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KERALA KARSHAKAN

English journal

The First English farm journal from the house of Kerala Karshakan

Cut Foliage

Unleashing the Beauty of Nature in Indoor

INSIDE KERALA KARSHAKAN

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Mail: editorejournalkkfib@gmail.com Log on to http://www.fibkerala.gov.in
Phone: 0471-2314358

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Chief Editor
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Editor
Haripriya Devi V V

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Al Unaise A J

Design & Layout
Rajesh V

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Anthurium

Cut Foliage

UNLEASHING THE BEAUTY OF NATURE IN INDOOR

K.R.Vijayalatha
V.Jegadeeswari
G.Sidhdharth
J.Suresh
Horticultural College and Research Institute for Women, Tiruchirappalli

The floriculture industry which includes the production and distribution of cut flowers, cut foliage, potted plants, garden-bedding plants, planting supplies, services and other related products has grown to

Monstera

be a significant global industry that is changing and expanding quickly. The continuous demand in the sector has resulted in development of new production centres in Asia, Africa and Latin America which were traditionally located in Japan, USA, Italy, Colombia and Netherlands. In Asia, India, China and Thailand are moving in the direction of more intensive horticulture. India has a long history of cultivating flowers and has linked floriculture to culture and heritage from ancient times.

Scope for Ornamentals

The ornamental crop sector is thought to be worth roughly $60 billion in US dollars. The global market has been expanding annually at a rate of about 12%. Ornamental crops industry include plant nurseries, production of tissue-cultured plants, landscaping, cut foliage, dried flowers and trade of loose flowers, cut flowers, potted flowering, foliage plants. This also include production and sale of seeds, bulbs, corms, rhizomes, tubers, tuberous roots of ornamental plants.

Cut foliage

Cut foliage includes leaves or portions of leaves, stems,

Thuja

branches and other plant components with or without ornamental fruits. These can be used as dried or fresh decorations either by themselves or in combination with other flowers in bouquets. In some markets especially in the USA cut greens are also termed as the chopped foliage. Some of the popular cut foliage were Thuja, Eucalyptus, Acalypha, Cordyline, Aralia, Duranta, Asparagus, Monstera, Scindapsus, Philodendron, Coleus, Cosmus, Emu grass, Fountain grass, Bear grass, Pampas grass, Golden rod, Anthurium, Areca, Christmas palm, Chinese fan palm, Leather leaf fern, Sharon fern

Cut foliage - Uses

Cut foliage is greenery that is used in big amounts either alone or in combination with flowers to create beautiful arrangements. Though species with berries are currently becoming popular, evergreen plants with green, silver or variegated foliage are typically chosen. Various floral arrangements incorporate cut greenery as a background, lining and filler material. Additionally they serve to define and infuse life into bouquets, wreaths and garlands. They are useful for interior design, adding vibrant colors to a house, workplace or public dining establishment. The following are the benefits of cut foliages over commonly grown cut flowers.

1.A specific crop can be produced year-round as opposed to cut flowers which are seasonal

2.There is no time limit for storage

3.Reduced possibility of quality degradation during transit

4.Extended durability

Importance of Cut foliage

Around the world, the floral industry is evolving to meet the greatest range of needs and

Eucalyptus

adapt to shifting vogue. The newest addition made to attain this increased diversity is the cut foliage sector. Along with cut flowers, these pretty plants also referred as florists' greens and cut greens are used as fillers in bouquets and other floral arrangements. The cut foliage industry has significantly advanced the floriculture industry. Due to their complex structure, eye-catching colors and appropriate foliage; tropical foliage plants are highly valued in the industry. Many species of ornamental plants are used in floral arrangements, bouquets, wreaths and dried arrangements because of their exquisite, delightful and charming foliage. When compared to cut flowers the investment cost is minimal and there is also little chance of damage occurring during transit.

Scope for Cut foliage in India

In India, there exists little scope for plants whose cut foliage can be strategically utilized for decoration. The few pieces of cut foliage that are available in our local markets are either sourced from roadside trees or our rapidly disappearing forests. In order to gain momentum

Acalypha

Cut foliage includes leaves or portions of leaves, stems, branches and other plant components with or without in both domestic and foreign markets it is now imperative to grow ornamental plants only for their foliage in a methodical and organized manner. Tropical cut foliage plays a significant role in the floral industry. There is a huge market for the numerous varieties of cut foliage especially in Europe, Japan and the United States.

In the country, cut foliage has a lot of potential to replace flowers especially in the homesteads of Kerala and the Northeastern region during the lean season. Worldwide urbanization has led to a marked cultural shift among the urban masses where vegetation and flowers blend well with the evolving social genre. In India, the floriculture industry has

Solidago

Chinese fan palm

recently grown in popularity and is steadily becoming more profitable. Within the realm of agro-exports the trade of cut foliage is recognized as a critical area of focus for reviving the economy that has stagnated.

The modern cut flower industry cannot exist without the cut foliage industry which has grown to be a booming sector in many nations. The cut foliage industry is an essential component of the green industry and is closely related to the cut flowers. Cut foliage is still underutilized but it has sufficient potential to replace flowers especially in hard times. Various herbs, shrubs and trees have beautiful foliage that can be used in floral arrangements.

Suitability of Agro climatic conditions for the production of Cut foliage in India

India has a wide range of agro climatic conditions that are ideal for cultivating a broad range of foliage plants. Abundant sunshine throughout the year, especially in autumn and winter, is very advantageous for the year round production without depending on artificial light. Along with low labor and investment costs, India boasts a high degree of diversity in its native flora and a variety of soil types that are ideal for growing various types of foliage plants. The new emerging markets of Japan, Australia and the Middle East are relatively close to the cut foliage sector. Furthermore, when the rest of Europe is unable

to grow tropical foliage plants, India's climate is ideal for high-quality production during the months of November to March, when demand is at its highest.

In contrast to cut flowers, cut foliage is in high demand all year round in Japan, USA and Europe. However, production in these areas is very low while demand is high during the cooler months which last for more than six months. India's diverse agro climatic conditions allow for nearly year-round production.

Desirable characters of Cut foliage

Certain characters influence the consumer's preference for cut foliage, such as

1.Luminous appearance
2.Longer keeping quality
3.Aesthetically pleasing hue, form, texture, and stem length
4.Absence of pests and diseases
5.Freedom from external damage
6.Resistance to handling and transportation conditions

Foliage as Fillers

Foliage adds contrasts and backdrop to the other flowers in bouquets and arrangements. These bulk them up with low cost materials like leaves of Phelodendron. Monstera, Anthurium etc.

Ideal filler should have the following:

1.It should guarantee value for money and offer bulk.
2.It should have a consistent, clean and polished appearance.
3.Ought to have a long enough stem.
4.Improvement in quality through shape and color
5.Freshness and long shelf life are required.
6.In the corporate sector, vase life should be extended

Ensuring long keeping quality for cut foliage

Based on substantial research, Flowers and Plants Association suggests the following easy measures to make sure that cut greens, foliage and fillers look good and last longer

1.Removal of stems by cutting

Pampas grass

them at least 3 cm (1") off in a slanted manner using a sharp knife or scissors.

3.Removal of leaves from below the waterline to prevent rotting and water pollution

4.Direct sunlight, heat or drought should be avoided

5.Foliage and fillers should be kept away from them the storage of fruits and vegetables.

6.Removal of faded flowers and leaves

Conclusion

Floriculture for commercial purposes is a very new industry as it has only been around for ten years. The concentrated efforts of the government, entrepreneur's zeal and the expanding local and international market demand have led to an unparalleled expansion. Cut foliage is a growing industry that is an essential part of the green industry and the cut flower industry. Cut foliage can be

Bio fortified rice

Bridging Genomic Gaps

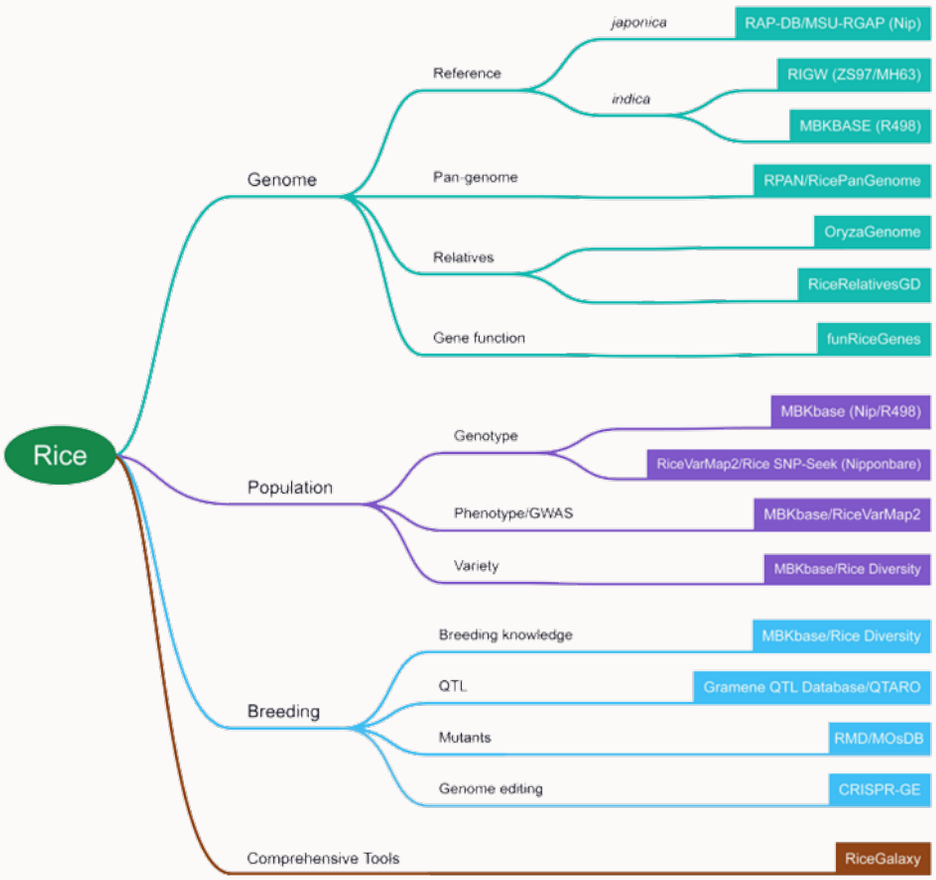
Omics and Bioinformatics for nutri-dense rice

Sona Charles
Scientist
(Agricultural Bioinformatics),
Crop Improvement and
Biotechnology,
ICAR-IISR, Kozhikode.

Introduction

Nutritional quality enhancement through biofortification breeding is the key to beat hidden hunger and to ensure global nutritional security. The current scenario of post covid socio-economic depression, international wars and extreme climatic changes exacerbates nutritional insecurity on a global scale. Many developing and underdeveloped countries in the Pacific-Asiatic belt rely on rice as their staple food. Thus, biofortification programmes of rice will be an efficient strategy to address food and nutritional security.

