

## Rice landraces of Tamil Nadu –a review

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India being a floristically diverse and genetically rich nation is endowed with huge rice germplasm collections. As per the vedic evidences, in olden days about 400 landraces of paddy had been in cultivation in Tamil Nadu which is an agrarian state of India. But due to the introduction of high yielding cultivars these landraces went out of cultivation leading to genetic erosion. However, a few hundreds of landraces are in cultivation in small pockets in Tamil Nadu. So it is our bound duty to conserve the available landraces, sort out the duplications and maintain the identity of the cultivars by the way of precise morphological, biochemical and molecular characterization for the valuable traits possessed by these landraces. According to ancient Tamil literature, some of these landraces are resistant to biotic and abiotic stresses while some others are known for their nutritional and therapeutic values in rice. Landraces of Tamil Nadu origin were extensively studied for their tolerance against abiotic stresses whereas the clinical validation of several of the landraces with nutritional and medicinal value is gaining importance in view of the growing interest of the consumers for a health conscious diet. In this context, traditional knowledge about the indigenous cultivars will help to explore the scientific basis of the nutraceutical values of the traditional cultivars by the plant breeders for sustaining food as well as the nutritional security and for overcoming the future challenges

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India is recognised as one of the mega diversity centres of the world as it contributes about 12% of the global biota. India with its genetic wealth of 1,50,170 species ranks 12<sup>th</sup> in the world in terms of total number of catalogued species<sup>1</sup>. Varied type of climatic conditions and ecosystems made India a floristically diverse and genetically rich nation. India shares 4 of the 34 global biodiversity hotspots spread across the world<sup>2</sup>. Tamil Nadu being a southernmost state of India stands first in the angiosperm diversity with majority of endemic species found along Western Ghats which is one among the four biodiversity hotspots present in India. India exhibits a wide genetic biodiversity for the principal food crop rice which plays a vital role in nations economy and is life for Indians particularly. In olden days, nearly 400 landraces of paddy had been in cultivation in Tamil Nadu. All these landraces are genetically diverse collections with wider adaptability and resistance against various biotic and abiotic stresses. Several

ancient Tamil literature mentioned about the rice landraces with remarkable nutritional status and significant therapeutic and medicinal values. But due to green revolution, many of these genotypes went out of cultivation leading to genetic erosion. In view of challenges caused due to climate change and consumer requirement for a healthy and nutritional diet it is essential to conserve the available landraces, characterize them for their specific traits for the effective utilization in the rice improvement programmes. In this regard, a detailed review about the genetic potentiality of landraces of Tamil Nadu origin is presented hereunder for harnessing the beneficial genes that the landraces possesses for many of the valuable traits.

### Floral diversity of India

India with only 2.2% of world's land area houses about 49,003 species of flowering and non-flowering plants which is more than 11% of the world's known flora and rank tenth in the world and fourth in Asia in terms of plant diversity<sup>3</sup>. Angiosperms comprise of

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ca. 18,532 species, which represent ca.10% of the world's known flowering plant species<sup>4</sup>. A great variety of climatic and altitudinal variations coupled with diverse ecosystems have contributed immensely to the floristic diversity with approximately 20,000 vascular plants and 4300 endemic species thus making India a floristically and genetically rich nation in the world. The Indian gene centre is one of the 12 mega diversity centres of the world and it has Eastern Himalayas, Western Ghats, Indo-Burma and Sunderland (Nicobar Islands) regions as four 'biodiversity hotspots' out of 34 spread around the world<sup>2</sup>.

#### **Tamil Nadu-Land of rich floral biodiversity**

Tamil Nadu, being the southernmost state of the India accounts for about 4% of the total area of the country. Tamil Nadu has 5745 taxa (2757 herbs, 1365 shrubs, 1115 trees and 508 climbers) and ranks first among the states in the country in angiosperm diversity. Among the 5745 taxa, fabaceae dominates with 547 taxa followed by poaceae, asteraceae, rubiaceae and orchidaceae. Out of 5745 taxa, 212 are reported to be strict endemics. About 86% of these endemic species are reported from Western Ghats and their adjoining regions, 8% from Eastern Ghats and 6% from plains and coastal regions<sup>5&6</sup>. So, Western Ghats is one among the four biodiversity hotspots present in India.

Even though India is the richest country for plant diversity in the world, 1052 species are in the threatened category of which 36% of plants are red listed<sup>7</sup>. In recent decades, India started recognising the importance of plant diversity and has taken steps to conserve and sustainably use its plant diversity.

#### **TNAU's initiative in plant genetic resources conservation**

Tamil Nadu Agricultural University (TNAU), a renowned institution of the country established a gene bank facility during the year 2010 so as to conserve genetic wealth of various crops to meet the future challenges. The gene bank functions in the name of the legendary rice breeder Dr. K. Ramiah. It has facilities for both medium- and long-term storage with a cold storage space of 5000 cubic feet. The *Ramiah* gene bank presently has a total of 27,000 accessions of more than 21 species including 4346 accessions of rice.

