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RESEARCH ARTICLE

A REVIEW ON 'MEDINI' AN AROMATIC RICE VARIETY FROM KARNATAKA, INDIA

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ABSTRACT

Rice (*Oryza sativa* L.) is a dietary staple food crop and the grain being consumed by atleast 50 per cent of the world's population. In Karnataka, rice is a staple food, grown under a variety of soils and wide range of rainfall and temperature. Aromatic rice varieties have been most sought-after commodity among the farmers as well as the consumers across the world due to their greater economic returns and palatability, respectively. Many aromatic genotypes exist across the world, Basmati and Jasmine rice being the most popular among them in the international trade. Besides, there is a huge diversity of aromatic landraces meeting the taste and specific quality preferences of many consumers across the world which have gained attention in the international forum. Short grained aromatic rice of eastern India, popularly known as 'Medini' rice is one among the few other groups of non-Basmati aromatic rice prevailing in our state and their trade potential is yet to be realized. They are quite different from Basmati in terms of their physical and biochemical characteristics as well. These groups of genotypes are popular among the people in the area for making several indigenous dishes like Paysam, pulao, fried rice, khichdi, pitha, momos, thupka, many breakfast items and also used in different rituals in this region. However, the major factor affecting the aroma in rice is based on their genetic makeup. The review gives an insight into identifying and documenting the climatic and social aspects of traditional rice 'Medini' variety in village called Medini in Kumta taluk, Uttara Kannada district, Karnataka. Make a comparative study on aromatic rice (medini) and nonaromatic rice, further exploring the plant, microbial interaction, and its metagenomics.

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INTRODUCTION

The Karnataka state, a region inhabited predominantly by Kannada speaking people, is situated between 110 31' and 180 45' North latitude and 740 12' and 780 40' East longitude and lies in the west-central part of peninsular India. Its maximum spread from north to south is about 700 km and from east to west 400 km. It is bound on the north by Maharashtra state, on the northeast by Goa, on the east by Andhra Pradesh, on the south and southeast by Tamil Nadu, on the southwest by Kerala with a coastline bordering the Arabian Sea. The state with geographical area of around 1.91 lakh sq km is the eighth largest in the country. It has a variety of topographical situations ranging from the coastal plains to gentle slopes and culminating in the spectacular heights of the Western Ghats. Karnataka is blessed with abundant water wealth with as many as seven major rivers and a number of rivulets and streams. The important rivers beimg Sharavathi, Kali, Nethravathi, Varahi, Bedthi, Aghansani, Krishna, Ghataprabha, Malaprabha, Bhima, Tungabhadra and Cauvery. These rivers swell in monsoons and a majority of them take out into mere trickle after the monsoons.

Rice Knowledge Management Portal (RKMP) [Directorate of Rice Research, Rajendranagar, Hyderabad 500030. Email: naiprkmp@gmail.com, pdrice@drricar.org, -24591217]. In Karnataka rice is a staple food, grown under a variety of soils and wide range of rainfall and temperature. Only around 44 per cent of the total acreage is under irrigation while the rest is under the regime of monsoon. Rice is cultivated in places where the rainfalls are as heavy as 3000 mm and in others where it is just 600 mm. In some areas only one crop is grown and in certain other areas three crops are raised. The unique feature of rice culture in the state observed is either sowing or transplanting in all seasons of the year. The duration of the rice varieties cultivated in the state varies from 100 to 180 days depending on season and agro-climatic location. Major rice growing areas of the state can be broadly classified into two seasons, viz., kharif (June-July) and summer (January-February). In all the six rice growing ecosystems, Kharif sowing is common while during summer season the crop is cultivated mainly in the irrigated maidan areas of north and south. In the tank-fed areas, the crop is taken up late in the season (August-September) depending upon the monsoon showers.

In coastal area, one can see a specific situation where a second crop is sown in September-October and harvested in January-February and the third crop is cultivated between December-January and March-April. In each district, nearly 60-80 per cent of the total area is covered during Kharif (wet) season while the remaining area is occupied in late Kharif and summer (dry) season.The state has 1.3 million ha under rice cultivation, which is mainly irrigated area. The area has decreased from 1.45 to 1.30 million ha during last seven years. The state average productivity is 3.4 tonnes/ha. The major constraint in production is the zinc deficiency suggested interventions observed are growing of hybrids KRH 2, PA 6201, 6444 and Suruchi, system of Rice Intensification (SRI) to save water and seed cost or balanced use of major and minor nutrients.

