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**REVIEW ARTICLE** **OPEN ACCESS**

# Breeding in mushrooms: A review

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**ABSTRACT**
*Mushroom is a fruiting body developed from a group of mycelium. Most of mushroom belongs to Basidiomycotina. Mushroom are of different type of edible mushroom like button mushroom, oyster mushroom, paddy straw mushroom, milky mushroom, shiitake mushroom. Mushroom has various nutitional quality like mushroom has a rich source of proteins and vitamin B complex, mushroom also have lingo cellulolytic activity which secrete large amount of oxidizing enzymes of industrial importance. Breeding of mushroom has objective to develop disease and pest resistant strain, high nutritional quality and high storability of mushroom. A large number of hybrid strains have been developed by various breeding methods like Horst U1 by hybridization, LAU09 by mutation breeding etc. This article discuss about various types of methods of mushroom breeding and obstacles in breeding of mushroom.*
***Keywords:*** *Mushrooms, Cultivation, Disease resistance, Transgenic breeding, protoplast fusion, hybridization, Agrobacterium mediated transfer*

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## INTRODUCTION

Mushroom is fruiting body of fungi developed from group of mycelium buried in substratum. Most of mushrooms belong to Basidiomycotina and some of them to Ascomycotina. Mushroom have been cultivated since time immemorial. Mushroom consist of higher amount of protein content than plants. Mushroom have lower fat and high fibre content and consist of all amino acids except, iron [6]. There are many different species of mushroom which are cultivated on commercial bases for example Paddy straw mushroom –*Volvariella spp*, Oyster mushroom –*Pleurotusspp,* Button mushroom –*Agaricusspp*, Milky mushroom –*Calocybespp* , Shiitake mushroom –*Lentinullaspp* , Jew's ear mushroom –*Auricularia*sp. Mushroom has many medicinal qualities like immuno-modulation, anti-cancer, anti-hypertensive, anti-diabetic, antiviral, antibacterial, nephro-protective, livo-protective, etc. [14].

The oyster mushroom consist of folic acid which is helpful in curing anaemia and it also have antioxidant property because of compound like Ergothioneine. The button mushroom is most widely cultivated in world. Mushroom breeding is latest science as compared to plant breeding or animal breeding. Breeding of mushroom aims at developing strains of disease resistance, pest resistance, good nutritional quality, more storability. Most of mushroom breeding programme has been successful in button mushroom-*Agaricus bisporus*. 1st hybrid of button mushroom Horst U1 was developed by Dr. Greda Fritsche in 1980s.

## NEED FOR MUSHROOM BREEDING

Improvement in the yield and quality traits of mushroom as well as evolving high yielding disease and pest resistant mushroom are the major role of mushroom breeding.Production of hybrid with thick mushroom cap and prolific nature of hybrid strain increased yield potential of mushroom. Brown blotch disease caused by *Pseudomonas tolaasii* is most damaging disease in *Pleurotus* spp. Therefore, breeding for developing resistant towards this bacteria is effective in controlling brown blotch disease. Many fungi cause disease in mushroom and it becomes really difficult to control fungal disease because mushroom itself is a fungi. Adding to it, somehow if disease is controlled by fungicide but after sometime fungicide resistant strains is developed by pathogen therefore, it becomes necessary to develop resistant cultivars [12]. Breeding for sporeless strains because many spore strains of oyster mushroom caused allergic reaction to the cultivator. Breeding for quality improvement and shelf life [4]. Kim and coworkers developed high shelf life strain in *Pleurotuseryngii*

## DIFFERENT METHODS OF MUSHROOM BREEDING

### Hybridization

It is crossing of self sterile and compatible homokaryotic lines that help in creation and selection of desired traits. The first effort in developing hybrid was made by Dr. G. Fristche in Netherlands in late 1970s. That led to development of two new varieties U1 and U3. Horst U1 is a cross between a white and an off-white strain [14]. Hybrid strains not only produced disease and pest resistance but also have reduced environmental effects. Horst-U1, Horst-U2 , S-11 , S-791 strains of *A. bisporus* are other examples of the breeding successes. Hybridization to produce high yielding variety in *Pleurotus* spp was done for first time in *Pleurotus ostreatus*. For developing high yielding, long shelf life and good quality, the cross was made between ATCC367 and HOLLAND150.Intraspecific hybridization is cross between two compatible monokaryon from different strain of same species which produces dikaryon which is known as intraspecific hybrid. Intraspecific hybridization of *P. flabellatus* was achieved by selective dikaryotization with an objective of better nutritional quality [3]. Intergeneric hybridization is mating between two homokaryotic of different genera . drawback of intergeneric hybridization is that no fruit body formation take place due to sterility and homokaryotization [4].

### Mutation breeding

The process in which mutant varieties are developed with quality traits like resistance against fungicides and diseases, higher yields, tolerance for high temperature, sporeless strain without changing the whole genome using physical, chemical mutagens. Physical mutagens ( uv radiation, ionizing radiation) and chemical mutagens ( ethylmethane sulfonate, bromouracil, diethyl sulfate etc)are capable of bringing changes in sequences of DNA. A high yielding strain of *Ganodermalucidum* was achieved by uv mutagen. Its mycelia yield raised by 21% and polysaccharide by 31%. Seven high yielding strains ( UV32, UV34, UV35, UV43, UV44, UV45, UV46) were obtained from straw mushroom(*Volvariella volvacea)* by UV induced mutagenesis [2]. The improvement of *Pleurotus pulmonarius* LAU09 strained was achieved by UV light exposure for 30 to 120min and strained obtained LAU30, LAU60, LAU90,LAU120 out of these mutant strain LAU90 shown highest mycelia growth whereas LAU120 strain shown least mycelia growth incomparison to LAU09 strain [1].