#### **Significance of rice as life in India & Tamil Nadu**

Rice besides being a staple food for southern parts of the country is intermingled with the culture and plays a vital role in rituals performed during religious

functions and festivals. In South Indian marriages, rice mixed with turmeric is showered over newly married couples by relatives and friends during the wedding ceremony as a symbol of prosperity, eternity, continuity and fertility. During marriages, several rice based rituals are customary and are carried out with more concern<sup>8</sup>. During baby shower function, a variety of rice dishes are prepared and offered to pregnant lady along with sets of bangles which is named as *Godh bharai* in North India, *Valaikaapu* in Tamil Nadu and *Seemandham*<sup>9</sup> in Kerala and after child birth, the first solid food given to baby after six months is prepared using rice. In Tamil Nadu, kids pursue their educational career by writing the beginning letter of Tamil over rice grains and it is done particularly during *Vijayadhasami* with a belief that the child will perform well in studies. It is a tradition in Tamil Nadu, wherein ladies used to put *Kolam*<sup>9</sup> (drawing in geometric pattern) using rice flour at the time of pooja which will serve as food for ants. Thus it is evident that, from birth to till death rice plays a prominent role in the life of the Indians.

#### **Biodiversity of traditional landraces of Rice**

##### *Indian scenario*

Based on vedic evidences, India was endowed with more than 2 lakh (200,000) rice varieties which is a huge rice biodiversity that no other nation in the earth could possess<sup>10</sup>. However, this rich rice biodiversity has been steadily declining in phases due to the scientific advancement created in the field of plant breeding and genetics leading to genetic erosion. Currently, as per the estimation by the NBPGR of the Government of India (GOI) there are about 75,000 to 100,000 landraces of paddy available in India. Deb<sup>10</sup> in his famous book titled "Seeds of Tradition, Seeds of Future" provided detailed morphological descriptions of 416 Indian traditional rice varieties, which are on the verge of extinction from farmers' fields.

##### *Tamil Nadu status*

Ancient Tamil literature and technical texts had extensively mentioned about rice and its cultivation methods. *Pallu pattu*, an ancient Tamil literary work related closely to the agrarian society had mentioned about 150 landraces of paddy.

More than one hundred different varieties of rice had prevailed in North Arcot district<sup>11</sup> and about 100 varieties were available in Ramanathapuram district of Tamil Nadu<sup>12</sup>. In olden days, nearly 400 landraces

of paddy had been in cultivation<sup>13</sup>. These rice landraces of Tamil Nadu origin displayed a wide diversity in their inherent morphological and agronomical traits. There had been rice varieties with grains varying in colour from golden yellow to purple and from short bold to extra long slender grain type. Currently, only 100-150 traditional landraces are in existence and being cultivated in small pockets by farmers of Tamil Nadu.

#### **Rice varieties and present day scientific findings documented in ancient Tamil literature**

The period from 500 BC to 100 AD is called as *Sangam* period in Tamil and this is considered as the golden period wherein agriculture flourished well in Tamil Nadu with many new agricultural innovations. Many Tamil literary works were created during this period and are called as classical *Sangam* literature. In these literary works, nine different types of rice were mentioned along with the land/soil type suitable for cultivation so as to get high yield. They are

- (i) *Sennel*: Suitable for cultivation under irrigated lowland condition. It has droopy panicles with red-coloured grains. As per the Tamil literature, *Agananuru* red-coloured grains are good for health
- (ii) *Vennel*: Well-developed grains will be pearl white in colour. It is cultivated using tank-fed irrigation. Tamil literature *Kurunthogai* (210:2-3) specified that this variety was grown in Thondhi the capital city of Chera kingdom
- (iii) *Salinel*: It was a high yielding variety in ancient times and it was irrigated using canal water. It was mostly cultivated in Cauvery delta region of Chola kingdom and a place Saliyur is named in memory of this variety
- (iv) *Mudanthanel*: Suitable for cultivation in plains, i.e., in wetlands. It has droopy panicles with long, elongated sturdy stems as mentioned in Tamil literature *Pathitruvalu*
- (v) *Iyvananel*: It is cultivated in hilly regions. It is otherwise called as hill paddy or white paddy. This variety is always sown along with foxtail millet according to Tamil literature *Purananuru*
- (vi) *Thoarainel*: It is one among the rice varieties grown under upland condition. It has short panicles. It is known from the Tamil literature *Malaipadukadam* that this variety grows well and produces grains using rain water received during monsoon period

(vii) *Kuzhanel*: It is suitable for cultivation under hilly regions. It is normally raised during monsoon rain period and grown using spring water

(viii) *Thoappinel*: It can be grown under garden land situation. The cooked rice of this variety will be red in colour and bigger in size as per the sayings of *Perumpanatrupadai* an ancient Tamil literature

(ix) *Moongilnel*: Rice grains is pure white in colour

In Tamil literature *Seevagasinthamani*, there was a detailed explanation regarding the processing of seeds for sowing. After harvest, the seeds chosen for sowing were covered using paddy straw and plastered with cow dung slurry and stored. At the time of sowing, the stored seeds would be soaked in water in the existing pond/ tank/well for half a day. Later, the soaked seeds were shade dried by covering the seeds using the paddy straw for seven days. After seven days the pregerminated seeds will be sown in the field. Thus, the present day technology of using pregerminated seeds for realizing good yield was followed in the ancient period itself by Tamilians as evidenced in this literature.