Aromatic plants indicate plants have sweet smell or fragrant aroma (Lakshman, 2017). Factors that should enforce to a greater adoption of MAS in medicinal plants include:

- Establishment of facilities for marker genotyping and staff training within many medicinal plant breeding organizations in different corners of the world.
- •Currently available data on genes/QTLs controlling traits and the identification of tightly-linked markers in different plants.
- Development of useful strategies for using markers in breeding
- Establishment and creation of public databases for QTL/marker data especially for various medicinal plants
- Available resource for generating new markers from DNA sequence data from different medicinal plant genome sequencing and research in functional genomics. It is also important that future endeavours in marker assisted selection are based upon lessons that have been learnt from past successes and failures in using MAS. Further, optimization of marker genotyping methods in terms of cost-effectiveness and a higher level of integration between molecular and conventional breeding represent the main challenges for the greater adoption and impact of MAS on different medicinal plants in the near future (Allard, 1999; Kadner *et al*., 2002; Bhattacharjee and De, 2005; De, 2016).

Types of rice

Brown rice: Brown rice contains all parts of the grains: bran (full of fiber), germ and endosperm (which is rich in carbohydrates) its considered a whole grain. Research shows that whole grain foods can reduce cholesterol and lower the risk of stroke, heart disease and type 2 diabetes making brown rice a healthy option.

White rice:A milling process to remove the bran and germ from brown rice turns it white and strips it of the most nutritious parts. That's why white rice is classified as "refined grain" most companies artificially fortify their white rice with additional nutrients to replace the natural nutrients removed in the milling process.

Aroma evaluation: Aroma in leaves was determined accordingto the method described by Sood and Siddiqui (1978). When the plants were forming side- shoots (ie at the tillering stage). 2 gm of two or three leaves were excised from each F_1, F_2 or parent individual, cut the tissue into pieces and placed these in petridishes containing 10 mL of 17 % (w/v) potassium hydroxide (KOH). The petridishes were kept at room temperature (25^0C) for about 10 min and then opened one by one and the samples smelled and rated for the presence or absence of aroma. The tasting of individual rice grains has traditionally been the preferred method of aroma evaluation so we also assessed aroma by chewing 12 single grains, one at a time, from each F_2 plant and rating each plant assessed as homozygous aromatic if all 12 F_3 grains were aromatic or as non- aromatic if some of the grains were non- aromatic (Ahn *et al*., 1992).

Amylose content: Many of the cooking and eating characteristics of milled rice are influenced by the ratio of two kind of starch; amylose and amylopectin in the rice grain (SanjivaRao*et al*., 1952). Amylose is the linear fraction of starch in the non-glutinous varieties, whereas amylopectin, the branched fraction, makes up the remainder of the starch. Amylose content corelates negatively with taste panel scores for cohesiveness, tenderness, colour and gloss of the boiled rice. Amylose is almost absent from the waxy (glutinous) rice. Such rice do not expand in volume, are glossy, sticky and remain firm when cooked. These rice are the staple food of people in Northern and Northeastern Thailand and Laos.

Gamma – Aminobutyric Acid (GABA): GABA is a non protein amino acid produced primarily from the decarboxylation of glutamic acid by the enzyme glutamate decarboxylase which is highly active during germination of rice (Liu *et al*., 2005). It as a main inhibitory neurotransmitter in the mammalian cortex. During water absorption, glutamate decarboxylase (GAD) in brown rice is activated and converts glutamic acid into gamma-aminobutyric acid (GABA). According to Noriko Komatsuzaki *et al*., (2007), glutamic acid is a amino acid, a form of stored protein in brown rice which is changed into an amide. The GABA quantity can be enhanced by soaking brown rice in warm water at 20-40^0C (Shinmura *et al*., 2007). Some of the microbes viz, lactic acid bacteria, Bacillus licheniferous Bacillus subtilisgrup, Bacillus megaterium and *Bacillus pumilis*, present on the surface of brown rice also mediate the stimulation of GABA synthesis (Kim *et al*., 2013). The knowledge on the microbes and process involves in GABA synthesis is still in the dark (Oh and Choi, 2000). Scientist observed that BR germinated for 72 hours with soaking in chitosan solution at the concentration of 100 ppm recorded 7.6 times more GABA than that in native BR and 1.3 times more than in the control germinated in distilled water.

