TECHNOLOGY OUTREACH FOR LIVELIHOOD IMPROVEMENT

-A TECH MANUAL

INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION, DEHRADUN

(An Autonomous body of Ministry of Environment, Forest and Climate Change, Government of India)

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INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
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Foreword

Dr. Suresh Gairola, IFS
Director General
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ICFRE with its Headquarters at Dehradun is an apex body in the national forestry research system that promotes and undertakes need based forestry research and extension. The Council that came into being in 1986 has a pan India presence with its 9 Regional Research Institutes and 5 Centers in different bio-geographical regions of the country. Since then research in different fields of forestry has been a major focus of ICFRE.

There is an earnest need to present its research findings to the stakeholders in a simple and lucid manner, to improve the visibility and relevance of ICFRE. Therefore it was decided that the information available on the technologies, processes, protocols and practices developed by ICFRE be published in the form of operational manuals/user manuals. It is also desirable that the manual should be a comprehensive national level document depicting extent of knowledge in applicable form.

Accordingly, 18 scientists of ICFRE were nominated as National Subject Matter Coordinators (NSMCs) to carry out the task on the specified subject. These NSMCs were assigned the task to select and nominate nodal officers from other Institutes of ICFRE as well as other organizations if necessary, collect and collate the information on the subject from various sources in coordination with the nodal officers of ICFRE institutes.

The present publication 'Technology Outreach for Livelihood Improvement' aims to make available various forest based technologies to the stakeholders living in and around forest areas for their economic upliftment. This manual is built on the technological outcome of the research conducted by different institutes of the ICFRE towards livelihood

improvement. Contributions made by other institutions in this area are also included. The manual contains all essential and need based technical inputs in an easy to understand manner for use by the stakeholders. I believe that this manual will be of immense use and significance to diverse group of those stakeholders who are engaged in various aspects of forestry towards livelihood promotion in the country.I congratulate all the contributors for their efforts in bringing out this publication.

I hope this manual would be useful in implementation of different programmes of afforestation/reforestation in combinations with soil and water conservation measures ensuring livelihood related options and enhancing green over in the region. This altogether will strengthen capacity to conserve these valuable resources, reduce forest degradation, increase green cover, protect habitats, sequester carbon and favour societal benefits.

I congratulate the efforts made by the authors and I am sure that this publication will prove effective to all the people working towards the conservation and sustainable management of native biodiversity in the country.

Dr. Suresh Gairola

Preface

Dr. V. K. Varshney
National Subject Matter Coordinator (NSMC)
ICFRE

Ensuring livelihood security is vital to enhance the quality of life of people. Livelihood initiatives are being promoted for the marginalized and poor people through different programmes in the country. In this context, forestry based activities are important in assisting and improving livelihood conditions of the rural and forest dependent communities. This publication titled 'Technology outreach for livelihood improvement' is in tune with one of the recent initiatives of the Indian Council of Forestry Research & Education (ICFRE), Dehradun aiming to extend the outcome of the forestry research to the stakeholders for enhanced forest productivity and livelihood security. This manual is an attempt to epitomize some of the innovative forestry interventions undertaken by the institutes of the ICFRE and non government organizations for creating livelihood. The manual is comprised of 26 forest based inventions, with all essential information including (i) The problem or situation being addressed by the innovation; (ii) Description of the innovation and its salient features; (iii) Required resources in terms of raw materials, equipments, machineries, etc.; (iv) Specific problems / obstacles likely to be faced by the user during use and their solutions; (v) impact of the innovation; (vi) Suitability and possibility for upscaling; (vii) Economic viability; (viii) Significance for (and impact on) policy-making; (ix) Possibility and scope of extension to the stakeholders; (x) Description of the institution responsible and its organisational aspects, for their full use. It is believed that the publication will be of great benefit to various stakeholders such as forestry professionals, scientists, tree growers, farmers, communities living in and around the forests, tribals, NGOs, wood based industries, value addition industries, forestry students and others engaged in promotion of forestry and agroforestry towards livelihood security in the country. This work owes great deal to the vision, positive criticism and guidance of Dr. Suresh Gairola, Director General, ICFRE and the entire team of Directorate of Extension. I express my heartfelt thanks to various nodal officers, scientists of ICFRE institutes and other organizations for their contributions, cooperation and collaboration to make this document possible. My special thanks are due to Dr. Y. C. Tripathi, Scientist-F, Chemistry & Bioprospecting Division, FRI, Dehradun for his help in editing of the document. Any suggestions for improvement of the manual are most welcome.

Dr. V. K. Varshney
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Contents

1 A PROTOCOL FOR CULTIVATION OF MEDICINALLY IMPORTANT MUSHROOM, *GANODERMA LUCIDUM*

1. GENERAL INFORMATION

- Title of Innovation

  A protocol for cultivation of medicinally important mushroom, *Ganoderma lucidum*

- Brief Description : *Ganoderma lucidum* has been widely used as a medicine in many pacific countries. The emperors of the great Japanese and Chinese dynasties drank it with their special teas and mushroom concoctions to achieve greater vitality and longer life. A protocol has been developed for the cultivation of *G. lucidum* on billets of Poplar (*Populus deltoides*). The advantage of the present cultivation protocol is the use of side branch piece (Billets) obtained after pruning and lopping of poplar trees easily available in poplar growing areas of north India.

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- Name and position of key or relevant persons or officials associated : Sona Singh, Ph. D. Scholar; Dr. P. K. Gupta, Scientist-G, C&P Discipline, Forest Products Division, Forest Research Institute, Dehradun and Suresh Chandra, Scientist-B, Forest Pathology Discipline, Forest Protection Division, Forest Research Institute, Dehradun.

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Ganoderma lucidum (Fig. 1) is used as a remedy to treat more than 20 different illness including migraine and headache, hypertension, arthritis, bronchitis, asthma, gastritis, hypercholesterolaemia, hepatitis , cardiovascular problems and cancer including leukaemia. Such is the vast usage of this fungus in treatment of various ailments that a new therapy known as ganotherapy has come in practice and gaining fast access in the modern day medicines. Most of the products of this medicinal mushroom available in Indian markets are either imported or repacked and sold. In India though the cultivation of this mushroom was tried earlier but the time taken for fruiting is more than 100 days whereas in the present protocol the method is simple, economical and less time taking (70 – 80 days).

Fig. 1: Fruit bodies of *Ganoderma lucidum*

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 Isolation of pure culture: Pure culture of *G. lucidum* can be isolated from fruiting body on Potato Dextrose Agar (PDA) medium or it can be obtained from Forest Pathology Discipline, Forest Protection Division, Forest Research Institute, Dehradun.

3.2 Preparation of spawn: Used tea leaves and wheat bran are used as the inoculum medium. Used tea leaves are thoroughly washed in running water to remove the impurities. Used tea leaves and wheat bran (1:1 w/w) supplemented with water to maintain the required moisture are filled in polypropylene bags. The polypropylene bags are sealed with rubber bands and autoclaved at 15 lbs for 15-20 minutes. After cooling, polypropylene bags are inoculated with small discs (5 mm) of pure culture and incubated in a BOD incubator at 25 ± 1°C. The spawn is prepared in 15 days.

Fig. 2: Poplar Billets

3.3 Spawn production: Poplar Billets (10-15 cm length and 4-5 cm diameter) are dipped in 1% malt extract solution overnight, packed in polypropylene bags and autoclaved at 15 lbs for 20- 25 minutes. After autoclaving, the billets are cooled at room temperature and inoculated with spawn of *G. lucidum* prepared on used tea leaves and wheat bran. The inoculated Billets are incubated in an incubator at 25 ± 1°C. The Billets of poplar are completely colonized (Fig. 2) in 15-17 days.

Fig. 3: Emergence of Primordia

3.4 Cultivation: For cultivation, a low cost mist chamber is prepared. A sand bed is laid at the base of the chamber. After complete colonization, the Billets are taken out and buried in the sand bed vertically and then covered with a thin layer (1-2 cm) of unsterilized garden soil inside a low cost chamber, made up of bamboo sticks and polythene sheet. The sand bed is watered twice daily to maintain the humidity of 60-70% with temperature 25-30°C. These conditions continued throughout the growing period. After 15-17 days of burying of Billets, the first fruiting initials (primordia) begin to emerge as pin heads, whitish to golden in colour (Fig. 3). Formation of antler takes further 10-12 days. The emerging antlers are reddish brown in colour. Growth can be noticed from day-to-day. Once the stipe (stem) achieves 2 – 3 cm height, windows for cross ventilation are opened to reduce the level of carbon dioxide to initiate cap formation. Cap

Fig. 4: Grown Fruit Bodies

formation takes another 15-17 days. The margins of matured fruiting bodies turn reddish brown from whitish to golden (Fig. 4) and are harvested. This whole process of cultivation takes 70-80 days to harvest 1st mature crop (Table 1 and Flow Chart).

Table 1. Cultivation cycle of *Ganoderma lucidum*

Conditions/ Phase	**Spawn run**	**Primordial formation**	**Antlers formation**	**Cap formation**	**Fruiting body development**	**Crop cycle**
Temperature (^{o}C)	22-27	22-27	22-27	22-27	22-27	70-80 days
Relative Humidity (%)	70-80	70-80	70-80	65-75	60-70	
Duration (Days)	15-17	15-17	10-12	15-17	15-17	

Flow chart of *Ganoderma lucidum* cultivation

Poplar Billets (10-15 cm long X 4 – 6 cm dia) dipped overnight in 2% malt extract
↓
Autoclaved in polypropylene bags
↓
Inoculated with spawn prepared on waste tea leaves
↓
Covered with mycelium
↓
Buried in sand and covered with soil
↓
Kept inside a polyhouse (mist chamber)
↓
Watered
↓
Appearance of antlers
↓
Opening of windows
↓
Cap development and maturation
↓
Harvesting

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Hot Air oven, Autoclave, Laminar Flow, Incubator, Refrigerator, Glasswares, Poplar wood Billets, Polypropylene bags, Bamboo sticks, Polyethylene sheets.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Market linkages are to be established.

6. IMPACT OF THE INNOVATION

Growing of *G. lucidum* is gaining popularity for economic and wellness benefits. Age old traditional practices of mono cropping culture are not economically viable for the farmers. As an off farm activity with good economic returns with minimal investments, growing of *G. lucidum* has a key role in creating livelihood.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Cultivation of *G. lucidum* holds the potential for developing a business and industry model.

8. ECONOMIC VIABILITY

The economics of cultivation of *G. lucidum* has been estimated using its production statistics and cost of processed products (in the form of capsules) (Table 2). The production cost includes the growing cost i.e. cost of the land, raw material (Billets), energy consumption, financial and man power cost, etc.

Area for growing 36 Billets (about 5" × 2-3"or 12.5 × 5-7.5 cm)

Total area for growing 36 Billets = $1 \times 1 m^2$

Distance between 2 Billets = 5" (12.5cm)

Cropping cycle: In 1st flush, one can get 36 fruiting bodies (1st crop) from 36 Billets in just 75 days. In 2nd flush, from the same 36 Billets in next 30 days, 26 fruiting bodies can be harvested (2nd crop). In 3rd flush, in the next 30 days, 16 fruiting bodies can be harvested (3rd crop).

In total from 36 billets in 135 days, 78 fruiting bodies can be cultivated.

Dry weight of fruiting body/Billet = 6 g (Av.)

Dry weight of 78 fruiting body = 78 × 6 = 468 g

In 135 days, 468 g of dried *G. lucidum* can be produced.

Capsule Preparation: 200 mg powder is used for preparing 1 capsule so from 468g (468000 mg) powder, 2340 capsules can be made. Details of production cost are given in Table 2.

Table 2. Production cost of *Ganoderma lucidum* and *Ganoderma* Capsule

Item	Cost in Rs
Cultivation Cost (per sq. meter)	
Man power cost (Isolation of the fungus + Watering / Sand / Soil)	200
Spawn preparation (Billets, Polypropylene bags, Autoclaving)= Rs. 6/ piece for 36 pieces	216
Low cost moist chamber (Bamboo + Polythene sheet	200
Total	**616**
Capsule Production Cost	
Readymade empty gelatin capsules (Rs. 100/1000 piece) (for 2340 capsules)	234
Filling charge (Rs. 0.1/capsule)	234
Bottles (capacity 60 capsules/bottle) @ Rs. 2/- (39 bottles)	78
Labelling (printing + paper/bottle) @ Rs. 4/- (39 bottles)	156
Designing of label (One time)	400
Total capsule making and packaging cost	**1102**
Total Input (cultivation + capsule making) Cost	**1718**

Output cost:

Selling price of 1 capsule in market = Rs. 2.50

Selling price of 2340 capsule in market = Rs.5850

Total profit = output cost - input cost

= Rs. 5850-1718 = Rs. 4132

Table 3. Annual cost benefit analysis of *Ganoderma lucidum* cultivation in north India and *Ganoderma* capsule making

Production cost per year	Yearly Production (kg/m^2)	Value of sale	Earning rate
Without cost of the land Rs. 3282/sq.m.	1.26	Rs. 15750	79.16%
With cost of the land * Rs. 5282/	1.26	Rs. 15750	66.46%

* Cost of land = Rs. 2,000/- per sq. m. (in urban/semi-urban areas in north India).

It can be said that Rs. 4,000/- can be earned through cultivation of *G. lucidum* from one sq. meter area and capsule making in 135 days. The earning rate of *G. lucidum* cultivation is 66% if cost of land is included and 79% without cost of land (Table 3). It can be said that if the cultivation is done on own land then there will be maximum benefit to the grower.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Implementation of the protocol in the field and its adoption by the mushroom growers can help the government and other bodies to take a policy decision on cultivation of medicinal mushroom and marketing.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The economic benefits worked out for the cultivation of this medicinal mushroom will attract the growers to adopt its cultivation. Hands-on trainings and exposure visits and follow-up technical support will help them to take up this activity as a business prospect. Trainers can be trained and they can take up the work as field extension workers. The protocol has already been extended to the mushroom growers and farmers of Dehradun region using the Baghban Gramodyog Samiti at adopted village Shyampur of FRI, Dehradun and Centre for Business & Entrepreneurship Development, Dehradun.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Forest Research Institute, Dehradun, is a constituent institute of Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

2 A PROTOCOL FOR CULTIVATION OF SHITAKE AS OFF FARM HOUSEHOLD ENTERPRISE

1. GENERAL INFORMATION

- Title of Innovation

  A protocol for cultivation of Shitake as off farm household enterprise

- Brief Description : *Lentinula edodes* (Shiitake), an edible macro fungus, is the world's second largest mushroom under cultivation. Shiitake is valued due to its culinary and nutraceutical properties. It also has antiviral, antibacterial and antitumor properties. Shiitake contains chemical compounds that may help boost immune health and serves as a source of B vitamins.China, Japan and America shares major percent of the world market in production of Shitake. Today, hundreds of mushroom growers in the U.S. utilize forest farming to produce Shiitake mushrooms on hardwood logs. There are very few growers in India who are cultivating Shiitake mushroom on either wood logs or sawdust logs on individual level. Shiitake mushroom cultivation is one of the best options for the landless poor for the livelihood development and an alternate to the traditional mono cropping pattern of agriculture system in temperate hill regions. The cultivation is done indoors by harnessing local climatic conditions. Himalayan Research Group (HRG) at Shimla (Himachal Pradesh) is making efforts to disseminate the technology for cultivationof Shiitake to the local communities and those without agriculture land in the hills under temperate climatic conditions for their economic upliftment. Shiitake cultivation is done on sawdust logs prepared from sawmill waste mixed with rice bran and water, then filled into the polypropylene bags. The protocol has been standardized for its use in Indian conditions.

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2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Mountain areas have favourable climatic conditions which are good for temperate mushroom cultivation under natural conditions without investing much on infrastructure development. The agriculture land division among siblings is another major issue which is restricting the agriculture production and in coming days situation would be alarming. Mushrooms being indoor crop would be better option for the local communities especially women as an alternate livelihood. Shiitake mushroom has a quality to be stored after drying and can give growers better economic returns, while otherwise mushroom is a highly perishable crop. It is used for boosting immune system, in treatment of HIV/AIDS, lowering blood cholesterol levels, atherosclerosis, diabetes,

eczema, colds and flu, treating prostrate and breast cancer, and as an anti ageing agent. It is also beneficial in management of hepatitis B, herpes, high blood pressure and stomach ache. Shiitake mushroom is a healthy option for our nutrient deficit diets. Shiitake enjoys gourmet status in the culinary world which is why they are carefully produced through the labor-intensive method of forest farming and at household level.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Shiitake cultivation on sawdust is an easy technology (Fig. 5). The substrate material is prepared by mixing the sawdust with 10% wheat bran and water to soak. The mixture of sawdust from different broad leaved tree species is used, which is mostly procured from Punjab, Haryana and Uttarakhand saw mills. The mixture is soaked overnight then filled into polypropylene bags and closed with cotton plugs. The bags are sterilised for two hours at 121^{0}Cin an autoclave, and bags, after cooling, are inoculated with sawdust spawn of shiitake. It takes about two months to fully colonize the bags at 25-27^{0}C. After complete colonization bags are shifted to lower temperature between 12-18^{0}C. The bag's colour starts turning into brown during this period and bump formation occurs. The colour change shows that the bags are mature enough for fructification. If the climatic conditions are congenial in the cropping room and moisture content is good in the bags then crop starts easily otherwise bags need to be soaked in water at the same temperature for 4-6 hours. After that, crop starts appearing within 10 days. The growers can take 4-5 flushes of crop in regular intervals after soaking the bags into water. It takes almost 6-9 months to wrap up the full crop. Shitake is handpicked by holding the mushroom stalks and gently twisting away from the substrate blocks. Using Shitake bag cultivation instead of the natural logs, mushrooms can be harvested faster and the yield is higher .

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Raw materials: Broad leaved trees sawdust from sawmills, rice bran polypropylene bags and cotton.
- Equipment required for spawn preparation: Refrigerator, Autoclave, Laminar flow, and BOD incubator.
- For cropping a dark room of 10 feet x10 feet size is minimum requirement for a small farmer. The preference is given to people in the areas where they can not afford to invest on infrastructure development under temperate conditions, and beneficiaries are selected on the basis of rooms available with them.

5. SPECIFIC PROBLEMS / OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

Non availability of the broad leaved trees sawdust in bulk can be a constraint. *Quercus incana* (Oak) wood logs can also be used for cultivation of Shitake. Oak species is of common occurence in many parts of the hill regions. Sawdust has to be aged before its use. The substrate should not be over wet otherwise clogging of the air occurs. Good aeration usually gives good results. Shitake spawn must be from authentic sources to avoid contamination. Substrate material must be free from contamination and hence autoclaved for 2hrs. Caution should be taken to avoid mold contamination during spawning. Not more than 5% bags should be contaminated. Harvested fruit bodies not sold as fresh Shitake should be dried at 60 ^{0}C.

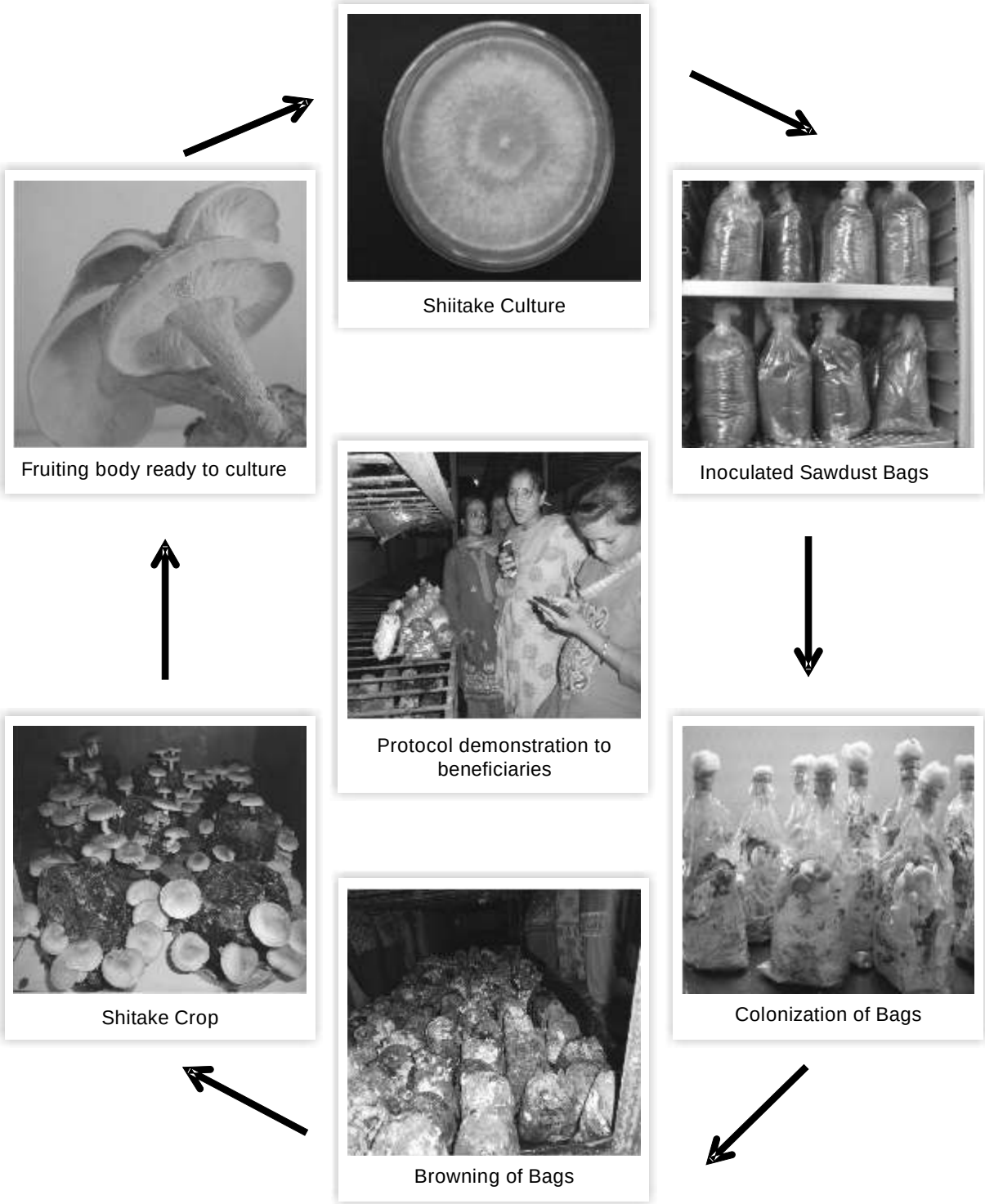

Fig. 5: Cultivation of Shitake and its demonstration to beneficiaries

6. IMPACT OF THE INNOVATION

Growing Shitake in sterilized bags is gaining popularity worldwide. Shiitake mushroom is very good livelihood options in the hill regions with temperate climatic conditions. Age old traditional practices of mono cropping culture are not economically viable for the farmers. With the increasing population, division of land is another major issue in the hilly rural areas. As an off farm activity with 100% economic returns with minimal investment Shitake cultivation has a key role in poverty alleviation. The technology was demonstrated to the selected number of people at grassroots level in District Mandi, Himachal Pradesh. People are keen to take up the technology. Once the cultivation is taken up by the farmers it will be a better option for livelihood generation with 100% economic returns.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

It can be cultivated on larger scale by using the wood logs as well as sawdust. The best part of this mushroom is it can be sold and stored in dried form. It has long shelf life in comparison to button mushroom. Local materials can be further tried for the cultivation of this mushroom to reduce its cost of cultivation. It is a high demand mushroom in the hotel industry due to its culinary properties and efforts are needed to popularize it on larger scale and provide home based small units through technology dissemination.

