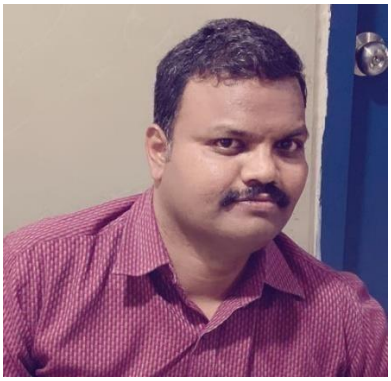

Er. G.D. Kiran Babu
Chief Scientist (Chemical Engineering)

Research interest/Area of R&D Activities:

Er. G.D. Kiran Babu's team has been working on development of innovative processes & equipment designs and improvements in the existing designs employed in the production of natural plant products such as aromas, nutraceuticals, phytochemicals, fruit pomace, on different scale of operations ranging from small capacities to commercial-size units. An innovative portable distillation apparatus employed in production of essential oil and hydrosols was designed and developed to meet the requirement of small/marginal farmers, entrepreneurs, aromatherapists etc. A mobile essential oil distillation unit was developed to facilitate the marginal farmers in the remote areas through extracting freshly harvested aromatic crops in their field, which minimises the oil losses apart from saving the daily transportation cost. Standardized the processes for producing quality-specific essential oils using the above machinery. Invented a tea processing machinery including polyphenol oxidase (PPO) inactivator used during green tea manufacture and a tea-shoot preconditioning device for withering during black tea manufacturing. Developed another innovative design for separation of seed from vegetable pulp employed in the food processing industry. Some of these designs were got patented in different countries. Consultancy/technology transfer on setting up of essential oil processing, tea catechin and steviol glycoside production facilities were undertaken for clients on turn-key basis including erection, commissioning, training of manpower, troubleshooting, quality analysis of the produce etc. Provided/evaluated detailed project reports (DPR) for the clients on essential oil production technologies. Published the knowledge base in national and international journals. Process development, upscaling and commercialization of technologies for production of steviol glycosides, *β*-aescin, natural colours and dyes, rutin, catechins, borneol etc. including plant machinery erection at client's site, start-up runs, technical back-up on quality of above products was provided. These process know-hows were also got patented in India and in abroad. Further, worked in the area of supercritical carbon dioxide extraction of medicinal and aromatic plants (MAPs) for producing high quality extracts. Developed state of the art pilot scale facilities for process upscaling and standardization of

production parameters for extraction of MAPs. Presently working on improved process development and upscaling of natural products extraction from Ashwagandha, Senna, Kalmegh, Aloe vera, etc. Actively involved in the promotion and extension of medicinal and aromatic crops in the Deccan Plateau for economical upliftment of the regional farmers. Counselling and advisory services to the industry involved in essential oils production and to the farmers cultivating the MAPs. Human resource development through mentoring, skill development and training programs.

SCI Publications:

1. **G.D. Kiran Babu**, Singh B, Joshi VP and Singh V. 2002. Essential oil composition of Damask rose (*Rosa damascena* Mill.) distilled under different pressures and temperature. *Flav. Fragr. J*. **17**(2): 136-140.

2. **G.D. Kiran Babu** and V.K. Kaul. 2005. Variation in essential oil composition of rose-scented geranium (*Pelargonium* sp.) distilled by different distillation techniques. *Flav. Fragr. J*. **20**(2): 222-231.

3. **G.D. Kiran Babu**, V. Shanmugam, S.D. Ravindranath and V.P. Joshi. 2007. Comparison of chemical composition and antifungal activity of *Curcuma longa* L. leaf oils produced by different water distillation techniques. *Flavour Fragr. J*. **22**(3): 191-196.

4. **G.D. Kiran Babu** and V.K. Kaul. 2007. Variations in quantitative and qualitative characteristics of wild marigold (*Tagetes minuta* L.) oils distilled under vacuum and at NTP. *Ind. Crop. Prod.,* **26**(3): 241-251.