India harbours a rich diversity of rice germplasm and several Traditional Rice Varieties (TRVs) from Kerala have been found to possess promising nutritional and beneficial qualities. The need of precise characterisation of this rich genetic repository is at alarming stage. In the genomic era, several sophisticated techniques are in shelf to pick



Tree of genomic data base and bioinformatic tools for rice

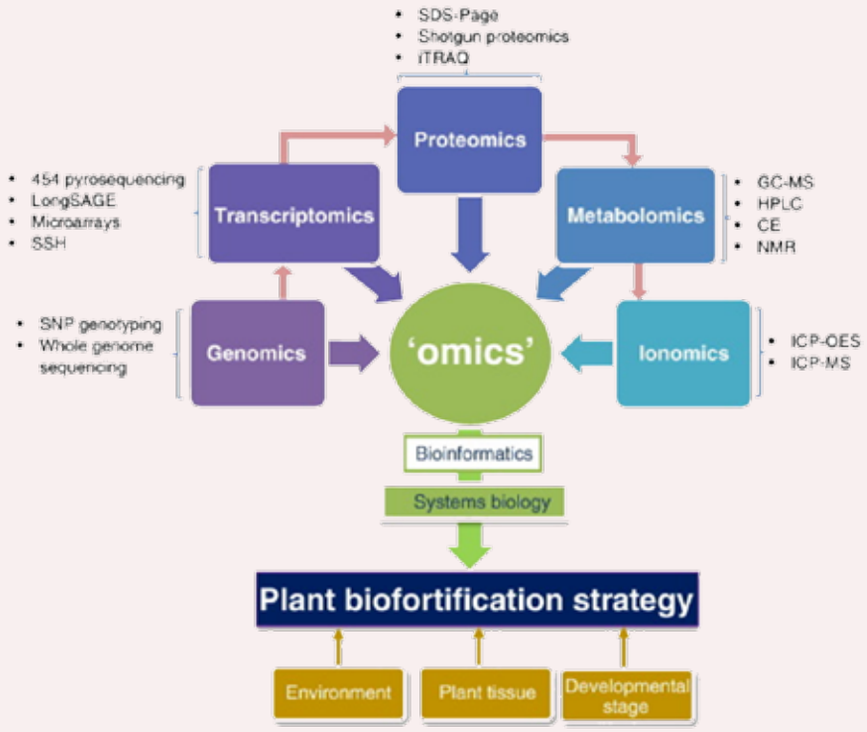
out beneficial biofortification traits followed by strategic integration into the breeding pipeline. The observable trait is cumulative output of its genetic value, environment and interaction effects.Thus, an uphold in genotypic value of any trait will yield better phenotype in desired direction. The powerful bioinformatics tools and multi-omics approaches open the door to decipher deeper genomic insights and thus paving the way to design future nutrient-dense rice varieties.

The knowledge and skill on bioinformatic tools and computational algorithms will assist breeders to scale up breeding goals. Bioinformatics plays a pivotal role in agriculture by leveraging computational tools and data analysis to enhance crop yield, quality and resilience.In agriculture, bioinformatics plays a vital role as it is employed for tasks such as deciphering plant genomes, identifying beneficial traits, optimizing breeding programs and understanding the molecular mechanisms behind crop responses to environmental factors. This synergy between biology and informatics fosters development of future bio-fortified varieties.

Role of bioinformatics tools in bio-fortification research

The large quantum of biological data produced from various experiment demanded the birth of a new branch in science in order to deal with data storage, analysis, integration and interpretation, known as “Bioinformatics”. The secrets of nature are encoded in the genetic material (DNA/RNA) using simple genetic code comprising of four nucleotides (A, T, G, C). Hence the genomic sequence information yielded from various sequencing platforms will be long stretches of codons and only bioinformatics tools can extract meaningful insights from the same. The sequence-level variations composed of copy number variations (CNVs), presence-absence variations (PAVs), InDels, or simple point mutations (SNPs), are fundamental under players of phenotypic variation.Scientists working on biofortificationaspect of rice genotypes are certainly interested in the sequence level variation underpinning nutrient remobilization, metal homeostasis (Eg: Zn, Fe), acquisition, utilization etc. Certain TRVs (Traditional rice varieties) have evolved innate mechanism for essential metal homeostasis viz.,specific metal transport channels, metal uptake, accumulation, utilization etc. bioinformatics and multi-omics studies help to highlight genomic region, molecular mechanism and cellular interacting partners which govern promising biofortification traits.

The genomic insight on sequence level variation, candidate genes and specific biochemical pathways associated with biofortification



. An Outline of Multi-Omics Approach for Biofortification

pipeline need to be explored. For instance,the sequence variation associated with high Fe and Zn levels in particular rice germplasm could be mined out using transcriptome sequencing and computational analysis. The genome wide association study or QTL mapping establishes functional relationship between trait of interest and genomic regions. This information is further amenable to integrate with breeding programme for nutrient-dense rice varieties.

Thus, a thorough understanding on type of our data and strategic choice on correct bioinformatic tools is inevitable to produce significant end results. The bulk and detailed multi-omic data regarding nutritional traits in rice along with sophisticated bioinformatic tools assist deep exploration into trait of interest to boost genetic gain in the desired direction.

Role of bioinformatics in integrating Omics data

The data reduction, simplifications followed by focus on key genes, transcripts, metabolites and pathways underpinning nutrient metabolism and accumulation is necessary to synthesise future bio-fortified rice varieties.The significance of bioinformatics and computer based approaches in various aspects of development of biofortified varieties are detailed below.

1. Genomics Approaches

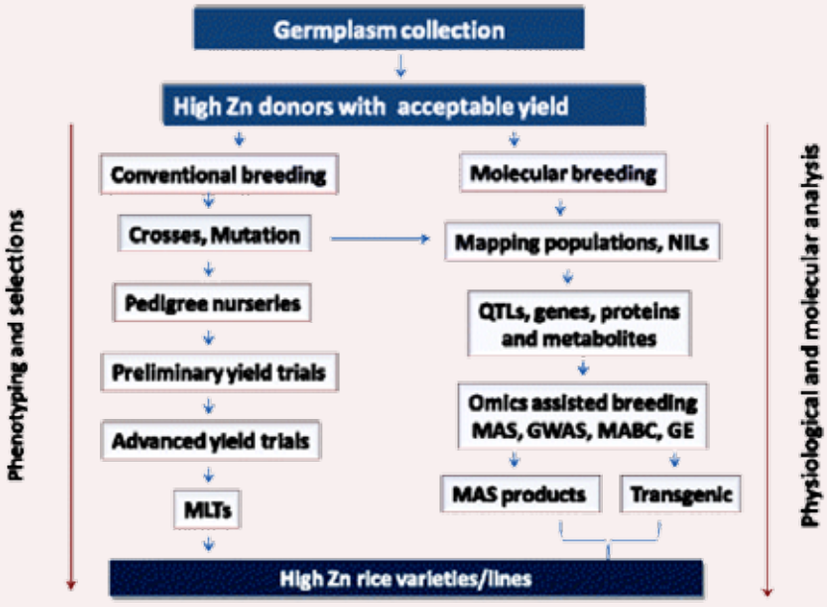
Genomic data analysis is crucial for rice biofortification, a process aimed at enhancing the nutritional content of rice varieties. Bioinformatics tools enable researchers to sift through vast genomic datasets, identifying genes related to essential nutrients such as vitamins and minerals. By pinpointing these genes, scientists can strategically modify or breed rice varieties with heightened nutritional profiles. It not only accelerates the identification of key genes but also aids in understanding the complex interactions within the genome that influence nutrient content. This computationally aided targeted approach, holds promise for addressing nutritional deficiencies and improving the health impact of rice consumption globally.

Bioinformatics provides an array of tools to identify genes associated with nutrient content in crops like rice. Through tools like Genome-Wide Association Studies (GWAS) and Quantitative Trait Loci (QTL) analysis, genes linked to specific traits and genomic regions associated with nutrient levels may be identified. Comparative genomics reveals unique genes involved in nutrient accumulation, while expression profiling identifies those actively engaged in nutrient metabolism. Metabolic pathway analysis uncovers genes contributing to nutrient content and databases like the Rice Genome Annotation Project (RGAP) provide genomic information. Machine learning predicts nutrient-related genes and functional genomics tools like CRISPR/Cas9 validate their roles. This integrated approach advances our understanding of rice genetics, aiding in the development of biofortified varieties.Some key tools, databases and approaches are detailed below:

1.1 Genome-Wide Association Studies (GWAS)

Association mapping accounts ancestral recombination events occurred in the natural population by working on the principle of linkage disequilibrium to uncover trait associated genomic region with precision. Moreover, this approach does not demand time required for construction of a mapping population. Thus, it opens door for immediate scanning and evaluation of our rich genetic resource to uncover key genes governing biofortification (Eg: Zn/ Fe homeostasis) and to incorporate those into breeding pipeline for accelerated genetic gain. A high throughput phenotyping platform offering multi-environment/ multi-season trait phenotypic data coupled with the genome wide marker data (Whole genome scan) is utmost important associate functional variants (allels/SNP) to phenotype with precision. Apart from this, the knowledge on mating system of crop, familiar relatedness (Kinship/K matrix), Population structure (Q matrix) etc are pre-requisite for choice of number of markers and to establish significant association by reducing false positive and negative results.

Genome-Wide Association Studies (GWAS) helps scientists to make significant strides in improving the nutritional value of rice through biofortification. It utilizes genetic variations across a population to identify genes linked to specific traits, including nutrient content. In a study by (Descalsota et al., 2018), 144 different rice varieties were examined to pinpoint specific genetic markers (QTLs and SNPs) related to biofortification. They discovered key regulators, like OsMTP6 and others that play a crucial role in balancing iron and zinc levels. By identifying rice varieties with a combination of these key markers, which show both high zinc content and good yields, GWAS is proving to be instrumental in customizing rice varieties for better nutrition. Another study by (Liu et al., 2021)expanded on this approach, using 212 different rice populations. They identified specific genetic markers associated with zinc content in different parts of the rice plant, providing valuable information for targeted efforts in improving rice nutrition through breeding programs. These studies collectively highlight how GWAS is helping uncover the genetic basis of nutritional traits in rice, paving the way for the development of rice varieties with enhanced nutritional value.



1.2 Rice genome databases

The advances in NGS and the birth of third-generation sequencing platforms, including ONT (Oxford Nanopore Sequencing) and SMRT (Single Molecule Real-Time Sequencing), have improved read length while reducing sequencing time within a reasonable budget. This has necessitated a shift from whole-genome information of model organisms to several non-model organisms. Moreover, the availability of more efficient sequence assembly platforms and multi-omic data from various branches such as transcriptomics, proteomics, ionomics and metabolomics, generated across different species and functional tiers, demands specific specialized databases for easy and organized data storage, analysis and retrieval. International Rice Genome Sequencing Project (IRGSP)

sequenced whole genome of rice; Oryzasativa ssp. japonica cv. Nipponbare and at present 430Mb of genome size is estimated and resequencing are progressing. The chromosome wise sequence information's are made available in public domain. The Rice SNP-seek database is online repository for rice re-sequencing data harbours extensive source of genetic variation data for 'The 3000 Rice Genomes Project' and having data regarding about 20 million rice SNPs and InDels. Some notable specialized genomic databases of rice are presented in a flowchart in Figure 2.