8. ECONOMIC VIABILITY

Cultivation of shiitake mushroom is economically viable as almost 100% economic return is assured. Though this mushroom takes longer time period (6-9 months) to cultivate, but yields 4-5 crops on the same substrate material. A small room of 10ft x10 ft can adjust 300 sawdust bags of one kg each in three tier and is sufficient for a small grower. Cost of production of one bag is Rs. 50-60 and around 1kg of mushroom is produced per bag which is sold in the market at Rs. 100-120/kg. 10kg of fresh mushroom becomes one kg on drying. Dried mushroom costs around Rs. 1500/- per kg.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY MAKING

Shitake mushroom farming being promising in poverty alleviation and strengthening livelihoods can be integrated in traditional farming. This proposition will also help to check migration of people from the hills.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

Shiitake cultivation is very good alternative for the grass root level communities at the village level in temperate Himalayan region. It addresses the poverty, livelihood, nutrition, health and women empowerment through generation of a nutritious source of medicinally valued food and a reliable source of income. Technology for Shitake cultivation can be extended to Himalayan regions in other states. Shiitake cultivation technology has been demonstrated to different women beneficiaries at the HRG field station (Fig. 5).

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Himalayan Research Group (HRG) is a non-governmental organization set up by the qualified and dedicated like-minded professionals to achieve the sustainable development of mountainous regions in June 1997. HRG aims to bring economic prosperity to the local communities in an eco-friendly manner with application of scientific innovations and technology transfer. HRG has a well equipped research lab and office at Shimla. The field activities are carried out through its regional centre at village Dhangiara in District Mandi of Himachal Pradesh. Keeping in view the grass roots initiatives for the development of rural communities, Science for Equity, Empowerment & Development (SEED) Division, DST, Govt. of India, selected HRG for long term prestigious CORE SUPPORT programme in August 2005.

3 CULTIVATION PROTOCOLS OF MEDICINAL AND AROMATIC PLANTS

1. GENERAL INFORMATION

- Title of Innovation

  Cultivation Protocol of Medicinal and Aromatic Plants

- Brief Description : A variety of medicinal and aromatic herbs are used in pharmaceuticals, food preparations, cosmetic and beauty aids in the world over since time immemorial. India is one of the custodians of medicinal plants in the world. The state of Uttarakhand is rich in medicinal and aromatic plants (MAPs) and has very rightly been declared as an Herbal State. Ayurveda, Unani and Homeopathy have been utilizing MAPs in their varied preparations since ages. Large gap in demand and supply of the MAPs and their indiscriminate collection from the wild have depleted these resources. This necessitates their conservation and large scale production by cultivation. Cultivation of MAPs will reduce the pressure on the wild sources and ensure their sustainable availability for the users. In this context, protocols for cultivation, harvesting and post harvest management of the State Government and National Medicinal Plant Board (NMPB) prioritized five MAPs including *Asparagus racemosus* (Shatavar), *Ocimum sanctum* (Tulsi), *Rauvolfia serpentina* (Sarpagandha), *Thymus serpyllum* (Banajwain) and *Crepidium acuminatum* (Jeevak) have been developed by the Non Wood Forest Products (NWFP) Discipline of the Forest Research Institute (FRI), Dehradun.

- Name and contact details of person or institution responsible for the innovation : Dr. Lokho Puni, Dr. A.K. Sharma, Dr. B.P. Tamta and Dr. Vishavjit Kumar, NWFP Discipline, Silviculture and Forest Management Division, Forest Research Institute, Dehradun -248006

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2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

The MAPs are better earners than many field crops. There is immense scope for further improvement in their productivity and adaptability, in order to obtain increased return. MAPs have immense potential for incorporation into various existing cropping patterns and can be grown as intercrop, mixed crops and under crops. Cultivation package of these plants will help in enhancement of the productivity per unit area, sustainable raw material availability for herbal industries, income generation and reducing the pressure on forests.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 *Asparagus racemosus*

- Description and Distribution: *Asparagus racemosus*, commonly known as Shatavar is an indigenous medicinal plant used in traditional systems of medicine. It is a perennial, excessively branched under

shrub found throughout the tropical and subtropical parts of India upto 1200 m. The roots are tuberous, 15-40 cm long and grey in color. The roots are accredited with immense medicinal value and find multipurpose therapeutic uses in traditional medicine systems. Medicinal properties of the roots are attributed to their steroidal saponins called shatavarins. It is estimated that in India, more than 500 tonnes of Shatavar roots are needed every year for various medicinal preparations.

- Soil and Climate: Plant usually grows in a variety of soils including medium black having pH 7-8, electrical conductivity 0.15mS/m, organic carbon 0.79% and phosphorus 7.3 kg/acre. It can be easily grown in sub-tropical andsub-temperate agro-climatic regions up to 1400 m.
- Land preparation: The soil is given 20-30 cm deep ploughing followed by 2-3 harrowing after few days. Grasses and weeds are removed. The land is properly leveled and 40-45 cm. broad ridges are prepared for plantation, leaving 15-20 cm furrow space as a channel for irrigation.
- Nursery raising and planting: Seeds are sown in April on raised beds at 5 cm apart to facilitate decay of its hard seed coat by the time monsoon commences. Germination starts in 8-10 days after the first shower of monsoon in June. Seedlings are transplanted on ridges at 60 x 60 cm apart. Vegetative propagation is done by division of rhizomatous disc present at the base of the aerial stem by keeping two buds along with 2-3 tuberous roots. One year old seedlings can be planted during April-May followed by mulching with available leaf litters like Litchi leaves, Oak leaves, etc. to conserve moisture and suppress weeds at the time of planting (Fig. 6)

Fig. 6: Nursery raised seedlings og Shatavar

- Weeding: Weeding is done twice during rainy months, thereafter once in next 2-3 months.
- Irrigation: Irrigation is given after the rainy season is over, at the rate of two irrigations in winter season and one per month in summer season. (adjustment is required depending on the local climate).
- Manures, Fertilizers and Pesticides: It is preferable to grow Shatavar without chemical fertilizers and pesticides. For organic cultivation, Farm Yard Manure (FYM) and Vermicompost @ 15 t/ha give best root yield. Precaution should be taken for rodents and rats which occasionally eat tender shoots. To prevent diseases, bio-pesticide like neem (kernel, seeds and leaves) gives good result. Chitrakmool, Dhatura, Cow's urine etc. can also be used.
- Harvesting and post harvest management : Harvesting is done before new shoots starts coming out. White and fair tubers without any spots of length 5 to 10 cm and thickness 1.5 cm are collected leaving one third of tubers for regeneration. Collection of rotten, diseased and damaged tubers should be avoided. If raised from seeds, plants should be dug out in winter after 20 months of planting, or after 8 months if raised from 1 year old seedlings (Fig. 7).

Fig. 7: Harvesting of Shatavar roots

The root cover is peeled using bamboo splits or knife immediately after harvesting and dried preferably in shade. Roots are separated and washed with water followed by boiling in water for 10-15 minute (young roots)/20-30 minute (hard roots) (Fig. 8).

Fig. 8: Post harvest processing of Shatavar roots

- Yield: The average yield of the roots is about 4.5kg fresh weight per plant after 20 months of age. The expenditure of cultivation is Rs.10,027/per ha and return per ha is Rs.36,000/-

3.2 *Ocimum sanctum*

- Description and distribution: Commonly known as Tulsi, it is an aromatic annual herb of high medicinal value. The well branched plant attains a height upto 1meter. Fresh or dried leaves of the plant are well recognized in traditional systems of medicine. Tulsi plant grows almost in every region of India, which has varying geographical and environmental conditions in different regions. Besides its use as an effective anti-inflammatory, antibiotic and antipyretic medicine in everyday regime for cold, cough and flu, it also possesses properties like healing of wound, anti-oxidant, anti-carcinogenic, anti- inflammatory and anti-ulcerogenic. The leaves yield an essential oil (upto 2%) of commerce. Composition of the oil varies according to the geographical distribution and variety of the source plant material.
- Soil and climate: Grows well on variety of soils. Rich loam to poor laterite, saline and alkaline to moderately acidic soils are well suited. Well-drained soil helps better vegetative growth. Water logging causes root-rot and stunts growth of the plants. Long days and high temperature favours the growth and oil production.
- Land preparation: Land is ploughed to fine tilth and plots of convenient sizes for irrigation are laid out. 15 tones of FYM per hectare during the preparation of land is added and mixed well in the soil. Organic manures such as vermicompost, green manure etc. may be used as per requirement.
- Nursery raising and planting: Seeds are sown in 3rd week of February. About 200-300g seeds are enough for planting in one hectare area. Seeds are sown 2cm deep in the nursery beds and seeds germinate in 8-12 days. Seedlings are ready for transplanting in 6 weeks and transplanted during mid April at 40 cm x 40cm and 40cm x 50cm to get high herbage and oil yield per/hectare.
- Weeding: Mulching reduces weeding requirements. First weeding is done after one month of planting and the next as per requirements.
- Irrigation: Depends upon the moisture content of soil. In summer 3 irrigations per month are necessary while in rainy season no irrigation is required. 12-15 irrigations are enough in a year.
- Disease management: To prevent diseases, bio-pesticides should be prepared (either single or mixture) from Neem (kernels, seeds and leaves), Chitrakmool, Dhatura, cow's urine etc. For powdery mildew, spraying the plants with water jet washes down the fungus.
- Harvesting and Post harvest management: The first harvest is obtained after 90-95 days of planting when the plant is in full bloom and lower leaves turn yellowish Only the clean and the healthy leaves are collected. Harvesting is done at every 65-75 days interval on bright sunny days. Harvesting can be delayed by a day or two if there is rain in the previous day. Harvested material must be spread thinly in the shade over a flat surface having good ventilation and no dust, and turned or moved atleast twice a day. Tulsi can be harvested 4 times a year (Fig. 9)

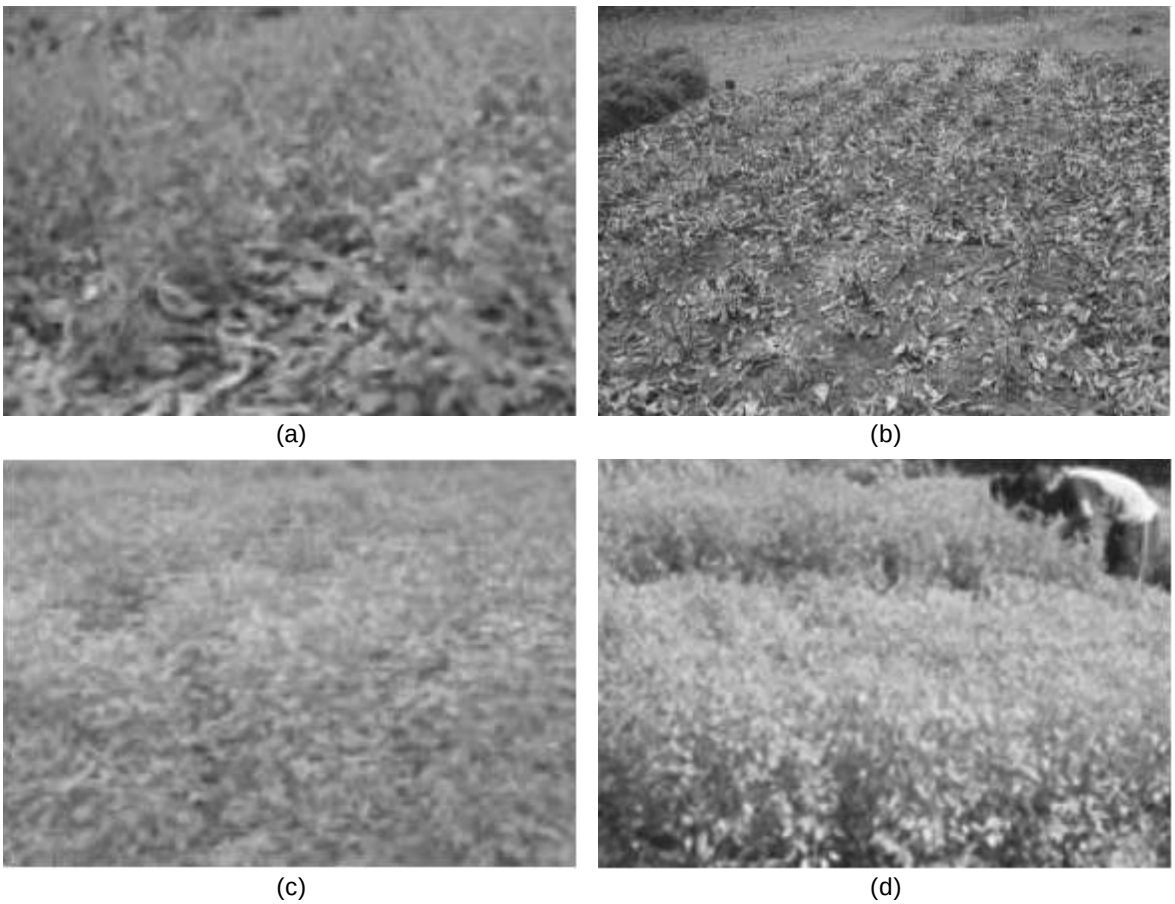

Fig. 9: Tulsi ready for harvesting: (a) 1st Harvest: Cut at 6 to 8inch; (b) 2nd Harvest: Pluck buds after 45 days; (c) 3rd Harvest: After 25 days cut at 2 feet height- (d) 4th Harvest (Last harvest): Pluck all the buds & leaves

- Yield: About 11 tones green herbage per hectare per year.

3.3 *Rauvolfia serpentina*

- Description and distribution: It is a small perennial erect about 75 cm high and glabrous shrub commonly known as Sarpgandha. The species grows in humid tropical areas of India. It grows in the foothills of Himalaya ranges up to the elevation of 1300 -1400 msl and almost throughout the country. Its roots are used for treating high blood pressure, insanity, insomnia, epilepsy, asthma etc. in Ayurvedic system of medicine. Roots contain more than 60 indole alkaloids of which the principal hypotensive alkaloids are reserpine and rescinnamine.
- Soil and Climate: Grows well in deep, loamy to clay loam rich in organic matter having pH 6 to 8.5. Water logged lands and frosty conditions must be avoided. The roots go down the soil upto 60 cm depth. It grows better in hot humid areas; both in open and in partial shade areas. Plants cultivated in open areas are found to be more prone to fungal diseases during monsoon rains than in the partial shade areas and well drained soils are preferred. It grows well in forest areas having tall tree canopies and can also be

intercropped with Soybean, Garlic, Ginger, and other vegetables having shallow roots.

- Land preparation: The land is ploughed to a fine tilth and plots of convenient sizes are laid out for management and irrigation.
- Nursery raising and planting: Sarpgandha is recommended to grow through seeds (Fig.10). Seeds are collected during June-July. The seeds sown after removing the pulp germinate immediately, however, some seeds will germinate in the next year. 6 kg seeds are required to be sown in one hectare. Seeds can be dibbled lightly in the forest areas during rains. The seedlings are transplanted into the polybags or root trainers for planting in next year (Fig. 11). Planting can be started before the onset of monsoon with the plants raised in polybags if irrigation is given. Planting materials are also propagated by cuttings of root, stem and leaf. Plants raised from cuttings produce small and branchy roots and mortality rate is very high since the roots do not go down deep like the plants from seed origin.
- Weeding: Mulching is done to conserve the moisture and annihilate weeds if plantation is done before monsoon rains. Litchi and Karanja leaf litter is also found to be good mulching materials.
- Irrigation: It is a deep rooted plant and hence can withstand a long period of drought. At planting irrigation is given once, then mulch is placed in the field.
- Disease management: Sarpagandha leaves are voraciously eaten by catterpillars. It reduces the growth of the plant. To control the insects, eiher neem extract is sprayed or affected plants are physically removed or destroyed.
- Harvesting and Post harvest management: Root maturity takes 18-20 months or more. The roots are dug out during autumn(Novemer - December) (Fig. 12). Roots are cut into 12-15 cm pieces to facilitate drying and storage and it can be kept for 1-3 years

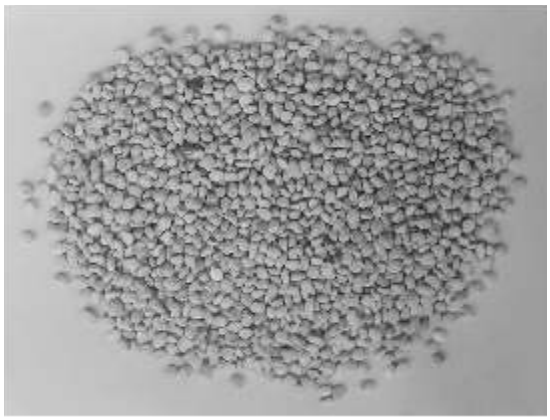

Fig. 10: Sarpgandha seeds

Fig. 11: Nursery raised Sarpgandha seedlings

Fig. 12: Harvested roots of Sarpgandha seedlings

in godown. Bark is bitter and contains most of the alkaloids hence smaller lateral roots are also rich in the active principles. Therefore, the bark is also collected during harvesting.

- Yield : 20-25 Quintal dry weight/ha

3.4 *Thymus serpyllum*

- Description and distribution: Commonly known as Banajwain, Wild thyme or Creeping thyme, *Thymus serpyllum* is a perennial and evergreen herb, 10-25cm high and is commercially important for its pleasant aromatic oil. In India, it is found in the Himalayas of Jammu & Kashmir, Himachal Pradesh, and Uttarakhand between an altitude ranges of 1500-4500 m. It is also grown in the gardens of western India. The whole plant has enormous medicinal and economical significance. The medicinal properties of wild thyme have extensively been used in official and traditional medicine for many years and centuries, respectively. The yield of oil from fresh plants is 0.27 % and from the dried plants is up to 0.60 %. The major component of the oil is thymol (45.8 % to 48.4 %). The leaves and flowers are also used in culinary.

- Soil and Climate: The plant prefers a light but fertile and calcareous soil for good growth and oil content. A warm climate is best suited for the crop. It can be grown in both hill and plains but hilly region is best suited for its cultivation.

- Land preparation: The land is prepared well by repeated ploughing or digging and brought to a fine tilth and divided in to plots of convenient size.

- Nursery raising and planting: Thyme can be propagated by seeds. Seeds are sown in the nursery in April in prepared beds in rows 90 cm apart in fine soil because the seedlings are very small and remain inconspicuous for several weeks after germination. Seedlings are thinned out 30 - 45 cm. within the rows. While planting the seedlings and or rooted cuttings they are planted 30 - 45 cm apart and 60 cm apart in rows, respectively.

- Vegetative propagation: Ex-situ germplasm conservation technique for thyme has been developed by NWFP Division of FRI (Fig.13) and which enabled to cultivate in its natural habitat at field stone wall in Pauri hill area (Fig.14). This high altitude herb can also be domesticated in the lower plain like Dehradun (700 msl). Bricks are laid in the form of a box having height of 1m and

Fig. 13: *Ex- Situ* germplasm bank of Thyme

Fig. 14: Thyme grown in stone wall

convenient length. Sufficient gap is kept between the bricks and the space is filled up with soil preferably having high percentage of clay. Healthy shoot cuttings of the plant about 10 cm length are obtained by the start of monsoon season followed by planting of 2-3 cuttings together in the soil between the bricks and the top surface of the box. Regular watering is be required to maintain the germplasm properly.

