Scented rice (*Oryza sativa* L.) Cultivars of India: A Perspective on Quality and Diversity

Altafhusain Nadaf • Sarika Mathure
Narendra Jawali

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Altafhusain Nadaf
Department of Botany
Savitribai Phule Pune University
Pune, Maharashtra, India

Sarika Mathure
Department of Botany
Savitribai Phule Pune University
Pune, Maharashtra, India

Narendra Jawali
Molecular Biology Division
Bhabha Atomic Research Centre
Mumbai, Maharashtra, India

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Foreword

Scented rice is attractive to humans because of low odor threshold levels of volatile compounds including 2-acetyl-1-pyrroline. This trait has been selected by humans despite it apparently reducing the resistance of the rice plant to stress and being a genetically recessive trait because it is so attractive to rice consumers. This is a great example of human selection for an agricultural trait that would be deleterious for the plant in the wild growing under natural selection but can be highly successful under human selection in a domesticated crop. Scented rice is a traditional food of India. Scented rice is of great cultural and economic significance in India.

During the past decade, Dr. Altafhusain Nadaf and his team undertook a very demanding challenge to understand the aroma volatiles contributing in rice aroma for Indian scented rice genotypes, the outcome of which is produced in the form of this book. This book provides an important and comprehensive account of the majority of basmati and non-basmati cultivars of scented rice found in India, their quality parameters, the volatiles contributing in aroma and their method of detection, diversity analysis, and the molecular markers associated with quality traits. Knowledge of these cultivars is central to the continuation of the production and use of this important food crop. I am convinced that this book will serve people with a broad spectrum of interests and will stimulate future research in this economically important category of crop.

University of Queensland
St Lucia, QLD, 4072, Australia

Prof. Robert Henry

Preface

Ancient India is one of the oldest regions where cultivation of *Oryza sativa* L. began. Among the several cultivated rice varieties, scented rice constitutes a small but special group of rice, considered as of best quality. Indian subcontinent flourishes with hundreds of indigenous aromatic cultivars and landraces, and the diversity of scented rice of India is highest in the world. The foothill of the Himalayas is the center of diversity of scented rice (Group V); from here by westward route, scented rice cultivars are distributed in different states of India. Years of natural and human selection led to the development of several locally adapted scented rice genotypes. Basmati rice – the scented pearl – is nature's gift exclusive to the Indian subcontinent. In addition to basmati varieties, many indigenous non-basmati scented rice varieties are also locally cultivated. Majority of the indigenous scented rice cultivars are small and medium grained. Though the non-basmati types do not possess all the characteristics of basmati, these varieties excel equally as far as aroma and other characters are concerned. Hence, non-basmati varieties are traded popularly in market and fetch high premium in national as well as international market. Flavor volatiles or aroma and texture are the principle sensory qualities of rice and have been rated as the major criteria for preference. More than 100 volatiles contribute in the pleasant rice aroma. Among these, 2-acetyl-1-pyrroline (2AP) possesses low odor threshold value and hence is regarded as the principle aroma compound contributing to the aroma character of rice. In addition to aroma, cooking and eating qualities of rice are valuable properties, especially in Asia, where it is consumed as staple food.

This book is the original research work that provides deep insights on the diversity, grain morphology, physicochemical and cooking quality assessment, aroma volatile profiles, genetic diversity assessment, and marker validation for important quality parameters with special reference to the aromatic rice cultivars cultivated in the state of Maharashtra and part of Karnataka. Through personal collections and rice research station collections, we documented a total of 124 scented rice cultivars. For the first time our study listed seven landraces – Girga, Kothmirsal, Kala bhat, Chimansal, Jiri, Kalsal and Velchi from Maharashtra, and Kali kumud from Belgaum – indigenous to these regions. The grain morphological characteristics of 88 cultivars have been carried out, and the representative cultivars belonging to basmati (3) and non-basmati (57) groups were characterized for their physicochemical properties and cooking characteristics.