Cleaned brown rice is soaked in water for few days while the series of naturally occurring microbes will multiply and this population is dominated by LAB [lactic acid bacteria] in brown rice. The endogenous grain amyloses will produce the fermentable sugars and it serves as a source of energy for the lactic acid bacteria during the process of fermentation. The term LAB is a broad group of gram positive, catalase-negative, non-sporing rods and cocci, which utilize carbohydrates during fermentation and produce lactic acid as the major end product (Aguirre and Collins 1993). According to the pathways by which hexoses are metabolized they are divided into homofermentative and heterofermentative.

Aroma of rice: Buttery *et al*., (1982) isolated and identified 2-acetyl-1-pyrroline as an important compound contributing to the aromatic odour.

Lin *et al*., (1990), Ahmed *et al*., (1995) and Tanchotikul and Hsieh (1991) confirmed the reports of Buttery *et al*., (1983) and Paule Powers (1989) that 2-acetyl-1-pyrolline was the characteristic odour of aromatic rice varieties. It is a common practise in Asia to include Pandan (*Pandananusamarylli folius*) leaves in cooking non aromatic to give it an aroma. Buttery *et al* (1983) analysed Pandan leaves and found that the major volatile component was 2-acetyl-1-pyrroline. They found a high correlation between 2-acetyl-1-pyrroline in pandan leaves and aromatic rice. The concentration of 2-acetyl-1-pyrroline in pandan leaves was 10 times greater than aromatic rice and 100 times greater than non-aromatic rice. The concentration of 2AP was lower in aged aromatic rice. Kim, (1999) reported that hydrocarbon compounds were not significantly different between aromatic and non-aromatic rice, but aromatic rice had higher levels of alcohol (mainly, n-pentanol, 1-octen-3-ol, menthol and estragol), aldehydes and ketones (eg- n-pentanol, n-heptanal and n- nonanal), acids and other compounds. Aromatic rice had 15 times more 2-acetyl-1-pyrroline than non-aromatic rice. However, the aroma quality may be differed due to different planting, pre-harvest and postharvest handling and storage. For a more extensive elucidation of all effective and fundamental factors contributing to fragrance, it is essential to explore target quantitative trait loci (QTLs) and their inheritance and locations.

Methods of aroma test: The conventional methods of plant selection for aroma are not easy because of the large effects of environment and very low odor threshold (0.1µ/kg) in water. The 2-acetyl 1-pyrroline (2AP) is found in all parts of plants of aromatic rice varieties except far line in aromatic rice genotypes may explained by the presence of mutation resulting in a loss of function of the *fgr* gene product (Roy et al., 2018). The sensory tissues and grains after reacting them with solution of 1.7% (w/v) KoH are used for aroma test. However, this method is not reliable as the test can be personally biased due to saturation of nostril sense at different levels. The gas chromatography technique is a destructive, expensive and requires large amount of samples for aroma analysis in rice. Aroma is the most important quality parameter of all aromatic rice. The aromatic compound 2-acetyl-1-pyrolline (2AP) is generated in the entire aerial part and it can be detected even in the minute quality. The strength of aroma was scored in 0-3 scale where 0 denotes no aroma, 1 denotes slight aroma, 2 denotes moderate aroma and 3 denotes strong aroma. More than 100 volatile compounds have been identified in rice. A study has confirm the presence of 2-acetyl -1-pyroline (2AP) as the principal aroma compound in all the scented rice varieties. A recessive gene BADH2 encoding Betaine aldehyde dehydrogenase (BADH2) mapped on chromosome 8 of rice has been identified in genetic studies as the controlling gene for the level of 2-acetyl-1-pyrolline (2AP). The BADH2 also contributes to stress tolerance due to which the level of aroma contributing compound 2AP is higher in the plant exposed to stress (Bradburry *et al*., 2009).

