



Performance of different oyster mushrooms in five agro-ecological zones of Kerala

Akhil G.L.¹, Susha S. Thara*², Radhika N.S.¹, Sajeesh P.K.¹ and Binitha N.K.¹

¹Department of Plant Pathology, College of Agriculture , Padannakkad

²Department of Plant Pathology, College of Agriculture, Vellayani

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Abstract

A study was undertaken during December 2020 to February 2021 to evaluate the suitability of oyster mushrooms in different agro-ecological zones of Kerala viz., coastal plains, midland laterites, foothills, high hills and Palakkad plains. The oyster mushroom species selected were *Pleurotus florida*, *Pleurotus djamor*, *Hypsizygus ulmarius*, *Pleurotus sajor-caju* and *Pleurotus citrinopileatus*. The sporocarps of five species of oyster mushrooms were studied based on the size, texture and colour of sporocarp, gill arrangement, stipe length and colour of pinhead. Performance of all the species were evaluated based on yield and growth characteristics. *H. ulmarius* was found to be best suited oyster mushroom species for cultivation in coastal plains with biological efficiency (BE) of 102.99 per cent, foot hills (92.73 per cent BE) and high hills (123.30 per cent BE). In midland laterites and Palakkad plains, highest BE of 82.70 per cent and 103.80 per cent respectively were obtained from *P. djamor*. Earliness in primordial initiation and less crop duration was observed in *P. djamor* from all the five agro-ecological zones of Kerala. From the present study it was evident that *H. ulmarius* was adapted to the climatic conditions prevailing throughout Kerala. *P. djamor* performed well in areas having higher temperature (more than 28°C), lesser rainfall and lesser humidity (80 per cent).

Key words: Agro-ecological zones, Biological efficiency, *Hypsizygus ulmarius*, *Pleurotus citrinopileatus*, *Pleurotus djamor*, *Pleurotus florida*, *Pleurotus sajor-caju*, Suitability.

Introduction

Mushrooms have a long history of use among humans both as a food and medicine. The demand and production of mushroom is increasing day by day due to the awareness about its nutraceutical and therapeutic properties. Oyster mushroom is commonly called as 'Dhingri' in India and stands second among the total mushroom production in the world. They grow on various types of substrates and generally prefer a temperature range of 20 to 30°C and humidity of 80 to 90 per cent (Jyothi, 2019). The cultivation of various species of oyster mushrooms demonstrated their potential to thrive under wide range of temperature and relative humidity (Adebayo and Martinez-Carrera, 2015).

Among all the cultivated mushrooms, oyster mushrooms have the maximum number of commercially cultivated species which can be cultivated throughout the year. Kerala, with its humid tropical climate, is found to be suitable for the cultivation of oyster mushrooms. These findings indicated the scope for the large-scale production of oyster mushroom throughout Kerala. Kerala is divided into five agro-ecological zones from coastal plains to high hills, with each zone having varied climatic conditions (KAU, 2016). But no studies have been conducted on the suitability of different oyster mushrooms for the specific agro-ecological zone of Kerala. The aim of current study was to identify the best suited oyster mushroom for different agro-ecological zones of Kerala.

* Author for correspondences: Phone: 9387813940 Email: susha.thara@kau.in

Materials and Methods

Isolation of mushroom

Healthy mushrooms collected from pest and disease – free high yielding beds were taken for tissue culturing (Jyothi, 2019). A small portion of tissue from the junction of pileus and stipe was detached aseptically and placed in the Petri plates containing solidified Potato Dextrose Peptone Agar (PDPA) medium and incubated at room temperature ($26\pm 2^{\circ}\text{C}$). After 72 h, the mycelial growth observed was purified by hyphal tip method in which the growing mycelia tip is transferred to Petri plates containing PDPA medium and pure cultures of the five species of oyster mushrooms were maintained.

Mushroom spawn preparation

The mushroom spawn of the five species were prepared as per the standard procedure (Sinden, 1934). Clean and unbroken paddy grains were used as substrate for mushroom spawn production. Washed grains were cooked in boiling water until the seed coat just begun to split open. Then excess water from the grains were drained off and spread evenly on a disinfected tarpaulin sheet. After sufficient drying, the boiled grains were mixed with calcium carbonate at the rate of 40 g kg^{-1} of grains, to maintain the pH of the grains around 7 and to avoid sticking together of grains. These were packed in polypropylene bags ($30\text{ cm}\times 15\text{ cm}$) at the rate of 300 g per bag and sterilized by autoclaving at a pressure of 1.02 kg cm^{-2} at 121°C for 2 h. After cooling, the bags were inoculated aseptically with mycelial bits of size $1\text{ cm}\times 1\text{ cm}$ from ten days old cultures of all the five species of oyster mushroom and incubated at room temperature ($26\pm 2^{\circ}\text{C}$) until the mycelium completely covered the grains (Jose, 2018).

Mushroom bed preparation

Mushroom beds were prepared as per the procedure described by Bhaskaran et al. (1978). Paddy straw was sterilized chemically by soaking in 100 L of water containing 7.5 g carbendazim and 50 mL formalin for 18 hours. Then the excess water was

drained off and the straw was spread over a clean silpaulin sheet under sun to reduce the moisture content to 60 per cent. The beds were prepared in polythene bags of $60\text{ cm}\times 30\text{ cm}$ size. Paddy straw was twisted and placed in bag. Spawn was laid over the twist towards the sides, over which paddy straw twists were again laid and spawning was done. Likewise, four layers were prepared and the upper layer was fully spread with spawn. Each bag was filled with 1 kg straw (dry weight) and 150 g of spawn. The bags were made compact, tied at the top and provided with around 15 pin holes for air circulation. The beds were incubated in dark room with adequate aeration for the spawn run. After complete spawn run, slits were cut on the bed for primordial initiation. The fruiting bodies produced were then used for recording the macroscopical and microscopical observations. (Jose, 2018).

