Department of Agriculture Development & Farmers' Welfare
Farm Information Bureau

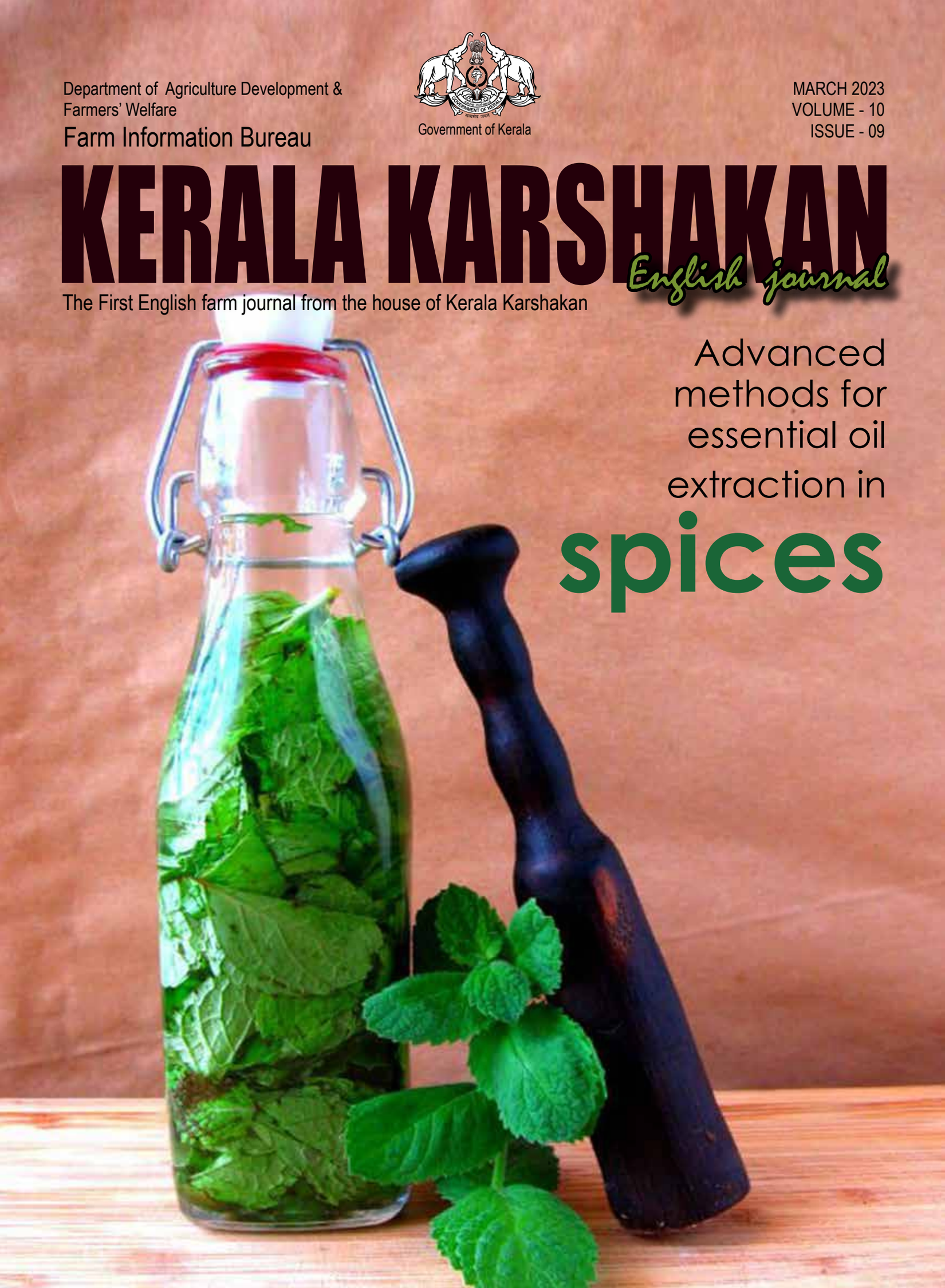
Government of Kerala

MARCH 2023
VOLUME - 10
ISSUE - 09

KERALA KARSHAKAN

English journal

The First English farm journal from the house of Kerala Karshakan



Advanced methods for essential oil extraction in spices

INSIDE KERALA KARSHAKAN

English journal

MARCH 2023 Volume - 10 Issue - 09

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Glory lilyan

Important Medicinal Climber

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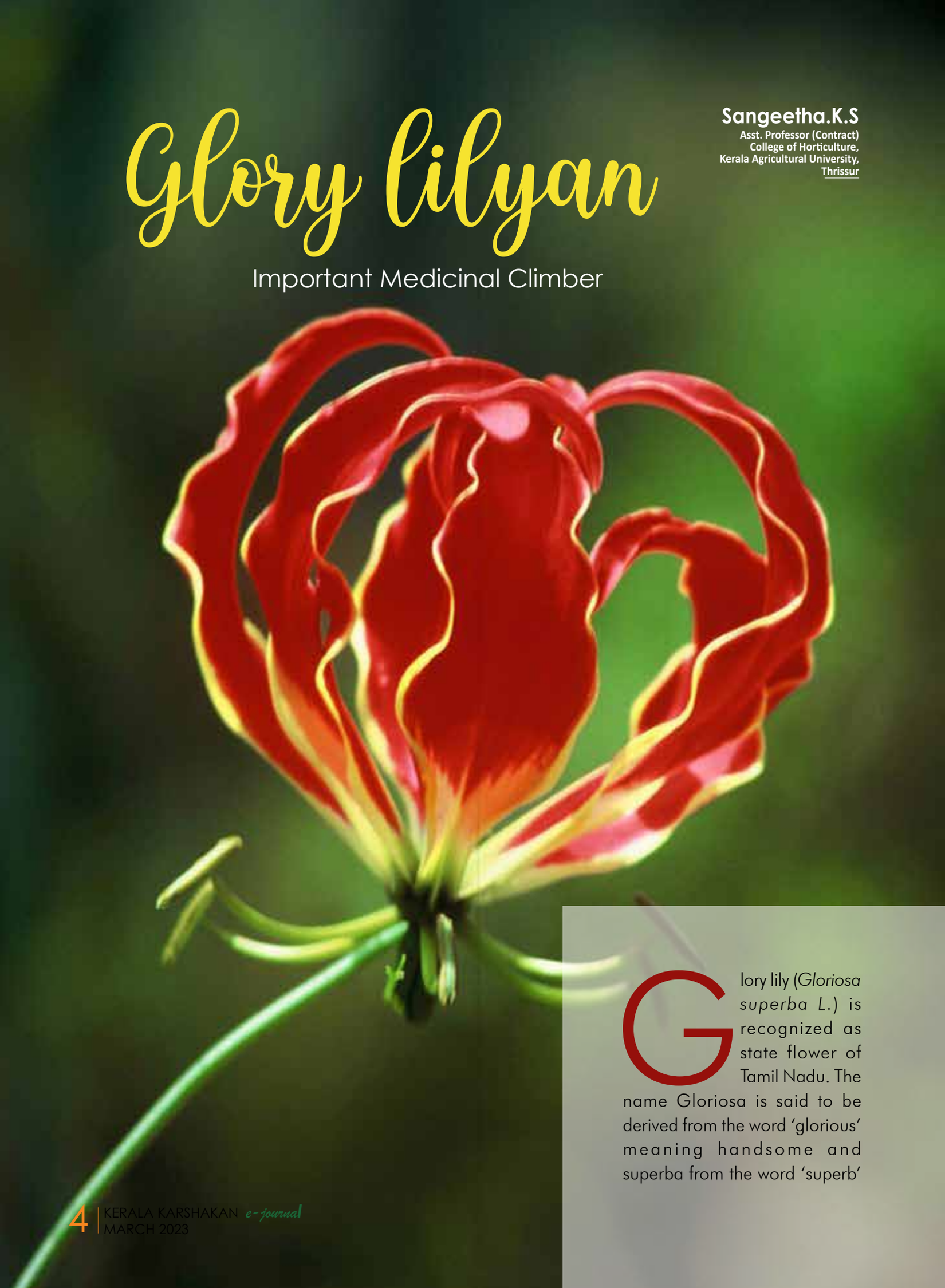
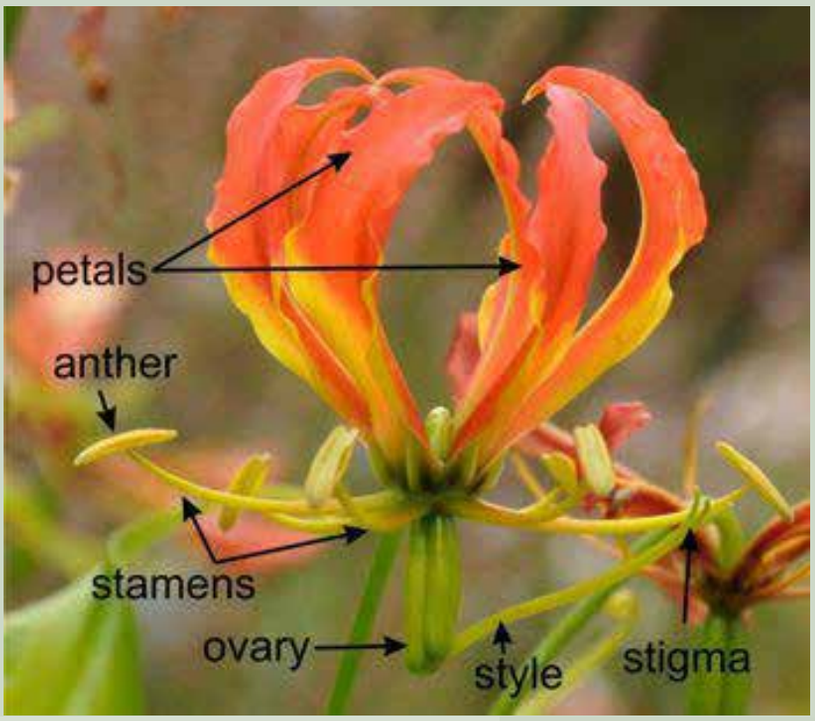


Glory lily (*Gloriosa superba L.*) is recognized as state flower of Tamil Nadu. The name Gloriosa is said to be derived from the word 'glorious' meaning handsome and superba from the word 'superb'

meaning splendid or majestic kind. It is native of South Africa and is widely distributed across the tropical and subtropical countries. Its natural distribution spreads mainly in tropical Asia, viz., India, Sri Lanka, Malaysia and Myanmar. In India, it is commonly found in Himalayan foot-hills of Central India, Tamil Nadu, Andhra Pradesh, Karnataka and West Bengal.

It is a herbaceous, climbing perennial, growing between 3.5 to 6 m in length, usually trained at 1.5 m above the ground level. The vines are tall, semi hard stemmed with tuberous roots that support themselves by means of cirrhosed tips. Leaves are sessile, alternate; flowers bright, solitary, at first greenish later becoming yellow and finally scarlet; fruit capsules containing many seeds.Red, loamy soils with good drainage and a pH range of 6.5-7.5 are suitable for its cultivation. The ideal temperature for cultivation of this crop is between 25°C and 32°C during day and 15-20°C during night.

It is propagated by tubers, seeds and by micro-propagation. Tubers each weighing 40-60g are selected for planting as they are vigorous and ensures maximum field stand. Gloriosa produces bi-forked tuber during the growing season and each of these forks has only one growing bud. Field is prepared by formation of ridges measuring 45 cm width, 45 cm



height and of convenient length depending upon the local soil types for planting of tubers. For conventional irrigation system, farmers adopt furrow planting. Planting of tubers is done during July-August. The tuber rate varies from place to place and in practice, farmers use 1-2 ton of healthy tubers to plant one hectare of land. The tubers are planted at a spacing of 45-60 cm. As a prophylactic measure against soil borne pathogens, application of *Trichoderma viride* and *Pseudomonas fluorescens* (each at 5 kg/ha.) is recommended.

Ten tonnes of compost is required for one hectare. A fertilizer dose of 60 kg N, 25 kg P_2O_5 and 40 kg K_2O/ ha is recommended. Of the nutrients, the whole P_2O_5 and K_2O and one-third of nitrogen is applied as a basal dose and the remaining two-third of nitrogen is given in the first six to eight weeks after planting. During the initial stages of crop establishment, frequent weeding is required to avoid competition

of weeds with the main crop. While weeding, utmost care is to be taken to avoid any damage to the growing tip of the rhizomes as once the growing tip is damaged it does not sprout again during the season.

Frequent irrigation is required during the sprouting time. An irrigation interval of 4-7 days during initial period and later on at an interval of 15 days is recommended. On an average basis, a plant requires 5 litres of water per day. No irrigation is required after flowering. Flood irrigation is in vogue in cultivated areas and off late drip irrigation is receiving popularity among growers.

The plant requires some kind of support, since the stem is tender. When the plants are about 30-40 cm tall, they should be staked or tied to wires or allowed to climb on some sort of frame. There are two types of structures adopted by farmers. One method is planting of four feet wooden sticks alongside of the furrows with the spacing of about 15 feet between sticks. 3-4 steel wires are tied parallel to the tip of wooden sticks. Sorghum straw is inserted in between steel wires. This facilitates the plant to climb. In the other method, the farmers use iron rods (3'*3'*3'), instead of wooden sticks and rest of the support system is same as in the case of wooden support system. The main disadvantage of wooden system is that wooden sticks are to be replaced frequently due to termite attack. It is characterized by very low seed set in nature. Hence, hand pollination is required due to peculiar position of stigma and anthers. Muslin cloth or cotton tied sticks can be used for pollination. Morning time (between 7-10 a.m.) is preferred for hand pollination.