Comparative studies on aromatic rice (Medini) and nonaromatic rice: Rice is among the most important staple crops consumed worldwide. There are 20 Oryza species, two of which are sativa, which originated in the humid tropics of Asia, and glaberrima, which originated from West Africa. Asian cultivated rice has evolved into three eco-geographic races (indica, japonica and javanica). Indica cultivars account for 80% of cultivated rice, and feed about three billion people, mainly in developing countries. Indica and japonica vary widely in grain shape, size, color and chemical composition. These cultivars have different quantities of amylose and amylo-pectin which affect cooking quality and possible uses (Chaudhary *et al*., 2001).Aromatic rice can be identified by its distinctive, nutty flavor, and a "popcorn-like" aroma. Jasmine, Della and Basmati are aromatic rice types that have increased consumer acceptance in recent years. Rice consumption is increasing in the United States, due in large part, to the growing ethnic populations, particularly the Mexican and Asian, that eat rice as a staple in their diets. There is little information of the factors that contribute to the acceptability of rice flavor. The basic chemical composition of the rice grain, which forms the basis for the eventual cooked flavor, is genetically controlled and can be modified via breeding. Rice can be divided into two main categories aromatic and non aromatic rice. Asia's aromatic rice includes Jasmine rice from Thailand and Basmati from India and Pakistan. Non-aromatic rice types are neutral in flavor and usually short grained. Examples of rice forms include organic, boutique, brown, pigmented, sticky, parboiled and milled rice. Some rice types are valued for their color, which is determined by levels of anthocyanin pigment in different layers of the pericarp, seed coat and outer grain layer (Tajima *et al*., 1992). The endosperm color of rice ranges from white and various shades of translucent to red, purple and black (Chaudhary *et al*., 2001). Glutinous rice, also called the sticky rice, has different consistencies, which are determined by two kinds of starch in the kernels, amylose and amylopectin. The more amylopectin gives rice stickier structure. Glutinous rice is easily distinguished from other type by its milky color. Combining glutinous and aromatic characters creates "boutique" rice, which include many traditional Lao cultivar and others grown and consumed in Thailand and Cambodia. These rice types are considered to have the greatest potential for export markets, and breeding programs have focused on boosting their yield. In China, scientists have developed waxy-aromatic type, *Shangnong xiangnuo*, from a local aromatic cultivar japonica. Surveys have shown that both developed and developing countries in Asia grow rice organically (Chaudhary *et al*., 2001).

Flavor perception is a response to compounds present in a particular food. It involves a complex series of reactions with the food and our nose, tongue and other parts of our mouth. The main ingredients that determine rice texture are rice starches, proteins and lipids which affect its 2 cooking and eating quality and the rice of good eating quality shows low amylose and low protein contents and large breakdowns that can be measured by amylo graphs. It was found that aroma and appearance were the most important acceptance factors for cooked rice, for Asian consumers living in the United States. Though the chemical composition of rice grains varies widely, depending on environment, soil and variety but the net protein utilization and digestible energy in rice are the highest amongst the common cereal grains (Zhou *et al*., 2002). The headspace of fragrant rice varieties has shown that 2 -acetyl -1-pyrroline is the main cause of distinctive fragrance in aromatic rice like Jasmine and Basmati. Basmati grains contain 0.09 parts per million of the chemical compound 2-acetyl-1-pyrroline, which is about 12 times more than concentrations found in unscented rice varieties and gives Basmati its distinctive spicy fragrance. The aroma combined with fine, slender grains and a soft, fluffy texture after cooking has made Basmati the world's most sought-after rice commanding prices up to 10 times more than common rice on international markets (Chaudhary *et al*., 2001). The desirability of fragrance has resulted in strong human preference and selection of aromatic rice. Non fragrant varieties of rice contain much smaller amounts of 2-acetyl-1-pyrroline (Widjaja *et al*., 1996). In China, non-milled black rice is used as natural colorant in cakes, dumplings, porridge, New Year cakes and black wine. It is also considered highly nutritious, rich in B vitamins and is believed to contain many trace elements like manganese and calcium.

Aromatic rice is not only famous for its taste and aroma but also the number of health benefits and nutritious values it comes with. It is also rich in fibre, which is also gluten-free and highly beneficial for people on any kind of diet. Basmati rice is not only rich in flavour or health benefits but also has a rich history in the Indian Royal Heritage. Basmati Rice has always been associated with luxury and royalty and why not? It is the king of rice after all! Basmati is translated as 'The fragrant one" which is the exact definition of this rich cuisine. Basmati Rice's aroma is one of a kind and cannot be matched with any plain grain of rice ever. Basmati Rice has many benefits that make it so special when compared to plain grain rice. This is because the rice consists of many attributes which people do not even know about. Basmati rice was consumed by royals and the rich since centuries because of its many health benefits.

