Role of Fungi in the Development of Value-Added Products

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National Centre for Microbial Resource
National Centre for Cell Science, Pune
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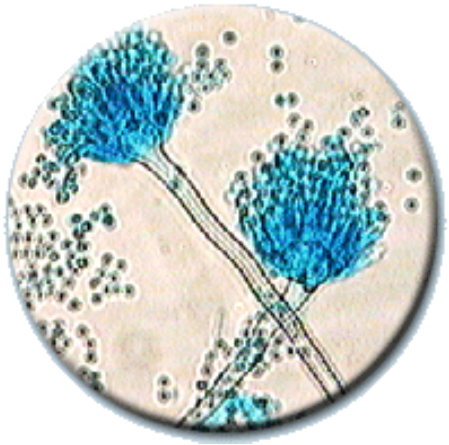
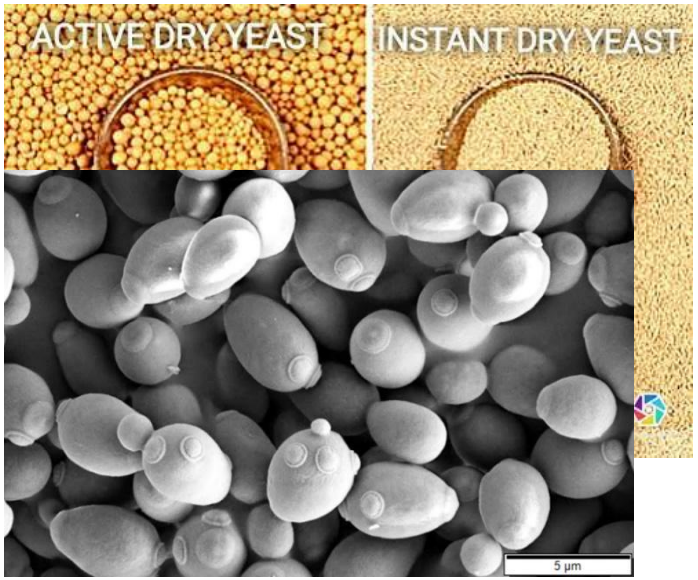


Aspergillus



Saccharomyces cerevisiae

***Agaricus* sp.**

***Pleurotus* sp.**

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Image Source: Google

Flow

- Fungi and Value Added Products
  - Fungi and Food
  - Fungi in Dye Production
  - Fungi in Perfumes
  - Fungi in Paper Making
  - Fungi and Myco-packaging
  - Fungi in Bread and Cheese Making
  - Fungi in Soya Sauce Making
  - Fungi and Medicines
  - Entomopathogenic Fungal Products
  - Value Addition of Nursery Products using VAM inoculants
  - Role of Fungal Pectinase
- Fungi in Waste Treatment
  - Municipal Waste (Wet and Dry)
  - Agricultural and Poultry Waste
  - Industrial Waste (Distillery Spent Wash)
- Unusual Applications of Fungi for Sustainability

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Fungi in Value Added Products

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Mushroom Cultivation (Oyster)

- Mushrooms: rich source of protein, vitamins, minerals, anti-oxidants, fibers and low calorific value.
- Agricultural substrates: wheat/paddy straw, bagasse, rice bran, saw dust, etc.
- They are excellent source for cultivating oyster mushroom *(Pleurotus* spp.).
- The substrate left after mushroom cultivation are good source of manure/ compost.

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Mushroom Kit

- Readymade mushroom bags/ mushroom kits are not available.
- NCCS-NCMR plans to develop such a kit.
- Common man can grow fresh mushrooms at home.

Image Source: Google image, TOI

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Mushroom Growing Kit

- In the market we have button mushrooms which is quite popular.
- Oyster mushroom does not hold much market.
- Advantage: can be cultivated with minimum care and more sturdy.
- These mushroom bags of oyster will be popular as 3-4 crops mushrooms.
- They have applications in fresh vegetable market

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Value addition of edible mushrooms

Anima Majumdar, Deenajpur, West Bengal

Anjali Rawat, Dehradun, Uttarakhand

Source: The Better India, Soumya foods Pvt. Ltd

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Perfumes/ Fragrance Compounds from Mushrooms

- Many mushrooms produces certain compounds which are ketones, terpenes, esters, etc.
- They have good fragrance particularly natural flavours like cucumber, fruit like, garlic, raspberry, etc.
- They have applications in perfume and fragrance industries.