- Irrigation: Since the crop is planted late in summer, it requires frequent irrigation during the dry period.
- Weeding: Weeding is done at regular intervals to encourage the good growth of plants and mulching is advised in hilly areas which help to protect planst from the frost injury.
- Diseases management: The wilt disease is major problem in the crop. The disease can be controlled by improving the phyto sanitation and drenching the soil with a Blitox or M-45 at 0.3% concentration.
- Harvesting and Post harvest management: The leaves and flowers are harvested five month after sowing/ planting (Fig. 15). For extraction of the oil, fresh herb is collected in dry days, at the stage when it just starts flowering. To maximize essential oil yield, only one harvesting per year is done, when 50% of flowers have bloomed. The leaves and flowers are plucked from the plants or shoots of about 15 cm are cut off from the plants. The harvested materials are dried in the shade or in dryer immediately after harvest and stored in airtight containers to prevent the loss of flavor. The dry leaves are of brownish-green in colour and are curled usually not longer 6-7 mm. The dry shoots may also be powdered and packed. Sun drying of thyme is not recommended, as it often results in rapid decrease of product quality.
- Yield: Under favorable conditions, the yield of dry herb is around 1100-2200 kg/ha.

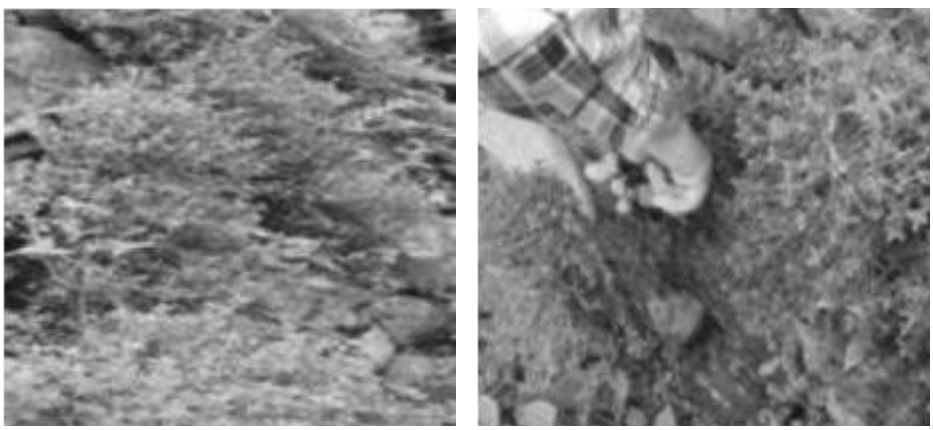

Fig. 15. Harvesting of Thyme

3.5 *Crepidium acuminatum* Syn *Microstylis wallichii, Malaxis acuminata*

- Description and distribution: *Crepidium acuminatum* commonly known as Jeevak is an erect, tuberous, small, terrestrial orchid, about 20–25 cm high. The stem tends to be pseudo-bulbous at the base which is the medicinal important part of the plant. New plants arise from the rootstock and the mother plant decays as the daughter plant grows. Leaves are simple, three or five in number, and sheathing at the base. Flowers

bloom in mid-May and the plant remains in full bloom till October. Fruiting is completed in October–November, after which it enters into dormant stage. The species is found in temperate to subalpine ranges of the Himalayas, between 1800 m and 2300 m altitude. Its distribution is scarce and restricted. It is a shade loving species and needs rich humus and soil moisture. It preferably grows on the cool northern and western hill slopes. Jeevak plant is an important medicine traditionally known since ages. It is rejuvenating tonic, styptic aphrodisiac, and antioxidant. It is an important ingredient of Ashtawarga, under Jivaniya Varga of Charaka Samhita, which literally means 'life-giver.

- Soil and Climate: It grows in loose sandy loam soil, rich in humus, chiefly on upper stratum of organic layer in the wet localities. The requirement of mean annual rainfall ranges between 1000 mm and 1500 mm, and the optimal mean annual temperature range is 10 - 15 °C. The species thrives well in moist, shady places covered with thick leaf litter deposits in dense Oak - Deodar forest zone.
- Land preparation: Initial land preparation is done in November or December. The field is left fallow for the entire winter. It needs large quantity of organic manure and layering of leaf litter (40–50 tonnes/ hectare), which are applied in two doses. The land is again ploughed in next May, followed by mixing of half the amount of FYM and leaf litter in the soil in a pulverized form. Remaining half of the organic manure is added to the field after planting. Raised beds are prepared to provide good drainage. Mulching of the beds with leaf litter ensures control of weed growth, checks soil erosion, and helps to conserve moisture during the dry period.
- Nursery raising and Planting
    - Seed propagation: Orchids are characterized by very small seeds that are not fit for propagation. Studies conducted on this species suggest that seeds show poor germination and produce seedlings of low vigour. Also, the fruiting pods are very small and most of the seeds are dispersed before collection. Seed viability studies are also not available.
    - Vegetative propagation: Only vegetative parts, whether pseudobulbs, daughter plants, nodal segments of rhizomes or tubers, are feasible as propagation material. Each pseudobulb has four to five nodal segments. These pseudobulbs are collected in the first half of November. Mature bulbs may

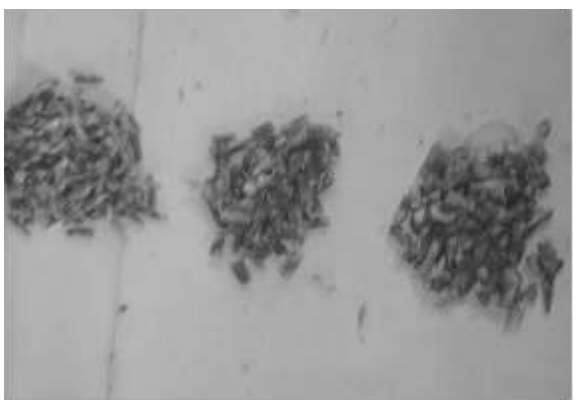

Fig. 16. Cuttings of Pseudobulb

Fig. 17. Sprouting of Pseudobulb

be collected from the wild sources in the rainy season. The crop is raised by planting whole, half or segmented pseudobulbs directly in main field in the first fortnight of May. The soil is sun-dried or treated with fungicide to check the fungal attack. About 2,50, 000 nodal segments or1,25,000 bulbs are required for planting as a sole crop in 1 hectare of land at a spacing of 20 cm × 20 cm. Pseudo bulbs cuttings when transplanted in natural occurrence of species, tip portion and whole bulbs show better performance (Fig. 16 and Fig.17). Orchid can be grown as a sole crop as well as an intercrop with plants like Colocasia, Ginger and Turmeric.

- Irrigation practices: This species is planted just before the onset of the rain, so irrigation is needed immediately. However, if rains do not commence within a week of planting, repeated irrigation becomes necessary to save the sprouting bulbs. Frequent watering is required in the early stages of the cropping. Thereafter, sprinkler irrigation may be done twice a week.

- Disease management: Attack of white grub or June beetle, a subterranean pest, is occasionally noticed on the bulbs. Application of Phorate @ 10 g/litre as a basal treatment at the time of planting can check the white grub attack. Manual picking or sun drying soil also helps in countering the grub. No fungal attack has been reported in the field. Moist bulbs are susceptible to attack of rot fungus during storage. Beds under open conditions show leaves tinged yellow, which is not the case in beds in shade.

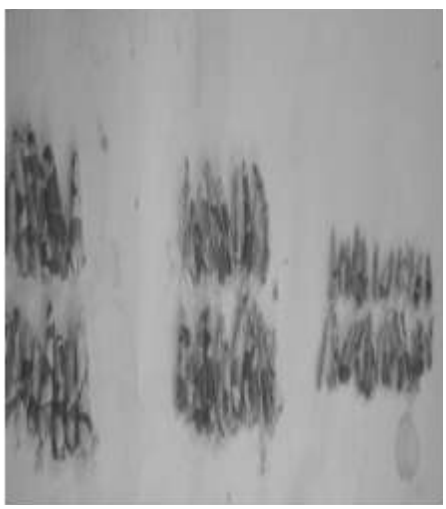
Fig. 18: Grading of pseudobulbs of Jeevak

- Harvesting and Post harvest management: The crop matures in five months and the tubers are ready to be harvested when dormancy sets in during the last week of October or first week of November. Bulbs are dug carefully after watering. The injured bulbs cannot be stored and are prone to decay. The study carried out by NWFP Division FRI in natural habitat of species indicated that maximum harvesting percent (59.31) in forest area is of small bulbs and these bulbs are retained in the forests for regeneration purpose. The percent of harvesting of middle bulbs was 29.65 which are used for propagation purpose and only 11.04% was used in marketing purpose. Pseudobulbs are graded in to small, middle and big size (Fig.18). Small size pseudobulbs contain 1880 numbers having average length and diameter of 2.89 cm and 0.48 cm, respectively. Middle sized pseudobulbs contain 940 numbers having average length and diameter of 3.59 cm and 0.79 cm, respectively. Big size pseudobulbs contain 350 number shaving average length and diameter of 5.00 cm and 1.17 cm, respectively. Only big size and middle size pseudobulbs are collected from the forest areas. Storage of harvested pseudobulbs is done by burying them in sand/soil. Pseudobulbs can also be stored in pots or brick chambers filled with sand or inside the pits made on the sloping walls of terraces. Storage in sand and inside sloping pits gives 100% protection for future

plantation, but there are chances of damage due to rodent attack and accumulation of water inside the pits. The produce is cleaned, dried in shade, and stored in cool dry place for marketing

- Yield: Average yield of dried pseudobulbs varies from 600 kg per hectare to 750 kg per hectare.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Quality planting materials of *Asparagus racemosus, Ocimum sanctum, Rauvolfia serpentina, Thymus serpyllum* and *Crepidium acuminatum* can be obtained from the natural habitat and high altitude nursery of NWFP Discipline.
- FYM, insecticides, fungicides and mulching materials as per recommended doses.
- Tools for weeding and hoeing nursery, irrigation and storage facilities and processing unit for value addition.

5. SPECIFIC PROBLEMS/OBSTACLES LIKELY TO BE FACED BY THE USERDURING USE AND THEIR SOLUTIONS.

Use of chemical fertilizers and pesticides should be avoided. Instead biopesticides must be used.

- Shatavar: Marketing strategy should be planned. Buyers should be contacted and the requirements should be followed before harvesting
- Tulsi: Any foreign materials to get mixed up should not be allowed.
- Thyme: During harvesting lower portion of the stem, along with any yellow or brown leaves, should be rejected. Only shoot portion along with flowers are harvested. If the plants are cut very short, they cannot withstand the frost and will not survive.

  Processing unit should be available near cultivation sites especially for aromatic plants. Always there should be a link between buyers /industries with cultivators.

6. IMPACT OF THE INNOVATION

Growing of *Asparagus racemosus, Ocimum sanctum, Rauvolfia serpentina, Thymus serpyllum* and *Crepidium acuminatum* is resource friendly and can be adopted by farmers, tree growers and others. The approach prevents environment degradation and loss of genetic diversity in the wild and encourages growers to cultivate these species.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The cultivation protocol is quite suitable in respective habitat zones of the species. Farmers can grow these medicinal plants in large areas on a community basis to meet huge industrial demand and in small areas to meet the requirement of traditional systems of medicine.

8. ECONOMIC VIABILITY

Developed cultivation protocols are economically viable and can be adopted by the growers of the trees and / medicinal plants growers. Since cultivation of medicinal plants is labour intensive, and market for herbal products is increasing worldwide, local communities can earn livelihood by growing the medicinal plant and selling their produce.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The protocols developed provide a practical example of economic potential and research on MAPs, which can help policy makers in linking livelihood and socioeconomic development with natural resource conservation.

10. POSSIBILITYAND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/COMMUNITIES/ INDUSTRIES, ETC.)

The protocol has great potential to be extended to the local communities in respective habitat zones of the species.. Buy back arrangements with the industries will ensure sustainable supply of these medicinal plants. All members of the value chain of the medicinal plants including farmers, tree growers, processing industries, SFDs, herbal industries, Ayurveda practioners, export houses, etc. should be included in the extension programme for strengthening producer- market linkages.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Forest Research Institute, Dehardun is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

4 MACRO-PROLIFERATION TECHNIQUE FOR MULTIPLICATION OF KUTKI AND MUSHAKBALA

1. GENERAL INFORMATION

- Title of Innovation (Technology/ Practice/ Protocol/ Product): Protocol

  Macro-proliferation technique for multiplication of Kutki and Mushakbala

- Brief Description : Macro-proliferation is a low cost simple technique. This method ensures that each propagule possesses some part of shoot along with rhizome parts and some roots at the time of separation from mature healthy plant. The concept of this propagation technique is that each separated propagule possesses shoot portion, stored food material and 1-3 tiny roots so that under congenial conditions it starts growing as an individual plant immediately. Keeping this in mind, macro-proliferation technique has been developed for vegetative multiplication of Kutki (*Picrorhiza kurroa* Royle ex Benth.) and Mushakbala (Valeriana jatamansi, Jones), the important medicinal plants species of temperate Himalaya. By the application of this technique a healthy mature plant of Kutki and Mushakbala can be multiplied 8 to 12 times successfully. In addition to multiplication, >50% yield of rhizomes and roots can be recovered for marketing or various other uses. Time of separation, portion of shoot/root/rhizome to be retained in each propagule and providing appropriate growing conditions for plantation of separated propagules are found to be critical factors for achieving success through this technique.

- Name and contact details of person or institution responsible for the innovation : Dr. Sandeep Sharma, Scientist-G, Silviculture and Forest Management Division, Himalayan Forest Research Institute, Shimla -171 013; Email: sharmas@icfre.org; Mobile: +919418129759

- Name and position of key or relevant persons or officials associated : Jagdish Singh, Scientist-F, Silviculture and Forest Management Division, Himalayan Forest Research Institute, Shimla - 171 013; Email: singhj@icfre.org; Mobile: +91 8219053885

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Western Himalayan region is endowed with rich diversity of medicinal and aromatic plants. A number of medicinal plants species found in this part of India are extensively used by the locals since ancient times for curing various human ailments. Besides this, large quantities of temperate medicinal plants are being extracted continuously to fulfill the ever growing requirements of herbal based Industries of the country. Kutki and Mushakbala are important temperate medicinal plant species found in western Himalayas and possess great potential for commercial cultivation. Due to overexploitation and unscientific extraction from the natural habitat, the populations of these medicinal plants species have come down steadily in last couple of decades.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 Macro-proliferation technique for multiplication of Kutki

Kutki (Fig.19) is difficult to propagate through seeds but the vegetative propagation can be done easily with number of scientific advantages over sexual propagation. The genetic makeup of the plant could be easily retained through vegetative propagation technique and is considered faster. This species possesses inherent proliferating capacity and offset planting capabilities for its reproduction.

Fig. 19: Mature plant of Kutki

Specifications

The following specifications are desired in the separated propagules for better success:

i) Shoot length : 3-5cm

ii) Presence of leaves on separated propagule : ½ to 2

iii) Rhizome length : 3-6 cm

iv) No. of roots : 1-3

Besides these, time of macro-proliferation (separation) and appropriate conditions for rapid establishment of macro-proliferated propagules(Fig. 20) are very critical and given in the Table1:

Table 1. Time of macro-proliferation and appropriate conditions for rapid establishment of macro-proliferated propagules of Kutki.

S. No.	Time of Macro-proliferation (Month of the year)	Conditions for rapid establishment of marco-proliferated propagules	Success Rate
1.	April to October	Placement in Poly-house conditions for 1½ months and subsequent planting in the field	Almost 100%
2.	July to September	Placement in Sand trays for 1 ½ months and subsequent planting in the field	> 90%
3.	August	Direct planting in field for 2 ½ to 3 years	>75%

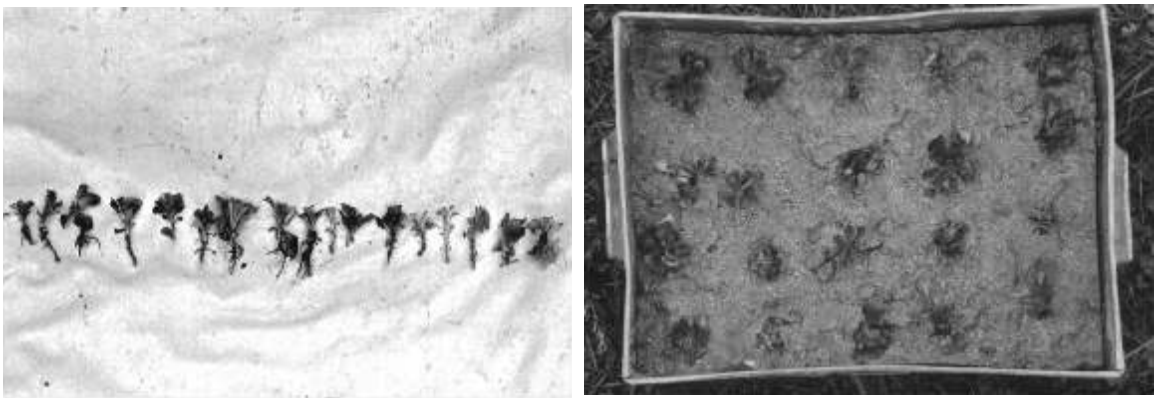

Fig. 20. Macro-proliferated propagules of Kutki

Fig. 21. Rejuvenated macro-proliferated plants of Kutki under Poly-house condition

3.2 Macro-proliferation technique for multiplication of Mushakbala

Mushakbala (Fig. 22) can be easily grown through seeds but the vegetative propagation has scientific advantage over sexual propagation. The genetic makeup of the plant could be easily retained through vegetative propagation technique and is considered faster. This species possesses inherent proliferating capacity and offset planting capabilities for its reproduction.

Fig. 22: Mature plant of Mushakbala

Specifications

The following specifications are desired in the separated propagules for better success:

i) Shoot length : 5-8cm

ii) Presence of leaves on separated propagule : ½ to 2

iii) Rhizome length : 2-5cm

iv) No. of roots : 1-4

Besides these, times of macro-proliferation (separation) from mature plant and appropriate conditions for rapid establishment of macro-proliferated propagules(Fig. 23) are very critical and given in Table 2:

Fig. 23. Macro-proliferated propagules of Mushakbala

Table 2. Time of macro-proliferation and appropriate conditions for rapid establishment of propagules of Mushakbala

S. No.	Time of Macro-proliferation (Month of the year)	Conditions for rapid establishment of marco-proliferated propagules	Success Rate
1.	April to October	Placement in normal Poly-house conditions for 1½ months and subsequent planting in the well prepared agriculture fields.	Almost 100%
2.	June to September	Placement in fine river sand trays for 1 ½ months and subsequent planting in the well prepared agriculture fields.	> 95%
3.	June to August	Direct planting in well prepared agriculture fields for 2 ½ to 3 years.(Fig. 24)	> 90%

Fig 24. Successful establishment of macro-proliferated propagules of Mushakbala directly planted in the field

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Mature plants of Kutki and Mushkbala can be obtained from the nursery of the institute or from wild. Secateurs, nursery implements to uproot plants and Dibbler for planting propagules in the nursery beds/ agriculture fields are required. Fine river sand, trays and poly-house are needed to get more success in entire growing period. These materials are readily available in the local market.

5. SPECIFIC PROBLEMS / OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

It is simple manual technique. It requires secateurs or scissors to separate macro-proliferated propagules from healthy mature mother plant. Even unskilled labourer can learn this separation technique within half an hour. The separated propagules should be planted immediately as per the facilities available to avoid desiccation or placed in moist clothes/moss. The month of application of this technique also depends upon the facilities available for subsequent establishment. In general it is always better to go for this technique during rainy season. The specifications of separated propagules must be taken into account for better survival.

6. IMPACT OF THE INNOVATION

Kutki and Mushakbala are important medicinal plant species of high temperate Himalaya and recommended for cultivation in high hills. Therefore, this technique possesses great potential in maintaining the supply of quality planting material (QPM) of the species continuously for cultivation in the farmer's field located in high hills as well as for *in-situ* enrichment. These species have potential to diversify the traditional agriculture/horticulture practices and augmentation of farm income in Himalayan region. Supply of quality raw material can also be ensured for pharmaceutical industries.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The technique is quite suitable for mass multiplication of Kutki and Mushakbala. As the multiplication is through vegetative means, therefore the desired variety/strain/selection of these species could be multiplied easily for the benefit of enhancement of productivity and maintaining the genetic superiority while opting for commercial cultivation of these plants species. The technique being very simple can be easily up scaled under field conditions. Through this technique, HFRI Shimla has produced > 8 lakhs QPM of these species under various NMPB funded projects in last one decade.

8. ECONOMIC VIABILITY

The cost of production of nursery stock through this technique comes out to be < Rs. one per plant where as through traditional techniques it is around three times more than this cost. Besides cost, quality planting material of Kutki and Mushakbala can be produced quickly by this technique which will help in taking up their commercial cultivation augmenting thereby rural income of hill farmers. The harvestable age of these medicinal plants is also reduced by one year as compared to nursery stock produced through seeds.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The developed technique will help in protection, conservation and mass multiplication of Kutki and Mushakbala. Thus, it can be linked to livelihood and socio-economic development programmes with natural resource conservation.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The technology has great potential for future dissemination in temperate regions of the North West Himalaya through training and demonstration programmes, and by developing and disseminating user friendly publicity material in vernacular language for popularizing this technique in the field at grass root level. The main end users of this technique will be local communities of high hill zone of north-western Himalaya and State Forest Departments of Himachal Pradesh, J&K and Uttarakhand. Technology should also be popularized among other members of the value chain of the medicinal plants including processing industries, herbal industries, Ayurveda practioners, etc.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Himalayan Forest Research Institute (HFRI) Shimla is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

5 PROTOCOL FOR INTERCROPPING OF CHORA, KUTKI AND MUSHAKBALA WITH APPLE

1. GENERAL INFORMATION

- Title of Innovation

  Protocol for intercropping of Chora, Kutki and Mushakbala with Apple

- Brief Description : Medicinal plants are considered as health care resource and commonly used in traditional medicine by rural population for treating various diseases. The use of herbal medicine is an age-old tradition and the recent progress in modern therapeutics has stimulated the use of natural product worldwide for diverse ailments and diseases. The World Health Organization (WHO) has estimated that as many as 80%of the world population is dependent on traditional medicine for their primary health needs. In Himachal Pradesh, temperate fruit growing is the main activity of mid and higher hill farmers. Till recently growing of temperate fruits was lucrative business but continuous failure of these fruit crops in last 4-5 years due to erratic rainfall accompanied with very less snow fall, increased incidence of various insect pest and diseases attacks, overall rising temperature and decreasing forest areas of the region, shortened chilling hours required by the apple trees during winter for optimum flowering and fruit setting etc.; thus resulted in low yields and lower qualities. Consequently the production in horticultural crops has reduced considerably and now farmers are looking other alternatives to supplement their incomes by diversifying farming practices. Owing to high demand and ready market availability medicinal plant species could be commercially raised as intercrop with the horticultural plantations thereby helping in protection and production of endangered species, which would ultimately help in productivity enhancement per unit area of land and in mitigating the poverty in rural areas. Intercropping models developed for different species in different horticultural crops will help the farmers in the long run to go in for commercial cultivation of medicinal plants in a sustainable manner in the region.