Biological Efficiency (BE) (per cent) is calculated using the formula,

BE (per cent)

$$= \frac{\text{Total fresh weight of mushroom harvested per bag (g)}}{\text{Dry weight of substrate per polybag (g)}} \times 100$$

Evaluation of yield and performance of the mushroom species under five agro-ecological zones

To evaluate the yield and performance, five species of oyster mushrooms were cultivated in farmer's field of five agro-ecological zones of Kerala. Five locations were selected with three replications for each of the five treatments.

The selected locations in five agro-ecological zones in Kerala were as following

1. Coastal plains - Mushroom production unit, Dept. of Plant Pathology, College of Agriculture, Padannakkad, Pin-671328
2. Midland laterites – Mrs. Suma Devi S, Venjaramoodu Thiruvananthapuram
3. Foothills – Mr. Lalu Thomas, Kunnicothu, Kollam
4. Highhills – Mr. Bhagyaraj, Parakkottu, Vagamon

Table 1. Macroscopic characters and growth parameters recorded

Sl. No	Parameters observed/ recorded
1. Macroscopic characters	Sporocarp colour, Gill arrangement, Stipe length, Colour of pinhead, Texture of sporocarp, Species of oyster mushroom, Sporocarp weight (g), No. of sporocarp, Pileus length (cm), Pileus breadth
2. Biometric observations	Sporocarp weight (g), No. of sporocarp, Pileus length (cm), Pileus breadth (cm), Stipe length (cm), Gills (No. cm ⁻¹)
3. Growth and yield parameters	Species of oyster mushroom, Time taken for complete spawn run (days), Time taken for pin-head formation (days), Time taken for first harvest (days), Total crop period (days), Total yield from first harvest (g), Total yield from second harvest (g), Total yield from third harvest (g), Total yield from three harvests (g), BE (per cent)

5. Palakkad plains – Mr. Abhilash R, Kanjikode, Palakkad

R based web application GRAPES was used for Pooled analysis (Gopinath et al., 2021).

Results and Discussion

The sporocarps from the five species of oyster mushrooms were studied based on the size, texture and colour of sporocarp, gill arrangement, stipe length and colour of pinhead (Plate 1,2). They produced fleshy sporocarp with distinct colours. *P. florida* produced white, fleshy sporocarp having comparatively large pileus with 6.62 cm x 7.52 cm while *P. djamor* produced pinkish white leathery sporocarps with smaller pileus. *H. ulmarius* produced creamy white fleshy sporocarps with large pileus (7.0 cm x 7.52 cm). *P. sajor-caju* produced greyish white leathery sporocarp with dimensions of 7.10 cm x 5.32 cm. Significantly long and stout stipe with an average length of 5.32 cm was one of the characteristic features of *P. sajor-caju*. *P. citrinopileatus* produced golden yellow delicate

sporocarp with comparatively short stipe in large bunches. Gills were attached to the stipe in decurrent fashion except in *H. ulmarius* which was non-decurrent. Stipe length was significantly higher in *P. sajor-caju* (5.32 cm) while stipe was absent or very short in *P. djamor* (0.80 cm). Macroscopic observation of five species of oyster mushrooms is given in Table 2 and 3.

According to Tewari (1991), most part of South India is ideal for cultivation of oyster mushroom. Uddin et al. (2011) recommended temperature range of 14-27^o C with relative humidity 70-80 per cent as optimum for better growth of oyster mushrooms. They also reported that, the minimum days required for prime ordial initiation, maximum number of fruiting bodies and biological efficiency were found in this temperature and humidity range. Iqbal et al. (2016) observed 37 days for pin head formation and 39 days for maturation of the oyster mushroom cultivated on paddy straw.

In coastal plains, the highest yield of 1029.96 g with

Table 2. Macroscopic characters of five species of oyster mushrooms cultivated in paddy straw substrate

Characters	Sporocarp colour	Gill arrangement	Stipe length	Colour of pinhead	Texture of sporocarp
<i>P. florida</i>	Pure white, fleshy	Decurrent	Comparatively longer	Purewhite	Leathery
<i>P. djamor</i>	Pinkish white	Decurrent	Comparatively short stipe	Pinkish, faded on maturity	Delicate and watery
<i>H. ulmarius</i>	Creamy white	Non decurrent	Comparatively longer	Greyish blue, later turns to creamy white	Fleshy
<i>P. sajor-caju</i>	Greyish white	Decurrent	Longer	Grey colour later turns to greyish white	Leathery
<i>P. citrinopileatus</i>	Golden yellow	Decurrent	Comparatively short stipe	Bright yellow colour, later turns to golden yellow	Delicate and watery

Values are mean ± SD of four replications

Values followed by similar superscripts are not significantly different at 5 per cent level

Table 3. Biometric observations of sporocarp of five species of oyster mushroom cultivated in paddy straw substrate

