Technologies Developed by ICAR-Directorate of Mushroom Research for Commercial Use

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Technologies Developed by ICAR-DMR for Commercial Use

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A. Commercial Strains of Different Mushrooms Released by ICAR-DMR, Solan

Commercial strains of different mushrooms released by ICAR-DMR, Solan

a. Released strains of *Agaricus bisporus* (white button mushroom)

1). DMR-Button-03 (White button mushroom)

Developer : Shwet Kamal, Manjit Singh, R.C. Upadhyay, O.P. Ahlawat

Essential Traits of Fruit Bodies:

- **Avg. cap diameter** : 43 mm
- **Avg. cap length** : 9 mm
- **Avg. stem length** : 17 mm
- **Avg. fruit body weight** : 12 g
- **Fruit body colour** : White to off white
- **Yield** : Avg. 20-22 kg/100 kg compost

Fig. 1. DMR-Button-03 (white button mushroom)

Fig. 2. DMR-Button-06 (Brown button mushroom)

2). DMR-Button-06 (Brown button mushroom)

Developer : Shwet Kamal, Manjit Singh, R.C. Upadhyay, O.P. Ahlawat

Essential Traits of Fruit Bodies:

- **Avg. cap diameter** : 41.5 mm
- **Avg. cap length** : 9.3 mm
- **Avg. stem length** : 18 mm
- **Avg. fruit body weight** : 10 g
- **Fruit body colour** : Brown
- **Yield** : Avg. 20-25 kg/100 kg compost

3). DMR Button –NBS-1

Developer : Shwet Kamal, Manjit Singh, R.C. Upadhyay, O.P. Ahlawat, V.P. Sharma

Mushroom farm unit : Completely environment controlled unit
Culture characteristics and growth : Fine and shining mycelial growth
Growth rate : On compost extract agar media 2.1mm/day
On malt extract agar 2.33mm/day
Spawn run time in pasteurized compost : 13 days
Casing run time : 7 days
Time taken for first harvest after casing : 14 days

i). Unique morphological characteristics

- **Fruit body shape** : Cap dome shaped without any depression
- **Avg. cap dia.** : 48 mm
- **Avg. stem dia.** : 15 mm
- **Avg. cap length** : 9 mm
- **Avg. stem length** : 18 mm
- **Avg. gill size** : 2.0 mm
- **Avg. fruit body wt.** : 14 g
- **Fruit body color** : Pure white
- **Veil opening** : Compact fruit body, later veil opening

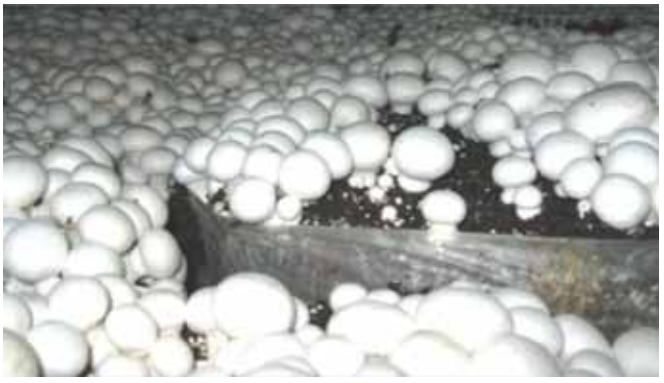


Fig. 3. DMR Button–NBS-1 strain

ii). Agronomic features (e.g. resistance to over watering/ under watering, high CO_2, low/high Temp. etc.)

- **Pasteurized compost**
- **Compost moisture <62%**
- **Spawn rate @ 1% of wet weight of compost**
- **Spawn run conditions** : Temperature : 24-26°C (Bed temperature)
  Relative humidity : 90-95% (Cropping room)
  CO_2 : >8000 ppm (Cropping room)
  Light : Not required
- **Casing conditions** : 1.5 inch layer of soil + FYM (1 ½ year old) (1:1)
  Temperature : 24-26°C (Bed temperature)
  Relative humidity : 90-95% (Cropping room)
  CO_2 : >8000 ppm (Cropping room)
  Light : Not required
  Light watering on mushroom bed during spawn run
- **Fruiting/cropping room conditions**
  Temperature : 14-16°C (Bed temperature)
  Relative humidity : 85-90% (Cropping room)
  CO_2 : >800-1000ppm (Cropping room)
  Light : Not required
  Air circulation /exchange : three –four air change/day
  Light watering on alternate days specially, if required
  Harvest at 4-5 cm size of button without leaving any fruit body part on bed
  Packaging in perforated polythene/ polypropylene or paper bags / punnets
- **Yield** : 18-21 kg/100kg compost.

4). DMR Button –NBS-5

Developer : Shwet Kamal, Manjit Singh, R.C. Upadhyay, O.P. Ahlawat, V.P. Sharma, Satish Kumar

Mushroom farm unit : Completely environment controlled unit
Culture characteristics and growth : Fine and shining mycelial growth
Growth rate : On compost agar media 1.8mm/day
On malt extract agar 2.66mm/day
Spawn run time in pasteurized compost : 12 days
Casing run time : 6days
Time taken for first harvest after casing : 13-14 days

i). Unique morphological characteristics of DMR-BUTTON- NBS-5

- **Fruit body shape** : Cap dome shaped without any depression
- **Avg. cap dia.** : 40 mm
- **Avg. stem dia.** : 12 mm

- **Avg. cap length** : 12 mm
- **Avg. stem length** : 18 mm
- **Avg. gill size** : 2.5 mm
- **Avg. fruit body wt.** : 13.75g
- **Fruit body color** : White to off white depending upon humidity level
- **Veil opening** : Compact fruit body, later veil opening

Fig. 4. DMR Button–NBS-5 Strain

ii). Agronomic features (e.g. resistance to over watering/ under watering, high CO_2, low/high temp. etc.)

- **Pasteurized compost**
- **Compost moisture <62%**
- **Spawn rate @ 1% of wet weight of compost**
- **Spawn run conditions** :

Temperature : 24-26 °C (Bed temperature)
Relative humidity : 90-95% (Cropping room)
CO_2 : >8000ppm (Cropping room)
Light : Not required

- **Casing conditions** : 1.5 inch layer of garden soil + FYM (1 ½ year old) (1:1)

Temperature : 24-26 °C (Bed temperature)
Relative humidity : 90-95% (Cropping room)
CO_2 : >8000ppm (Cropping room)
Light : Not required
Light watering on mushroom bed on spawn run

- **Fruiting/cropping conditions:**

Temperature : 14-16 °C (Bed temperature)
Relative humidity : 85-90% (Cropping room)
CO_2 : >800-1000ppm (Cropping room)
Light : Not required
Air circulation /exchange : three –four air change/day light watering on alternate days specially if required harvest at 4-5 cm size of button without leaving any fruit body part on bed
Packaging in perforated polythene/ polypropylene or paper bags

- **Yield :** 20-23 kg/100kg compost.

5). DMR Button –04 (U-3-54)

Developer : Shwet Kamal, Manjit Singh, R.C. Upadhyay, O.P. Ahlawat, V.P. Sharma

Mushroom farm unit : Completely environment controlled unit
Culture characteristics and growth : Fine and signing mycelial growth
Growth rate : On compost agar media 1.8mm/day
On malt extract agar 2.1mm/day
Downward linear growth on compost 2.7 mm/day
Spawn run time in pasteurized compost : 12 days
Casing run time : 6days
Time taken for first harvest after casing : 13-14 days

i). Unique morphological characteristics of DMR-BUTTON-04 (U-3-54)

- **Fruit body shape** : Cap dome shaped without any depression
- **Avg. cap dia.** : 45 mm
- **Avg. stem dia.** : 15 mm
- **Avg. cap length** : 9 mm
- **Avg. stem length** : 22 mm

- **Avg. gill size** : 2.1 mm
- **Avg. fruit body wt.** : 12 g
- **Fruit body color** : Pure white
- **Veil opening** : Compact fruit body, later veil opening

Fig. 5. DMR Button–04 (U-3-54) Strain

ii). Agronomic features (e.g. resistance to over watering/ under watering, high CO_2, low/high temp. etc.)

- **Pasteurized compost**
- **Compost moisture <62%**
- **Spawn rate @ 1% of wet weight of compost**
- **Spawn run conditions** :

Temperature : 24-26 °C (Bed temperature)
Relative humidity : 90-95% (Cropping room)
CO_2 : >8000ppm (Cropping room)
Light : Not required

- **Casing conditions** : 1.5inch layer of soil + FYM (1 ½ year old) (1:1)

Temperature : 24-26 °C (Bed temperature)
Relative humidity : 90-95% (Cropping room)
CO_2 : >8000ppm (Cropping room)
Light : Not required
Light watering on mushroom bed on spawn run

- **Fruiting/cropping conditions:**

Temperature : 14-16 °C (Bed temperature)
Relative humidity : 85-90% (Cropping room)
CO_2 : >800-1000ppm (Cropping room)
Air circulation /exchange : three –four air change/day
Light watering on alternate days specially if required
Harvest at 4-5 cm size of button without leaving any fruit body part on bed
Packaging in perforated polythene/ polypropylene or paper bags

- **Yield** : 22 kg/100kg compost.

6. DMR-Button-14 (High yielding strain)

Developer : Shwet Kamal, V.P. Sharma, Anupam Barh, Rakesh Bairwa

Fig. 6. DMR-Button-14

i). Fruit body characters

- **Avg Cap diameter** : 52 mm
- **Avg Cap length** : 12 mm
- **Avg Stem length** : 14 mm
- **Avg Fruit body weight** : 14 g
- **Fruit body colour** : White to off white
- **Yield** : Average 23-25 kg/ 100 kg compost

ii). Spawn run conditions

- **Temperature** : 24±2 °C (bed temperature)
- **Relative humidity** : 90-95% (cropping room)
- **CO_2** : 15000-20000 ppm (cropping room)
- **Light** : Not required
- **Air circulation/exchange** : No air exchange required

iii). Fruiting/cropping

- **Temperature** : 16 ± 2 °C (bed temperature)
- **Relative humidity** : 80-85%
- **CO_2** : < 1000 ppm
- **Light** : No light required

- **Air circulation/exchange** : three-four exchanges equal to the volume of room/hr
- **Heavy watering during flush breaks and light watering during flushes**
- **Harvesting twice, once morning and once after noon**
- **Harvest at 5-6 cm cap size without leaving any fruit body part on bed**
- **Packaging in perforated polythene/polypropylene or paper bags.**

7. DMR-Button-59 (High yielding strain)

Developer : Shwet Kamal, V.P. Sharma, Anupam Barh, Rakesh Bairwa

Fig. 7. DMR-Button-59

i). Fruit body characters

- **Avg Cap diameter** : 44 mm
- **Avg Cap length** : 10 mm
- **Avg Stem length** : 16 mm
- **Avg Fruit body weight** : 12 g
- **Fruit body colour** : white to off white
- **Yield** : Average 22-24 kg/ 100 kg compost

ii). Spawn run conditions

- **Temperature** : 25±2 °C (bed temperature)
- **Relative humidity** : 90-95% (cropping room)
- **CO_2** : 15000-20000 ppm (cropping room)
- **Light** : Not required
- **Air circulation/exchange** : No air exchange required

iii). Fruiting/cropping

- **Temperature** : 15 ± 1 °C (bed temperature)
- **Relative humidity** : 80-85%
- **CO_2** : < 800 ppm
- **Light** : No light required
- **Air circulation/exchange – Four exchanges equal to the volume of room/hr**
- **Heavy watering during flush breaks and light watering during flushes**
- **Harvesting twice, once morning and once after noon**
- **Harvest at 4-5 cm cap size without leaving any fruit body part on bed**
- **Packaging in perforated polythene/polypropylene or paper bags**

b). Released strains of Oyster mushroom PSCH-35

Developer : R.C. Upadhayay, Anupam Barh, V.P. Sharma, Satish Kumar, Shwet Kamal, Sudheer Kumar Annepu, Anil Kumar

PSCH-35 strain: PSCH-35develop by crossing DMRP-255 and DMRP-112 strains of *Pleurotus sajor-caju*.

Fig. 8. *Pleurotus* mushroom PSCH-35

i). Fruit body traits

- **Average fruit body weight** : 6-10 g (Approx.)
- **Avg. pilus dia.** : 7.0 cm
- **Avg. stipe dia.** : 0.9 mm
- **Avg. cap length** : 6.5mm
- **Avg. stem length** : 1.5-2.0 mm
- **Mushroom fruit bodies do not have the any off smell**

ii). Spawn run and fruiting conditions

- **Spawn run temperature** : 24-30°C
- **Fruiting temperature** : 24±2°C
- **Relative humidity** : 85-90%
- **Conc. of CO_2 during spawning** : 10000-20000 ppm
- **Conc. of CO_2 during fruiting** : <500 ppm

c. Released strains of Shiitake mushroom

1. DMR Shiitake - 38

Developer : V.P. Sharma, Satish Kumar, Manjit Singh

i). Unique traits of fruit bodies:

- **Shape of fruit body** : Spherical, center is dark brown and light brown with white scars uniformly distributed throughout the cap from outside
- **Size of fruit cap dia.** : 6.5-8.0 cm (Approx.)
- **Fruit stipe length** : 5.0-6.0 cm (Approx.)
- **Fruit body weight** : 40-45g (Approx.)
- **Color of fruit body** : Brownish

ii). Spawn run conditions:

- **Temperature** : 23-25°C
- **Relative humidity** : 75-80% (cropping room)
- **Conc. of CO_2 during spawning** : 5000-8000 ppm (cropping room)
- **Light** : 8-10 h daily

Fig. 9. Fruiting of DMR Shiitake-38

iii). Fruiting/ Cropping room conditions:

- **Temperature** : 20-22°C
- **Relative humidity** : 80-85% (cropping room)
- **Conc. of CO_2 during fruiting** : 600-800 ppm (cropping room)
- **Light** : Fluorescent light 8-10 h /daily
- **Air circulation/exchange** : Two times daily (5-10 min./exchange)
- **Light watering daily is required**
- **Harvesting once in a week**
- **Packaging in perforated polythene/polypropylene or paper bags**

iv). Yield : 31-40 kg/100 kg of saw dust substrate

2. DMR Shiitake - 388

Developer : V.P. Sharma, Satish Kumar, Manjit Singh

i). Unique traits of fruit bodies:

- **Shape of fruit body** : Spherical, fruit bodies are pale yellow in color initially which turns into light brown with maturity,uniform ring of white scars present on the cap
- **Size of fruit cap dia.** : 6.0-7.0 cm (Approx.)
- **Fruit stipe length** : 5.0-6.0 cm (Approx.)
- **Fruit body weight** : 35-39 g (Approx.)
- **Color of fruit body** : Light Brownish in color
- **Veil opening** : Veil open from the beginning of fruiting

ii). Spawn run conditions:

- **Temperature** : 23-25°C
- **Relative humidity** : 75-80% (cropping room)
- **Conc. of CO_2 during spawning** : 5000-8000 ppm (cropping room)

Fig. 10. DMR Shiitake-388

- **Light** : 8-10 h daily
- **Air circulation/exchange** : Nil
- **No watering during spawn run stage**

iii). Fruiting/ Cropping room conditions:

- **Temperature** : 20-22 °C
- **Relative humidity** : 80-85% (cropping room)
- **Conc. of CO_2 during fruiting** : 600-800 ppm (cropping room)
- **Light** : Fluorescent light 8-10 h /daily
- **Air circulation/exchange** : Two times daily (5-10 min./exchange)
- **Light watering daily is required**
- **Harvesting once in a week**

Packaging in perforated polythene/polypropylene or paper bags

iv). Yield : 22.3-43.9k g/100kg of saw dust substrate

3. DMR Shiitake – 356

Developer : V.P. Sharma, Sudheer Kumar Annepu, Satish Kumar, Shwet Kamal, Anupam Barh

i). Fruit body characteristics

- **Fruit body shape:** Fleshy mushrooms with round caps and firm stipe
- **Fruit body size:** Cap dia. 8.2-8.6 cm stipe length 5.9-6.1mm
- **Fruit body weight:** 23-27g
- **Fruit body colour:** Light to dark brown cap, creamy white gills, light brown stem
- **Veil opening:** opened veil from beginning

ii). Spawn run conditions

- **Temperature –** 25±2ºC (bag temperature)
- **Relative humidity –** No role
- **CO_2 –** 5000-6000 ppm (cropping room)
- **Light –** 4-6h daily
- **Air circulation/exchange-** Nil
- **No watering during spawn run**

Fig. 11. DMR Shiitake - 356

iii). Fruiting/cropping

- **Temperature -** 20±2ºC (bag temperature)
- **Relative humidity –** 75-80%
- **CO_2 –** 1000-1500ppm
- **Light –** Fluorescent light 8-10 hours/day
- **Air circulation/exchange –** Two times/day (5-10 min/exchange)
- **Light watering daily is required**
- **Harvesting once in week**
- **Packaging in perforated polythene/polypropylene or paper bags.**

iv). Yield: 40-46kg/100kg of dry substrate

4. DMR Shiitake – 327 (High yielding strain)

Developer : V.P. Sharma, Sudhir Kumar Annepu, Satish Kumar

i). Fruit body characteristics

- **Fruit body shape:** Fleshy mushrooms with round caps and firm stipe
- **Fruit body size:** Cap dia. 9.4-9.7 cm stipe length 5.8-6.0 mm
- **Fruit body weight:** 28-30g
- **Fruit body colour:** Light to dark brown cap, creamy white gills, light brown stem
- **Veil opening:** opened veil from beginning

ii). Spawn run conditions

- **Temperature –** 25±2ºC (bag temperature)

- **Relative humidity –** No role
- **CO_2 –** 5000-6000 ppm (cropping room)
- **Light –** 4-6h daily
- **Air circulation/exchange-** Nil
- **No watering during spawn run**

iii). Fruiting/cropping

- **Temperature -** 20±2ºC (bag temperature)
- **Relative humidity –** 75-80%
- **CO_2 –** 1000-1500ppm
- **Light –** Fluorescent light 8-10 hours/day
- **Air circulation/exchange –** Two times/day (5-10 min/ exchange)
- **Light watering daily is required**
- **Harvesting once in week**
- **Packaging in perforated polythene/polypropylene or paper bags.**

Fig. 12. DMR Shiitake - 327

iv). Yield: 48-52kg/100kg of dry substrate

d). Released strains of milky mushroom

1. DMR Milky - 334

Developer : V.P. Sharma, Satish Kumar, Manjit Singh

i). Unique traits of fruit bodies:

- **Shape of fruit body** : Spherical cap with long stipe
- **Size of fruit cap dia.** : 7.0-8.0 cm (Approx.)
- **Fruit stipe length** : 11.0-12.0 cm (Approx.)
- **Fruit body weight** : 33-38 g (Approx.)
- **Color of fruit body** : White in color
- **Veil opening** : Veil open from the beginning of fruiting

Fig. 13. DMR Milky - 334

ii). Spawn run conditions:

- **Temperature** : 25-30˚C
- **Relative humidity** : 80-85% (cropping room)
- **Conc. of CO_2 during spawning** : 5000-8000 ppm (cropping room)
- **Light** : no light required during spawn run
- **Air circulation/exchange** : Nil

iii). Fruiting/ Cropping room conditions:

- **Casing** : 3-4 cm thick layer of casing soil (75%) + sand (25%) sterilized in autoclave at 15 psi for one hour or chemically treated with formaldehyde solution
- **Temperature** : 28-34˚C (bag temp.)
- **Relative humidity** : 80-90% (cropping room)
- **Conc. of CO_2 during fruiting** : 600-800 ppm (cropping room)
- **Light** : Fluorescent light 8-10 h /daily
- **Air circulation/exchange** : Once in day (5-10 min./exchange)
- **Watering once or twice in a day is required**
- **Harvest mushroom daily**
- **Packaging in perforated polythene/polypropylene or paper bags**

iv). Yield : 74-82 kg/100 kg of wheat dry straw/paddy straw substrate

2. DMR Milky - 985 (High yielding strain)

Developer : V.P. Sharma, Satish Kumar, Manoj Nath

Fig. 14. DMR Milky - 985

i) Unique traits of Fruit bodies

- **Shape of the fruit body** : Spherical cap with long stipe
- **Size of fruit cap dia.** : 7.0-8.0 cm (approx)
- **Fruit stipe length** : 11.0 – 12.0 cm (approx)
- **Fruit body weight** : 46-47 g (approx)
- **Colour of the fruit body** : white in colour
- **Veil opening** : veil open from the beginning of fruiting

ii) Spawn run conditions

- **Temperature** : 25-30°C
- **Relative Humidity** : 80-85% (cropping room)
- **Conc. Of CO_2 during spawning** : 5000-8000 ppm (cropping room)
- **Light** : No light required during spawn run
- **Air circulation/exchange** : Nil
- **Light watering required every 2-3 days**

iii) Fruiting / cropping room conditions

- **Casing** : 3-4 cm thick layer of casing soil (75%) + sand (25%) sterilized in autolave at 15 psi for one hour or chemically treated with formaldehyde solution
- **Temperature** : 28-34°C (bag temp.)
- **Relative humidity** : 80-90% (cropping room)
- **Conc. Of CO_2 during spawning** : 600-800 ppm (cropping room)
- **Light** : Flourescent light 8-10h/ daily
- **Air circulation/exchange** : Once in day (5-10 min/ exchange)
- **Watering once or twice in a day is required**
- **Harvest mushroom daily**
- **Packaging in perforated polythene/ polypropylene or paper bags**
- **Time taken for first harvest -33 days**

iv) Yield: 55.27kg/100 kg of wheat dry straw substrate

e. Released strains of paddy straw mushroom (*Volvariella volvacea*)

1. DMRO-247

Developer : O.P. Ahlawat, Manjit Singh, Satish Kumar

Fig. 15. DMRO-247 Paddy Straw Mushroom (*Volvariella volvacea*)

i). Unique traits of fruit bodies:

- **Shape of fruit body** : Oval shaped
- **Fruit body size** : Big in size (5.0-7.0 cm long × 4.0-5.0 cm wide)
- **Fruit body weight** : 14-18 g (Approx.)
- **Color of fruit body** : Light brown in color
- **Veil opening** : Lesser tendency of veil opening
- **K / Na ratio in fruit body** : 8.0 to 12.0 on different substrates
- **Protein content (dry wt. basis)** : 32-37% on different substrates
- **Texture of fruit body** : Comparatively hard

ii). Spawn run conditions:

- **Temperature** : 30-35 °C (bed temperature)
- **Relative humidity** : 90-95% (cropping room)
- **Conc. of CO_2** : 5000-8000 ppm (cropping room)
- **Light** : Not required
- **Air circulation/exchange** : Once or twice in a day (4-5 min/day)

Light watering on mushroom bed on completion of spawn run

iii). Fruiting/cropping conditions:

- **Temperature** : 28-32 °C (bed temperature)
- **Relative humidity** : 85-90%
- **Conc. of CO_2** : 600-800 ppm
- **Light** : Fluorescent light 4-5 hours/day
- **Air circulation/exchange** : 3-4 times/day (4-5 min/exchange)
- **Very light watering on alternate days only if required**
- **Harvesting twice, once morning and once after noon**
- **Harvest at button stage without leaving any fruit body part on bed**
- **Packaging in perforated polythene/polypropylene or paper bags**

2. DMRO-484

Developer : O.P. Ahlawat, Manjit Singh, R.C. Upadhyay, Shwet Kamal

i). Fruit body traits:

- **Size of fruit body** : Big oval shaped (5.0-7.0 cm long × 3.0-5.0 cm wide)
- **Fruit body weight** : 14-20 g
- **Fruit body color** : White or gray in color
- **Veil opening** : Lesser tendency of veil opening
- **Fat content** : 0.79%, less than brown strain
- **Fiber content** : 6.02%, higher than brown strain
- **Potassium/Sodium ratio** : 128.03, slightly higher than brown strain
- **Protein content (dry wt. basis)** : 36.88% on composted substrate slightly less than brown strain
- **Mineral content** : All elements like calcium, sodium, potassium, iron, copper, zinc and magnesium higher (1.06 to 1.50 times) than brown strain
- **Vitamin D content** : 0.58 fold less than brown strain
- **Fruit body texture** : Comparatively hard

ii). Spawn run conditions:

- **Temperature** : 30-35 °C
- **Relative humidity** : 90-95% (cropping room)
- **Conc. of CO_2** : 5000-8000 ppm (cropping room)
- **Light** : Not required
- **Air circulation/exchange** : Once or twice (4-5 min/day)
- **Light watering on mushroom bed on completion of spawn run**

Fig. 16. Fruiting of DMRO-247

iii). Fruiting/cropping conditions:

- **Temperature** : 28-32 °C
- **Relative humidity** : 85-90%
- **Conc. of CO_2** : 600-800 ppm
- **Light** : Fluorescent light 4-5 hours/day
- **Air circulation/exchange** : 3-4 times/day (4-5 min/exchange)
- **Very light watering on alternate days specially if required**
- **Harvesting twice, once morning and once after noon**
- **Packaging in perforated polythene/polypropylene or paper bags**

B. Composting Technologies Developed by ICAR-DMR

1. Indoor composting technique of white button mushroom compost preparation

The technique of indoor composting was developed by Dr B. Vijay. The procedure is discussed as below:

- Protocol for the production of environment friendly white button mushroom compost in 12 days time against 20 and 28 days normally taken in short and long method of composting respectively.
- Procedure for production of such compost was performed using aerated phase-I bunkers keeping intermittent temperature range. This method produces significantly more compost per unit weight of the ingredients taken compared to present day technologies being used by the seasonal and environment control units. Yields obtained were also higher compared to other techniques. Further, such technique improved the consistency of the compost quality.
- -4 day : Mixing and wetting of ingredients is done out door
- -3 day : Turning, trampling by Bobcat, through mixing of ingredients and addition of water
- -2 day : High aerobic heap of substrate is made
- 0 day : Filling in phase –I bunker
  Blower fan switched on @ 5 min/h
- +3 day : Emptying the bunker, turning and mixing of composting mixture and refilling the compost in another phase-I bunker
- +6 day : Phase-I operation over and compost transferred to phase-II tunnel
- +12 day : Phase-II operation over

2. Shortening the production period of button mushroom composting under long method of composting

This technique was developed by Dr B. Vijay. The procedure of technique is explained as below:

- Production of compost by long method takes around 28-30 days for its completion.
- This Directorate has developed a technique where in productive white button mushroom compost can be produced in 16 days time.
- Standard formulations as suggested by DMR, Solan can be used. Turning schedule is as follows:
  - -1 day wetting of the ingredients
  - 0 day pile formation
  - +4 day 1st turning
  - +6 day 2nd turning
  - +8 day 3rd turning (add gypsum)
  - +10th day 4th turning
  - +12th day 5th turning
  - +14th day 6th turning
  - +16th day check for smell of ammonia, if no ammonia smell than spawn.
  - Additional turning may be given if ammonia smell persists.

