Treatments	Weight of mycelium (mg) (mean ± S.D)
1.	Light	88.870 ± .279
2.	Dark	97.460 ± .499

*** Incubation period of 10 days**

Table 5.1: The significance of differences between the Means as determined by Student's t-test for mycelium weight of *Morchella deliciosa* in light and dark conditions

Sr. No.	Treatments	Weight of mycelium (mg) (mean ± SD)	t-value
1.	Light	88.870 ± .279	26.042
2.	Dark	97.460 ± .499	

*** Incubation period of 10 days**

***** P ≤ 0.001;** P ≤ 0.01; * P ≤ 0.05; NS: Non-Significant Difference at P ≤ 0.10**

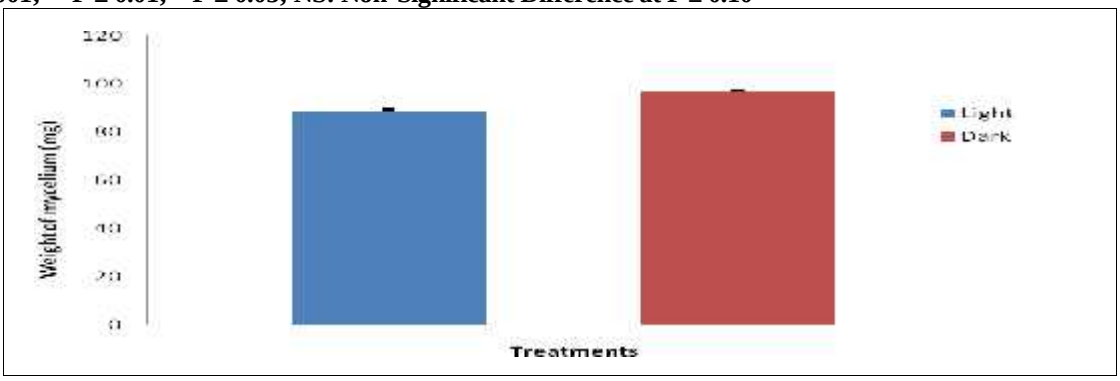

Fig. 5:Weight of mycelium (mg) of *Morchella deliciosa* under light and darkness.