#### **Replacement of traditional rice varieties by modern rice varieties**

During 1966-67 only 25% of the total area was under high yielding varieties which increased to 57.8% during 1986-87 and 76.7% by 1996-97. In many areas, high yielding modern varieties were adopted by farmers and the cultivation of landraces / varieties was declined as much as 85% – 100%. So, from statistical reports, it is evident that the high yielding varieties introduced in 1960s coinciding with green revolution steadily replaced the indigenous landraces and made them out of cultivation leading to genetic erosion. Therefore existing landraces needs to be conserved so as to harness the unique traits harboured by these landraces.

#### **Meaningful way of naming rice landraces by ancient Tamilians**

The art of naming rice varieties was detailed in the Tamil literature *Pallupattu*<sup>13</sup>. Indigenous rice landraces were named based on their significance/ special attributes/ morphological features which is explained below by citing the names of the few Tamil landraces as examples.

##### **i. Names as indication of the colour of the grains**

*Sigappukuruvikar*, *Senthazhai* and *Sennel* - red-coloured grains and *Karunchoorai*- dirty black-coloured grains

ii. **Names as indication of the appearance of the plant /whole grains**

*Kudai vazhai*- earhead is like open umbrella, *Thuyamalli* –cooked sample of this variety looks like white jasmine flowers, *Pitchavari*- striped grains, *Ponmani*-grains look like golden beads, *Matta nel*-strong and stout grains, *Mottaikoor*- blunt tip, *Nedu mookan*-long-beaked grains and *Mookan nel*- beaked rice

iii. **Names as indication of the duration of the crop**

*Nootripathu*- 110 days duration and *Thonooran*-90 days duration

iv. **Names as indication of season of the crop**

*Karthigai Samba*- sown in the month of November-December, *Chithirai kar*- sown in the month of April-May, *Kuruvai*-sown in the month of May-June and *Sornavari*- cultivated during April 15<sup>th</sup> to August 15.

v. **Names as indication of smell/aroma**

*Punugu samba*, *Manakkathai*, *Kasthuri samba*, and *Karpooralalai*.

vi. **Names as indication of location/place/district**

*Arcot kitchilli* (district name), *Seethapakkam* (Place name), *Malaimundan* (hill rice) and *Vaikundha* (heaven).

vii. **Landraces in the name of God**

*Thillaikoothan*, *Thiruvarangan*, *Aadhivarangan*, *Patchai perumal*, *Uyyakondan* and *Maruthi*.

viii. **Landraces named in the memory of characters mentioned in epic Hindu literature**

*Ponnayakan*, *Senthinayagam*, *Seethabogam*, *Kallimadayan*, *Thillainayagan*, *Kalingarayan*, *Kuttralan*, *Alagiyamanavalan* and *Maduraivanan*.

ix. **Names as indication of specific traits**

*Muttakar*- cost of cultivation is less, *Norungan*-drought tolerant with fragile grains, *Varappukudainchan*- drought tolerant due to deep rootedness, *Psini*-(stingy person) named as it expands less after cooking, *Uvarkondan*- suitable for saline soil, *Manavari*- suited for dryland condition, *Poongar*- drought tolerant, *Kuliyadichan*-saline and drought tolerant, *Kalarpalai* and *Kalarsamba* - suitable for alkaline soil, *Arupatham Kuruvai*- flowers in sixty days, *Kaivara samba*- resistant to drought and water logging, *Puzhuthi peratti kar* – suitable for dryland condition and *Maduvu muzhungi* -suitable for cultivation in the vicinity of lakes.

x. **Names as indication of two traits - colour and appearance**

*Sivappusirumani*- grains look like red-coloured small beads, *Vellai sirumani*- grains look like white-

coloured small beads and *Muthu Vellai*- white pearl-shaped grains.

xi. **Names as indication of two traits – colour and season**

*Karungkuruvai*- black-coloured grains and suitable for sowing during May-June, *Thangasamba*-golden yellow-coloured grains and suitable for cultivation during September-January and *Vellai samba*- white-coloured grains and suitable for cultivation during September-January.

xii. **Names as indication of two traits – Appearance and season**

*Milagu samba*- grains resembling pepper and suitable for cultivation during September-January, *Kothamalli Samba*- grains resembling coriander and suitable for cultivation during September-January, *Seeraga Samba*- cumin-like seeds (Fig. 1) and suitable for cultivation during September-January (aromatic fine rice which fetches premium price in the market), *Ponkambi Samba*-panicles look like golden rods and are suitable for cultivation during September-January.

xiii. **Names as indication of two traits – Place/ famous person and season**

*Salem samba*, *Athur samba*, *Coimbatore samba*, *Rajapalayam samba*, *Rangoon samba*, *Tiruchengodu samba*, *Tituthuraipoondi Kar*, *Pudupatti samba*, *Sembilipuram samba* *Chitthan Samba*, *Ottan Samba* and *Gobikar*.

xiv. **Names as indication of colour of the grain and speciality dish prepared out of it**

*Vellai puttu*- white-coloured grains and suitable for making puttu, *Karuppu puttu*- black-coloured grains and suitable for making puttu.

xv. **Names as indication of multiple traits**

*Peruthandu vellai samba* –*Peruthandu* (sturdy stem) *vellai* (white colour) *samba* (season), *Velai chittiraikkar*- *Vellai* (white) + *chitirai* (name of sowing month in Tamil) + *kar* (season).