3. Zero Energy Polytunnel (ZEPT): A rapid composting method for *Agaricus bisporus* / Button mushroom

This technique was developed by Dr GC Wakchaure. The procedure of technique is explained as below:

In mushroom production it is necessary to design a growing pattern to balance yield against cost and to reduce energy use. Commercial cultivation of *Agaricus bisporus*/ button mushroom is highly scientific and engineering activities necessitates well composted substrate for its growth. In India, at present most commonly long (traditional) and short (tunnel) methods of composting are used for preparing the *Agaricus bisporus*/ button mushroom compost. It takes four to six weeks to complete the process in seven to eight turnings with an interval of three–four days to avoid anaerobic condition of substrate. The long method had problems of non maintenance of efficient temperature control, moisture levels, and requirement of huge manpower to oxygenate the pile. White button mushroom (*Agaricus bisporus*) farming is highly scientific and engineering based activity involving four steps; composting, conditioning, spawning and casing. This technique enables to produce the button mushroom compost in a reliable environment friendly low cost, short duration, natural pasteurization, and outdoor composting technique based on self-heating by thermophilic fungi to improve the production profitability of mushroom farming.

- The major considerations for design of the zero energy polytunnel involve in size and shape of compost pile, optimization of passive ventilation, materials for pipe/stands, spacing between the adjoining pipes and stands, frame design and selection of polythene sheet cover.
- The size and shape of the compost pile mainly depends upon the particle size and angle of repose of compost prepared. The angle of repose of compost varies with composting period and bioengineering properties viz., moisture content, bulk density and particle size of compost ingredients. For determining the angle of repose, compost is prepared using standard formulation by short and long methods separately.
- The minimum angle of repose (42-45°) is used to ascertain the suitable size and shape of compost pile so that the compost pile remains stable.
- Trapezoidal shape pile is most stable. Based on series of experimentation with consideration of minimum angle of repose (42-45°), best size i.e. 6 m length × (2.7 m bottom + 0.6 m top) width × 1.40 m height of the pile is best. Size of the compost pile and tunnel depends upon the compost required. Thus trapezoidal compost tunnel (4-5 tones capacity) of slightly higher size 6 m length × (2.7 m bottom + 0.70 m top) width × 1.6 m height can also be used.
- Zero energy polytunnel method reduced 50% and 37% compost-production cost as compared to short and long methods. It also reduces 60% and 40% of composting time as compared to the long and short methods.
- The appropriately designed polytunnel structure reduced time of composting, increased compost yield and mushroom yield, and reduced labour requirement for turnings. The technology was also tested at the seasonal/commercial grower's farms.
- The design of zero energy Polytunnel and quality of matured compost depend on bioengineering properties of the compost ingredients. The heat generated during the composting is used for pasteurization and conditioning. Hence it is energy free process and technique is named as zero energy polytunnel.
- The method increases compost production significantly and improves quality and yield of button mushroom.

Fig. 1. Zero Energy polyrunnel rapid composting method for *Agaricus bisporus*

4. Post composting supplementation in *Agaricus bisporus* / button mushroom compost

- Supplements used in the mushroom cultivation can be of both animal and plant origin which may be carbohydrate rich, protein rich or oil rich substances.
- Technique for post composting supplementation to grow *A. bisporus* compost under seasonal growing / controlled conditions have been perfected at this centre.
- Coarsely ground cotton seed meal, cotton seed cake, soybean meal, defatted soybean cake can be used supplements.
- Sterilize the supplements with 0.5% formaldehyde and add in the compost at the time of spawning @ 1% fresh wt of the compost.
- One kg of supplement would require around 1.0 ml of commercial formalin dissolved in 700 ml water.
- Solution should be properly mixed with supplement so that dough could be made.
- Put dough in some container and seal the container for 48 hrs.
- Increase in yield due to supplementation with cottonseed meal or soybean meal is over-whelming (15-20% increase). whether tried on LMC or on short method compost.

C. Mushroom Cultivation Technologies developed by ICAR-DMR

1. Cultivation of different species of oyster mushroom:

1.1 Cultivation of pink oyster (*Pleurotus djamor* var. *roseus*) mushroom

Cultivation technology of this mushroom was developed by Dr R.C. Upadhyay. Pink oyster mushroom (*Pleurotus djamor* var. *roseus*) has a light to dark pink colored cap and can readily colonize on any kind of agricultural waste including wheat or paddy straw, sugar cane bagasse. The texture of fruit body is hard compared to other species. This mushroom is suitable for cultivation in the month of April in northern and in plain regions of Central states of India. The biological efficiency of this species ranges from 50- 90%.

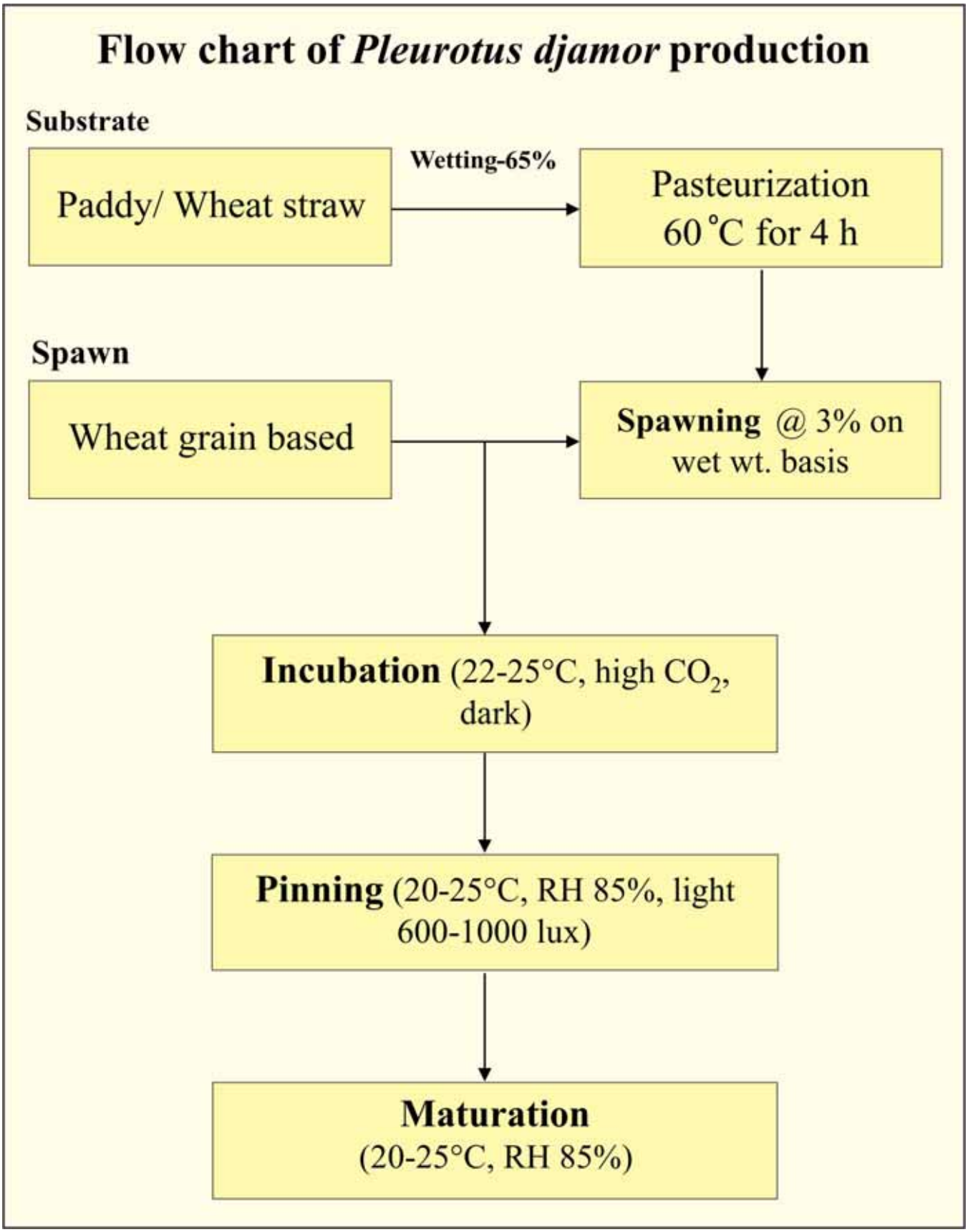
- Wet the substrate
- Add one per cent lime and make pile
- Give turning on third day and remake/form pile
- Keep the pile as such for two days
- Pasteurize the substrate at 60 ºC for 4 hours
- Add spawn @ 3% on wet wt. basis
- Fill 5 kg substrate per bag
- Incubate bags at 22-25 ºC under dark conditions
- Spawn run will be completed in 8-10 days
- Make holes of one inch diameter all over the surface of the bags
- Spray water twice in the rooms
- Provide light (600-1000 lux) for 3-4 hours daily
- The pinning will start within 10-12 days.
- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

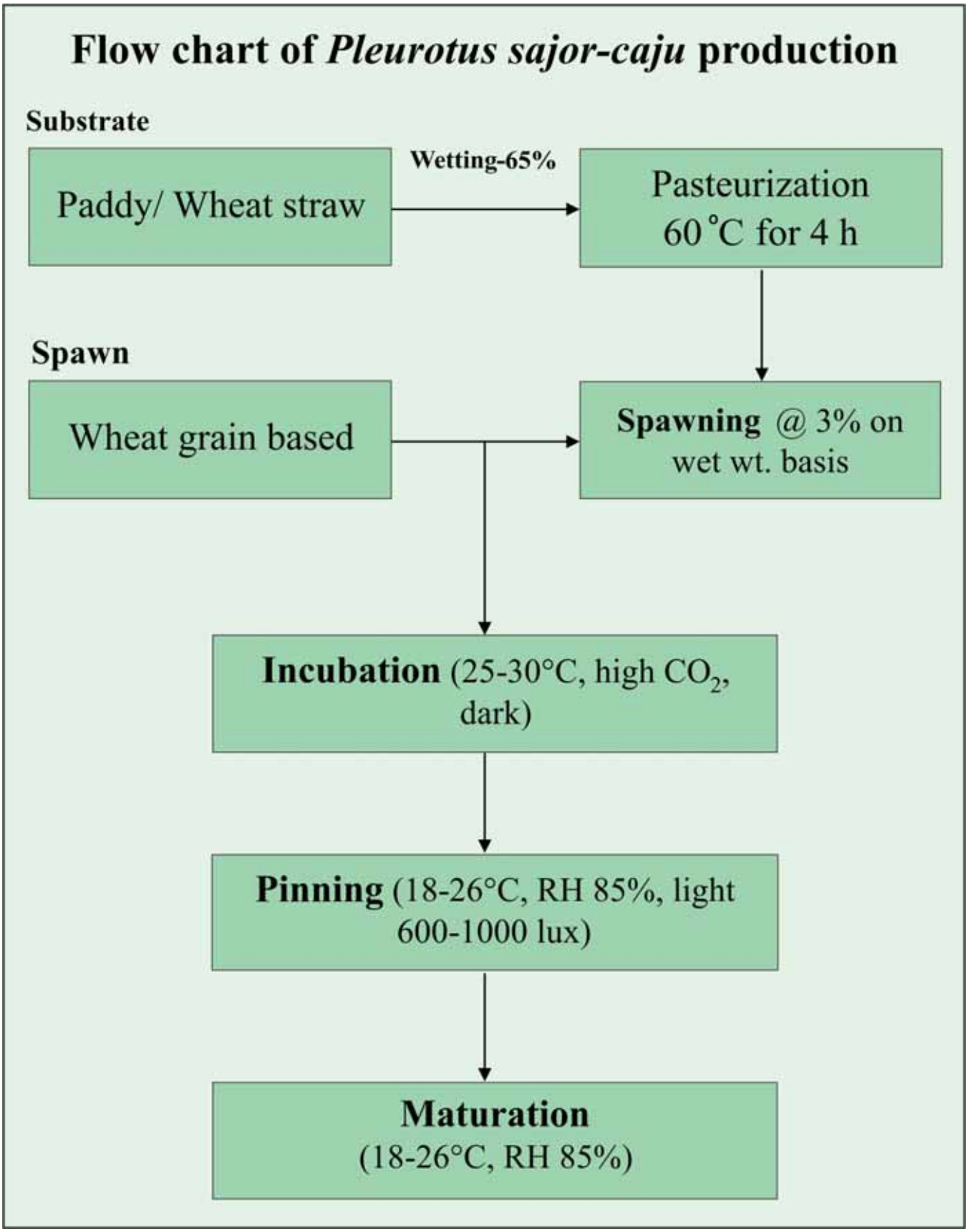
Fig. 1. Different cultivation steps of *P. djamor* Mushroom (a-d)

1.2 Cultivation of *Pleurotus sajor-caju* oyster mushroom

Cultivation technology of this mushroom was developed by Dr R.C. Upadhyaya. Color of this mushroom is marginally grey when grown in initial months of summer. This species require 25-30 ºC for spawn run and 18-26°C for fruiting. This mushroom is suitable during March- April month for plain regions of north and eastern parts and Central states of India. The biological efficiency of this species ranges from 40 - 80%.

- Wet the substrate
- Add one per cent lime and make pile
- Give turning on third day and re make pile
- Keep the pile as such for two days
- Pasteurize the substrate at 60 ºC for 4 hours
- Add spawn @ 3% on wet wt. basis
- Fill 5 kg substrate per bag
- Incubate bags at 25-30 ºC under dark conditions
- Spawn run will be completed in 8-10 days
- Kept the spawn run bags at 18-26°C for fruiting. Make holes of one inch dia. around the bags
- Spray water twice in the rooms
- Provide light (600-1000 lux) for 3-4 hours daily
- The Pinning will start within 10-12 days.


Flow chart of *Pleurotus djamor* production
Substrate
Paddy/ Wheat straw
Wetting-65%
Pasteurization
60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-25°C, high CO_2, dark)
Pinning (20-25°C, RH 85%, light 600-1000 lux)
Maturation
(20-25°C, RH 85%)


Flow chart of *Pleurotus sajor-caju* production
Substrate
Paddy/ Wheat straw
Wetting-65%
Pasteurization
60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (25-30°C, high CO_2, dark)
Pinning (18-26°C, RH 85%, light 600-1000 lux)
Maturation
(18-26°C, RH 85%)

- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

Fig. 2. Different cultivation steps of *P. sajor-caju* Mushroom (a-d)

1.3. Cultivation of *Pleurotus florida* oyster mushroom

Cultivation technology of this mushroom was developed by Dr R.C. Upadhyay. *Pleurotus florida* pileus is flat and white in color, require the 22-28°C for spawn run (ideal 24°C) and fruiting can be obtained at 15-22°C. The quality of this variety is very good as due to its flat fruit body which makes it less prone to bacterial infection due to lesser deposition of water on fruit bodies. Therefore, it can be grown on Northern and Central states of India during winter months. The biological efficiency of this species ranges from 50- 90%.

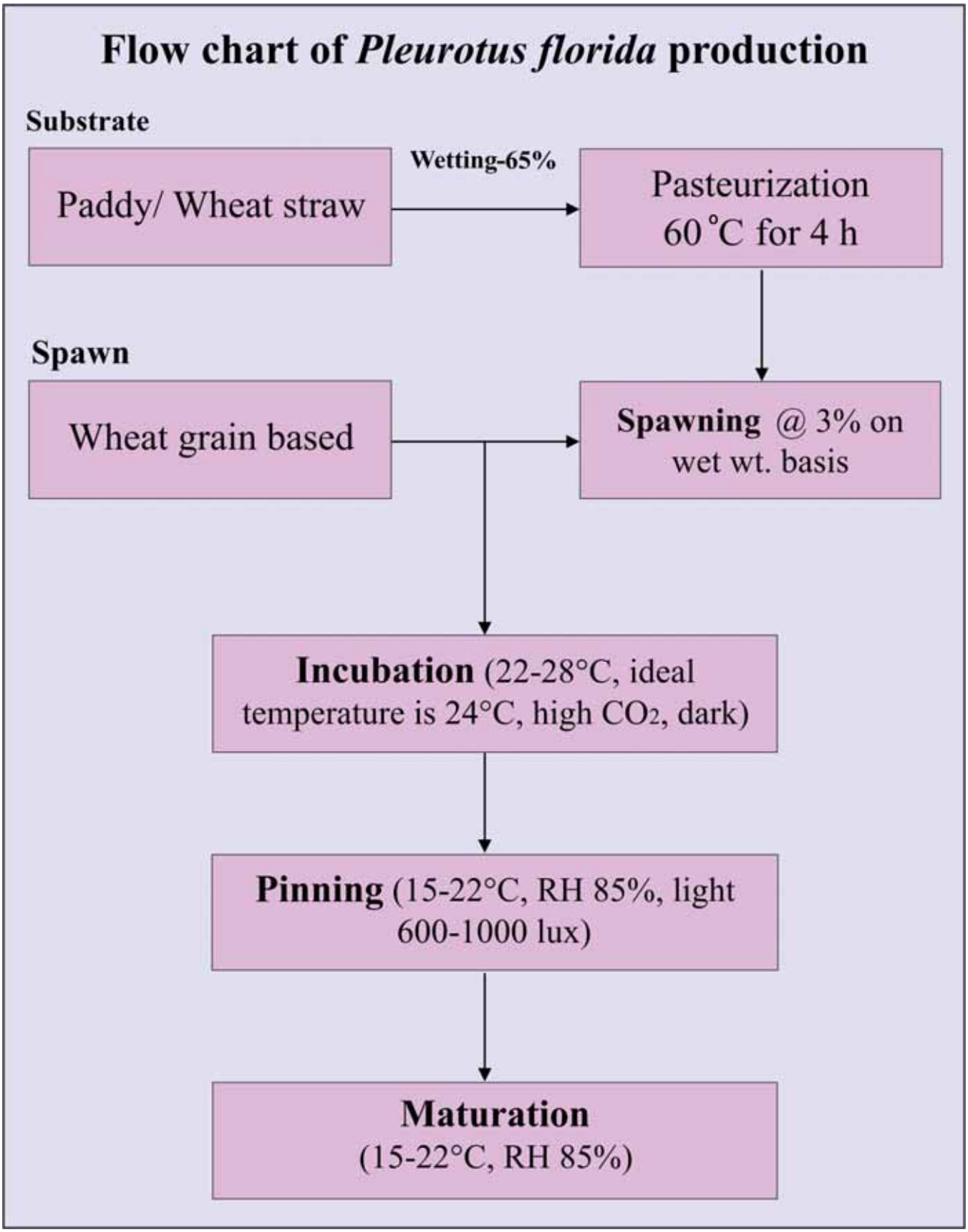
- Wet the substrate
- Add one per cent lime and make pile
- Give turning is on third day and re make pile
- Keep the pile as such for two days
- Pasteurize the substrate at 60°C for 4 hours
- Add spawn @ 3% on wet wt basis
- Fill 5 kg substrate per bag
- Incubate bags at 22-28°C (24 °C is ideal temperature for spawn run) under dark conditions
- Spawn run will be completed in 8-10 days
- Keep the spawn run bags at 15-22°C temperature. Make holes of one inch dia. around the surface of the bags
- Spray water twice in the rooms
- Provide light (600-1000 lux) for 3-4 hours daily
- The Pinning will start within 10-12 days.
- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

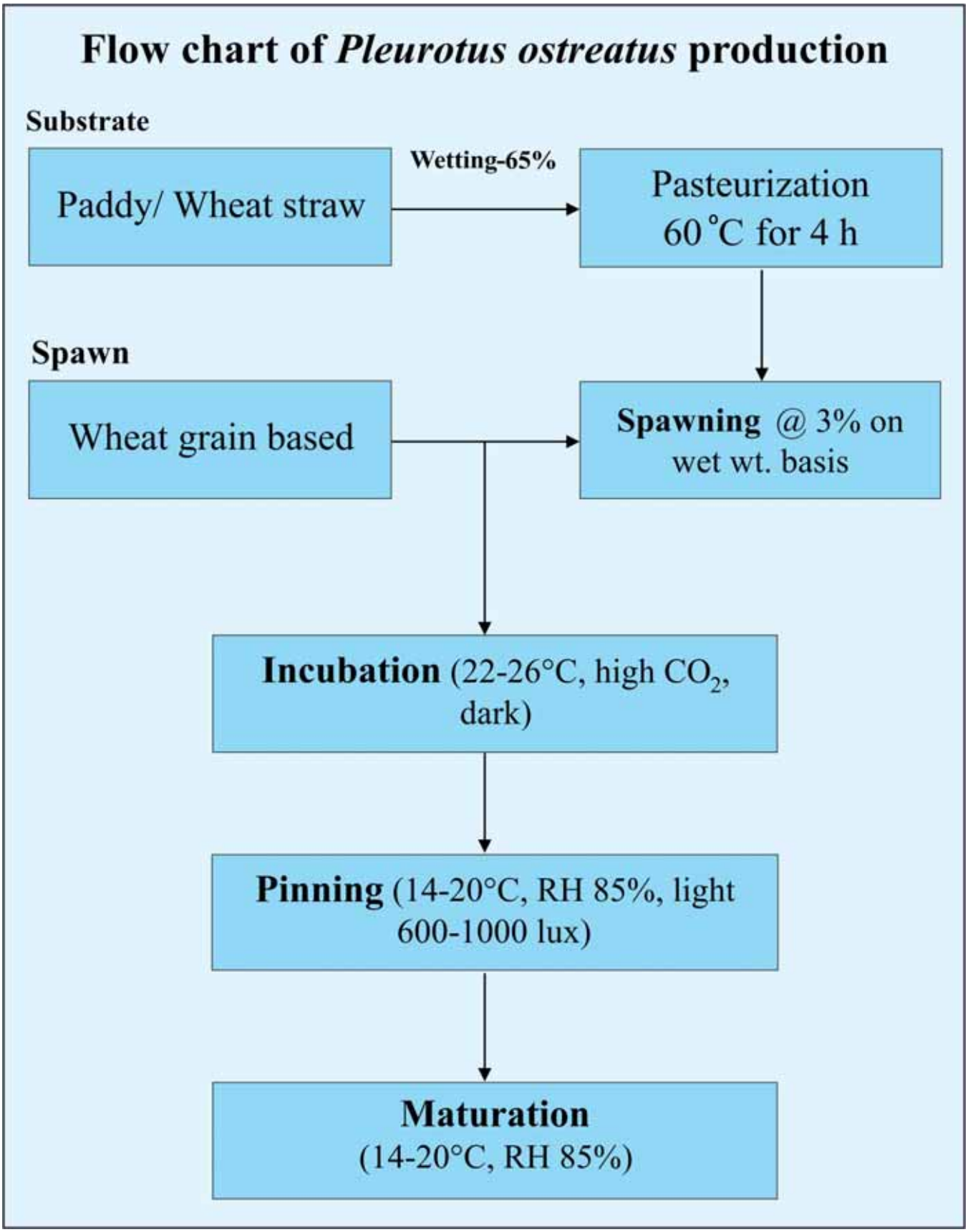
Fig. 3. Different cultivation steps of *P. florida* Mushroom (a-d)

1.4 Cultivation of *Pleurotus ostreatus* oyster mushroom

Cultivation technology of this mushroom was developed by Dr R.C. Upadhyay. *Pleurotus ostreatus* varies in piles color from gray white to bluish brown shade and can be cultivated on any kind of agricultural waste including wheat or paddy straw, sugar cane bagasse. The species is more important with regard to its variability. This mushroom is suitable for lower hills and plain region of north and eastern parts of India. This can be grown in months of November and February.