2.Transcriptomics Approach

Scientists have used various methods like studying specific tissues, examining gene activity and looking at metabolic processes to find key genes responsible for maintaining the balance of essential metals like iron and zinc in rice. Certain gene families, such as RT/IRT (ZIP), HMA, YSL and NRAMP are crucial for metal homeostasis. Transcription factors like OsNAC, OsIDEF andOsIRO also play important roles in boosting the activity of genes related to metal balance. Some traditional rice varieties naturally have high levels of essential metals due to their built-in mechanisms and specific transporter genes. Identifying and studying these important transporter genes, along with transcription factors and metabolic pathways, is essential for developing rice varieties rich in nutrients. Once these key genes are identified, the goal is to transfer them into high-yielding commercial rice varieties. Comparing gene activity during grain filling in regular and zinc-enriched rice varieties, using comparative RNA-seq analysis, helps identify specific genes involved in zinc balance (Figure 2). The genes that are overexpressed or underexpressed, especially in high zinc types, can be pinpointed using Differential Gene Expression analysis (DGE). By employing genomics-assisted breeding with accurate and consistent quantitative trait loci (QTLs), genes and haplotypes, scientists can swiftly create rice varieties fortified with zinc and iron.

The transcriptomic data (eg: microarray data) and proteomic data (eg: GCMS) regarding Zn and Fe homeostasis generated from various omics platforms gives an extensive list of co-expressed transcripts. The next crucial step is the correct interpretation of the huge data to mine out the underlying biological significance. A spectrum of bioinformatics tools and associated computer algorithms assist to interpret data. The clustering computer algorithm is such a tool to organise, visualise patterns in large expression datasets and to group transcripts for mineral homeostasis based on co-expression. Thus, it is possible to derive a functional relationship by integrating multi omics data. Apart from this, the high-throughput expression data from tiers helps to group transcripts based on their predicted or known functions. The GO ontology (http://www.geneontology.org) resource can be used for this purpose to pool omics data to gain insight on biological functions. Expasy, aSwiss bioinformatics resource portal, harbours various tools for genomic, transcriptomic, proteomic, metabolic data analysis and for interaction study and associated visualization tools.

3.Proteomics Approach

For a comprehensive understanding of cellular biology, transcriptomics and genomictechniques may be combined with modern techniques such as tandem-MS and LC-MS/MS to generate proteomics data. Mass spectrometers combined with gas chromatographs are widely used to profile volatile and metabolite compositions in homogenized rice flour. Bioinformatics plays a crucial role in analyzing and interpreting proteomic data for rice biofortification. Proteomic data analysis involves acquiring, pre-processing, identifying and quantifying proteins, as well as annotating their functions. The steps include data acquisition using mass spectrometry, data pre-processing to clean and standardize the data, protein identification by comparing experimental spectra and quantitative analysis to measure protein quantities. Functional annotation involves categorizing proteins based on their biological

roles, such as Gene Ontology (GO) annotation, Cluster of Orthologous Groups (COG) analysis and metabolic pathway annotation using databases like KEGG.

Pathway analysis tools, including KEGG, DAVID, Reactome and others, help identify enriched pathways and biological processes related to differentially expressed proteins. These tools offer insights into the underlying biological mechanisms, contributing to a better understanding of rice biofortification.In a comparative proteomic study by(Sarkar et al., 2015), they analysed two rice lines, finding higher levels of phenolic compounds, anthocyanins and antioxidants in red rice (Mali Daeng) compared to white rice (KDML105). This suggests a nutritional advantage in the red rice variety. Proteomics methods also help understand gene expression changes in transgenic rice, affecting translation activity and food quality. (Ramli& Md. Zin, 2015)in 2015 studied seed storage proteins in rice varieties, associating them with nutritional quality. Additionally, proteomic analysis of chalky rice grains under high-temperature stress revealed insights into starch degradation's role in chalkiness (Kaneko et al., 2016). By combining proteome analysis with crop genetics, researchers gain valuable information about protein content and related genes in different plant parts under varying conditions.

4. Metabolomics Approach

Metabolomics is the study of small molecules in a biological system, providing insights into the qualitative and quantitative differences in bioactive compounds among various rice varieties. For instance, a study identified over 3,000 compounds and genetic variations related to nutritional pathways in rice. This research explored how genetic variations affect nutritional compounds like vitamin E and phenolics, along with changes in the cooked rice metabolome. Another study comparing normal and giant embryo rice found that the latter has higher quality attributed to increased bioactive compounds. However, the major challenge in metabolomicslies in extracting and interpreting large amounts of data within a biological context.

In studying the metabolomics of rice, tools like MetaboAnalyst process metabolite data, conduct statistical analysis and explore pathways by normalizing data and visualizing metabolomic patterns. XCMS Online pre-processes and analyzes liquid chromatography-mass spectrometry (LC-MS) data, detecting peaks and aligning profiles for statistical analysis. MZmine processes mass spectrometry data, detecting peaks and quantifying metabolites. Metabolite Set Enrichment Analysis (MSEA) identifies pathways based on metabolite sets, aiding in pattern recognition. MetaboLights serves as a repository for sharing metabolomics data and provides analysis tools. ChemSpider is a database for chemical compounds, facilitating metabolite identification. KEGG and HMDB map and analyze metabolic pathways, aiding in metabolite mapping. Cytoscape visualizes network data, helping researchers understand metabolite interactions. MassBank is a mass spectral database enabling metabolite identification. These tools collectively contribute to processing, analyzing and interpreting metabolomic data, enhancing our comprehension of rice's metabolic processes.

5. Ionomics Approach

Ionomics focuses on studying the mineral nutrients and trace elements in plants across different growth stages and environments. It's an effective method that uses techniques like X-ray crystallography and mass spectrometry to identify genes and gene networks regulating the ionome. For example, a genome-wide association study (GWAS) on 17 mineral elements in rice grains from 529 accessions provided insights into variations in mineral compositions among different rice types(Yang et al., 2018). Another study analyzed trace elements in 1,763 rice accessions to identify germplasm with increased mineral content and better nutritional quality(Pinson et al., 2015). These efforts are crucial for exploring genetic resources and

understanding how mineral levels change in rice tissue.

Designing Genetically Modified Rice for Enhanced Nutrition

Bioinformatics plays a pivotal role in designing genetically modified (GM) rice with enhanced nutrition by providing valuable insights and tools throughout the development process. In this process, it first identifies target genes through approaches like Genome-Wide Association Studies (GWAS), analyzing genomic data to unveil genetic variations linked to desirable nutritional traits. Subsequently, CRISPR Design Tools(e.g., CRISPRdirect, Benchling) aid in the precise selection of gene targets for CRISPR/Cas9 editing, ensuring the focused enhancement of specific nutrient-related genes. Additionally, tools for promoter and regulatory element analysis(PlantPAN 3.0, PLACE) contribute to optimizing gene expression by scrutinizing promoter regions and regulatory elements.

Comparative genomics tools(Ensembl, Phytozome) facilitate the selection of genes from species with naturally elevated nutrient levels. The understanding of genetic networks is enhanced through network analysis tools(Cytoscape and STRING), enabling the selection of multiple targets for a comprehensive nutrient boost. Tools predicting off-target effects(CRISPOR, CCTop), coupled with expression profiling through RNA-Seq analysis(DESeq2, edgeR), ensure the safety and precision of GM rice modifications. Data integration platforms like Galaxy and Bioconductor offer a holistic view of genetic and molecular changes induced by modifications. Finally, risk assessment tools such as AllergenOnline and PROVEAN analyze the modified genome and its protein products, ensuring a meticulous evaluation of potential unintended consequences or allergenicity. By leveraging these bioinformatics tools, researchers adeptly navigate each stage, guaranteeing precision and safety in the design of genetically modified rice for enhanced nutrition. All these steps are summarised in Figure 3.

Biofortification Bioinformatics tools forTrait Mapping and Marker-Assisted Selection in Rice Breeding

Trait mapping and marker-assisted selection (MAS) in rice breeding benefit significantly from the application of bioinformatics tools. During trait mapping, QTL (Quantitative Trait Loci) mapping tools such as QGene and MapQTL are employed to analyze genetic markers across populations, identifying specific genomic regions associated with traits like yield, disease resistance, or nutritional content. Concurrently, genetic marker identification utilizes Single Nucleotide Polymorphism (SNP) discovery tools like TASSEL and GATK to pinpoint SNPs and other markers within the rice genome, crucial for correlating variations with desired traits. Genome browsers like GBrowse and UCSC Genome Browser aid in visualizing and analyzing genomic data, facilitating the interpretation of marker locations within the rice genome. Marker-trait association analysis is conducted using tools like PLINK and TASSEL, which assesses correlations between genetic markers and target traits, identifying markers significantly associated with the trait of interest.

In the subsequent phase of MAS, decision support tools like Flapjack and Breeding View assist breeders in selecting plants based on favourable markers, streamlining the breeding process through informed and efficient plant selection. Integration with breeding databases, such as Crop Breeding Database and Breedbase, ensures the storage, management and analysis of extensive genetic and phenotypic data, fostering collaboration and providing a comprehensive resource for ongoing breeding programs. Finally, data visualization tools like R and ggplot2 facilitate the creation of clear and interpretable plots and graphs for presenting trait mapping and MAS results. Through the systematic application of bioinformatics tools at each stage, rice breeders can accelerate the identification of desirable traits, enhance the efficiency of marker-assisted selection and contribute significantly to the development of improved rice varieties. The breeding approach for high Zn rice varieties are given in Figure 4.

Bioinformatics to unwind interactions for mineral homeostasis at molecular levels The protein-protein interaction and the knowledge on interacting partners of a candidate gene is necessary to predict the functional consequence of over expression, knock-down and knock-out at the biological/ phenotypic scale. The Fe/Zn accumulation and distribution in rice grains involves various tiers of interacting partners and co-regulation. Phosphorus in rice seeds is converted into inositol hexaphosphate (InsP6), which mainly accumulates in the aleurone layer. Phytic acid (InsP6) serves as a storage compound for phosphorus and forms salts with metal cations such as calcium, potassium and iron, with zinc being loosely bound. Iron, primarily bound to phytic acid, is regulated by the iron-chelate transporter OsYSL9. Zinc initially accumulates around the aleurone layer during seed development and then moves to other parts. Through transgenic approaches, the co-expression of genes like OsNAS1 and HvNAATb can enhance the levels of iron and zinc in rice grains, thereby improving their nutritional value.The putative interacting partners can be estimated in silico using various interaction database/tools like STRING (Search Tool for the Retrieval of Interacting Genes/ Proteins), BioGRID(Biological General Repository for Interaction Datasets), STITCH (Search Tool for Interactions of Chemicals), Interologous Interaction Database (I2D) etc. Cytoscape facilitates the merging of interaction data with various biological data types to enable comprehensive analysis. A practical scenario on use of these tools is described by Kandwal and co-workers in 2022. They identified a nonsense OsVIT2 Mutant in rice showing increased grain Fe and Zn level without reduction in yield. We can easily figure out the interacting partner genes using STRING platform and visualize using Cytoscape tool. It generates idea on interacting genes which we can subject to study further for its expressions in mutant (OsVIT2). These extension in studies establishes functional relationship among genes and help to estimate functional scale changes imparted upon manipulation in single gene or transcript.

Nowadays, rice research is increasingly relying on the applications of machine learning algorithms, showcasing their efficacy in tasks such as predicting DNA N6-adenine methylation sites and ranking causal genes associated with quantitative trait loci (QTL). Machine learning applications extend to predicting grain quality parameters and help to choose appropriate donors from the vast germplasm resources cost effectively.