- Basmati Rice is Diabetes and Allergy friendly
- It has a very low glycaemic index
- It contains a high level of fibre which is good for the digestive system
- Basmati Rice contains all 9 essential amino acids
- It is a good choice for people with a higher blood pressure as it controls the BP
- The aroma is what makes a difference
- The finest texture and delicate grains
- Does not break while cooking
- Compliments a number of cuisines
- An essential ingredient for heritage delicacies

This is the reason the price of Basmati Rice is way much higher than that of Plain Rice or any Ordinary Long Grain Rice. Aroma in scented rice is considered as one of the major important quality traits preferred. Aroma in scented and basmati rice is due to 2-acetyl-1-pyrroline. The aroma development in rice grain is influenced by both genetic and environmental factors. Rice (*Oryza sativa* L.) (21=24) is an autogamous, monocot crop belonging family poaceae and sub family oryzoidea. Aroma in rice is considered as one of the major important quality traits preferred. The popcorn like smell, soft texture and palatability of aromatic rice production in the market consumer now-a-days have become more conscious of the quality of the rice than they consume and after prefer fragrance rice due to their characteristics and pleasant odour. Hence, to meet the growing demand of aromatic rice, breeders have an interest in improving the qualities of aromatic rice varieties along with its yield. After green revolution various compounds have been reported to be responsible for rice aroma in which is the compound 2-acetyl-1-pyrroline has been found to be a major compound responsible for the pleasant aroma in scented rice (Buttery *et al*. 1983).

Genetics of rice aromatic aroma: The genetics of the aroma characteristic is somewhat complex. Berner and Hoff (1986) concluded that a single recessive gene controlled the aromatic nature of Della. Della is a variety of rice which is grown in US. This gene was located on chromosome 8 as determined by RFLP technology (Ahn *et al*., 1992). Several others (Ghose and Butany 1952; Sood and Siddiq 1978; Reddy and Reddy 1987) suggested the aroma characteristic was a single recessive gene. In contrast, Kadam and Patankar (1938) results suggested a single dominant gene. Dhulappanavar and Mensinkai (1969) interpreted their result to indicate two dominant aroma genes that interacted in a duplicate or complimentary manner. Reddy and Sathyanarayranaih (1980) concluded that there were three complementary recessive aroma genes. Dhullappanavar (1976) suggested there were four complementary recessive aroma genes. Pinson suggested that there were four complimentary recessive aroma genes. Pinson (1994) found that Jasmine 85, A-301, Della-x and P145917 each contained a single gene for aroma and that they were allelic. Amber and Dragon Eyeball 100 each contained two aroma genes, a novel gene plus one allelic to the gene in A-301, Della-Z, Jasmine 85 and P145917. Buttery et.al (1983) suggested that the difference between aromatic and non-aromatic rice was not the presence or absence of 2AP but a difference in the quantity of the chemical in the grain. Multiple alleles of a single aroma gene could produce slightly different alterations in the same enzyme that resulted in rice with different aromatic intensities.

The unique allele of the fgr gene in fragrant rice suggests one of several possibilities: fragrant rice may have been the outcome of a separate domestication event or may arisen and evolved independently in a wild relative or in a genetically or geographically isolated population. Basmati rice types have previously been described as being a genetically distinct cluster that has a poor combining ability with other rice genotypes crosses with non-fragrant varieties often lead to low seed production or sterility (Pinson 1994). Evidence for the gene that encodes BAD2 and fgr being the same gene comes from many lines of enquiry, including positional, genetic, biochemical and physiological. 1) the gene that encodes BAD2 is in the exact chromosomal location suggested by genetic mapping; 2) the loss of function is consistent with a recessive trait. 3) a gene for amino acid metabolism downstream of proline is suggested by metabolic evidence and betaine-aldehyde-dehydrogenase (BAD) is a credible biochemical candidate in this pathway and 4) elevated fragrance in response to stress has been reported (Yoshihashi *et al*., 2004) as would be predicted from this biochemistry. The complete association of the deletion in the gene that encodes BAD2 with fragrance in a wide range of unrelated germplasm is especially convincing evidence. Genetic complementation experiments and analysis of biochemical reactions catalyzed by BAD2 and BAD1 may provide further insights into the basis of fragrance rice.