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2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Intercropping of temperate medicinal plants will give an option for diversification of crops to the farmers, so that if one crop fails other crop could compensate the loss. Most of the farmers have small land holding therefore intercropping of medicinal plants with horticultural plantations will help in productivity enhancement per unit area and sustainable income generation through intercropping of temperate medicinal plants with horticultural plantation.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Himalayan herbs have received unprecedented attention the world over. Heavy biotic pressure, ruthless extraction and illegal trade however are well acknowledged with other factors contributing to endangerment of medicinal plants. Though collection of medicinal plants from wild would be ideal for the pharmaceutical industries due to quality considerations, but due to the shrinking forest resources and shortage of the raw material from the wild, they have to resort to cultivation practices that are close to the natural setting. The alternative way to provide the plant material needed for medicine is to cultivate them. This will reduce the pressure on the wild sources as well.

3.1 Intercropping of *Angelica glauca* (Chora) with Apple

Angelica glauca Edgew. (Family Apiaceae), commonly known as 'Chora' is a high value medicinal and aromatic plant species of the Himalaya. It is a native and endemic plant species, distributed along 2600 to 3,700 msl in Himachal Pradesh, Uttrakhand and Jammu & Kashmir. The plant is used as a cordial stimulant in the treatment of dyspepsia and constipation. The dried roots contain about 1.3% essential oil. In the apple orchards of the high hill temperate region, field beds (as per the availability of inter spaces) should be prepared in the inter spaces during the month of February-March. Farm Yard Manure (FYM) 20 tonne/ hectare should be applied as a basal dose to improve the fertility/nutrient content of field beds prepared in the inter spaces. The field beds should be prepared along with sufficient paths to facilitate the movement and carry out routine horticultural operations easily. Seedlings of Chora should be planted in the spacing of 45 cm x75 cm in the field beds (Fig.25). Irrigation after weekly interval during hot summer season along with monthly or half monthly weeding during April to August is recommended for optimum growth and yield. For inter cropping Chora, apple orchard of age between 26 to 30 years has been found to be best for optimum yield. The roots are harvested after two and half years generally during the month of September-October. After harvesting roots are thoroughly washed with clean water, dried under shade and packed.

Fig. 25: Chora intercropped in Apple plantation

3.2 Intercropping of *Picrorhiza kurroa* (Kutki) with Apple

Picrorhiza kurroa (Family: Scrophulariaceae), commonly known as 'Kutki' is widely distributed in the alpine and temperate Himalayas in Kashmir, Himachal Pradesh, Uttarakhand and Skkim between an elevation of 3000-4000 masl.The dried rhizomes and roots of the plant are known for therapeutically important picrosides mainly picroside-I and picroside-II (kutkoside). Kutki is of several commercially available hepatoprotective formulations. In the interspaces of Apple orchard, field beds should be prepared along

with sufficient paths during the month of February-March. A basal dose of FYM 25 tonne/hectare should be applied in the field beds (Fig. 26). Seedlings of Kutki should be planted in the spacing of 30 cm x 40 cm in the field beds. Irrigation after weekly interval during hot summer season along with monthly or half monthly weeding is recommended during the months of April to August for optimum growth and yield. Apple orchard of age between 26 to 36 years has been found to be best for optimum yield of Kutki. The root part can be harvested after three years generally during the month of September-October. The average yield is 7 quintals/ hectare after three years of planting. After harvesting roots are thoroughly washed with clean water, dried under shade and packed.

Fig. 26: Kutki intercropped in Apple plantation

3.3 Intercropping of *Valeriana jatamansi* (Mushakbala) with Apple

Valeriana jatamansi Jones (Family Valerianaceae) commonly known as 'Mushakbala' is widely distributed in temperate Himalayas between an elevation of 1500-3500 masl and is one of the major income generating non-timber forest products of the region. It has been used since long for the treatment of hysteria, epilepsy and asthma. Presently it is used in medicine as antispasmodic, carminative, diuretic, hypnotic, nervine, sedative and stimulant.Its odorous rhizomes containing essential oil are highly medicinal and used in Ayurvedic and Unani systems of medicine. Essential oil and extract of the species also find uses in flavour, pharmaceutical and fragrance Industries and about 30 products are commercially available. In the Apple orchards of the high hill temperate region, field beds (as per the availability of interspaces) should be prepared in the interspaces during the month of February-March. Farm Yard Manure 20 tonne/ hectare should be applied as a basal dose to improve the fertility/nutrient content of field beds prepared in the interspaces. The field beds should be prepared along with sufficient paths to facilitate the movement and carry out routine horticultural operations easily. Seedlings of Mushakbala should be planted in the spacing of 30cmx40 cm in the field beds. Irrigation interval for one day is recommended during hot summer season for optimum growth and yield. Maintenance of the intercropping field should be carried out by regular weeding and hoeing etc. Monthly or half monthly weeding is recommended during the months of April to August, failing which the weeds will suppress the growth of medicinal plants, thus hampering

Fig. 27: Mushakbala intercropped in Apple plantation

the yield of the species. Apple orchard of age 30 years has been found to be best for optimum yield (Fig. 27). Harvesting of the species is carried out after two and half years generally during the month of September-October. After harvesting rhizomes are thoroughly washed with clean water, dried under shade and packed.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Quality Planting Material (QPM) of Chora, Kutki and Mushakbala can be obtained from the nursery of the Himalayan Forest Research Institute at Field Research Station Brundhar, Jagatsukh (Kullu) H.P. FYM as per recommended dose is required during the preparation of field beds. Khurpi and Hoe are required for carrying out weeding and hoeing. Kudali and Secateurs are required during harvesting of the crops. These minor equipments are easily available in the market.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

As market rates for medicinal plants are fluctuating, hence cultivator may ensure buy back arrangement. Water logging conditions should be avoided for intercropping of these medicinal plants as it may cause considerable mortality in the field. Harvested roots should be properly shade dried in well ventilated condition and packed in the gunny bags.

6. IMPACT OF THE INNOVATION

Growing of Chora, Kutki and Mushakbala as intercrops in Apple plantation has complementary effect on base crop. Cultivation of these threatened medicinal plants will not only help in their conservation but also in strengthening of income of local communities.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The protocol is quite suitable in high temperate regions of north western Himalayas where horticultural crops viz. Apple and Cherry are being grown. Farmers can grow these medicinal plants in large areas on a community basis to meet huge industrial demand and in small areas to meet the requirement of traditional systems of medicine.

8. ECONOMIC VIABILITY

After two and half years of plantation, the average yield of the roots of Chora is 23 quintal/ hectare. The market rate may vary from Rs. 60 to Rs. 100/- per Kg. In addition to Apple crop, intercropping of Chora with Apple could generate net returns of Rs. 80,000 to Rs. 1,30,000/ hectare. The average yield of Kutki roots in intercropping with Apple is about 7 quintal/ hectare after three years of planting. The market rate may vary from Rs. 200 to Rs. 225/ Kg. In addition to apple crop, intercropping of Kutki with Apple could generate net returns of Rs. 90,000 to 160,000/ hectare. After three years of planting, the average yield of Mushakbala rhizomes is about 12 quintal/ hectare. The market rate may vary from Rs. 120 to Rs. 150/Kg. In addition to Apple crop, intercropping of Mushakbala with Apple could generate net returns of Rs. 90,000 to 150,000/ hectare. The

protocol is quite economically viable as after the gestation period farmer gets additional income through sale of medicinal plants produce.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Not only the conservation (both *ex-situ* and *in situ*) of medicinal plants is vital but sustained availability of their quality planting material also needs to be ensured for various user groups. There should be considerable value addition of medicinal plants through simple primary and secondary processing techniques to enhance the stake of communities in medicinal plants conservation. Promotion of cultivation, value addition and commercialization of medicinal plants needs to be accelerated and all the legal and regulatory mechanisms related to these issues should also be taken into account.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The protocol has great potential to be extended amongst the communities in high hill temperate region of north western Himalayas. For sustainable supply of these medicinal plants, buy back arrangements can be made with industries. Industries can also be included in the extension programme for making them aware about the availability of the medicinal plants produce for their use. This will also provide an opportunity to the farmers to interact with the industries to ensure the sale of their produce or making buy back arrangements. Technology should be extended to the all members of the value chain of the medicinal plants including farmers, tree growers, processing industries, SFDs, herbal industries, Ayurveda practioners, etc.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

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6 A PROTOCOL FOR CULTIVATION OF CHIRATA

1. GENERAL INFORMATION

- Title of Innovation

  A protocol for cultivation of Chirata

- Brief Description : Agro technology of Chirata cultivation has been standardized for benefit of the farmers of high altitude zone in Himalayas. Annual demand of Chirata in India is reported to be 60,000-1,00,000 Kg and is imported mainly from Nepal. Collection of this species in India have declined in recent years due to the excessive extraction from the nature before seed ripening. Therefore, commercial cultivation of this species to meet the increasing demand is the answer which will provide high economic returns to the farmers and help in conservation of related species in the nature. Agro technology has been standardised for commercial cultivation by involving local communities for their economic upliftment. Cultivation of Chirata on abandoned agriculture lands on the hill slops away from the human habitation provide good niche to achieve organic certification and employment opportunities for rural people.

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- Name and position of key or relevant persons or officials associated : Dr. Maninder Jeet Kaur, Principal Scientist cum Secretary, Himalayan Research Group, Core, DST, Govt. of India, Umesh Bhawan, Chotta Shimla 171002; Email: maninderjk@rediffmail.com; Mobile: +9198160 22599

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Animal menace is a big problem in the hills. Small landholding for the marginal framers is another issue which restricts the agriculture production. Therefore, cultivating medicinal plants is an alternate to the agriculture crops and help in diversification to earn better in comparison to the traditional cropping system or an option to the monoculture cropping pattern.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Chirata can easily be cultivated in temperate zone of mountains through seed sowing. Initially seed producing material was collected from wild growing plants. This material was multiplied by local communities as master growers and procured from them @ Rs. 15/-per gm. 1 gm material contains 10,000-12,000 seeds (Fig. 28). Seeds are very expensive (1 lakh rupees per kg). Seeds, very small in size, are soaked in water overnight then

mixed with vermicompost and then broadcasted into the fields. Seeds start growing after 4-5 months of sowing in August-September. In next year August plant has white flowers, which is right stage to harvest the crop. The crop takes 18 months to complete the cycle.

Fig. 28: Chirata Seeds

3.1 Field preparation: Agriculture land should be moist and less sunny. Field needs to be prepared in the month of January-February. After ploughing, fields left untreated for 20-25 days. At the end of month, fields are mixed with vermicompost (4000 Kg/hectare). Fields are divided into small plots of 90 cm width with bunds of 10cm. height, and 20 - 25 cm of space in between for watering the crop.

3.2 Seed sowing: For proper sowing, seeds are soaked in water for 12-15 hrs then mixed with vermicompost. 1 gm seed is mixed with one kg of vermicompost. Then seeds are spread into the fields followed by light dusting of soil. Seeds start growing after 4-5 months of sowing in August- September. Weeding needs to be done 2-3 times.

3.3 Crop harvest: It takes almost 18 months to mature the crop. Crop takes a year to bloom. During summers crop starts growing and plant reaches to the height of 2 ft. After one year plant has white flowers in August next year. At this stage crop is ready to harvest. (Fig.29).

Fig. 29: Chirata at harvesting stage

Fig. 30: Harvested Chirata

3.4 Drying and Storage: Crop is dried in sun. After drying the crop, it is tied into small bundles which are ready to deliver in the market (Fig. 30).

3.5 Yield: 12-15 quintal per hectare. Estimated selling price is Rs. 30,000/- quintal.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Agriculture land, seeds, vermicompost, store to stack material, grading and packing machine, shed to install machinery and workable area.

5. SPECIFIC PROBLEMS / OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Poor seed germination and spoilage after harvesting are major problems faced by farmers. Due to climate fluctuation disease infestation, insect pest attacks, market uncertainty, loss of crop due to prolonged rains or winters are other challenges. These are mainly mitigated by regular training and management practices in the field by technical team. Ayrurvedic drug manufacturers and pharmaceutical industry use Chirata in their preparations and quality is assessed as per physical condition of material and assessment of bitterness through taste. Even after providing analytical reports, industries shirk in accepting the material. Setting up of semi processing and product development units near to the site of cultivation is the solution to overcome the problem. Interventions of National Medicinal Plants Board can simplify the procedures and develop effective strategy and framework for marketing the farmers' produce.

6. IMPACT OF THE INNOVATION

Chirata has usage in primary health care as Chirata decoction, being immunity enhancer, is an effective remedy for common ailments like fever, hepatitis and other viral infections. Chirata cultivation is the best livelihood generation option to the stale agriculture. Standardized technique made possible the commercial cultivation of Chirata around 70 hectare area involving more than 1000 farmers. Large scale cultivation of Chirata will check its adulteration being done with the species imported from Nepal.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Chirata cultivation protocol is suitable to be upscaled at commercial level. There is also every possibility of upgrading the value chain of Chirata through value addition and product development.

8. ECONOMIC VIABILITY

The cultivation of Chirata is highly economical in comparison to the traditional crops in case the market is assured and manufacturers pick up the crop well in time. In Ayurveda, Chirata being one of the ingredients of several Ayurvedic formulations is in high demand. There is 15 quintal of Chirata crop production in one hectare. The input cost of cultivating Chirata is one lakh rupees per hectare while total income per hectare is Rs. 4,50,000/- with net profit of Rs. 3,50,000/- per hectare.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Protocol of Chirata cultivation is good alternate for agriculture diversification in high mountain areas where animal menace is the main problem. This model provides good economic returns with lesser inputs at par with cash crops and is a better option to check migration of people from the hills. .

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDS/ COMMUNITIES/ INDUSTRIES, ETC.)

Developed technique, being simple and profitable, can be replicated in different Himalayan states through community participation for gainful employment. For sustainable supply of Chirata, buy back arrangements can be made with industries. Industries can also be included in the extension programme for making them aware about the availability of this medicinal plant produce for their use. This will also provide an opportunity to the farmers to interact with the industries to ensure the sale of their produce or making buy back arrangements. Technology should be extended to all the members of the value chain of medicinal plants including farmers, processing industries, SFDs, herbal industries, Ayurveda practioners, etc. Setting up a herbal industrial units near the cultivation sites will augment the employment generation to the rural communities. HRG has an expertise and can extend the technology to the stakeholders.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

HRG is a non-governmental organisation set up by the qualified and dedicated like minded professionals to achieve the sustainable development of mountainous regions in June 1997. HRG aims to bring economic prosperity to the local communities in an eco-friendly manner with application of scientific innovations and technology transfer. HRG has a well equipped research lab and office at Shimla. The field activities are carried out through its regional centre at village Dhangiara in District Mandi of Himachal Pradesh. Keeping in view the grass roots initiatives for the development of rural communities, Science for Equity, Empowerment & Development (SEED) Division, DST, Govt. of India, selected HRG for long term prestigious CORE SUPPORT programme in August 2005.

7 IN VITRO PROPAGATION PROTOCOL OF VULNERABLE MEDICINAL PLANT, *EMBELIA RIBES*

1. GENERAL INFORMATION

- Title of Innovation

  In vitro propagation protocol of vulnerable medicinal plant, *Embelia ribes*.

- Brief Description : *Embelia ribes* commonly known as Vidanga, a useful medicinal plant in Ayurveda, improves the functioning of the digestive system and alleviates flatulence, gaseous belching and constipation. However, the species is vulnerable in the wild due to excessive harvesting and is only available in certain pockets of Western Ghats and north-eastern part of India. An economical *in vitro* propagation protocol has been developed which has potential for mass clonal propagation of *Embelia ribes*.

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- Name and position of key or relevant persons or officials associated : Dr. Animesh Sinha, Scientist-E, Institute of Forest Productivity, NH-23, Lalgutwa Ranchi 835303. Email: sinhaa@icfre.org; Mobile: +91 9431564462

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Embelia ribes, is vulnerable plant species which has enormous demand in pharmaceutical industry for appetizer, carminative, laxative, anthelmintic properties and in treatment of liver diseases. The development of *in vitro* clonal procedure of the species is useful for its conservation and sustainable utilization.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Immerse explants for 5-10 min in 2% Cetrimide solution and make free from detergent by 3-4 washings with distilled water. Treat for 10-15 min with 0.2% (w/v) Bavistin solution followed by rinsing with distilled water. Treat explants with 0.2% (w/v) ascorbic acid for 1 h in deep freezer. Surface sterilize by a quick dip in 70% alcohol followed by deep in 0.1% aqueous mercuric chloride solution for 5-7 min.

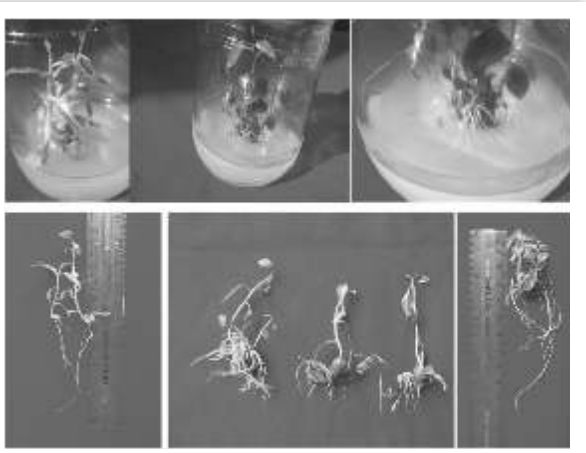

Fig. 31: *In vitro* propagation of *Embelia ribes*

Rinse three times with sterilized distilled water and inoculate in semisolid Murashige and Skoog (MS) medium supplemented with antioxidants for 4 weeks. Excise sprouted bud from explants and transfer to semisolid MS medium supplemented with 6-benzylaminopurine (BA) (13.3 µM) to yield 3-4 shoots in 4 weeks. Subculture proliferated shoots in semisolid MS medium supplemented with BA (13.3 µM). Rooting of microshoots > 2.5 cm in ½MS with Indole 3-Butyric Acid(IBA) (49 µ M) occurs within 4 weeks. Hardening for 4 weeks in poly-tunnel and then transfer into polybags and keep under 50% shades for 8 – 10 weeks. The protocol with 95% multiplication rate is extremely efficient (Fig. 31).

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Basic tissue culture laboratory and hardening facilities.
- Chemicals/supplements: Cetrimide, Bavistin, Ascorbic acid, semisolid MS medium, plant hormones (BA, IBA) which are easily available in the market.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

The limitation of true plant specimens to collect explants should be addressed by proper identification as the species is extremely rare and there is wide spread problem of improper identification at the sources from where parent material can be taken for multiplication.

6. IMPACT OF THE INNOVATION

Rapid mass multiplication of *E. ribes* through tissue culture and their large scale cultivation in farmers field will reduce the threat of extinction of this species from wild.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

No up scaling is required as the success rate of plantlet production is already optimal.

8. ECONOMIC VIABILITY

A comparative evaluation of regular *in vitro* protocol with the developed one reveals that using sugar and tap water instead of sucrose and Millipore water, the cost was reduced by 45% for shoot multiplication, without compromise in multiplication rate, and 95% for *in vitro* adventitious rooting in liquid medium in *E. ribes*.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The protocol should be included in the SFDs schemes as a viable strategy for conservation of this vulnerable species and *ex situ* conservation through large scale cultivation on farmer's field.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

Extension can be done through transfer of protocol to various user agencies.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Institute of Forest Productivity, Ranch is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

8 VEGETATIVE PROPAGATION PROTOCOL FOR CONSERVATION OF A RARE TREE, VITEX PEDUNCULARIS

1. GENERAL INFORMATION

- Title of Innovation (Technology/ Practice / Protocol/ Product) Protocol

  Vegetative propagation protocol for conservation of a rare tree *Vitex peduncularis*

- Brief Description : *Vitex peduncularis,* locally called 'Choroigorwa' or 'Nagbael' by the tribals of Jharkhand, has been so much exploited (massive extraction of the bark) that it is on the verge of extinction. Owing to its scare distribution in nature coupled with poor regeneration, the bulk of the requirement of the bark of this species is obtained probably through illegal channels. Low cost vegetative propagation protocol for conservation of rare tree species *Vitex peduncularis* has been developed which involves air layering.

