Curriculum Vitae

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Educational Qualifications:

Ph. D. (Biological Sciences) 2010- 2016: AcSIR, CSIR- Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow, Uttar Pradesh, India

Master of Science (Biotechnology) 2007-2009: SRM University, Chennai, Tamil Nadu, India

Bachelor of Science (Biotechnology) 2004-2007: Jiwaji University, Gwalior, M.P., India

Research Experience:

Third Post Doc at Department of Post Harvest & Food Science, Agricultural Research Organization (ARO), Volcani Institute, Ministry of Agriculture, Israel (Sept. 2023-Jan.2024)

Finally, joined as post-doctoral fellow in Department of Post Harvest and Food Science, Agricultural Research Organization (ARO), Volcani Institute on the project ***" ABA as a regulator of sucrose metabolism during endodormancy of potato tuber".*** This project aims to focus our research on the molecular mechanism by which ABA interacts with sucrose metabolism, leading to endodormancy duration changes.

Second Post Doc at MIGAL Galilee Research Institute, Tel-Hai College, Kiryat Shmona-Israel (Nov. 2021 to Sept. 2023)

Joined as post-doctoral fellow in Plant Science Department at MIGAL, Israel on the BARD project ***"Elucidating the genes that are involved in the biosynthetic pathway of hydrolyzable tannin in pomegranate".*** In this project, several transcription factors were cloned and over-expressed in pomegranate via *Agrobacterium rhizogenes* mediated transformation systems.

First Post Doc at CSIR-CIMAP, Lucknow, India (June 2017 to Sept. 2021)

Worked as Research Associate for more than four years on the project entitled: ***"Metabolic engineering through hairy root cultures of A. belladonna– an endangered medicinal plant for therapeutically distinctive alkaloid production alternatives and targeted derivatization of phytomolecules for value-addition.***

Ph.D., Biological Sciences at CSIR-CIMAP, Lucknow, India (August 2012 to December 2016):
Title: Re-routing the metabolic flux of phenylpropanoid pathway through heterologous gene expression in hairy root cultures for production of curcuminoid.

Two innovative research ideas accomplished (***Journal of Biotechnology 2021; 328:23–33***):

- Development of alternate curcumin production source in *Atropa belladonna* hairy roots via heterologous expression of two curcuminoid synthase genes.
- Enhancing water solubility of curcumin by its glucosylation through heterologous co-expression of "glucosyltransferase" gene in *A. belladonna* HR clones.

Research Achievements:

Besides doctoral studies, I have also gained comprehensive experience with respect to several other appropriate *in vitro* techniques including cell / organ culture as well as other molecular mechanism studies pertaining to respective metabolic pathways of the concerned medicinal plants.

(a) Hairy roots as production alternative of therapeutically important metabolites:

In this context, my team effort first time demonstrated stevioside production from the HR cultures of *Stevia rebaudiana* by probing the underlying process of gene expressions **(*Plant Cell Tissue Organ Culture 2016; 126:511–521*)**. Then again, HR culture of *Boerhaavia diffusa* revealed production of two metabolites- Boeravinone B and Eupalitin followed by up-scaling in stirred tank bioreactor **(*Protoplasma 2016; 253:1145-1158*).** We have reported six pharmaceutically active Pentacyclic-triterpenes (PCTs), namely Corosolic, Arjunic, Ursolic, Oleanolic, Maslinic and Betulinic acids in the hairy root (HR) clones of four *Ocimum* species (***Industrial Crops and Products 2022; 177:114465***).

(b) Hairy roots as biocatalyst for biotransformation of exogenous natural molecules:

Another important contribution includes the effective utilization of the biocatalytic potentials of HR clones of diverse medicinal plants towards the effective biotransformation of exogenous natural substrates for its value addition. In this context, my team effort led to the bioconversion of artemisinin to two reduced products amongst which, 4-a-hydroxy-1-deoxyartemisinin revealed promising anti-plasmodial activity profile in tandem with notable TNF level lowering potential through i*n-silico* and *in-vitro* bioactivity analysis **(*Journal of Molecular Catalysis B: Enzymatic 2015; 113:95–103*; *Now Journal name changed as Molecular Catalysis*).**

We have also contributed very constructively in bringing out a review concerning the notable outcome of the HR mediated biotransformations during the last twenty years as a step towards green chemistry for value addition to a wide range of exogenous substrates through divergent chemical reactions **(*Biotechnology Advances, 2012; 30:461–468*)**.