- Wet the substrate
- Add one per cent lime and make pile


Flow chart of *Pleurotus florida* production
Substrate
Paddy/ Wheat straw
Wetting-65%
Pasteurization
60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 3% on
wet wt. basis
Incubation (22-28°C, ideal
temperature is 24°C, high CO2, dark)
Pinning (15-22°C, RH 85%, light
600-1000 lux)
Maturation
(15-22°C, RH 85%)


Flow chart of *Pleurotus ostreatus* production
Substrate
Paddy/ Wheat straw
Wetting-65%
Pasteurization
60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-26°C, high CO_2, dark)
Pinning (14-20°C, RH 85%, light 600-1000 lux)
Maturation
(14-20°C, RH 85%)

- Give turning is on third day and re make pile
- Keep the pile as such for two days
- Pasteurize the substrate at 60 ºC for 4 hours
- Add spawn @ 3% on wet wt basis
- Fill 5 kg substrate per bag
- Incubate bags at 22-26 ºC under dark conditions
- Spawn run will be completed in 8-10 days
- Kept the bags at 14-20 ºC temperature and make holes of one inch dia. all over the surface of the bags
- Spray water twice in the rooms
- Provide light (600-1000 lux) for 3-4 hours daily
- The Pinning will start within 10-12 days
- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

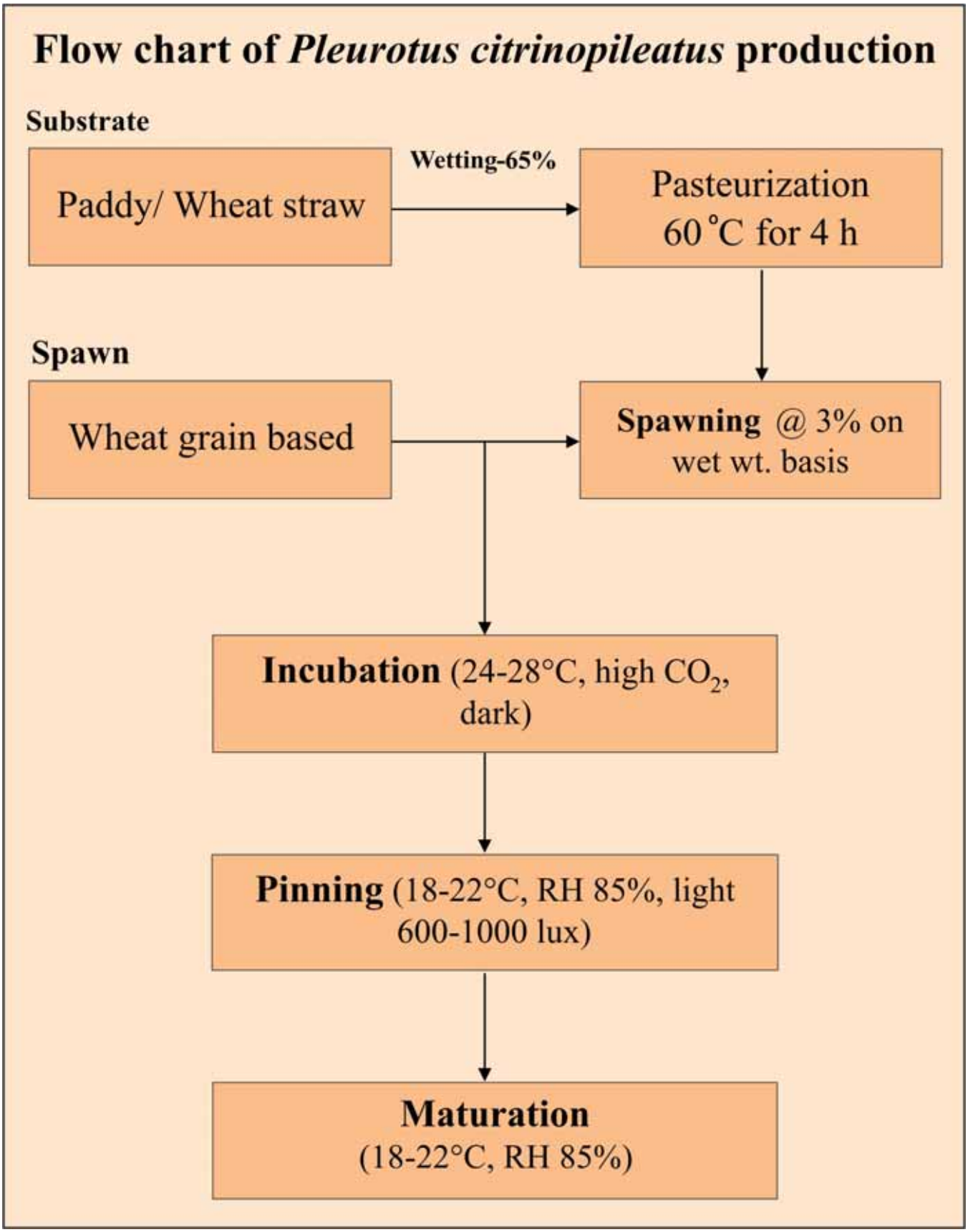
Fig. 4. Different cultivation steps of *P. ostreatus* Mushroom (a-d)

1.5 Cultivation of Yellow Oyster (*Pleurotus citrinopileatus*) mushroom

Cultivation technology of this mushroom was developed by Dr R.C. Upadhyay. Yellow oyster mushroom (*Pleurotus citrinopileatus*) can be grown in spring season in North India and require relatively higher temperature as compared to the winter species of Oyster mushroom. This mushroom is suitable for lower hills and plain region of north and eastern parts and Central India. The biological efficiency of this species ranges from 40-70%. This species is suitable for cultivation during the months of March and October month in North India and Plains when room temperature is below the 28 ºC.

- Wet the substrate
- Add one per cent lime and make pile
- Give turning is on third day and re make pile
- Keep the pile as such for two days
- Pasteurize the substrate at 60 ºC for 4 hours
- Add spawn @ 3% on wet wt basis
- Fill 5 kg substrate per bag
- Incubate bags at 24-28 ºC under dark conditions
- Spawn run will be completed in 8-10 days
- Shift the bags at 18-22 ºC temperature for fruiting. Make holes of one inch diameter all over the surface of the bags
- Spray water twice in the rooms
- Provide light (600-1000 lux) for 3-4 hours daily
- The Pinning will start within 10-12 days

Fig. 5. Different cultivation steps of *P. citrinopileatus* Mushroom (a-d)


Flow chart of Pleurotus citrinopileatus production
Substrate
Paddy/ Wheat straw
Wetting-65%
Pasteurization
60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (24-28°C, high CO2, dark)
Pinning (18-22°C, RH 85%, light 600-1000 lux)
Maturation
(18-22°C, RH 85%)

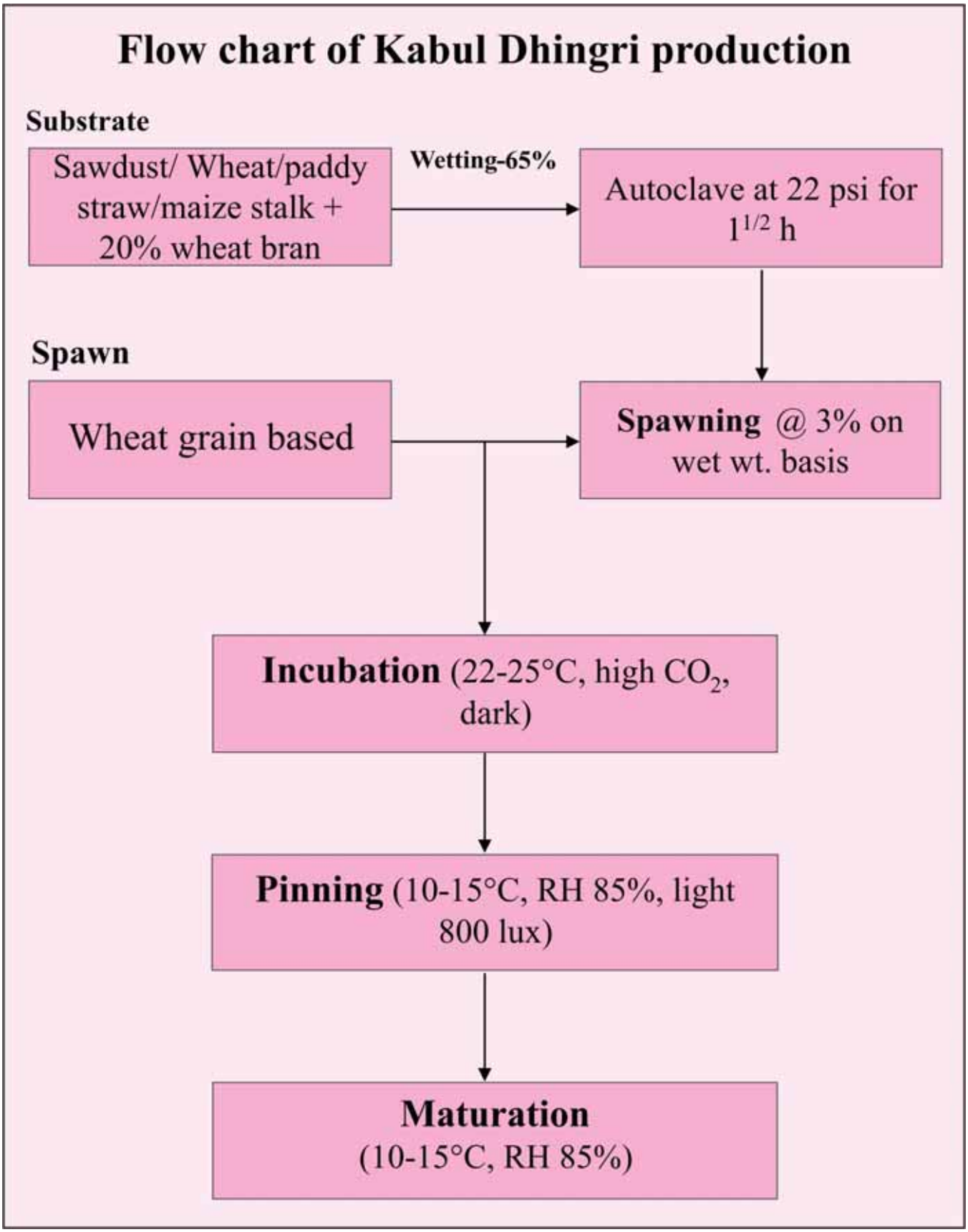
- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

1.6. Cultivation technology of *Pleurotus eryngii* (Kabul Dhingri) production

Cultivation technology of this mushroom was developed by Dr Satish Kumar and Dr VP Sharma. *Pleurotus eryngii*, commonly known as the king oyster mushroom, has been used extensively in North Africa, Europe and Asia. This mushroom is also known as Kabul Dhingri due to its natural occurrence in high altitude regions of North West Himalayas. *Pleurotus eryngii* is a popular mushroom due to its excellent consistency of cap and stem, culinary qualities and longer shelf life. A great deal of work has been carried out on therapeutic potential of *Pleurotus eryngii*. The edible Fungi perform multiple bioactivities: anticancer, antiviral, antioxidant, antimicrobial, anti-leukaemia, hypolipidemic, immuno-modulating and estrogen-like activity. These bioactive properties depend on its bioactive compounds such as polysaccharides, eryngiolide A, ubiquinone-9, pentacyclic triterpenoid. Commercial cultivation of king oyster is done on wheat straw, paddy/ maize stalk/ saw dust supplement with organic nitrogen materials. The cultivation technology developed by ICAR-DMR is as under:

- This mushroom can be grown on or sawdust/wheat straw substrate
- Substrate is wetted thoroughly for 16-18 hours
- After wetting 20% wheat bran is added in the substrate and mixed thoroughly
- Two kg substrate is filled per polypropylene bag or polypropylene bottles can be used with 1.5 kg of substrate
- The bags are plugged with non absorbent cotton by inserting ring on the mouth of bags
- The filled bags are sterilized in autoclave for 1.5 hours at 22 psi
- Once sterilized the bag should be cooled down to 20 ºC, they are inoculated with wheat grain based spawn @ 3% dry weight basis
- Inoculated bags are incubated at 22-25 ºC
- Spawn run will be completed in 15-20 days
- PP bag is removed
- Blocks are then placed in the cropping room at a temperature of 10-15 ºC and relative humidity 80-85% maintained
- Light (800-1000 lux) is provided for five hours for optimum development of fruiting bodies
- Mature fruit bodies are harvested 3-4 days after pinning

Fig. 6. Cultivation steps of *Pleurotus eryngii* (King oyster mushroom) (a-e)


Flow chart of Kabul Dhingri production
Substrate
Sawdust/ Wheat/paddy straw/maize stalk + 20% wheat bran
Wetting-65%
Autoclave at 22 psi for 1 1/2 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-25°C, high CO2, dark)
Pinning (10-15°C, RH 85%, light 800 lux)
Maturation
(10-15°C, RH 85%)

2. Cultivation technologies of different mushrooms

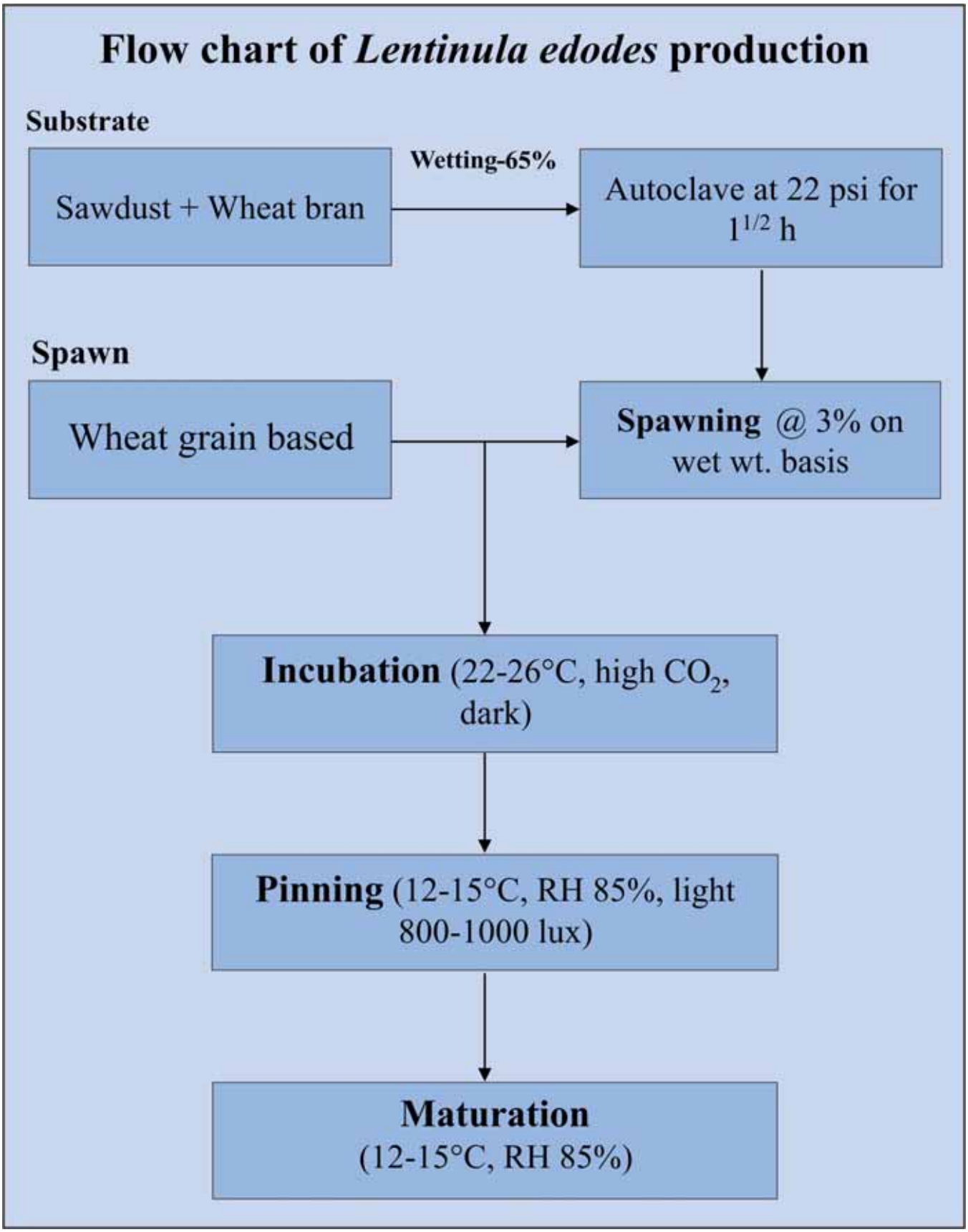
Four different mushrooms i.e. *Lentinula edodes*, *Panus lecomtei*, *Lentinus sajar-caju* and *Panus velupitus* has been successfully cultivated in ICAR-Directorate of Mushroom Research. Cultivation methodology is explained as below:

2.1 Technology for short duration fruiting in shiitake Mushroom

This technology was developed by Dr VP Sharma, Dr Satish Kumar & Dr Manjit Singh. The Shiitake (*Lentinula edodes*) mushroom is the most important edible medicinal mushroom with excellent nutritional value. Its nutritional components include bio-active polysaccharides such as β-D-glucan, heteroglucan, xylomannan, lentinan and eritadenine; free sugars including arabinose, arabitol, mannose, mannitol, trehalose and glycerol; vitamins (B2, B12, D2) and dietary fibre. Numerous bio-components present in *L. edodes* aid in its pharmacological potency against hypertension, hyperlipidemia and cardiovascular complications, depressed immunity, hepatic disorders and cancer. In addition, its anti-oxidative, anti-fungal and anti-microbial aspects have been duly attributed to its bio-functional .Traditionally shiitake has been grown on natural logs of various species of trees. Commercial cultivation of shiitake is done on sawdust of broad leaves trees (tuni, poplar, oak, mango etc.) enriched with the organic nitrogen source. The short duration cultivation technology is follow as:

- Cultivation was carried out on sawdust of selected trees (80 kg), wheat bran (20 kg), $CaCO_3$ (1 kg) and $CaSO_4$ (0.5 kg)
- Mixed substrate was filled in Poly Propylene bags (1.2- 1.5 kg wet/ bag)
- Bags sterilized in an autoclave at 22 psi for 90 minutes
- Grain spawn was inoculated @3% (wet wt basis, top spawning and bags incubated at 4 hr/20 hr light / dark cycles at 22-25 ºC. Spawn run take 36-40 days including bump formation
- Cold water treatment by immersing spawn run synthetic logs in cold water (6-8 ºC) for 10-15 minutes after removing PP bag
- A room temperature of 12-20ºC, RH (85-90%) and light for 10-12 hours were maintained
- After 2-3 days of the cold water treatment small primordia developed which mature into full grown fruit bodies in next 3-4 days
- Harvest mushrooms at an early stage before unveiling the margin of the cap
- 600-800 g of fresh mushrooms can be harvested from 1 kg of dry substrate
- Mushroom can be consumed fresh or sun dried

Fig. 7. Different cultivation steps of *Lentinula edodes* (a-e)


Flow chart of Lentinula edodes production
Substrate
Sawdust + Wheat bran
Wetting-65%
Autoclave at 22 psi for 1 1/2 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-26°C, high CO2, dark)
Pinning (12-15°C, RH 85%, light 800-1000 lux)
Maturation
(12-15°C, RH 85%)

2.2 Cultivation of *Panus lecomtei* Mushroom

This technology was developed by Dr VP Sharma and Dr Anupam Barh. *Lentinus strigosus* (*Panus lecomtei*), commonly known as ruddy panus mushroom is emerging as an edible mushroom especially in the tropical and sub tropical regions of the world. The mushroom contains a substantial amount of useful nutritional and medicinal compounds. This mushroom is commercially cultivated at ICAR-DMR as following procedure:

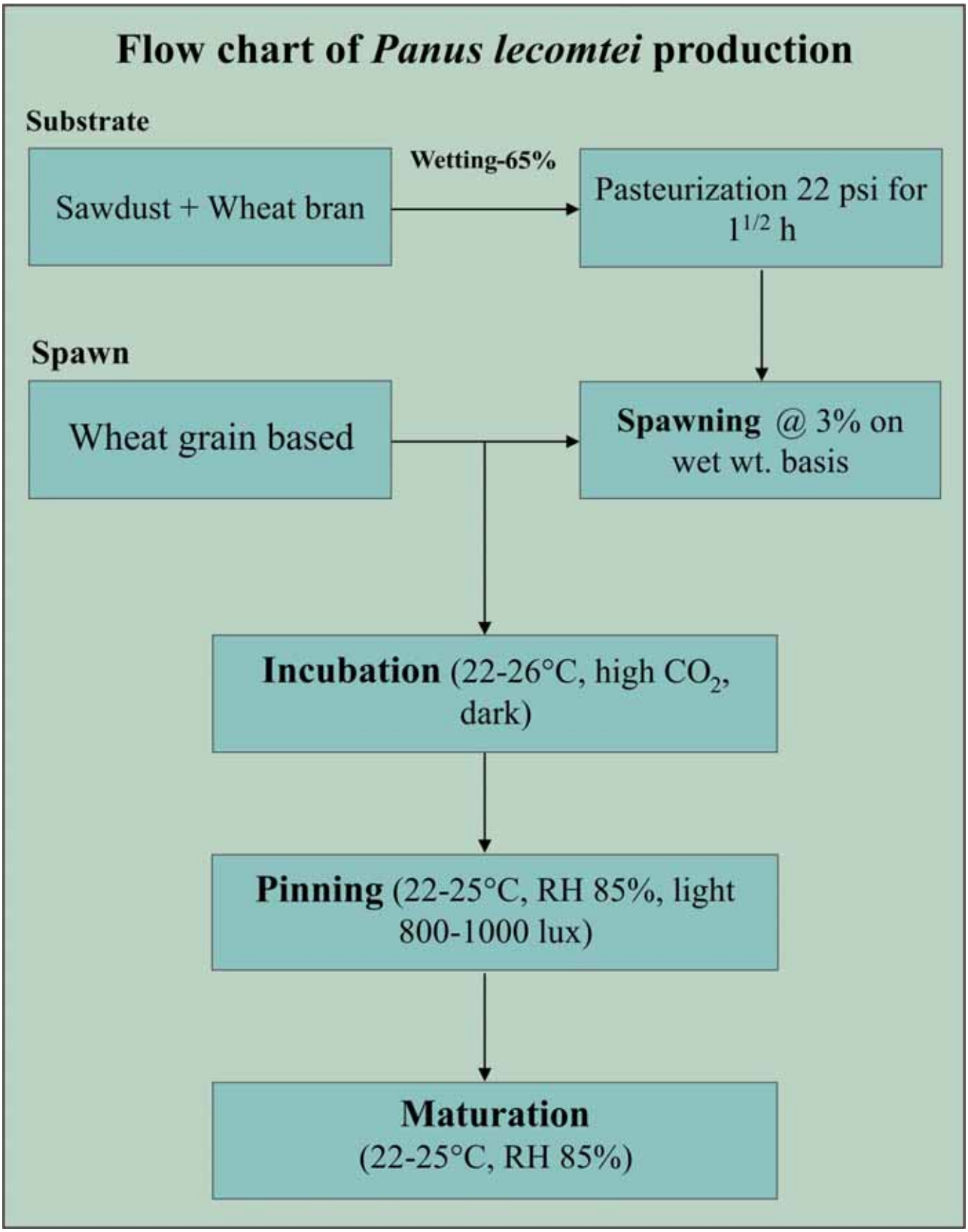
- Cultivation was carried out on sawdust of selected trees *viz.* Tunni, Mango, Shisham (80 kg), wheat bran (20 kg), $CaCO_3$ (1 kg) and $CaSO_4$ (0.5 kg)
- Mixed substrate was filled in Poly Propylene bags (1.2- 1.5 kg wet/ bag)
- Bags sterilized in an autoclave at 22 psi for 90 minutes
- Grain spawn was inoculated @3% (wet wt basis, top spawning) and bags incubated at 4 hr/20 hr light / dark cycles at 23-25 ºC. Spawn run took 25-30 days
- After complete spawn run bags were shifted to cropping room temperature of 22-25 ºC, RH (85-90%) and light for 10-12 hours were maintained
- After 30-35 days from spawning small primordia will develop which mature into full grown fruit bodies in next 3-4 days
- Harvest mushrooms at an early stage before unveiling the margin of the cap
- 500-600 g of fresh mushrooms can be harvested from 1 kg of dry substrate
- Mushroom can be consumed fresh or sun dried