Source: demeterfragrance , ballyhouramushrooms

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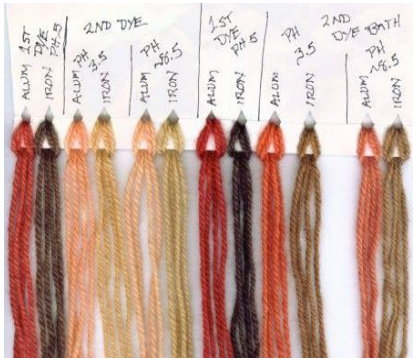
Dyes and Pigments from Mushrooms and Micro Fungi

- Mushroom produces lot of dyes and pigments which can be used in dyeing wool, cotton, paper, etc.
- Pigments from edible mushroom can be used in foods with not much difficulty.
- These are natural compounds and hence eco-friendly.
- They have applications in dye industries.



Source: mushrooms for colour, fungi perfecti

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Paper from Mushrooms

- Mushroom are been used to produce hand made papers.
- These are natural and hence eco-friendly.
- They have applications in paper industries.

Source: mushrooms for colour, fungi perfecti

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Myco-Packing Material

- Agricultural waste products such as wheat/rice husk, oat hulls, cotton burrs are cooked and cooled.
- The material is seeded using fungal mycelium.
- This processed and inoculated material is then placed in molds of desirable shapes and sizes.
- The material is left to be incubated over a period of five- six days.
- Mycelium grows, consumes the feedstock, creating a chitinous polymer matrix that forms the lightweight, non-compressible structure.
- NCCS-NCMR is working on developing the myco-packaging material using fungi.

NCCS-NCMR displaying their initial experiments on myco-packaging

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Source: various sources

- Eco-friendly
- Biodegradable

- Good replacement of thermo-cool, styrofome

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Role of Fungi in Other Food Products

- Soya Sauce, Cheese, Bread, etc.

Penicillium roqueforti and other species of *Penicillium*

Saccharomyces cerevisae (bakers yeast)

Soy sauce is a condiment produced by fermenting soybeans with *Aspergillus oryzae* or *Aspergillus sojae* fungi with water and salt

Source: various sources

Role of Fungi in Medicines

Somya Spawn Lab Pvt Ltd.,
Dehradun, Uttarakhand

Source: Soumya Foods Pvt. Ltd., Mushroom Learning Centre-Kolhapur

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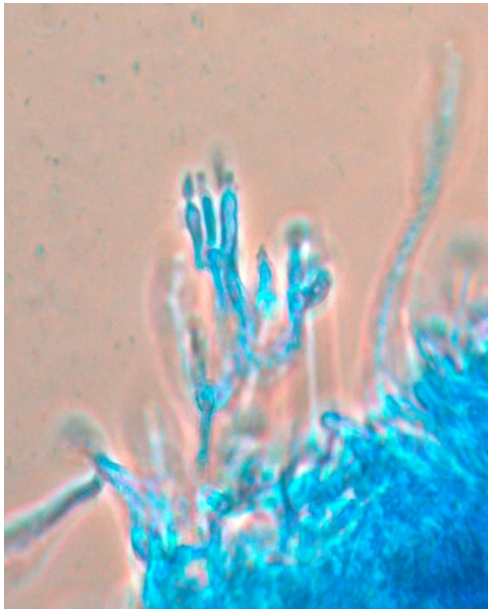
Entomopathogenic Fungal Products

MCC 1026	*Paecilomyces lilacinus*
MCC 1021	*Beauveria bassiana*
MCC 1027	*Metarrhizium anisopliae*
MCC 1011	*Metarrhizium anisopliae*
MCC 1022	*Beauveria bassiana*
MCC 1023	*Lecanicillium tenuipes*
MCC 1024	*Beauveria bassiana*
MCC 1028	*Lecanicillium* sp.
MCC 1029	*Paecilomyces* sp.
MCC 1129	*Metarhizium anisopliae*
MCC 1130	*Metarhizium* sp.
MCC 1127	Lecanicillium sp
MCC 1145	*Beauveria* sp.
MCC 1150	*Beauveria* sp.
MCC 1188	*Metarhizium anisopliae*
MCC 1189	*Metarhizium anisopliae*
MCC 1190	*Metarhizium anisopliae*
MCC 1192	*Metarhizium anisopliae*
MCC 1193	*Metarhizium anisopliae*
MCC 1194	*Metarhizium anisopliae*
MCC 1195	*Metarhizium anisopliae*
MCC 1196	*Metarhizium anisopliae*
MCC 1197	*Metarhizium anisopliae*
MCC 1224	*Paecilomyces* sp.
MCC 1267	*Beauveria* sp.
MCC 1288	*Paecilomyces* sp.
MCC 1333	*Metarhizium rileyi*
MCC 1356	*Beauveria* sp.
MCC 1357	*Metarhizium anisopliae*
MCC 1660	*Beauveria felina*
MCC 1858	*Beauveria pseudobassiana*
MCC 1931	*Metarhizium brunneum*



At NCCS-NCMR, we are trying to develop a good, efficient myco-pesticide against *Helicoverpa* sp.