(c) Calli / adventitious root cultures as alternate production source of Phyto-molecules:

Apart from my contributions in hairy root-based research, I have also contributed in the area of *in-vitro* production of secondary metabolites from calli cultures **[i]** anti-cancer pentacyclic triterpene-Betulinic acid from callus cultures of four different *Ocimum* species **(*Protoplasma 2015; 252:647–655*) [ii]** Combretastatin A4 from callus of *Combretum microphyllum* (***Plant Cell Tissue Organ Culture. 2020; 143:681–691***). *In vitro* production of two anticancer labdane diterpenoids (andrographolide and neo-andrographolide) from callus/adventitious root cultures of *Andrographis paniculata* **(*Protoplasma 2018; 255:1387–1400*).**

(d) Biotechnological intervention in monocot plant- *Curcuma amada* (Mango Ginger):

We had extensively studied an important monocot medicinal plant- *C. amada*, to elucidate its underlying medicinal properties as well as to establish its *in-vitro* multiplication/conservation protocol to raise disease-free propagules/raw-materials. In this venture, a labdane-type diterpenoid compound, i.e. labda-8(17), 12-diene-15, 16-dial, first time isolated, showing anti-tubercular activity against $H_{37}RV$ strain of *Mycobacterium tuberculosis* **(*European Journal of Medicinal Chemistry 2010; 45:4379–4382*).** Additionally, optimized a reverse phase HPLC-PDA-MS based process for the quantification of this anti-tubercular diterpenoid from different accessions of mango ginger collected from various geographical locations to ascertain the best bioresource **(*Food Chemistry 2012; 131:375–379*)**.

We had also showed competence in the area of microbiology by isolating and characterizing the predominant endophytic fungus from *C. amada* rhizomes showing the potential

to produce 2,3-pentanediol as major fungal metabolite having anti-aging effect in *Caenorhabditis elegans* (***Protoplasma 2014; 251:1089–1098***). Apart from this, optimized a rapid low-cost protocol for efficient *in vitro* multiplication and conservation of *C. amada* utilizing *Luffa* sponge (*Luffa egyptica*) as a novel storage matrix for maintaining contamination-free, genetically uniform germplasm through synthetic seed technology (***Industrial Crops and Products 201; 36:383–388***).

(e) Devising cost-effective techniques for Plant Tissue cultures:

Another area of my interest remained focused towards devising cost-effective techniques for ensuring affordability of *in vitro* culture practices towards their useful commercial exploitations. We had developed a low-cost strategy for long-term cultivation (>6 years) of *Rauvolfia serpentina* HR culture by replacing sucrose with Table sugar, resulted in >94 % reduction media cost with increase in the overall productivities of terpene indole alkaloids [reserpine, ajmalicine and yohimbine] ***(Biotechnology Letters 2014; 36:1523–1528***).

Research Skills:

- ***Plant Tissue Culture:*** Callus/ Adventitious roots/ Hairy root based secondary metabolites, Micropropagation, Synthetic seed technology, Somatic embryogenesis, Bioreactor-upscaling
- ***Molecular Biology:*** Gateway cloning, CRISPR-Cas9 mediated gene editing, qRT-PCR
- ***Phytochemistry:*** Metabolomics, HPLC, GC-MS
- ***Microbiology:*** Endophytes fungal metabolites

Scientific Contributions:

- ✓ **Life member:** Society of Biological Chemists (India)
- ✓ **Review editor:** Frontiers in Plant Sciences, Frontiers in Bioengineering and Biotechnology
- ✓ **Reviewer:** Industrial Crops and Products, Food Chemistry, Bio-protocol

Research Publications:

Research Articles:

1. **Singh S**, Yaritz U, Ramer N, Holland D, Amir R, Tian L (**2024**) Rapid production of abundant transgenic pomegranate (*Punica granatum*) hairy roots. Plant Cell Tissue Organ Culture 157:46.
2. Pandey P*, **Singh S***, Negi AS, Banerjee S (**2022**) Harnessing the versatility of diverse pentacyclic triterpenoid synthesis through hairy root cultures of various *Ocimum* species: An unprecedented account with molecular probing and up-scaling access. ***Industrial Crops and Products*** 177:114465. **(* Equal Authorship)**
3. **Singh S**, Pandey P, Akhtar MQ, Negi AS, Banerjee S (**2021**) A new synthetic biology approach for the production of curcumin and its glucoside in *Atropa belladonna* hairy roots. ***Journal of Biotechnology*** 328:23–33.
4. Pandey H, Pandey P, **Singh S**, Banerjee S (**2020**) Unveiling the future reservoir of anti-cancer molecule-Combretastatin A4 from callus and cell aggregate suspension culture of flame creeper (*Combretum microphyllum*): growth, exudation and elicitation studies. ***Plant Cell Tissue Organ Culture*** 143:681–691.
5. Pandey P, **Singh S**, Banerjee S (**2019**) *Ocimum basilicum* suspension culture as resource for bioactive triterpenoids: yield enrichment by elicitation and bioreactor cultivation. ***Plant Cell Tissue Organ Culture*** 137: 65–75.
6. **Singh S**, Pandey P, Ghosh S, Banerjee S (**2018**) Anticancer labdane diterpenoids from adventitious roots of *Andrographis paniculata*: augmentation of production prospect endowed with pathway gene expression. ***Protoplasma*** 255: 1387–1400.