Gloriosa is a perennial plant. The crop flowers during September – October and matures in 170-180 days after planting. A single plant produces 75-100 flowers and a single fruit contains 70-100 seeds. The right stage of harvest is when the capsule starts turning light green from dark green and skin of the fruit shows shrunken appearance and becomes light in weight. At this stage, when pressed the pod gives a cracking sound. The harvesting time is February (for crops planted in July). The fruits are harvested and dried in the shade for 10-15 days. The rhizomes, which are, buried beneath the soil again sprouts and the plant cycle continues with the advent of monsoon. The rhizomes are finally harvested after 5-6 years of plantation, cut into small pieces and dried in shade. After three years, from a well-managed field under irrigated conditions, about 300 kg/acre of dried seeds may be harvested. About one of tuberous roots is harvested after five years of the plantation (at the end of economic life of the plantation).

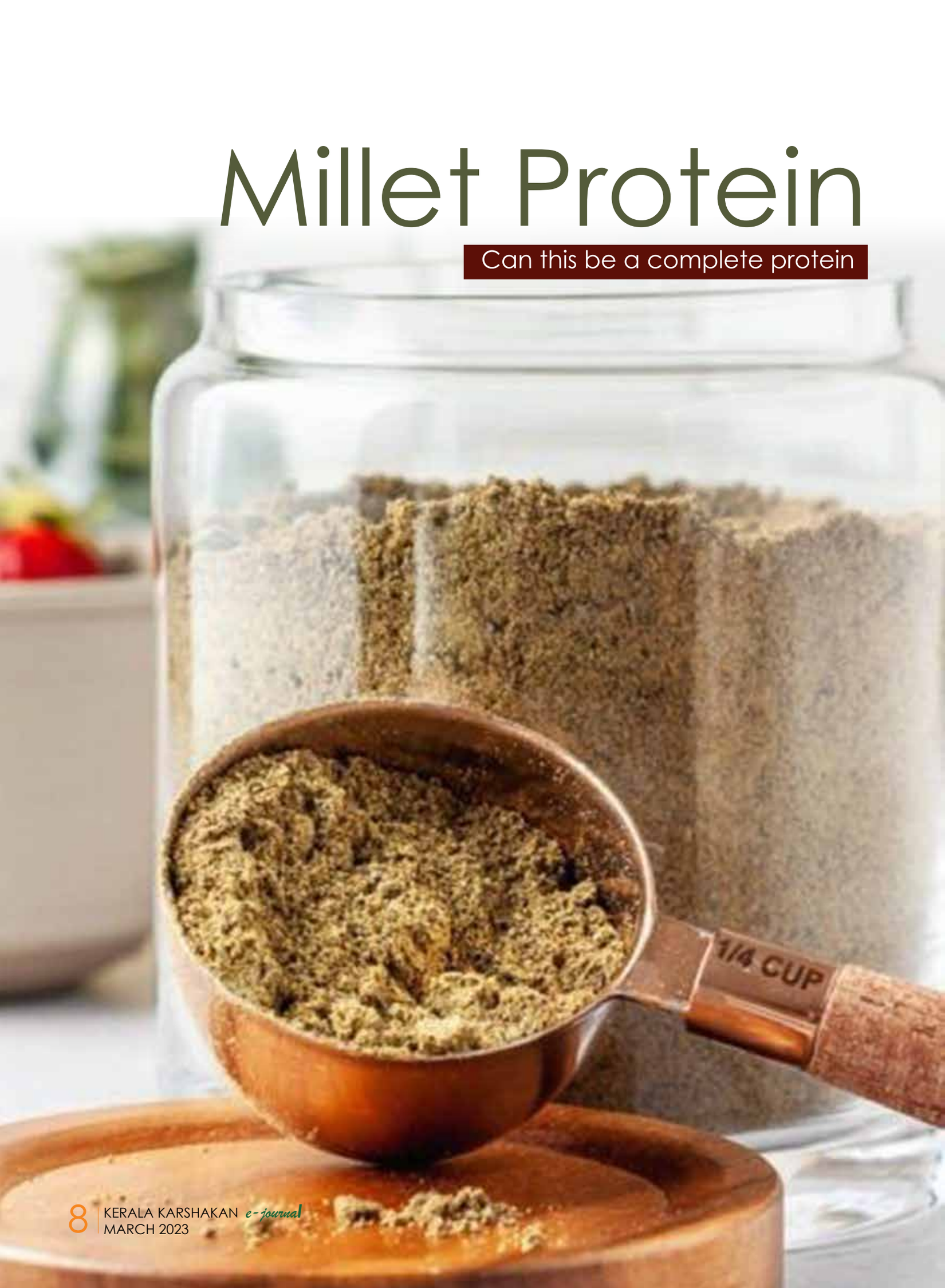
Medicinal uses

The tubers are used as tonic, antiperiodic, antihelmenthic and also against snake bites. It is used as poultices to relieve neuralgia, used in topical applications to treat arthritic conditions, swellings of the joints, sprains and dislocations. The tuber is traditionally used for the treatment of bruises and sprains, colic, chronic ulcers, hemorrhoids, cancer, and leprosy and also for labour pains. Paste of the tuber is externally applied for parasitic skin diseases. The tuber, pods and leaves were used to treat infections of guinea-worms, schistosomes (causing bilharzia), roundworm, tapeworm, liver fluke and filarial.

Soup made from leaf or tuber sap after due processing are administered to women suffering from sterility, delayed puberty, delayed childbirth and menstrual problems. Leaf juice, unripe fruits mixed with butter, and tuber macerate has been reported to kill head lice. It has to be mentioned with caution that glory lily tuber is extremely poisonous and causes fatal death if consumed. Seeds and tubers contain valuable alkaloids viz., colchicine and colchicoside as the major constituent, which is used to treat gout and rheumatism. Due to the action of colchicoside on spindle fibre formation during cell division, the plant has been identified as a potential anti cancerous drug.

Millet Protein

Can this be a complete protein



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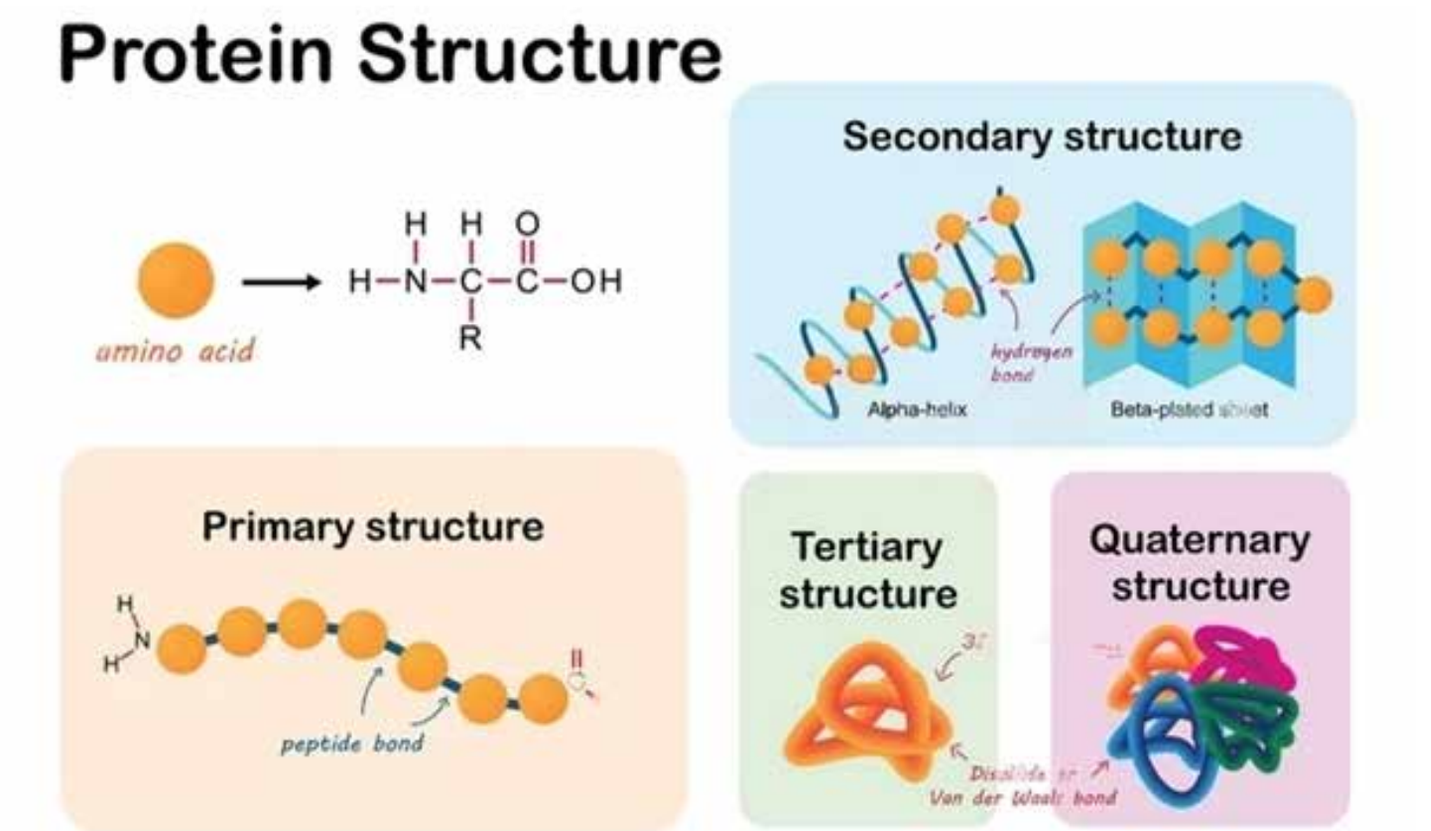
Polymers of L- α – amino acids are known as proteins, The macronutrient protein. which is made up of amino acids, is crucial. The proteins we eat are broken down in the digestive tract and taken up as free amino acids and minuscule peptides. Protein is present in every organ and tissue of the body including muscle, bone, skin and hair. Of the 21 amino acids that make up protein, 9 amino acids are essential, that must be obtained from food because they are not produced by the body: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Amino acids are the building blocks of protein and are responsible for its structure. Primary, secondary, tertiary and quaternary structures are the four main stages at which protein structure is defined.

Based on their functionality proteins are differentiated into 9 types as follows, Structural proteins, storage proteins, catalytic proteins, contractile proteins, regulatory proteins, receptor proteins, genetic proteins, gefence proteins, and transport proteins. Nutritional proteins are classified



into three groups as follows, Complete proteins, Incomplete proteins and Poor proteins. Proteins that are composed of all essential amino acids are known as Complete proteins, while proteins lacking one essential amino acid are known as incomplete proteins, and if proteins lack more than one essential amino acid they are known as Poor proteins. For example – Casein and egg albumin are complete proteins, pulses and cereals fall under incomplete proteins as

they are lacking lysine and corn is poor protein as they lack tryptophan and lysine.

The majority of the protein found in cereals comes from endosperm storage proteins, which are relatively low in dietary necessary (indispensable) amino acids. Since different amounts of these amino acids are needed, quality can only be taken into account in relation to needs. Typically, millets are referred to as Nutri cereals, Amaranthus, quinoa, and buckwheat are referred to as pseudocereals, and oats, barley, and wheat are considered cereals. As cereals lack lysine which is one of the essential amino acid they are known as incomplete proteins. the protein content of major millets is as follows – finger millet 7-9g, sorghum 10 -11.5g, pearl 10.5-11.8 g and minor millets have exhibited the following protein content, foxtail millet11-12.3 g,

Little millet 7- 8.5 g, Kodo millet 8-9g, Proso millet 11.5-12.5 g and Barnyard millet 6-8 g; As per the Indian Recommended dietary allowances every adult individual should consume approximately 54-60gms of proteins per day based on body weight. In fulfillment of Protein RDA, it is mandatory to include both complete and incomplete proteins in daily diets.

Millet Protein

Millets are superior to maize, and rice in terms of fatty acids and are high in amino acids, particularly sulfur-containing amino acids (methionine and cysteine). Millets generally have low levels of lysine though this varies with cultivar. However, most cereals have a good amount of vitamins and minerals in addition to the necessary amino acids.

Amino acid composition's concentration and distribution pattern majorly impact the bioavailability of the protein in millets. The structural and qualitative characteristics of the millet proteins as well as their fractionation were significantly impacted by the novel processing methods, such as microwave, ultrasonic and high-pressure processing. The non-thermal procedure ensured that the millet protein's structure and stability were changed and their functionalities improved. In terms of making millet protein complete, it's the best way possible through developing composite products in secondary processing.

In secondary processing – Cold extrusion, non-thermal processing will show the best end-product results in terms of the development and bioavailability of the complete protein. There are some products like Plantain peel incorporated jowar pasta, and multi-millet chicken soup.