### Protoplast fusion

It is a non-conventional method of gene transfer as it involves breaking down of the natural barrier of gene exchange as found in conventional system of breeding. Protoplast fusion between white oyster mushroom *(Pleurotus floridae)* and brown oyster mushroom *(Pleurotus cystidiosus)* resulted in 22 colonies out of which four strains FS1,FS2,FS3,FS4 were confirmed to fusants on basis of their clamp connection. FS1 and FS2 shown more number of fruiting body and higher productivity [11].

**Table 1: Details of *Agrobacterium tumefaciens* mediated gene**

| Species | cell type | Agrobacterium strain | Co- culture condition | Plasmid marker | Promoter | Reporter | Gene | References |
|---|---|---|---|---|---|---|---|---|
| *Agaricusbisporus* | Protoplast<br>tissue<br><br><br>Protoplast<br>tissue<br><br><br>tissue<br>tissue | LBA1100<br>AGL-1<br>EHA105<br>LBA1100<br>AGL-1<br>LBA1126<br>AGL-1<br>AGL-1<br>EHA105 | $25^0$C, 5days<br>$25^0$C, 3days<br>$25^0$C, 5days<br>$25^0$C, 2-3days<br>$25^0$C<br>$25^0$C, 3days | PTAS10<br>pBGgHg<br><br>pUR5750<br>pGRAhph004<br><br>pBlue<br>pBHg | *A.niger*gpd<br>*A.bisporus*gpd<br><br>*A.niger*gpd<br>*A.bisporus*gpd<br><br>*A,bisporus*spr1<br>*A.bisporus*gpd | Egfp<br><br><br>GFP<br><br><br>GFP<br>Pabs | hph (25)<br>hph (50)<br><br>hph(30)<br>hph(50)<br><br>hph(25)<br>hph(50) | [9]<br>[7]<br><br>[20]<br>[5]<br><br>[13]<br>[19] |
| *Pleurotus eryngii* | Tissue<br>Protoplast | GV3101<br>AGL-1 | $25^0$C, 7-14days<br>$1^0$C, 25days | pCAMBIA1304<br>pBGgHg | CaMV35S<br>*A.bisporus* gpd | IL-32<br>eGFP | hph(20)<br>hph(120) | [8]<br>[15] |
| *Pleurotus ostreatus* | Spore<br>Mycelium<br>Tissue | AGL-1<br>GV3101 | $25^0$C, 3days | pPEH | *P.ostreatus*gpd | | hph(50) | [10] |
| *Volvariella volvacea* | Spore<br>Mycelium<br>Tissue | EHA105<br>LB4404 | $3^0$C, 28days | pLg-afp235 | *L. edodes*gpd | Afp | | [21] |

### *Agrobacterium tumefaciens* mediated gene transfer

A soil inhabiting plant bacterium, *Agrobacterium tumefaciens* is able to transfer a piece of DNA known as T- DNA from tumor inducing plamid (Ti plasmid) into host genome . transformation of both homokaryon

and heterokaryon can be achieved by *Agrobacterium tumefaciens* [6] . *A. tumefaciens mediated* transfer has been applied to many mushroom like *Agaricus bisporus, Ganoderma lucidum, Pleurotus eryngii*and many more as shown in table 1 [16].

**Transgenic breeding**

No transgenic mushrooms are available at commercial scale but researchers are trying to develop transgenic mushroom. Various techniques such as polyethylene glycol, bombardment have been used to transfer DNA into protoplast, mycelium. Polyethylene glycol (PEG) is a chemical which help foreign DNA to enter into host cell because PEG is known to increase cell permeability [16]. Paticlebombardment method has been carried out in mushroom. In this introduction of DNA into cells involves bombardment of cells with high velocity microprojectile coated with DNA. In this tungsten or gold particle coated with foreign DNA are bombarded into recipient tissue [18].

## OBSTACLES IN MUSHROOM BREEDING

Breeding in *Agaricus bisporus* is difficult because of secondary homothallic life cycle of this fungus. QTL mapping require recombination between strains but due to low recombination frequency between homologous chromosomes during meiosis causes hurdle in mushroom breeding. During mapping of gene recombination frequency has to be analysed for each individual therefore, it is a time consuming task. Isolation of single mushroom cell is nearly impossible because fungal cells are highly connected to form mycelia. Spores of fungi have thick cell wall therefore, some cell wall has to be removed to introduce foreign DNA.

## CONCLUSION

Breeding of mushroom is a continuous process which help in genetic improvement of previous strains which either became susceptible to disease or insect pest. Also breeding is done to achieve high nutritional quality and increasing shelf life. Already in previous paragraph different types of breeding method involved in breeding have been discussed. Breeding in mushroom is difficult due to various reasons like secondary homothallic nature of fungus, cells are highly interconnected.

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