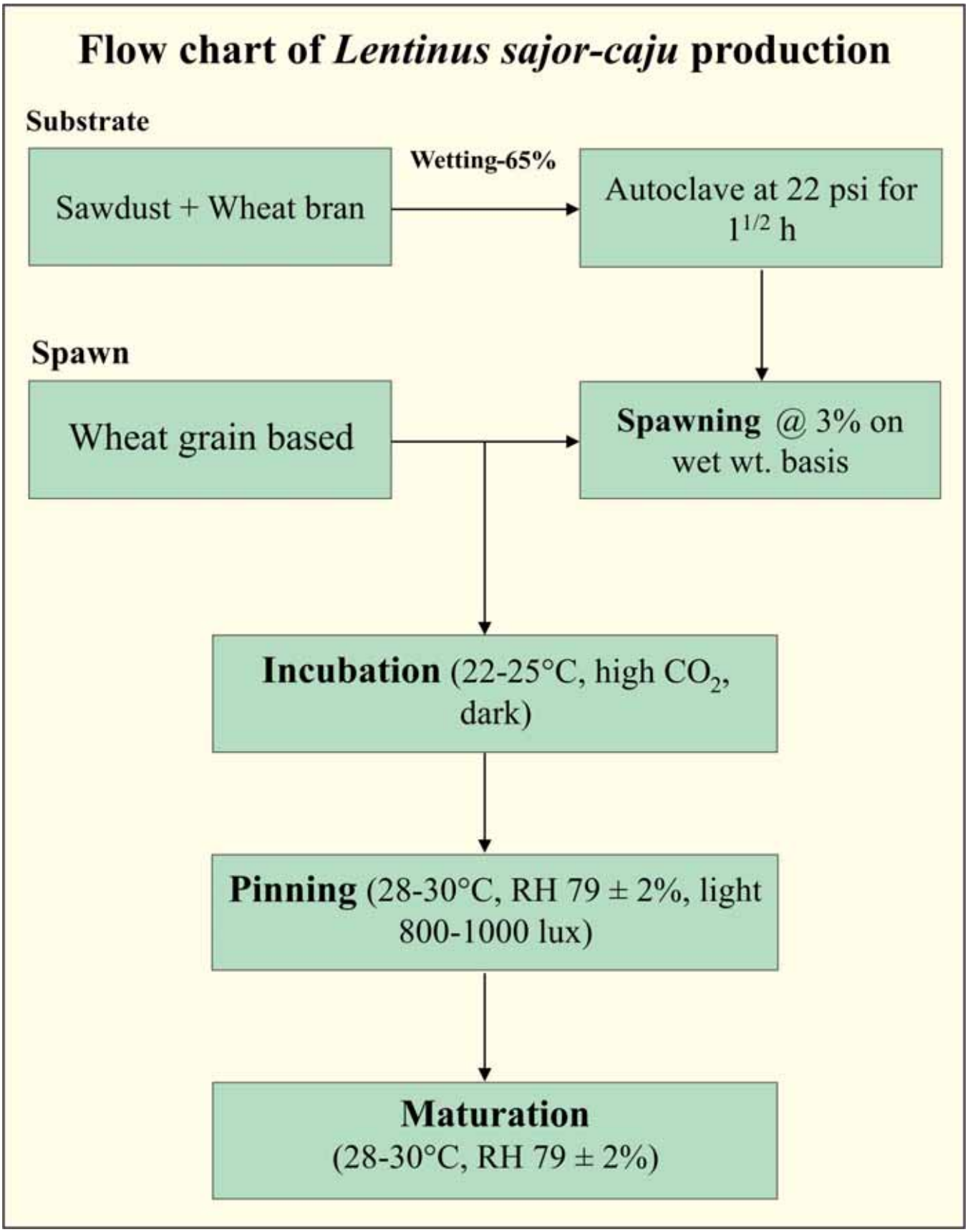
Fig. 8. Different cultivation steps of *Panus lecomtei* (a-e)

2.3 Cultivation of *Lentinus sajor-caju* Mushroom

This technology was developed by Dr VP Sharma and Dr Satish Kumar *Lentinus sajor-caju* previously known as *Pleurotus sajor-caju* is saprophytic wild edible mushroom (SWEM). This mushroom can be commercially cultivated as per following procedure:

- Cultivation can be carried out on sawdust of selected trees *viz.* Tunni, Mango, Shisham (80 kg), wheat bran (20 kg), $CaCO_3$ (1 kg) and $CaSO_4$ (0.5 kg)
- Mix substrate was filled in Poly Propylene bags (1.2- 1.5 kg wet/ bag)
- Sterlize bags in an autoclave at 22 psi for 90 minutes
- Inoculate grain spawn @3% (wet wt basis) and incubate bags at 4 h /20 h light / dark cycles at 22 -25 ºC. Spawn run will be completed 25-30 days


Flow chart of Panus lecomtei production
Substrate
Sawdust + Wheat bran
Wetting-65%
Pasteurization 22 psi for 1 1/2 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-26°C, high CO2, dark)
Pinning (22-25°C, RH 85%, light 800-1000 lux)
Maturation (22-25°C, RH 85%)


Flow chart of Lentinus sajor-caju production
Substrate
Sawdust + Wheat bran
Wetting-65%
Autoclave at 22 psi for 1 1/2 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-25°C, high CO2, dark)
Pinning (28-30°C, RH 79 ± 2%, light 800-1000 lux)
Maturation
(28-30°C, RH 79 ± 2%)

- Soak bag in cold water for 15 minutes, and then inverted to remove excess water for another 15 minutes.
- After 30-35 days from spawning small primordia developed which mature into full grown fruit bodies in next 7-10 days
- Harvest mushrooms at an early stage before unveiling the margin of the cap
- 500g of fresh mushrooms can be harvested from 1 kg of dry substrate
- Mushroom can be consumed fresh or sun dried

Fig. 9. Different cultivation steps of *Lentinus sajor caju* (a-f)

2.4 Cultivation of *Panus velutinus* Mushroom

This technology was developed by Dr VP Sharma, Dr Anupam Barh, Dr Babita Kumari and Dr Satish Kumar. *Panus velupitus* belongs to the Basidiomycotina sub-division and to *Agaricaceae* family. Commercialization is due to its flavor/ taste and nutritional and medicinal properties such as antibiotic, anti-carcinogenic and antiviral compounds. This mushroom can be cultivated following the procedure as:

- Cultivation can be carried out on sawdust of selected trees (80 kg), wheat bran (20 kg), $CaCO_3$ (1 kg) and $CaSO_4$ (0.5 kg)
- Mixed substrate is filled in Poly Propylene bags (1.2- 1.5 kg wet/ bag)
- Sterilize bags in an autoclave at 22 psi for 90 minutes
- Inoculate grain spawn @ 3% (wet wt basis, top spawning) and incubate bags at 4 h /20 h light / dark cycles at 23-25 ºC. Spawn run took 40-50 days
- Keep bags in cropping room temperature of 28 ± 1 ºC, RH of 79 ± 2%, and give light for 10-12 hours were maintained
- After 50-55 days from spawning small primordia will developed which will mature into full grown fruit bodies in next 7-10 days
- Harvest mushrooms at an early stage before unveiling the margin of the cap
- 500 g of fresh mushrooms can be harvested from 1 kg of dry substrate

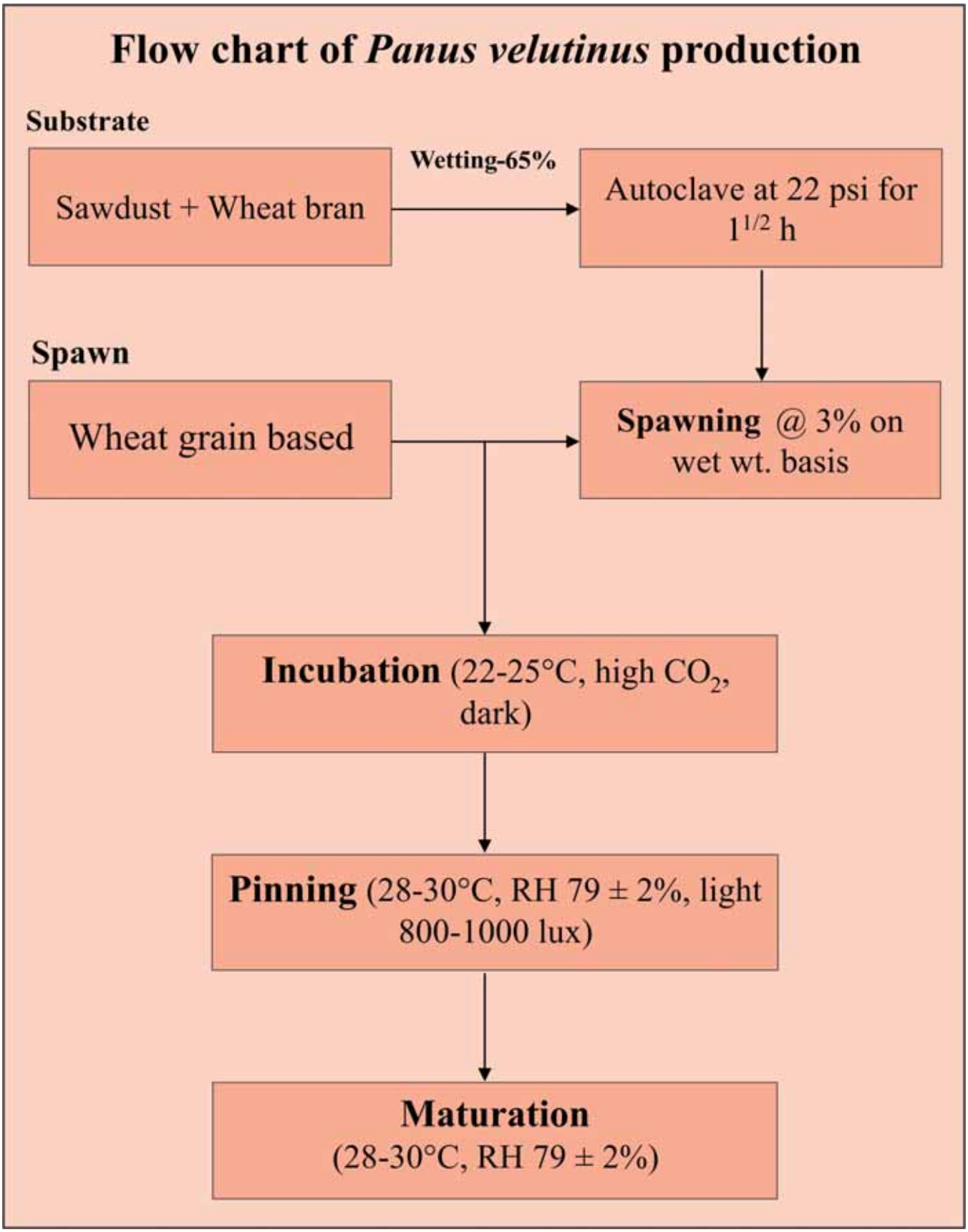

Flow chart of Panus velutinus production
Substrate
Sawdust + Wheat bran
Wetting-65%
Autoclave at 22 psi for 1 1/2 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (22-25°C, high CO2, dark)
Pinning (28-30°C, RH 79 ± 2%, light 800-1000 lux)
Maturation
(28-30°C, RH 79 ± 2%)

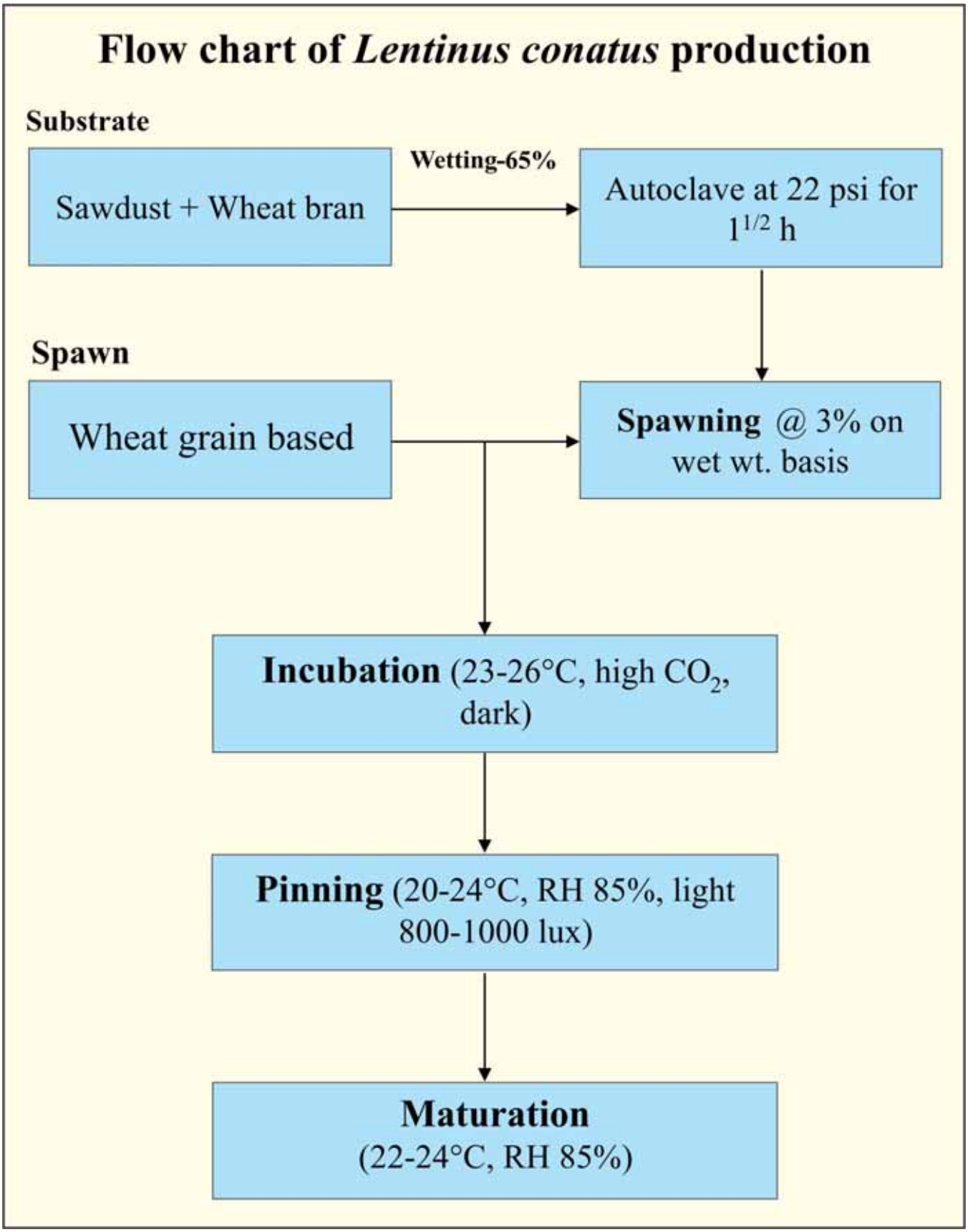
Fig. 10. Different cultivation steps of *Panus velutinus* (a-f)

2.5. Cultivation of *Lentinus conatus* Mushroom

This technology was developed by Dr VP Sharma and Dr Satish Kumar. *Lentinus conatus* is has edible and medicinal mushroom. This mushroom can be successfully cultivated on saw dust substrate at ICAR-DMR as per the following procedure:

- Cultivation can be carried out on sawdust of selected trees (80 kg), wheat bran (20 kg), $CaCO_3$ (1 kg) and $CaSO_4$ (0.5 kg)
- Mixed substrate is filled in Poly Propylene bags (1.2- 1.5 kg wet/ bag)
- Bags are sterilized in an autoclave at 22 psi for 90 minutes

Fig. 11. Cultivation steps of *Lentinus conatus* (a-e)


Flow chart of Lentinus conatus production
Substrate
Sawdust + Wheat bran
Wetting-65%
Autoclave at 22 psi for 1 1/2 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (23-26°C, high CO2, dark)
Pinning (20-24°C, RH 85%, light 800-1000 lux)
Maturation
(22-24°C, RH 85%)

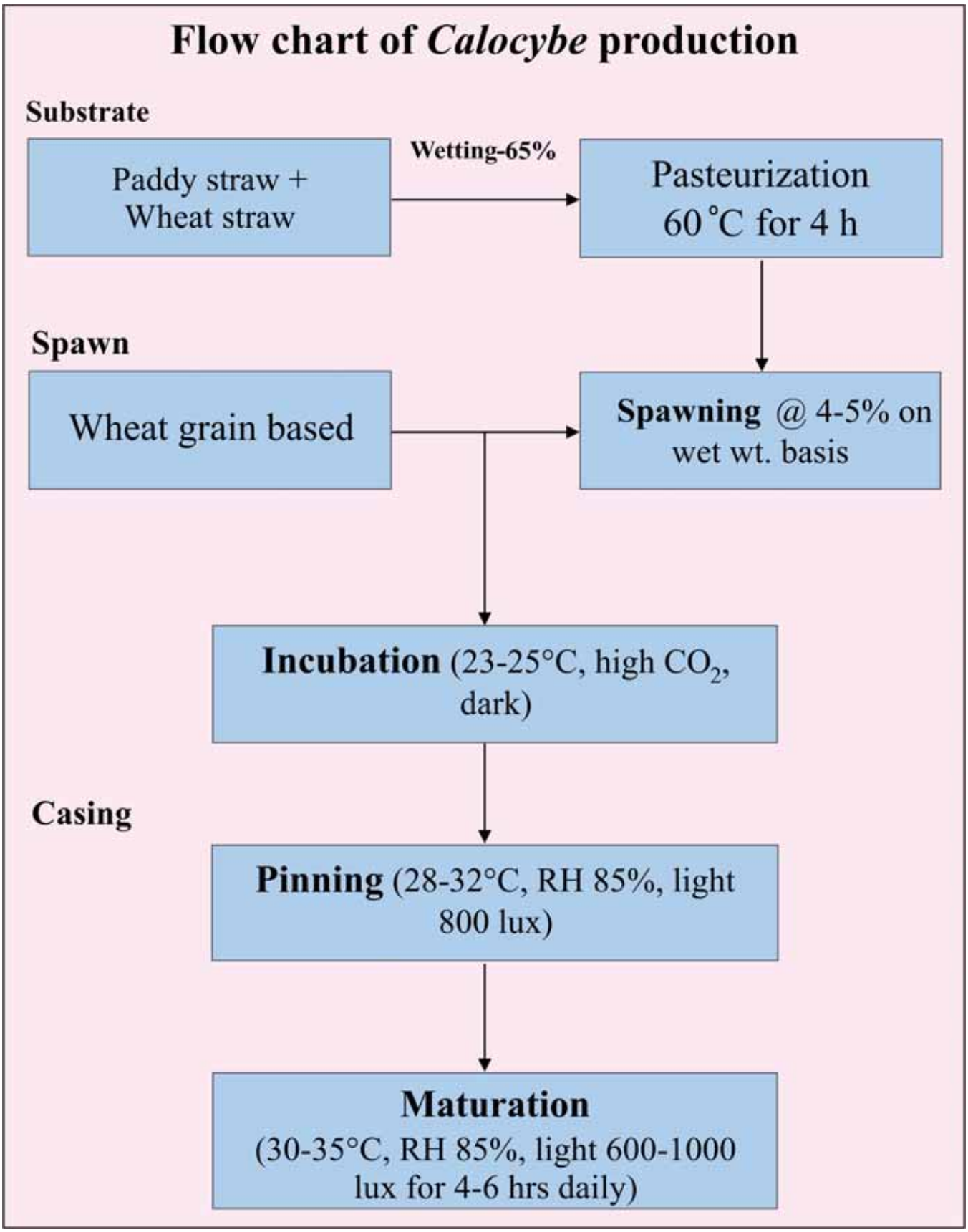
- Grain spawn is inoculated @ 3% (wet wt basis, top spawning) and bags are incubated at 4 h /20 h light / dark cycles at 23-25 ºC. Spawn run took 25-30 days.
- After complete spawn run bags are shifted to cropping room at a temperature of 20-24 ºC, RH (85-90%) and light for 10-12 hours.
- After 30-35 days from spawning small primordia will develop which will mature into full grown fruit bodies in next 3-4 days.
- Harvest mushrooms at an early stage before unveiling the margin of the cap
- 500-600 g of fresh mushrooms can be harvested from 1 kg of dry substrate

3. Cultivation technology of milky mushroom (*Calocybe indica*)

Cultivation of milky mushroom was developed by Dr RP Tiwari. Milky white mushrooms are highly suitable for commercial production in coastal area with humid tropical and subtropical climate. Milky white mushroom extracts are known to have anti-hyperglycemic effect and anti-lipid per oxidation effect. *Calocybe indica* can be grown on wide range of substrates (paddy/wheat straw/ sugarcane bagasse, etc.)

- Wet paddy/wheat straw in water for 16-18 hrs
- Make pile of the wetted substrate
- Give turning to the pile after 2 days
- Add 1% calcium carbonate
- After thoroughly mixing of calcium carbonate make pile of the substrate again
- Pasteurize substrate at 60 ºC for 4 hours
- Spawn @ 4-5% on wet weight basis
- Fill 5 kg wet substrate per polythene bags
- Incubate bags at 28-32 ºC under dark conditions
- Spawn run will be completed in 15-20 days
- After complete spawn run case the bags
- Use sterilize casing material (soil 75% + sand 25%) of pH 7.8-7.9
- Maintain temperature 30-35 ºC and RH 80-90% in cropping
- Maintain high relative humidity (85-90%) by spraying water once or twice on the bags and in the room
- After casing, primordia will be formed in 6-8 days
- Provide light (600-1000 lux for 4-6 hours daily

Fig. 12. Different cultivation steps of milky mushroom *Calocybe* sp. (a-e)


Flow chart of *Calocybe* production
Substrate
Paddy straw + Wheat straw
Wetting-65%
Pasteurization 60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 4-5% on wet wt. basis
Incubation (23-25°C, high CO_2, dark)
Casing
Pinning (28-32°C, RH 85%, light 800 lux)
Maturation (30-35°C, RH 85%, light 600-1000 lux for 4-6 hrs daily)

- Harvest mushrooms of 7-8 cm diameter by twisting the fruit body
- Harvested fruit bodies can be consumed fresh or store clean mushrooms by wrapping in film for longer period

4. Paddy Straw Mushroom cultivation (*Volvariella* sp.)

Cultivation technology of paddy straw mushroom was developed by Dr OP Ahlawat. Presently its cultivation is done in south-east Asian countries like Philippines, Malaysia. In India this mushroom is cultivated in the States like Orissa, Andhra Pradesh, Tamil Nadu, Kerala and West Bengal. The excellent unique flavor and textural characteristics distinguish this mushroom from other edible mushrooms. The straw mushroom is known to be rich in minerals such as potassium, sodium and phosphorus. Potassium constitutes the major fraction of major elements followed by sodium and calcium. This mushroom can be cultivated on paddy straw and Cotton Ginning Mill waste.

- Take Paddy straw as substrate for cultivation of paddy straw
- Add cotton ginning mill waste to the substrate
- Add 5% chicken manure
- Wet thoroughly with 1.5% lime added water
- Make pile of the mixed substrate
- Give turning after three days.
- Re-stack and repeat the process for next three days
- Pasteurize substrate at 60-62 ºC for 3-4 hours and then condition at 45-50 ºC for 2-3 days for complete elimination of Ammonia.
- Add spawn @1.5% on wet weight basis
- Cover the beds with plastic sheet
- Spawn run will be completed in 4-5 days at 32-35 ºC
- Remove plastic sheets from spawned substrate
- Maintain room temperature at 28-32 ºC, RH-80-85%
- Give intermittent fresh air circulation and fluorescent light (600 lux) for 4-5 hours/day.
- Harvest first flush after 9-10 days of spawning.
- Harvest at button stage, packaging
- Shelf life of mushroom is low hence fresh mushroom is consumed.