Plantain Jowar Pasta

Pasta is one of the most used foods in the western side

Processing of Plantain Jowar Pasta

Blend all flours including gums and salt in a blender

↓

Add water and condition for 2 hours

↓

Extrude the pasta in tubular pasta die

↓

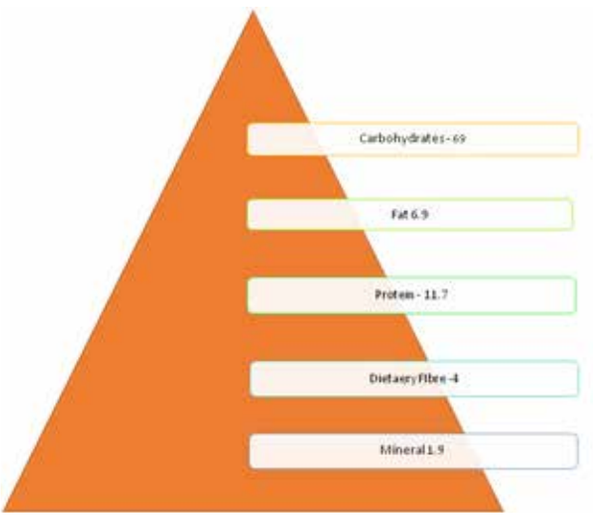
Steam the pasta for 20mins

↓

Dry steamed pasta, in a tray dryer for 6 hours @600C

↓

cool pasta to room temp and pack in the pouches



Plantain Jowar Pasta

and the most tried food in other parts of the globe. The pasta is made in the cold extruder, usually, pasta is made with wheat and water. But here due to the lack of gluten we need more amount of starch content in pasta making starch content here forms gelatinization and gives proper binding and textural properties to the product.

Pasta is made using the following ingredients 60% Jowar, 20% Arrowroot powder, 15% plantain powder, and 5% gums and salt.

Multi Millet chicken soup mix

Soup is meant to be the best refreshing drink. When this refreshing drink. can give you a major change in mood, why can't it be healthy refreshment, in terms of balanced nutrition? It is all about balanced/complete nutrition, but when it is known millet protein is incomplete, we have come up with High lysin content foods, to make millet soup with complete nutrition.

Multi millet chicken soup is developed with Jowar, Ragi, foxtail, little millets, (12.5% each – 50%) and chicken powder (25%), dehydrated vegetables (15%), Tapioca starch (5%), Spices (5%)

Soup Making

Unpack the soup mix into 200ml of water, mix well until lump free, boil it for 4-5 mins, serve hot n healthy and nutritious refreshing Multi Millet Chicken Soup.

Conclusion

Yes, it is possible to make every/any dish with millet, but when it comes to complete and balanced nutrition in terms of micronutrients, and availability of all essential amino acids, only lysine is deficient. In making millet complete protein, it is always suggested to make combination with high lysine foods like, chicken, plantain, Banana Flour and meat. In making the dishes healthy and nutritious, composite products i.e; combining two different commodity ingredients and making one product are always convenient and widely accepted by manufacturers and even consumers throughout the globe.

Processing of Multi Millet Soup mix

Blend the millet flour together

↓

Dehydrate chicken Breast and made it into powder
(Cooked and dried in tray dryer at 60^{0}C for 12 hours)

↓

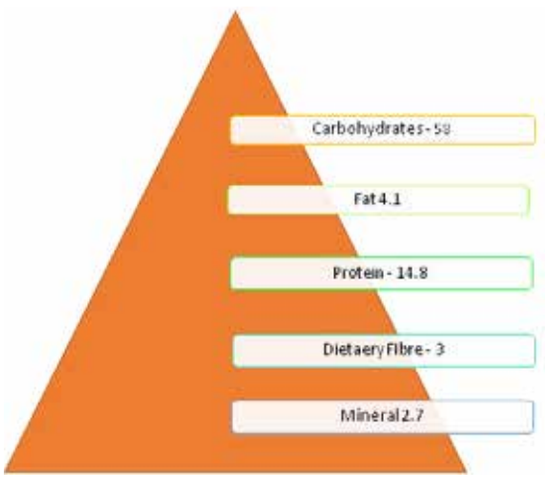
Dehydrate Vegetables
(Carrots, beans, onions, and potatoes, are blanched, dried in a tray dryer at 60^{0}C for 12 hours)

↓

Blend Multi Millet flour, Chicken powder, tapioca starch, and spices

↓

Pack the mix in pouches and stores in cool n dry place



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Advanced methods for essential oil extraction in spices

Introduction

Spices are food adjuncts that are valued for their aroma, taste, medicinal and preservative properties. India being the spice bowl of the world, produces over 75 spices out of the 109 varieties listed by International Organization for Standardization (ISO). India exported spices worth US $ 4.18 billion in the year 2020-21 which was 34% more than the previous year records. Thus, spice industry of the country is found to be a dynamic sector contributing

profusely to the economy of the nation. Compared to the various forms of spices, spice extractives have better stability in terms of flavour and storage. The two important categories of extractives include, essential oils and oleoresins. In order to recover these extractives, cell-matrix of the respective spice has to be disrupted. Generally, dried spices are used for the extraction purposes compared to fresh spices as they have better stability and are more concentrated. Dried material is crushed to increase the surface area so that solvent can well diffuse into the cell matrices.

Essential oils are volatile aromatic liquid oils extracted traditionally by hydro or steam distillation of spices. They are complex mixtures of low molecular weight compounds and are responsible for the aroma produced from any spice. There are approximately about 3000 essential oils being extracted and among these around 300 are of commercial importance. Essential oil does not represent complete active constituents of a spice as they contain only volatile components. Oleoresins are the non-volatile part of any spice and they are highly concentrated with wholesome flavour, aroma and pungency of the respective spice. Compared to fresh and ground spice, oleoresins are considered more hygienic. Extraction of oleoresin involves the use of various solvents and acetone is the most commonly used one. The threshold solvent in the extract after the extraction is removed by evaporation or distillation. Solvent extraction is the conventionally followed method for the extraction of

oleoresin.

Essential oil extraction methods

Generally, essential oils are extracted either by traditional or by innovative or non-traditional methods. Traditional methods of oil extraction mainly comprise of hydro-distillation which includes water distillation, water and steam distillation and direct steam distillation. The elevated temperatures involved in these methods can cause chemical modification of the oil components and loss in volatile molecules. Often in solvent extraction, it is impossible to obtain a solvent-free product and this process usually results in loss of the highly volatile components. These disadvantages have led to the development of new ''green'' techniques in essential oil extraction, which typically use less energy and avoid solvents. Some of these new technologies are discussed below:

- Super critical fluid extraction (SFE)
- Microwave assisted extraction
- Headspace trapping techniques
- Solid phase micro-extraction (SPME)
- Ultrasound assisted extraction

Supercritical fluid extraction (SCFE)

Super critical fluid extraction is a novel technique in extraction process wherein compressed gas can be used to dissolve solids (solutes). Fluids beyond their critical conditions are known as supercritical fluids and they exhibit the behavior and physicochemical properties of both liquids and gases. Carbon dioxide is commonly used supercritical fluid in food

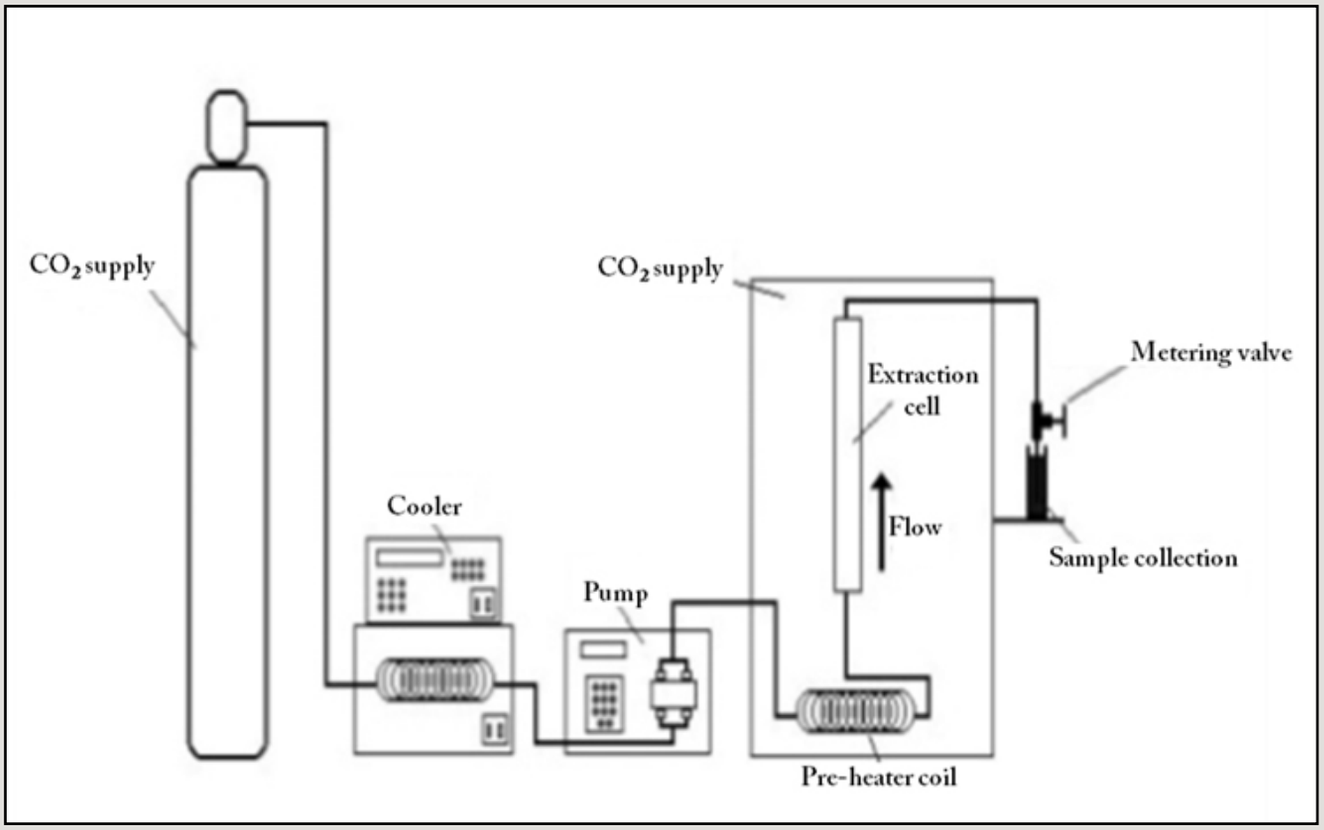

Fig. 1 Batch type super critical fluid extraction system

processing extraction operations which at super critical conditions (Tc = 31^{0}C, Pc = 73 atm) has the flowability of gas and density comparable to that of liquids and hence the solubilizing power of liquids. After extraction the solvent can be removed by releasing pressure when CO_2 leaves the solute and escapes as gas. In general, fluids near their critical points have the dissolving power comparable to that of liquids and transport properties of gas. These unusual physico-chemical properties can be judiciously exploited to carry out separation operation by extraction which may be otherwise difficult by traditional extraction process using organic solvents.

SCFE has the following advantages:

- Quick extraction process
- Improved separation process
- No problems of residual solvents
- Results in products which are relatively pure
- Lower operating costs

SCFE process consists of two units namely extraction unit and expansion unit separated by an expansion valve. Schematic arrangement is shown in Fig. 1.

The material is fed into a cylindrical vessel known as extraction section. The vessel is filled with CO_2 or other SCFE solvent, and is pressurized using a compressor until the desired pressure is reached which can be read on the pressure gauge. Usually pressures are of the order of 75 – 300 atm (7.5 to 30 MN/m^2). The preferred temperature range is 35 – 80 ^{0}C. The system is allowed to equilibrate for sufficient time with the food solids and SCFE fluid. The diffusion of SCF into solid matrix is rapid, but the solubility of solute into solvent may require prolonged contact time for better extraction. The extracted CO_2 is taken into another chamber known as the separation section. All extracted material with solvent at higher pressure is trapped in expansion tank. Once pressure is released, CO_2 loses its super critical nature and solubility of solute drastically reduces and solute is separated. CO_2 is either lost off or recycled into compressor for next extraction. The spent solids are discharged from the extraction chamber.