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2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Large scale seed propagation is difficult in *Vitex peduncularis* due to low germination capacity. Therefore, standardization of appropriate vegetative method of its propagation was done aiming at conservation of valuable genetic resources to this rare species.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Healthy mature trees are used to take a 2-3 cm strip from a branch and girdled using budding knife. About 25 g of commercial moist moss should be placed around the cut surface and wrapped with a polythene sheet so that the cut surface is completely covered, tied on both sides to avoid leakage of water from inside. Rooting is observed in the layers just after 6 weeks (Fig. 32). At this time the propagules are detached apart from mother plant. The propagules are than planted in growing media containing 1:1:2 of FYM, Sand and Soil. After 2 weeks, new sprouts and shoots start appearing from the planted material. The success rate is more than 77%.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Budding knives, Peat moss, Polythene sheets, FYM, Sand and Soil.

Fig. 32. Air layering of *Vitex peduncularis*

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

Availability of healthy trees of desired phenotypic characteristics should be ensured by careful selection which has reduced due to over exploitation and destructive harvesting.

6. IMPACT OF THE INNOVATION

Protocol is important as no other clonal propagation procedure is reported for the species. It will help in conservation and sustainable utilization of the species.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Growth regulatory substances may enhance success.

8. ECONOMIC VIABILITY

The protocol is economically viable as unit cost for raising the propagule through this technique is as low as below Rs. 2.00.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Developed protocol can become a part of strategies for conservation and sustainable utilization of forest genetic resources.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

Developed protocol being simple and cost effective is suitable to be extended to the SFDs, farmers, tree growers, herbal practitioners, herbal industries through training, field level demonstrations and capacity building.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Institute of Forest Productivity, Ranchi is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

9 CLEFT GRAFTING PROTOCOL FOR THE LAC HOST TREE, KUSUM

1. GENERAL INFORMATION

- Title of Innovation

  Cleft grafting protocol for the Lac host tree, Kusum

- Brief Description : The method of propagation through cleft grafting has potential for clonal propagation of elite genotypes of *Schleichera oleosa* (Kusum), the most important Lac host, having desirable characteristics which is not possible through other procedures.

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- Name and position of key or relevant persons or officials associated : Dr. Animesh Sinha, Scientist-E, Institute of Forest Productivity, NH-23, Lalgutwa, Ranchi 835303. Email: sinhaa@icfre.org; Mobile: +91 9431564462

2 THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Propagation of Kusum is difficult due to short viability and low germination. Further it is also extremely rooting recalcitrant tree species making clonal propagation troublesome endeavour.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Young healthy seedlings of Kusum, 30-50 cm tall having stem diameter about the thickness of a pencil are used as rootstocks while scions collected from tree having age between 8 - 20 years with 8-12 mm diameter are prepared from semi-hard wood portion 10-15 cm below the end of a young branchlet. Scions are cut to a length of 15-20 cm leaving the petioles intact on the scion, the end of which was cut to a wedge approximately 1.5 cm long. The rootstock have to be decapitated at a level where the diameter was close to that of the scion. A split is made in the rootstock, the scion inserted and the graft tied with polythene tape. The grafting scion and end of the scion

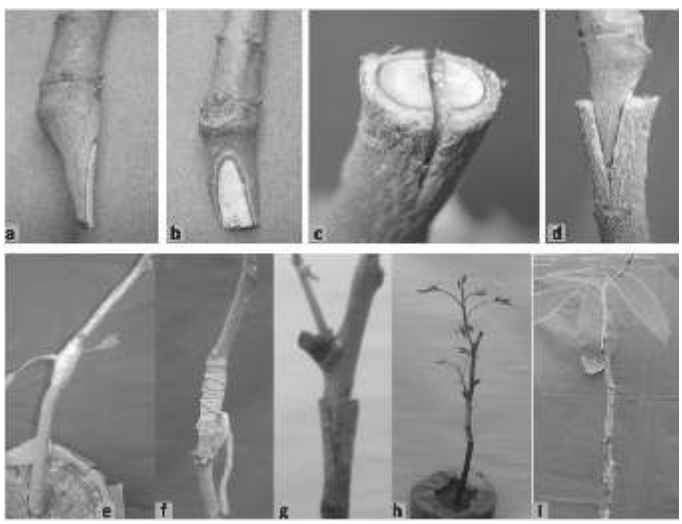

Fig. 33. Cleft grafting in Kusum

are then covered with plastic bag and kept under shade giving a success rate of about 60 %. The best time of grafting is between mid of June to mid of August (Fig. 33).

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Secateurs, Sharp knives, Polythene sheets which are readily available in the local markets.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

The availability of proper rootstock and scions is the key of the success. Thus, prior raising of seedlings in sufficient numbers to be employed as rootstock and identification of appropriate trees for scions is essential.

6. IMPACT OF THE INNOVATION

Multiplication of elite Kusum tree for Lac cultivation will increase production thereby, income of the Lac farmers and tribal families.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The protocol is simple. However, scaling up can be done in identification of growing media and propagation environment.

8. ECONOMIC VIABILITY

The protocol is very economical and viable for large scale application.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Lac cultivation is undertaken by the farmers, SHGs and tribal families traditionally on Kusum in eastern India but availability of good young host trees has diminished due to improper regeneration and lack of efficient propagation techniques.The protocol can not only address this but ensure livelihood generation and enhanced income by high quality Lac produced on Kusum.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

Extension can be done through transfer of protocol to various user agencies such as SFDs, farmers, nursery managers, Lac cultivators through field level demonstration and capacity building.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

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10 PROTOCOL FOR PRODUCTION OF BAMBOO (*DENDROCALAMUS HAMILTONII*) SHOOTS

1. GENERAL INFORMATION

- Title of Innovation

  A protocol for production of Bamboo (*Dendrocalamus hamiltonii*) shoots

- Brief Description : Bamboo shoots are nutritionally rich in proteins, carbohydrates, vitamins, fibres, minerals and very low amount of fat. Despite the health benefits, bamboo shoot consumption in India is mostly confined to Northeastern states where they form an indispensable part of several traditional dishes. Both fresh or dried and fermented or pickled shoots are used in the traditional dishes (Fig. 34 a, b, c, d).

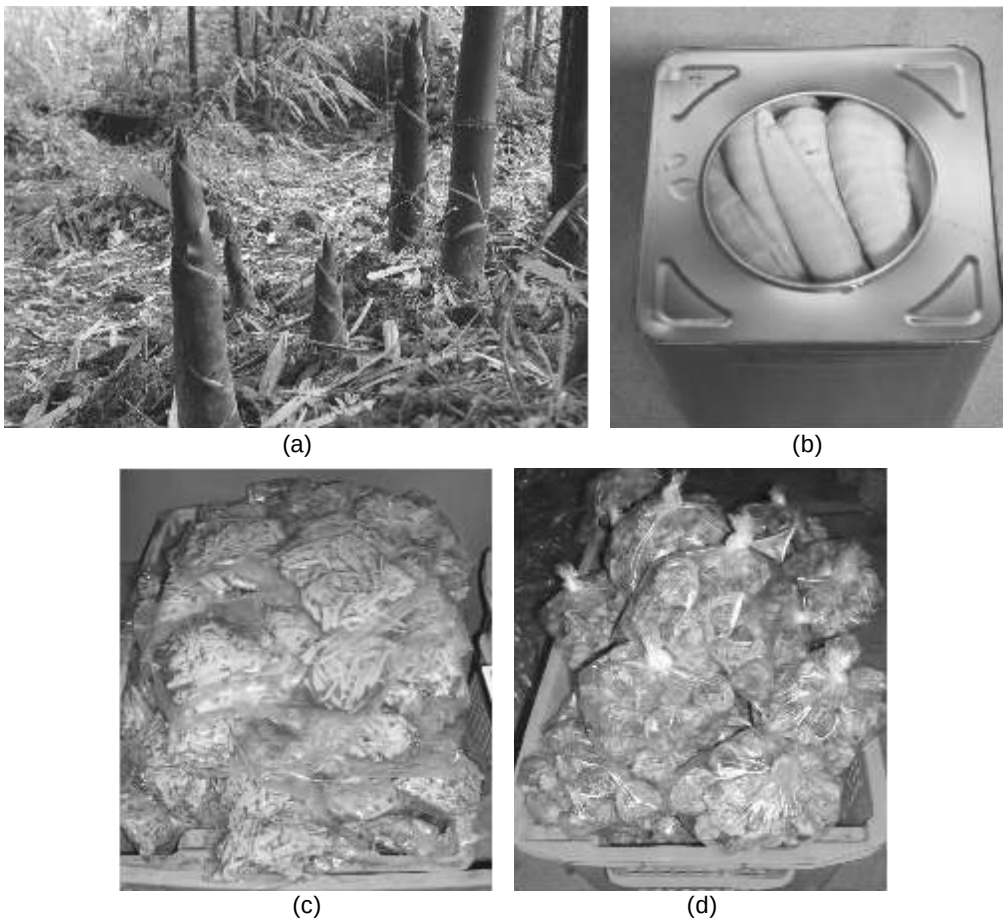

Fig. 34. Natural and processed bamboo shoots (a) Shoots emerging from ground; (b) Partly processed shoots; (c) Pickled shoots; (d) Dried shoots

The prospect of bamboo shoot industry in Northeast India is bright owing to the large extent of area under bamboo and the rich bamboo diversity. The common edible bamboos in Northeast India include *Bambusa tulda, Bambusa nutans, Dendrocalamus asper, Dendrocalamus giganteus, Dendrocalamus hamiltonii*, etc. *Dendrocalamus hamiltonii* is a large sized multipurpose bamboo species extensively found in the north-eastern parts of India. High extract ability combined with high nutritional value of the tender shoots makes it an excellent species for bamboo shoot industry. A protocol of scientific clump management has been developed for *D. hamiltonii* which has the potential to increase edible shoot yields manifold. The package of practices has been developed by taking into account the *D. hamiltonii* clump and culm physiology, and includes (i) planting technique, (ii) fertilizer requirement and schedule, (iii) supplemental irrigation, (iv) soil working around clumps, (v) harvesting schedule of shoot and culms, (vi) maintenance of clump hygiene, (vii) maintenance of clump structure.

- Name and contact details of person or institution responsible for the innovation : Dr. S. Pattanaik, Scientist F, Rain Forest Research Institute, Jorhat (Presently posted at Institute of Forest Biodiversity, Hyderabad; Email-pattanaiks@icfre.org; Tel-04066309506
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  Sri K. Borah, Rain Forest Research Institute, Jorhat
  Dr. S. Trivedi, Retired Forest Officer, Rain Forest Research Institute, Jorhat
  Dr. K.G. Prasad, Director (Retired), Rain Forest Research Institute, Jorhat

2 THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

A very large percentage of total bamboo shoot production in the north-eastern parts of India comes from natural forests. Unscientific clump management practices are negatively affecting both 'edible bamboo shoot' as well as 'bamboo culm' production. Bamboo cultivation incorporating scientific clump management practices has the potential to increase productivity of both bamboo shoots and culms, thereby increasing returns to the farmer.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

A *Dendrocalamus hamiltonii* rhizome carries 8-11 culm buds (Fig. 35) and each bud has the potential to develop into culms but only 1-2 buds develop into culms in a growing season. The

Fig. 35: *Dendrocalamus hamiltonii* rhizome showing culm buds

rhizome diverts all its food reserve for the growth and development of these 1-2 culms and other buds remain dormant. Factors like space, nutrition and moisture affect the number of buds that develop into full length culms. However, if the newly emerged shoots from the first flush are harvested for food purpose (edible bamboo shoot), more buds get activated as a stress response. In order to activate maximum number of culm buds, all emerging shoots from subsequent flushes are also harvested for edible shoot purpose except one shoot, which is allowed to grow to full length culm. *D. hamiltonii* clumps managed this way can yield more shoots than what is obtained in natural conditions. The salient features of the package are described below.

3.1 Planting of *D. hamiltonii* seedlings/offsets

Field preparation is done with a tractor mounted Mouldboard plough (MB) or disc plough. A spacing of 5x5m (400 seedlings/hectare) is ideal for large sized bamboo like *Dendrocalamus hamiltonii*. Following alignment and staking, pits (30cucm for seedlings, 60 cucm for offsets) are dug up at the marked places. The dugout soil is left for weathering for about a month. During planting the polybag is removed and the seedling/offset is placed vertically in the pit keeping the ball of earth flush with the ground level. The soil around the root zone of seedling/offset is compacted with foot to remove air pockets. Planting is usually done after a few good monsoon showers. While *D. hamiltonii* seedlings need about five years for clump establishment, offsets develop clump earlier.

3.2 Fertilization

At the time of planting the dugout soil is fortified with a basal dose of Urea-100gm, Single Super Phosphate-100gm, Muriate of Potash-50gm and 5kg vermicompost/farm yard manure (40 kg Urea, 40 Kg SSP, 20 Kg MOP, 2 ton vermicompost/farm yard manure per hectare). During subsequent years of establishment only Nitrogen (Urea - 200 gm/plant) is applied through side dressing. The Nitrogen dosage is doubled with the beginning of the productive phase (6th Year onwards) of the bamboo clumps. Annual fertilization increases shoot production by 30%.

3.3 Supplemental irrigations

Flood irrigation during spring season (February-March) plays crucial role in hastening the culm bud activation process. Provision should be made for two such irrigations at a month interval.

3.4 Soil working around clumps

It is observed that culm buds present on bamboo rhizome nodes get activated acropetally i.e. base upwards. Soil working involves raising soil around clumps by about 5-10 cm to help activate the buds present at the upper nodes of the rhizome. This is an annual operation which may be combined with fertilizer application.

3.5 Harvesting schedule of bamboo shoots

Once the *D. hamiltonii* clumps reach productive stage (from sixth year onwards in case of seedlings; fourth year onwards in case of offsets), all newly emerged shoots are harvested from the first flush. From

subsequent flushes one shoot per rhizome is retained and other shoots are harvested. The retained shoot is the future capital and allowed to grow into culm.

3.6 Maintaining clump hygiene

As bamboo shoots are harvested for human consumption, maintenance of clump hygiene is must to prevent soil borne fungal diseases of clump and pesticide contamination of edible shoots. Botanicals like Garlic extract (10 ml/Liter) or Linseed oil may be applied, as preventive measure, to the cut wounds on source rhizome after every harvest of shoots. Also, *Trichoderma viridae* (soil drench @10g/ Liter) or VAM fungi (Soil application around clump) may be applied as curative measure against pathogenic fungi.

3.7 Clump structure

A balance between old and young culms need to be maintained in order to make the clump congestion free and activate more number of culm buds from rhizome. A clump structure of 2:2:1, for one, two and three-year-old culm age groups, need to be maintained for optimum production of bamboo shoots and culms. All culms beyond 3 years need to be removed.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

No special equipments are needed. Common farm equipments like crowbar, phowrah, axe, knife, sickle, sprayers etc. are needed for small holding plantations. A tractor is needed for large holding plantations.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

- The protocol involves intensive harvesting of tender shoots which may lead to disease outbreak. Adoption of clump hygiene measures listed in section 3.6 is must to prevent outbreak of diseases.
- Bamboo blight is a major disease recorded in bamboo plantations. The symptoms of blight include (i) premature death of culm, (ii) wet rotten patches on internodes, (iii) infected culms turning brownish grey and drying up. The blight disease can be managed by (a) removal of severely infected culms/clump, (b) controlled light burning of clump, (c) avoidance of water stagnation, (d) drenching of soil around bamboo clump with a combination of 0.2% Bavistin, 0.3% Dithane M-45 and 0.3% Fytolan, (e) discontinuation of bamboo shoot harvesting till the blight symptoms persist.
- Access to a bamboo shoot processing industry is another obstacle envisaged for large-scale adoption of this package of practices. This problem can be solved by establishing a bamboo shoot growers cooperative society and establishing primary bamboo shoot processing units.

6. IMPACT OF THE INNOVATION

- This protocol for *D. hamiltonii* clump management has the potential to increase the returns to bamboo farmer manifold.

- Bamboo shoot production, both for domestic consumption and exports, can be scaled up with this protocol.
- The time, labour and cost requirement for collection of bamboo shoots comes down drastically compared to collection from natural forest areas.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

This protocol is amenable to both small holding and industrial scale bamboo shoot farming. Bamboo shoot production can be easily upscaled through bamboo growers' cooperative societies and establishing primary bamboo shoot processing units.

8. ECONOMIC VIABILITY

The scientific clump management practices included in the protocol is expected to yield an average annual net income of Rs. 1.7 Lakhs per hectare. A benefit to cost ratio of 3.067 estimated at 12% discount rate (Table 1).

Table 1. Cost of cultivation

Location: Jorhat, Assam Year: 2019	
Particulars	**Values (in Rs.)**
i) Cost of establishment and maintenance (1-15 years):	7,76,200
ii) Benefits from bamboo component (5-15 years): a) Benefit from sale of bamboo shoots (@Rs. 25/kg) b) Benefit from sale of bamboo culms (@ Rs. 25/culm)	 23,25,000 10,00,000
iii) Benefit from agricultural crops (1-5 years): iv) Benefit from thinned material for fuel and fodder (1-5 years)	50,000 4000
v) Net income per ha	26,02,800
vi) Average annual net income per ha	1,73,520
vii) Net Present Worth @12% discount rate	7,56,858
viii) Discounted B:C ratio @12% rate	3.067
ix) Internal Rate of Return (IRR)	18%

8. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Like the policy decision to establish common facility centres (CFCs) for bamboo culm processing at various locations in northeastern parts of India, the Indian Government may think of establishing bamboo shoot processing centres, which will promote bamboo shoot production on an industrial scale, both for domestic consumption and exports.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

This protocol has huge scope in the north-eastern states of India. It can be extended to all bamboo growing communities in the north-eastern states of India.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS

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11 BOREHOLE METHOD OF RESIN TAPPING

1. GENERAL INFORMATION

- Title of Innovation

  Borehole method of resin tapping

- Brief Description : Pine resin is an important non-timber forest product. It is used to produce rosin and turpentine, which are important industrial chemicals which fetch high price in national and international markets. Rosin is widely used to produce adhesives, paper sizing agents, printing inks, detergents, and so on, while turpentine is usually the raw material of varnishes, aroma chemicals, disinfectants, cleaning agents and others. Pinus roxburghii, commonly known as 'Chir pine' is a principle pine species, widely distributed from 450 m to 2250 m altitude in the Western Himalayan region of the country. It is the main source of resin for the commercial use in India. Resin Tapping is an important forest based industries having a bearing on the rural economy and its products. Millions of people worldwide, especially in developing countries, depend on the collection of gums, resin and latex for their livelihoods. Pine resin is an important forest produce in the world. Tapping is the common method of harvesting the resin from the resin yielding trees. Bore hole method of resin tapping from Pinus roxburghii is an improved method over the earlier known methods such as 'Cup and Lip' and 'Rill method' of tapping and has been standardized at Forest Research Institute, Dehradun.

- Name and contact details of person or institution responsible for the innovation : Dr. G.S. Rawat, Ex Head and Dr. B.P Tamta, Scientist- E, NWFP Discipline of Silviculture and Forest Management Division, Forest Research Institute, Dehradun - 248006

- Name and position of key or relevant persons or officials associated : Dr. B. P. Tamta, Scientist-E, NWFP Discipline of Silviculture and Forest Management Division, Forest Research Institute, Dehradun - 248006; Email: tamtabp@icfre.org ; Mobile: +919452224498

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Previous methods namely "Cup-and- Lip" method and "Rill method" known for resin tapping have limitations. The "Cup-and- Lip" method causes more damage to pine tree due to deep wound made in it. Though the "Rill method" has been a widely used method, it is labour intensive as eight months are required to collect the resin and the quality of the collected resin is also not good. Further, application of higher concentration of acid, used as freshener, adversely affect the growth of trees. Borehole technique of resin tapping from Chir pine is an improved method to overcome the above limitations.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Holes are made near the ground level with the help of a drilling machine into tree's sapwood to open the resin ducts and resin exudate is collected in a closed container. The hole in each tree is done approximately 10 cm above the ground. The holes of 15 cm depth and 2.5 cm diameter are suitable for obtaining maximum resin yield. Immediately after making the hole the stimulants (mixture of sulphuric acid and ethephon i.e., 2-chloro-ethyl phosphonic acid) are sprayed inside each freshly made hole. Spray volume of 1 to 2 ml are applied to each hole. Chemical treatment is done once only, immediately after boring holes. After treatment a spout is installed inside the hole by gently hammering with a small mallet or pushing with palm of the hand to achieve compression fitting in the hole. The spout is meant for joining the collection container (HDPE polybag, 35.3 cm x l2 cm) tightened to each spout. Once the polybag is filled with resin, it is removed from the tree and poured into a collection can and immediately a new poly bag is tied for future collection of resin (Fig. 36). Following are the advantages of bore hole method of resin tapping over the conventional methods:

- There is less stress on the tree due to small size (2.5 cm diameter) of the hole and the hole heals fast.
- Prolong resin flow can be obtained from bore hole for a period of several months without wounding the stem.
- The technique is very suitable for protection of trees against fire, insect, pest and diseases.
- The holes are made with the help of a machine, therefore quantum of the labour required is significantly reduced.
- Rosin obtained from borehole tapped resin is of better grade with slightly lower acid number, saponification number and higher softening point.
- Quality of turpentine oil in terms of the yield and pinene contents is superior.
- The technique is very effective in conservation and management of pine trees.

Bark Shaving

Drilling

Spraying

Fixing of Spout

Fixing of polythene to Spout

Collection of resin

Collected resin

Fig. 36. Steps of resin tapping

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Tools: Bark Shaver, Drilling Machine, Spout/ Nose Adaptor, Hammer, Spray Bottle, Raw materials: Sulphuric Acid, Ethepon, Cable Tie, HDPE Poly bags, Collection Canes and Measuring Tape. These items are readily available in the market.