Conclusion

In essence, the collaboration between omics sciences and bioinformatics holds immense promise for enhancing the nutritional quality of rice. By leveraging advanced tools and methods, scientists can uncover the genetic secrets that contribute to nutrient levels in rice varieties. This knowledge not only aids in the development of nutrient-rich rice but also guides the creation of genetically modified varieties. Bioinformatics tools play a crucial role in every step, from identifying key genes to designing genetically modified rice. Moreover, they assist in the efficient breeding of rice varieties with desirable traits. As we embrace these technological advancements, the journey towards healthier and more nutritious rice varieties becomes an encouraging step in combating global nutritional challenges.

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Ornamental Cabbage

A Stunning Addition to Floriculture"

Dr. Udaya T V,
Dr. Pratheeksha C T
Dr. Tanuja R N
Department of Floriculture and Landscape Architecture, College of Horticulture, University of Horticultural Sciences, Bagalkot

Ornamental cabbage, also known as *Brassica oleracea,* is a captivating addition to the world of floriculture. With its vibrant foliage and bold rosette shapes, it has become a favorite among landscapers, gardeners and floral designers seeking to add texture and color to their projects. Unlike its culinary counterpart, ornamental cabbage is cultivated for its aesthetic appeal rather than its taste. Here's everything you need to know about this fascinating plant.

A Visual Feast

The appeal of ornamental cabbage lies in its striking foliage. The leaves form dense rosettes with wavy, frilly, or serrated edges. They come in an array of colors, including shades of white, pink, purple, and green, which often intensify as temperatures drop in late autumn and winter. This makes ornamental cabbage a perfect choice for adding visual interest to gardens and floral arrangements during colder months when other plants may fade.

Landscaping and Design Applications

Ornamental cabbage is incredibly versatile in landscaping and floral design. Its bold textures and vibrant hues make it a standout feature in:

1. Garden Borders and Beds: Plant ornamental cabbage in clusters or as a border plant to create striking visual contrasts. Pair it with other cool-season plants like pansies, violas, or dusty miller for a harmonious display.

2. Containers: Use ornamental cabbage in pots or containers to decorate patios, balconies, and entryways. Its compact growth habit makes it ideal for confined spaces.

3. Floral Arrangements: The unique foliage of ornamental cabbage is a favorite among floral designers. It adds an unexpected pop of color and texture to bouquets and centerpieces, making it a versatile addition to both casual and formal arrangements.

Seasonal Appeal

One of the most remarkable qualities of ornamental cabbage is its ability to thrive in cooler weather. Unlike many other plants, its colors become more vivid as temperatures drop, making it an essential plant for fall and winter gardens. It can withstand light frosts, which often enhance the plant's visual appeal by intensifying its colors.

Morphology of Ornamental Cabbage

Ornamental cabbage is a biennial plant grown primarily for its foliage. It displays a

rosette growth habit with the following distinct morphological characteristics:

1. Leaves: The most striking feature of ornamental cabbage is its leaves. They are large, broad, and arranged in overlapping layers that form a compact rosette. The edges of the leaves are often wavy, frilly, or serrated, adding to their decorative appeal. The foliage comes in a variety of colors, including shades of white, pink, purple, and green, which deepen in intensity as temperatures cool.

2. Stem: The plant has a short, stout stem that remains mostly

hidden beneath the dense foliage. This stem provides structural support to the rosette.

3. Roots: Ornamental cabbage has a fibrous root system that anchors the plant firmly in the soil and allows efficient uptake of water and nutrients.

4. Flowers: Although rarely grown for its blooms, ornamental cabbage produces small yellow flowers on tall stalks during its second year of growth. These flowers are typical of the Brassicaceae family and are not the primary feature of interest.

5. Growth Habit: The plant typically grows to a height of 12-18 inches (30-45 cm) and a similar width, making it a compact and manageable choice for gardens and containers.

Varieties and Species in Ornamental Cabbage

Ornamental cabbage comes in a wide range of varieties that differ in color, leaf texture, and size. These varieties are all cultivars of Brassica oleracea and are bred specifically for their ornamental value. Some popular varieties include:

1. Osaka Series: Known for its smooth, rounded leaves and vibrant rosettes in shades of white, pink, and purple, the Osaka series is a favorite for container gardening and landscaping.

2. Peacock Series: The Peacock series features finely cut, feathery leaves that resemble ferns. The foliage is available in stunning shades of white, red, and purple, making it ideal for intricate garden designs.

3. Nagoya Series: This variety is distinguished by its heavily fringed and ruffled leaves. The Nagoya series is available in bright hues of red, white, and

pink, making it a dramatic addition to any garden.

4. Pigeon Series: Compact and uniform, the Pigeon series is perfect for small spaces or as border plants. The leaves are smooth and form tight rosettes in shades of purple, white, and pink.

5. Kamome Series: With deeply serrated and curled leaves, the Kamome series stands out for its unique texture. It comes in vibrant colors like red, white, and a mix of both, adding a bold statement to landscapes.

6. Color-Up Series: This series offers a wide range of colors and is specifically bred to thrive in cooler climates. It's a versatile choice for both ornamental and educational purposes.

A Visual Feast

The appeal of ornamental cabbage lies in its striking foliage. The leaves form dense rosettes with wavy, frilly, or serrated edges. They come in an array of colors, including shades of white, pink, purple, and green, which often intensify as temperatures drop in late autumn and winter. This makes ornamental cabbage a perfect choice for adding visual interest to gardens and floral arrangements during colder months when other plants may fade.

Growing Ornamental Cabbage

Ornamental cabbage is a hardy biennial that thrives in cool climates. It is typically grown as an annual in floriculture. Here are some key tips for growing this stunning plant:

1. Soil and Location: Choose a well-drained soil with a slightly acidic to neutral pH (6.0-7.5). Plant in a location that receives full sunlight for at least six hours a day, as light enhances the vibrancy of its colors.

2. Planting: Start seeds indoors 6-8 weeks before the last frost or directly sow them into the garden in late summer. Transplant seedlings into the garden when they are about 4-6 weeks old.

3. Care: Water regularly to keep the soil consistently moist but not waterlogged. Fertilize with a balanced fertilizer every 4-6 weeks to promote healthy growth. Remove any yellowing

or damaged leaves to maintain its aesthetic appeal.

4. Pests and Diseases: Watch for common pests such as aphids, cabbage worms, and whiteflies. Use organic or chemical control methods as necessary. Proper spacing and good air circulation can help prevent fungal diseases like powdery mildew.

Sustainability and Care

Ornamental cabbage is low-maintenance and eco-friendly. It requires minimal water and fertilizer, making it an excellent choice for sustainable gardening. Once its life cycle is complete, the plant can be composted, further contributing to environmentally conscious gardening practices.

Conclusion

Ornamental cabbage is much more than just a decorative plant. It's a testament to how floriculture can transform even the most unexpected species into works of art. Whether you're a professional landscaper or an enthusiastic gardener, this vibrant and versatile plant deserves a place in your designs. Its ability to thrive in cooler weather and its striking visual appeal make it a standout choice for any garden or floral arrangement.

Vinayak D
I Year BSc. (Hons) Ag, College of Agriculture,
Vellayani, Thiruvananthapuram

Biomimicry

Mimicking nature for a better Tomorrow

WHAT IS BIOMIMICRY?

Hearing the term "BIOMIMICRY," the first thing that pop up in the mind of a science enthusiast might be the pseudocopulation between the Mediterranean orchid Ophrys and a species of bumblebee to facilitate pollination. But, biomimicry or biomimetics is a design

philosophy that uses nature as inspiration to address complex problems. It is basically the process of learning from and then emulating nature's form, processes, and ecosystems to create more sustainable designs.

WHY COPY NATURE?

Nature is one of the most sophisticated systems in the universe, that exceeds any man-made system in complexity and sustainability. Nature has had

KERALA KARSHAKAN *e-journal* 29
APRIL 2025

billions of years to evolve and optimise its systems through natural selection, leading to incredibly complex and interconnected ecosystems. Another aspect of nature that makes it very complicated is its unparalleled diversity. The sheer variety of life forms and their interactions within ecosystems creates an unparalleled level of complexity. Natural systems operate across massive scales, from microscopic cellular processes to global weather patterns, demonstrating an impressive level of interconnectedness. Processes such as the highly intricate photosynthesis that makes the life on earth possible cannot be conceived by the human mind. Many of the human problems can be solved by emulating the natural systems. Nature can serve as a perfect model to be strived for while designing sustainable agricultural models, ecofriendly architecture designs and more.

BIOMIMICRY: THE ART OF COPYING

Picasso said, "Good artists borrow. Great artists steal." This is true in the design philosophy of biomimicry. Man is trying to steal the ideas from the nature and biomimicry is the art of doing it. Biomimicry is explicitly about nature inspired innovation with the end goal of creating more sustainable models.

ORIGIN AND HISTORY

The term 'biomimicry' comes from the Greek words bios, meaning 'life', and mimesis, meaning 'imitation'. The history of biomimicry can be divided into four eras. The first is the pre 15th century Basic Biomimicry Era. A renowned Chinese carpenter of this era Lu Ban is credited with the invention of umbrella, inspired by a giant lily leaf, and the saw, inspired by a serrated vine system. He got the idea for umbrella when he saw children using lotus leaves to shield themselves from the rain. He thus made the first umbrellas using silk.

The second is the emergence of early biomimicry innovators between 15th and 20th centuries. Leonardo da Vinci who belonged in this era is often called the father of biomimicry, because he was the one to first use nature as inspiration for his invention. He closely observed the anatomy and flight of birds and made detailed sketches and numerous notes to propose what he referred as "flying machines." His research later inspired the Wright brothers to invent the world's first successful motor operated airplane. Even though Leonardo Da Vinci could not build his biomimicry invention, his sketches and notes stand as a simple but profound example of biomimicry.

The next era is the era of emergence of modern biomimicry in the late 20th century. Perhaps the most famous example of biomimicry is Velcro. In 1941, Swiss electrical engineer George de Mestral, while walking with his dog noticed the burrs sticking to him and his dog. When he studied the burrs under magnification, he found their clinging property was the result of hundreds of tiny hooks. His observation sparked the idea for the very useful invention we know as Velcro fastening. Another pioneer of biomimetics belonging to this era is R. Buckminster Fuller, designer, educator, and Systems Thinking pioneer whose nature inspired designs were both resource efficient and widely beneficial. In the 20th century, Otto Schmitt established biomedical engineering and coined the term "biomimetics" as he invented the Schmitt trigger, inspired by the squids' nervous system. Janine Benyus is an American biologist, author, science writer and innovator. She may not have coined the term biomimicry, but she certainly popularized it in her 1997 book "Biomimicry: Innovation Inspired by Nature". The last era of biomimicry is the current one that started in the 21st century known as the Cambrian

Explosion of Biomimicry and Research. A prominent name of this era is Claire Janisch (1975-2022), a chemical engineer. Claire founded Biomimicry SA, Syntropy and Learn Biomimicry. In 1998, another major contributor Dayna Baumeister arrives on the biomimicry scene. A pioneering biomimicry thought leader, business consultant, and professor, Dayna has been instrumental in the creation of modern biomimicry, the "formalised" education and application of biomimicry. She designed the world's first Biomimicry Professional Certification Program, a two-year master-level course in biomimicry. In 1998 Dayna and Janine founded a site called Biomimicry 3.8 aimed at developing the field of biomimicry. In2006, the Biomimicry Institute was founded as a not-for-profit organisation. In 2007, Ask Nature, a collection of biological strategies and nature inspired innovations was created. Today it is the most widely used biomimicry resource and portal to the wisdom nature holds. From 2017, the Ray of Hope Accelerator project created by Biomimicry institute provides funding for the most innovate nature inspired startups to scale systemic solutions to the world's most pressing environmental challenges. In 2020 "Learn Biomimicry" was founded by Jess Berliner, Alistair Daynes and Claire Janisch aimed at providing education regarding the discipline of biomimicry via internet.