Advantages of using CO_2 as SCFE fluid are:

- CO_2 is most unobjectionable as a solvent from health point of view and scores over most of the organic solvents
- It is ubiquitous in nature. It is inexpensive and readily

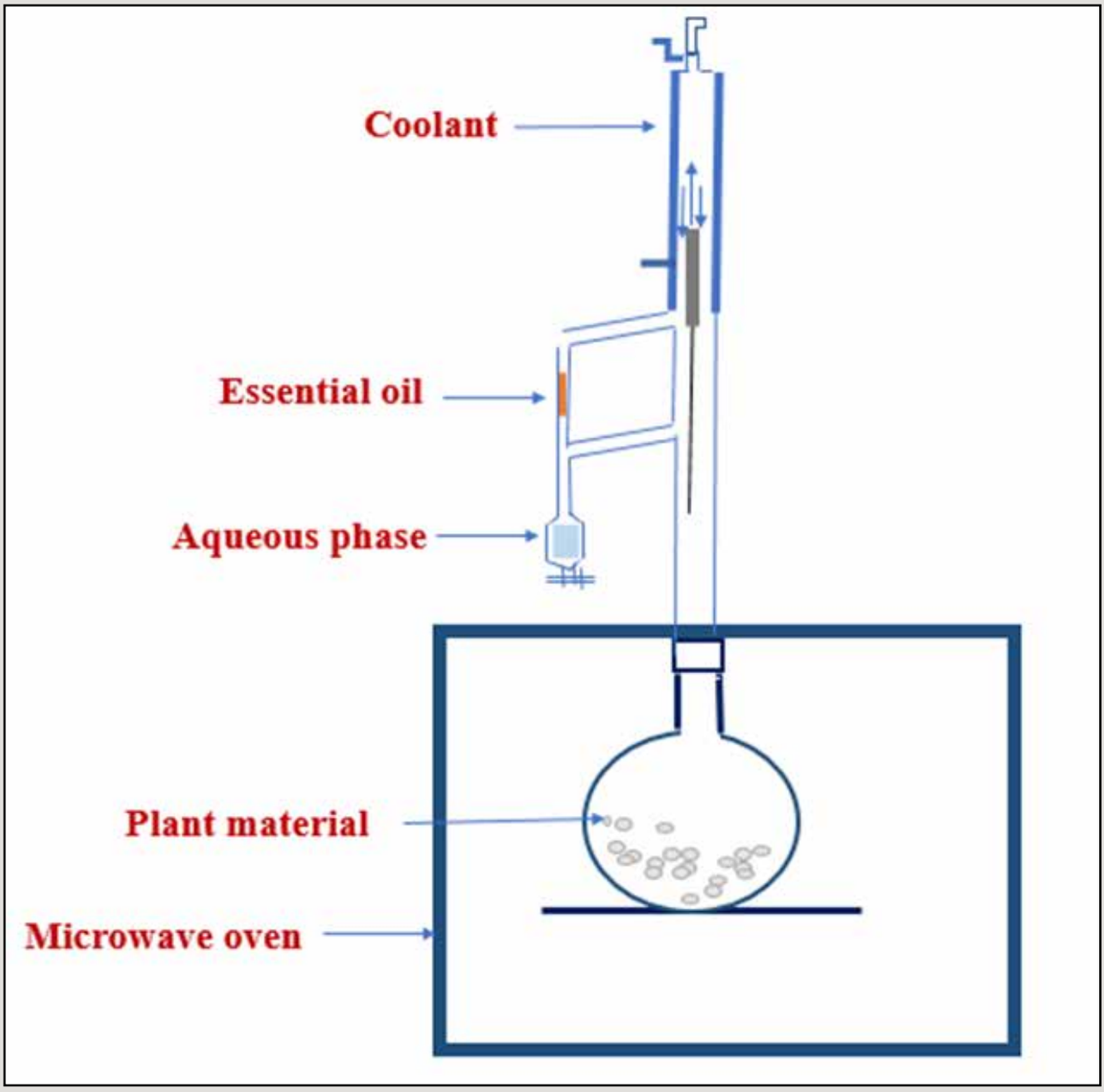

Fig.2 Microwave distillation apparatus

available in pure form.

- It is inert and does not react with solute during extraction
- It is neither inflammable nor toxic
- It does not corrode the container in its native form or in combination with moisture

Microwave-Assisted Extraction

Microwaves are non-ionizing electromagnetic radiation in the frequency range of 300 MHz - 300 GHz with a wavelength of 1 mm-1m. Microwaves penetrate the material until moisture is located and heats up the material volumetrically thereby facilitating higher diffusion rate and pressure gradient to expel moisture from inside of material. Extraction using microwaves involves keeping the fresh plant material in a microwave reactor, without any added solvent or water. The internal heating of the in-situ water within the feed material enlarges and stretches out the plant cells and leading to the rupture of the glands and oil-bearing receptacles. This process thus releases essential oil, which is evaporated by the in-situ water of the plant material. A cooling system outside the microwave oven condenses the distillate continuously. The excess water is refluxed to the extraction

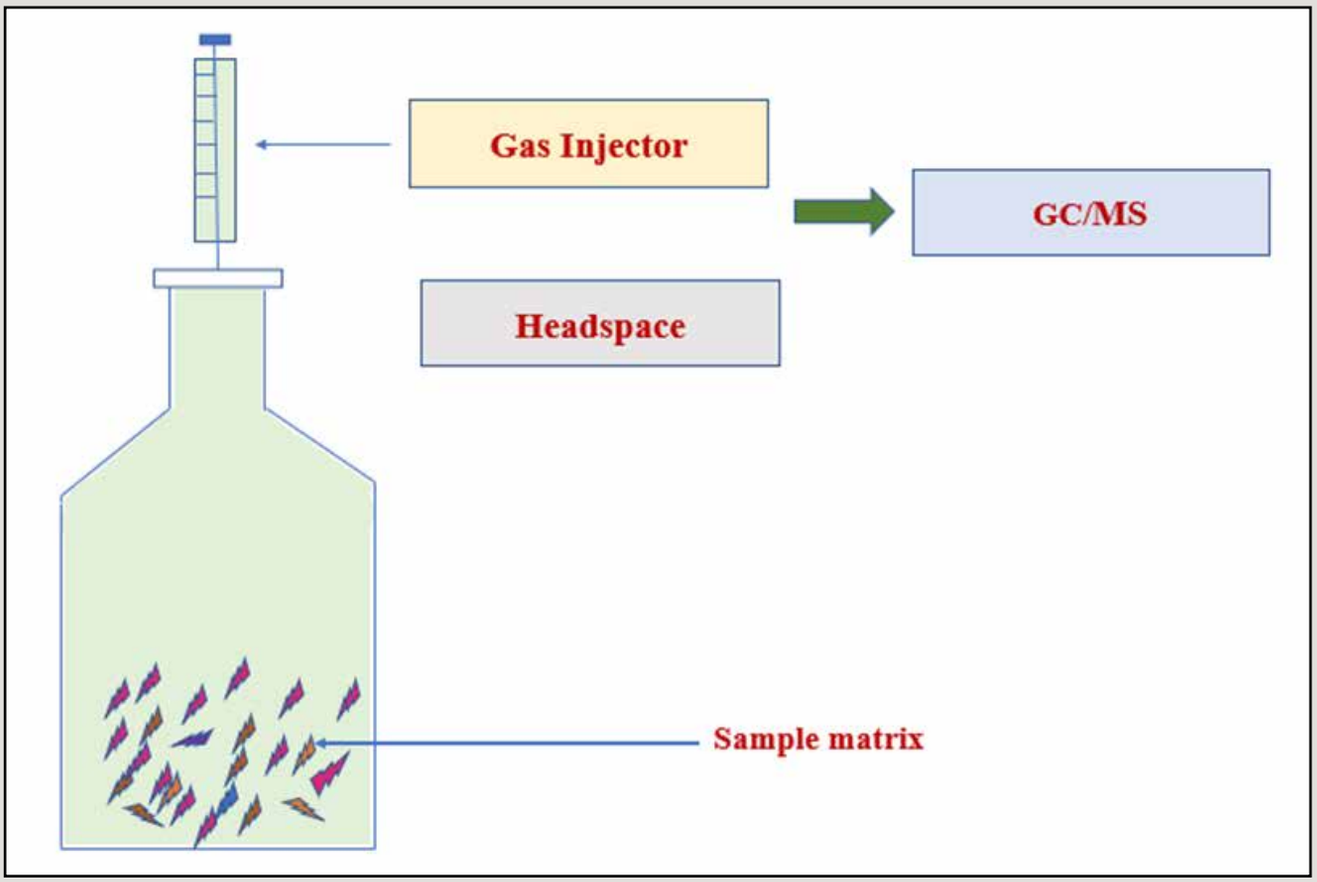

Fig.3 Static head space sampling

vessel in order to restore the in-situ water to the plant material. The extracted compounds were removed from the aqueous extract by simple decantation. MAD is a green technology and appears as a good alternative for the extraction of edible essential oils from aromatic plants in food industry. Schematic representation of microwave-assisted distillation unit is shown in Fig. 2.

Headspace Trapping Technique

Headspace trapping is essentially a separation technique in which volatile material is extracted from a heavier sample matrix and injected into a gas chromatograph for analysis. The process involves extracting a small volume of the headspace vapor from the aromatic material through a vial and transferring it to the GC column. Headspace trapping techniques are of three types: static, dynamic and vacuum head space technique. In the static headspace sampling technique, analyte is kept in a closed vial and the headspace air above the solid or a liquid sample is sampled and directed on to the gas chromatography column (Fig. 3).This method is convenient for extraction of volatiles from various food matrices. A major draw back of this method is its low sensitivity, especially when compared to solid-phase microextraction methods. Dynamic headspace trapping is an extraction technique used to concentrate analytes from a solid or liquid matrix. The sample is heated and agitated in a sealed vial and the headspace above the sample is purged onto a solid sorbent tube. The solid sorbent tube is then thermally desorbed into the gas chromatograph. Vacuum headspace sampling technique involves suction of the headspace air through a vacuum pump with condensers cooled with liquid nitrogen to condense odorous principles. This technique is also used by some perfumery companies for commercial-scale production of fragrances.

Solid phase microextraction

Solid phase microextraction is a solvent-free and non-invasive technique used to trap flavors from aqueous samples or from the headspace of food matrices. The system uses fiber coated with an extraction phase: a liquid (polymer), a solid (sorbent), or a combination of both (Fig. 4). The coated fiber is encased in a protective needle

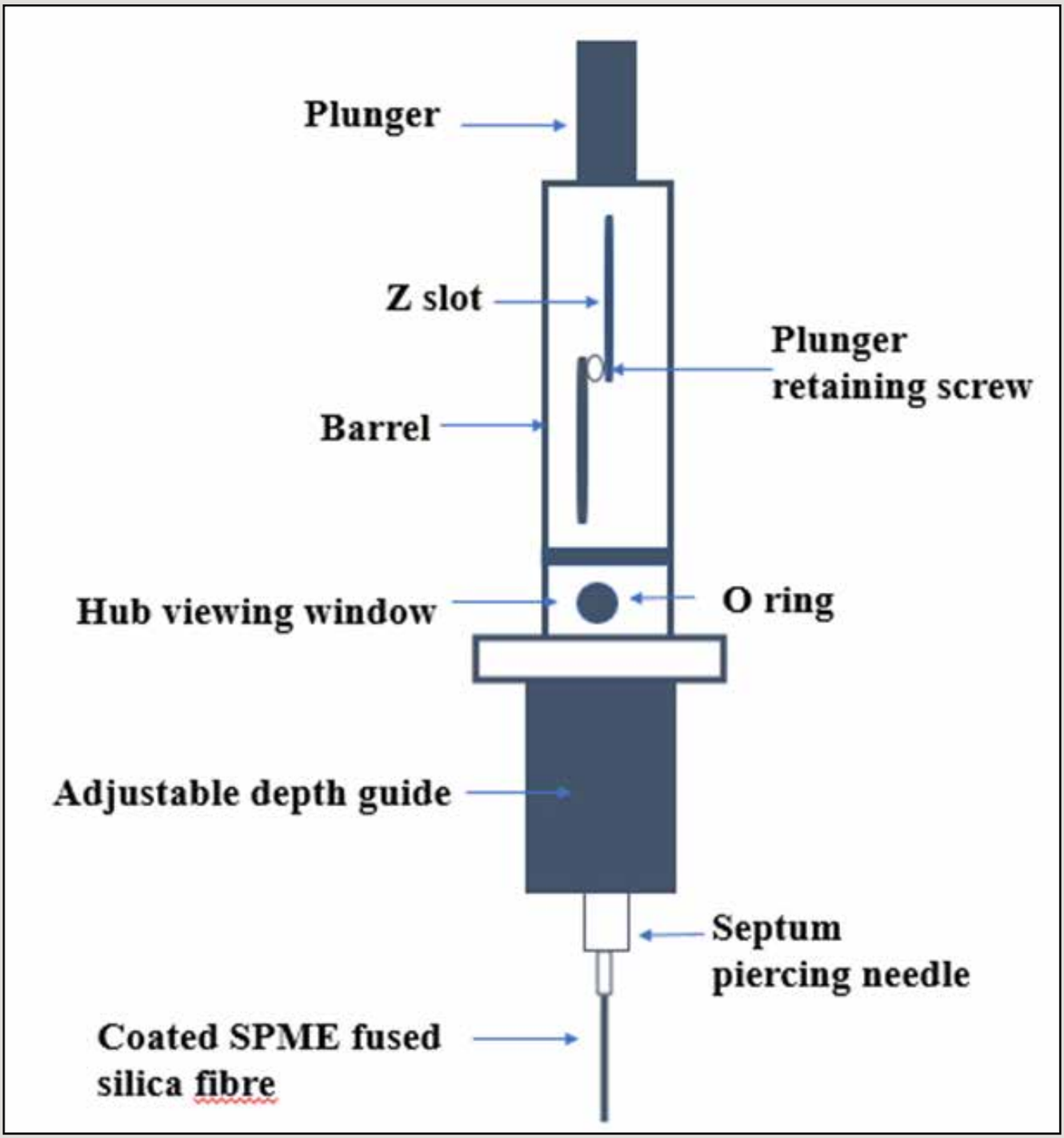

Fig.4 Solid phase micro extraction

and attached to a holder that resembles a syringe.When the fiber is exposed to a sample, the analytes partition from the sample into the stationary phase until an equilibrium is established. The coating on fiber extracts compounds from the sample either by absorption (liquid coatings) or adsorption (solid coatings). After the extraction, the fiber is removed and inserted directly into a chromatographic instrument, gas chromatography or high-pressure liquid chromatography for desorption and analysis. Advantages of SPME include easiness for automation, solvent-free, non-destructive to samples and the reusable and inexpensive nature of fibers.