For qualitative and quantitative analysis of volatile compounds contributing in aroma, a highly sensitive head space-solid phase micro extraction (HS-SPME) coupled with gas chromatography flame ionization detector (GC-FID) technique was used, and a standard method was developed. Using this method, 35 marketed rice samples and 91 scented cultivars from the core collection were analyzed. Quantitative analysis of 23 major volatiles was done in both categories. In marketed samples, rice types (Basmati, Ambemohar, Kolam, Indrayani, and local) significantly contributed to the variation in 2AP, hexanal, nonanal, decanal, benzyl alcohol, vanillin, guaiacol, and indole. The method developed suffices the need of rapid and reliable method for quantification of 2AP and other aroma-related volatiles from aromatic rice cultivars. Among the 91 cultivars, 2AP, octanal, nonanal, decanal, benzyl alcohol, 2-phenylethanol, 2 amino acetophenone, indole, 1-hexanol, 1-octen-3-ol, and nonanoic acid exhibited significant variation in concentration. The study revealed that non-basmati scented landraces can endow better prospects in aromatic rice research owing to diversity in volatile composition and adaption of local conditions.

Genetic diversity assessment among the cultivars using Amplified Fragment Length Polymorphism (AFLP) revealed a high level of genetic diversity among the non-basmati groups. Validation of markers associated with selected grain quality traits in scented rice cultivars was done with respect to aroma, apparent amylose content, and grain length. The *badh2* marker for aroma allowed satisfactory discrimination of basmati from non-scented cultivars and identification of heterozygotes with the exception of 16 non-basmati scented cultivars. The SSR marker linked with *Wx* for apparent amylose content could segregate scented rice cultivars. RM-431 is linked with QTL for grain length, and no correlation was shown between allele size of RM-431 amplified and grain length.

We hope that this book will be useful to the rice scientists and breeders working on the improvement of aromatic cultivars. It will also be a guideline for qualitative and quantitative assessment of aroma volatiles involved in pleasant rice aroma.

Pune, Maharashtra, India — Altafhusain Nadaf
Sarika Mathure
Mumbai, Maharashtra, India — Narendra Jawali

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Authors

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About the Authors

Altafhusain Nadaf is working as an associate professor at the Department of Botany, Savitribai Phule Pune University, Pune, in the area of biochemistry and molecular genetics of scented rice for the past 13 years. He was awarded Erasmus Mundus Action 2 India4EU II scholarship to visit the University of Bologna, Italy, as a visiting professor for one month (2014) and DST-BOYSCAST fellowship to work as a visiting fellow at the Centre for Plant Conservation Genetics, Southern Cross University, Lismore, Australia, for one year in 2010–2011. He has received research grants by several funding agencies including DST Fast Track Scheme for Young Scientists and DBT Rapid Grant for Young Investigators (RGYI). He has successfully guided several Ph.D. and M.Phil. students and women scientists (under DST Women Scientists Scheme – A and B). He is working as a reviewer for many international journals. He has in his credit more than 45 research papers published in peer-reviewed national and international journals of repute. He has presented his research work at national and international level.

Sarika Mathure is working on characterization of Indian scented rice cultivars with respect to their quality traits, diversity, and molecular markers. She has obtained her doctoral degree in biotechnology from Savitribai Phule Pune University, Pune. She has published 6 research papers in international refereed journals. She is involved in quantitative analysis of rice volatiles. Her work was presented in several international and national conferences.

Narendra Jawali former head of the Molecular Biology Division, Bhabha Atomic Research Centre, Mumbai, India, obtained his doctorate degree in biochemistry from Mumbai University. He was member secretary of Basic Sciences Committee, Board of Research in Nuclear Sciences, a research funding agency of the Government of India. He carried out research in the area of biochemistry and molecular genetics of plants. His investigations on rRNA sequences have increased understanding of molecular phylogeny and evolution of species belonging to subgenera *Vigna* and *Ceratotropis* of the genus *Vigna*. His studies in wheat have led to a genetic linkage map, QTL map, and SCAR markers for a rust resistance gene. His collaborative studies have resulted in understanding the mechanism of salt tolerance in rice and revealed quality and genetic diversity among some non-basmati scented rice from south India. His studies have revealed the mechanism of electron transport and role of Cytb557 in nitrate reductase and the reaction mechanism and regulation of phosphoenolpyruvate carboxylase and malic enzyme from maize.