SOME INTERESTING BIOMIMICRY INVENTIONS

Water Repelling Lotus Leaf

The best-known example in biomimicry is that of lotus leaf, known for their super hydrophobicity. This hydrophobicity is a result of the microstructure on the surface of the leaf rather than surface chemistry. Scientists and engineers have used the lotus leaf, over the years, as an inspiration to generate super hydrophobic surfaces, mostly for self-cleaning purposes. Water repelling, dust resistant paints are also made by taking inspiration from the lotus leaf.

Bird of Paradise for Hingeless Sun Shading System

The Flectofin's design, inspired by the natural mechanics of the Bird of Paradise (Strelitzia reginae), utilizes an efficient mechanism without hinges for its sun shading systems. The laminae of Flectofin are slender, thin components reinforced with fibers that function like flexible beams. When the laminae experience bending forces from environmental factors such as wind or variations in sunlight, the fiber arrangement allows them to flex and twist in a precise manner, similar to the petal laminae of bird of paradise. This innovation resolves a significant issue found in traditional sun shading systems, which often depend on numerous small parts connected by delicate hinges. Over time, these hinges can deteriorate due to regular movement, leading to a decrease in the system's longevity.

Slime Mould for City Planning

Atsushi Tero, a scientist from Hokkaido University in Japan has devised a unique way to easily map out complex rail network using slime moulds. Slime moulds (Myxomycete) are unicellular organisms that can map out complex routes and communicate it without the help of any advanced brain or nervous system. This unique ability is a result of billions of years of adaptation and evolution aimed at the goal of feeding and survival. So, to test the practicality of their use in mapping out complex traffic routes in big cities, Atsushi Tero and team placed oat meals, one of the favourite foods of slime moulds across the various locations corresponding to major cities in Japan. Slime moulds were able to map out the locations within a short time period of 5-6 days, which took the Japanese engineers years to

plan. This technology, perfected in nature, can really help in traffic mapping in city and housing development planning.

Mosquito Inspired Less Painful Needle

Mosquitos have effectively evolved along with humans to be extremely stealth at sucking the blood out of our body. They have adopted to various chemical and physical tools to sneak up on humans without creating noticeable pain stimuli. One of them is the highly evolved mosquito proboscis. It is evolved in such a way that the piercing is not noticeable at all. Researchers M K Ramasubramanian, O M Barham and V Swaminathan from India has developed a 3-prong needle mimicking the mosquito proboscis that significantly reduced the pain caused by needle insertion. This example clearly showcases the beauty of biomimicry.

BIOMIMICRY IN AGRICULTURE

Perhaps the most useful application of biomimicry might be in the agricultural sector. Biomimicry can reduce the use of toxic pesticides and synthetic fertilizers, create biodiverse systems with soil fertility and minimize the environmental impact of agriculture. The concept of sustainable farming is now morerelevant than ever. The essence of biomimetic design lies in its commitment to sustainability. Nature's designs have been refined over eons to ensure the optimal use of resources and energy. By emulating the nutrient cycles, self-regulation, and resilience observed in ecosystems, agricultural industries can reduce waste, conserve resources, and minimize their environmental impact.

TO DISINFECT PLANTS

Pesticides can be hazardous to people and the environment in both the short and long term. Biomimicry technology is one of the alternatives to conventional pesticides and synthetic fertilizers that can help farmers protect their crop harvests while simultaneously controlling pests and diseases. When an electrical charge is applied to a solution of salt (NaCl), the sodium and chloride will separate. The positive side of the electrical charge attracts the negatively charged chloride. There, it forms a link with the water's hydrogen and oxygen to produce hypochlorous acid (HOCl). The human body naturally contains hypochlorous acid. In particular, white blood cells release it to combat infection. The science-supported process can be used to disinfect water in a way that is safe for both the environment and human health. Growers may lessen the impact agriculture has on consumers by avoiding using synthetic fertilizers and harmful pesticides on the foods we raise. Agricultural workers, who are at risk of everyday exposure to harmful chemicals due to the presence of pesticides, can also benefit from the switch to biomimicry technology. Although applying biomimicry solutions in agricultural contexts has several advantages, it is still in its infancy in terms of impact.

FOR SOIL REMEDIATION

Salt-contaminated soil has been treated using a method that involves applying iron ferrocyanide to the surface. Here, the biomimetic process mimics the pore networks in vascular plants, using a reservoir wick with tiny pores to draw clean water from contaminated soil to the larger pores. Water is driven through the soil by the external environment, which creates a fine pore contact that attracts solutes and a crystallization inhibitor like ferrocyanide. As the water evaporates, the salts rise to the top due to this ferrocyanide complex instead of staying in the soil. Solutes concentrate as the water evaporates, creating and expanding dendritic crystals. On clay soils, however, this surface treatment is ineffective, and it does not work well with additional water. It has the potential to effectively eliminate high levels of sodium chloride, making it suitable for treating saltwater spills in the oil and gas industry. Additionally, it can

address the global economic impact of soil salinization in agriculture. The method's water efficiency makes it viable as well as cost-effective in a dry climate where fresh water may be scarce for soil decontamination and phytoremediation.

FOR MINIMIZING POST-HARVEST LOSS

Approximately one-third of the world's total food production is lost as post-harvest losses. The students at Pratt Institute designed a storage facility 'Tomato's Home' to reduce the post-harvest loss of tomatoes in Nigeria. The design was inspired by plants and animals and the storage method was devised emphasizing natural ventilation and insulation. The storage structure involves clay bricks in a rib shape like that of a cactus, the undulating design causing turbulence in the surrounding airflow to lower the interior temperature. A layer of white powder, inspired by the branches of quiver trees, reflects sunlight to further lessen heating, while inside the ventilation is similar to a cricket's respiratory system. Tomato's Home has a one-way airflow system similar to how a cricket breathes. The floor of the structure has layers of thatchto create a cushion of air, much like the shell of a desert snail. Meanwhile, the storage units gently hold the tomatoes inside layers of loofah like peas in a pod, with an exterior of woven teak protecting the delicate produce.

FOR FLOOD PREVENTION

Flooding emerges as a severe challenge to the global agriculture and threat to the food security.E-Colant.Net offers a powerful solution for flood prevention by mimicking the natural shapes and patterns found in shark fins, tilapia gills, fish scale, and Devil's claw. This innovative system enhances water filtration, restores habitats for both animals and plants, and promotes biodiversity within a thriving ecosystem. With minimal impact on the surrounding environment, E-Colant. Net effectively reduces river erosion and sediment buildup, creating a stable base for plant growthessential for supporting the entire ecosystem.Another model named "Bryosoil," inspired by three moss species (Sphandae, Thuidium, and Campylopus), mimics their characteristics to reduce water flow rate, facilitate infiltration, store water, and promote evaporation to provide an integrative solution for flood control.Bryosoil is a modular and multi-functional soil system that uses 3 geometric patterns found in bryophytes to help prevent floods and fight the heat island effect. It catches water from a flooding event and manages it, depending on the risk. It is composed of 3 layers that perform 5 functions: it slows down the flow, redirects it, infiltrates the water into natural soil, harvests stormwater, or evaporates it. These layers replace the existing paradigm of water management that is based on pipe systems.

FOR REDUCING CARBON FOOTPRINT

Known as "soil-swimming robots" or "agrowormbots," agricultural subsurface robots present a viable way to reduce carbon footprint in agriculture. These "agrowormbots" successfully imitate the behaviour of worms, using biomimicry to duplicate the ecological balance found in nature. Because they use battery-powered electrical engines instead of fossil fuels, these underground robots are environmentally benign. The "agrowormbots" effectively identify plants that are sources of residual nitrogen and nurture them instead of removing them, eliminating the need for nitrogen fertilizers. These robots use artificial intelligence and soil residue to support plant growth and maintain a balanced ecosystem. This approach also addresses parasitic plants and reduces reliance on harmful

nitrogen fertilizers.

CHALLENGES AND LIMITATIONS OF BIOMIMICRY

1.COMPLEXITY

Natural systems are often incredibly complex, and it is easy to understand how they work and how to emulate them in a design. Biomimicry is an interdisciplinary field that combines biology, chemistry, physics, architecture and so on. One man cannot be thoroughly trained in all these subjects. That is why team work is very important in this field. Even the idea can be conceived easily sometimes, it requires the aid from people belonging diverse fields to implement it.Nature's solutions have evolved over millions of years through a process of natural selection, fine-tuning organisms to specific environmental conditions. Replicating these solutions in a human context often requires a deep understanding of intricate biological processes that can be difficult to fully comprehend. Many natural systems are not easily transferable to human technology because the underlying ecological, genetic, and evolutionary factors are highly complex. For example, while the structure of a spider's silk or the efficiency of a bird's wing may inspire innovation, the biochemical pathways that enable such efficiency are often beyond current technological capabilities to mimic.

2. COPYRIGHT ISSUES

Since the ideas are derived from nature directly, there are chances for legal issues regarding patents and copyrights. There are also concerns about "biopiracy," where knowledge or resources from indigenous cultures or natural environments are used without fair compensation or regard for the source.

3.ETHICAL AND ENVIRONMENTAL CONCERNS

While biomimicry aims to create more sustainable and ecologically friendly solutions, it is not without ethical and environmental concerns. The practice of extracting biological materials or inspiration from nature raises questions about the impact on ecosystems and biodiversity. For example, the commercialization of natural resources or the patenting of biological models could lead to exploitation, overharvesting, or the introduction of invasive species.Furthermore, the implementation of biomimetic solutions might inadvertently disrupt natural processes. Although biomimicry seeks to reduce environmental harm, it may sometimes introduce unintended consequences, such as the ecological impact of manufacturing synthetic materials that mimic natural ones or the depletion of natural resources required to create biomimetic technologies. For instance, while bio-inspired buildings that mimic termite mounds for temperature regulation may be energy-efficient, the long-term environmental costs of producing the materials used to construct these buildings may outweigh their benefits.

4.LIMITED KNOWLEDGE AND TECHNOLOGICAL BARRIERS

Despite growing interest in biomimicry, the field is still in its infancy when it comes to fully understanding and harnessing the complexity of biological systems. Scientific research on biomimicry is often based on initial observations or case studies that may not be applicable to a wide range of problems. The scientific community still has a long way to go in terms of deciphering how various biological structures and processes function at the molecular and systems levels.Moreover, many biomimetic innovations face significant technological barriers. Advanced materials science, nanotechnology, and biotechnology are required to replicate natural systems, but these fields are still developing. Even with rapid technological advancements, creating biomimetic solutions often requires substantial financial investment and long-term

research, making it difficult for smaller organizations or startups to participate in biomimicry-based innovation. The reliance on cutting-edge technology also limits the accessibility of these solutions, especially in regions or industries that lack the necessary infrastructure or expertise.