Species of oyster mushroom	Sporocarp weight (g)	No. of sporocarp	Pileus length (cm)	Pileus breadth (cm)	Stipe length (cm)	Gills (No. cm ⁻¹)
<i>P. florida</i>	11.71±3.32 ^a	106.50±6.55 ^{cd}	6.62±0.35 ^a	7.52±0.59 ^a	3.22±0.22 ^b	12.00±0.81 ^c
<i>P. djamor</i>	8.75±4.00 ^{ab}	98.25±5.25 ^d	4.90±0.18 ^b	6.50±0.14 ^{bc}	0.80±0.07 ^c	17.50±0.57 ^a
<i>H. ulmarius</i>	9.33±1.90 ^a	115.50±5.50 ^{bc}	7.0±0.54 ^a	7.52±0.37 ^a	3.35±0.25 ^b	13.75±0.95 ^b
<i>P. sajor-caju</i>	11.07±2.34 ^a	125.25±12.03 ^b	6.67±0.97 ^a	7.10±0.76 ^{ab}	5.32±0.65 ^a	17.50±1.00 ^a
<i>P. citrinopileatus</i>	5.05±1.79 ^b	169.50±8.96 ^a	5.45±0.70 ^b	6.17±0.53 ^c	3.30±0.21 ^b	11.75±0.50 ^c
CD (0.05)	4.228	10.802	0.929	0.792	0.519	1.199
SE (m)	1.403	3.584	0.308	0.263	0.172	0.398

Values were recorded on 3rd and 4th day after primordial initiation, Values are mean ± SD of four replications

Values followed by similar superscripts are not significantly different at 5 % level

Table 4. Comparative performance of five species of oyster mushrooms cultivated in paddystraw substrate in coastal plains

Sl. No	Species of oyster mushroom	Time taken for complete spawn run (days)	Time taken for pin-head formation (days)	Time taken for first harvest (days)	Total crop period (days)	Total yield from first harvest (g)	Total yield from second harvest (g)	Total yield from third harvest (g)	Total yield from three harvests (g)	BE (per cent)
1	<i>P. florida</i>	16.00±1.00 ^{ab}	19.33±1.15 ^b	23.33±1.55 ^b	61.66±3.21 ^b	432.20±1.00 ^b	274.00±4.00 ^b	180.00±15.00 ^b	886.20±10.41 ^b	88.62
2	<i>P. djamor</i>	11.66±1.15 ^c	14.66±0.57 ^c	18.66±1.15 ^c	53.66±1.52 ^c	373.00±3.00 ^c	210.00±10.00 ^c	140.00±5.00 ^c	723.00±10.14 ^c	72.30
3	<i>H. ulmarius</i>	15.33±1.15 ^b	19.66±0.57 ^b	22.33±0.57 ^b	58.66±3.21 ^b	520.00±5.00 ^a	309.09±0.00 ^a	200.87±0.00 ^a	1029.96±22.96 ^a	102.99
4	<i>P. sajorcaju</i>	18.33±1.52 ^a	22.66±2.08 ^a	26.00±2.00 ^a	67.00±1.73 ^a	350.00±3.00 ^d	50.10±12.00 ^c	50.00±3.00 ^d	550.10±18.67 ^c	55.01
5	<i>P. citrinopileatus</i>	16.66±1.52 ^{ab}	18.66±1.52 ^b	24.33±1.52 ^{ab}	60.66±2.08 ^b	370.00±7.00 ^c	198.00±2.00 ^d	62.00±2.00 ^d	630.00±13.22 ^d	63.00
	CD(0.05)	2.349	2.395	2.486	4.481	7.846	9.060	13.194	28.908	
	SE(m)	0.745	0.760	0.789	1.422	2.490	2.875	4.187	9.174	

Values are mean ± SD of three replications Values followed by similar superscripts are not significantly different at 5 per cent level

Abiotic parameters inside the mushroom house: RH- 93.87, Temperature- 27.5^oC, CO₂ concentration H⁺ 1000 ppm

a BE of 102.99 per cent was recorded from *H. ulmarius* which was followed by *P. florida* (88.62 per cent BE) and *P. djamor* (72.30 per cent BE). The total yield from first harvest was significantly higher from *H. ulmarius* (520.00 g) followed by *P. florida* (432.20 g). Significantly low yield was obtained from *P. sajor-caju* (50.00 g) and *P. citrinopileatus* (62.00 g) from third harvest which indicates the possibility of limiting the economic cropping period of these mushroom upto second harvest. *H. ulmarius* was found to be the best suited oyster mushroom species for cultivation in coastal plains. Comparative performance of five species of oyster mushrooms cultivated in paddy straw substrate in coastal plains is given in Table 4.

In foothills, the highest yield of 927.33g was recorded from *H. ulmarius* with BE of 92.73 per cent, which was followed by *P. florida* (832.33g). The yield obtained from *P. sajor-caju* (811.00 g) and *P. citrinopileatus* (800.00 g) did not vary significantly. Lower yield was recorded from *P. djamor* (Table 5). Total yield from first harvest was significantly higher in *H. ulmarius* (455.33 g) followed by *P. florida* (428.33 g.) *H. ulmarius* was found to be the best suited oyster mushroom species for cultivation in foothills.

High hills region was found to be the best agro-ecological zone for cultivation of oyster mushroom based on total yield. In highhills, the highest yield

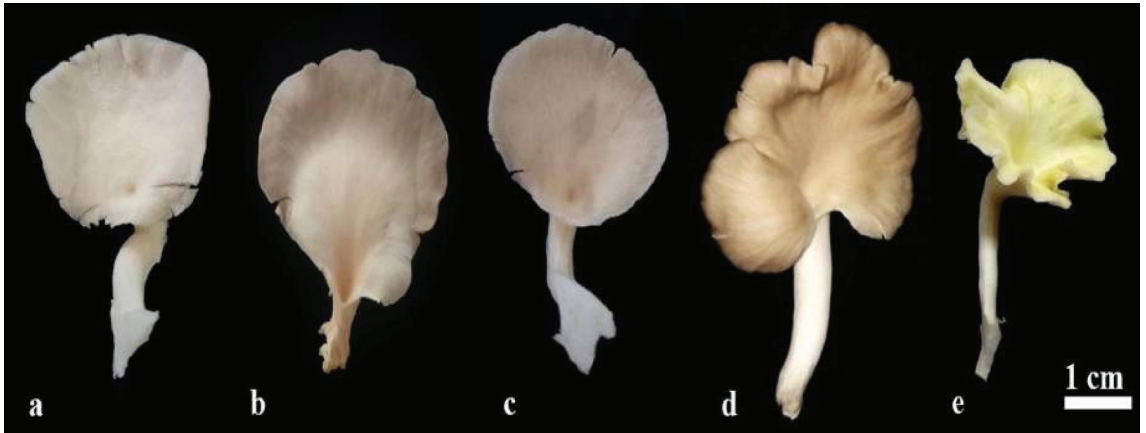


Plate 1. Morphological variation in sporocarp of five species of oyster mushrooms **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