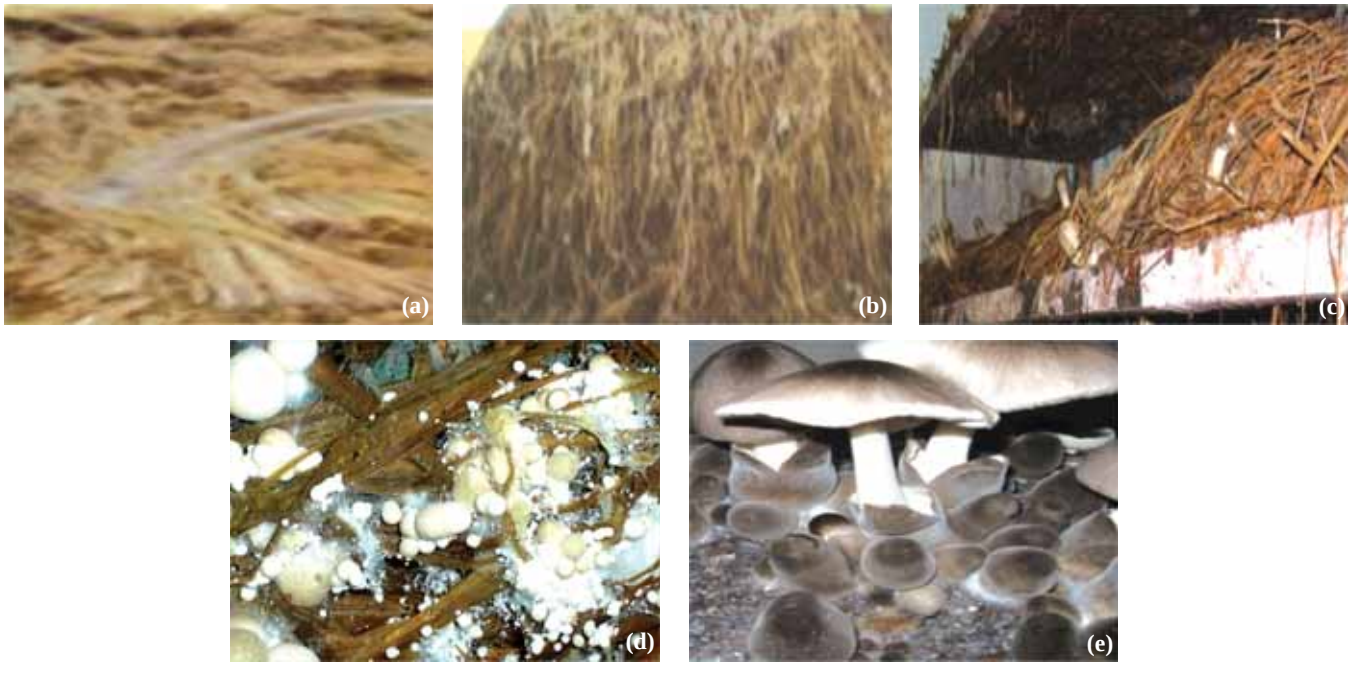
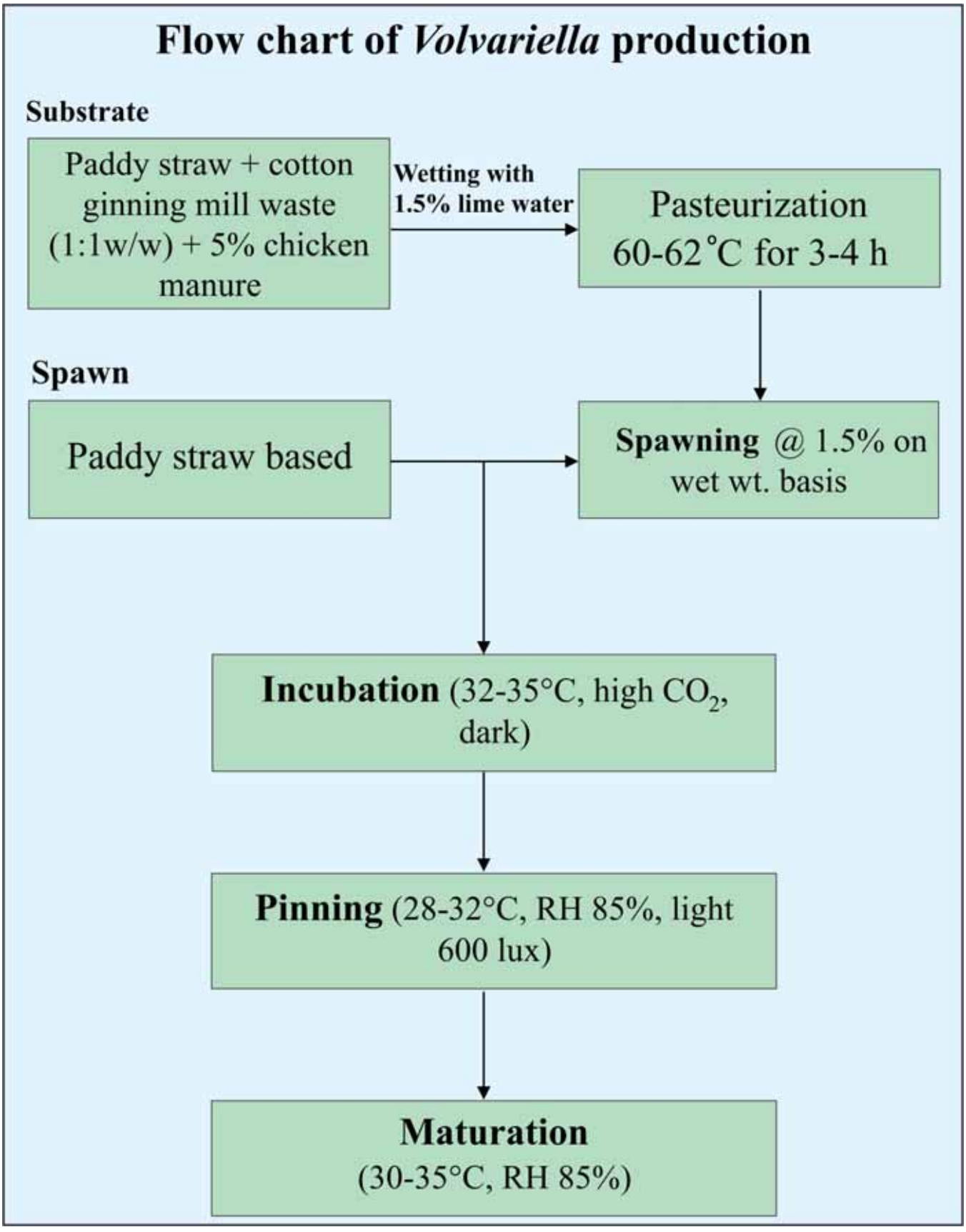


Fig. 13. Different cultivation steps of paddy straw mushroom sp. (a-e)


Flow chart of *Volvariella* production
Substrate
Paddy straw + cotton ginning mill waste (1:1w/w) + 5% chicken manure
Wetting with 1.5% lime water
Pasteurization 60-62˚C for 3-4 h
Spawn
Paddy straw based
Spawning @ 1.5% on wet wt. basis
Incubation (32-35°C, high CO_2, dark)
Pinning (28-32°C, RH 85%, light 600 lux)
Maturation (30-35°C, RH 85%)

5. Cultivation technology of *Auricularia polytricha*

Cultivation technology of this mushroom was developed by Dr Manjit Singh & Dr Kiran Mehta. Black ear mushroom has the oldest record of cultivation by the Chinese dating back to 600AD. It is commercially cultivated in some of the S.E. Asian countries. This mushroom ranks fourth among all cultivated edible mushroom. This mushroom is believed to cure sore throat, anemia, certain digestive disorders especially piles on regular consumption. In India this mushroom is collected and consumed in North-Eastern States.

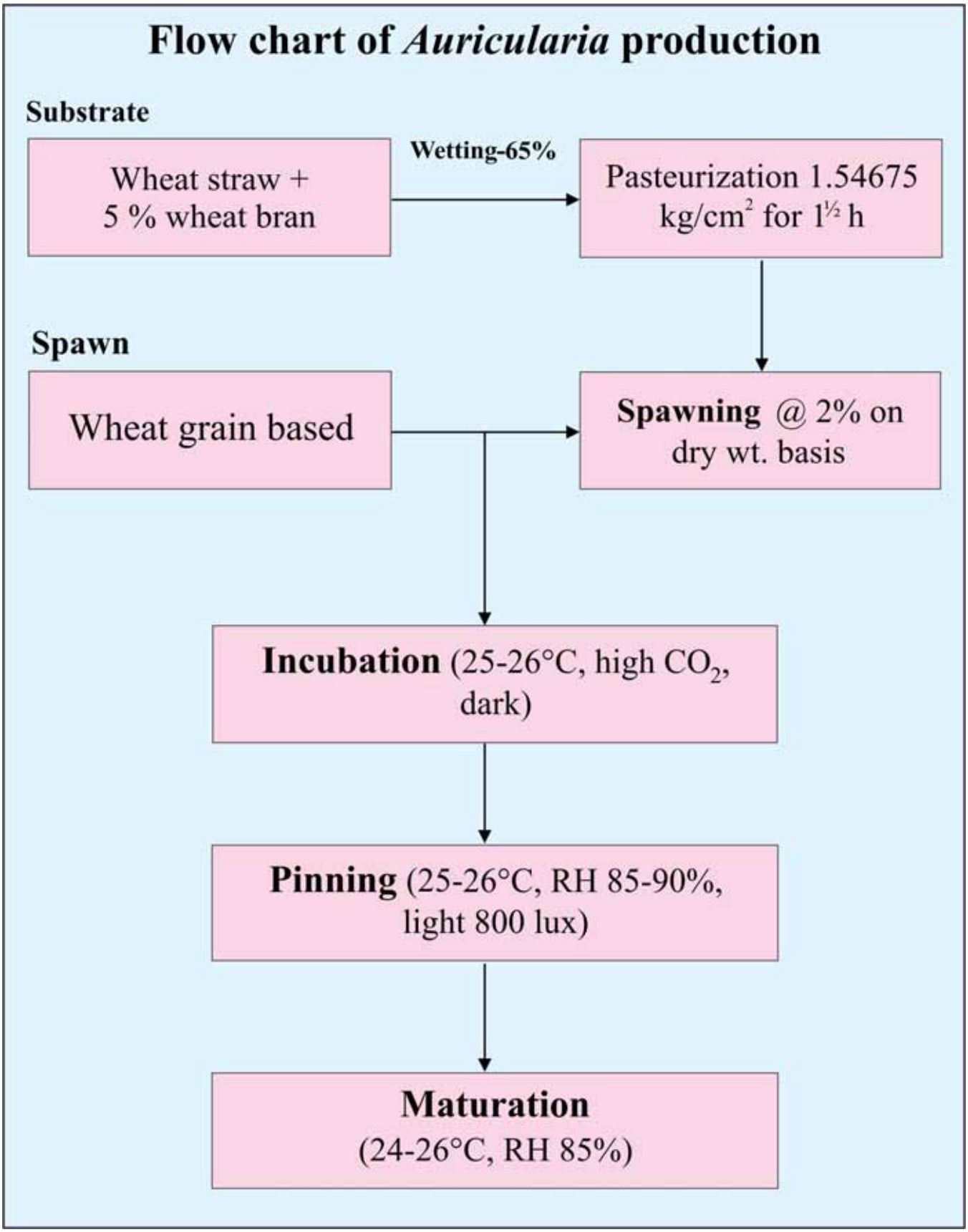
- Fresh wheat straw of good quality is soaked in water for 16-18 hours in water
- Excess water is drained out.
- Add 5% wheat bran (w/w) in soaked wheat straw.
- Fill 2 kg substrate in each polypropylene bag and autoclave at 1.54675 kg/cm^2 pressure for 1-1.5 h
- On cooling, add spawn @ 2% dry weight basis
- Incubate the spawned bags at 25-26 ºC
- Spawn run will be completed in 20-25 days
- On completion of spawn run give cross cut to give slits and hang the bags for fruiting at 25-26 ºC
- Maintain high relative humidity (85-90%) by spraying water once or twice on the bags and in the room
- Give diffused light and aeration for 1-2 hrs daily
- Fruit bodies will emerge after 10-12 days after giving the cross cuts and will mature for harvesting in the next 4-5 days
- Harvest mature fruit bodies which can be consumed fresh or can be dried

Fig. 14. Different cultivation steps of *Auricularia polytricha* (Black ear mushroom) (a-d)

6. Cultivation of winter mushroom *Flammulina* on polypropylene bags and bottles filled with saw dust substrate

Winter mushroom *Flammulina* cultivation technology was developed by Dr V P Sharma & Dr Satish Kumar. *Flammulina velutipes* (winter mushroom; Enokitake) is one of the wood decaying fungi. It occurs all over the world in areas such as China, Siberia, Asia Minor, Europe, Africa, North America, Australia and Japan. This mushroom is particularly known for its taste and preventive as well as curative properties for liver diseases and gastroenteric ulcers. This mushroom has been reported to contain immunodo-modulatory, antitumor and antibiotic substances.

- Saw dust is wetted thoroughly with water for 16-18 hours
- Add 5% wheat bran in the wetted saw dust
- Fill two kg substrate in each polypropylene bags
- Plug the bags with non-absorbent cotton by inserting ring at the mouth of the bag
- Sterilize the filled bags in autoclave at 1.54675kg/cm^2 pressure for 1-1.5h
- Inoculate cooled bags with wheat grain based spawn @ 4% dry weight basis
- Incubate the spawned bags at temperature between 22-25 ºC for mycelial growth
- After spawn run, keep the bags in the dark at a temperature of 10-14 ºC and maintain the RH at 80- 85%
- Primordia will form in 10-12 days after reducing the temperature
- Harvest fruit bodies of 14-18 cm stipe length
- Harvested fruit bodies can be consumed fresh or can be sun dried


Flow chart of *Auricularia* production
Substrate
Wheat straw + 5 % wheat bran
Wetting-65%
Pasteurization 1.54675 kg/cm² for 1½ h
Spawn
Wheat grain based
Spawning @ 2% on dry wt. basis
Incubation (25-26°C, high CO2, dark)
Pinning (25-26°C, RH 85-90%, light 800 lux)
Maturation (24-26°C, RH 85%)

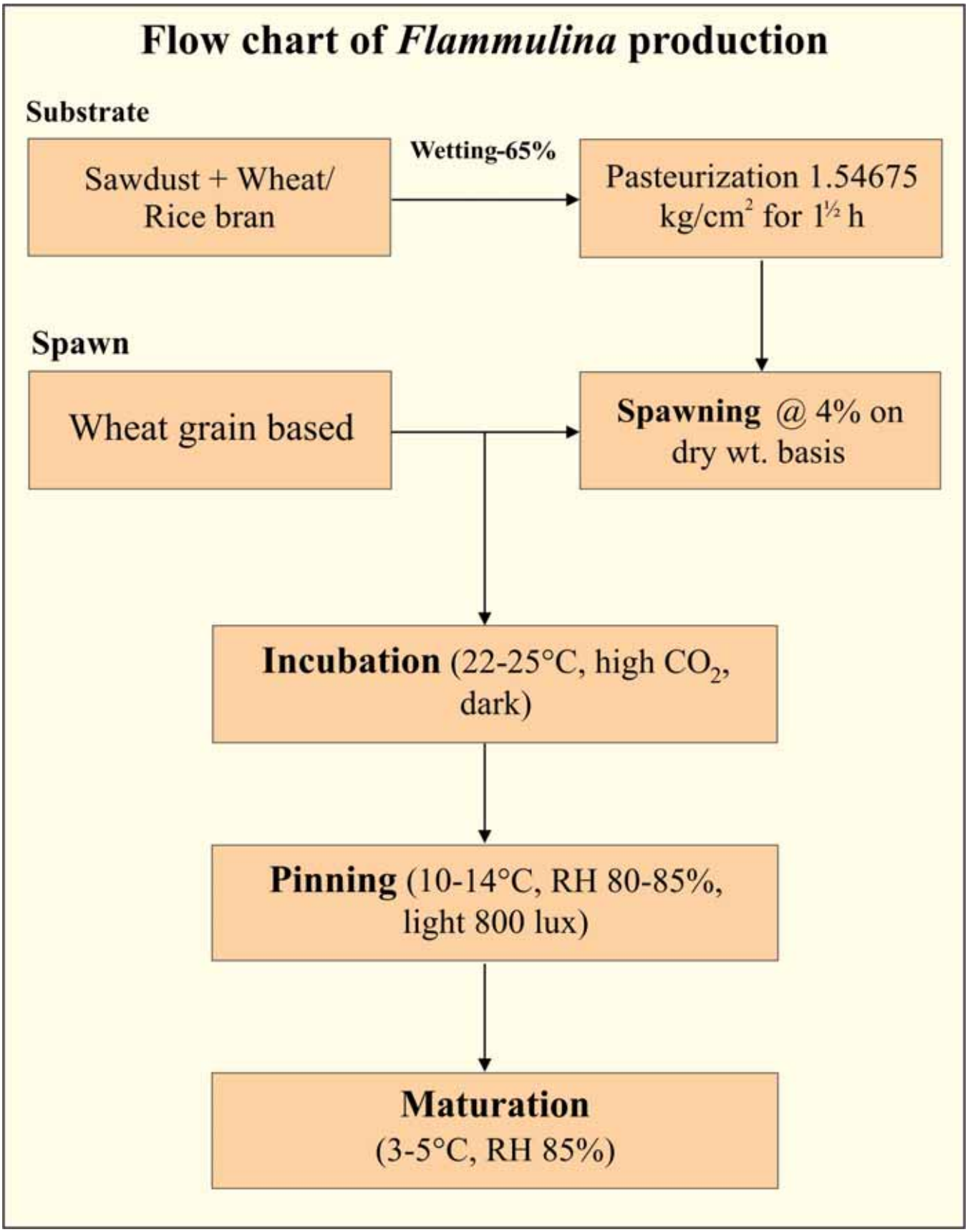
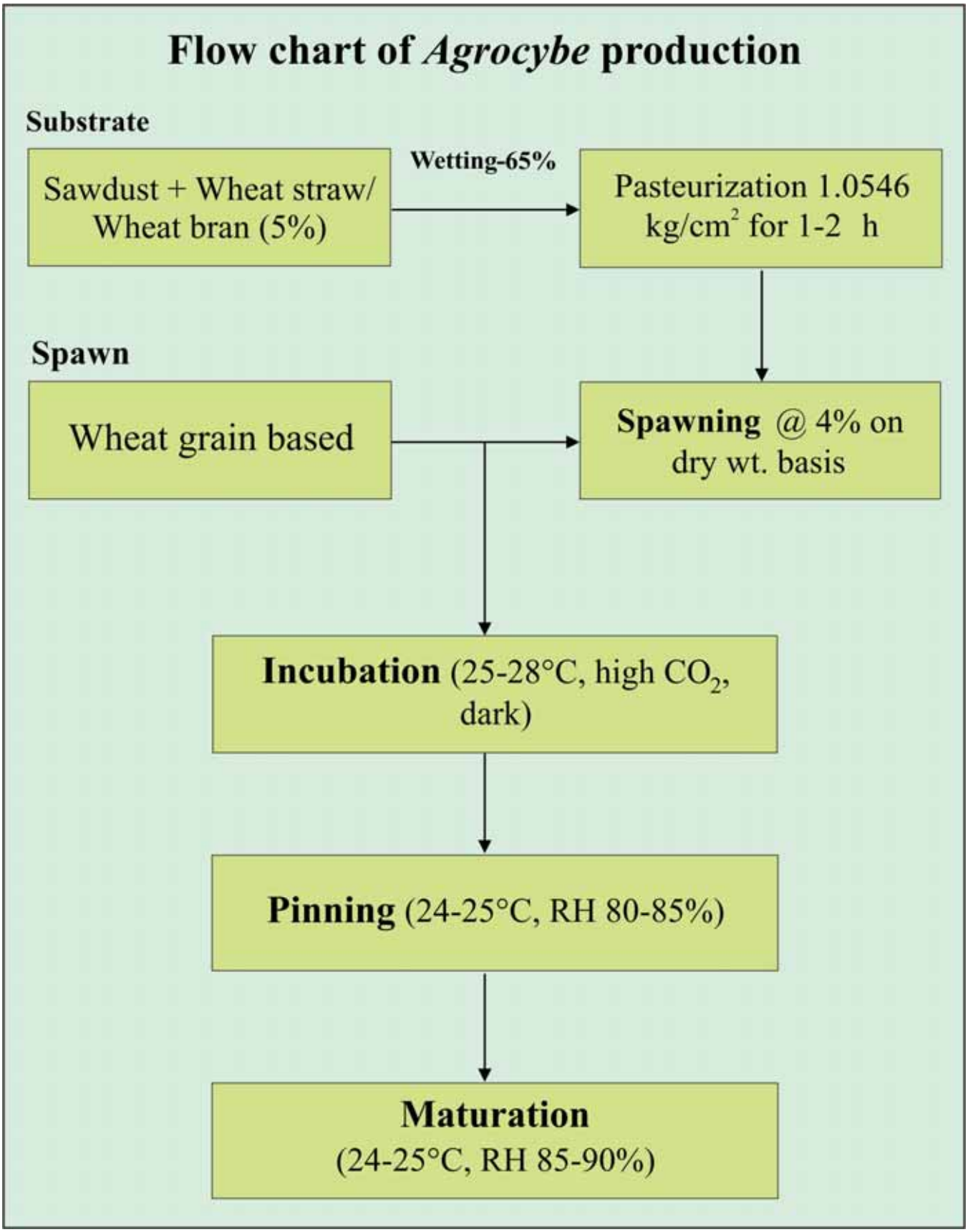

Flow chart of *Flammulina* production
Substrate
Sawdust + Wheat/ Rice bran
Wetting-65%
Pasteurization 1.54675 kg/cm² for 1½ h
Spawn
Wheat grain based
Spawning @ 4% on dry wt. basis
Incubation (22-25°C, high CO2, dark)
Pinning (10-14°C, RH 80-85%, light 800 lux)
Maturation (3-5°C, RH 85%)

Fig. 15. Different cultivation steps of winter mushroom *Flammulina* (a-f)

7. Cultivation technology of *Agrocybe aegerita*

Cultivation technology of this mushroom was developed by Dr VP Sharma & Dr Satish Kumar. *Agrocybe aegerita* (Brig.) Sing., commonly known as 'black poplar mushroom'. It has unique flavor and nutritive value It is cultivated in Japan, Korea, Australia and China. It is an important valuable source possessing varieties of bioactive secondary metabolites such as indole derivatives with free radical scavenging activity, anticancer activity, and also agrocybenine with antifungal activity. It is cultivated on wheat straw or sawdust

Fig. 16. Different cultivation steps of *Agrocybe aegerita* sp. (a-f)


Flow chart of Agrocybe production
Substrate
Sawdust + Wheat straw/ Wheat bran (5%)
Wetting-65%
Pasteurization 1.0546 kg/cm2 for 1-2 h
Spawn
Wheat grain based
Spawning @ 4% on dry wt. basis
Incubation (25-28°C, high CO2, dark)
Pinning (24-25°C, RH 80-85%)
Maturation
(24-25°C, RH 85-90%)

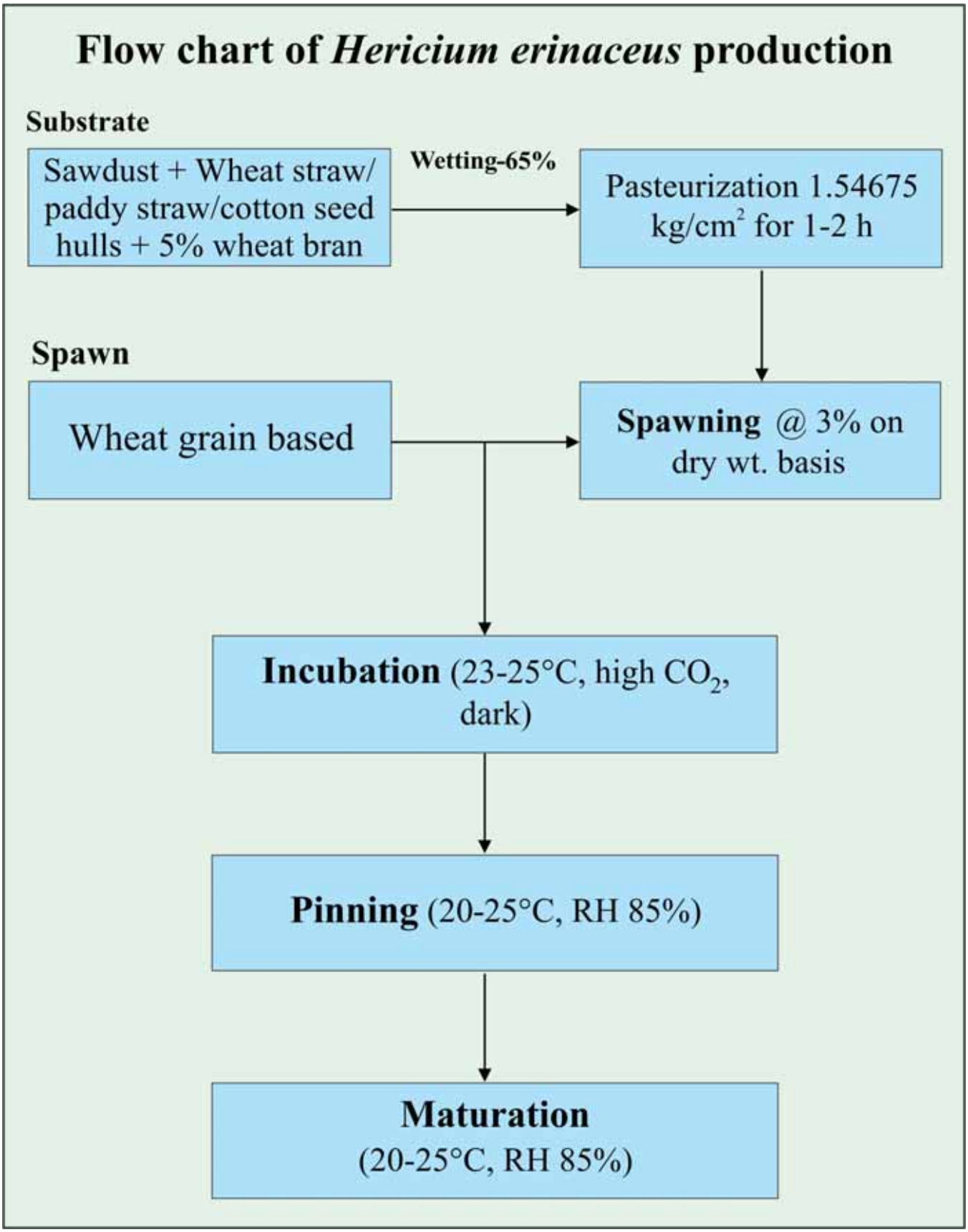
- Soak good quality wheat straw overnight for 16-18 hours and then remove the straw and drain out excess water
- Mix 4-5 % wheat or rice bran on wet weight basis
- Fill 2 kg substrate in each polypropylene bag
- Autoclave filled bags at 1.0546kg/cm2 for 1-2 hours
- After cooling, spawn the substrate @ 4% aseptically dry wt. basis
- Incubate at 25-28 ºC
- Spawn run will be completed in 20-25 days
- Cross cut or give slits and hang the bags for fruiting at 24- 25 ºC with 85-90% RH
- Spray water daily on bags and in the room
- Small primordia will appear after 5-8 days after opening the bags which will become ready to harvest in the next four days
- Average weight of a single fruit body is 3.5g
- Fresh mushrooms can be consumed or sun dried
- Fruit bodies can be stored in the refrigerator for 7-10 days

8. Cultivation of *Hericium erinaceus* (Monkey Head Mushroom)

Cultivation of *Hericium erinaceus* mushroom was done by Dr. Satish Kumar &Dr VP Sharma. *H. erinaceus* is a very exceptional mushroom and declared in the red list of endangered species in various European countries. *Hericium erinaceus* contains a number of polysaccharides, such as β-glucan, heteroglucans, heteroxylans, as several cyanthane derivative triterpenes known as hericenone and erinacine. *Hericium erinaceus* is a choice edible when young, and the texture of the cooked mushroom is often compared to seafood. This mushroom is rich in some physiologically important components, especially β-glucan polysaccharides, which are responsible for anti-cancer, immuno-modulating, hypolipidemic, antioxidant and neuro-protective activities of this mushroom. *H. erinaceus* has also been reported to have anti-microbial, anti-hypertensive, anti-diabetic. This mushroom can be grown on saw dust, sugar cane bagasse, cotton seed hulls or chopped paddy straw as substrate.