5. SPECIFIC PROBLEMS/OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Sloppy area can cause difficulty in drilling. HDPE polybags required for resin collection being flammable should be kept away from the fire. Domestic animal, local people and wild life can cause low resin yield. Training should be done to make the labour skilled, participatory fire prevention and control mechanism must be developed on resin tapping sites. Regular supervision of the SFD officials must be carried out to assure resin tapping as per procedures.

6. IMPACT OF THE INNOVATION

The developed technique is superior to the previous tapping methods in terms of less damage to tree, higher flow rates of resin and its quality, mechanization and hence reduced labour requirements, and protection of trees against fire, insect, pest and diseases

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The bore hole technique for resin tapping being economical and effective in management of pine resources in India is suitable to be adopted by SFDs and forest based industries.

8. ECONOMIC VIABILITY

Resin tapping from pine trees is an economic activity, particularly in the hills of Himachal Pradesh, Uttarakhand, Jammu & Kashmir and north-eastern states. In 2015-16, annual production of the pine resin from the northern hill states was estimated around 8,000 to 9,000 tons. Resin is processed into commercially important products- rosin and turpentine. Rosin has a wide range of applications including adhesive, paper size and printing ink manufacture while turpentine is used either as a solvent for paints and varnishes or as raw material for fractionation and production of value added derivatives. World production of turpentine is about 3.3 lakh tons per annum from all sources, of which about 30 % is estimated to be pine turpentine. World-wide total annual production of rosin is about 1.0 million tons, of which almost 60% is derived from pine resin. Resin produced by the bore hole method is superior in terms of the yield and quality of the constituent chemicals-rosin and turpentine. Further, this method of tapping does not adversely affect the quality of the pine trees. Thus, resin tapping from the Chir pine using bore hole method is economical.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Policy interventions are needed to introduce the bore hole technique in the working plans of the SFDs and replace the conventional methods for tapping of pine resin.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The technique has great potential to be extended to the SFDs and industries in all Chir pine areas of Himalayas. Capabilities of the forest officials engaged in resin tapping and industries involved in resin processing and value addition could be advanced through training programmes.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

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12. OTHER RELEVANT INFORMATION

There is a need to explore the possible use of the bore hole technique in other resin yielding tree species.

12 A FACILE AND ECOFRIENDLY PROCESS FOR SISAL FIBER EXTRACTION

1. GENERAL INFORMATION

- Title of Innovation

  A facile and ecofriendly process for natural fiber extraction from *Agave sisalana*

- Brief Description : Natural fibres have been used for various purposes since long and remained as a source of livelihood. Natural fibre obtained from *Agave sisalana* (Sisal) leaves (Fig.37) on account of its durability and specific strength properties holds immense industrial and commercial importance. Sisal fibre is very long, with an average length of 0.6 to 1.2 m and it is creamy white to yellowish in colour. It is coarse and strong, durable and has the ability to stretch. It also has good insulation properties and is highly resistant to bacterial damage and deterioration in saltwater. In addition to common usages, Sisal fibre is an excellent material for manufacturing high strength textile and reinforcement composites for various other high end applications. Sisal plants consist of a rosette of fleshy leaves growing from a central bud. The leaves are dagger shaped and when mature 1 m to 1.5 m long and about 10 cm wide weighing 500 to 700 gm each. The first harvest can be made when the plants are about 2 yrs old and they remain productive for 7 - 10 years. A plant of sisal produces about 200-250 leaves and each leaf contains approximately 1000 fibre bundles. The average fibre content of the leaves is about 3.5%–5%. However, the yield and quality of fibre largely depends on climatic conditions and cultivation practice and extraction method.

Fig. 37: *Agave sisalana*

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2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Despite the high water content, the fleshy pulp of Sisal leaves is firm and the leaves are rigid. Fibre is conventionally extracted from leaves either by retting or mechanical method. Water retting process involving microbial decomposition is time consuming, water intensive, unhygienic and eco-unfriendly. Mechanical extraction with the help of a machine involves repeated crushing and scraping of leaves, cause nearly 20% loss

in fibre recovery and the process is energy intensive as well. Pre-treatment of Sisal leaves with chemicals (acid or alkali) though aid smooth fibre extraction; the process has problem of effluent disposal, thus is eco-unfriendly. Biological pre-treatment is an ecofriendly alternative method for fibre extraction. Hence, a process has been developed for efficient extraction of good quality fibre through biological pretreatment of Sisal leaves.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

In this process Sisal leaves are treated with biological material (animal faeces like cow dung, etc) in specified concentration for 15-20 days. Thereafter treated leaves are taken out of the solution. Separation of fibre is done by mild scraping the leaves. Blunt knife is used to scrape the flesh away. Scrapping is started near the tip of the leaf and gradually moved along the length of the leaf. Extracted fibres are then cleaned with water.

- Collection of leaves: Sisal leaves of length not less than a meter should be harvested from 2-3 year old plant depending upon growing conditions. Leaves are cut manually with a sharp cutting tool at 2.5cm –5 cm from the bole and then tied in bundles. It is essential to leave sufficient leaf area at each cutting to enable the plant to continue growing. About 20–25 leaves are left on the plant at the first cutting, and this number is usually decreased to 15–20 leaves at subsequent cuttings. The terminal spines are removed before or after the leaves have been cut (Fig. 38).

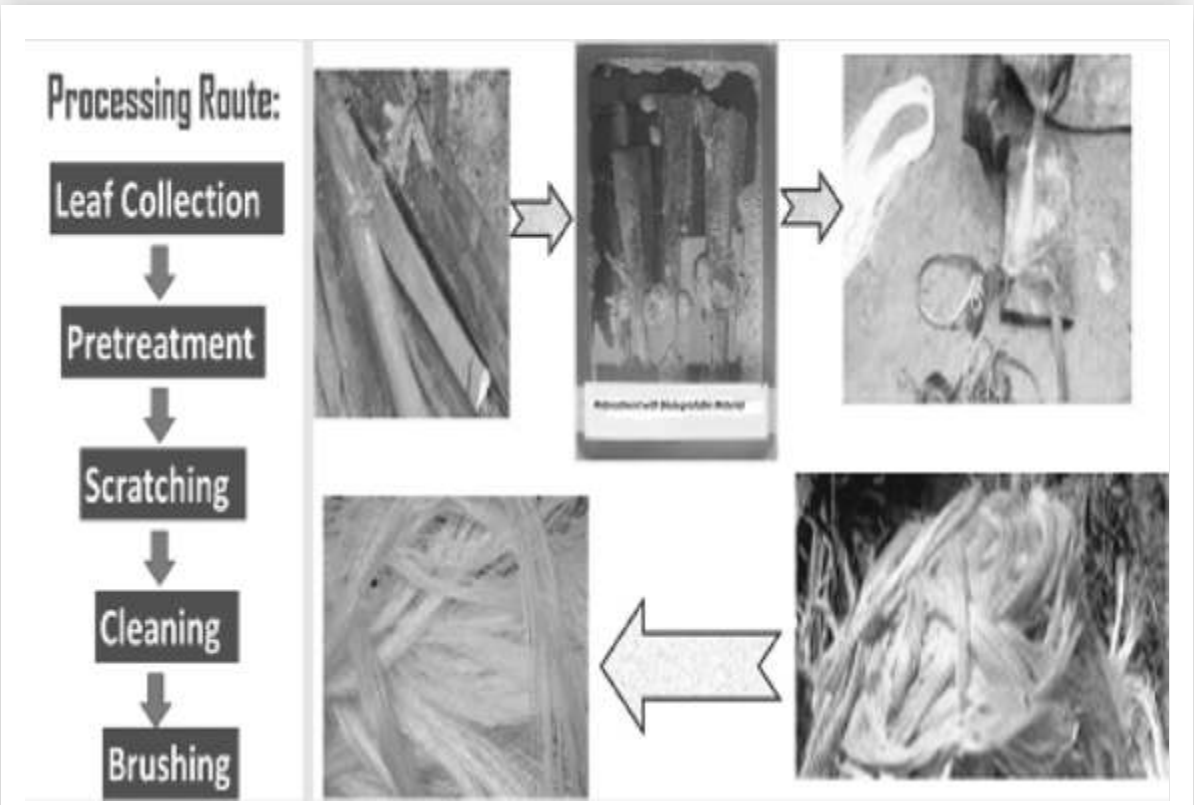

Fig. 38. Steps of fiber extraction

- Thumping of leaves: In order to slack the grip of non-fibrous matters which bind fibers with the pulp, leaves are mildly thumped with a wooden log or hammer without damaging the fibre.
- Pre-treatment of leaves: Leaves are submerged unfolded in a tank containing cow dung-water mixture (1:3) for 15-20 days with intermittent turning.
- Separation of fibre: Sisal fibres are separated from the pre-treated leaves by scrapping away the pulp materials with a blunt metal knife. Scrapping should be started near the tip of the leaf and gradually moved along the length of the leaf.
- Washing, Cleaning, Drying & Brushing: Fibres recovered from pre-treated leaves are washed with water several times to remove remaining part of the pulp. Mild detergent solution can also be used to properly clean the fibres. Washed and cleaned fibres are then dried in the sun or by hot air.

  Proper drying is important as fibre quality depends largely on moisture content. Hot air drying generallyresults in better grades of fibre than sun drying. Appearance, colour and physical properties are the main features to decide the quality of sisal fibre. Dried fibres are brushed to straighten the tangled, wavy fibres and to polish them.
- Yield and quality of fibres: As high as 4.65% yield of fibre can be achieved through biological pretreatment of Sisal leaves. The fibres produced by the process are found to have better anatomical and micro structural properties, thus better quality. The treatment solution left after the process being biological in nature can be easily disposed off in nearby gardens or agricultural/horticultural fields which makes the entire process ecofriendly. Furthermore, the green waste generated after fibre extraction can be profitably used as fertilizer and for vermicomposting and biogas production.

Salient features of the process

- Simple, facile and efficient process
- High yield of quality fibre
- No machinery and energy requirement
- No hazardous effluent generation, thus ecofriendly
- Can be coupled with other economic ventures

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

The process doesn't require any equipment or machinery. The source material for natural fibre is full grown leaves which are harvested from the mature Sisal plants. Other items required in the process are as under:

- A wooden log or hammer for thumping of leaves to loosen the grip of non-fibrous matters which bind fibers with the pulp.
- A tank (concrete/metal) or pit lined with plastic (to prevent leaching of treatment solution in the ground) for pretreatment of sisal leaves. Its dimension will depend on size and scale of fibre production.

- A blunt metal knife to scrap away the pulp materials from pretreated leaves and separation of fibre.
- Other materials required are cow dung, water and mild detergent for pre-treatment of leaves and washing and cleaning of fibres.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

- Sisal leaves have a few minute teeth along their margins. Therefore, while harvesting the leaves, one needs to be very careful of the sharp points and wear eye protection and strong gloves.
- Leaf sap released while scrapping of treated leaves can cause a serious skin rash (dermatitis). Hence, it is advised to wear rubber hand-gloves while scraping the leaves.
- Only blunt knife (e.g. an old butter knife) should be used to scrape the flesh away from treated leaves.
- Tank or pit made in open should be covered to avoid alteration in concentration of treatment solution due to excessive evaporation of water in summer or addition of water during rains.
- Fibre extraction process from Sisal leaves should be started as soon as possible after cutting, because leaf juices tend to harden, making fibre extraction more difficult.

6. IMPACT OF THE INNOVATION

Sisal occupies 6th place among fibre plants, representing 2% of the world's production of plant fibre and it accounts for about 70% of the world's hard fibres. Non-traditional uses of sisal fibre offer promising new possibilities for producers. The development of efficient fibre extraction and further promotion of the use of natural fibres may open a new frontier to the profitable cultivation of sisal and fibre extraction. Conventional mechanical method cause loss in fibre yield and the process is energy intensive while water retting process is time consuming, water intensive, unhygienic and yield low quality. Further, pretreatment of Sisal leaves with chemicals (acid or alkali) is eco-unfriendly due the problem of effluent disposal. Developed process involving biological pre-treatment is an ecofriendly alternative method for fibre extraction which is beneficial in terms of yield and quality. The process doesn't require high input in terms of machinery, energy, chemicals or any other materials and can be adopted by farmers, tribals and others with minimum input cost.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Sisal has a promising future owing to the new uses of its fibre. The ecofriendly process of fibre extraction can be easily upscaled at any level depending upon availability of raw material and product requirement. However, Sisal fibre extraction process can be more economically attractive if inclusive biorefinary approach is adopted. The residual biomass after fibre extraction can be used to produce compost, biogas as fuel for cooking, lighting, and for powering farm machinery. Liquid effluent from the process can be used as fertilizer. Sisal cultivation itself can create 150 man-days employment per hectare per year. The activities of fibre extraction, value addition to extracted fibre and biomass utilization for vermicomposting and biogas are ecofriendly and

helps in promotion of organic farming and non-conventional energy utilization. Better utilization of the byproducts would help to make cultivation of Sisal more profitable.

8. ECONOMIC VIABILITY

Sisal fibre is a very strong, lustrous natural fibre and can take the wear and tear equivalent of coir. The huge advantage of sisal fibre over coir is that it is a white material which takes the dye very well and is softer than coir. Apart from the traditional applications sisal finds its way in environment friendly engineering materials due to low density, high specific strength and biodegradability. Sisal fibre and its allied activities like cultivation, fibre extraction, value addition etc. are labour intensive, low-tech and has high potential for employment generation (Fig. 39).Present scenario indicates that the use of plant fibre based engineering products like composites, automobile parts, paper, etc. are picking up momentum worldwide. Railways are also a potential application area where in it is estimated that about 350 TPA fibre composites are required to manufacture doors, luggage racks, panels, partitions, seating etc. Packaging materials for bags, boxes, crates, containers, which is now made up of wood, can be replaced by cost-effective sisal reinforced composites. Boats can be made by replacing the conventional polymer composite fibres with sisal as reinforcement. The market potential of

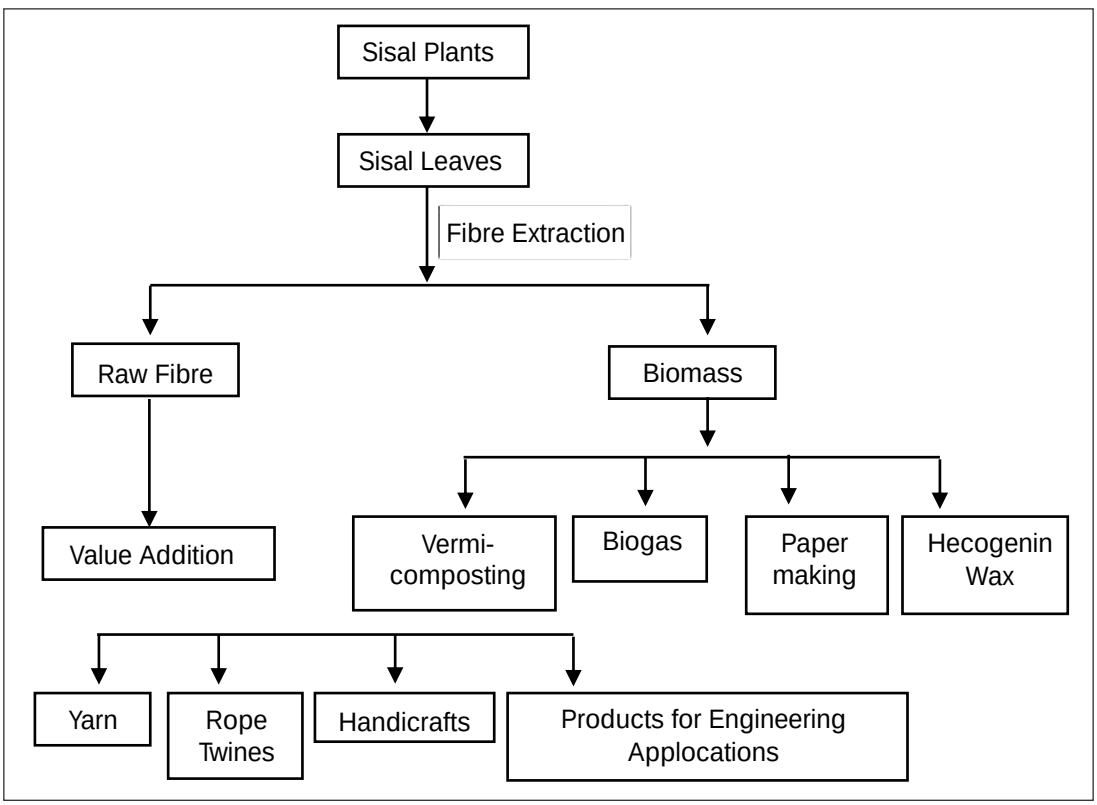

Fig. 39. Multiple uses of Sisal fibres and Byproducts

geotextiles for roads, paved road networks and railway applications in India is estimated to be 2,72,500 tonnes, of which a considerable portion can be earmarked for sisal-based textiles.

Sisal has a promising future not only because of the new uses of this fibre but also because of growing public awareness that natural fibres, like sisal, are environmentally friendly. India possesses a large chunk of wastelands and practically, one of the viable cultivation on such a dry ecosystem is sisal. The tremendous potential of sisal cultivation as well as Sisal fibre as a resource has not so far been fully exploited in the country for value addition and as a source of employment generation in tribal, rural and semi-urban sectors. There is a great scope for the development of Sisal based technologies for rural and engineering applications Further, there may well be other potentially valuable byproducts found in the fleshy waste discarded after fibre extraction, apart from compost, cattle feed and biogas.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Substantial Sisal plants are available in forest and tribal areas as biofence and wild growth without recognizing the economic importance of Sisal fibre. Proper utilization of this resource can create additional employment and income opportunities in these areas. The major beneficiaries will be forest dependent communities, tribal farmers, women and youth. Sisal fibre extraction can be promoted at cluster level where the members can own jointly the required infrastructure facilities for fibre extraction, value addition and marketing. Policy interventions with regard to promotion of Sisal cultivation, use of ecofriendly process for fibre extraction, skill development for value addition and establishment of producer-market linkage may result in developing rural agro-industries, organic farming and value added utilization of renewable sources.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/INDUSTRIES, ETC.)

Sisal fibre and its allied activities like cultivation; fibre extraction, processing and making value added products are sources of employment opportunity and income generation. The present experience indicates that trained artisans and women are able to sustain with the income generation through the sisal related activities. The engineering applications of sisal fibre like buildings, automotives, railways etc. are the prospective areas where it can generate employment potential. Easy to raise on wastelands in a wide range of agro-climates, sustained fibre yield for a considerable long duration, versatility of the fibre as a potential input material for various applications makes it a viable option for employment generation and rural development. Therefore, awareness on the economic potentiality of Sisal fibre among tribals, famers and other forest dependent communities may provide opportunities for employment and additional income generation.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Forest Research Institute, Dehradun is one of the constituent institutes of Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council under Ministry of Environment, Forest & Climate Change, Govt. of India.

12. OTHER RELEVANT INFORMATION

Sisal has an edge as it can be grown in wastelands; require minimum maintenance; withstand in many agro ecological conditions and produces continuous fibre for seven to eight years. It is usually grown on land that is unsuitable for any other agricultural activity apart from grazing. Other advantages are that the crop is drought resistant, does not require the use of fertilizers, herbicides or insecticides, can be inter-cropped and inter-grazed. The plant grows fast and all year round. Being a labour intensive crop, it offers employment to rural communities in areas which are often not suitable for other crops. Thus Sisal related activities will create employment opportunities for rural and tribal youth, women and farmers. The financial requirement for setting up of a sisal fiber extraction unit will depend on size and scale of intended venture.

13 A PROCESS FOR MAKING OF HANDMADE PAPER FROM LANTANA BIOMASS

1. GENERAL INFORMATION

- Title of Innovation

  A process for making of handmade paper from Lantana biomass

- Brief Description : *Lantana camara*, an obnoxious weed, is a serious threat to ecology. Process developed for production of handmade paper from *Lantana camara* offers a simple and economically viable management of this weed. Demand of various types of handmade papers is very high in the market. Adoption of this technology will not only reduce the burden on our forests but also provide a livelihood support to local communities.

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- Name and position of key or relevant persons or officials associated :

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ii. Sh. Mahipal Singh, Chief Technical Officer, Cellulose and Paper Discipline

iii. Dr. Gyanesh Joshi, Senior Technical Officer, Cellulose and Paper Discipline

iv. ShriJaipal Singh Rawat, Technical Officer, Cellulose and Paper Discipline

v. ShriAshish Sharma, Senior Technical Assistant, Cellulose and Paper Discipline

2. THE PROBLEM OR SITUATION BEING ADDRESSED

Lantana camara is a major problem in forests and agricultural areas in most regions of India as it forms dense thickets, spreads gregariously, out competes pasture species, and affects both flora and fauna. Management of Lantana is a challenging task. Attempts to manage this weed using mechanical, chemical and biological means have met with limited success. Alternatively, luxurious growth and vigorous survival make this weed of potential economic value for utilization of its abundantly available biomass into value added products offering thereby an efficient and effective method of its management. In this context, a simple and economically viable process for production of handmade paper from cellulosic biomass of Lantana biomass was developed.

3. DESCRIPTION OF THE PROCESS AND ITS SALIENT FEATURES

The process of making handmade paper from *Lantana camara* involves following steps (Fig.:40).