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Value Addition of Nursery Products using VAM inoculants

With VAM inoculation

No VAM inoculation

Source: various sources

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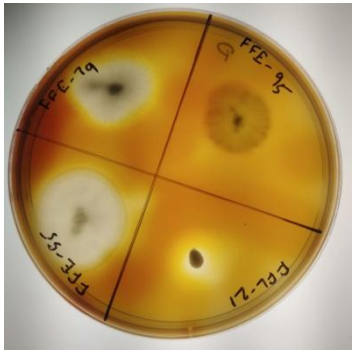
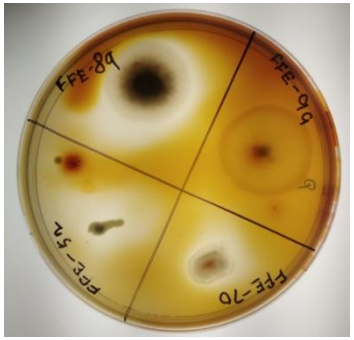
Role of Fungal Pectinase





- Fungal pectinases are extensively used in various industries like wine industry; food industry; paper industry for bleaching of pulp and waste paper recycling; in the processing of fruit–vegetables, tea–coffee, animal feed; extraction of vegetable oil and scouring of plant fibres.

- Because of its healing properties, pomegranate peels can effectively fight acne, pimples and rashes

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Fungi in Waste Treatment

- Municipal Waste (Wet and Dry)
- Agricultural and Poultry Waste
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Treating Municipal Waste

- Wet Organic Waste: raw vegetables, cooked food from canteens, restaurants.
- Dry Organic Waste: Garden waste, leaves, stems, etc.

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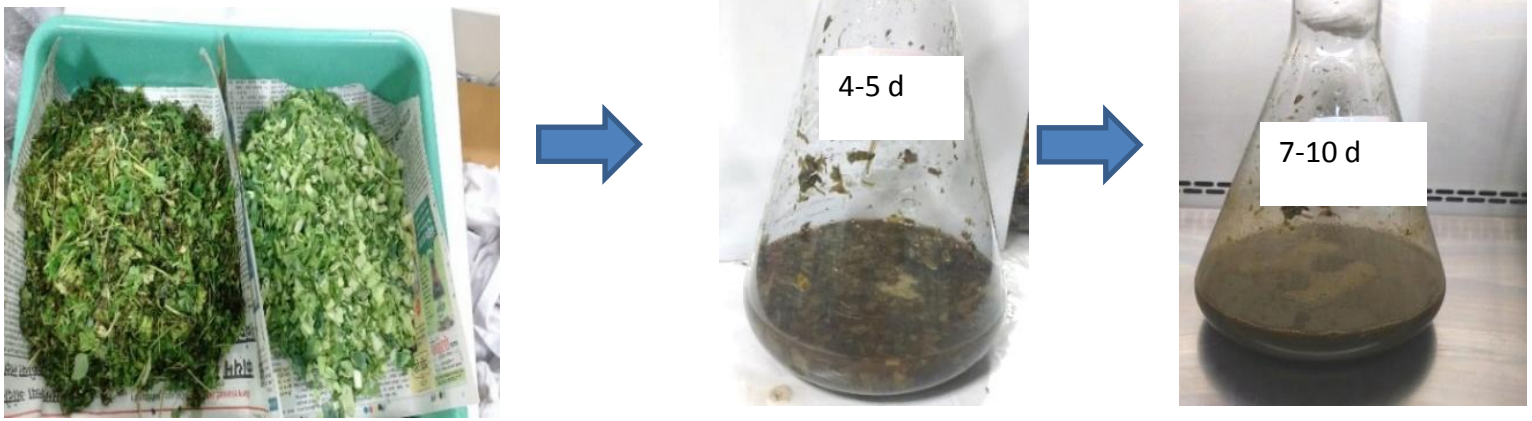
Wet Waste Composting

Composting at NCCS-NCMR

- Fungi were screened for enzymes cellulase, laccases, amylases, etc.
- Vegetable waste was collected from the local vegetable market and shredded.
- The flasks were inoculated with selected fungal cultures and incubated.
- In a week the solid waste was degraded and liquefied.