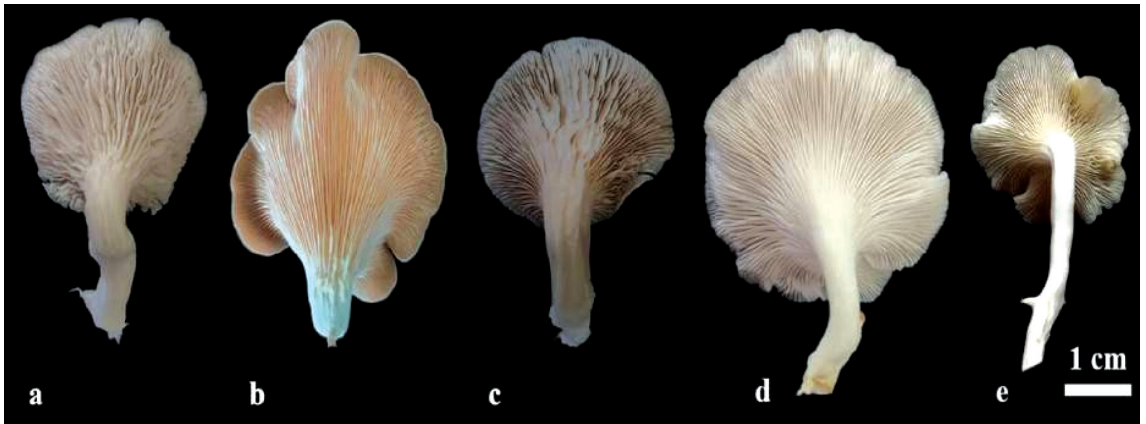


Plate 2. Sporocarp showing gills **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

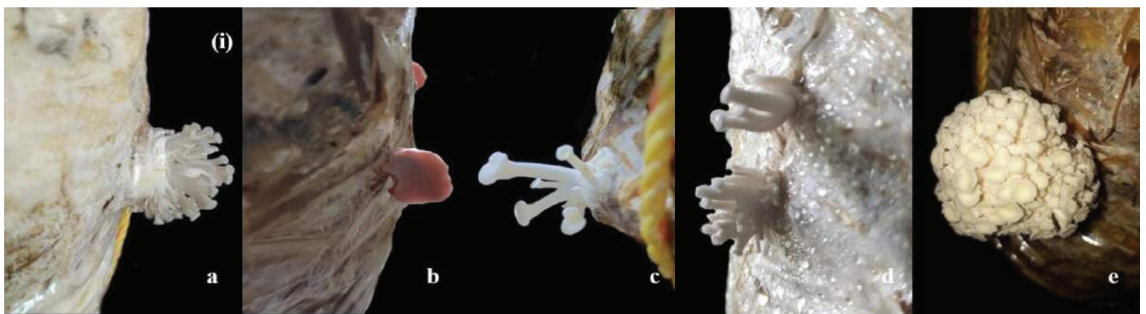


Plate 3. Pin-head emergence in five species of oyster mushrooms in Coastal plains. **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

of 1233.00 g was obtained from *H. ulmarius* with BE of 123.30 followed by *P. florida* (1148.30 g) and *P. djamor* (1050.30 g). Total yield from first harvest was significantly higher in *H. ulmarius* (658.30 g) followed by *P. djamor* (530.30 g). Total yield from third harvest was significantly low for

P. citrinopileatus (65.00 g) followed by *P. sajor-caju* (80.00 g). *H. ulmarius*, *P. florida* and *P. djamor* were found to be best suitable for cultivation in high hills based on comparatively low total cropping period and high yield (Table 6).

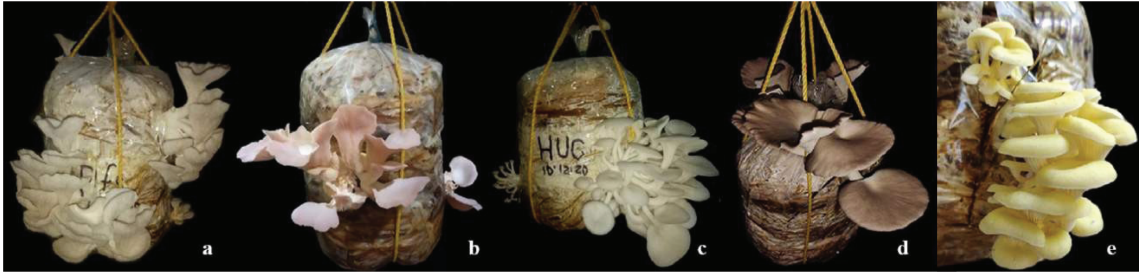


Plate 4. Mature sporocarp of oyster mushrooms cultivated in Coastal plains **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