Fig. 40. Steps of making handmade paper from *Lantana camara*

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES

- Raw Materials: *Lantana camara* and cotton / muslin cloth
- Chemicals: Sodium hydroxide, rosin, alum, water.
- Equipments and Machineries : Chopper, Digester, Screening machine, Beater, Agitator, Pulp disintegrator, Pulp tanks, Hydraulic press, Calendar machine, Moulds, Sheet making machine, Weighing balance. All these machinery and instruments are readily available in the market.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

In handmade paper making, evenness and consistency of the sheet is a very vital aspect. The common defects include cloudy sheet formation with excess of fibre lumps or knots, weight and thickness variations in sheets,

and development of undesirable wave patterns on sheet. These defects are overcome by adopting some easy practices like formation of knots and lumps can be minimized by lowering the beater roll over the bed plate during beating. Frequent stirring of pulp with the help of the wooden rod at the front portion of the trough, while beating, should be ensured for thorough mixing of the materials. Extra precautions should be taken to prevent settling of partially beaten lumps around the beater roll, sand trap and inside the hood. Fine beating practices should be maintained and pulp fibrillation be allowed to the extent accepted for free and wet beating operations and controlling the consistency to the desired levels. Wave and slipping of higher grammage sheets can be controlled by making small pads and using side supporting wads during couching.

6. IMPACT OF THE INNOVATION

Developed process offers an effective and economically viable measure for management of the difficult to manage Lantana camara through its utilization as a feedstock for production of handmade paper. Utilization of Lantana will revive productivity of the invaded lands. Handmade paper being ecofriendly product opens new market possibilities. If handmade paper units in rural areas are installed, capacity building is done, goal of generation of sustainable livelihood for the rural and tribal people and forest conservation will be simultaneously achieved.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

There exists numerous possibilities for up scaling the small handmade paper manufacturing units into larger ones by enhancing their installed capacity.

8. ECONOMIC VIABILITY

Demand for handmade paper and its value added products is rapidly growing. Due to increasing public awareness on environment issues, people preference for eco-friendly products is rising. Handmade paper products find usage in the stationery, greeting card, packaging industry and have tremendous unexplored potential in export markets. Different varieties of handmade papers can be used for interior decoration, corporate gifts, and office purpose. New attractive varieties of environmental friendly handmade paper have very good demand in India and abroad. In rural areas, handmade paper units can be established with minimal investment in comparison to machine made paper units. These units can be adopted by a group of individuals or by SHGs under various government aided schemes.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Handmade paper making from Lantana has significant potential to be included as one of the strategies in the Invasive Species Management Framework (ISMF) to mitigate the effect of invasion.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDS/ COMMUNITIES/INDUSTRIES, ETC.)

Developed process is suitable for extension to various beneficiaries including SFDs, rural communities, NGOs and paper mills. Handmade paper industry is included in development programme of Khadi and Village Industries Commission (KVIC) of India. With the help of the KVIC small scale handmade paper manufacturing

units can be installed in the targeted areas and demonstration cum training programmes could be organized for capacity building of the users. Technical assistance can also be provided to the small handmade paper manufacturing units for upscaling into larger ones.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Forest Research Institute is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

12. OTHER RELEVANT INFORMATION

Technology for making handmade paper can be replicated to the other raw materials such as the waste products of the textile industry, different bast fibres available locally and recycled secondary fibres, sisal, hemp, parthenium or any other waste lignocellulosic biomass having adequate strength properties.

14 VILVEKAM – A BIOPESTICIDE FOR MANAGEMENT OF TEAK DEFOLIATOR

1. GENERAL INFORMATION

- Title of Innovation

  Vilvekam – A biopesticide for management of teak defoliator

- Brief Description : Biopesticide can be developed by an effective utilization of natural resource available in plenty and botanical insecticides are an interesting alternative for insect pest control in an ecofriendly way. It is reported that about 1 million ha of forest area and 25-30 % agriculture crops are being destroyed by insect pests annually. Teak defoliator, *Hyblaea puera*, is one of the most serious forest insect pests in India which causes severe damage to teak (Tectona grandis), one of the most favoured timber species all over the world and a species of significant ecological and socio-economic importance throughout the tropics. India produces about 90,000 mt of pesticides and the aftermath effects of toxicity as residues in soil, water resources and crops affects public health. Hence, there is a need to develop ecologically sound, environmentally safe and economically viable pest management strategies to avoid these problems. Natural and biological control of pest and diseases affecting cultivated plants and forest trees has emerged as an important tool for Integrated Pest Management (IPM). Plants elicit phytochemicals that are toxic to many insects and only about 2,50,000 plant species have been properly evaluated for this purpose. There are about 227 biopesticides with 15 types of which most of them are microbial biopesticides. Neem formulation is the only oil based biopesticide formulation available in the market. Hence, the seed oil based cost effective biopesticide formulation 'Vilvekam" has been developed from *Aegle marmelos* (Bael in English and Vilvam in Tamil) for the management of teak defoliator (Fig. 41).

Fig. 41: Vivekam- a Biopesticide

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- Name and position of key or relevant persons or officials associated :

  Dr. S. Murugesan, Scientist 'G'& GCR, Institute of Forest Genetics and Tree Breeding, Coimbatore.

  Smt. R. Sumathi, ACTO, Chemistry and Bioprospecting Division, Institute of Forest Genetics and Tree Breeding, Coimbatore.

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

In India, teak grows naturally in 9 million hectares of southern tropical deciduous forests of Peninsular India. Currently1.5 million hectares of teak plantations exists in India and around 50,000 hectares are planted annually. The major teak growing states are Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka and Kerala besides, Uttar Pradesh, Gujarat, Odisha and Rajasthan. About 187 insect species have been found feeding on living Teak trees in India. Amongst them, the teak defoliator, *Hyblaea puera* Cramer (Hyblaeidae, Lepidoptera) is the most widespread and serious pest. Outbreak of this pest occurs almost every year in teak growing regions of India. Studies in young teak plantations at Nilambur of Kerala in South India showed that defoliation by *H. puera* caused loss of 44.1% of the potential wood volume increment over a 5 year cumulative period. All conventional pest management strategies have been failed in managing *H. purea*. Hence needed newer strategies to contain this pest.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Fruiting season of Bael is from March to October. 100 seeds (2.5 to 4 inch diameter) of Bael weigh 250 gm. 100 gm of seeds yield 25ml of oil when extracted with petroleum ether. The solvent is recovered during concentration of the oil under vacuum. 400 gm of seeds yield 100ml of oil. 10 liter of biopesticide is prepared by diluting 100ml of seed oil with 9900ml water using 1ml Tween 20 (Emulsifier). 4 liters of prepared biopesticide is enough to treat 1 lakh teak seedlings in nursery. 40ml of seed oil is needed to prepare 4 liters of biopesticide. This is 1% (10,000 ppm) of biopesticide for controlling 80% of larvae infesting seedlings in a nursery (Fig. 42).. The

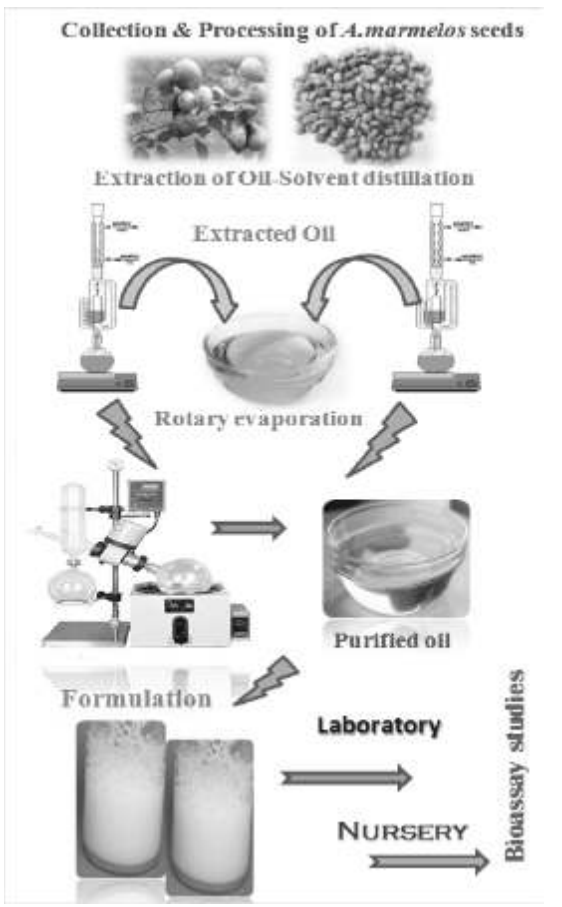

Fig. 42: Steps for seed oil extraction

formulation was found effective in managing the larval stages of teak defoliator, *H. purea. A. marmelos* seed oil derived biopesticide is a promising biocontrol agent against early developmental stages of teak defoliator in nursery and young plantations of Teak (Fig. 43, Fig. 44)

Fig. 43. Application of Vivekam in Teak nursery

Fig. 44. Vivekam treated healthy teak seedlings in nursery

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Raw material: Seeds of *Aegle marmelos*, Sticking agent: Adjuvant (1 ml of Tween 80)

Equipment: Conventional oil extractor, Rotary evaporator.

5. SPECIFIC PROBLEMS /OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

The oil may get rancid during storage. This can be minimized through proper storage practices by storing oil in a cool dark place in an air tight container with little or no exposure to oxygen. A suitable antioxidant such as BHT/ Ascorbic acid can also be added to the oil during storage for enhancing the shelf life of the oil.

6. IMPACT OF THE INNOVATION

The extent of damage by the teak defoliator in nursery is so heavy that production of quality planting stock is limited. Conventional management strategies have been failed to contain the pest and leaves pesticide residues in the environment causing health hazards. The advantage of using the biopesticide is safeguarding and supplying the quality planting material to the stakeholders. Application of the developed bio pesticide will reduce the pest infestation drastically and contribute considerably for growth increment State forest nurseries and forest development corporations, plantation companies will be directly benefited. The technology being simple, field usable and effective in terms of cost and application, abundant availability of the raw material locally at affordable price, is easy to adopt by SFDs, industries, and the tree growers. Collection of Bael seeds will generate employment to rural women. Youth can also easily adopt the technology and generate income for livelihood.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The technology is suitable for upscaling at any level because processing of the Bael seeds to produce oil and its formulation are quite simple and economically viable.

8. ECONOMIC VIABILITY

Currently, biopesticides share of the total crop protection market globally is $4.4 billion, which accounts for just 5% of it. Biopesticide use at a global scale is increasing by almost 17% every year and likely to increase 21% by 2030. It appears that the global market must increase further in the future if these pesticides are to play a visible role in substituting chemical pesticides and reducing the current over-reliance on them. Hence, newer biopesticides with consistent efficacy are warranted. Biopesticide application can save Rs. 38,000/ ha loss from teak defoliators. Rs. 675/ teak tree can be saved with application of biopesticide against the defoliator.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The technology will also accelerate innovative efforts for developing pesticides of plant origin for management of other pests of forestry importance. The use of biopesticides in forestry as a component of Integrated Pest Management (IPM) may be included in forest policy. Application of biopesticides in forest sector will bring with them new regulatory and economic challenges that must be addressed through joint working between social and natural scientists, policy makers and industry.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The technology can be extended to the stakeholders including SFDs, tree growers, rural women and youth, industries, etc. for livelihood generation. Training to these stakeholders will lead to their enhanced capability for use of the technology.

11.DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Institute of Forest Genetics and Tree Breeding, Coimbatore is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

15 A PROCESS FOR THERMAL MODIFICATION OF WOOD

1. GENERAL INFORMATION

- Title of Innovation

  A process for thermal modification of wood

- Brief Description : Heat treatment of wood at high temperature (150-250°C) in inert/vacuum environment is one of the chemical free and most promising wood modification techniques to improve its aesthetics, dimensional stability, and decay resistance. Different properties including dark brownish color can be controlled by varying the process parameters. Heat treated wood does not require any further preservative chemical treatment to enhance its durability. This process can enhance properties of poor quality woods as a substitute for certain high value species being used for different applications such as parquet flooring, light furniture, siding, cladding, decking etc. IWST developed technology has made possible to produce thermally modified wood (TMW) from certain plantation timbers. A number of wood products from TMW have also been prepared.

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2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Fast grown plantation timbers are generally associated with certain material deficiencies/ limitations such as variability in appearance and higher amount of sapwood having higher susceptibility to rot and fungal attack, and presence of juvenile wood with excessive shrinkage/swelling leading to warping, cracking, bowing etc. To overcome these limitations, thermal modification of wood is one of the economical and eco-friendly alternatives.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

For producing thermally modified wood, air-dried wooden planks are subjected for treatment at higher temperatures in the range of 150 ºC -250ºC for certain duration (2 to 8 hours) under partial vacuum or in a controlled environment depending on the timber species and required level of product performance. There four phases of heat treatment (i) controlled initial heating and drying of wood (at around 100ºC); (ii) slow ramping of temperature for accomplishing desired target temperature (150 -250ºC);(iii) maintenance of treatment temperature for accomplishing desired thermal modification; (iii) controlled slow cooling of heat treated wood material inside the chamber. This process brings about desired improvements in the properties

and performance of the wood material. A microprocessor controlled vacuum chamber is used for heat treatment of wooden planks at the laboratory scale (Fig. 45). Wood and bamboo based industries, Forest corporations etc. have been using the plantation timbers having higher proportion of sapwood which makes the wood vulnerable to decay against bio-deteriorating agencies, poor aesthetics and lower dimensional stability. Thermal modification of wood takes care of the above stated problems without using any external chemical treatment. Some of the thermally modified wood species may not be suitable for outdoor applications without certain special chemical treatments.

Vacuum oven Condenser & filterChilling unit

Fig 45. Microprocessor controlled vacuum chamber for heat treatment of wood

Different plantation grown wood species such as rubberwood (*Hevea brasiliensis*), Acacia (*Acacia auriculiformis*), Eucalypts (*Eucalypts tereticornis*), *Melia dubia*, Poplar (*Populus deltoides*), Subabul (*Leucaena leucocephala*), Casuarina(*Casuarina equisetifolia*) and bamboos have been successfully heat treated using a small vacuum oven and their various processing parameters have been optimized.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

The wood material from plantation grown timbers as detailed above is subjected to controlled high temperature treatments under inert environment (vacuum condition). An enclosed chamber of required size is needed to thermally modify the dry wood material. In addition, a vacuum pump of suitable capacity, heating and cooling controller, chiller and volatile gas condenser, which are readily available in the market, are also required for complete fabrication of thermal treatment unit.

5. SPECIFIC PROBLEMS / OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Depending on the timber species, initial condition of the wood, degree of thermal modification required, usage of treated wood for the end product, the process parameters have to be maintained with in the given range. The volatile compounds emitted during high temperature processing of wood material need to be condensed properly and should not be allowed to be released in the open atmosphere. Proper training and technical expertise will be required for running the thermal treatment plant. Over and under thermal modification of wood may result in poor quality product. However, regular cleaning and overall maintenance of the products produced from thermally modified wood such as UV-resistant protective coating may be required to be applied for longer and satisfactory service life.

6. IMPACT OF THE INNOVATION

Developed process of thermal modification of wood opens potentially profitable market for timber species which are generally not very profitable in terms of their overall wood quality point of view. Thermally modified wood has improved durability and dimensional stability besides uniform darker colour and may be able to fill the demand gap of high value traditional timbers for certain value-added applications. The technology also has a huge growth potential due to growing health concerns of preserved wood treated with hazardous chemicals. The process of thermal modification of wood is very useful to the timber processing and products industry for many interesting opportunities. The process to thermally modify such woods may be transferred to interested wood based industries. Recently, a few wood and bamboo based industries and forest department corporations have been approaching IWST to provide technical consultancies. MOUs between IWST and the interested industry have been prepared/submitted and are at various stages for transfer of technology.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Process parameters of the heat treatment of different woods and bamboos have been optimized in the laboratory using a small size vacuum oven. However, the thermal modification process needs to be tested at the pilot scale before transferring it to the wood processing industry for large scale operations. The cost of heat treatment depends upon the amount of improvements and quantity of wood subjected to thermal modification. A small size thermal treatment plant of wood (about 80-100 cft) is required to be established at the institute for testing the process at the pilot scale. The estimated cost of fabricating such a plant is Rs.40-50 lakhs (Fig. 46). A few wood and bamboo based industries and Forest

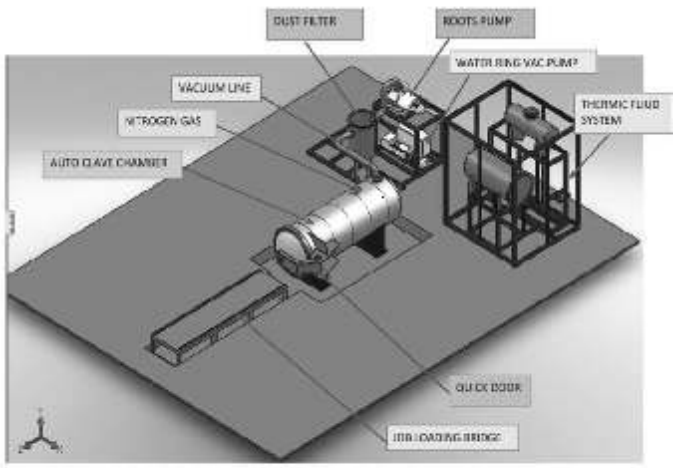


Fig 46. Schematic diagram of pilot plant for thermal modification of wood

Departments/Corporations have shown their interest in establishing and commissioning thermal treatment plants for production of thermally modified wood material from fast grown plantation timbers for different value-added applications.

8. ECONOMIC VIABILITY

Imported thermally modified woods, mostly softwood species are being sold in Indian market at very high prices. The purpose of thermal modification is to provide value addition to economically unattractive plantation species which are generally associated with low durability and poor dimensional instability. The treatment process results in a small increase in the cost of the timber, however, the product will be economically viable keeping in mind value addition and improved performance. A small size thermal treatment plant of wood may be established for processing the thermally modified wood at a small scale. The main heat source to thermally modify wood may be low priced wood/agro-based lingo-cellulosic wastes. It may be established and commissioned under a tin shade for production by the industry.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

- Usage of thermally modified wood is increasing gradually in many parts of Europe and North American countries in different applications. End users prefer thermally modified wood compared to wood treated with preservative chemicals which possess serious hazards to human and environment. As stated above, thermal treatment of wood is a chemical free process and modified wood exhibits improved decay resistance. This would help in preserving the products produced from low durability wood species. Fast grown plantation timbers may be put to value-added usage using this process of wood modification. This would facilitate the carbon locking in wood for longer terms and also the enhanced durability of wood would help in conserving our natural forests.
- It may be noted that fast grown plantation timbers contain higher amount of sapwood which should be treated/modified in order to enhance their service life. Improved characteristics of thermally modified wood offer the timber product industry many potential and attractive new opportunities to produce the wood products having better quality, performance and overall appearance.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/COMMUNITIES/INDUSTRIES, ETC.)

- For processing the plantations woods, this Institute is in position to provide technical know-how on thermal treatment technology to produce alternative to scarce and highly priced primary/imported timbers for different applications. Wood processing industries need to be approached for testing of this process at the pilot scale.

11.DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Institute of Wood Science & Technology, Bengaluru is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

16 A PROCESS FOR CHEMICAL MODIFICATION OF WOOD

1. GENERAL INFORMATION

- Title of Innovation

  A process for chemical modification of wood

- Brief Description : Wood modification aims at enhancing the performance of wood by altering the molecular structure of the cell wall components. A process of solvent free chemical modification of wood by acetic anhydride has been developed. Modified wood is produced by reacting acetic anhydride with wood under specified conditions. Chemically modified wood exhibit high dimensional stability, improved durability, superior UV resistance and paint retention. Modified wood is considered ideal for outdoor use including wooden windows, doors, decking, outdoor furniture etc.

- Name and contact details of person or institution responsible for the innovation : Dr. K. K. Pandey, Scientist G, Institute of Wood Science and Technology, 18th CrossMalleswaram, Bengaluru. Email: kkpandey@icfre.org

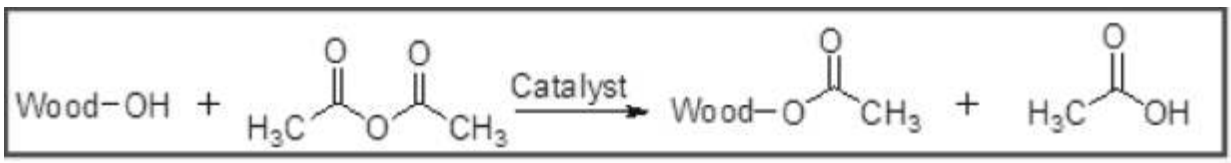
2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

The scarcity of the most of the conventionally used timber species like Teak has necessitated use of fast growing plantation timbers. Unfortunately, most of the plantation timbers have little resistance to biological or physical degradation and require preservative treatment to increase their service life when used outdoors. Traditional wood preservatives such as chromated copper arsenate (CCA) are under threat because of environmental concerns about leaching of copper, chromium and particularly arsenic into the environment. There has been growing environmental and legislative pressure on the use of traditional biocide based wood preservatives. Therefore, there is a pressing need to develop alternative more environmentally friendly treatments to prevent such degradation. One means of achieving this, which does not rely on metal-containing wood preservatives, is the chemical modification of wood. This process can enhance properties of low durability woods as a substitute for certain high value species in different outdoor applications. The process also helps in climate change mitigation by enhancing carbon locking period in wood.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

- Chemical modification involves replacing hydrophilic OH groups of wood constituents by more hydrophobic groups.

- Acetylation of wood is the most stable and industrially accepted process. In the process, acetic anhydride reacts with the hydroxyl groups of cell wall polymers of wood and replaces hydroxyl groups with acetyl groups.



• IWST has developed a process of solvent free acetylation of wood by acetic anhydride. The presence of small amount of catalyst elevates the rate of modification resulting in significant reduction in reaction time.