Ultrasound assisted extraction (UAE)

Ultrasonic-assisted extraction also known as sonication-assisted extraction is an important technique for extracting volatile compounds from the biological materials. The

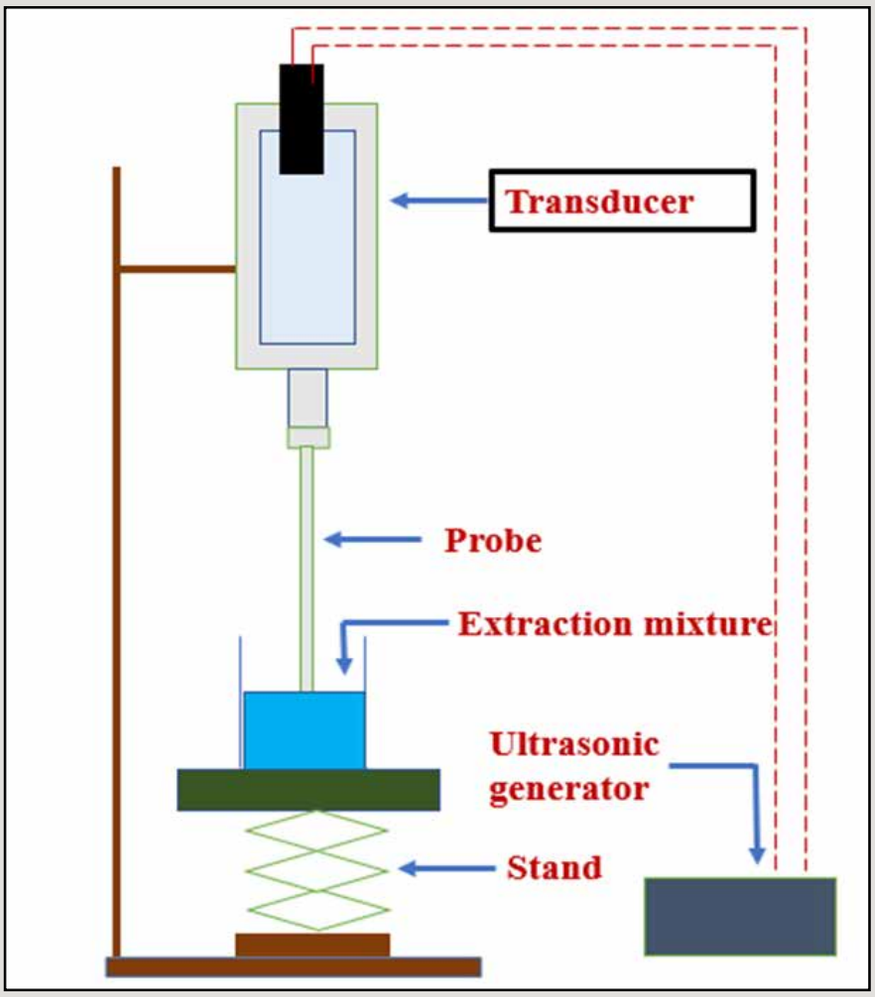

Fig.5 Ultrasound assisted extraction

mechanical effect of ultrasound accelerates the release of organic compounds contained within the plant body due to the phenomenon called cavitation that eventually disrupts the cell wall and enhances contact between solvent and target cell constituents. Generally, ultrasound is applied either by ultrasonic cleaning bath or ultrasonic probe system. Ultrasound-assisted extraction is cheaper than microwave assisted extraction systems. A schematic drawing of a UAE system is shown in Fig. 5. Power ultrasound with frequencies between 20 kHz and 100 MHz are applied for ultrasound assisted extraction techniques. When a food matrix is exposed to power ultrasound, the microbubbles are formed, grown and eventually collapsed by a phenomenon called cavitation. Cavitation is the generation of small vacuum bubbles or voids in the liquid, which implode at the solid sample resulting in localized high temperatures (about 4500°C) and pressures (about 50 MPa). These forces produce effects such as sonolysis, destruction of cell membranes, and the extraction of intracellular material. A major drawback of ultrasound distillation is the detrimental effect of ultrasound energy (more than 20 kHz) on the active constituents of medicinal plants through the formation of free radicals and consequently undesirable changes in the drug molecules.

Conclusion

Essential oils that constitute the volatile constituents of spices are generally derived from one or more plant parts, such as flowers, leaves, stem, bark, wood, roots or seeds. However, the process of extraction plays a vital role affecting the physical properties and chemical constituents of the final product. Essential oils are evaluated for their appearance as well as olfactory properties. Advanced extraction methods enhances the quality of extracted oils as they are not subjected to extreme temperature conditions. However, advanced research and development should be made to enable continuous production of essential oils by innovative extraction technologies.

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SPACE SAVING BEAUTY GREEN WALLS

Vertical Gardening is a special kind of urban gardening suitable to small spaces, particularly for decorating walls and roofs in various styles. A vertical garden is a garden that grows upward (vertically) using a trellis or other support system, rather than on the ground (horizontally). These gardens may be of portable type. Plant stands are made in such a way that the beauty of the plants is viewed from all sides. Portable types of plant stands can be kept at the entrance of house or even inside a big hall. Pot plants can be replaced from time to time for a change and to introduce variety. It can be shifted from place to place.

Benefits: Green walls are not only spectacularly beautiful, but also helpful in enlivening the ambiance, absorb hot gas in the air, reduce both indoor and outdoor temperature, providing a healthier indoor air quality as well as a more beautiful space. With the vertical garden, we use vertical space to stack, hang and plant, saving your horizontal space. This is an important feature for those short of planting space in corridors, or apartments with small balconies. It acts as a natural insulation for hot and cold air and save energy for your building. It provides protection to buildings from adverse temperature and hence improves the life expectancy of the buildings.

Types of Vertical Greening System

1. Green Facades: A type of green wall system in which

climbing plants or cascading groundcovers are trained to cover specially designed supporting structures.Plants are either grown in ground or in elevated containers where they are watered and fertilized. Green facades can be anchored to existing walls or built as freestanding structure, such as fences or columns

2. Green walls / Living walls: Living wall system composed of pre-vegetated panels, vertical modules or planted blankets that are fixed vertically to a structural wall or frame. These panels can be made of plastic, expanded polystyrene, synthetic fabric and support a great diversity of plants species. These tend to require more maintenance such as fertilizer and water than green facade systems that are planted into the ground.

a) Modular Green Wall: They are made up of recycled poly propylene material. It has attractive look, highly durable in nature and it can be easily installed.

b) Vegetated Mat Wall: This system is composed of 2 layers of synthetic fabric with pockets filled with the plants and growing media. The fabric walls are supported on a framework and backed by a waterproof membrane against the building wall. Nutrients and water are delivered through an irrigation system at the top of the wall.

Establishment: Location is an important part of vertical gardening. Make sure to place garden arbours and other structures where they will not shade out other plants. Plants grown outside in vertical gardens can include flowers, herbs or vegetables.

Plants for Vertical Gardening: Flowering plants such as impatiens, moss roses, annual lobelia, sweet alyssum or sedum are examples of plants that fill-in mass, making planter look like a colourful carpet. Annuals such as nasturtium, morning glories and sweet peas will grow quickly in a single growing season and then die off. Vines are an obvious choice for growing on fences, garden arbours, and trellises which are attractive for both their foliage and flowers. Wisteria and trumpet creeper are popular vines that have beautiful flowers and fill out with lush, green leaves. Popular perennial vines include ivy, clematis, bougainvillea, climbing roses, jasmine and honeysuckle. There are a number of fruits and vegetables that can be used in vertical garden. Eg: Cucumbers, tomatoes, melons and pole beans can be grown on vertical structures such as trellises.

Growing Media: Weightless media with highwater holding capacity, highnutrient holding capacity, good porosity and neutral pH is most suitable. Cocopeat, Perlite, Sphagnum moss, vermiculite, vermicompost, shredded bark and leaf molds are the common media combinations used. Soil is not used since it increases the weight of the green walls.

Irrigation: Irrigation system is designed to minimize water consumption. Interruptions to the water supply are a common cause of plant failure on green walls. Water consumption varies with heat and sun exposure, but compared to normal green spaces or a lawn, the consumption is normally lower.

Light: Even if the least light demanding species are used, artificial light is normally necessary indoor. A few species will stay fine at 900 lux, but a slightly increased level at some parts of the surface will broaden the variation of species that can be used.

General Considerations

- Watering at appropriate time
- Careful selection for wind prone areas (Succulent and hardy plants)
- Removing the dried leaves
- Keeping the structure clean
- Disposing the water from drainage system
- Pruning if necessary
- Timely application of fertilizers

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AROMATIC CROPS

A SUSTAINABLE APPROACH FOR REMEDIATION OF HEAVY METAL CONTAMINATED SITES

Introduction

Industrialization and urbanization have no doubt made our life easygoing but this privilege has come to us at several costs and environmental pollution is the most severe among them. Mainly two pollutants viz. inorganic and organic, are responsible for the deterioration

of the health of soil and water ecosystems. Inorganic pollutants have high toxicity and among these, heavy metal pollution is posing a great threat to the existing livelihood as well as the environment. Phytoremediation has emerged to be one of the most preferable choices for combating metal pollution. However, use of edible crops for phytoremediation is not viable because the heavy metals enter into food chain via consumption either by humans or animals. As a solution to tackle this problem, aromatic crops can be an alternative, as they are non-food crops, thus minimizing the risk of food chain contamination. Aromatic crops can be grown on heavy metal contaminated soils, without causing any significant risks of metal transfer from soil to oil and alterations in essential oil composition.

Phytoremediation strategies

According to Landmeyer (2011), phytoremediation is the application of plant controlled interactions,with groundwater and organic or inorganic molecules, at contaminated sites to achieve site specific remedial goal. The strategies used for the process

of phytoremediation can be categorized into phytoextraction, phytostabilization, phytodegradation, phytovolatilization, rhizofiltration and rhizodegradation. Phytoextraction is the process of absorption of contaminants from contaminated sites by roots and their translocation and accumulation in the above ground plant parts, whereas phytostabilisation is the use of certain plant species to immobilise contaminants in the soil and groundwater by absorption and accumulation by roots, adsorption onto roots or precipitation within the root zone of plants. Phytodegradation involves breakdown of contaminants taken up by plants through metabolic processes within the plant. Phytovolatilization results in extraction of contaminants from contaminated sites through roots, conversion into less-toxic ones within the plant and release into the atmosphere in volatile forms through the leaves. In rhizofilteration, adsorption or precipitation onto plant roots or absorption of contaminants from the solution surrounding the root zone takes place, whereas rhizodegradation results in breakdown of contaminants with in the plant root zone, which is carried out by bacteria or other microorganisms flourishing in the rhizosphere.

Phytoremediation - a solution for heavy metal contamination

The main concept behind phytoremediation is that plants extract toxic elements from the soil, convert them into less toxic forms without contaminating the food chain as well as give economic benefits. Remediation through plants is a more sustainable and feasible approach than any other methods as it does not harm the physical and biological properties of soil. Moreover, it improves the quality of soil with time. There are several reports on utilization of plants as a tool in remediation of contaminated sites. Indian mustard (*Brassica juncea L.*), an edible oil producing crop is mostly used for phytoremediation purposes. Other crops such as sunflower (*Helianthus annuus*), rapeseed (*Brassica napus*), and maize (*Zea mays*) are also widely used. But the problem of heavy metal contamination remains the same if we use edible crops for phytoremediation. These crops are being consumed by human or animals in one orthe other forms. Ecologically, use of edible crops for phytoremediation is not viable because the heavy metals enter into food chain either through consumption by human or animals.

Aromatic crops for phytoremediation and its benefits

The cultivation of aromatic crops at heavy metal contaminated area is a profitable and feasible option. Aromatic crops are cultivated especially for their secondary metabolites and there is little or limited risk involved in the use of the key product (essential oils), since it is not directly linked to food chain. Aromatic crops being natural colonizers, perennial in nature with multiple harvests, unpalatable and highly tolerant against stress conditions, can be a potential candidate for remediation purpose. The benefits of using aromatic plants for phytoremediation can be categorized as, environmental and economic.The major environmental aspect regarding use of aromatic plants for phytoremediation is that by using them, contaminant's entry into the food chain can be reduced. Economic aspect is regarding the ever increasing demand of essential oil. Aromatic grasses can be grown on contaminated sites which can help in their restoration and also for the extraction of essential oil for monetary benefits. A large number of aromatic plants have been tested for their phytoremediation potential. Perennial aromatic grasses (Family- Poaceae) like vetiver, lemon grass, palmarosa and citronella. Other plants like ocimum, mint, lavender, salvia, rosemary (Family – Lamiaceae), chamomile (Family – Asteraceae) and geranium (Family – Geraniaceae), hold great potential for phytoremediation of heavy metal contaminated sites (Pandey et al., 2019).