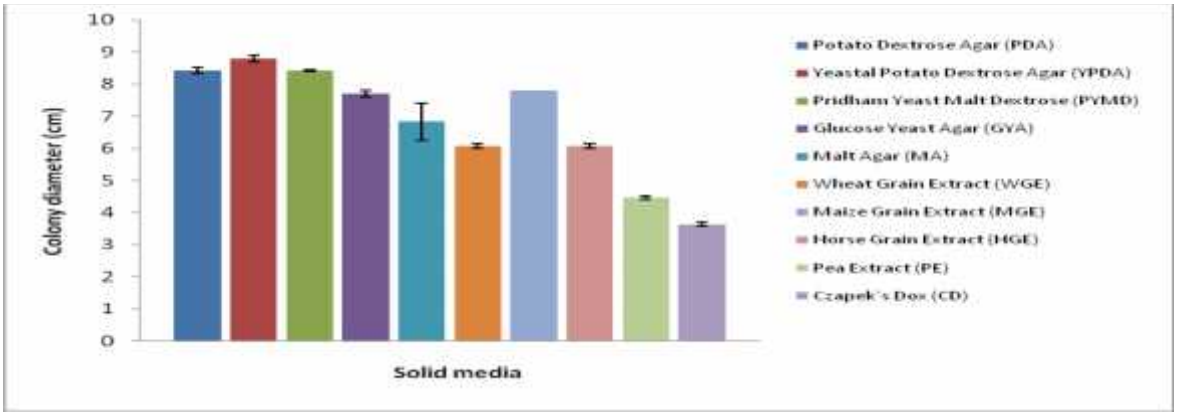

Fig. 1: Colony diameter (cm) of *Morchella deliciosa* on different solid media

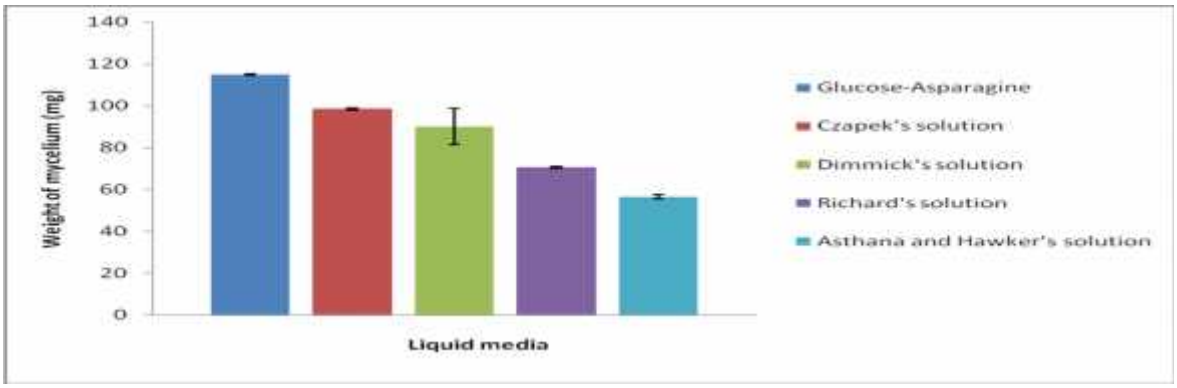

Fig. 2:Weight of mycelium (mg) of *Morchella deliciosa* in different liquid media

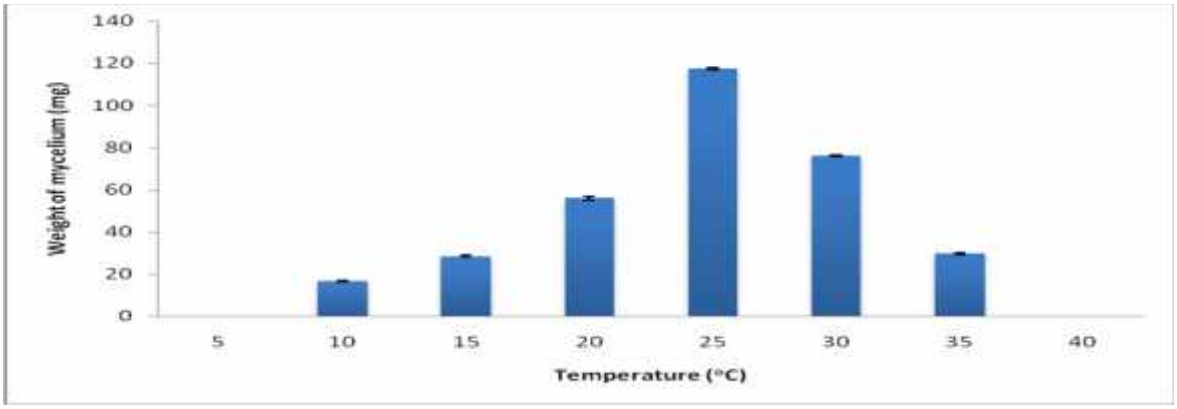

Fig. 3: Weight of mycelium (mg) of *Morchella deliciosa* at different temperatures