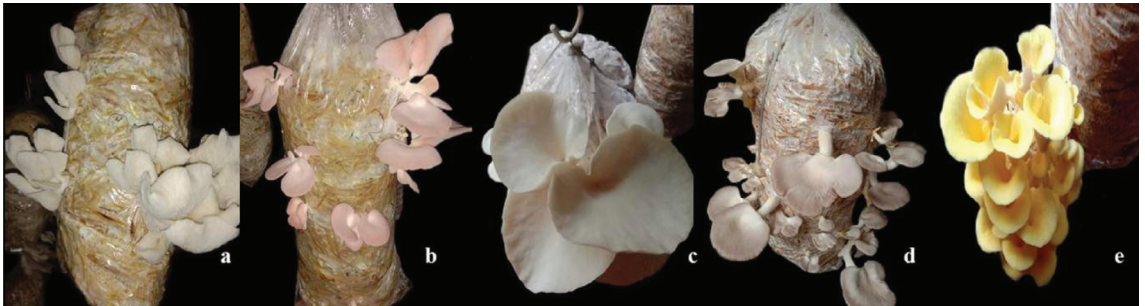


Plate 5. Mature sporocarp of oyster mushrooms cultivated in midland laterites **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

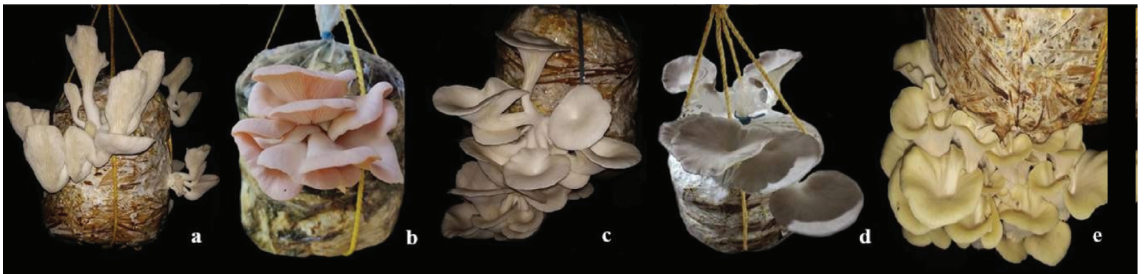


Plate 6. Mature sporocarp of oyster mushrooms cultivated in foothills. **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

Shukla and Jaitley (2011) compared the yield of *H. ulmarius* and *P. sajor-caju*. They observed that the maximum average yield of 855.52g per kg dry substrate was recorded by *H. ulmarius* followed by *P. sajor-caju* 742.98 g per kg dry weight substrate. Biswas and Kuiry (2013) evaluated the cultural characters and yield of *P. sajor-caju*, *P. flabellatus*, *P. florida*, *P. eous*, *P. ostreatus* and *H. ulmarius*. *H. ulmarius* was found to be most suitable species in terms of biological efficiency (156 per cent), spawn run period (15 days) and average weight of sporophore (7.98 g), followed by *P. florida* (121.5 per cent BE), *P. sajor-caju* (115.5 per cent BE) and *P. ostreatus* (103.25 per cent BE).

H. ulmarius was found to be the best suited oyster mushroom species for cultivation in coastal plains (102.99 per cent BE), foothills (92.73 per cent BE) and high hills (123.30 per cent BE). Mishra et al. (2015) studied about the growth and yield characteristics of ten species of oyster mushrooms and they obtained the highest biological efficiency (BE) of 97.50 per cent from *H. ulmarius*. This was followed by *P. djamor* (75.05 per cent), *P. citrinopileatus* (68.52 per cent BE), *P. sajor-caju* (63.85 per cent BE) and *P. florida* (53.17 per cent BE). Sumi (2016) conducted multi locational trials in Idukki, Wayanad and Vellayani and revealed that *H. ulmarius* can be cultivated throughout the year

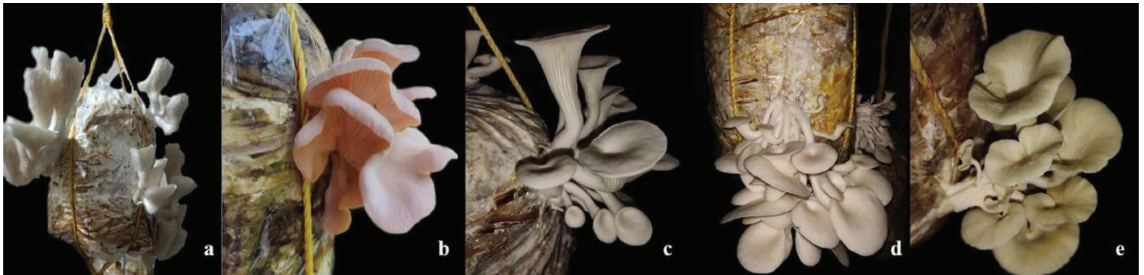


Plate 7. Mature sporocarp of oyster mushrooms cultivated in High hills. **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

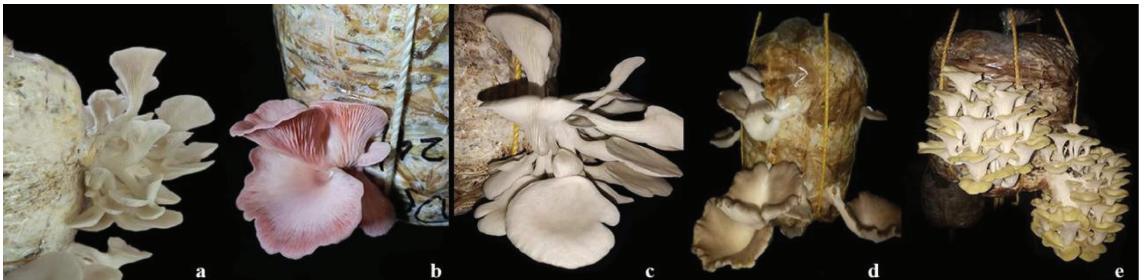


Plate 8. Mature sporocarp of oyster mushrooms cultivated in Palakkad plains. **a.** *P. florida*; **b.** *P. djamor*; **c.** *H. ulmarius*; **d.** *P. sajor-caju*; **e.** *P. citrinopileatus*