Fig. 1 — Grain view of Seeraga Samba

### TNAU's role in collection and conservation of traditional rice germplasm

In the colonial India in 1912, two Government Economic Botanists were posted to work on rice - one at Dhaka, presently in Bangladesh and another at Paddy Experiment Station, Coimbatore in Madras province. The Paddy Experiment Station presently designated as Department of Rice under the Centre for Plant Breeding and Genetics in Tamil Nadu Agricultural University, Coimbatore is more than 100 years old and possesses old germplasm collections and records pertaining to it. Important germplasm centres in India were listed by Rai<sup>14</sup> where he pointed out that Paddy Experiment Station had 2000 accessions of rice during 1911- 1914. These accessions differed widely in duration, grain quality, rice texture, flavour, fineness etc., and morphological characters such as stem colour, seed coat etc.

The prime task of this centre at the time of inception was to collect and conserve the native genetic diversity existing in rice. The old volumes of records indicated the efforts of germplasm collection undertaken with the help of revenue officials at that time. The preliminary collections mostly included traditional varieties known after their area of adoption and season. The germplasm collection grew as the years passed and presently a total of 4346 accessions are preserved in the *Ramiah* Gene Bank at Coimbatore. A total of 136 landraces of Tamil Nadu origin is maintained at Department of Rice (Fig. 2).

### Characterization of rice landraces of Tamil Nadu origin

#### *Resistance against plant hoppers and leaf hoppers*

Seventy four indigenous rice landraces were evaluated by Venkatesh *et al.*,<sup>15</sup> for their resistance against *N. lugens*, *S. furcifera* and *N. nigropictus* using standard seed box technique and reported that the entries *Panamara samba* and *Karthigai samba* showed resistant to both BPH and WBPH.

#### *High temperature stress tolerance*

*Thattan Samba* and *Panamara Samba* were reported as potential donors for the development of heat-tolerant varieties based on early morning flowering (EMF) trait exhibited by these genotypes<sup>16</sup>.

#### *Drought resistance*

Genetic studies on drought tolerance had shown that *Norungan* and *Nootripathu* were resistant to drought<sup>17-21</sup> and hence used as donors in drought resistant breeding programme<sup>22</sup>. Several QTLs for drought tolerance, plant phenology and yield under drought stress were mapped using *indica* rice genotypes *Norungan* and *Nootripathu* adapted to rainfed environment<sup>23-26</sup>. Screening of rice landraces for drought tolerance at seedling stage using hydroponics revealed that genotypes *Kuliyadichan*, *Chandikar*, *Mattaikar* and *Nootripattu* were resistant to drought by possessing better source-sink relationship<sup>27</sup> (Fig. 3).



Fig. 2 — A few of the landraces collections maintained at TNAU



Fig. 3 — Grain view of drought tolerant landraces

#### **Sodicity/Salinity tolerance**

Sodicity tolerance in 13 landraces were assessed by Geetha<sup>28</sup> using soil-based screening method and reported that *Norungan* and *Mattaikar* were suitable for cultivation under sodic soils. In the tsunami affected lands of Tamil Nadu, only the traditional rice cultivar *Kalarpalai* survived and produced some reasonable yields while modern cultivars failed to grow<sup>29</sup>. Indigenous rice landraces were evaluated for early-stage seedling salinity tolerance using simple sequence repeat markers and phenotypic screening wherein the genotypes, *Kuzhiadichan*, *Sornamugi* and *Poongar* possessed a high degree of salinity tolerance with genomic regions linked to *saltol* locus while in the other salt-tolerant genotypes, *Boomi* and *Garudan Samba*, the trait does not seem to be linked to *saltol* locus and therefore, can be used as a new source for mapping QTL for seedling-stage salinity tolerance<sup>30</sup>. In a study conducted to assess the performance of traditional cultivars under natural saline condition (pH: 7.7, EC: 3.6) it was observed that genotypes viz., *Rajamannar*, *Pal kudaivazhai*, *Kuzhiadichan* and *Rajamudi* performed well by registering high biomass production and growth analysis parameters<sup>31</sup>.

#### **Climate resilient landraces for changing climate**

Cauvery delta Zone of Tamil Nadu is highly prone to drought, flood, and pest and disease outbreak due to unpredictable climatic conditions. Hence a study was undertaken by Muralikrishnan *et al.*,<sup>32</sup> to document the rice traditional varieties suitable for biotic and abiotic stress management under changing climate in this zone. Based on systematic evaluation and matrix ranking it was deduced that out of 69 traditional rice varieties popular in Cauvery delta districts, 20 landraces viz., *Samba Moshanam*, *Norungan*, *Mappillai Samba*, *Arupathamkuruvai*, *Seeraga Samba*,

*Kudaivazhai*, *Thangasamba*, *Pichavari Karuppukavuni*, *Thuyamalli*, *Karungkuruvai*, *Kattuyanam*, *Vaigunda*, *Perungar*, *Vellaikkuruvai*, *Kalurundai*, *Aathurkichili*, *Kichedi Samba*, *Karudan Samba* and *Kaivara samba* can be exploited for mitigating the effects of climate change in this zone.