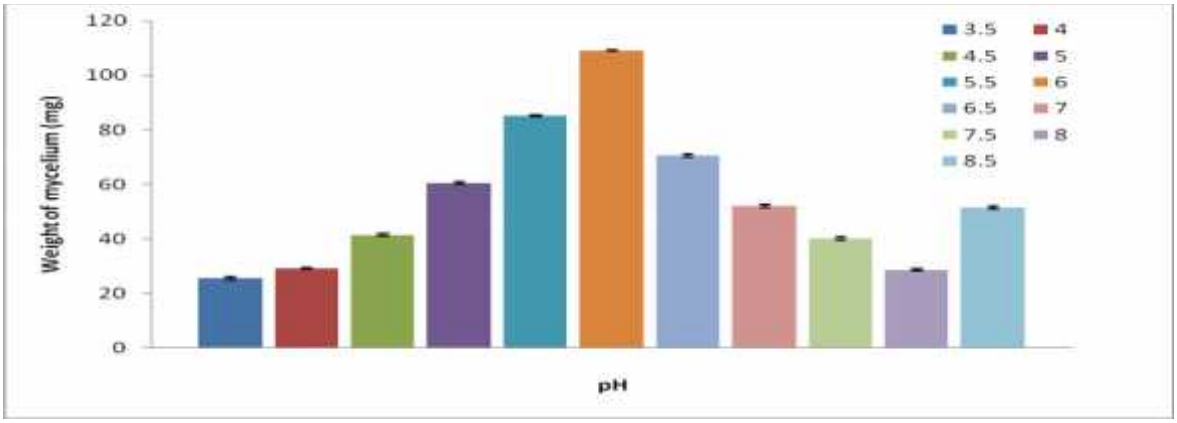

Fig. 4: Weight of mycelium (mg) of *Morchella deliciosa* at different pH values

Results

Results drawn from the ten solid media tried for the growth of *Morchella deliciosa*, clearly indicated that Yeastal Potato Dextrose Agar medium supported maximum growth of mycelium while, Czapek's Dox permitted minimum colony diameter(Table 1). The mean colony diameter of Yeastal Potato Dextrose Agar was significantly more than all other tested solid media (Table 1.1).

Results of five liquid media tried for the growth of *Morchella deliciosa* proved that Glucose-Asparagine showed maximum mycelial weight whereas minimum growth was recorded in Asthana and Hawker's solution (Table 2). Whereas, the comparison of mycelial weight means observed in all the five liquid media pairs was very significant (HSD: 0.00; F-value: 9283.584; $P \leq 0.001$) (Table 2.1).

Maximum and minimum growth of *Morchella deliciosa* occurred at 25°C and 10°C, respectively (Table 3). The growth ceased completely at 5°C and 40°C. The mean mycelial growth was significantly more than at all other temperature values studied (Table 3.1).

Maximum growth of *Morchella deliciosa* was recorded at pH 6.0 and (Table 4). The mean mycelial weight (mg) at pH 6.0 was significantly more than all other pH values studied (Table 4.1).

Regarding growth of mycelium of *Morchella deliciosa* was better in dark than under light conditions (Table 5). Student's t-test, revealed that weight of mycelium in dark was statistically very significant under dark conditions than under light conditions (Table 5.1).

Discussion

A detailed physiological study of an organism is as important as the study of any of its other aspects. In the present study physiological requirements (media, temperature, hydrogen ion concentration light and darkness) of *Morchella deliciosa* were investigated with the cultures raised from their sporocarps.

The literature has references showing evidence of best growth of mushrooms mycelium on Yeastal Potato Dextrose Agar (YPDA) and Potato Dextrose Agar (PDA). Good mycelial growth on YPDA has been recorded by Jandaik and Kapoor (1975a) in case of *Pleurotus sajor- caju, Podaxis pistillaris and Phellorina inquinans.* Rangad and Jandiak (1977) also reported YPDA as best medium for growth of different species of *Pleurotus, Agrocybe aegerita Flammulina valutipes and Stropharia rugoso- annulata.* Thianga and Jandaik (1979) also recorded best growth of *M. procera* on YPDA. Chaturvedi (1987) recorded YPDA as best medium for the growth of *P. ostreatus.* Shad (1989) recorded best growth of *M. esculenta, M. conica and M. deliciosa* on PDA. Nair and Devi *et ai.,* (1987) also recorded the YPDA as the best medium for culturing *Coprinus lagopus.*

Among five liquid media tested for determining their comparative suitability for vegetative growth of *Sparassis* crispa investigated, Glucose-Asparagine supported maximum average mycelial growth. Rangad and Jandaik(1982) also recorded maximum growth of *F.velutipes,Agrocybe aegerita* and *Stropharia-rugoso-annulata* in Glucose- Asparagine, Mehta (1985) and Chaturvedi (1987) observed Glucose- Asparagine medium to favour maximum vegetative growth of *Pleurotus sapidius and Pleurotus ostreatus.* Singh and Lakhanpal (1988) also recorded maximum growth of *T. himalayansis* in Glucose Asparagine solution. Shad (1989) also found glucose asparagine to support maximum growth of *M. esculanta, M. deliciosa, M. Conica, M. crassipes and M. semilibra.* With regard to the effect of temperatures, it was recorded that all the sixteen mushrooms studied could grow in a wide temperature range of 10- 35°C but failed to grow below 10°C and above 35°C. Rangad and Jandaik (1977) have reported maximum growth of *Agrocybe aegerita and Stropharia rugoso- annulata* at 25°C. Mehta and Bhandal (1988) also recorded growth of *P. ostreatus, P. florida, P. saroj- caju, P. flabellatus, P. sapidus and P. cystidiosus at 25*^{O}C. While, Gupta (1990) recorded 25°C to be the optimum temperature for vegetative growth of *M. esculenta, M. conica, M. crassipes, and M. angusticeps*. The highest radial diameter, mycelia density and dry mycelia weight were recorded at temperature 25°C for *Pleurotus ostreatus (Ali et al., 2004).*Effects of temperature (5-34^{o}C)were investigated on hyphal growth of *Pleurotus flabellatus* . The temperature for hyphal growth of *Pleurotus flabellatus* varied from 20^{o}C to 31^{o}C with optimum temperature at 25°C (Li Rong et al., 2004). Song *et. al.,* (2004) conducted studies on growth conditions of liquid culture for *Morchella conica.* The optimum temperature for *Pleurotus nebrodensis* was 25^{o}C. The studies indicated that the suitable temperature for mycelial growth was 22-28°C although 25°C was optimum (HongTao et. al., 2005). Similarly, Yadav and Yadav (2012) observed 25°C to be the optimum temperature for the growth of *Cantharellus cibarius and Scleroderma bovista.*