Table 5. Comparative performance of five species of oyster mushrooms cultivated in paddy straw substrate in foothills

Sl. No	Species of oyster mushroom	Time taken for complete spawnrun (days)	Time taken for pin-head formation (days)	Time taken for first harvest (days)	Total crop period (days)	Total yield from first harvest(g)	Total yield from second harvest(g)	Total yield from third harvest(g)	Total yield from three harvests(g)	BE (per cent)
1	<i>P. florida</i>	18.33± 1.52 ^{ab}	22.00± 1.00 ^{bc}	25.33± 0.57 ^b	59.33± 2.30 ^c	428.33± 2.00 ^b	234.00± 2.00 ^c	170.00± 5.00 ^b	832.33± 40.07 ^b	83.23
2	<i>P. djamor</i>	15.33± 0.57 ^c	17.00± 1.00 ^d	20.00± 1.00 ^c	53.66± 2.51 ^d	385.50± 2.00 ^d	295.10± 3.00 ^a	90.00± 3.00 ^c	768.60± 23.15 ^c	76.86
3	<i>H. ulmarius</i>	17.66± 1.15 ^b	20.66± 0.57 ^c	24.00± 1.00 ^b	60.33± 0.57 ^{bc}	55.33± 10.00 ^a	252.00± 4.00 ^b	220.00± 0.00 ^a	927.33± 42.02 ^a	92.73
4	<i>P. sajorcaju</i>	19.66± 1.15 ^a	23.66± 1.00 ^a	27.00± 1.00 ^a	64.00± 1.73 ^a	423.00± 3.00 ^b	58.00± 10.00 ^b	130.00± 2.00 ^c	811.00± 34.59 ^{bc}	81.10
5	<i>P. citrinopileatus</i>	18.66± 0.57 ^{ab}	22.33± 0.57 ^{ab}	25.33± 0.57 ^b	63.66± 1.52 ^{ab}	395.00± 5.00 ^c	290.00± 5.00 ^a	15.00± 10.00 ^d	800.00± 28.05 ^{bc}	80.00
	CD(0.05)	1.937	1.627	1.558	3.387	9.695	10.097	9.558	62.457	
	SE(m)	0.615	0.516	0.494	1.075	3.077	3.204	3.033	19.821	

Values are mean ± SD of three replications. Values followed by similar superscripts are not significantly different at 5 per cent level
 Abiotic parameters inside the mushroom house: RH- 87.80, Temperature- 28.5°C, CO₂ concentration H⁺ 1250 ppm

in all the three regions except April-May in cool climate of Idukki and Wayanad. An average yield of 1.096 kg kg⁻¹ dry weight of paddy straw (109.60 per cent BE) was reported for *H. ulmarius* and 0.976 kg with BE of 97.5 per cent for *P. florida*. High yield of *H. Ulmarius* and *P. florida* is due to the production of large fruiting clusters and large sporo

carps, higher moisture content of pileus and also the adaptability of both mushrooms to lower temperature and high humidity.

P. djamor was found to be the best yielder (BE of 82.70 per cent) in midland laterites. The yield recorded from *H. ulmarius* and *P. djamor* were on

Table 6. Comparative performance of five species oyster mushrooms cultivated in paddy straw substrate in High hills

Sl. No	Species of Oyster mushroom	Time taken for complete spawnrun (days)	Time taken for pin-head formation (days)	Time taken for first harvest (days)	Total crop period (days)	Total yield from first harvest(g)	Total yield from second harvests(g)	Total yield from three harvests(g)	Total yield from three harvests(g)	BE (per cent)
1	<i>P. florida</i>	15.66± 1.15 ^c	19.00± 1.00 ^c	23.00± 1.00 ^b	59.00± 1.73 ^c	495.30± 5.00 ^c	393.00± 0.00 ^a	60.00± 10.00 ^a	1148.30± 39.06 ^b	114.83
2	<i>P. djamor</i>	11.66± 0.57 ^d	15.00± 0.00 ^d	17.66± 0.57 ^c	54.00± 1.00 ^d	530.30± 10.00 ^b	325.00± 10.00 ^c	195.00± 5.00 ^c	1050.30± 10.78 ^c	105.03
3	<i>H. ulmarius</i>	16.33± 0.57 ^{bc}	20.33± 0.57 ^b	23.66± 1.15 ^b	63.66± 1.15 ^b	658.30± 2.00 ^a	354.70± 4.00 ^b	220.00± 0.00 ^b	1233± 19.46 ^a	123.30
4	<i>P. sajor-caju</i>	19.33± 0.57 ^a	23.00± 0.00 ^a	26.33± 0.57 ^a	67.33± 2.08 ^a	382.50± 2.00 ^d	269.10± 0.00 ^d	80.00± 20.00 ^d	731.60± 24.00 ^d	73.16
5	<i>P. citrinopileatus</i>	17.66± 0.57 ^b	21.33± 0.57 ^b	24.33± 0.57 ^b	60.66± 0.57 ^c	320.00± 10.00 ^c	225.00± 5.00 ^c	65.00± 5.00 ^d	610.00± 68.00 ^c	61.00
	CD(0.05)	1.329	1.050	1.485	2.573	12.419	9.661	19.081	69.142	
	SE(m)	0.422	0.333	0.471	0.816	5.574	4.336	6.055	21.942	

Values are mean ± SD of three replications

Values followed by similar superscripts are not significantly different at 5 per cent level