#### **Fragrance**

Whole genome sequencing of *Seeragasamba* a short-grain aromatic rice variety of Tamil Nadu resulted in the identification of a new *badh2* allele (*badh2-p*) with an 8 bp insertion in the promoter region of the *BADH2* gene responsible for fragrance in the aromatic rice varieties<sup>33</sup>.

#### **Medicinal and therapeutic value**

##### **Evidences from literature pertaining to Siddha and Ayurveda**

India being a floristically and genetically rich nation in the world has sound traditional knowledge on Ayurveda and *Siddha* medicines and it is endowed with literature which are more than three thousand years old written in two great Indian languages, Sanskrit and Tamil. Ancient Tamil literary works that describe the medical significance of the plant species are *Agathiyar Gunapadam* or *Gunavagadam* and *Pathartha Guna Chintamani* of *Yogis* and *Siddhas*<sup>34</sup>. These works were palm manuscripts (inscribed in palm leaves) written more than 350 years ago. In addition to these works, different classical treatise of *Agathiyar*, *Bogar*, *Theriyar* and *Sarabendrar* texts of the *Marathi* rulers of Thanjavur also explains in detail about the medicinal use of rice.

Indigenous landraces described in *Pathartha Kunapadam* along with its therapeutic value were compiled in the book “*Siddha Maruthuva Thogai Agharathy*” a publication of Tamil University, Thanjavur. The details of the varieties mentioned in the ancient Tamil literature are as follows.

- (i) *Karungkuruvai*: It is a highly desired landrace by the *Siddha* physicians who use it for the treatment of filariasis, skin diseases, urinary tract infection and poisonous bites. Filariasis caused by mosquitoes could be cured completely only by *Siddha* medicine by using *lehyam* made out of this traditional rice variety. The way of preparing *lehyam* using *Karungkuruvai* paddy is explained in detail in the ancient Tamil text *Pulippani Vagadam* 500 (Fig. 4).
- (ii) *Kalundai Samba*: Rice is round in shape. Consumption of this rice increases the stamina and physic by imparting muscle strength.



Fig. 4 — Grain view of landrace *Karung Kuruvai*

- (iii) *Korai Samba*: It resembles nut grass. It is used for the control of urinary tract diseases and controls pruritis
- (iv) *Seetha bogam*: Consumption of this rice provides colour to the skin and improves spermatogenesis. It takes care of indigestion.
- (v) *Chensamba*: It controls excessive hunger and cures skin diseases with pus and psoriasis.
- (vi) *Punugu Samba*: It has an aroma of civet cat. It controls thirst and hunger and wards off tiredness.
- (vii) *Manakathai*: Used for the treatment of skin-related problems, snake bite. Prolonged consumption of this rice controls ulcers. Rice has a pleasant odour.
- (viii) *Manisamba*: Anti diabetic rice. Food made using this rice can be digested easily, so it is good for elderly people and infants. Grains resemble beads.
- (ix) *Malligai Samba*: It is an aromatic rice. Rice/cooked food is pure white in colour and look like jasmine. It improves strength and reduces the dermatitis and irritation in eyes. It helps the skin to be free from wrinkling and prevents the internal organs from quick ageing.
- (x) *Maisamba*: Rice is dark black in colour. It cures fever, vomiting, ingested toxins and removes ageusia and anorexia
- (xi) *Vaalaanarici*: It gives colour to the skin and helps in gaining body weight. It suppresses anorexia- loss of taste.
- (xii) *Karuppu Kavuni*: It is also called as emperors rice/forbidden rice. It controls diabetes, hypertension, prevents cancer, reduces bad cholesterol, improves eyesight and it is a wonderful detoxifier for liver.
- (xiii) *Mappillai Samba*: In olden days, it is a tradition in many parts of Tamil Nadu that the bridegroom before marriage has to lift a heavy

rock just to prove his valiance. In order to gain energy for performing this, the bride groom is given with *kanji* prepared out of this variety. It helps in nourishing veins, muscles, nerves and blood.

- (xiv) *Poongar*: It is wonderful rice for women hormonal problems and boosts the immune system. It is recommended for pregnant women and lactating mothers. When consumed regularly the pregnant ladies will give birth to healthy baby.
- (xv) *Kattuyanam*: This variety grows very tall that even an elephant can hide inside the cultivated area. It reduces the cholesterol and the heart-related risks. It enhances the digestion. It is popularly called as the enemy of diabetes.
- (xvi) *Kullakar*: It reduces the body mass index and acts as a cardiogenic.
- (xvii) *Garudan Samba*: It cleans the intestine and improves blood circulation and blood purification. It is also used for the treatment of urinary tract infection and has got anti-inflammatory and hypocholesterolemic effects.
- (xviii) *Illupaipoo samba*: It is used for treating rheumatism and arthritis. It prevents paralysis.
- (xix) *Vaalaan Samba*: Good for women's health. It facilitates normal delivery by strengthening the pelvis bone.

#### *Scientific reports as supportive evidences for therapeutic value of traditional landraces of Tamil Nadu*

In recent years, due to the increased incidences of life style related diseases research work has been focused on unraveling the scientific basis of landraces reported to have therapeutic value in ancient Tamil literature and the results published are reviewed below.