Vetiver (*Chrysopogon zizanioides*)seems the most suitable aromatic grass for remediating both surface and deeper contaminants in soils because of good and deep rooted system, which penetrate vertically deep into the soil and its initial growth rate of 3 cm per day, reaching over 2 m in just six months to 6 m in three years. Since vetiver has longer life duration it can be considered as a long-term putative candidate. Rotkittikhun et al. (2010) found that vetiver can tolerate high lead concentrations without exhibiting any phytotoxicity and can be used for stabilization of heavy metals in contaminated land. Pandey et al. (2019) observed that lemongrass (*Cymbopogon flexuosous*) could be an ideal candidate to grow in tannery effluent contaminated sites for phytoremediation. It acted as a potential phytostabilizer for chromium and phytoextractor for nickel and lead. Boruah et al. (2000) found that Java citronella (*Cymbopogon winterianus*) can act as a potential phytostabiliser of cadmium. Field experiment by Pandey et al. (2015) revealed the heavy metal uptake of shoots and roots of palmarosa (*Cymbopogon martini*), when grown in tannery sludge. Geranium (*Pelargonium sp.*) is used as multi metal hyperaccumulator and this property has been patented (Krishnaraj et al., 2001). Mint (*Mentha sp.*) can act as a phytostabilzer in heavy metal contaminated sites, as most of the metals are accumulated in the roots with minimum translocation to the aerial parts. Basil (*Ocimum spp.*) can act as a potential phytostabiliser.

A comparative evaluation of arsenic accumulation in basil was investigated by Siddiqui et al. (2013) and it was found that maximum arsenic was accumulated by *Ocimum gratissimum*, followed by *Ocimum basilicum* and *Ocimum tenuiflorum* and the order of accumulation was roots > stem > leaves. Chamomile (*Chamomilla recutita*) acts as a metal excluder or facultative metallophyte. Salvia (*Salvia sp.*) and lavender (*Lavandula sp.*) were found to be hyperaccumulator of metals. Rosemary (*Rosmarinus officinalis L.*) can act as a potential biomonitor, phytostabiliser as well as hyper accumulator.

Risk assessment and sustainable utilization of contaminated biomass

The major concern regarding the feasibility of phytoremediation is the safe disposal of contaminated plant biomass. Many methods for safe disposal are available, which include burning/direct combustion, biomethanation, gasification, bricketting, chemical extraction and phytomining. The major product of aromatic crops is essential oil which is mainly used for non-edible purposes like soaps and detergents manufacturing, preparation of insect repellents, cosmetics and perfumes. Hence, they can be considered as a putative selection for minimizing food chain contamination. The critical limit of heavy metals for food is chromium -1.5 ppm, cadmium - 1.5 ppm, nickel - 2.5 ppm and lead - 1.3 ppm. The heavy metal accumulation in essential oils of aromatic crops grown in contaminated sites were well within these critical limits. In case, any accumulation of metal ions occur in oil, it can be removed by adsorption using modified activated carbon (Allwar et al., 2015).

Conclusion

A sustainable approach to mitigate heavy metal contamination in environment is the need of the hour. Aromatic plants for remediation is a promising solution, as they act as phytostabilisers, hyperaccumulators and facultative metallophytes. They are also economically valuable and promising because they are safe (no food chain contamination) and the key product (essential oils) is free from the risk of metal toxicity and is unpalatable to herbivores. Hence, aromatic plants could be suggested as a better candidate for phytoremediation of heavy metal contaminated soil.

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Epilachna Beetle

A Threat to Cultivation of *Bitter gourd* and Its Related Species

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Bitter gourd (*Momordica charantia var. charantia*) and its related species, namely teasel gourd(*M. subangulata* var. *renigera*) and spine gourd (*M. dioica*) are used as fresh vegetable, *dried & stuffed* products and also in nutraceutical and medicinal industries. The crop is severely damaged by a variety of insect pests and many act as vector for the viral diseases.

Among several insect pests, Epilachna beetle,red pumpkin beetle, and fruit flies are serious concern. Species of *Henos epilachna* (=Epilachna) namely, *H.vigintioctopunctata*, *H. indica* and *H. dodecastigma* are common in India and called as melon ladybird beetles or spotted leaf-eating beetles or hadda beetles belonging to the Family-Coccinellidae, of the Order- Coleoptera. Epilachna beetles are multivoltine, oligophagous insects, infesting crops by grubs as well as adults. The stages of the pests namely eggs, grubs and pupae are

Fg.1 Damage pattern of Epilachna grabs and adult on teasel gourd leaves

seen on the under surface of the leave, whereas adult moves on the plant.

Distribution: The genus *Henos epilachna* is a serious pest of many agricultural crops and has been reported from Australia, Africa, Asia, Afghanistan, America, Middle East and Siberia. In India, it has been reported from almost all the states.

Hosts: Besides *Momordica* sp., Epilachna beetles has been reported as a serious pest of brinjal, cucumber, pumpkin, melon, tobacco, tomato, and even some medicinal plants such as *Datura innoxia, D. stromonium, Solonum nigrum, Physalis minima, Withania sominfera and Amaranthus caudatus*.

Nature of damage: The growth and development of plants are greatly hampered and fruit yield is markedly reduced at

Fg. 2 Copulation

Fg. 3 Eggs Laid in Batches

Fg. 4a Grubs Feeding on lower Surface of the leaf

Fg.4b Grubs Feeding on Leaves causing 'windows'

severe condition of infestation. Both adults and larvae (grubs) cause damage to the plant, however grubs feed voraciously on the green matter of the leaf. The grubs found on the lower surface of the leaves preferably young leaves, scrape the chlorophyll and feed voraciously on the parenchyma and the lower epidermis between the veins, and skeletonize it in a characteristic manner leaving intact the upper epidermis as well as the tougher tissues (veins, midrib, etc.) in the form of "window". The affected leaves become translucid, take a greyish - brown, shrivels,curl-up and later dry up (Fig. 1). In cases of severe attack, the young plant can dry up completely and die. Adult beetle feeds on both surface or even on the rind of fruit; leaving spiral-shaped scars and deteriorating fruit quality and market appeal. Adult beetle flies and can cause damage to large crop areas during their peak activity. Nevertheless, adults are not responsible for as great level of injury as are the larvae.

Life cycle

Mating and oviposition: Mature adults start mating, after 2-3 days of emergence (Fig. 2). A gravid female lays about 200 to 370 eggs during lifespan in 4-6 batches, on the lower side of the leaves.

Eggs: Freshly laid eggs are

Fg.4c Grubs with branched spines

pale-yellow to orange-yellow, elongated, usually in clusters of 5 to 45 (Fig. 3). An egg is approximately 1.3mm in length and 0.6mm in width. The incubation period was observed as 5-8 days.

Larva: Newly hatched larvae (grubs) are approximately 1.6mm in length and light yellow in color. Larvae are soft bodied and covered with six longitudinal rows of stout branched spines on the back. At first, the spines are yellow, but later become darken on the tips, and thus more conspicuous (Figs. 4a, 4b and 4c). Larva moult four times during the development. Mature larva is approximately 6-7mm in length. During their earlier stages, the grubs are gregarious in nature but as they grow old, they tend to split into smaller groups.

Prepupa and pupa: Fully grown 4th instar grubs gradually stop feeding and spend about 1-3 days in pre-pupal stage. The average pre-pupal length and breadth recorded approximately as 5mm and 3 mm, respectively. Pupation occurs when mature larvae aggregate and attach themselves, by the posterior end of their bodies, to the lower surface of the leaves or stem (Fig. 5). Larvae pupate in this position. During pupation, the larval skin is pushed backwards from the thorax towards the abdomen, where it remains as a whitish, wrinkled mass. It ceases its motion and pupates. Pupa is yellow, spineless, and of the same size and shape as of the adult. The pupal period lasts for 3-5 days with an average of 4 days.

Adult: The adult is oval or hemispherical in outline, about 6-7mm in length. Newly emerged adult is straw or cream-yellow in color and shortly after emergence, 28 black spots of variable size appear on the dorsal side of *H.vigintiocto punctata* (Fig.6a), 6 black spots of variable size appear on the dorsal side of each wing of *H. indica* (Fig.6b) and 7-14 black spots on each elytra appears on *H.dode castigma* (Fig. 6c).The whole body is covered with fine short hairs. Adults darken with age and finally attain orange brown color with a bronze tinge. Adult males are slightly smaller in size than adult females.The adults start feeding a day after emergence. The longevity of adult male and female was recorded as 21 to 25 days and 28 to 32 days with an average of approximately 23 days and 30 days respectively. The beetles were found active from April to middle of the October, and second highest population was recorded during middle of September.

Management

- The beetles are strong fliers, so crop rotation to distant fields tends to limit colonization and populations.
- The pest population can be suppressed effectively, by regular picking and killing of eggs, grub, pupa and adult, if cropped area is small.
- Introduction of parasite

Fg.5 Pupa

Fig 6a vigintioctopunctata

Fig 6b H Indica

Fig 6c H dodecastingina

namely, *Tetrastichus ovulorum*, *Achrysocharis appannai* (to parasitize the eggs), *Solindenia vermai*, *Pleurotropis epilachinae*, *Tetrastichus sp.*, *Ugamenoni* (to parasitize the grubs), and *Pleurotropis foveolatus* (to parasitize the pupa) are encouraged.

- In nature, hymenopteran insect *Chrysocharis johnsonii*, parasitize on grubs and pupae, there by reduces the population of beetles.
- Larvae and adults can be shaken down in container of kerosinized water early in the morning.
- The weekly foliar sprays of aqueous neem seed kernel extracts at concentration of 25, 50 and 100g/L or neem oil applied with an ultralow-volume sprayer at 10-20L/ha significantly reduce the damage by this beetle.
- Spraying of organic decoctions like cow urine with bird eye chilli (25g) diluted in 10L. water or yeast traps placed in coconut shell or spraying castor oil /neem oil emulsion plus garlic extract diluted in water or 4-8 % Clerodendron plant extract or 2-5 % castor seed extract or azadirachtin 0.03% 2.5-5L in 500-750L of water reduces the population of the beetles.
- When insecticide application becomes essential, quinalphos 25 EC @ 2 ml per L. of water is sprayed.

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Leaf spot disease associated fungal pathogens and its management in Arecanut (*Areca catechu L.*)

Key words: Arecanut, Leaf spot. Pestalotiopsis leaf spot. Phyllosticta leaf spot and

Arecanut is one of the major plantation crop grown in humid tropics of India and traditionally crop is grown in states of Karnataka, Kerala, Assam, West Bengal, Tamil Nadu and Maharastra. Mainly Karnataka occupies major share in production and export even in value addition. Crop is sensitive to various biotic and abiotic factors among that fungal leaf spot disease causes drastic

reduction in yield. The leaf spot disease associated fungal pathogens are *Colletotrichum gloeosporioides*, *Pestalotiopsis palmara* and *Phyllosticta arecae* are the main reason for etiology.The disease was epidemic in the last 1-2 years at traditional growing area like Chikkamagalore, Shivamogga, Dakshina Kannada and Uttara Kannada districts and as per our survey we recoded 30-80% of disease severity. Main reasons for disease outbreak are development of new virulent race in fungal pathogens. Monocropping, lack of resistance source for seedling production, climatic factors like temperature, relative humidity, wind velocity, direction and prolonged leaf wetness. Improper management of gardens includes timely action of plant protection measures. So here we highlighted few points regarding symptomatology, epidemic conditions and management of leaf spot in arecanut.