5.SCALABILITY ISSUES

Another limitation of biomimicry lies in the scalability of natural designs. Many biological systems are highly specialized to function on a small scale or in specific conditions. Scaling these solutions up to meet human demands can be difficult. For example, while certain plant-based systems excel at solar energy absorption or water filtration at a micro level, replicating these properties in larger, more industrial-scale applications can require materials and processes that nature has not optimized. This gap between micro and macro levels can lead to inefficiencies or prohibitively high costs when attempting to adapt biomimetic solutions for mass production.In addition, many biological materials that inspire biomimicry, such as the adhesive properties of gecko feet or the self-healing capabilities of some plant tissues, may not yet be easily replicated with synthetic materials. Even if scientists and engineers successfully replicate a design, they may not be able to achieve the same performance, durability, or cost-effectiveness at larger scales, which hinders the practical application of such biomimetic innovations.

6.ECONOMIC AND MARKET BARRIERS

While biomimicry has the potential to lead to more sustainable and efficient products, the economic feasibility of implementing biomimetic solutions on a large scale can be challenging. The cost of research and development, combined with the need for specialized materials or manufacturing processes, can result in products that are expensive to produce and not immediately competitive in the market. In many cases, the existing technologies that biomimetic solutions aim to replace may already be well-established, cheaper, and more efficient in their current form, making it difficult for biomimetic alternatives to gain market traction.Additionally, the innovation and adoption of biomimicry are often slow due to regulatory barriers, patent issues, and a lack of incentives for businesses to adopt more sustainable practices. Market-driven forces tend to prioritize immediate returns on investment over long-term ecological or social benefits, which may deter the widespread implementation of biomimetic technologies.

CONCLUSION

Biomimicry offers exciting potential for solving some of humanity's most pressing challenges, from environmental sustainability to innovative design. However, it is important to recognize the limitations of this approach. The complexity of natural systems, scalability issues, ethical concerns, technological barriers, and economic challenges all pose significant hurdles to the widespread application of biomimicry. To fully realize its potential, continued interdisciplinary research, technological development, and a more nuanced understanding of nature's systems are necessary. Additionally, careful consideration of the ethical and environmental implications of biomimicry is essential to ensure that its solutions contribute to the well-being of both humanity and the natural world. Only by addressing these limitations can biomimicry achieve its promise of sustainable, innovative solutions that are both effective and responsible.

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Basmati Rice

A Fragrant nutritious cereal for every meal

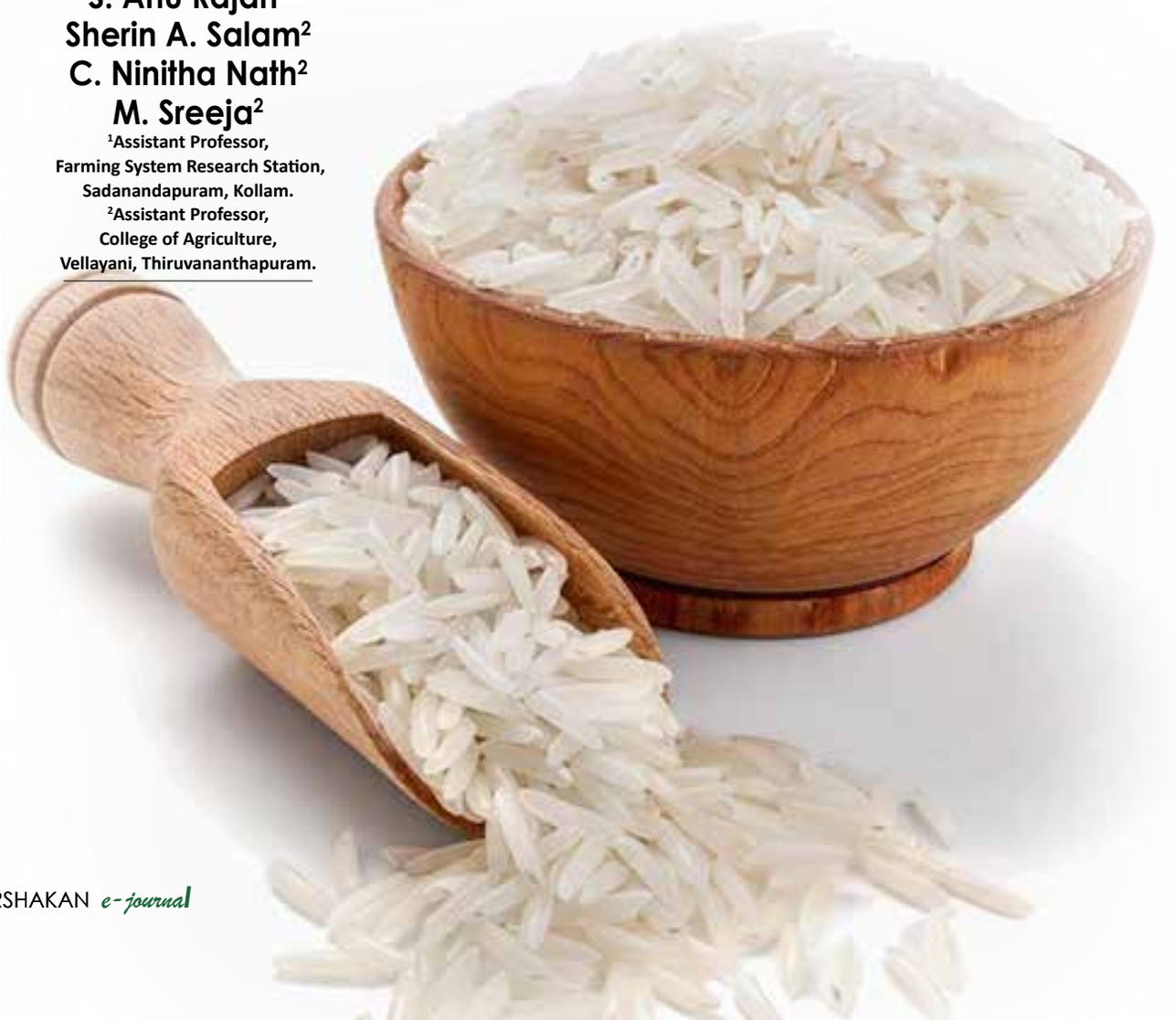
R.V. Sindhu[1]
S. Anu Rajan[2]
Sherin A. Salam[2]
C. Ninitha Nath[2]
M. Sreeja[2]
[1]Assistant Professor,
Farming System Research Station,
Sadanandapuram, Kollam.
[2]Assistant Professor,
College of Agriculture,
Vellayani, Thiruvananthapuram.

Introduction

Rice is an important staple food globally, especially to the people of Asia, that contributes to a major part of the diet for billions of people. Rice provides significant portion of the caloric intake as it functions as the primary source of nutrients for majority of world's population. It is an important cereal grain that functions as the fundamental part of the diet. Apart from the role as food crop rice has significant role in the social, cultural and economic aspects of the people.

Characteristicsof Basmati rice

Basmati rice is characterised by its long grain size, special aroma, flavour and unique cooking qualities. The term "basmati" is derived from Sanskrit and Hindi words "Vaas" meaning



"fragrance or perfumed" and "mati" means "full of "meaning rice with "full of aroma". It is often referred as "queen of perfumed rice".Basmati rice was traditionally grown in Indo-Gangetic plains, where the specific soil conditions, climate, and water sources plays significant role to its unique characteristics.

Origin and History

The origin of basmati rice is considered to bethe Indian subcontinent. There are references of basmati rice in ancient Sanskrit literature. It is believed that basmati rice has been cultivated for more than 2000 years back. In due course this basmati ricegained an important place in Indian and Pakistani cuisines especially in northern regions. Now basmati rice has high popularity and acceptance because of its peculiar quality. India government obtained geographical indication tag for basmati rice in 1997. Now adays basmati rice is widely cultivated in regions like Punjab, Haryana, Himachal Pradesh, Uttar Pradesh, Uttarakhand etc.

cooking quality. The longer the aging process, the better the quality of the rice.

Types of Basmati Rice

The different types of basmati rice includeBrown and White Basmati Rice.Both varieties are gluten free and have high contents of carbohydrates.

Brown basmati rice: It has outer bran layer which makes it more nutritious. When cooked it has chewing texture along with nutty aroma. It is packed with soluble and insoluble dietary fibre.

White rice: It is processed by removing bran & germ layers and has softer texture when cooked. Both the rice varieties contain all the eight essential amino acids.

Nutritional Value

This is primarily composed of carbohydrates, making it an excellent source of energy. It is also relatively low in fat and protein. Basmati rice is highly valued because of its high nutrient profile. This also contains vitamins, minerals, fibre, protein and minimal fat which makes it a healthy and perfect meal. Besides, it also contains essential nutrients like copper, zinc, calcium, potassium, magnesium and vitamins B1, B6, E and K which makes this variety super health food. Basmati rice cultivated in India and Pakistan has low level of arsenic content compared to other varieties.

One cup of basmati rice contains just over 200 calories, better than white rice, which is a refined grain. One cup (163 grams) of cooked white basmati rice contains Calories: 210, Protein: 4.4 grams, Fat: 0.5 grams, Carbs: 45.6 grams, Fiber: 0.7 grams, Sodium: 399 mg. Folate: 24% of the Daily Value (DV), Thiamine: 22% of the DVSelenium: 22% of the DV, Niacin: 15% of the DV, Copper: 12% of the DV, Iron: 11% of the DV, Vitamin B6: 9% of the DV, Zinc: 7% of the DV, Phosphorus: 6% of the DV, Magnesium: 5% of the DV.

Quality Attributes of Basmati Rice

Quality of basmati rice is determined by several attributes like appearance, milling quality, cooking quality and nutritional quality. The important attributes are as follows.,

1. Grain Shape and Length.

High quality basmati rice are long and slender

2. Aroma

Basmati rice has a pleasant nutty aroma.

This aroma is due to the presence of a compound called 2-acetyl-1-pyrroline giving the peculiar fragrance which increases while cooking.

3. Colour

High quality basmati rice should have a consistent color indicating uniformity in processing. It can be either white or light yellow or golden.

4. Texture

The key feature of basmati rice is that it remains separate and will not stick togetherwhen cooked

5 Aged quality

One- or two-years aged basmati rice is often preferred as aging enhances its aroma and taste.

Health Benefits

1. Blood sugar level regulation.

The Glycaemic Index (GI), (how quickly blood sugar level rises in body after consuming a particular food) of basmati rice ranges between 50 and 58 which is categorised under low to medium range makes this rice a healthy alternative of carbohydrates. This helps to regulate blood sugar level.

2. Fiber Content

Apart from low GI Value Basmati rice has high fiber content which helps to reduce the risk of Type II Diabetes

3. Gluten Free

This is a best choice for people who follow gluten free diet

4. Improves health of Heart

Consuming whole grains like brown basmati rice lower risk of heart disease. Whole grains help to reduce blood cholesterol levels. They also help to reduce the risk of high blood pressure.

5. Anticancerous

Brown basmati rice has more fiber content that other types. High fiber rich diet helps to reduce the risks of cancer.