5. Renu Rawat, Ashu Gulati, **G.D. Kiran Babu**, Ruchi Acharya, V.K. Kaul, Bikram Singh. 2007. Characterization of volatile components of Kangra orthodox black tea by gas chromatography-mass spectrometry. *Food Chem*. **105**(1): 229-235.

6. V.H.K. Verma, Bikram Singh and G.D. Kiran Babu. 2008. Essential Oil Composition of *Bothriochloa bladhi*. *J. Essent. Oil Res.* **20**: 55-56.

7. **G.D. Kiran Babu** and Bikram Singh. 2009. Simulation of *Eucalyptus cinerea* oil distillation: A study on optimization of 1,8 cineole production. *Biochem. Engg. J.* **44**(2-3): 226–231.

8. **G.D. Kiran Babu** and Bikram Singh. 2010. Characteristics variation of Lavender oil produced by different hydrodistillation techniques (Chapter 7). *In*: Comprehensive Bioactive Natural Products - Quality Control & Standardization Vol. 8, Eds. V.K. Gupta, S.C. Taneja, B.D. Gupta. Studium Press LLC, Houston, Texas, USA. pp. 122-136.

9. Rikki Saini, Shailja Guleria, Vijay K. Kaul, Brij Lal, **Garikapati D. Kiran Babu** and Bikram Singh. 2010. Comparison of the Volatile Constituents of *Elsholtzia*

fruiticosa Extracted by Hydrodistillation, Supercritical Fluid Extraction and Head Space Analysis. *Natural Product Communications*, **5** (4): 641-644.

10. T.S. Mann, **G.D. Kiran Babu,** S. Guleria and Bikram Singh. 2011. Production of *Eucalyptus cinerea* oil by hydrodistillation and supercritical carbon dioxide extraction techniques: A comparative study. *Natural Product Communications*, **6**(1): 107-110.

11. Robin Joshi, Poonam, Rikki Saini, Shailja Guleria, **Garikapati D. Kiran Babu**, Manisha Kumari and Ashu Gulati. 2011. Characterization of volatile components of tea flowers (*Camellia sinensis*) growing in Kangra by GC/MS. *Natural Products Communications*, **6**(8): 1155-1158.

12. Shailja Guleria, Vikas Jaitak, Rikki Saini, Vijay K. Kaul, Brij Lal, **G.D. Kiran Babu,** Bikram Singh and R.D. Singh. 2011. Comparative studies of volatile oil composition of *Rhododendron anthopogon* by hydrodistillation, supercritical carbon dioxide extraction and headspace analysis. *Natural Product Research,* **25**(13): 1271-1277.

13. Rikki Saini, Vikas Jaitak, Shailja Guleria, Vijay K. Kaul, **G.D. Kiran Babu**, Bikram Singh, Brij Lal and R.D. Singh. 2012. Comparison of headspace analysis of volatile constituents with GC–MS analysis of hydrodistilled and supercritical fluid extracted oil of *Capillipedium parviflorum*. *J. Essent. Oil Res*., **24**(3): 315-320.

14. T.S. Mann, **G.D. Kiran Babu**, S. Guleria and Bikram Singh. 2013. Variation in the volatile oil composition of *Eucalyptus citriodora* produced by hydrodistillation and supercritical fluid extraction techniques. *Nat. Prod. Res*.: Formerly Natural Product Letters, **27**(7): 675-679. DOI:10.1080/14786419.2012.682996.

15. Robin Joshi, **G.D. Kiran Babu**, Ashu Gulati. 2013. Effect of decaffeination conditions on quality parameters of Kangra orthodox black tea. *Food Research International*, **53:** 693-703. http://dx.doi.org/10.1016/j.foodres.2012.12.050.