- Wet the substrate thoroughly
- Add 5% wheat bran
- Fill 2 kg substrate in each polypropylene bags
- Plug the bags with non-absorbent cotton by inserting a ring on the mouth of the bag
- Autoclave the substrate at 1.54kg/cm^2 for 1-2 h

Fig. 17. Different cultivation steps of *Hericium erinaceus* (a-f)


Flow chart of Hericium erinaceus production
Substrate
Sawdust + Wheat straw/ paddy straw/cotton seed hulls + 5% wheat bran
Wetting-65%
Pasteurization 1.54675 kg/cm2 for 1-2 h
Spawn
Wheat grain based
Spawning @ 3% on dry wt. basis
Incubation (23-25°C, high CO2, dark)
Pinning (20-25°C, RH 85%)
Maturation
(20-25°C, RH 85%)

- Add spawn @ 3% on wet wt basis
- Incubate bags at 23-25 ºC for 20-25 days
- The optimum temperature for fructification is between 18-20 ºC
- Fruiting will start after 7-10 days of bag opening
- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

9. Cultivation technology of *Hericium coralloides* (Coral tooth fungi)

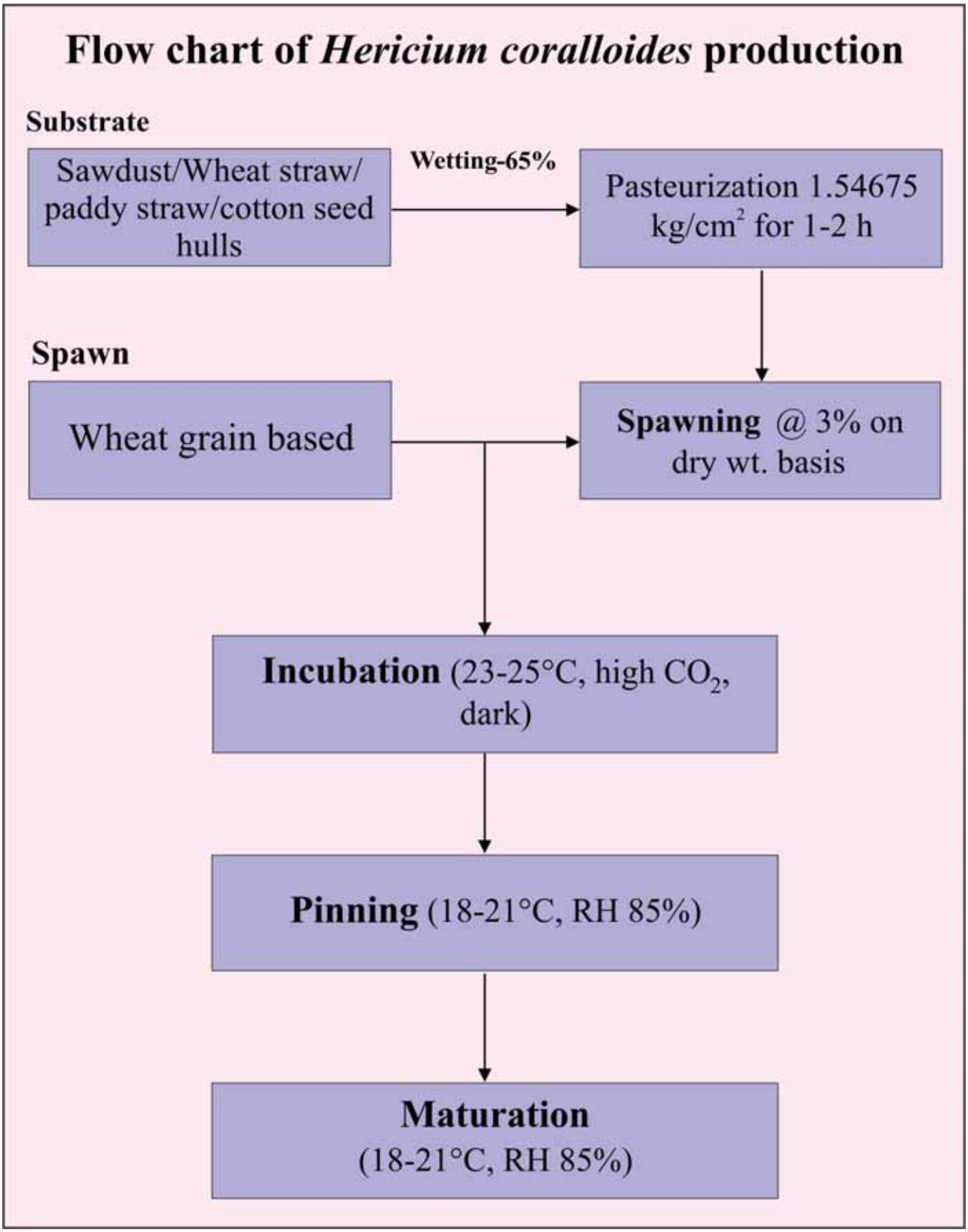
Cultivation of *Hericium coralloides* mushroom was done by Dr. Satish Kumar & Dr VP Sharma. *H. coralloides* is a saprophytic fungus, commonly known as coral tooth fungus. It grows on dead hardwood trees. When young , the fungus is soft and edible, but as it ages the branches and hanging spines become brittle and turn into a light shade of yellowish brown

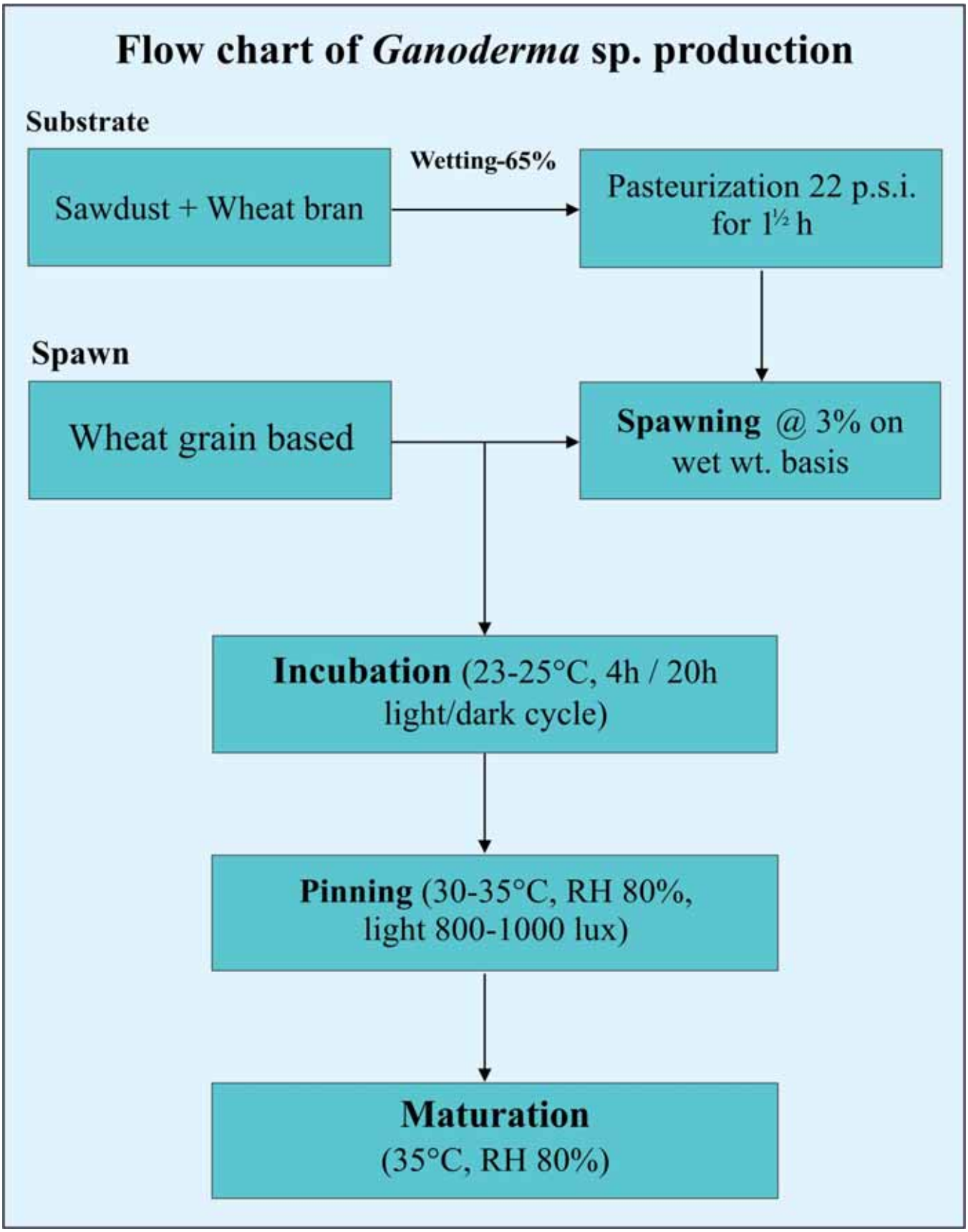
- Wet the substrate thoroughly
- Add 5% wheat bran
- Fill 2 kg substrate in polypropylene bags
- Plug the bags with non-absorbent cotton by inserting a ring on the mouth of the bag
- Autoclave the substrate at 1.54 kg/cm^2 for 1-2 h
- Add spawn @ 3% on wet wt basis
- Incubate bags at 23-25 ºC for 20-25 days
- The optimum temperature for fructification is between 20-24ºC
- Fruiting will start after 7-10 days of bag opening
- Harvest mature fruit bodies
- Mushroom can be consumed fresh or sun dried

Fig. 18. Different cultivation steps of *Hericium coralloides* (coral tooth fungus) sp. (a-f)

10. Cultivation technology of *Ganoderma* sp. Mushroom

Cultivation technology of *Ganoderma* mushroom was developed by Dr RD Rai, Dr VP Sharma & Dr Satish Kumar. *Ganoderma* sp. is a widely used medicinal mushroom which is cultivated on saw dust substrate at high temperature and 80% RH.


Flow chart of Hericium coralloides production
Substrate
Sawdust/Wheat straw/ paddy straw/cotton seed hulls
Wetting-65%
Pasteurization 1.54675 kg/cm2 for 1-2 h
Spawn
Wheat grain based
Spawning @ 3% on dry wt. basis
Incubation (23-25°C, high CO2, dark)
Pinning (18-21°C, RH 85%)
Maturation (18-21°C, RH 85%)


Flow chart of Ganoderma sp. production
Substrate
Sawdust + Wheat bran
Wetting-65%
Pasteurization 22 p.s.i. for 1½ h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (23-25°C, 4h / 20h light/dark cycle)
Pinning (30-35°C, RH 80%, light 800-1000 lux)
Maturation (35°C, RH 80%)

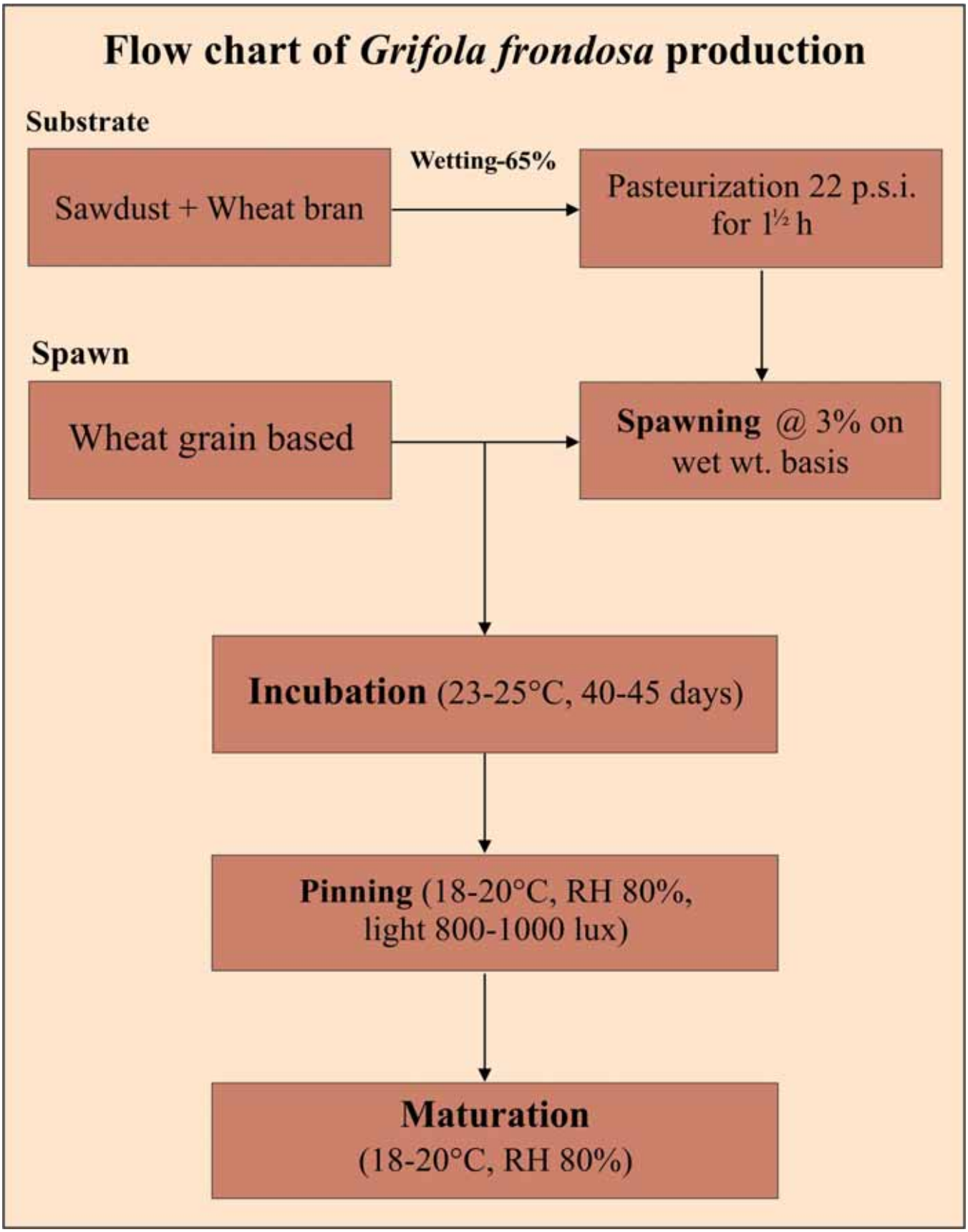
- Cultivation is carried out on sawdust (tuni, mango) supplemented with wheat bran, $CaCO_3$, $CaSO_4$ and sugar (80:20:1.0: 0.5kg)
- Substrate is filled in Poly Propylene bags (1.2- 1.5kg wet/ bag). Bags are sterilized in an autoclave at 22 psi for 90 min.
- Grain spawn is inoculated @3% (wet wt. basis and bags are incubated at 4 h/20 h light/ dark cycles at 23-25 ºC
- Mycelium run will be completed within 30 days and then bags shifted to cropping room at 35 ºC Temperature and 80% RH.
- Fruit bodies start developing and mature after 15 days. Harvest the fruit crop and dry using hot air oven.

Fig. 19. Cultivation steps of *Ganoderma* mushroom (a-f)

11. Cultivation of *Grifola frondosa* Mushroom

Grifolia frondosa mushroom cultivation technology was developed by Dr Satish Kumar and Dr VP Sharma. Maitake (*Grifola frondosa*) is a popular mushroom in Asia for its tasty flavor and immune stimulating property. The following procedure is adopted to cultivate Maitake (*Grifola frondosa*) mushroom.

- Mixed substrate is filled in Poly Propylene bags (1.2-1.5kg wet/ bag)
- Bags are sterilized in an autoclave at 22 psi for 90 minutes
- Grain spawn is inoculated @ 3% (wet wt basis, top spawning) and bags incubated at 4 hr/20 hr light / dark cycles at 23-25 ºC. Spawn run took 40-45 days
- White young mycelia penetrate throughout the surface of the substrate in the sealed bags. After a month (30 days), orange brown exudates indicating metabolic activities which cause discoloration of the white mycelia. At the surface of the substrate, tighter mycelial growth gives rise to a surface mycelial mat toward later stage of the spawn run. The surface of the mycelial mass becomes uneven with grayish amorphous
- After 40-45 days grayish primordia reaching 1-2" in diameter are formed on the substrate surface in the closed bags. Transfer these bags to a cropping room for fruiting-body development. After 2-3 days, open the top of the bags
- The optimum temperature for fructification is between 18-20 ºC for induction of fruiting suitable temperature, High RH and good ventilation are required. Fruiting body development having three main stages i.e. primordia stage or brain stage, cauliflower stage and cluster flower stage
- The Brain Stage: As the dark grayish black primordia grow, convoluted folds appear on the surface, as if a brain
- The Cauliflower Stage: Further growth includes unfolding of the convoluted folds on the surface of the dark primordia into overlapping young pilei (caps) formed in a cluster. This is followed by elongation of the lateral stems, each with a young pileus (cap) on the upper portion. The stems are highly and repeatedly branched, sharing a short and chunky base. This stage is a "cauliflower" look alike when the color of the fruiting body becomes lighter to almost white


Flow chart of *Grifola frondosa* production
Substrate
Sawdust + Wheat bran
Wetting-65%
Pasteurization 22 p.s.i. for 1½ h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (23-25°C, 40-45 days)
Pinning (18-20°C, RH 80%, light 800-1000 lux)
Maturation (18-20°C, RH 80%)

- The Cluster Flower Stage: As the mushroom continues to grow, overlapping fan-shaped caps in a cluster are developed along the elongated stems, creating the cluster flower stage. The color of the mushroom becomes progressively lighter during the intricate morphogenesis from the dark grayish-black primordia
- Maitake mushrooms fully formed, as if cluster flowers. Mushroom is ready to harvest, when the mushroom cluster has been fully formed and increases in size. The fan-shaped or semi-circular, irregularly-shaped petals (caps + lateral stems) extend outward like a cluster flower in bloom, reaching 80% in unfolding

Fig. 20. Different cultivation steps of *Grifola frondosa* Mushroom (a-f)

12. Cultivation technology of *Macrocybe* Mushroom

Cultivation technology of *Macrocybe giganta* was developed by Dr RC Upadhyay. *Macrocybe giganta* is a genus of family *Tricholomataceae. M. gigantea*, has been widely found growing on elephant dung in Kerala state in India. *Macrocybe* mushroom is commercially grown on wide range of substrates (paddy/wheat straw/ sugarcane bagasse etc.) at Directorate of Mushroom Research, Chambaghat as following method:

- Wet paddy/wheat straw in water for 2-3 day
- Make pile of the wet substrate
- Give turning to the pile after 2 days
- Add one per cent calcium carbonate
- After thoroughly mixing of calcium carbonate make pile of the substrate
- Pasteurize substrate at 60 ºC for 4 hours
- Spawn @ 3% on wet weight basis
- Fill 5 kg wet substrate in each polythene bags
- Incubate bags at 28-32 ºC under dark conditions
- Spawn run will be completed in 15-20 days
- After complete spawn run case the bags
- Use sterilize casing material (soil 75% + sand 25%) of pH 7.8-7.9
- Maintain temperature 30-35 ºC and R.H. 80-90% for cropping
- Maintain high relative humidity (85-90%) by spraying water daily once or twice on the bags and in the room
- After casing, primordia will be formed in 6-8 days
- Provide light 600-1000 lux for 4-6 hours daily
- Harvest mushrooms of 7-8 cm diameter by twisting
- Harvested fruit bodies can be consumed fresh or store clean mushrooms by wrapping in film for longer period

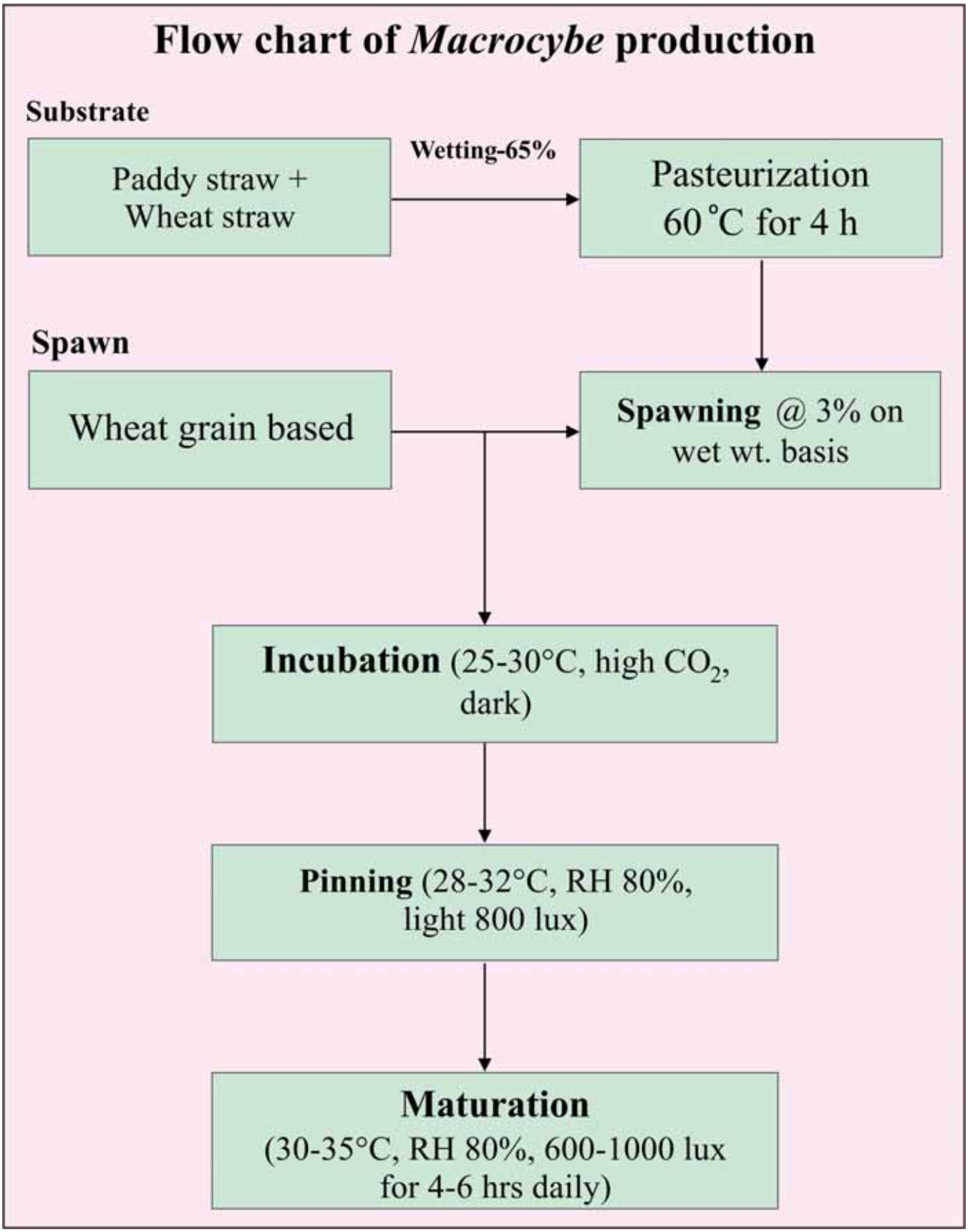

Flow chart of *Macrocybe* production
Substrate
Paddy straw + Wheat straw
Wetting-65%
Pasteurization 60 °C for 4 h
Spawn
Wheat grain based
Spawning @ 3% on wet wt. basis
Incubation (25-30°C, high CO_2, dark)
Pinning (28-32°C, RH 80%, light 800 lux)
Maturation (30-35°C, RH 80%, 600-1000 lux for 4-6 hrs daily)

Fig. 21. Different cultivation steps of *Macrocybe* mushroom (a-e)

13. Cultivation of *Macrolepiota* Mushroom

Cultivation technology was developed by Dr VP Sharma, Dr SR Sharma and Dr Satish Kumar. *Macrolepiota procera* (Scop. ex Fr.) Singer, commonly called the Parasol Mushroom, is an edible saprophytic mushroom. *M. procera* has a very large and stately sporocarp. The cap is about 10 to 30 cm in diameter and has a beautiful snakeskin pattern. *Macrolepiota* mushroom commercially cultivated on compost prepared by short method of composting.