6.Improved brain health

Basmati rice is rich in vitamins like thiamine which is very crucial in brain health.

7. Promotes Digestion.

The high fiber content enhance digestion and prevents issues like bloating and constipation.

8. Weight Management

Due to the low glycemic index and high fiber content basmati helps to manage weight.

Basmati rice is used in a wide variety of dishes. It is commonly served with curries, biryanis, and other spicy dishes. It is also a popular ingredient in fried rice dishes. The rice should be rinsed thoroughly to remove any excess starch. Then, it should be soaked in water for at least 30 minutes before cooking. This helps to ensure that the grains cook evenly and do not become too sticky.

Conclusion

As basmati rice has cultural, culinary and health benefits it is gaining importancein the national and international market.Basmati rice has a very nutritive profile compared to other varieties of rice. It is fortified with essential vitamins and minerals andit has high dietary fibres, low arsenic content and low to medium glycaemic index (GI) which helps to improve digestion and reduce the risks of several diseases.

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"Mamey sapote Unlocking the Potential of a Tropical Fruit"

Reeba A. John[1]
Manju P.R.[2]
Simi S.[2]
[1]Research Scholar, Department of Fruit Science,
[2]Assistant Professor, Department of Fruit Science, College of Agriculture, Vellayani

Introduction

Mamey Sapote (*Pouteria sapota*), a tropical fruit native to Central America, is gaining recognition worldwide for its unique flavour, vibrant colour, and exceptional nutritional profile. With its rich, creamy flesh that blends hints of pumpkin, sweet potato, and apricot, Mamey Sapote is increasingly becoming a sought-after delicacy in both local markets and international export hubs. Its rich history, stretching back to ancient Mesoamerican civilizations, has made it an integral part of tropical cuisine and traditional medicine.

Traditionally grown in Mexico, Central America, and the Caribbean, Mamey Sapote is now cultivated in tropical and subtropical regions across the globe, including parts of Southeast Asia, the Caribbean, the United States, and India. Its adaptability to various agro-climatic conditions has fuelled its spread, while its impressive array of health benefits ranging from high levels of vitamins, minerals, and antioxidants has contributed to its rising popularity in health-conscious markets.

As global demand for exotic fruits continues to increase, Mamey Sapote stands at the forefront, offering farmers and agriculturalists opportunities for diversification, enhanced income, and sustainable agricultural practices.

Flower buds

Fruit set in Mamey Sapote

This article delves into the fascinating world of mamey sapote, exploring its origins, cultivation practices, and potential as a key player in the future of global tropical fruit markets.

Nutritional Significance

Mamey Sapote is a powerhouse of nutrients, making it an exceptional addition to any diet. It is rich in vitamins, minerals, and antioxidants, which contribute to various health benefits. The fruit is an excellent source of Vitamin C, an antioxidant essential for immune function, and Vitamin A, important for vision and skin health. It contains potassium, calcium, and magnesium, all crucial for maintaining heart health, muscle function, and bone strength. Mamey Sapote is high in dietary fibre, which aids digestion and promotes gut health. The fruit's high natural sugar content provides a quick energy boost, making it an excellent source of fuel for active individuals. Mamey Sapote also boasts a moderate fat content, primarily from heart-healthy monounsaturated fats. This combination of nutrients makes the fruit a balanced fruit with potential health benefits for cardiovascular health, immune support, and

overall well-being.

Therapeutic Uses

Mamey Sapote has been used for its therapeutic properties for centuries in its native regions. The fruit's therapeutic applications include antioxidant properties.The fruit's high content of Vitamin C and other antioxidants help combat free radical damage, reducing the risk of chronic diseases like heart disease and cancer. Mamey Sapote has demonstrated anti-inflammatory properties, which may help in managing conditions like arthritis and other inflammatory disorders. Due to its high fibre content, Mamey Sapote is a natural remedy for constipation and supports regular bowel movements.The fruit's Vitamin A content helps in maintaining healthy skin, promoting a youthful appearance and aiding in the healing of wounds and scars. In traditional

Mamey Sapote tree in full bearing

Double seeded Mamey Sapote fruit

medicine, various parts of the Mamey Sapote tree, including its leaves and bark, have been used to treat fevers, infections, and as a natural remedy for sore throats.

Origin and Evolutionary Distribution

Mamey Sapote (*Pouteria sapota*) is a tropical fruit native to the lowland regions of Central America, specifically in southern Mexico, Guatemala, and Belize, where it has been cultivated for centuries by ancient civilizations like the Maya and Aztecs. Over time, during the age of European exploration, the fruit spread to the Caribbean and parts of South America, including Colombia, Venezuela, and Brazil, where it became integrated into local diets and agricultural practices. The fruit's cultivation extended beyond the Americas in the 20th century, reaching tropical and subtropical regions around the globe. The United States, particularly Florida, adopted Mamey Sapote cultivation, taking advantage of its subtropical climate to establish large-scale production. California also saw some adoption, though on a smaller scale. Southeast Asia followed suit, with countries like the Philippines, Malaysia, and Indonesia cultivating Mamey Sapote due to their warm climates. Similarly, India's southern states such as Kerala, Tamil Nadu, and Karnataka embraced the fruit, which thrived in the tropical conditions and provided farmers with a high-value crop alongside traditional fruits like mangoes and bananas. Today the crop has spread to Australia, parts of Africa, and the Middle East also beginning to grow the fruit.

Botany

Mamey Sapote is an evergreen tree belonging to the Sapotaceae family, characterized by its large, dense canopy and a robust trunk. The tree can grow up to 10–20 meters in height, with a broad, rounded crown that provides ample shade. Its leaves are dark green, glossy, and leathery, with an elliptical shape, typically measuring between 10 to 20 cm in length. The tree produces small, inconspicuous flowers that are hermaphroditic, meaning they contain both male and female reproductive organs. These flowers are typically white or pale yellow and are borne in clusters. The pollination of Mamey Sapote is often facilitated by insects, such as bees, which help transfer pollen between the flowers, ensuring fruit production.

Single seeded Mamey Sapote fruit

Air layering in Mamey Sapote

The fruit is a large, oval berry with a rough, brownish skin. When ripe, the flesh inside is a vibrant orange or pinkish-red, with a soft, creamy texture and a sweet, distinctive flavour. The size of the fruit typically ranges from 15 to 30 cm in length, with a single large seed in the centre. The fruit is highly valued for its unique flavour, which has been described as a combination of sweet potato, pumpkin, and apricot. The fruits have a relatively long maturation period, taking approximately 18–24 months from flowering to fruit harvest depending on the variety.

Climate and soil

Mamey Sapote requires tropical or subtropical climate with temperatures ranging from 20°C to 35°C and well-drained, loamy soils with a slightly acidic pH for optimal growth. The tree thrives in areas with consistent rainfall, though it is sensitive to frost and requires protection from extreme cold

Varieties

The most commonly cultivated varieties are the "Hawaiian" and "Florida" cultivars, which are both favoured for their size and quality of flesh. The Hawaiian variety is known for its larger fruits, which can weigh up to 1.5 kg, and its creamy, sweet flesh with a rich orange colour. This variety is highly regarded for its excellent texture and flavour, making it ideal for fresh consumption as well as for use in smoothness, ice creams, and desserts. The Florida variety, on the other hand, is slightly smaller, with fruits typically weighing between 500 grams and 1 kg, but it is equally prized for its smooth, buttery flesh and sweet flavour. It is more commonly found in the United States, particularly in Florida, where the climate suits its growth.

In addition to the Hawaiian and Florida varieties, there are other cultivars with unique characteristics adapted to different climates and regions. For instance, the "Pantin" variety, commonly grown in the Caribbean and parts of Central America, has a smaller fruit size but is known for its dense flesh and excellent taste. Meanwhile, the "Fuchs" variety, originating from the Dominican Republic, is appreciated for its early fruiting and resistance to disease, making it a valuable cultivar for farmers seeking reliable production. Research on genetic diversity and breeding has led to the identification of various other local cultivars, each adapted to specific environmental conditions. These varieties are crucial for ensuring the sustainability and productivity of Mamey Sapote cultivation, with on-going studies aimed at improving disease resistance, fruit yield, and flavour consistency across different regions.

In Kerala, Mamey Sapote is cultivated primarily in the southern and coastal regions, where the tropical climate supports its growth. Among the varieties grown, the "Pantin" variety is particularly popular due to its smaller fruit size and dense, flavourful flesh, which is well-suited to local consumer preferences. Additionally, the "Florida" variety has been introduced and is being cultivated for its relatively larger fruit and smooth, sweet flesh. These varieties are favoured for their adaptability to the humid conditions of Kerala, with local farmers also experimenting with other cultivars to enhance

yield and resistance to pests. Studies indicate the potential for increased commercial production of the crop, driven by local demand and the fruit's growing popularity in the region.

Propagation

Seed propagation is the most common method of propagation followed in mamey sapote. However, seeds often exhibit poor viability and do not always produce plants true to type. Typically, it takes several months for the seeds to germinate, and seedlings may take 4–7 years to fruit. Seed-grown trees may have significant variability in fruit quality and tree characteristics.

Asexual propagation is more reliable method of propagation involves grafting or budding, particularly onto rootstocks that are well-suited to local conditions. Grafting can produce fruiting trees in as little as 3–4 years, ensuring the desired fruit quality and consistency. Common grafting techniques include approach grafting, cleft grafting, and veneer grafting.

Another technique for Mamey Sapote propagation is air layering, where a section of the tree's branch is induced to form roots while still attached to the parent tree. Once roots develop, the branch is severed and planted as a new tree.Recent research also focuses on improving grafting techniques to accelerate fruiting and enhance resistance to pests and diseases (Cortes *et al.*, 2022).

Harvest and Yield

Harvest and yield are influenced by several factors, including tree age, climate, and cultivation practices. Typically, the trees begin bearing fruit 3 to 5 years after planting, with peak production occurring around 8 to 10 years of age (Avendaño-Arrazateet et al., 2019). Under optimal conditions, mature trees can yield between 50 to 100 fruits annually, with each fruit weighing between 500 grams and 1.5 kg, depending on the variety. Harvesting is done manually, with fruits being collected once they reach full maturity, typically after a 12 to 24 month growing period following flowering.

Recent Research

Recent research on Mamey Sapote has focused on improving its cultivation practices, genetic diversity, and post-harvest management to enhance production and fruit quality. Studies by Cortes *et al.*,(2022) have explored advanced grafting techniques to accelerate fruiting and increase resistance to common pests and diseases, which are a significant concern in tropical regions. Additionally, research on soil and water management practices, including the use of micro-irrigation systems and organic fertilizers, has been conducted to optimize yield and ensure sustainable farming practices (Nickum *et al.,* 2010). Genetic studies have also been underway, focusing on identifying superior cultivars with higher resistance to environmental stressors such as drought and fungal infections (Martínez-Castillo et al., 2019). In the realm of post-harvest technology, studies by Jiménez *et al.* (2022) have investigated methods for extending shelf life, such as optimal storage conditions and the development of natural preservatives, to ensure the fruit's availability in global markets. These advancements aim to boost the commercial viability of Mamey Sapote, increasing its presence in international markets while addressing the challenges faced by farmers worldwide.