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17. **Garikapati D. Kiran Babu**, Aarti Sharma and Bikram Singh. 2016. Volatile Composition of *Lavandula angustifolia* Produced by Different Extraction Techniques. *J. Essent. Oil Res.* **28**(6):489-500. http://dx.doi.org/10.1080/10412905.2016.1162210

18. **G.D. Kiran Babu**, Vipan Thakur and Bikram Singh. 2016. Variability in the composition of *Lavandula angustifolia* extracts due to extraction methods. *J. Herbs Spices & Med. Pl.* **22**(2): 173-182. http://dx.doi.org/10.1080/10496475.2015.1136979

19. **G.D. Kiran Babu,** Shudh Kirthi Dolma, Mohit Sharma, S.G. Eswara Reddy. 2018. Chemical composition of essential oil and oleoresins of *Zingiber officinale* and toxicity of extracts/essential oil against diamondback moth (*Plutella xylostella*). *Toxin Reviews,* https://doi.org/10.1080/15569543.2018.1491056

20. Kumar AN., Sneha A., Srinivas K.V.N.S., **Babu G.D.K.,** Kumar J.K., Kumar M.V., Jnanesha A.C., Vinutha K. 2023. Optimisation of harvesting time and drying techniques for higher sennosides in *Cassia angustifolia* Vahl. by RP-HPLC. *Industrial Crops & Products* **197**, 116591. https://doi.org/10.1016/j.indcrop.2023.116591.

Patents:

1. **G.D. Kiran Babu,** P.S. Ahuja, V.K. Kaul, V. Singh. Portable distillation apparatus for essential oils and hydrosols preparation.
Bulgaria Patent No.: 64393 B1/BG; dated: December 31, 2004.

2. **G.D. Kiran Babu,** P.S. Ahuja, V.K. Kaul, V. Singh. Simple portable mini distillation apparatus for the production of essential oils and hydrosols.
US Patent No. 6,911,119 B2/US; dated: June 28, 2005.
US Patent Appl. Pub.: US2005/0082157 A1; dated: April 21, 2005

3. **G.D. Kiran Babu,** S.D. Ravindranath. A field convenient jacketed leaf inactivator for green tea processing.
WO 2005/093352 A1 (*to CSIR*); dated: October 6, 2005.

4. **G.D. Kiran Babu,** S.D. Ravindranath. A field convenient jacketed leaf inactivator for green tea processing.
Kenya Patent No.: KE324; Dated: 30/06/2009.

5. S.D. Ravindranath, **G.D. Kiran Babu,** Arindam Kar, Pankaj Kumar Maji. A mobile tea shoot pre-conditioning device for withering during black tea manufacture.
Bangladesh Patent No.: 1004621; Dt: 11/06/2007.

6. **G.D. Kiran Babu,** P.S. Ahuja, V.K. Kaul, V. Singh. A simple, convenient mini distillation apparatus for the production of essential oils and hydroids.
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7. **G.D. Kiran Babu,** P.S. Ahuja, V.K. Kaul, V. Singh. Simple portable mini distillation apparatus for the production of essential oils and hydrosols.
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11. S.D. Ravindranath, **G.D. Kiran Babu,** Arindam Kar, Pankaj Kumar Maji. A mobile tea shoot pre-conditioning device for withering during black tea manufacture.
Sri Lanka Patent No.: 13816, dated: 31/07/2006.

12. J. Kotesh Kumar, **G.D. Kiran Babu**, V.K. Kaul and P.S. Ahuja. A process for the production of steviosides from *Stevia rebaudiana* Bertoni. (to Institute of Himalayan Bioresource Technology, Palampur).

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1-0011187-000; Dated: 25/04/2013

13. R.P. Sood, V. Singh, B. Singh, **G.D. Kiran Babu**, V.K. Kaul. A device useful for the distillation of essential oils and a process thereof.
Indian Patent No.: 230990; Dated: February 28, 2009.

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15. **G.D. Kiran Babu,** P.S. Ahuja, V.K. Kaul, V. Singh. Simple, portable mini distillation apparatus for the production of essential oils and hydrosols.

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China Patent No.: ZL20051010967.7X; Dt: 29/09/2010

17. **G.D. Kiran Babu,** S.D. Ravindranath. A field convenient jacketed leaf inactivator for green tea processing.
India Patent Number: 252566; dated: May 23, 2012.

18. S.D. Ravindranath, **G.D. Kiran Babu,** Arindam Kar, Pankaj Kumar Maji. A mobile tea shoot pre-conditioning device for withering during black tea manufacture.
Vietnam Patent No: 1-0011353-000; Dt: 02/05/2013

19. **G.D. Kiran Babu,** S.D. Ravindranath. A field convenient jacketed leaf inactivator for green tea processing.
Sri Lanka Patent Number: 14218; dated: November 7, 2013.