The therapeutic potential of *Kavuni* (Fig. 5) grains was studied by Valarmathi *et al.*,<sup>35</sup> in comparison with popularly consumed rice varieties of Tamil Nadu and reported that phenolic acids and flavonoids were predominant in the *Kavuni* grains whereas sugars and fatty acids were predominant in the grains of a popularly consumed white rice varieties. *Kavuni* possessed significantly higher levels of different carotenoids ( $\beta$ -carotene-46.2  $\mu\text{g}/100\text{ g}$ ; lutein-221.6  $\mu\text{g}/100\text{ g}$ ), total phenolics (28.8  $\mu\text{g}/100\text{ g}$ ) and significantly higher level of inhibitory activity against  $\alpha$ -amylase and  $\alpha$ -glucosidase than CO 50 ( $\alpha$ -amylase IC<sub>50</sub>- 0.1, 1.0  $\mu\text{g}/\text{mL}$  and  $\alpha$ -glucosidase IC<sub>50</sub> 0.04, 0.05  $\mu\text{g}/\text{mL}$ ). Thus, *Kavuni* by exhibiting higher



Fig. 5 — Panicle and grain view of therapeutic landrace Kavuni

amount of antioxidants and by inhibiting the key enzymes like  $\alpha$ -amylase and  $\alpha$ -glucosidase has marked health benefits in preventing oxidative stress and diabetic complications. It is also reported to cure gastritis and peptic ulcers, as well as to enhance blood circulation by Mbanjo *et al.*,<sup>36</sup>. The remarkably higher content of lutein in *Kavuni* (50 times higher than that of popularly consumed white rice varieties)<sup>37</sup> plays a key role in maintaining proper vision<sup>38-42</sup>. So efforts are underway to tag the novel genetic locus linked with lutein accumulation in grains using *Kavuni*.

As per findings 3-Cyclohexene-1-methanol and  $\alpha$ ,  $\alpha$ , 4-trimethyl- present in red *Kavuni* were responsible for its anti-microbial activity<sup>9,43</sup>. Moreover the compound 3-hydroxy-4 methoxy benzoic acid present in *Red Kavuni* was used as a precursor for the synthesis of morphine. In addition to these compounds, fatty acid esters and fatty acids such as dodecanoic acid, ethyl ester (lauric acid ester) and octadecanoic acid present in this traditional cultivar increases low-density lipoprotein (LDL) cholesterol in the human body.

*Garudan Samba* an elite indigenous cultivar of Tamil Nadu was reported to have a phytochemical 9, 12-octadecadienoic acid (*Z, Z*) which has the potential to act as hypocholesterolemic, anti-arthritic, hepatoprotective, 5-alpha-reductase inhibitor, anti-histaminic, anti-coronary and anti-androgenic effects. In addition to these compounds, it also contains several other bioactive compounds like D-Mannopyranose responsible for preventing recurrent urinary tract infections; 4-Hydroxy-3-methylacetophenone for antimicrobial activity; caryophyllene for anti-inflammatory activity; ethyl  $\alpha$ -d-glucopyranoside for antituberculous activity<sup>42</sup>. *Garudan*



Fig. 6 — Grain view of *Elupaipoo Samba*

*Samba* also has higher fatty acids content which is known to be involved in antioxidant, anti-proliferative, and anti-inflammatory activities<sup>44,45</sup>.

The phytochemical analysis of traditional landrace *Mappillai samba* revealed the presence of phytosteroids, flavonoids, terpenoids, tannins, saponins, carbohydrates and cardioglycosides<sup>46</sup>. The GC-MS study showed the existence of more than 50% of the steroidal active compounds, *viz.*, stigmasterol,  $\beta$ - sitosterol and cyclolanostanol that helps in improving the male fertility.  $\beta$ -sitosterol present in *Mappillai samba* besides improving male fertility, has a hypocholesterolemic effect and also heals colon cancer whereas stigmasterol act as a precursor in the production of semi synthetic progesterone<sup>9</sup>. Reports on the presence of core molecule 1, 4-benzodiazepine-2 associated with neurological disorder in humans<sup>47,48</sup> and the therapeutically important metabolites phenylpropanoids, and polyamines in the grains of *Mappillai Samba*<sup>49</sup> makes it an ideal candidate for carrying out detailed research for the isolation of pharmaceutically important chemicals and development of novel pharmaceutically important chemicals for alternate and safe treatment of various ailments<sup>50</sup>.

Investigation on nutrient profiles, bioactive metabolites, antioxidant and anti-diabetic properties of traditional rice varieties such as *Puzhuthikar*, *Elupaipoo Samba* and *Valan Samba* had shown that *Puzhuthikar* possess three fatty acids: nonanoic acid, hydnocarpic acid and docosanoic acid which were responsible for its antibacterial, anti-inflammatory activities, antioxidant, hypocholesterolemic effect<sup>44</sup>. Anti-plasmodial activities, anti-cancer and chemo protective properties in *Elupaipoo Samba* (Fig. 6) might be due to two primary bioactive metabolites: Methoxy-nb-alpha-methylcorynantheol along with fatty acids and 4, 5-Nonadiene. On contrary, *Valan Samba* rice extracts contained rare terpenoids such as naphthalenone, longipinocarvone, phytol and

squalene. The phytol (a monounsaturated acyclic diterpene alcohol) was reported to be used a schistosomicide drug, for an endemic tropical disease.