- Spawn the substrate/ compost bag @ 4% on wet basis aseptically
- Incubate at 27 ºC and Spawn run will be completed in 18-20 days
- The primordia initiated after 18-20 days after the application of casing layer
- Spray water daily on bags
- After application of casing layer on small primordia within few days mature fruit bodies of size 16-30 cm long and 30 g weight will appear and become ready to harvest

Fig. 22. Initiation of primordia (a) and Growing fruit bodies (b)

Fig. 23. Mature fruit bodies of *Macrolepiota* Mushroom

14. Cultivation of *Stropharia rugosa-annulata* Mushroom

Cultivation technology of *Stropharia rugosa-annulata* was developed by Dr RC Upadhyay. *Stropharia rugosa-annulata* commonly known as the wine cap stropharia, "garden giant", burgundy mushroom or king stropharia (Japanese: *saketsubatake*),

is an agaric of the family *Strophariaceae*. It is widely regarded as a choice edible and is commercially cultivated. This mushroom can be cultivated on cereal straw, flax straw, corn cobs or sugarcane bagasse by autoclaving, hot water treatment or partially composting of the substrate. Commercial cultivation method of this mushroom developed by ICAR-DMR as explained below:

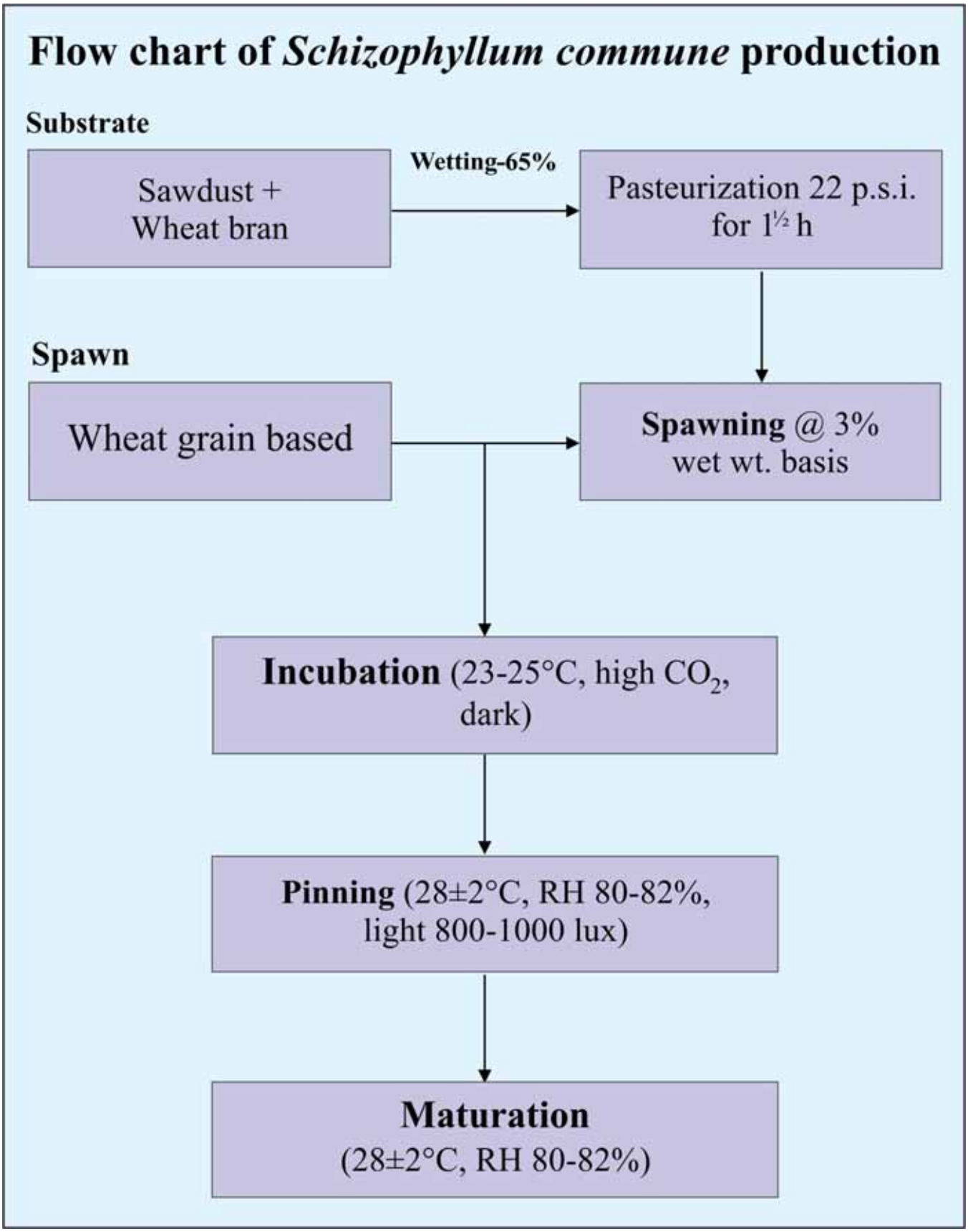
Fig. 24. Mature fruit bodies of *Stropharia rugosa-annulata* Mushroom

- Soak straw in hot water at 70 ºC for 15-20 minutes
- Spawn the substrate/ compost bag @ 4% on wet basis aseptically in polypropylene bags.
- Incubate the bags after spawning at 22-26 ºC.
- Spawn run will be completed in 20-30 days.
- After spawn run, the substrate bags are cased with mixture of loam soil + peat (1:1) or forest soil+ farm yard manure.
- For fruiting 16-20 ºC temperature with 70-80% RH, aeration and diffused light for few hrs required.
- Spray water daily on bags.
- Veil rupturing is the time of mushroom harvesting and 3 to 4 flushes can be taken at the interval of 15-20 days.
- Size of fruit body pileus vary from 5 to 40 cm in diameter and weight of mature fruit may be up to 450g.
- Yield has been reported from 3 to 30 kg/m^2

15. Cultivation of *Schizophyllum commune* Mushroom

Cultivation technology of *Schizophyllum commune* was developed by Dr VP Sharma. *Schizophyllum commune* is a species of fungus in the genus *Schizophyllum*. The mushroom resembles undulating waves of tightly packed corals or loose Chinese fan. “Gillies” or Split Gills vary from creamy yellow to pale white in color. This mushroom has many medicinal properties such as immuno modulatory, antifungal, antineoplastic and antiviral activities due to the presence of higher glucan complex carbohydrate than the other mushrooms. This mushroom is successfully cultivated on saw dust substrate at ICAR-DMR as following procedure:

Fig. 25. Cultivation steps of S*chizophyllum commune* (a-f)


Flow chart of Schizophyllum commune production
Substrate
Sawdust + Wheat bran
Wetting-65%
Pasteurization 22 p.s.i. for 1½ h
Spawn
Wheat grain based
Spawning @ 3% wet wt. basis
Incubation (23-25°C, high CO2, dark)
Pinning (28±2°C, RH 80-82%, light 800-1000 lux)
Maturation (28±2°C, RH 80-82%)

- Cultivation is carried out on sawdust/wheat straw of selected trees (80 kg), wheat bran (20 kg), $CaCO_3$ (1 kg) and $CaSO_4$ (0.5 kg)
- Mixed substrate is filled in Poly Propylene bags (1.2-1.5kg wet/ bag)
- Bags sterilized in an autoclave at 22 psi for 90 minutes
- Grain spawn is inoculated @3% (wet wt basis, top spawning) and bags incubated at 4 hr/20 hr light / dark cycles at 23-25 ºC. Spawn run took 25-30 days
- After complete spawn run bags were shifted to cropping room temperature of 28 ± 2 ºC, RH (80-82%)
- Water is sprayed on the cut opened surfaces of the bag to induce fructification
- After 2-3 days of the small primordia developed which mature into full grown fruit bodies in next 3-4 days
- Harvest mushrooms at an early stage before unveiling the margin of the cap
- 500-600 g of fresh mushrooms can be harvested from 1 kg of dry substrate
- Mushroom can be consumed fresh or sun dry

16. Cultivation of Entomopathogenic fungi: Cultivation technology for two entomopathogenic fungi i.e. *Cordyceps militaris* and *Isaria cicadae* has been developed by ICAR-DMR on artificial media

16.1 Cultivation of *Cordyceps militaris* Mushroom

Artificial cultivation technique of *Cordyceps militaris* was developed by Dr Satish Kumar, Dr Shweta Sharma, Dr Vrushali Deshmukh and Dr VP Sharma. *Cordyceps militaris* has been a foundation in combating numerous health problems with innumerable far-reaching therapeutic effects. *Cordyceps militaris* also known as caterpillar fungus is an entomopathogenic fungus with potential therapeutic values in the traditional oriental system of medicine. *Cordyceps militaris* mushroom can be cultivated artificially in laboratory.

Spawn preparation

- For preparation of liquid spawn take one litre of distilled water.
- Add 20 g dextrose, 10 g yeast extract and 10 g peptone.
- Pour the 100ml medium in each flask
- Autoclave these flasks at 15-20 psi for 30 minutes.
- After cooling inoculate these flasks with culture of *C. militaris* using laminar air flow.

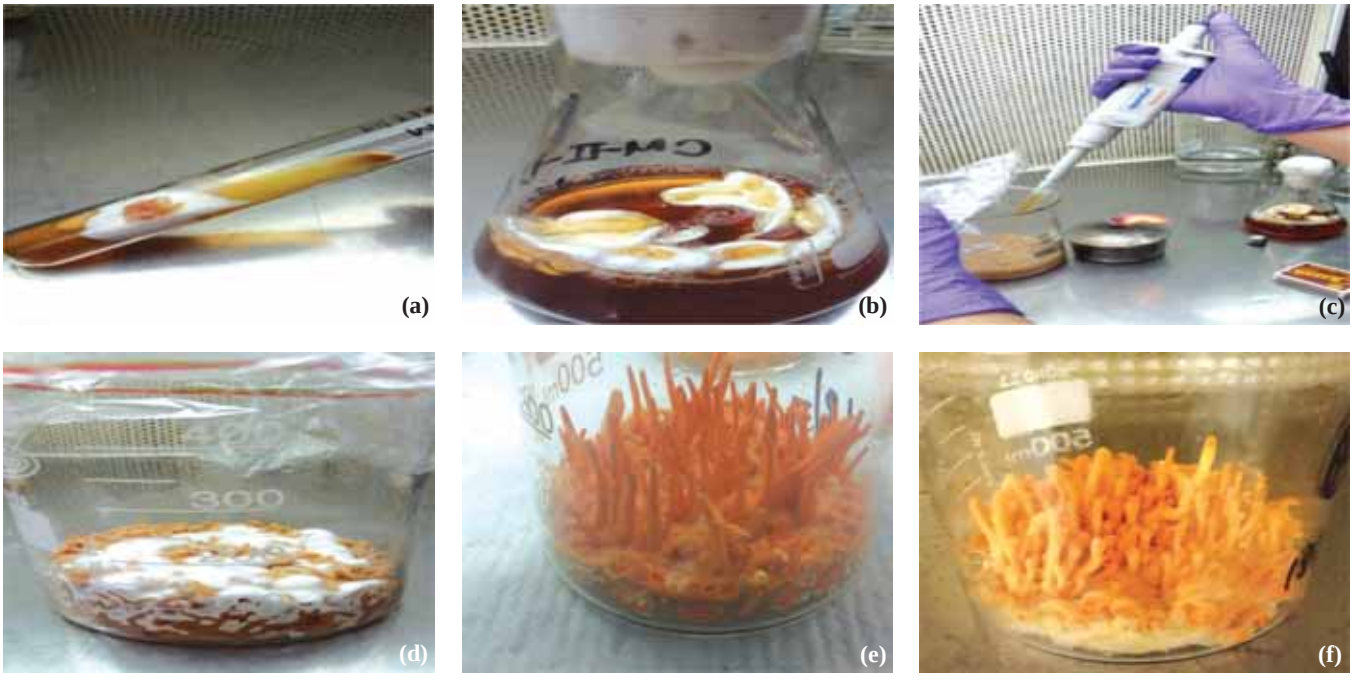
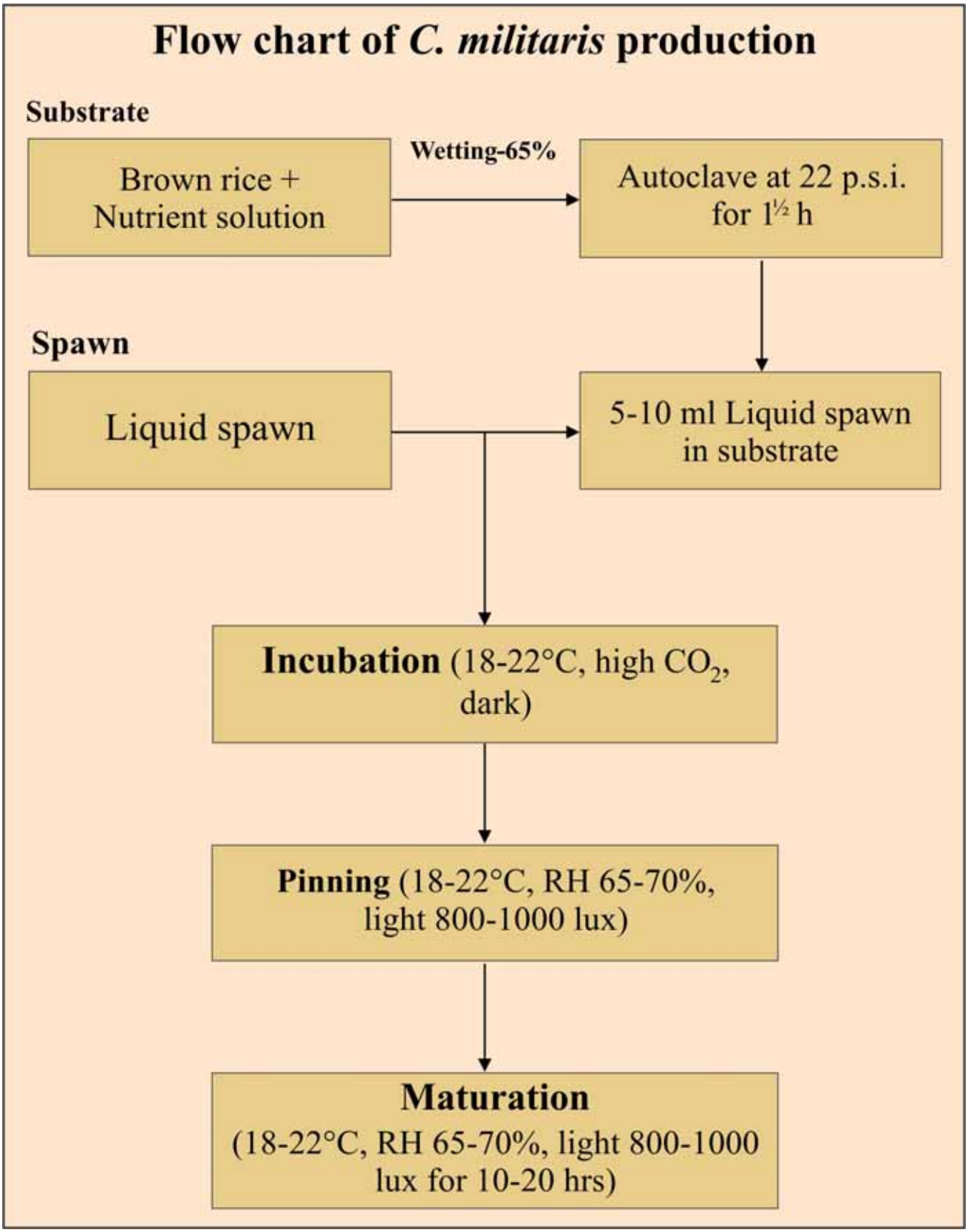


Fig. 26. Different cultivation steps of *C. militaris* Mushroom (a-f)


Flow chart of C. militaris production
Substrate
Brown rice + Nutrient solution
Wetting-65%
Autoclave at 22 p.s.i. for 1½ h
Spawn
Liquid spawn
5-10 ml Liquid spawn in substrate
Incubation (18-22°C, high CO2, dark)
Pinning (18-22°C, RH 65-70%, light 800-1000 lux)
Maturation
(18-22°C, RH 65-70%, light 800-1000 lux for 10-20 hrs)

- Keep the inoculated flasks on shaker for 5-6 days so that mycelia bits can be obtained.

Substrate preparation

- *C. militaris* is generally cultivated on the medium using brown rice as basal medium
- Soak the rice in water for 30 minutes and wash thoroughly.
- Put the rice on sieve and allow to dry for 30 minutes.
- Take 30 g rice in a jar and add 35 ml of nutrient solution.
- Cover the jars with piece of PP bag and autoclave at 15-20 psi for 40-50 minutes.
- After cooling, add 5-10 ml of liquid spawn per jar.
- Make small hole on the cap and plug it with non absorbent cotton using laminar air flow.
- Move the jars gently left to right or in a circular manner for uniform spread of liquid spawn on solid medium.

Cultivation

- After inoculation keep the jars under dark conditions for 8-10 days at 18-22ºC with RH of 65-70%.
- Jars can be covered with dark polythene.
- After through colonization of the substrate put the jars in light for 6-7 days
- The color of the mycelium will turn pink/ orange. Provide 800-1000 lux light daily for 10-12 hours.
- Pining will start in 12-15 days and with in next 20-25 days mature fruit bodies will be formed.
- Harvest the mushrooms from jars which can be sold fresh or sun dried.

16.2 Cultivation of Entomopathogenic fungus *Isaria cicadae*

Artificial cultivation technique of *Isaria cicadae* was developed by Dr VP Sharma, Dr Anupam Barh and Dr Babita Kumari. It is an entomopathogenic fungus with potential therapeutic values in the traditional oriental system of medicine. *Isaria* species are known to have exceptional pharmacological properties with therapeutic and biological activities such as immuno-modulation, enhancement of macrophage activity, promote phagaocytosis in macrophages, etc. With its wide array of secondary metabolites, it acts as biological response modifier to improve the immune responses in liver, kidney, spleen and thymus.

- Cultivation of *I. cicadae* was tried on various cereal grains i.e. wheat grain (WG), brown rice (BR), white rice (WR), soybean grain (SG), Ragi grain (RG) and Maize grain (MG).
- The grains chosen as substrate were pre-wetted to maintain the moisture up to 65% and pH was maintained 7.5 using $CaCO_3$ and $CaSO_4$.
- The grains were sterilized using autoclave at 121 ºC for 1.5 hours in flasks and inoculated with 3-4 mycelium bits of 10 mm diameter.
- The data was recorded in respect of days taken for mycelial colonization and days taken for basidiospore formation.
- On WG, mycelium of *I. cicadae* formed fluffy cotton balls like structure after 10th day of inoculation. Honey like exudates and primordial initiation was observed on 12th to 14th day of inoculation from water droplet area. The spawn run flask with primordial initiation were immersed in ice cold water for 5 minutes for chilling treatment and shifted to incubation room at temperature of 18 ± 2ºC. During incubation period, 70% humidity was maintained by spraying distilled water in between 2-3 days. Primordia developed into fruiting bodies within 12-14 days after shifting to 18 ± 2ºC temperature and 4 g of mature fruit bodies could be harvested from 200 g of WG substrate. The fruit-bodies of *I. cicadae* were whitish, branched, coral like to club shaped with conico-round heads approximately 3-6 cm in height, 1-2 cm broad, soon turned in to powdery mass.

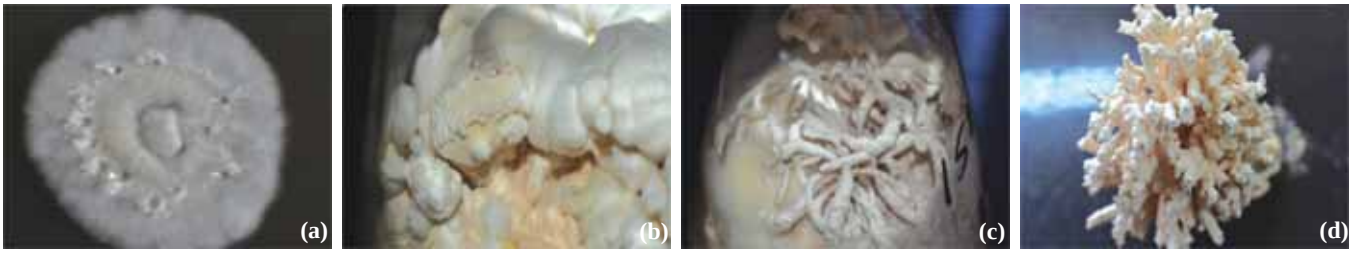


Fig. 27. Different cultivation steps of *Isaria cicadae* Mushroom (a-f)

17. Low cost ready to fruit bag developed in ICAR-DMR (Ghar-Ghar mushroom)

This technique is designed by Dr Anupam Barh and Dr VP Sharma and Dr Shwet Kamal. The main aim of this design is to provide the growing experience to the beginner growers and also to promote the mushrooms in urban and peri-urban areas.

- Low cost RTF technology is developed on oyster mushroom in 2017 by ICAR-DMR. The RTF is wheat straw based technology containing 2 kg of wet substrate. The spawn requirement for bag is 4 % of wet weight basis. The bags come with handy hanging options so that it can be hanged in rooms. On optimum temperature and humidity, each bag can produce 300-500 g of mushroom in three flushes. The fruiting requires temperature around 24 ºC and humidity around 80-85%. After pin head formation, humidity is created by spaying the water on fruit body and bags so that fruit body won't dry.
- The technology is developed on non-woven rectangular cube-shaped bio-degradable bags. The bag is provided with 3 holes on 4 sides. The dimensions of the bags are 35cm (L) X 15cm (B) X 12cm (T). This bag is durable for at least 2 years.
- The technology was released for cultivation of oyster mushroom (*Pleurotus* sp.). For pink oyster mushroom RTF bag the incubation period is of 13 days at 24 ºC. The crop fruits for three times with interval of 7-10 days at 24- 28 ºC. The pin development and fruiting require 75-85% humidity with minimum 200 lux light and optimum 800 lux light. The CO_2 of room must be below 1000 ppm. Aeration is required for the crop development. The spraying of water should be done at 2-3 times depending of dry and humid weather.

Fig. 28. Low cost ready to fruit bag

D. Disease Management Practices in Mushroom Production

1. Management of Mushroom Flies

This management technology was developed by Dr Satish Kumar.

- Sticky trap is used for monitoring and management of mushroom flies.
- The trap consists of a 15 W yellow bulb and a polythene sheet of any size coated with mustard oil hanged on the wall. Flies show photo-tactic behavior in the morning and evening hours, all the flies will stick to the polythene sheet.
- This trap is highly popular among the mushroom growers and is widely adopted in almost all the mushroom growing States of India.
- In addition to the trap, one or two spray application of deltamethrin, malathion or dichlorovos as adulticides on walls and floor is highly effective for fly control.
- Placement of UV fly catcher at the height of 4-5 feet effectively controls mushroom flies

2. Management of wet bubble disease (*Mycogone perniciosa*) in button mushroom

This management technology was developed by Dr V.P. Sharma, Dr Satish Kumar & Dr Anil Kumar.

Wet bubble pathogen (*Mycogone perniciosa*) of button mushroom has a world-wide distribution and can cause severe crop losses. Infected fruit bodies, spent mushroom substrate, farm yard manure, substrate material, ground water etc. are the major sources of inoculum. Disease transmits through contaminated irrigation water, air, casing soil, picker's hands, insects (like flies and mites). If the pathogen infects mushroom before the differentiation of stipe and pileus, the sclerodermoid masses are formed. Whereas infection after differentiation results in the production of thickened stipe with deformation of gills. *M. perniciosa* produces small thin-walled phialoconidia on *Verticillium*- like conidiophores and bicellular conidia which are commonly referred to as either aleuriospores or chlamydospores. Use standard crop management practices and be the earliest to jump to any disease control strategies.

- Wet bubble produced two main symptom types, one if young pin heads are infected they develop monstrous shapes which often do not resemble mushrooms. When infection take place before the differentiation of stipe and pileus the selerodermoid form resulted, whereas, infection after differentiation resulted in the production of thickened stipe with deformation of the gills.
- Always do composting on cemented floor
- Maintain proper moisture in compost and proper pasteurization at 59 ºC for 6-8 hrs
- Proper pasteurization of casing at 65 ºC with 65% moisture
- Treat empty room with 2% formalin
- Maintain proper hygiene and sanitation in and around mushroom house
- Use foot dips
- Harvesting should be done from new rooms to older rooms
- Use light trap for monitoring and controlling fungal gnats. Drench with 2% formalin before disposing off the bags
- Maintain 70 ºC temperature inside rooms for 8-10 hours
- Dispose off spent mushroom substrate in pits away from mushroom farm and cover it with layer of soil
- Ensure the cleanness of machinery and all equipment for spawning and compost filling.
- Ensure the cleanliness of growing rooms. (Floor, walls, shelves, cloths, racks and other equipments and tools must be thoroughly cleaned and treated with disinfectants)
- When the work is done, the machinery, equipment and rooms must be cleaned properly
- Disinfect the machinery, equipment and the corridor following the route of transportation, the nets, cloths and other inventory with 2% formalin solution before starting work
- Maintain the time needed for the contact action of the disinfectant and the processed surface (not less than 20 minutes), then thoroughly ventilate the growing rooms
- During compost filling and spawning, the personnel doing this work isn't allowed to enter a clean corridor or the warehouse, or contact personnel engaged in harvesting mushrooms. The components for the preparation of the casing soil must be stored special places, not allowing them to be mixed
- Keep clean the room where the casing soil is stored along with the area adjacent to it;
- Transport the casing mixture and its components to the growing rooms only in thoroughly washed and cleaned transportation
- After the application of casing layer, immediately remove the remains of the casing mixture from the working corridor and the growing room, then clean the floor machinery and equipment

- During the process, there should not be any work that doesn't have to do with the application of casing layer going on in the working corridor; the passageway must be closed
- Alternatively, a spray of 0.8 percent formalin on to casing surface, immediately after casing, can be effective. However, this concentration can be injurious if used at later stage in crop

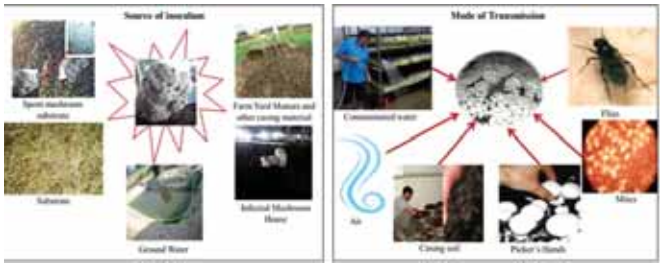


Fig. 29. Source of inoculum and different modes of transmission

Fig. 30. Wet Bubble (*M. perniciosa*) inoculated button mushroom bag and control bag

3. Management of yellow mould disease syndrome

This management technology was developed by Dr V.P. Sharma, & Dr Shwet Kamal.