Abiotic parameters inside the mushroom house: RH- 92.93, Temperature- 21.6°C, CO₂ concentration H⁺ 900 ppm

par with each other with BE of 80.6 per cent and 77.30 per cent (806.00 g and 773.03 g) respectively (Table 7). It has been observed that the total yield from third harvest was significantly low in *P. citrinopileatus* (75.00g) followed by *P. sajor-caju* (90.03g). Emergence of pinheads was first observed in *P. djamor* which took 16.00 days for pinhead formation and harvest within an average of 3.33

days after initiation. The time taken for first harvest was found to be significantly less in *P. djamor*, which yielded in 19.33 days, followed by *P. florida* (23.33 days). *P. djamor* completed the total crop period within 57.00 days followed by *P. florida* (63.00 days) while *P. sajor-caju* took an average of 74.33 days to complete the total crop period. Jatwa et al. (2016) reported that total crop period was

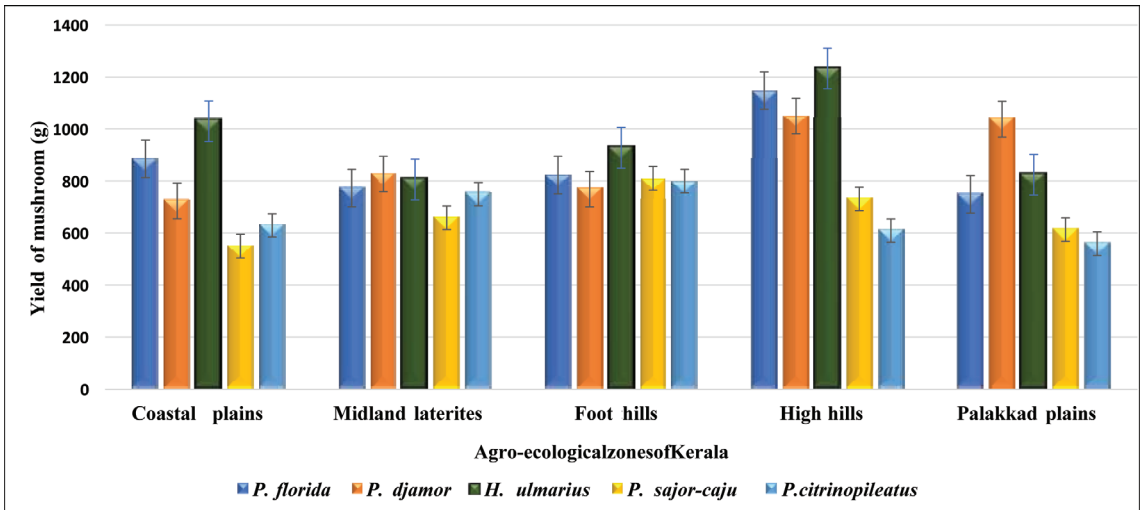
Table 7. Comparative performance of five species of oyster mushrooms cultivated in paddystraw substrate in midland laterites

Sl. No	Species of Oyster mushroom	Time taken for complete spawn run (days)	Time taken for pin-head formation (days)	Time taken for first harvest (days)	Total crop period (days)	Total yield from first harvest(g)	Total yield from second harvests(g)	Total yield from third harvests(g)	Total yield from three harvests(g)	BE (per cent)
1	<i>P. florida</i>	17.66± 1.15 ^b	21.00± 1.00 ^b	23.33± 0.57 ^c	63.00± 2.64 ^c	373.00± 1.00 ^c	250.00± 4.00 ^b	150.03± 1.00 ^a	773.03± 50.26 ^{ab}	77.30
2	<i>P. djamor</i>	12.66± 0.57 ^c	16.00± 1.00 ^c	19.33± 0.57 ^d	57.00± 2.64 ^d	425.00± 2.00 ^a	252.00± 2.00 ^b	150.00± 6.00 ^a	827.00± 36.51 ^a	82.70
3	<i>H. ulmarius</i>	17.33± 1.15 ^b	21.66± 0.57 ^b	24.33± 0.57 ^{bc}	67.66± 2.51 ^b	389.00± 11.00 ^b	277.00± 3.00 ^a	140.00± 2.00 ^b	806.00± 19.51 ^{ab}	80.60
4	<i>P. sajor-caju</i>	20.33± 1.15 ^a	23.33± 0.57 ^a	27.33± 0.57 ^a	74.33± 2.08 ^a	345.83± 1.00 ^d	223.00± 3.00 ^c	90.00± 3.00 ^c	658.83± 30.52 ^c	65.88
5	<i>P. citrinopileatus</i>	18.33± 1.15 ^b	21.00± 1.00 ^b	25.33± 0.57 ^b	69.33± 0.57 ^b	390.00± 5.00 ^b	285.00± 10.00 ^a	75.00± 5.00 ^d	750.00± 15.00 ^b	75.00
	CD(0.05)	1.937	1.329	1.050	4.068	10.031	9.558	7.046	59.774	
	SE(m)	0.615	0.422	0.333	1.291	3.183	3.033	2.236	18.969	

Values are mean±SD of three replications

Values followed by similar superscripts are not significantly different at 5 per cent level

Abiotic parameters inside the mushroom house: RH- 85.81, Temperature- 27.1°C, CO₂ concentration H⁺ 1300 ppm



Error bar represents standard error of means of observed values

Figure 1. Yield of five species of oyster mushrooms under five agro-ecological zones of Kerala

significantly higher in *P. sajor-caju* which was in agreement with the present study. Comparative performance of five species of oyster mushrooms cultivated in paddy straw substrate in midland laterites is given in Table 7.