Studies on comparative profiling of volatile compounds in popular South Indian traditional and modern rice varieties by gas chromatography–mass spectrometry analysis had illustrated that the pigmented landrace *Kaiviral samba* exhibited the highest linoleic acid (28.0%) and oleic acid (17.9%) content which were about 2 to 3 folds higher than that found in non-pigmented traditional as well as modern rice varieties<sup>51</sup>. Therefore, consumption of *Kaiviral samba* could prevent coronary heart disease as these fatty acids are reported to reduce the risk of occurrence of cardiovascular diseases<sup>52</sup>.

Squalene a triterpenoid compound is identified to be present in higher concentrations in the non-pigmented rice varieties *Kichilli samba* and *Seeraga samba*<sup>51</sup>, which plays a significant role in protecting the human skin surface from lipid peroxidation caused by exposure to UV and other ionizing radiation. The terpenoid compound squalene possesses antibacterial, anticancer, and immunostimulant properties<sup>53</sup>.

Thus only a few medicinal landraces mentioned in ancient Tamil literature have been analyzed for their therapeutic properties and many more landraces need to be studied and documented for combating the life style related diseases towards the welfare of the human kind.

#### **Nutritional profiling of Tamil Nadu landraces**

##### *Glycemic index*

The Centre for Indian Knowledge Systems (CIKS) in coordination with Ethiraj college for women, Chennai had analyzed the Glycemic Index (GI) of the traditional landraces of Tamil Nadu along with the popular rice variety Improved White Ponni (IWP) and reported that the GI of *Kullakar*, *Kavuni*, *Karungkuruvai* and *Kalanamak* were in the range of 50-55 whereas *Mappillai samba* and *Kudaivazhai* were in the range of 66-70 on a scale when the GI of Improved White Ponni was considered as 100 (Table 1). Whole genome sequencing of *Kavuni* and SNPs analysis using Nipponbare reference genome by<sup>54</sup> revealed that the granule-bound starch synthase I gene had T/G SNPs at the first intron/exon junction and a two-nucleotide combination, favouring high amylose content and low glycemic index in *Kavuni*.

##### **Nutritional value of traditional landraces of Tamil Nadu**

The scientists of CIKS studied the nutritive value of a set of selected 50 indigenous landraces of Tamil

Table 1 — Glycemic index of traditional landraces of Tamil Nadu

S.No.	Landrace	Mean GI (IWP as Control)
1.	<i>Karungkuruvai</i>	53.81
2.	<i>Mappillai Samba</i>	68.84
3.	<i>Kudhaivazhai</i>	66.34
4.	<i>Kalanamak</i>	50.71
5.	<i>Perungkar</i>	75.84
6.	<i>Kavuni</i>	52.36
7.	<i>Kullakar</i>	52.25
8.	<i>Neelam Samba</i>	84.37

(Source: Traditional rice varieties of Tamil Nadu; A source book)

Nadu by analyzing the total ash, total protein, and minerals like potassium, iron, calcium, magnesium, zinc and phosphorus content. The analysis was carried out in Laboratory Services Division of National Agro Foundation, Chennai which is a NABL accredited lab. The nutritional parameters estimated for various landraces were compared with the data of rice varieties published by the National Institute for Nutrition (NIN). Accordingly, out of 50 landraces evaluated, nutritional parameters were reported to be remarkably high in landraces viz., *Kaivara Samba*, *Kappakar*, *Karungkuruvai*, *Karuppukavuni*, *Kattuyanam*, *Koomvazhai*, *Kudhauvazhai*, *Kuliyadichan*, *Kullakar*, *Mappillai Samba*, *Neelam Samba*, *Poovan Samba*, *Sivappu Kavuni* and *Sivappu Kuruvikar* (Table 2)<sup>29</sup>. With respect to *Kavuni*,<sup>34</sup> also reported that it was nutritionally superior to the popularly consumed white rice varieties of Tamil Nadu due to its significantly lower level of total soluble sugars (29-35%), low fat content (8-35%) increased dietary fibre (21-52%) and protein (7-24%) and significantly higher amount of iron (20-30%), calcium (33-45%), copper (9.5-14.7%), sodium (21-38%), potassium (7-15%) and magnesium (8.9-26%). *Karungkuruvai* a highly treasured landrace as per Siddha medicine had a high content of total ash, calcium, zinc and phosphorus. The landrace *Kuliyadichan* recommended for lactating mothers had high protein, calcium and phosphorus. Likewise *Neelam*, *Samba* recommended for lactating mothers also had high calcium content. Traditional cultivar *Kullakar* known for its ability to reduce the body mass index possessed significantly higher mineral status. *Mappillai Samba* (Fig. 7) a well known traditional landrace of Tamil Nadu consumed for gaining energy and improving physic and stamina had high calcium, magnesium and phosphorus. Medicinal landrace *Kavuni* with antidiabetic property was also identified to be nutritionally significant.