Metagenomics: The word 'metagenomics of soil' was first coined by Handelsman *et al.* (1998) to explain the total genomes of soil microflora. In present era, the term 'metagenomics' is synonymous with the culture-independent application ofgenomics techniques to understand microbialcommunities present in their natural environments (Chenand Pachter 2005). This field arose in reaction to the fact that majority of microorganisms on Earth restrict their life to natural environment and all the organisms cannot be grown in broth or on plates inside the laboratory. It is surprising to know that as much as 99% or more of microbial communities remains unculturable, and hence cannot be studied and analysed in a way that microbial ecologists have become accustomed to over the past years. Metagenomics explores the fact that while some microorganisms are culturable and others are not, almost all of them are life-forms carrying DNA as genetic information. Therefore, metagenomic toolbox allows accessing, storing, and analyzing this DNA and thus providing an otherwise hard-to-attain insight into the biology and evolution of environmental microorganisms, independent of their cultural status. In today's metagenomics field, there are three major and often times overlapping directions that are recognized. The first is aimed towards linking phylogenetic analysis to its function. Once microbial ecologists got a satisfactory grip on this issue of predicting responsible organisms, they further tried to explore more about functions of predicted organisms (Amann, 2000). Among many complementary methodologies, metagenomics can help answer that question in an indirect, culture-independent manner. One example is through phylogenetic anchoring (Riesenfeld *et al*.,2004b), which involves the screening of large-insert environmental libraries for clones that carry phylogenetically informative genes and thereby analyzing their flanking DNA for genes that reveal possible environmental functions of the DNA's owner. A second trend in modern metagenomics involves its exploitation for the discovery of enzymes with novel,industrial and possibly exploitable properties. This aspect of metagenomics concluds that metagenomics "provides industry with an unprecedented chance to bring biomolecules into industrial application" (Lorenz and Eck, 2005). The third and most recent trend in metagenomicsis the mass sequencing of environmental samples.

The promise of this approach is to offer a more global or systems-biology view of the community under study. Indeed, in several instances has mass sequencing led to more complete assessments of genetic diversity and to first insights into the interactivities that occur in microbial communities (DeLong *et al*., 2006; Edwards*et al*., 2006; Gill *et al*., 2006). The present review therefore focuses on identifying and documenting the climatic and social aspects of traditional rice 'Medini' variety in village called Medini in Kumta taluk, Uttara Kannada district, Karnataka, understand the soil. Make a comparative study on aromatic rice (medini) and nonaromatic rice. Understand the plant and microbial interaction, its metagenomics and assess simple sequence repeats [SSR] from DNA of Medini rice with genes responsible for aromaticity. The methodology constitutes the Identification of important Rice cultivating Areas [IRCAs] based on the extent of rice cultivated the extent of traditional rice varieties cultivated the importance of traditional variety cultivated. Documentation of cultural and religious aspects of rice through interviews, questionnaire surveys, direct observation and literature surveys, Ecological assessment of important RCA's through comparison of biodiversity in traditional rice fields also research related to microbial biodiversity associated with the plant. DNA sequencing of aromatic genes and data analysis with respect to genome sequence available from database.

CONCLUSION

Rice has a decisive role in food, security and in improving the livelihood of people of this region. Most of the scented rice are inferior in agronomic performances and highly prone to environmental variations, yet it paves much attention for their first-rated aroma. Aroma in rice is unique and a superior grain quality trait, varieties are fetching a high export price in the International markets. This short grained aromatic medina rice prevailing in the North eastern part of karnataka, India, form a separate group of aromatic rice which is least exploited inspite of its significant potentiality and maximum consumption. The prevailing diversity remained unexplored and started to get replaced by the high yielding varieties in the region. It has the potential to cover area of favorable rain fed lowlands of coastal karnataka during kharif season. Popular with farmers of Karnataka, who have widely accepted this variety due to its improved yield, medium grain, high HRR, translucent kernel with strong aroma, excellent cooking and eating quality, and high economic returns due to its high sale value and easy marketability. With the continuous and marked improvement in the people's standard of living, the ethnic preference of rice is under conversion which increases the demand for superior fine quality rice.

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