In Palakkad plains, *P. djamor* produced significantly higher yield of 1038.00 g with a BE of 103.80 per cent (Table 8). It was followed by *H. ulmarius* (824.60g) with a BE of 82.46 per cent and *P. florida*

(749.00g) with a BE of 74.90 per cent. Comparatively lower yield of 560.00 g was obtained from *P. citrinopileatus*. Total yield from first, second and third harvest from *P. djamor* was 502.00 g, 335.00 g and 201.00 g respectively. Significantly low yield was recorded from *P. citrinopileatus* from third harvest (28.00 g) which indicates that the mushroom bed could be discarded after the second harvest. Yield was obtained from *P. djamor* within 22.33 days followed by *H. ulmarius* (24.33 days).

Table 8. Comparative performance of five species of oyster mushrooms cultivated in paddy straw substrate in Palakkad plains

Sl. No	Species of Oyster mushroom	Time taken for complete spawn run (days)	Time taken for pin-head formation (days)	Time taken for first harvest (days)	Total crop period (days)	Total yield from first harvest (g)	Total yield from second harvests (g)	Total yield from three harvests (g)	Total yield from three harvests (g)	BE (per cent)
1	<i>P. florida</i>	17.66±0.57 ^c	21.33±0.57 ^c	25.00±1.00 ^{bc}	62.33±2.51 ^c	450.00±10.00 ^b	185.00±5.00 ^c	14.00±16.00 ^b	749±13.52 ^c	74.90
2	<i>P. djamor</i>	15±1.00 ^d	19.33±0.57 ^d	22.33±0.57 ^d	60.66±2.51 ^c	502.00±8.00 ^a	335.00±1.00 ^a	201.00±10.00 ^a	1038±27.62 ^a	103.80
3	<i>H. ulmarius</i>	18±0.00 ^c	21.33±0.57 ^c	24.33±0.57 ^c	66.66±1.52 ^b	386.50±10.00 ^c	325.10±1.00 ^b	113.00±3.00 ^b	824.6±13.50 ^b	82.46
4	<i>P. sajorcaju</i>	21.33±0.57 ^a	24.33±0.57 ^a	27.66±0.57 ^a	72.66±2.08 ^a	325.50±5.00 ^d	202.30±2.00 ^d	86.50±1.00 ^c	614.3±12.01 ^d	61.43
5	<i>P. citrinopileatus</i>	19.33±0.57 ^b	23.00±1.00 ^b	25.66±0.57 ^b	68.66±1.52 ^b	320.00±2.00 ^d	212.00±2.00 ^c	28.00±0.00 ^d	560±27.18 ^c	56.02
	CD(0.05)	1.151	1.243	1.243	3.787	13.927	4.813	9.831	36.491	
	SE(m)	0.365	0.394	0.394	1.202	4.420	1.528	3.120	11.581	

Values are mean ± SD of three replications. Values followed by similar superscripts are not significantly different at 5 per cent level

Abiotic parameters inside the mushroom house: RH- 84.87, Temperature- 31.5°C, CO₂ concentration H⁺ 1100 ppm

Total crop period was significantly higher (72.66 days) in *P. sajor-caju*. *P. djamor* was found to be the best suited oyster mushroom species for cultivation in Palakkad plains considering the yield and cropping period.

Ahmed et al. (2009) reported that the optimum temperature range for spawn running and basidiocarp production of *P. florida* was 21-25°C and 20-28°C respectively while Dhar et al. (2011) observed an optimum temperature range of 20-25°C and 20-28°C for the spawn running and sporocarp formation of *P. sajor-caju*. Studies indicated that *P. djamor* required higher temperature of 30-35°C for spawn running and 21-35°C for basidiocarp production (Jatwa et al., 2016). *P. djamor*, reported to be performing better under warm conditions, yielded well under the different agro-ecological zones of Kerala. *P. djamor* performed well in areas having higher temperature, lesser rainfall and lesser humidity Both earliness in primordial initiation and less time taken for first harvest was observed from *P. djamor*, which took an average of 17.66-22.33 days for first harvest. Earliness in primordial initiation (14-19 days) and adaptation to lower relative humidity make this species promising for cultivation in Kerala during dry months.

From the present study it was evident that *H. ulmarius* was adapted to the climatic conditions prevailing throughout Kerala. The performance of *P. sajor-caju* was poor in all the agro-ecological zones. The cropping period was also higher for *P. sajor-caju* which was in accordance with Mandeel et al. (2005) who reported that *P. sajor-caju* took 18-22 days for primordial initiation and 25-27 days for first harvest. Comparatively low yield of *P. citrinopileatus* and *P. sajor-caju* in Kerala conditions is due to the fact that they prefer warm conditions and are suitable for cultivation in summer months. The optimum frutification temperature of *P. citrinopileatus* ranges from 21-29°C while temperature range of 23-25°C was found to be suitable for harvesting (Wang et al., 2005). Compared to other oyster mushroom the average

weight of fruiting body was less for *P. citrinopileatus* and *P. djamor* due to lower moisture content. Also, typically small sporocarps were produced by *P. citrinopileatus* which also may be responsible for the lower crop yield. Since the cultivation of golden oyster mushroom, *P. citrinopileatus* was done for the first time in Kerala its cultivation technology has to be standardized.

Conclusion

The present study demonstrated the performance of five species of oyster mushrooms in Kerala conditions. All the five species can be cultivated under the five agro-ecological zones of Kerala but *H. ulmarius*, *P. florida* and *P. djamor* performed better in terms of yield compared to *P. citrinopileatus* and *P. sajor-caju* in all the agroecological zones. *H. ulmarius* was found to be the best yielder in coastal plains, foothills and high hills. Considering the yield and earliness in bearing, *P. djamor* can be cultivated economically in midland laterites and Palakkad plains.

Pests such as flies (phorid flies and spring tail) were observed and contamination due to *Trichoderma* and *Coprinus* were observed. The contaminated beds were removed and discarded from the mushroom house as and when observed and no specific management was required.

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