Wet vegetable waste

Treatment of wet vegetable waste using microbes

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Dry Waste Composting

Source: some images are from Google images

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Dry Waste Composting

Conventional Dry-waste Treatment

- The garden litter is mixed with household wet waste and hope it turns into manure.
- The dry litter is comprised of wooden logs and leaves.
- These have a very complex structural organization and is more difficult to degrade.
- It is important to degrade the two kinds of waste separately.

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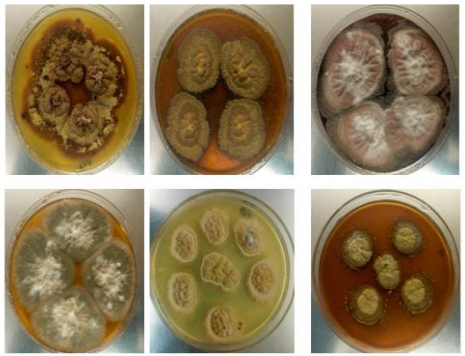
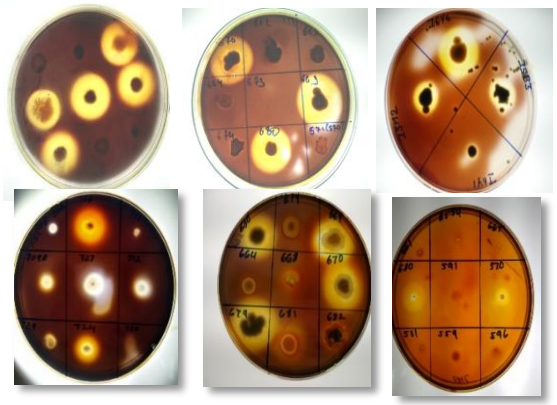
Dry Waste Composting

What we are doing at NCCS-NCMR

- Screen the NCCS-NCMR fungi for the enzymes they produce.



NCCS-NCMR culture collection fungi



Enzymatic screening for potential microbe

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Fungi in Waste Treatment

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Treating Poultry Waste

The Problem

- Thousands of tons of feather wastes are discarded in the environment.
- They are not properly treated.
- The residue is almost pure keratin and not easily degradable.

Work at NCCS-NCMR

- Collected 750 soil samples from Maharashtra
- Isolated more than 350 keratinolytic fungi.
- Screening them for keratinase activity.
- These will be tested for treatment of poultry waste at lab scale.