- Yellow mould syndrome produces three characteristic symptoms in mushroom beds viz., mat formation, confetti and yellow flakes with spore mass inside the compost beds either separately or in combination.
- The causal organisms of yellow mould disease encountered in button mushroom farms are *Myceliophthora lutea*, *Sepedonium chrysopermum* and *S. maheshwarianum*.
- In Himachal Pradesh, 20-60% crop losses and from Haryana 89% losses of white button mushroom have been reported.
- Although all these yellow mould causing organisms are capable to reduce the mushroom yield, but *M. lutea* is the most devastating fungus causing complete crop failure depending upon the stages of the infection.

Fig. 31. Confetti formation on the yellow mould infected bag of white button mushroom

- Under seasonal conditions, casing is normally chemically pasteurized and causes the problems of fungicidal residue in the mushrooms. As an alternative, tunnel sterilized casing soil showed drastically reduced fungal counts in comparison to control.
- 0.5% phosphate supplementation in the compost can increase yield upto 98% in comparison to untreated inoculated control and the disease could not establish in any of the treated bags.
- Extract of *Cannabis sativa* is very effective in reducing the growth of yellow mould pathogens without affecting the growth of *A. bisporus* when added in malt extract agar medium @ 5%.
- Use of pasteurised compost, sterilized casing soil may be a good alternative along with addition of P2O5 (0.5%) in compost to prevent crop losses due to yellow mould syndrome.

D. Mushroom Based Value Added Products

1. Processed Mushroom Products Developed by Directorate

The focus of Indian mushroom industry is predominantly on trade of the fresh produce rather than the real value addition. Almost entire domestic trade is in the fresh form while most of the export is in preserved form (canned or steeped). Various value added products such as mushrooms pickle, jam, sauce, candy, preserve, chips etc. can be prepared from fresh mushrooms whereas from the dried mushroom powder value added products like instant soup mix, bakery products, papad, nuggets etc. may be prepared. Many such value added products of mushrooms have been developed at ICAR-Directorate of Mushroom Research (Solan) and are being discussed as below:

1.1 Mushroom Pickle

Pickling of mushrooms is an easy home scale process for preservation of mushrooms to a value added product of high market acceptability. For preparing mushroom pickle, mushrooms are washed, sliced and blanched for 5 min in 0.05% KMS solution. The blanched mushrooms are washed in cold water for 2-3 times and the excess water is drained off. Then the mushrooms are subjected to salt curing process, in which 10% sodium chloride is added and kept overnight. The excess water oozed-out of mushroom is removed on the next day and spices & preservatives are mixed to the desired taste and quality of mushroom pickle. To 1 kg mushroom various spices *viz*. turmeric powder (20 g), black mustard seed powder (35 g), red chilli powder (10 g), cumin seed powder (1.5 g), carom seed (10 g), nigella seed (kalonji)(10 g), fennel seed powder (1.5 g) and mustard oil (200 ml) are added to prepare tasty pickle. Acetic acid and sodium benzoate within the permitted limits are used as preservatives. This pickle can be stored up to one year in the airtight bottles.

Fig. 32. Mushroom pickle

1.2 Mushroom Biscuits

Both button or oyster mushroom can be used to prepare delicious and nutritious mushroom biscuits using ingredients *viz*., refined wheat flour (*maida*) & mushroom powder (in 80:20 ratio), sugar (30%), ghee (bakery fats) (45%), baking powder (0.6 %), ammonium bicarbonate (0.3%), salt (0.6 %), milk powder (1.5 %) and vanilla essence (0.02%). For making biscuits all the dry ingredients are finely ground and sieved. Then fat and sugar are mixed well for 5-7 minutes using dough kneeder. These ingredients are then added to dough kneeder with other dry ingredients for dry mixing of 20-25 minutes. Thereafter, water is added to make dough cohesive and homogenous and mixing is continued for 10-15 minutes. Then dough is

Fig. 33. Mushroom biscuit

kept for 10 minutes covered with wet cloth. Thin sheets of dough (1.25 cm thick) are made and cut into different shapes of biscuits using different steel dies. These raw cut biscuits are then baked in hot oven (at 180ºC) for 20 minutes and after cooling biscuits are ready for packaging.

1.3 Mushroom soup mix

Mushroom soup mix was developed with 30% oyster mushroom powder, 30% corn flour, 25% milk powder, 8% salt, 3% sugar, 2% black pepper, and 2% oregano. This soup mix has to be boiled for 2 minutes with 14 times quantity of water for the preparation of good quality mushroom soup with characteristic aroma and taste. This mushroom soup mix can be stored for 90 days at ambient temperature and for 180 days at refrigerated temperature without any significant change in sensory, proximate, Vitamin D, antioxidant and microbial quality of soup mix.

Fig. 34. Mushroom soup

Fig. 35. Mushroom sauce

1.4 Mushroom sauce or ketch-up

Freshly harvested button mushrooms are washed, sliced and cooked in 50% of water for 20 minutes. Mushroom paste is prepared using a mixer grinder. Then salt (10%), sugar (25%), acetic acid (1.5%), sodium benzoate (0.065%), onion (10%), garlic (0.5%), ginger (3%), cumin (1 %), black pepper (0.1%), red chilli powder (1 %) and arrarote (0.2%) are mixed in the paste and cooked to bring its TSS to 35 °Brix. Then the ketch-up is filled in the sterilized bottles or jars.

1.5 Mushroom preserves (Murabba)

For preparing mushroom preserve, fresh button mushrooms are graded, washed, pricked and blanched in 0.05% KMS solution for 10 minute. Blanched mushroom is then dipped in 50 ºBrix sugar solution and refrigerated overnight. Next day mushroom is strained out of sugar solution and the solution is added with 0.1% citric acid and sufficient sugar to attain strength of 60 ºBrix by heating. Mushrooms are then dipped into it and kept overnight. This process is repeated to raise the concentration of syrup to 70 ºBrix and mushrooms are dipped into it for 1 week to prepare preserve. The preserve is then drained out of sugar syrup and filled in a container with freshly prepared sugar syrup of 68 ºBrix. The containers are then sealed airtight and stored.

Fig. 36. Mushroom murabba

1.6 Mushroom candy

The process for making candy is practically the same as that employed in the case of mushroom preserve, with the difference that the produce is impregnated with a higher concentration of sugar (75ºBrix) and is also partially dried under shade to attain the chewable consistency. The mushroom candy can be stored up to 8 months with excellent acceptability.

Fig. 37. Mushroom candy

1.7 Mushroom chips

Mushroom chips can be prepared from button or oyster mushroom both. For preparing mushroom chips, freshly harvested mushrooms are washed, sliced (in case of button mushrooms), divided in individual mushrooms from the bunch (in case of oyster mushrooms) and blanched in 2% brine solution. The mushrooms are dipped overnight in a solution of 0.1% of citric acid + 1.5% of NaCl + 0.3% of red chilli powder. After draining off the solution, the mushrooms are subjected to drying in cabinet dryer at 60ºC for 8 h. Then it is fried in the refined oil and good quality chips are prepared. After spices mixing, the chips are packed in polypropylene packets and sealed after proper labeling.

Fig. 38. Mushroom chips

1.8 Mushroom Jam

Development of mushroom jam would aid in preserving mushrooms for a year as a product that is nutritious as well as widely acceptable. For preparation of mushroom jam, washed and blanched mushrooms are ground into a paste. This mushroom paste is then added with sugar (1:1 to paste), pectin (1% of pulp) and citric acid (1% of pulp) and heated with continuous stirring to avoid sticking to pan till it reaches a TSS of 68º Brix. This prepared jam is hot filled in sterilized glass bottles leaving a head space of 0.8 to 1.0 cm. The bottles are then sealed and stored in a cool and dry place.

Fig. 39. Mushroom jam

1.9 Mushroom nuggets

For preparation of mushroom nuggets, mushroom powder (dried and coarsely ground mushrooms) is mixed with the black gram (*Urad*) dhal powder (1:8) and a paste is prepared by adding required quantity of water. Salt (2%) and red chilli powder (1%) are added to the prepared paste and round balls of 2-4 cm diameters are made. The prepared balls are spread over a steel tray and are sun dried. These mushroom nuggets can be straightaway deep fried and used as snacks or can be used in vegetable curry preparation.

Fig. 40. Mushroom nuggets

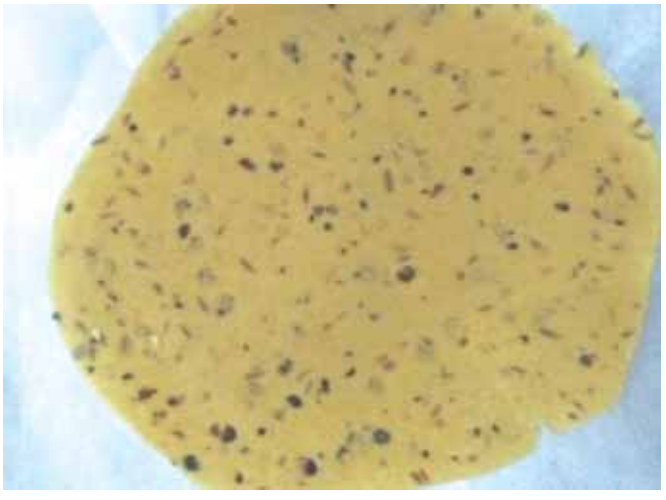


Fig. 41. Mushroom papad

1.10 Mushroom papad

Papad is a thin, crisp disc-shaped Indian snack food usually made from seasoned batter of peeled black gram flour (urd flour), lentils, chickpeas, rice, tapioca or potato, fried or cooked with dry heat. Papads can be supplemented for protein with mushroom either in the form of paste or dried powder in the batter prepared from other sources as mentioned above. This can make papad a wholesome food with high protein content.

1.11 Mushroom Bhujia

Bhujia is a deep fried snack of Indian origin prepared usually from bengal gram flour (*besan*) adding salt, spices, oil and baking powder into it. Mushroom powder can be incorporated into the bengal gram flour flour up to a level to 30% to prepare nutritious and healthy mushroom bhujia.

Fig. 42. Mushroom bhujia

1.12 Novel value added products of mushrooms

Mushroom based new products and fortified mushroom products have been developed including mushroom fortified corn extrudates, mushroom fortified cakes, ready to cook frozen mushroom tikki, mushroom fortified noodles, mushroom based vegetarian sausages, mushroom snack bar, mushroom multigrain bread and mushroom health drink powder etc.

1.13 Mushroom fortified corn extrudates

Fortification levels of mushroom in extrudates were optimized for sensory and nutritional properties to a level of 20% paste and 10% mushroom powder for both single and twin screw extruders.

1.14 Ready to cook frozen mushroom tikki

Ready to cook (3 min fry) frozen mushroom tikki was developed and cohesive binding properties of mushroom shreds was optimized by using response surface methodology and taking shred size, corn starch concentration and par frying time as the variables. Optimization was done on basis of fat absorption characteristics, textural and sensory properties.

1.15 Mushroom Based Vegetarian Sausages

Vegetarian sausages can be prepared from fresh mushroom by adding 5% saturated fat and binding agents such as carrageenan, soya protein concentrate, casein or xanthan gum.

1.16 Mushroom fortified cakes

Mushroom fortified cakes have been developed and fortification to a level of 20% (as wheat flour replacement) has been found to be optimum according to sensory and textural properties of both cake and batter prior to baking.

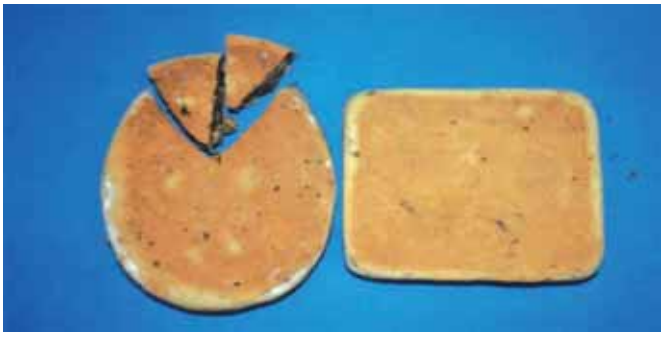


Fig. 43. Mushroom fortified cake

1.17 Mushroom fortified instant noodles

Ready to cook instant noodles fortified with graded levels of mushroom (*Pleurotus ostreatus*) powder have been developed and on the basis of their nutritional and sensory properties, the level of fortification of mushroom powder @ 4 % to noodle dough was optimized.

Fig. 44. Mushroom fortified noodles

1.18 Mushroom Snack bar

Mushroom fortified snack bar was developed with 20% white button mushroom powder, 40% sweeteners, 25% cereals, 10% peanuts and 5% dry fruits. This mushroom fortified snack bar can be stored for 30 days at ambient temperature and for 90 days at refrigerated temperature without any significant changes in sensory, proximate, Vitamin D, antioxidant and microbial quality of snack bar.

Fig. 45. Mushroom snack bar

1.19 Mushroom multigrain bread

Fig. 46. Mushroom multigrain bread

Mushroom fortified multigrain bread was developed with 5% oyster mushroom powder, 85% refined wheat flour, 6% whole wheat flour, 2% ragi flour, 2% oatmeal, and 1% flaxseeds. This bread was acceptable based on sensory analysis (overall acceptability score-6.88) and contained 8.23% protein, 30.54% carbohydrate, 1.36% fat, 1.02% ash, 0.21% fiber, 1264.72 IU Vitamin D, 4.07mg/100g iron, 198.44mg/100g calcium, 9.29 manganese, 1.3 copper, 1.27 zinc, 32.93 potassium and good antioxidant-properties (DPPH- 88.18 mg AEAC/100g, ABTS- 489.24 mg AEAC/100g). Shelf life of this mushroom fortified multigrain bread was determined to be 5 days at ambient temperature without any significant change in sensory, proximate, Vitamin D, antioxidant and microbial quality of bread.

1.20 Mushroom health drinks powder

Mushroom fortified health drink powder was developed with 10% oyster mushroom powder, 10% malted ragi, 20% whey-protein, 30% milk powder, 20% sugar and 10% cocoa. This health drink powder was found to be acceptable based on overall-acceptability score (8.17) and contained 25.01% protein, 62.55% carbohydrate, 3.96% ash, 6.43% fat, 4.53% fiber, 2435.9IU Vitamin D and good antioxidant-properties (DPPH-394.75 mg AEAC/100g, ABTS-1055.98 mg AEAC/100g).

Fig. 47. Mushroom health drink powder

1.21 Development of oyster mushroom spread

A nutritious and tasty mushroom spread was developed using oyster mushroom(10g) and tomato (90g) along with garlic (2g), ginder (1g), chilli (1g), salt (1g), sugar (1g), vinegar (2ml), vegetable oil (2ml), black pepper (0.5g) and oregano (0.5g). This spread can be used with bread, sandwiches, burgers, pizza, etc. The developed spread was found acceptable based on sensory analysis and contained 70.03% moisture, 2.97% protein, 14.77% carbohydrate, 7.78% fat, 4.44% ash, 2.45% fiber and 240.07 IU/g Vitamin D. This spread has a shelf life of three months at room temperature.

Fig. 48. Mushroom spread

1.22 Development of shiitake mushroom vegetables soup mix

A mushroom vegetable mixed soup mix was developed using shiitake mushroom powder (20%) along with vegetables mix (containing tomato powder, dried carrot shreds, partially cooked and dried peas, onion powder and garlic powder) (15%), corn flour (27.5%), milk powder (22.5%), salt (9%), sugar (3%), black pepper (2%) and oregano (1%).The developed soup mix was found acceptable based on sensory analysis and contained 2.8 % moisture, 8.62% protein, 71.44% carbohydrate, 4.02% fat, 13.12% ash, 3.47% fiber and 2681.48 IU/g Vitamin D.

Fig. 49. Shiitake mushroom vegetable soup

F. Other Important Technologies and E-Resources & Mobile Apps. Developed by ICAR-DMR

1. Techniques for enhancement in quality and shelf-life of harvested button mushroom

- Spray 0.2% solution of $CaCl_2$ on mushroom beds starting from pinhead initiation stage up to completion.
- Wash mushrooms with solution of 0.02% KMS + 100 ppm EDTA. It helps in maintaining superior quality of the stored mushroom.
- Pack the mushrooms in 100 gauge thick polypropylene bags which helps in retaining the quality for a much longer period than packaging in ordinary polythene bags.

2. RECYCLING of spent mushroom substrate (SMS)

Recycling of waste of mushroom compost or spent mushroom compost substrate into useful compost for horticultural crops is developed by Dr OP Ahalwat.

- Fresh SMS contains 1.9:0.4:2.4% (NPK), while 8-16 months old contains 1.9:0.6:1.0 (NPK).
- SMS does not fall in the category of hazardous substances as it does not contain heavy metals.
- SMS obtained from various sources vary in its physical and chemical properties.
- Treatments like rapid salt leaching and re-composting by aerobic or anaerobic methods for one to two years make SMS more suitable for growing flowers, vegetables, fruit, saplings, ornamental shrubs and other horticulture plants of economic importance.
- The use of anaerobically re-composted spent mushroom substrate as casing material gave superior button mushroom yield with better diseases management.
- SMS of paddy straw, oyster and button mushrooms can be used as feeding material for vermi-composting.

3. Mushroom e-learning portal with information on various mushrooms. The portal was designed and developed by Dr. Yogesh Gautam with following applications/utilization:

- Mushroom cultivation for beginners
- Spawn production technology
- White button mushroom (*Agaricus bisporus*) cultivation
- Oyster mushroom (*Pleurotus* sp.) cultivation
- Shiitake mushroom (*Lentinula edodes*) cultivation
- Milky mushroom (*Calocybe indica*) cultivation
- Paddy straw (*Volvariella* sp.) cultivation
- *Ganoderma* mushroom cultivation
- Winter mushroom (*Flammulina velutipes*) cultivation
- King oyster mushroom (*Pleurotus eryngii*) cultivation
- Post harvest technology of mushrooms
- Nutritional and medicinal value of mushrooms
- Management of spent mushroom substrate
- Production and marketing of mushroom
- Mushroom pest and diseases management

B. ICAR-MUSHROOM App has been developed by Deepak Sharma (Sr. Technical Asstt.) AKMU

- Main aim to design ICAR-MUSHROOM App is to help or assist mushroom growers, mushroom entrepreneurs, mushroom researchers and students.
- There are following active controls used in this application:
  - DMR-HOME: Cover photo with auto phone call link and auto mail link with DMR official website link
  - LINKS : MyGov, DARE, Farmers Welfare, ICAR, ASRB, DMR-Solan

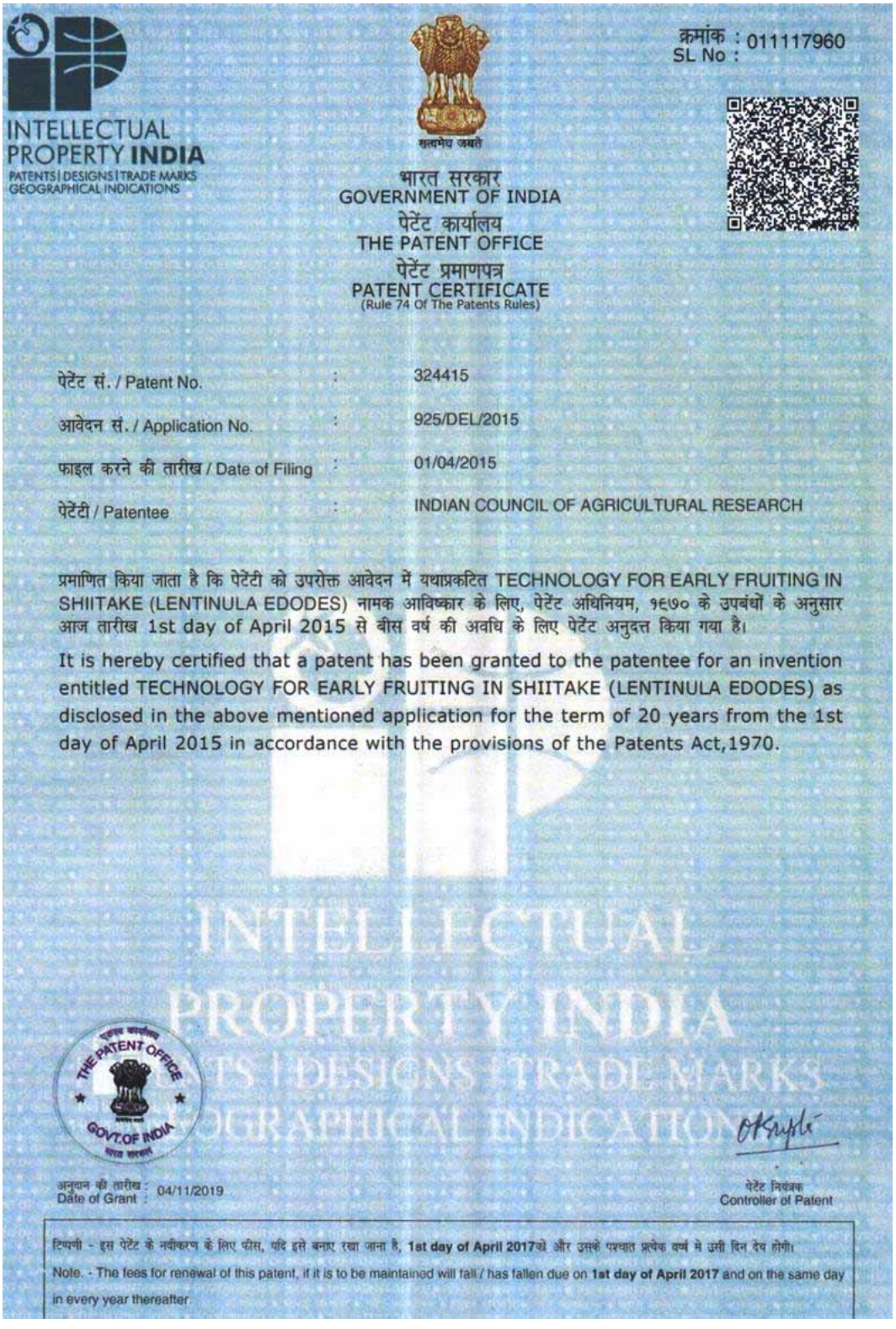
C. Video documentaries for e-learning

Six different digital documentaries were developed by Dr. Mahantesh Shirur and Dr. Sudheer Kumar Annepu in English and Hindi for e-learning

- Cultivation technologies of White button mushroom
- Cultivation technologies of Shiitake
- Cultivation technologies of Milky mushroom
- Cultivation technologies of oyster mushroom
- Cultivation technologies of paddy straw mushroom
- Spawn production technologies

Patent obtained

ICAR-DMR Solan obtained a patent for developing technology for early fruiting in Shiitake (*Lentinula edodes*) in 2019.



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सत्यमेव जयते

क्रमांक : 011117960
SL No :

भारत सरकार
GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE

पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

पेटेंट सं. / Patent No.	:	324415
आवेदन सं. / Application No.	:	925/DEL/2015
फाइल करने की तारीख / Date of Filing	:	01/04/2015
पेटेंटी / Patentee	:	INDIAN COUNCIL OF AGRICULTURAL RESEARCH

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित TECHNOLOGY FOR EARLY FRUITING IN SHIITAKE (LENTINULA EDODES) नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 1st day of April 2015 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled TECHNOLOGY FOR EARLY FRUITING IN SHIITAKE (LENTINULA EDODES) as disclosed in the above mentioned application for the term of 20 years from the 1st day of April 2015 in accordance with the provisions of the Patents Act,1970.

THE PATENT OFFICE GOVT. OF INDIA

अनुदान की तारीख :
Date of Grant : 04/11/2019

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, **1st day of April 2017**को और उसके पश्चात प्रत्येक वर्ष में उसी दिन देय होगी।

Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on **1st day of April 2017** and on the same day in every year thereafter

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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