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SOCIAL SECURITY & FOOD SAFETY IN DAIRY

How Kerala's Policies Make a Difference

Greeshma Greeshmam

Kerala, the picturesque state of India, blessed with lush green natural spaces, is also well placed at the national level due to its impressive performance on various human development indicators. The state's towering presence on multiple indices of NITI Aayog and similar studies done by different agencies is due to the priority accorded to the social and physical development of states' populationsby successive state governments. This is attained due to the state's traditional emphasis on social security and ensuring the state's

food security.

Various government schemes in Kerala are formulated to address the social welfare needs of multiple categories of people in the state. Among these categories, dairy farmers form a special group, as dairying is one of the primary/additional sources of income for small or marginal farmers and agricultural labourers in the state. It is also a significant source of income for homemakers in the state.

Dairying as a sector plays a crucial role in ensuring the state's food security. Among the various food sources for nutritional security, milk and milk products are rich in nutrients and provide energy and high-quality protein, along with a variety of essential micronutrients, particularly calcium, magnesium, potassium, zinc, and phosphorus, in a form that can be easily absorbed. Dairy and dairy products are vital sources of nourishment for the state's people, supporting healthy and active lifestyles.

Approximately 18.6 lakh litres of milk are procured daily throughout the state through the 3608 registered dairy co-operative societies. 378773 dairy farmers across the state are registered in these dairy co-operative societies. By intervening in the dairy industry through the Department of Dairy Development, the Government of Kerala opens the door for fiscal reforms, stabilisation measures, and the formation of economic policies that promote socio-economic growth.

Social Security in the Dairy sector

The novel idea of providing social security aid to dairy farmers in the country was implemented for the first time in Kerala. This idea bore fruit in the 1980s when Kudukkan Muhammed, a dairy farmer from Kunnembetta Dairy Co-operative Society of Kalpetta block, Wayanad, complained about the lack of social security benefits for the elderly dairy farmers during a district seminar organised by the Department of Dairy Development.

After several deliberations and legislative talks, the Kerala Dairy Farmers Welfare Fund came into force on 13th April 2007 (as per GO(P)4/06/AD) via legislation passed in the Kerala State Legislative Assembly on the same date. Its sole purpose was to ensure social security by providing pensions to dairy farmers during their old age and implementing different schemes for the welfare of their families.

A small proportion of the Kerala Dairy Farmers Welfare Fund fund is being collected from its members, dairy co-operative societies and regional unions. The contribution to the Fund, popularly known as Amsadaayam(share of income), shall be at the following rates, namely:-

1. Each dairy farmer twenty rupees per month (₹ 20/-);

2. Each dairy co-operative society shall,-

0.5 % of milk sold by the society locally;

0.3 % of milk is to be given by society to the Milma.

3. 0.75 % of milk to be sold by the Regional Unions (TRCMPU, ERCMPU, MRCMPU)

An 18-year-old dairy farmer who pours a minimum of 500 litres of milk during the previous financial year into a co-operative dairy society registered under the Department of Dairy Development can register in the Kerala Dairy Farmers Welfare Fund by paying the registration fee of 100 rupees. Any farmer who got the membership before or after 13.04.2007, who is 60 years or above, and who poured milk in a co-operative dairy society for any five (5) financial years is eligible for applying for the pension. Per the KDFWF, dated 19th February 2024, the total enrolled members are 422121.

The central assistance provided by KDFWF are:

Pension: Any member of KDFWF who is 60 and above is eligible for the pension. The pension amount per month is ₹1,600/-. Since January 2017,

the Government of Kerala has been paying ₹1,300 as its share in the pension amount and the remaining ₹300/- is paid by the KDFWF.

Family Pension: If a pensioner dies, their nominee will get ₹150/- from the KDFWF

Disability Pension: Any member with 40% disability or suffering from fatal diseases is eligible for this scheme. For the disability pension, age is not a criterion. Like the pension, the disability pension is also ₹1,100/-.

Educational Assistance: It is given to the children of KDFWF members who excelled in their SSLC, Higher Secondary, Graduation, Post Graduation or professional courses.

Marriage Assistance: KDFWF provides ₹5000/-as assistance for the marriage of KDFWF members' daughters. The KDFWF member should apply online within six months of marriage.

Cremation Assistance: When a KDFWF member is deceased, then ₹3000/- is provided for the cremation procedures.

Ksheerasuraksha: A scheme that gives medical assistance to those who have enrolled as members of KDFWF. Also, assist with severe diseases, contagious diseases, zoonotic diseases, permanent total disability due to accident & also to the nominees, in case of death of the beneficiaries. The Kerala government is providing ₹25,00,000/- for the Ksheerasuraksha Scheme.

(File Photo)

Awards: KDFWF provides awards for the best dairy farmer in the state and the best farmer in the district and blocks to encourage dairy farming across the state. The awards are given to the farmers who poured the highest quantity of milk in Dairy Co-operative Societies.

Ksheera Santhwanam: It is a comprehensive insurance policy for all dairy farmers across the state. It is a joint initiative of the Kerala Dairy Development Fund Board, the Dairy Development Department, three Regional Unions and the primary Dairy Co-operative Societies. Ksheera Santhwanam provides dairy farmers with health coverage, accident coverage, and life insurance. Moreover, it also provides insurance coverage to cattles under the Gosuraksha policy. The premium for this policy is comparatively lower than other insurance policies.

Food Security in the Dairy Sector

The Government of Kerala is putting significant efforts to ensure food security in the dairy market and to provide high-quality milk through the Department of Dairy Development. The quality control efforts of the department are focused on guaranteeing fresh, safe, and quality milk at the procurement stage, thereby ensuring that consumers in the state are receiving quality milk.

The dairy sector in Kerala consists of dairy farmers, dairy co-operative societies, milk processing centres, milk product selling outlets, and the Department of Dairy Development. Each constituent has demarcated responsibilities and functions in the food safety management system.

Farmers' Level: Around 10

lakh dairy farmers are registered in different Dairy Co-operative Societies spread across Kerala. The quality of milk available in the market depends on the quality at the production level. To ensure this, many aspects must be taken care of at the producer's level, such as the hygiene of cows, sanitation of cattle sheds and their premises, clean milking pails and other necessary utensils, etc. Dairy Extension Officials of the Department conduct awareness classes, seminars, group discussions and regular house visits to ensure these guidelines are implemented.

Dairy Co-operative Societies: The Dairy Co-operative Societies (DCS) across the state come under the purview of the FSSAI Act. Dairy Co-operative Society and its premises should be hygienic and sanitised. Effective measures should be taken to prevent any milk contamination. The DCS fixes the price for the milk poured by a farmer based on the predetermined rate for fat and solids-not-fat(SNF). The Department's Dairy Extension Officials and the officials of subsequent regional unions of KCMMF(MILMA) scrutinise the practices regularly.

Dairy Plant: A dairy plant is a highly mechanised set-up where milk is handled with minimum human intervention to prevent contamination. The milk processing procedure is undertaken with utmost care and caution. Machinery, utensils, and pipelines used for milk processing in a dairy plant are cleansed with hot water. All machinery and utensils that come in contact with milk are made of stainless steel. Technical experts visit these dairies annually per the requirements under FSSAI to review cleanliness, technical efficiency, and capacity to handle milk in diaries.

Quality Control Offices (QCO): The QCOffices at the district level control, coordinate and supervise all the developmental activities to ensure the quality of market milk, take remedial measures, facilitate the procurement of quality cow milk in dairy co-operative societies, and ensure fair prices for producers. Around 25 market samples are collected and tested monthly, and the report is furnished to the Food Safety Authority.

The other programmes carried out by the department to ensure food safety in the dairy sector are:

Dairy Farmers Contact Programme (DFCP/FCP): Through FCP, the farmers can interact with the technical and subject matter experts to find solutions for the issues they are facing and improve the quality of milk they produce.

Quality Awareness Programme (QAP): The QAP enables farmers to understand the causes of milk adulteration, health issues caused by milk adulteration, the hygienic environment and actions to be taken to prevent milk contamination, FSSAI guidelines, actions to be taken to enhance milk quality.

Consumer Interface Programme (CIP): The Department of Dairy Development provides a forum for consumers to interact with dairy officials to gain awareness about the quality of milk, possible adulterants, and precautions to

avoid health hazards.

Intensive Festival Drive Programme: During the festival seasons like Onam Sabarimala Pilgrimage, the demand for milk in the state increases, and a large amount of milk is brought into the state from neighbouring states. These milk samples may contain hazardous chemicals and adulterants, which could pose significant health hazards to the common public. Due to this, the department conducts specific quality testing drives throughout the state during the festival seasons to stop the inflow of hazardous and adulterated milk and dairy products. Additionally, all district headquarters have Milk Quality Information Centers where the quality of various milk brands is evaluated. Department officials are immediately notified to take legal action upon discovering substandard or adulterated milk. Facilities for testing milk at Check Posts: Special camps with laboratory facilities are set up at five main checkpoints in the state (Walayar, Meenakshipuram, Kumili, Aryankavu, and Parassala–, where the majority of the milk enters the state) to stop the entry of adulterated and low-quality milk during festival seasons. The samples from vehicles are taken, and those found adulterated or of low quality are denied entry into the state and reported to food safety authorities for further legal action. Permanent milk testing facilities have been set up at Parassala, Meenakshipuram, and Aryankavu Checkposts.

State Dairy Laboratory (SDL): The State Dairy Laboratory is one of the significant initiatives of the Government of Kerala, which was established with the aid of the Central Government under the flagship of the State Dairy Development Department. It was inaugurated on 21st April 2010. SDL mainly focuses on strengthening the dairy sector by ensuring the quality and safety of milk and milk products. It is equipped with state-of-the-art equipment to cater to various chemical and microbiological analyses of around 143 scopes, mainly Milk and Milk Products, Fodder, Feed and Feed Ingredients, Pet Foods, Bakery and Bakery Products, Cereals, Pulses, Flour, Maida, Rice Powder, Water - Drinking and Packaging Water and so on.

The major beneficiaries of State Dairy Laboratory include Dairy Co-operative Societies in the state, Milma (KCMMF), KLDB, Kerala State Poultry Development Corporation, Kottur Elephant Rehabilitation Centre (Elephant Feed), Neyyar Wildlife Sanctuary (Deer Feed), Water Authority Department, Kerala Feeds, Companies in Technopark, Hotels and Restaurants in Kerala (Water) and so on. Three regional labs at Kottayam, Palakkad and Kasargod work under the State Dairy Laboratory in Kerala.

Way Forward

The current pension eligibility for a member farmer is to pour 500 litres within 5 years. It doesn't review whether the member farmer is actively taking part in the activities of DCS before or after fulfilling the eligibility norms; ensuring active involvement and contribution of farmers will increase the milk procurement in DCS and help to achieve self-sufficiency in milk production in the state.

To prevent the spread of adulterated and low-quality milk, more testing facilities must be set up at checkpoints in the state. Establishing permanent quality-checking facilities at all checkposts in the state will prevent the spread of adulterated milk and milk products.

The dairy sector in Kerala, under the leadership of the Dairy Development Department, demonstrates how a state-run institution can play a significant role in achieving the developmental goals put forward by the government. Notably, in the last two decades, the sector has excelled in providing social security aid to the dairy farmers who toiled their lives in increasing clean milk production and ensuring food security for the public.

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