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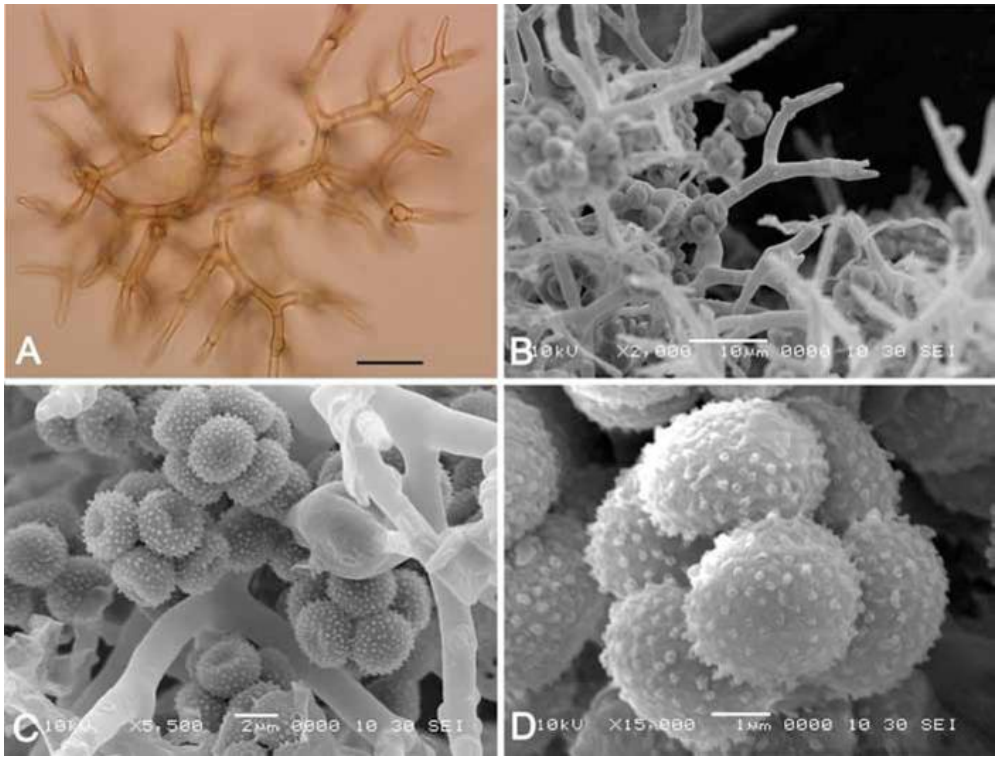
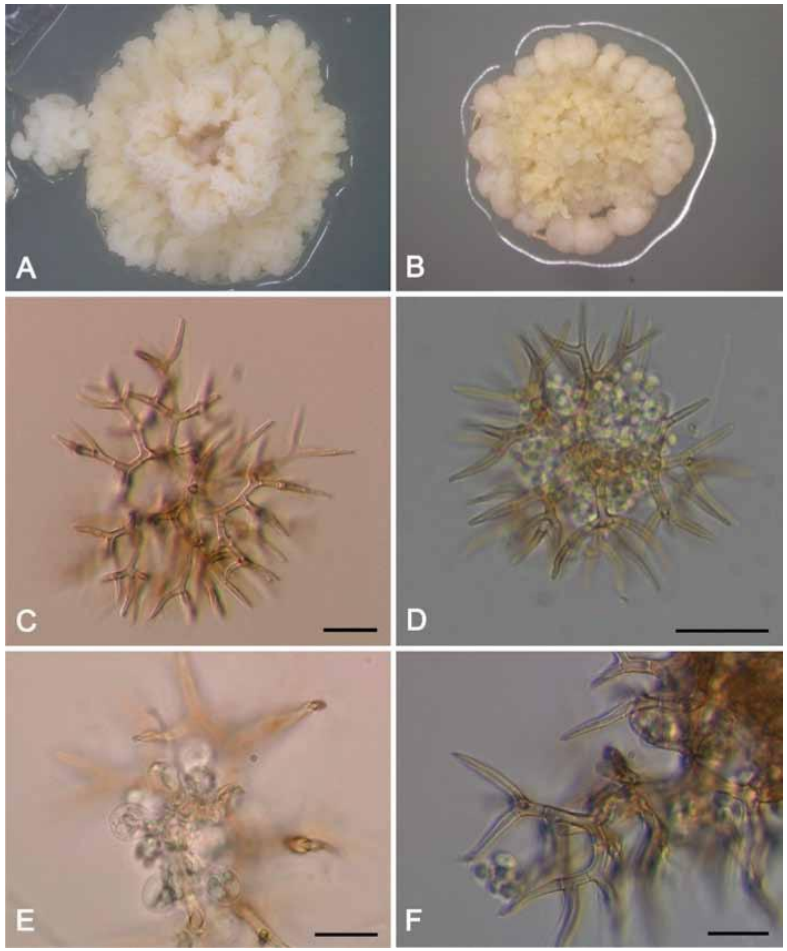
Keratinolytic Fungi