Table 2 — Nutritive analysis of landraces of Tamil Nadu

S. No	Landrace	Status	Total Ash (g/100 g)	Total Protein (g/100 g)	Potassium (mg/100 g)	Iron (mg/100 g)	Calcium (mg/100 g)	Magnesium (mg/100 g)	Zinc (mg/100 g)	Phosphorus (mg/100 g)
1	<i>Kaivara samba</i>	Boiled	1.30	9.54	327.9	5.8	41.5	79.5	1.6	234.4
2	<i>Kappakar</i>	Boiled	1.48	8.60	244.8	7.9	30.1	124.4	1.9	323.4
3	<i>Karunkuruvai</i>	Boiled	1.54	8.22	249.7	7.6	37.7	94.7	2.8	344.5
4	<i>Karuppu kauni</i>	Boiled	2.80	8.94	254.6	6.5	36.9	112.8	1.6	313.6
5	<i>Kattuyanam</i>	Boiled	0.72	8.51	335.0	7.3	40.1	154.5	2.2	437.4
6	<i>Koomvazhai</i>	Boiled	1.52	8.86	250.1	2.7	42.5	114.4	2.1	302.1
7	<i>Kudaivazhai</i>	Boiled	1.53	8.28	279.0	7.1	35.2	108.2	2.4	308.6
8	<i>Kuliyadichan</i>	Boiled	1.06	9.73	233.5	6.8	34.5	102.9	1.9	285.1
9	<i>Kullakkar</i>	Boiled	1.93	8.64	291.6	7.5	50.4	121.7	2.5	347.7
10	<i>Mappillai Samba</i>	Boiled	1.75	7.91	299.9	6.9	43.6	117.9	1.9	334.0
11	<i>Neelan Samba</i>	Hand pound	1.49	7.29	237.7	3.6	38.7	114.3	1.7	286.7
12	<i>Poovan Samba</i>	Boiled	1.56	7.58	305.6	5.6	36.7	132.4	2.5	344.5
13	<i>Sivappu Kowni</i>	Boiled	1.49	7.07	228.9	8.0	31.2	115.4	1.8	297.3
14	<i>Sivappu Kuruvikaar</i>	Boiled	1.46	7.87	257.4	40.8	31.4	130.6	2.2	325.8

(Source: Traditional rice varieties of Tamil Nadu; A source book, 2019)



Fig. 7 — *Mappillai Samba* a nutritional landrace of Tamil Nadu

#### Utilization of traditional rice landraces

Earlier attempts of rice breeding were mostly concentrated on improving the local rice through selection in Tamil Nadu as done elsewhere in India. These pureline selections (PLS) from locally collected germplasm resulted in the release of 67 new varieties with yield 10% higher than their original population and also adapted to the places where the original populations have been cultivated. For instance, TNR 2 (*Kattuyanam*) and TNR 1 (*Thiruthuraipoondikar*), were established as genotypes with tolerance to deep water conditions. GEB 24 (Kitchili Samba), ADT 16 (Konakuruvai) and CO 32 (*Thiruchengodu Samba*) were known for their excellent cooking quality. The CO 4 (*Anaikomban*) resistant to blast had been utilized in many resistant breeding programmes. ASD

7 (*Anaikomban*) and ASD 9 (*Avasara Samba*) were reported to be resistant against BPH with *Bph 2* gene while CO 22 was resistant against BPH with *Bph 1* gene<sup>55</sup>.

GEB 24 and TKM 6 rice varieties released by TNAU need special mention, which were identified as good donors for grain quality and multiple resistance respectively. Utilizing these two varieties many high yielding varieties were developed in India, IRRI, Philippines, Sri Lanka, and Thailand. TKM 6, the multiple resistant rice variety developed by crossing GEB 24 / CO 18 (PLS from *Vellaikar*) was used in many hybridization programme and many improved varieties have been developed subsequently.

#### Future Prospects

Even though Tamil Nadu is a cradle for wide genetic pool of traditional landraces enriched with valuable traits, only few hundreds of them have been retrieved back from genetic erosion due to consistent efforts on collection and scientific advancements adopted in conservation methods. However, these efforts need to be continued and strengthened so as to protect various landraces which are on the verge of extinction from farmers' fields. Several duplications are present in the germplasm collections as same landraces exist in different names in different parts of Tamil Nadu. On contrary, different landraces are also mentioned in same name in different places. Therefore, duplications have to be sorted out in the traditional cultivars by means of precise molecular characterization of germplasm entries so as to

maintain the identity of the landraces. With respect to biotic stresses, due to the evolution of new pathotypes and biotypes landraces will serve as a good repository for the identification of new resistant donors. The landraces of Tamil Nadu were extensively studied for their resistance against biotic and abiotic stresses however; the research work on characterization of landraces for nutritional and medicinal properties is gaining importance due to the sharp increase in lifestyle-related health issues and diseases – such as diabetes, cancer and heart problems. The landraces reported with nutritional and medicinal significance in ancient literature need to be clinically validated as the bioactive phytochemicals and micronutrient components from these traditional rice varieties when consumed as dietary supplements are expected to play a major role in attenuating the incidence of noncommunicable disease and for achieving nutritional security.

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### Conflict of Interest

Authors declare no competing or conflict of interest.

### Authors' Contributions

The review article conceptualized by SG was written by KA and MM under the supervision of SG and combined editing by SG and KG

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