Leaf blight *(Colletotrichum gloeosporioides)*

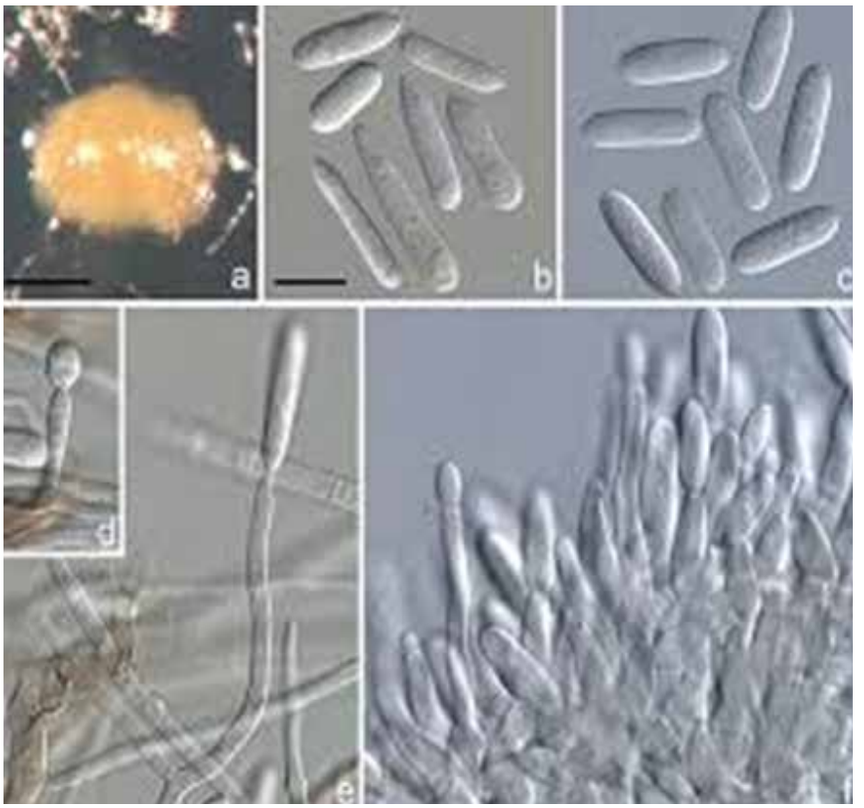
Symptoms

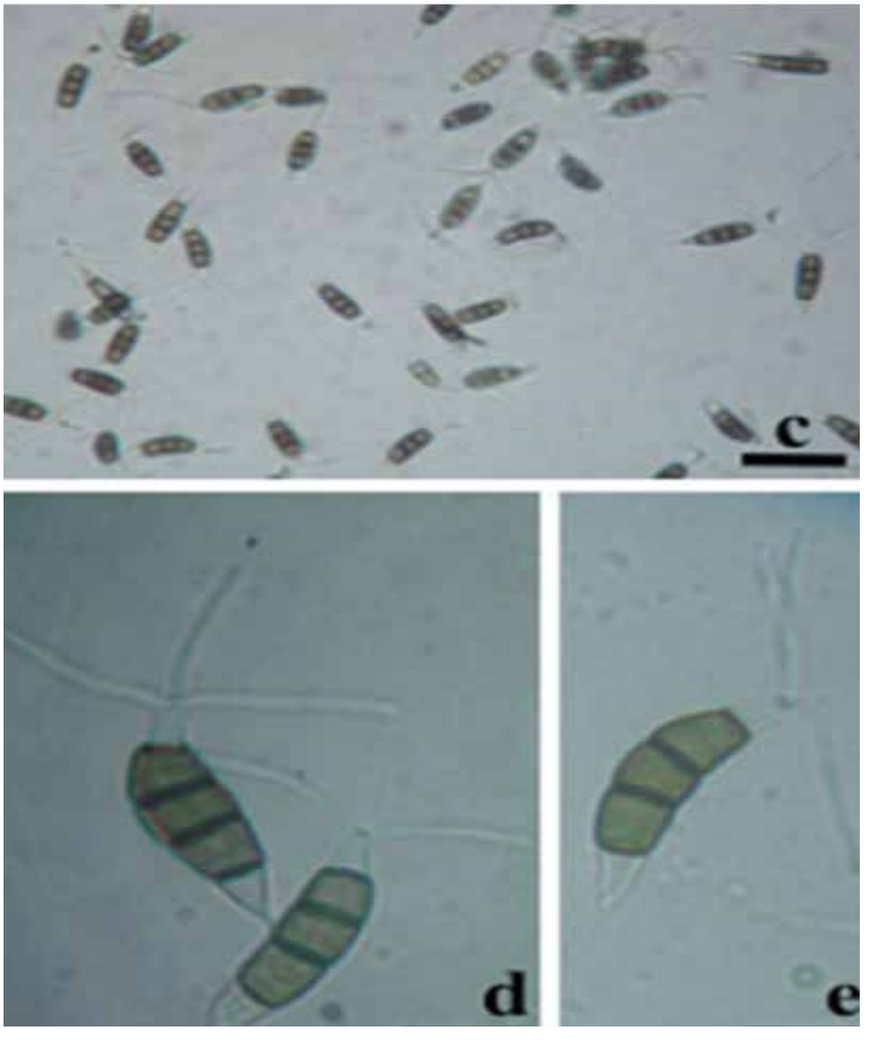
The disease began as circular to irregular spots which enlarged as the disease progressed. Later, the spots were light to dark brown in colour having ashy grey center, surrounded by dark brown margins and yellow halo. In severe cases, the adjacent spots eventually coalesced to form large irregular patches leading to shot-hole symptoms and finally covered the entire leaf lamina turning the leaf color to pale yellow.

Spore morphology: Cylindrical, straight with smooth round ends.

Epidemical condition: Fungus produces the conidia within 3 to 5 days at 30°C and at 90% relative humidity.

Survivability: Survival of conidia, sclerotia, and conidia in infected leaf debris was studied in soil maintained at five soil moisture levels. Survival of conidia and sclerotia declined rapidly under moist conditions (≥12% moisture, vol/wt), but





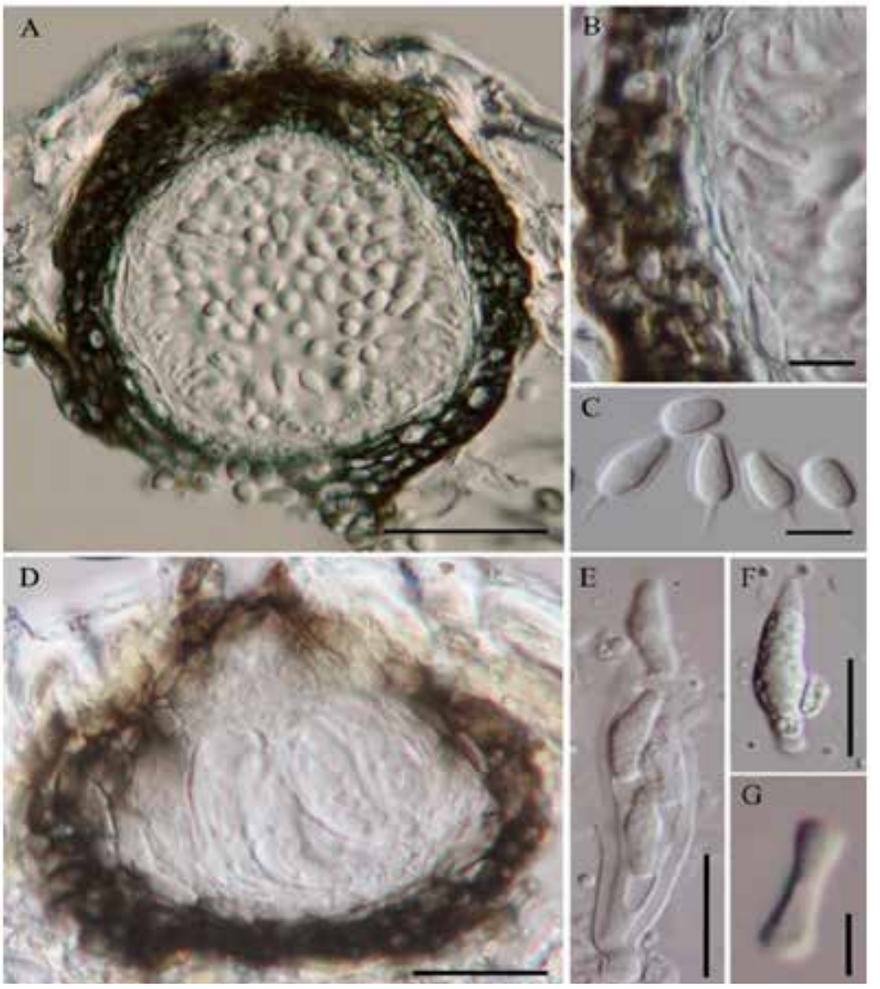
under dry conditions, viable conidia could be detected up to 12 months after incorporation into soil.

Pestalotiopsis leaf spot *(Pestalotiopsis palmara)*

Disease development by *Pestalotiopsis* can be restricted to only the leaf blade (leaflets or leaf segments) or only the petiole and rachis; or, it can develop on both tissues at the same time. Spots will begin as very small yellow, brown or black spots. If the disease is restricted, the spots may never be more than 1/4 inch in size. Under optimum environmental conditions, the spots may expand and increase in number until they coalesce to form a leaf blight or rachis blight. Often, the spots turn a grayish color that are outlined in black. The same type of lesions occurs on the petiole or rachis of the palm. One may even see lesions occur on leaf spines.

If the pathogen is causing a rachis or petiole blight, the disease is a more serious problem for two reasons. First, as the pathogen destroys tissue in the rachis or petiole, it will affect the vascular tissue, which in turn affects tissue in the leaflets or leaf segments. Second, if the pathogen has infected the spear leaf or other younger leaves, it may spread down the rachis or petiole to the apical meristem (bud) region and affect the growing point of the palm.

The conidia were fusiform, five-celled, straight or slightly curved. The cells



comprised three colored median cells and hyaline apical and basal cells with appendages.

Phyllosticta leaf spot: *Phyllosticta arecae*

The symptoms started as minute brown specks on leaves, which enlarged with dirty ashy brown centre, surrounded by yellow margin. The spots are round to oval and sometimes irregular. Adjacent spots coalesc to form bigger patches. The pycnidia will be evident on the ashy brown spotted areas. Severely infected leaf give a blighted appearance. Shredding, premature drying and dropping of the severely infected leaves are noticed.

Rao (1964) described the pycnidia of *P. arecae* as spherical to globose, dark brown ostiolate, sub-erumpent, scattered, few per spot and measured 77.5 to 109.2 μm in diameter. Pycnidiospores were hyaline, single-celled, sub-cylindrical with rounded ends and measured 4.2 to 6.5 μm x 2.75 to 4.0 μm.

Integrated disease management strategy:

- Integrated disease management needs to be adopted on community basis for effective management of the disease.
- Phytosanitation: Removal and burning of severely infected leaves.
- Community approach: Community level spraying needed for effective management.
- Quarantine measures should be strictly followed while transporting seedlings/seeds from disease affected areas.
- Nutrient management: Proper drainage, liming and nutrient application based on soil test report.
- Ad-hoc recommendation: First round spray of Propiconazole 25% EC @1ml/litre second spray in 25-30 days intervals with any of the following fungicides depending on the disease severity Carbendazim 12%+ Mancozeb 63% WP (SAAF) @2g/litre or Tebuconazole 38.9% SC 1ml/litre or Hexaconazole 5% EC 1ml/litre or Difenoconazole 25% ECor Zineb 68% + Hexaconazole 4% WP @2gm/litre or Flusilazole 12.5% + Carbendazim 25% SE@2ml/litre or Fluopyram 17.7% + Tebuconazole 17.7% SC@ 1ml/litre or Azoxystrobin 11% + Tebuconazole 18.3% SC @ 1ml/litre or fluxapyroxad 75 g/L+difenoconazole 50 g/L @ 1.2ml/litre or Tebuconazole 10%+Propineb 60% WDG @2g/litre or Fluxapyroxad 250 + Pyraclostrobin 250 SC @ 0.5ml/litre Metiram 55 % + Pyraclostrobin 5 % WG @1.5g/litre are effective against leaf spot disease in arecanut.

Carbon neutrality in farms Need and ways

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Recently, a 103 year old state-run seed farm at Aluva in Eranakulam district of Kerala was declared carbon-neutral, becoming the first of its kind in the country to achieve this status. Earlier this year, Kerala became the first state in the country to introduce carbon-neutral farming methods in selected locations, for which the government had set aside ₹ 6 crore in the 2022–23 budget. Carbon-neutral farming is a movement that is quickly gaining traction in the agricultural industry. It aims to lower carbon emissions from agriculture and related activities thus improving the sustainability of farming methods.

Carbon neutrality and Carbon-neutral farming

Carbon neutrality is a term that is used to describe the process of balancing the amount of carbon dioxide released into the atmosphere with an equivalent amount sequestered. Carbon-neutral farming is defined as achieving a net zero balance of all the greenhouse gas emissions and sinks occurring in the farming system or the farming product, in terms of their carbon dioxide equivalents, resulting in climate neutral systems. Essentially, it is all about practicing a scientifically validated methodology that arrests carbon emissions without affecting agricultural output. Thus, healthy crop yields can be achieved without harming the planet by using proper farm management strategies.

Why Carbon-neutral farming?

India announced that it will reach carbon neutrality

by 2070 as part of a five-point action plan that included reducing emissions to 50% by 2030 at COP-26 (the 26th United Nations Climate Change Conference in 2021), held earlier this year in Glasgow. India needs to take steps to reduce carbon emissions and at the same time increase sequestration in order to achieve this target. The agriculture sector is a major contributor to the world's greenhouse gas emissions, which are the key cause of global warming and climate change. According to an article in Science News, agriculture and livestock account for 14% of India's gross national greenhouse gas emissions, which rises to 22% when electricity used in agriculture sector is considered. Therefore, reducing emissions from the agricultural sector is necessary for India to move closer to its objective of becoming carbon neutral.

We must realise that carbon-neutral farming does not exist in a vacuum. By adopting carbon-neutral farming systems, we are also addressing a number of issues associated with conventional farming practices including unsustainable agriculture, input-intensive agriculture, produce quality, health concerns, environmental consequences, climate change, etc. Essentially, carbon-neutral farming is aligned with the larger concept of sustainable agriculture. Therefore, sustainable farming practices such as organic farming, precision farming, natural farming, biodynamic farming, integrated farming systems, conservation agriculture, climate-resilient agriculture, etc. work on shared principles and protocols that can be adopted in farms to achieve carbon-neutral status.

Basic principle behind carbon-neutral farming

Carbon-neutral farming, put simply, involves reducing carbon emissions while boosting carbon sequestration on the farm. Atmospheric carbon dioxide, biomass, soil organic matter, and the oceans are the primary sources of carbon that are actively circulating in the ecosystem. Oceans are the largest carbon reserve in the world, followed by soil in terrestrial ecosystems, while atmospheric carbon dioxide and biomass house relatively minor quantities. Carbon sequestration is the process of storing carbon in a carbon pool, which may be plants, soils, geologic formations, or the ocean, and preventing it from entering the atmosphere. Agricultural soils hold potential for expanded carbon sequestration, and thus provide a plausible way of mitigating the rising atmospheric carbon dioxide concentration. Carbon-neutral farming essentially aims at exploiting this potential by employing techniques to increase the amount of carbon sequestered in the soil.

Agriculture's carbon emissions and footprint

Before talking about the ways to achieve carbon neutrality in agriculture, it is crucial to understand about the carbon emissions associated with it. With regard to carbon emissions, agricultural activities can be classified as primary, secondary and tertiary sources. Primary sources of carbon emissions are from stationary processes like pumping water or drying grain, or from mobile processes like tillage, planting, harvesting, and transportation. Secondary sources of carbon emissions include the emissions associated with manufacturing, packaging and storing fertilisers and pesticides. While the tertiary sources of carbon emissions comprises of emissions associated with the acquisition of raw materials and fabrication of equipment and farm buildings, etc (Lal, 2004). Detailed knowledge about the carbon emissions associated with each source helps us formulate and adopt carbon efficient alternatives.