Gymnoascus verrucosus

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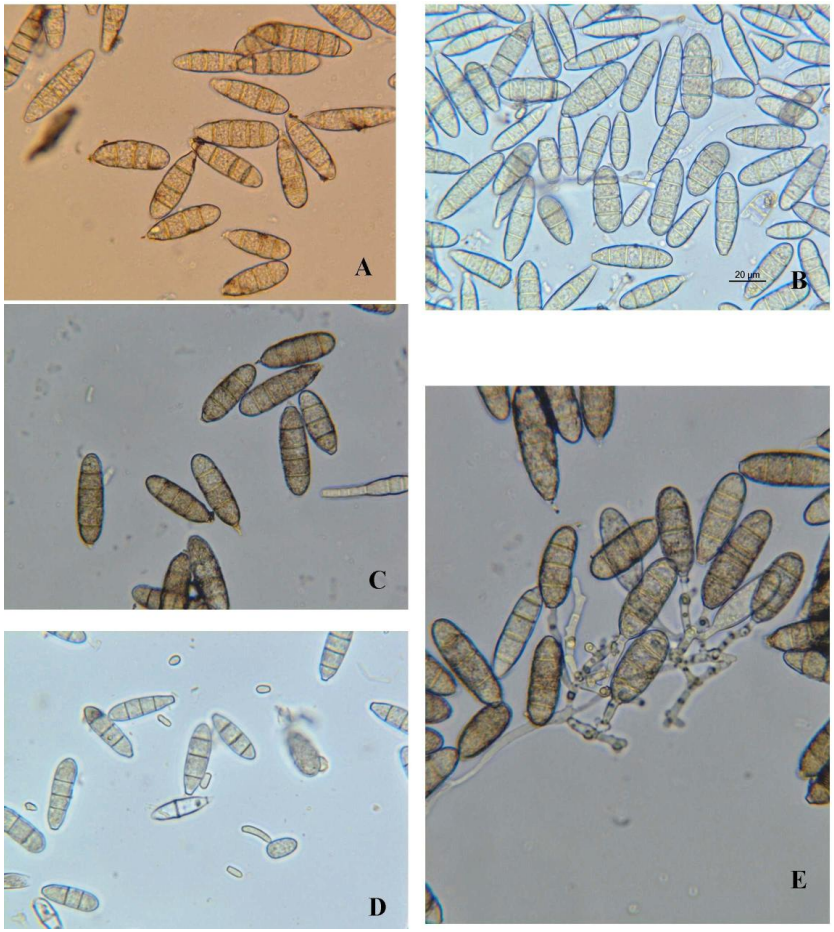
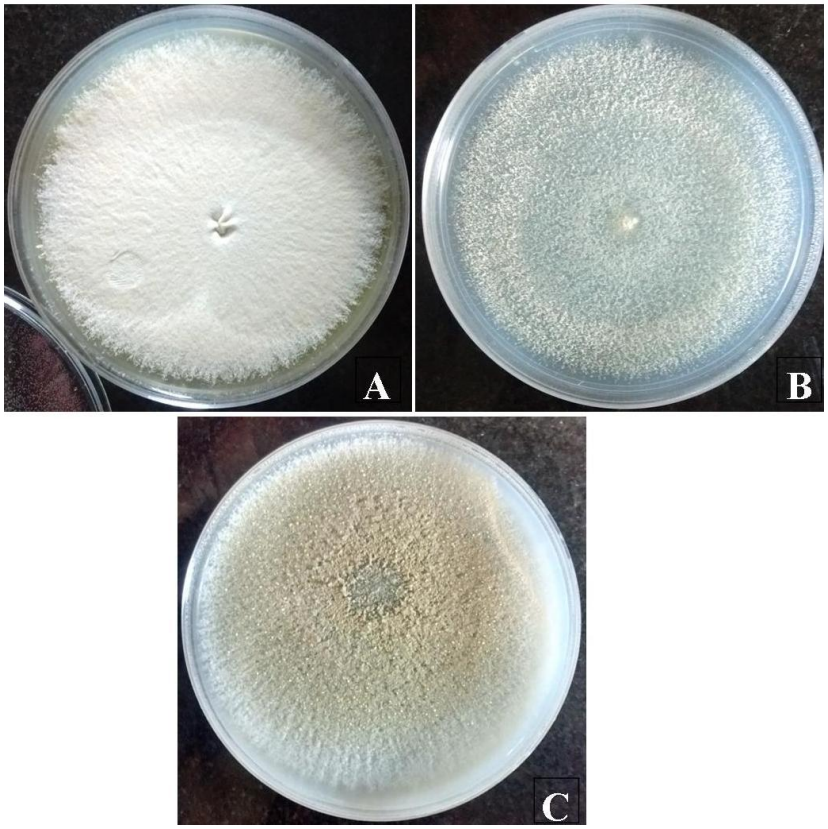
Keratinolytic Fungi





Nannizzia graeserae

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Treating Agricultural Waste

On-field composting using microbial cultures

Mushroom cultivation

Animal feed using enzymes

Image Source: Google image, TOI

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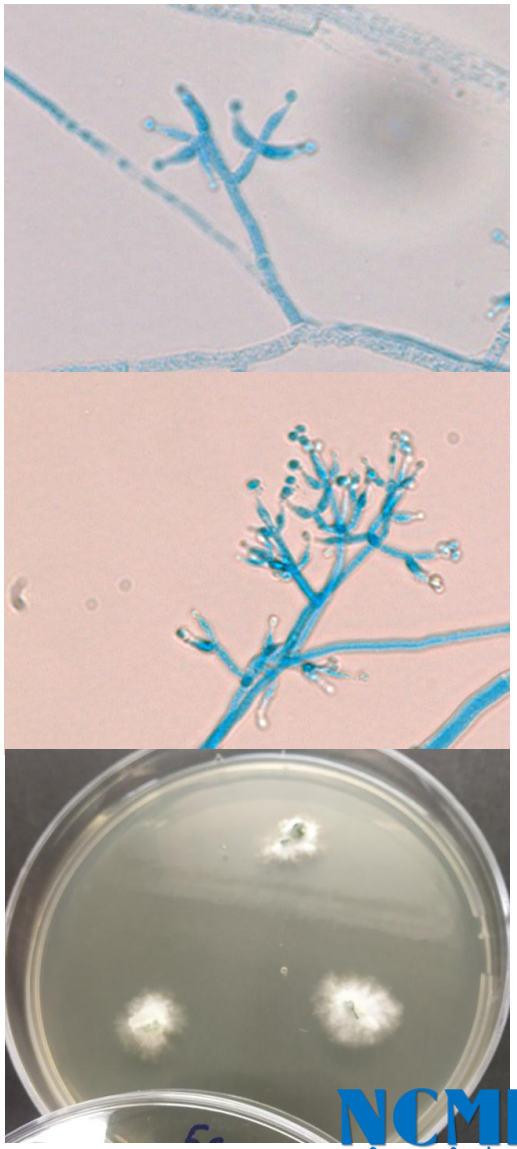
On Site Manure Preparation