20. Agnihotri Vijai Kant; Singh, Bikram; **Babu, Garikapati Dyva Kiran**; Chand, Gopi; Singh, Rakesh Deosharan; Ahuja, Paramvir Singh. Process for the modification of *Curcuma aromatica* essential oil.
Europe Patent EP2690969 A1; Dated: 5th February, 2014.

21. Shashi Bhushan, Sakshi Gupta, **Garikapati Dyva Kiran Babu**, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace.
US Patent No. 9,011,952 B2, Dated: Apr. 21, 2015.

22. S.D. Ravindranath, **G.D. Kiran Babu,** Arindam Kar, Pankaj Kumar Maji. A mobile tea shoot pre-conditioning device for withering during black tea manufacture.
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Indonesia No.: ID000041827, Dated: 15th March 2016

25. Shashi Bhushan, Sakshi Gupta, **Garikapati Dyva Kiran Babu**, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace.
Russia Patent No. 2591465, Dated: July 20, 2016.

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Europe Patent No. 2775864, Dated: February 24, 2016.

27. Shashi Bhushan, Sakshi Gupta, **Garikapati Dyva Kiran Babu**, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace.
Italy Patent No. 2775864, February 24, 2016.

28. Shashi Bhushan, Sakshi Gupta, **Garikapati Dyva Kiran Babu**, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace.
Poland Patent No. 2775864, February 24, 2016.

29. **G.D. Kiran Babu,** S.D. Ravindranath. A field convenient jacketed leaf inactivator for green tea processing.
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Europe Patent EP2690969 B1; Dated: 3rd October, 2018.

31. Agnihotri Vijai Kant; Singh, Bikram; **Babu, Garikapati Dyva Kiran**; Chand, Gopi; Singh, Rakesh Deosharan; Ahuja, Paramvir Singh. Process for the modification of *Curcuma aromatica* essential oil.
France Patent No. 2690969; Dated: 3rd October, 2018.

32. Agnihotri Vijai Kant; Singh, Bikram; **Babu, Garikapati Dyva Kiran**; Chand, Gopi; Singh, Rakesh Deosharan; Ahuja, Paramvir Singh. Process for the modification of *Curcuma aromatica* essential oil.
Germany Patent No. 2690969; Dated: 3rd October, 2018.

33. Agnihotri Vijai Kant; Singh, Bikram; **Babu, Garikapati Dyva Kiran**; Chand, Gopi; Singh, Rakesh Deosharan; Ahuja, Paramvir Singh. Process for the modification of *Curcuma aromatica* essential oil.
Brazil Patent No. BR112013023705-8; Dated: 29th October, 2019.

34. Shashi Bhushan, Sakshi Gupta, **Garikapati Dyva Kiran Babu**, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace.
Indian Patent No. 381049, Dated: November 1, 2021.

Technologies/Designs Developed:

1. A novel design of small-scale essential oil distillation apparatus – HerboStill™ was developed and licensed to industry for its commercial manufacture and marketing.

HerboStill™ – A Mini Essential Oil Distillation Apparatus

2. Design of a tea leaf roaster for inactivation of polyphenyloxidase used during green tea manufacturing was developed.

A field convenient jacketed leaf inactivator for green tea processing

3. Developed a novel tea shoot preconditioning machine for withering during black tea manufacturing.

Tea withering machine used during black tea manufacturing

4. Developed a unique mini solvent extraction unit used in herbal plant extracts production

A small-scale solvent extraction unit

5. Developed a unique design of truck mounted mobile essential oil distillation unit used in the processing of aromatic plants in the farmers' field.

Mobile essential oil distillation unit

6. A commercial scale production technology for the extraction of steviol glycosides from *Stevia rebaudiana* was developed and transferred to Indian industries.

7. Extraction technology for the production of rutin (quercitin-3-rutinoside) from *Eucalyptus youmanii* and *E. microrryncha* was developed.

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