7. Pandey H, Pandey P, Pandey SS, **Singh S**, Banerjee S **(2016**) Meeting the challenge of stevioside production in the hairy roots of *Stevia rebaudiana* by probing the underlying process. ***Plant Cell Tissue Organ Culture*** 126:511–521.
8. Gupta R, Pandey P, **Singh S**, Singh DK, Saxena A, Luqman S, Bawankule DU, Banerjee S (**2016**) Advances in *Boerhaavia diffusa* hairy root technology: a valuable pursuit for identifying strain sensitivity and up-scaling factors to refine metabolite yield and bioactivity potentials. ***Protoplasma*** 253: 1145-1158.
9. Pandey H, Pandey P, **Singh S**, Gupta R, Banerjee S (**2015**) Production of anti-cancer triterpene (betulinic acid) from callus cultures of different *Ocimum* species and its elicitation. ***Protoplasma*** 252:647–655.
10. Pandey P, **Singh S**, Tewari N, Srinivas KVNS, Shukla A, Gupta N, Vasudev PG, Khan F, Pal A, Bhakuni RS, Tandon S, Kumar JK, Banerjee S (**2015**) Hairy root mediated functional derivatization of artemisinin and their bioactivity analysis. ***Journal of Molecular Catalysis B: Enzymatic (Now as Molecular Catalysis)*** 113: 95–103.
11. Pandey P, Kaur R, **Singh S**, Chattopadhyay SK, Srivastava SK, Banerjee S (**2014)** Long-term stability in biomass and TIA production by *Rauvolfia serpentina* hairy root culture and cost approximation to endorse commercial realism. ***Biotechnology Letters*** 36:1523–1528.
12. Tiwari S*****, **Singh S***, Pandey P, Saikia S.K, Negi AS, Gupta SK, Pandey R, Banerjee S (**2014**) Isolation, structure determination, and antiaging effects of 2,3-pentanediol from endophytic fungus of *Curcuma amada* and docking studies. ***Protoplasma*** 251:1089–1098. **(* Equal Authorship)**
13. Banerjee S, **Singh S**, Pandey H, Pandey P, Rahman LU (**2012**) Conservation and Storage of *Curcuma amada* Roxb synseeds on Luffa sponge matrix and RAPD analysis of the converted plantlets. ***Industrial Crops and Products*** 36:383–388.
14. **Singh S**, Singh R, Banerjee S, Negi AS, Shankar K (**2012**) Determination of an anti-tubercular agent from different accessions of mango ginger (*Curcuma amada* Roxb.) by reverse phase HPLC-PDA- MS. ***Food Chemistry*** 131:375–379.
15. **Singh S,** Kumar JK, Saikia D, Shankar K, Thakur JP, Negi AS, Banerjee S (**2010**) A bioactive labdane diterpenoid from *Curcuma amada* and its semisynthetic analogues as antitubercular agents. ***European Journal of Medicinal Chemistry*** 45:4379–4382.

Review Article:

16. Kumar K, Debnath P, **Singh S*** Kumar N (**2023**). An overview of plant phenolics and their involvement in abiotic stress tolerance. **Stresses** 3:570–585. **(* Corresponding Author)**
17. Banerjee S, **Singh S,** Rahman LU (**2012**) Biotransformation using hairy root cultures – A review**.** ***Biotechnology Advances*** 30:461–468.

Book Chapter:

18. Banerjee S, **Singh S**, Pandey P (**2016**) "Hairy Root" Technology - an emerging arena for heterologous expression of biosynthetic pathway genes in medicinal plants". Sumita Jha (ed.), Transgenesis and Secondary Metabolism, Reference Series in Phytochemistry. Springer International Publishing Switzerland 2016, DOI 10.1007/978-3-319-27490-4_7-1. Page no. 1-28.