- *Trichoderma* which is commercially available as Tricho-H, Mycoharz, TrikoLogic, Trianum-P, Trichocon, etc.
- On-site composting
  - is done by making heaps of the raw material for proper aeration.
  - Tillers are used to ensure proper mixing and aeration.
  - High temperature indicates ongoing composting process.
- At NCCS-NCMR, we are screening different *Tichoderma* strains for better composting properties (*T. harzianum, T. viride, T. koningii, T. polysporum*).
- We aim bring the product with desired culture in the market with better composting ability.



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Large scale on site composting using agriculture waste and microbial cultures at Karanja, Yavatmal, Maharashtra by Vision Ecologica Pvt. Ltd.

Images not taken by the presenter




On site composting using mollasses

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Animal Feed Preparation

- Animal feed is prepared by combining
  - agro-waste (wheat straw, bran).
  - by-products from fermentation industry (molasses, fruit pulps).
  - Grains such as corn.
  - enhances the nutritional value of the agro-waste.

- Fungal mycelia when grown on agricultural waste produce enzymes such as cellulase, xylanase, amylases, proteinases and pectinases.

- Apart from increasing the nutritional value, it also reduces the packaging and transportation cost of shipping the feed. It also helps in controlling agro-waste.

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Animal Feed

Agro By-product	**Animals**
Mango by-product, Corn liquor waste	Fish
Apple by-product, Tomato waste	Poultry
Brewery waste	Chicken, Cow, Hamster
Brewery waste, Wheat bran, Rye bran	Pigs
Citrus by-product	Ruminants
Olive by-product	Sheep and Goat
Soyhull	Cow
Low- quality crop residues	Ruminants
Medium-quality crop residues	Pigs, Ruminants
cassava peels, cereal-grain waste	Pigs, ducks, cattle
Rice bran, coconut cake, soybean meal, Poultry liquor	Poultry, pigs, ducks, cattle

Fungi in Waste Treatment

- Municipal Waste (Wet and Dry)
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Industrial Waste: Distillery Waste

- There are around 200 molasses based distillery in Maharashtra.
- They require fresh water in for production of industrial alcohol.
- For 1L of alcohol production, 4L fresh water is required.
- It releases effluent known as spent wash.
- The spent wash is unpleasant in odor, dark brown color and high COD/ BOD values.
- The dark brown color is due to the presence of melanoidin.

Working of Distilleries

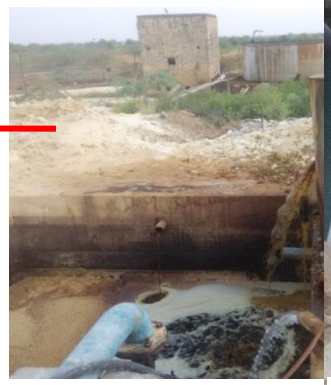
Distillery

Spent wash discharged from distillery

Actual site photograph of a distillery in Maharashtra

Dark brown colour spent wash

Dark brown colour spent wash stored in large container



Brown coloured spent is sent to Anaerobic Digester

Finally <u>Brown Colour Waste</u> is discharged to river after incubation in Lagoon for 90 d

Image Source: BioEra

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An effluent distillery site at Maharashtra

Pre-methanated spent wash Release Site

Post-methanated spent wash Release Site

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Results for Decolorization of Spent Wash

	Total No. of Cultures	Cultures Screened	Positive Cultures	Decolorization Activity
NCCS-NCMR Cultures	15139	4144	21	1*
			12	2*
			3	3*
In-situ Isolates	15	15	-	-
Wood Rotting Fungi	176	176	19	1*
			14	2*
			5	3*