One such indicator that can be used to quantify the greenhouse gas emissions associated with a certain product or process is the carbon footprint. Carbon footprint is a measure of the total greenhouse gas (majorly methane, nitrous oxide, carbon dioxide, water vapour, ozone and chlorofluorocarbons (CFCs)) emissions, both direct and indirect, by an individual, event, organization, service, place, process, or product, expressed as carbon dioxide equivalent (CO_2e). It takes into account all the inputs and processes within the confines of a defined system, in this case, farming. Carbon footprint (CF) identifies the source, quantity, and sink of greenhouse gases released from on-farm and off-farm activities. In this way, we will be able to

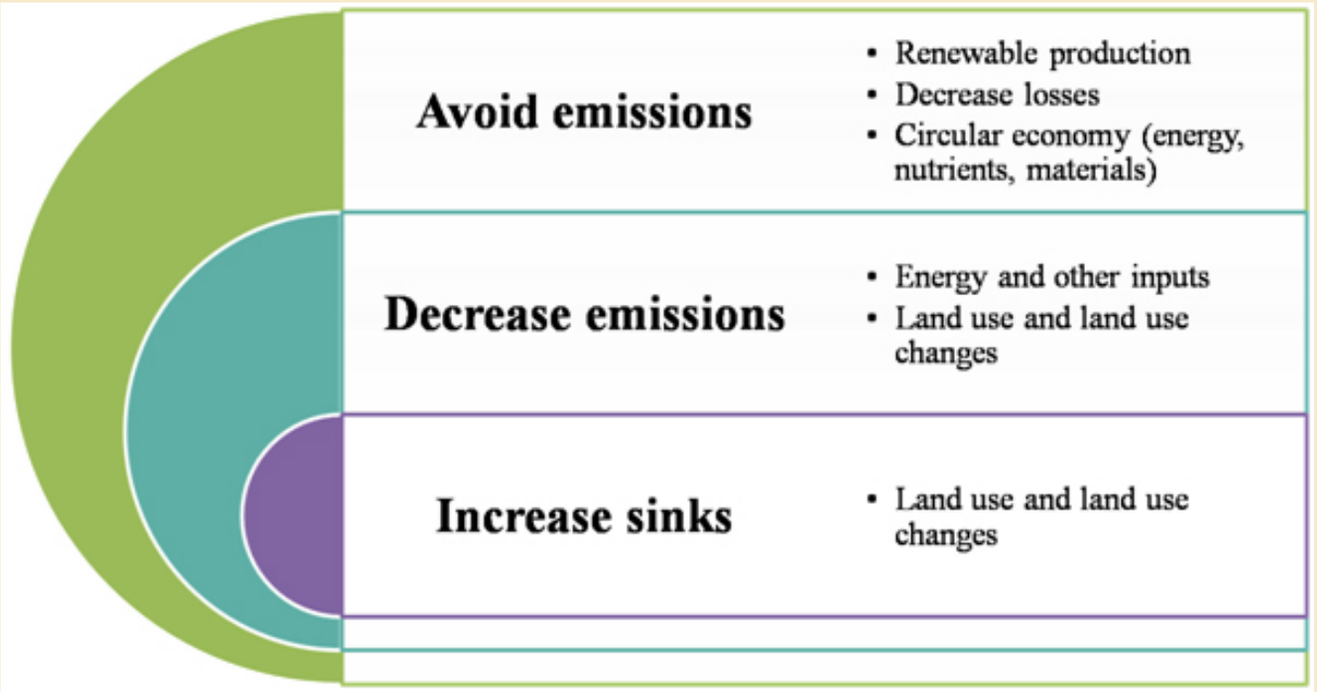

Figure 1 Overview of steps towards carbon neutral agriculture (Source: EIP-Agri Workshop Report, 2021)

get a comprehensive idea of the net carbon emissions, from which we can think of methods and make effective choices to achieve carbon neutrality in farms. However, the methods used to calculate the carbon footprint of agricultural systems at present lack consistency, and this research gap should be addressed (Sharma, 2021).

How to achieve carbon-neutrality in farming?

In order to walk towards carbon neutrality in the farms it is crucial to implement a strategy that aims at minimizing emissions and increasing sinks. **The EIP-AGRI Workshop:** Towards Carbon Neutral Agriculture, 2021 proposed such an integrated set of approaches, which include steps to avoid or reduce emissions and increase sinks (Figure 1).

Selecting what to grow is important for the success of any farming system. Climate-resilient and short-duration varieties are preferable since they contribute to minimising carbon emissions and maximising soil carbon. Varieties with deep root systems help sequester more carbon as root biomass. Also, C_4 crops sequester more carbon compared to C_3 crops, owing to their better carbon dioxide utilisation mechanisms. It is hard to achieve carbon neutrality in monocropping systems. Integrated farming system is a better approach, as it ensures a circular economy and its components even out carbon emissions. Planting intercrops and cover crops, adopting mixed cropping, and diversifying crop rotations can all help farms achieve a better carbon status. In the case of livestock, it is important to manage the feedstock and manure. For instance, feeding young grass to cattle can help reduce methane emissions. Methane generated from the manure can be used to meet the farm's energy requirements. Additionally, farm and animal waste can be composted and supplied as a nutrient supplement to the field. Agroforestry systems are also a successful strategy for achieving carbon neutrality because they contribute significantly to carbon sequestration.

Soil is most important carbon sink therefore it is crucial to take steps that improve soil health as we move towards carbon-neutrality. The soil should be disturbed as little as possible; conservation tillage or minimum tillage techniques can help with this. Conservation tillage reduces soil disturbance and breakdown while leaving surface

residues that may improve soil C and N content, crop productivity, and water retention. Strategies to increase soil organic matter like mulching, green manuring, incorporating crop biomass in soil preferably after composting or as residue, use of organic manures, increasing soil microbial activity, etc. should be given emphasis. It is best to refrain from the indiscriminate use of resources like chemical fertilisers, plant protection chemicals, etc. Although it is advisable to avoid using chemical agents, we can start with need-based applications of plant protection chemicals and site-specific applications of fertilisers. Water and nutrient management strategies like micro-irrigation and fertigation can prove helpful. Switching to organic farming is an excellent solution, as it removes most of the roadblocks in the way of achieving carbon neutrality on farms.

Apart from these, the use of non-conventional sources of energy for farm operations can help significantly reduce carbon emissions. Solar energy, biofuels like bioethanol and biodiesel, and biogas can substitute for fossil fuels. Despite the fact that the general principles and protocols for implementing carbon neutral farming are the same, location-specific strategies must be emphasised for better results.

Story of State seed farm, Aluva

According to a study conducted by the Kerala Agricultural University's College of Climate Change and Environmental Science between July 2021 and June 2022, the State seed farm's overall carbon storage was 213.45 metric tonnes, while its total carbon emissions were 43.08 metric tonnes, making it carbon-negative, a step above carbon-neutral. This feat was not achieved by the farm in a day or a year. For more than ten years, the 13.5 acre farm has been organic and free of chemical pesticides and fertilisers. Organic fertilisers from composted farm waste are used to supplement nutrients. Additionally, mixed farming practises have been adopted with native breeds of chicken, ducks, cows, and goats, as well as aquaculture, apiculture, azolla cultivation, and vermicomposting. The farm's primary crop is paddy, but it also grows vegetables, plantains, coconut palms, and tubers. There has been a considerable reduction in waste generation due to rearing of cows, goats, ducks, chicken, fish, bees and vermicompost. Ducks helps in control the pests in the paddy. The animals are fed fodder, grass, hay and barn produce on the farm. This circular economy created by the components helped the farm achieve carbon-negative status over time.

Way forward

Although we really value carbon neutrality, it's time to consider carbon-negative farms in India. For this to happen, all the stakeholders in agriculture have to work hand in hand. More policies and incentives promoting carbon-neutral farms have to be made. Researchers must focus at developing location-specific sustainable carbon-neutral farming models along with strategies to minimize emissions and increase sequestration. Also, there is a need to develop efficient monitoring systems for carbon emissions from farms. Farming community should be educated about the greater good associated with carbon-neutral systems, encouraging them to adopt the same.

Carbon-neutral farming promises an efficient mitigation strategy for contemporary issues like climate change and global warming, so it needs to be embraced.

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Cissus quadrangularis

"The Bone Setter Plant"

Cissus quadrangularis is an underutilized medicinal plant which is having vast medicinal properties particularly bone healing property. It belongs to the same family as that of grapes ie. Vitaceae.The plant which is widespread in the tropical and subtropical forests of Africa and South East Asia, is believed to be a native to India, Bangladesh, Sri Lanka, Java and West Africa.

The plant is popularly called as Asthisanharak (saves the bones from their destruction) or Asthisandhani (heals the bone fractures) in Sanskrit.Few other names like vafravati, asthisrnkhala, vajrangi and granthimalaare also given to this plant indicating the same property (Srivastava et al., 2011). It is commonly known as Adamant creeper, Square stalked vine, Edible Stemmed Vine, Veldt Grape, Bone setter or Devil's Backbone in English, Hadjod in Hindi, Kandvel in Marathi, Haddjor in Punjabi, Hadavhanga in Oriya, Vedhari in Gujarati, Pirandai in Tamil, Nalleru in

Telugu,Mangarahalli in Kannada and *Changalamparadana* in Malayalam. "Changala" in Malayalam means chain. Because it climbs up the trees by means of its stem which looks like chain links it is called ***Changalamparanda***

Plant description

Cissus quadrangularis is a long herbaceous cactus like climber reaching up to a height of 1.5 m. The leaf portion which constitutes only 5% - 8% of the aerial part consists of trilobed leaves which are 2-5 cm wide and they arise from each joint. Spring-like tendrils appear from the opposite side of the node. The plant forms dense canopy after maturation, and with the help of these tendrils they climb on any substratum for support. The green stem which constitutes the major portion, consists of fleshy quadrangular sectioned internodes which are 8 to 10 cm long and 1.2 to 1.5 cm wide. The plant is propagated by using this fleshy stem (30 cm long) having 3-4 internodes. It has small white, yellowish, or greenish flowers and red globular berries (Siddiqua & Mittapally, 2017).

In Ayurvedic and Unani systems the medicinal properties of stem, roots and leaves of the *Cissus quadrangularis* have been

cited,particularly, the roots and stems which are found to be the best in healing of fracture of the bones (Kumar, 2019; Zakiet al., 2020).The plant extracts and its powders are used in many Ayurvedic treatments and also for preparing many Ayurvedic medicines.

Phytochemical constituents

Cissus quadrangularis have numerous bioactive compounds such as alkaloids, resveratrol, piceatannol, pallidol, parthenocissin, phytosterol substances, vitamins, enzymes, nicotinic acid, tyrosin and triterpenoids. In addition, it contains calcium oxalate, β-carotene, ascorbic acid, β-sitosterol, ketosteroids, flavonoids like quercetin, and kaempferol (Pansare and Chandil, 2019). It contains inorganic minerals like Calcium, Iron, Copper, Zinc and Potassium (Zakiet al., 2020). Jainu and Devi (2004) as cited by Pansare and Chandil (2019) reported that100g of freshly prepared paste of Cissus contain 479 mg of ascorbic acid, 267 units of carotene and 696 mg of Vitamin E (Malik and Onkar, 2019)

Pharmacological effect

Cissus quadrangularis has been used from ancient time for strengthening bones and joints and also for promoting bone growth. Stem extract contains a high percentage of Calcium and Phosphorus, which are essential for bone growth (Siddhiqua and Mattapally, 2017). It increases bone mineral density and enhances the rate of fracture healing by accelerating the proliferative physiological process in the bone. It also increases the rate of bone regeneration and improves blood circulation and nutrient supply to the bone. It preserves bone tissue anabolism and regeneration and promotes osteoblastic proliferation and differentiation. (Malik & Onkar, 2019).

Phytochemicals present in Cissus such as saponins, flavonoids, tannins, terpenoids and steroids have anti-inflammatory effects. Glycosides, flavonoids and tannins have hypoglycaemic activities. Saponins possess hypocholesterolemic and anti-diabetic properties. It is also used as an anodyne, anabolic supplement (mainly for bones), digestive stimulant, hepatoprotective, blood detoxifier and also as aphrodisiac. It is used for heavy bleeding during menstruation due to its haemostatic property and also in bleeding piles due to its anti-haemorrhoidal activity. In high doses, *Cissus quadrangularis* extract also shows sedative and muscle relaxing effects (Malik & Onkar, 2019). The stem of *Cissus quadrangularis* is also reputed in Ayurveda as dyspeptic, digestive tonic, analgesic in eye and ear diseases, in the treatment of asthma and in complaints of the back and spine (Srivastava et al., 2011), internal bleeding and epistaxis. It is also used for curing gout, syphilis, venereal diseases, leucorrhoea, worm infestation, anorexia, obesity, peptic ulcer and also as a body

building supplement.

Conclusion

Cissus quadrangularis, a multifaceted medicinal plant has to be explored further scientifically for identifying its numerous unknown pharmacological properties. Advanced research is needed for exploring the usage of this plant for preparing wide variety of formulations, and further efforts are needed for systematic and scientific screening of its constituents to verify its efficacy and compatibility with different systems of medicine.

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