It is evident from the results that showed maximum growth at 25°C. The growth of mycelium starts decreasing with increase or decrease in optimum temperature. The results are in agreement with the references quoted in the literature.

For recording Optimum pH level for their growth of *Morchella deliciosa*, the mycelium was grown in the best suited liquid medium at different levels of pH. It was recorded that maximum growth of majority of the wild edible mushrooms studied occurred at slightly acidic pH i.e. 6.0. This was closely followed by 5.5 and 6.5 in acidic pH range. This finding is in agreement with the optimum pH for *Podaxis pistillaris* which had been recorded to be 6.0 by Jandaik and Kapoor (1975b). Thind and Jandaik (1979) also recorded pH 6.0 as best pH for growth of *Macrolepiota procera.* Rangad and Jandaik (1982) also recorded maximum growth of mycelium at pH 6.0 in *Stropharia- rugoso- annulata.* Nair and Devi (1986-87) also recorded pH 6.0, as optimum pH for the growth of *Calocybe lagopus.* Further, Ali *et al.,* (2004) reported pH 6.0 for the maximum mycelium growth of *pleurotus ostreatus.* During the screening of culture conditions for *P. pulmonarius and P. columbinus,* the best pH was reported 6.0 (QinnGhe *et al.,* 2004). Studies of Song *et al.* (2004) on growth conditions of *Morchella conica* revealed pH 6.0 as suitable for mycelial growth.

It is evident from the results that there is decrease in mycelial growth of studied, on either side of optimum pH. In other words the growth of mycelium increased with decreased in acidity upto optimum pH and decrease with increase in basicity.

Mycelium of *Morchella deliciosa* was found to grow better under dark conditions in comparison to light conditions. Better growth of *S. crispa* and *T. himalayansis* was also recorded in dark conditions by Sharma (1987) and Lakhanpal *et al.,* (1988).

Conclusion

All the solid media tested, supported good to moderate growth of these mushrooms species. However, the highest growth rate of these fungi was recorded in Yeastal Potato Dextrose Agar medium followed by potato dextrose agar; Czapek's Dox medium supported least growth of *Morchella deliciosa.* Good growth on YPDA may be ascribed to yeast extract which is known to contain growth enhancing substances like riboflavin. Least growth of this mushroom in remaining extracts may be attributed to the lack of nutrient content required for the growth of fungus used in present investigations.(Table 1 and Fig.1). Out of five liquid media tried Glucose-Asparagine showed maximum mycelial weight. (Table 2 and Fig.2).. The better growth of fungi in Glucose asparagines may be ascribed to free amino acid asparagine present in the solution.

Maximum and minimum growth of *Morchella deliciosa* occurred at 25°C and 10°C, respectively. The growth ceased completely at 5°C and 40°C.(Table 3 and Fig.3). The mean mycelial growth was significantly more than at all other temperature values studied. Maximum growth of *Morchella deliciosa* was recorded at pH 6.0.(Table 4 and Fig.4). Growth of mycelium of *Morchella deliciosa* was better in dark than under light conditions. (Table 5 and Fig.5).

It is inferred from the study on *Morchella deliciosa* that it also behaves in the same manner in culture as the other commercially cultivated mushrooms like *Agaricus bisporus,Pleurotus* and *Volvariella* spp.etc. There is need to develop and standardize the cultivation technology of these edible wild mushrooms for making them commercially cultivable and popular among the common people like other cultivated mushrooms.

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