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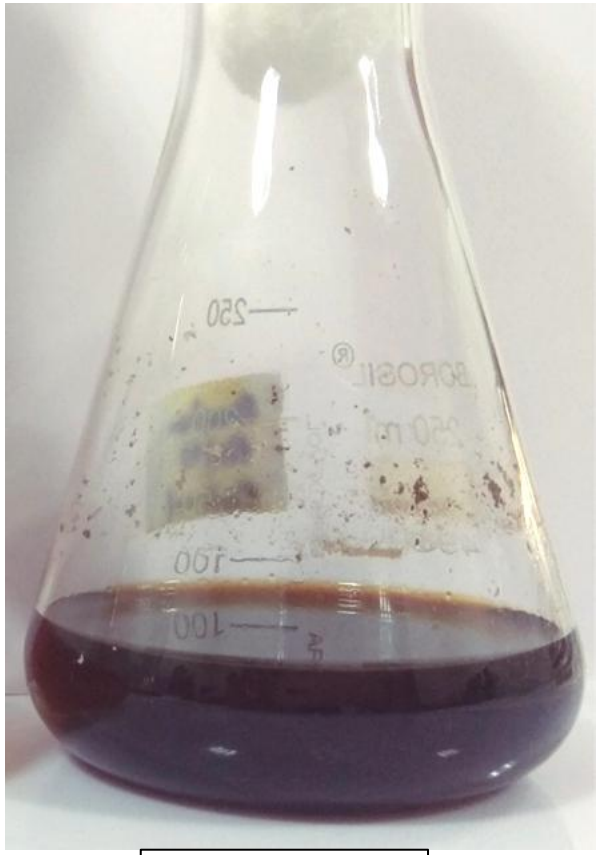
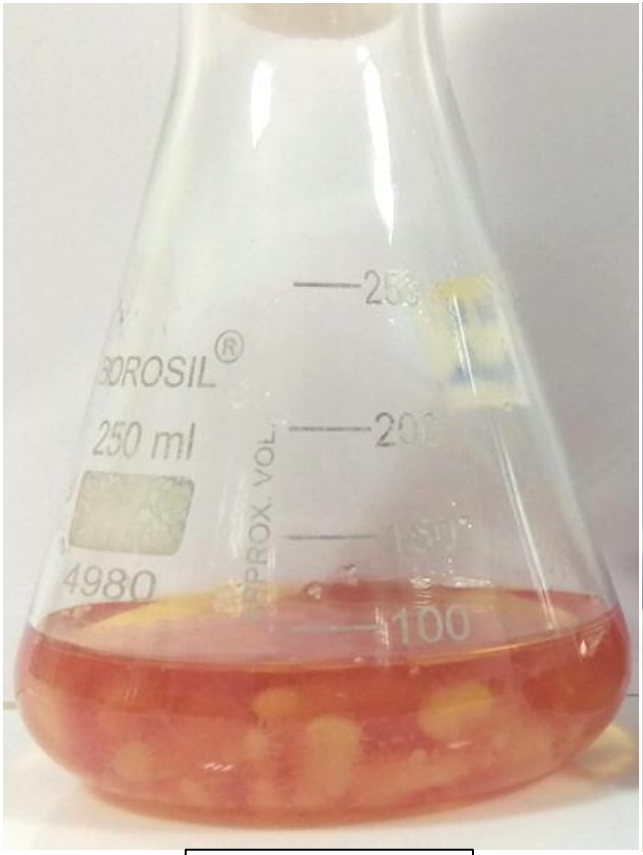
Decolorization Potential of Strain



0 Day



10 Day

15 Day*

*with 250ml medium

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Unusual Applications for Sustainability

- Use of fungi in road making.

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MycoRestoration of Abandoned Logging Roads

Overlaying wood chips with wheat straw, after inoculation with mycelia.

Source: Blog by Paul Stamets

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MycoRestoration of Abandoned Logging Roads

Fungi grow on the substrates and binds it. In this case *Pleurotus* species was used.

Source: Blog by Paul Stamets

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MycoRestoration of Abandoned Logging Roads

Myco-matting to the edge of roads creates a filtration interface, preventing erosion forces.

Source: Blog by Paul Stamets

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Conclusion

- Fungi play an important role in value addition of food and medicinal products.
- Fungi and especially fungal enzymes have lot of potential as biofertilizer, biopesticide and waste management.
- **Fungi and other microbes can help in sustainable development of the society and many startups in product development.**

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Acknowledgements

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• Sugar distilleries of Maharashtra

•Director, NCCS, Pune

Thank You!

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