Process

- The process of chemical modification of wood involves impregnation of swan wood with a chemical reagent(acetic anhydride)containing suitable catalyst (0.02M iodine or ~ 1% NBS)under vacuum/pressure in an enclosed reactor/chamber.
- The excess of the chemical reagent is syphoned off under vacuum.
- The impregnated wood is then heated at 100-120° C for 2 to 6h, depending upon the desired level of modification. he level of modification is characterized by weight percent gain (WPG) calculated using equation, WPG = [(Wm-Wo)/Wo] × 100, where Wo and Wm are oven dried weight of unmodified and chemically modified wood, respectively. A WPG in the range of 15%-20% is needed for outdoor applications.
- The residual chemical reagent (acetic anhydride) and byproduct (Acetic acid), are removed using condenser by heating under vacuum.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

An impregnation/reaction vessel of small size (pilot plant) having vacuum, pressure, heating and condensing options is required to be fabricated for producing modified wood. Since there is no readymade treatment plants available in the market, an industrial collaboration is essential to design treatment plant and for pilot scale trial of the technology. Chemical (acetic anhydride) is commercially available and is supplied under license.

5. SPECIFIC PROBLEMS / OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Modified wood is non-toxic and safe to handle and is considered ideal for outdoor use. Modified wood is produced by reaction of wood with acetic anhydride. Acetic anhydride is a clear colorless liquid with a strong odor of vinegar. It is corrosive chemical and the vapours of acetic anhydride are harmful. Therefore, safe use of this chemical needs to be taken during production of modified wood and design of plant.

6. IMPACT OF THE INNOVATION

Chemical modification open up avenues for utilization of low durability plantation timbers, thus reduce pressure on primary timbers. Chemically modified wood enhances durability of wood, thus also helps in conserving the forest and protecting environment.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The process has been tested at laboratory scale and needs pilot scale testing. To take technology forward, industrial collaboration is needed for pilot scale testing. Since readymade treatment plants are not available in Indian market and institute does not have technical experts to fabricate plant, industrial support is needed for design and commissioning of a pilot plant to take technology forward.

8. ECONOMIC VIABILITY

Chemically modified wood is being increasingly adopted by timber wood users in Europe and America to address the global outcry against the use of hazardous chemicals as wood preservatives. Chemically modified wood is not produced in India at present. However, imported modified pine wood is available in Indian markets and is getting acceptability and being sold at high price. There is scope to produce chemically modified hardwoods available in the country. The modification process results in an increase in the cost of the timber. However, if long term benefits such as good dimensional stability, increased service life and paint retention etc. of the modified wood is considered, the product should be economically viable. We have carried out wood modification studies at laboratory scale. The process needs pilot scale trial to work out actual cost of treatment per CFT.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

High durability timbers like Teak, Rosewood, Deodar, Sal are not available or are expensive. Alternate is use of fast grown plantation timbers. However, fast grown plantation timbers have inherent drawbacks and have less durability. These nondurable timbers when suitably treated or modified, would give adequate life under service conditions. Treatment / modification of wood reduces the maintenance costs by avoiding frequent replacements of timber and also widens the choice of timber species for different end uses. Timber protection, therefore, forms a very important part of the national effort to conserve the material resources of the country.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/COMMUNITIES/ INDUSTRIES, ETC.)

Developed process will be ready for extension to Stakeholders (Wood Industries) after of process parameters in pilot scale plant.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Institute of Wood Science & Technology, Bangalore is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

17 A PROCESS FOR MAKING WOOD POLYMER COMPOSITES

1. GENERAL INFORMATION

- Title of Innovation (Technology/Practice/Protocol/Product)

  A process for making wood Polymer Composites.

- Brief Description : Wood Polymer Composites are generically referred as the natural fiber reinforced thermoplastic composites wherein thermoplastic polymer like polypropylene (PP), High density Polyethylene (HDPE), Polystyrene, poly-lactic acid (PLA), etc. are reinforced with natural lignocellulosic fibers. The natural fibers have evolved as a potential alternative to inorganic fillers for various applications. They offer several advantages like low density, high specific properties, are non abrasive to processing equipment, low cost, reduced environmental impact, ability to be recycled after use, reduced dependence on non-renewable energy/material sources, lower pollutant emissions, lower greenhouse gas emissions, enhanced energy recovery, and possibility of end of bio-compostable/degradable material that makes them more attractive over conventional fillers like talc, glass fibers or carbon fibers. High performance composite materials with uniform densities, durability in adverse environments and high strength can be produced by using a variety of natural fibers and commercial thermoplastics by taking advantage of the properties of both the materials.

- Name and contact details of person or institution responsible for the innovation : Director, Institute of Wood Science and Technology, P.O. Malleswaram, Bengaluru, Email: dir_iwst@icfre.org

- Name and position of key or relevant persons or officials associated : Dr. Shakti Chauhan, Scientist- G, Institute of Wood Science and Technology, Bengaluru, Email: shakti@icfre.org

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

The process aims at utilizing lignocellulosic waste generated by wood and bamboo processing industries, forest weeds, recycled wood, agro residues like rice husk, wheat straw, etc. for high end, value added products. It also addresses the issue of reducing plastics from utility products by replacing part of polymers by natural fibers. The develop WPC material is light weight, stiffer and stronger than virgin plastics, recyclable and relatively more environmentally friendly. The use of bio-based polymers in composites opens up the avenue of replacing single use plastic products with bio-compostable/degradable material which is the need of the hour.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

WPC research is focused on expanding the choice of raw material, new production methods and technologies for manufacturing wood plastic composite with high efficiency and desired properties, developing completely bio-degradable composites for specific applications using bio based polymers and natural fibers . One of the major challenges in producing the WPC granules is the poor compatibility of natural fibers with commercial

thermoplastics. Institute of Wood Science and Technology (IWST) Bengaluru has synthesized a novel coupling agent that improves the compatibility of plastic with natural fibers. The composite material prepared using this coupling agent has exhibited markedly superior mechanical properties than conventionally used coupling agents. Composites have been prepared with up to 70% fiber loading using variety of natural fibers like wood, bamboo, jute, coir, rice husk, lantana, etc. The developed composites are stronger and stiffer than virgin polymers or conventional inorganic filler based thermoplastic composites, moisture resistant and dimensionally stable. This composite material has large scale applications in profile extruded and injection moulded utility products. The Institute has developed composite formulations for different end applications based on their property requirements.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES ETC:

- Raw materials:

1. Natural Fibers (wood, bamboo, sisal, jute, etc.)
2. Polymers (Polypropylene, Polyethylene, PLA, etc.)
3. Additives

1. Coupling agent (Maleic anhydride grafted Polyolefin or any other suitable coupling agent).
2. Lubricants
3. Colour pigments (if desired)
4. Anti-oxidants
5. UV stabilizer (for exterior applications)
6. Fungicide (if desired)

Most of the processing additives are commercially available and can be sed as such in the production of the composite granules. However, their proportions differ based on the end-product.

- Equipments:

1. Upstream equipments for fiber processing such as chipper, pulverizer, dryer, fiber size screen
2. Twin Screw Extruder for compounding
3. Palletizer
4. Injection moulding machine with appropriate mould depending on the product and/or profile extrusion system for extruded products (Depending on the product)

5. SPECIFIC PROBLEMS/OBSTACLES LIKELY TO BE FACED BY THE USER DURING THE USE AND THEIR SOLUTIONS:

The need for different tooling and mould designs that used for standard polymers has to be understood by the industry and the changes in the standard polymer processes have to be mastered by processing personnel. There are certain processing challenges which are generally not encountered in synthetic fibre reinforced thermoplastic composites. Low bulk density of fibers may lead to inconsistency and low output in the compounding. Presence of moisture and other volatiles in natural fibers may interfere with other additives and also pose significant challenges in defect free injection moulding of components. Natural fibers have much

lower thermal stability than polymers like PP, PE and therefore the composites thereof also exhibit relatively poor thermal stability which needs to be understood by the industry. The Institute can help industries in deciding about the formulations and optimization of process parameters for obtaining quality products.

6. IMPACT OF THE INNOVATION

Developed process has positive impact on environment thus by reducing the usage of plastics and using more of bio-based materials

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Based on the end user applications the process can be upscaled for commercial production of WPC granules of different grade suitable for different end-products. The processing equipments (extruder) are now very much standardized for industrial scale production of WPC and the existing injection moulding equipments used by the industries can effectively be used for product developments with slight modification in mould designs and optimizing the process parameters. The process can further be upgraded for production of completely biodegradable or compostable composites by using biopolymer such as polylactic acid (PLA).

8. ECONOMIC VIABILITY

A large amount of lignocellulosic fibre is available in the form of woody waste produced by wood based primary and secondary processing. Additionally, India is a home World's 45% bamboo forests producing 4.5 million tones annually. The technology provides a commercial opportunity to utilize such material for high value, large volume industrial and commercial applications creating a significant better value chain for such abundantly available resource. Simultaneously, there are regulatory requirements countries are imposing on the industries to increasingly use bio-based materials and consumer awareness is also increasing to use bio-based materials and products. This provides opportunities to industries to create bio-based products to differentiate, remain competitive and increase the profitability and sustenance. Wood Polymer composites offer slight economic advantage along with the environmental benefits. However the economic gains may depend on the scale of operation, availability of woody-waste and factors like labour cost, etc. Adding low value natural fibers to commercial thermoplastics is expected to result in cost savings at the same time improving the properties of the composites. A tentative cost estimate of WPC production is as follows:

Materials	**Material cost (in Rs.)/ Kg**	**Material cost (in Rs.) at 50% fiber loading/kg**
Virgin polymer	105.00	50.00
Woody waste after processing	14.00	6.00
Coupling agent	300.00 @ 5%	15.00
Additives (UV, AO, colour)	200.00 @ 3%	15.00
Processing cost	10.00	10.00
Total cost	629.00	96.00

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

WPC may be suggested for use in applications such as decking, stair railing, wall cladding, light structural applications, consumer goods, etc. Development of bio-compostable or biodegradable composite material can help in replacing single use plastic products which is a major concern. Therefore such products should be encouraged and policy based on wood product need to be formulated.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES ETC)

Sourcing of ligno cellulosic fibers and other agro fibers from small to medium scale growers can increase the income of communities. The institute can work with the industries in developing product specific formulations and optimizing process parameters for industrial scale production of the composite materials and products. The existing knowledge can be transferred to the industries.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Institute of Wood Science & Technology, Bangalore is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

18 AN EFFICIENT SOLAR WOOD DRYER

1. GENERAL INFORMATION

- Title of Innovation

  An efficient solar wood dryer.

- Brief Description : The use of renewable energy resources like solar energy for industrial processing may not only help to reduce environmental burdens but also to reduce the ever increasing dependency on non renewable resources. Drying is an important industrial processing operation. A solar wood drying kiln is an effective, simple and clean technology option for wood drying. An improvement over previous solar kilns was made which enabled the new solar kiln to trap 39 % more heat in winters. Moreover, for effective heat transfer other changes in the previous design have also been made.

- Name and contact details of person or institution responsible for the innovation : Dr. Shailendra Kumar, Scientist-C, Wood Seasoning Discipline, Forest Product Division, Forest Research Institute, Dehradun – 248006, E-mail: kumarsro@icfre.org; Mobile: +919837086111

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

India is pioneer in the wood drying solar kilns research worldwide. After rigorous research and development carried out at FRI, Dehradun, an industry friendly wood drying solar kiln evolved in the decade of 1970s, known as FRI solar kiln. This kiln used optimized single inclination south facing roof, whereas, the present design uses two optimized inclinations roofs as per two major seasons of the year: winter and summer. These optimized inclination angles enable the kiln to receive sufficient solar flux in clear winter days in order to generate heat sufficiently.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Developed kiln (Fig. 47; Fig. 48) has following features:

a. The inclined roof and south wall

The roofs were made of double glass glazing, with 5 mm thick glasses and keeping 38 mm space between the two glasses. The south facing roofs of the kiln is divided into two parts with respect to inclination from the horizontal surface based on elevation of the sun in summers and winters for Dehradun location. The lower south facing wall started from

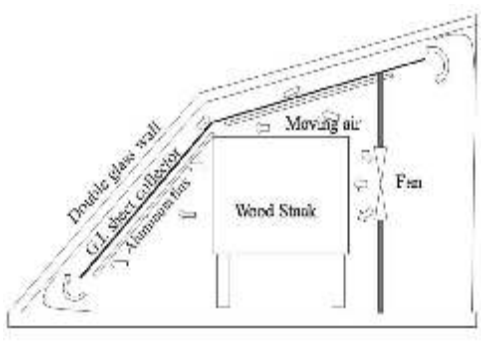


Fig.47: Diagram of solar wood dryer

a raised cemented foundation making an angle of 41owith the horizontal. The inclined roof which starts from the top of the lower south wall makes an inclination angle of 18o from horizontal.

b. Solar collectors

A blackened Galvanised Iron (G.I.) sheet flat plate solar collectors system below the double glass glazing roof was placed in such a way that collector runs parallel to the roofs by maintaining a gap of 10 cm. In order to raise the temperature quickly in early morning/late evening, the collector's east/west sides were made like a tray, having sides inclined in such a way that one side faces early morning sun and other side faces evening sun. This was done to facilitate incidence of solar rays near perpendicular to the tray like raised sides of the collectors.

c. Vertical east/west facing wall flat plate collectors for minimizing diurnal variation in solar energy availability:

The east/west walls are fully covered with blackened G.I. sheet to help wood drying in two ways. First, it prevents circulating air of kiln from striking directly the double glass wall, thus reducing the heat losses to surroundings. Secondly, the east/west wall collectors help to trap solar energy at almost perpendicular direction in early morning/ late evening to raise the kiln temperature quickly.

d. Aluminium fins:

The lower side of the main roof collector is attached with Aluminium fins by riveting from the lower side. The objective of the Aluminium fins was to enhance the heat removal efficiency of the collector system. However, due to use of rivets, efficient contact could not be ensured between G.I. collector and fins.

The results indicate that the empty kiln temperature rises as high as 98.1°C in April when ambient temperature was 37°C. In the winter months, the kiln temperature could reach a maximum of around 64 -70°C when ambient temperatures were around 21 -23°C.


Fig. 48: Developed solar wood dryer

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

The kiln can be constructed using common and easily available materials. The following materials are required for the kiln construction:

- Transparent glass
- Aluminum sheet
- Wood (for structural support) or steel angles (for metallic structure)
- Plywood

- Glass wool/ Rockwool
- Cemented foundation
- Fans for air circulation
- Humidifier for humidification
- Gasket and adhesives

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

The kiln may develop higher temperatures than desired in the summers; hence, a vigilant monitoring of the drying process is required especially in summers. For night time, kiln may get cooled in absence of solar heat. However, to address this problem, thermal storage system, auxiliary heating system etc. can be adopted depending upon economic feasibility in commercial production lines. If an auxiliary heating system is used in the night time, some additional arrangements like heat jacket maybe required to reduce excessive heat losses through glass walls.

6. IMPACT OF THE INNOVATION

India is transforming into an expanding village or sub-urban conglomeration. Wood sector contribute significantly in employment generation and earning of foreign exchange through exports. Wood drying is most important processing and most energy intensive operation and can consume over 70% of the energy of wood processing. India being a tropical country is gifted with rich solar insolation almost all across its geographical boundaries. Use of renewable energy resources like solar energy for industrial processing may not only help to reduce environmental burdens but also reduce ever increasing dependency on non renewable resources. This is an effective, simple and clean technology solution for wood processing.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

For the places where approximately 300 clear sunny days are available, solar kilns are highly advisable. The solar drying is most suitable for small-scale operations that have flexibility and non-critical supply schedules. The developed technology can be easily upscaled depending upon availability of raw material and product requirement.

8. ECONOMIC VIABILITY

Unlike conventional drying systems (steam heated kilns) solar drying kiln is a mechanically simple system which results in lower maintenance and energy costs. During the kiln drying of wood, unlike as in steam heated kiln, continuous presence of drying kiln operator is not required. The temperature and relative humidity inside the kiln can be adjusted by opening/ closing of the vents. Installation cost of solar kiln too is much lower as compared with steam heated kilns. Unlike steam heated kilns, solar kilns don't require boiler, piping and pumping etc. The solar drying is most suitable for small-scale operations that have flexibility and non-critical supply schedules. It is expected that the technology will end up comparably economical when the costs of fuel, manpower etc. are considered to run a boiler based wood dryer.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Today, world is facing the menace of human induced global warming. Solar energy has enormous potential to substitute the fossil fuels in heating for industrial processing which can help to achieve the goal of sustainable development. Promoting the use of solar energy as an eco-friendly choice for industrial processing operations like wood drying can help in achieving national goals of lowering carbon emissions.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The quality of drying is better in solar kilns compared to conventional kilns. Slower drying rate and higher relative humidity in kiln especially in night results into mild reconditioning and thus mitigate the drying stresses overnight. Reduction of air temperature in night also results in release of drying stresses. The drying kiln can be installed with wood drying capacity of 125-200 ft^3 for wood based industries and state forest corporations. The technology is also suitable for small artisans in the remote corners of the country.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Forest Research Institute, Dehradun is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

19 ULTRASONIC TECHNIQUE FOR DETECTION OF TREE TRUNK HOLLOWNESS

1. GENERAL INFORMATION

- Title of Innovation

  Ultrasonic technique for detection of tree trunk hollowness.

- Brief Description : Forest Research Institute, Dehardun has developed an ultrasonic technique to detect the location and magnitude of the deterioration (hollowness) inside the main tree trunks for different girths which helps either to take timely precautions for the safety of the valuable tree by giving suitable and effective treatment or to get good yield (timber) for utilization purposes. This technique is beneficial to the State Forest Departments and other agencies in management of urban forestry to take timely decision for removal of hazardous trees which are at prime locations for the safety of life. At diameter at breast height (DBH), the girth of tree trunk is measured using tape. Peripheral division of the girth is done into 6 or 8 segments for transducers. Trunks of girth less than or equal to 120 cm are divided into 6 segments and those of girth more than 120 cm are divided into 8 segments. At these segment points, bark is drilled up to wood in order to provide location for transducers. With the help of Vernier scale, liner distances between each pair of segment points and the time of travel within the wood medium is recorded from ultrasonic concrete tester and is fed into the software to see the presence of the hollowness.

- Name and contact details of person or institution responsible for the innovation : R. Ezhumalai, Scientist-D, Timber Mechanics Discipline, Forest Product Division, Forest Research Institute, Dehradun – 248006, E-mail: rezhumalai@icfre.org; Phone: 0135-2752671, 2224441;

  Rajesh Bhandari, Scientist-E, Timber Mechanics Discipline, Forest Product Division, Forest Research Institute, Dehradun – 248006, E-mail:bhandarir@icfre.org; Phone: 0135-2752671, 2224395

- Name and position of key or relevant persons or officials associated : Y. M. Dubey, Scientist-E (Retd.), Timber Mechanics Discipline, Forest Product Division, Forest Research Institute, Dehradun–248006, Phone: +919410558428

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Various non destructive testing techniques based on different concepts are known for use in the field conditions for deterioration detection mainly to identify hazardous trees, to prevent the spread of decay and to improve stand conditions. Among several non destructive test methods, vibration test technique (acoustic/ultrasonic) is one of them and employed to evaluate the elastic properties, presence of defects of wood and wood products as it has several advantages over traditional testing such as less time consuming, economical, reliable results and also easy to transport instruments at inspection site. Sounding a tree by striking it with a tool can detect advanced decay or hollows inside the trunk, but this method is not effective on large thick-barked trees. Therefore, acoustics and ultrasonic techniques which are non destructive testing

techniques and have proven to be effective for detecting and estimating deterioration in tree stems and wood structural members. These techniques are simpler and economic than other techniques. Because the propagation of stress waves is basically a mechanical phenomenon, these waves are frequently used to detect internal defects in wood.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Ultrasonic testing technique has been used for hollowness detection in tree trunk. Ultrasonic velocity in tree trunk is transmitted along the multiple transverse directions of the tree trunk (Fig.49).Ultrasonic velocity is determined along multiple transverse directions of the tree trunk. In the presence of hollowness, ultrasonic velocity decreases. Magnitude and location of hollowness in tree trunk is estimated using EXCEL sheet or software.

3.1 Defect detection in timber by ultrasound

Direct ultrasonic wave transmission technique is used for defect measurement in tree. Ultrasonic waves transmitted through decayed wood moves slowly compared to solid wood. Ultrasonic waves of lower frequency (25 KHz) along the multiple transverse direction of the tree trunk is transmitted and time taken between to reach at receiving ends (Points) is recorded. Ultrasonic velocity is determined based on the formula (distance/time). Presence of defect in tree is estimated on the basis of drop in stress waves velocity compared to the reference velocity. For eight or six point testing of the trees, its whole girth is divided in to eight of six parts at equidistance and trees trunk is divided into segments (Fig.49). Bark from these eight or six points (test points) is removed and surface of each points is made smooth with the help of drill machine or using suitable nail in the marked point for placing ultrasonic transducers (transmitter and receiver) for testing. Distance between these points is recorded at the accuracy of 0.1 decimal. Testing of trees for defect detection (8 or 6 points) is carried out by placing transmitter (transducer of frequency 25 KHz) at the point 1 and receiver of same frequency at point 2 using couplent with soft iron nail to make good contact among them or directly place the transducer at point where bark has been removed. Time (µ sec.) taken by the ultrasonic waves to travel from point 1 to 2 of the trees is noted. After that position of transmitter remains same at position 1of the tree and position of receiver varies from 2 to 3, 4, 5, 6, 7, 8 and for each position of receiver time is recorded. Thereafter, position of transmitter is kept at the point 2 of the tree and receiver is placed at the point 3, 4, 5, 6, 7, 8 and for each position of receiver, time is again recorded. The similar test procedure is followed for all point marked (1-8

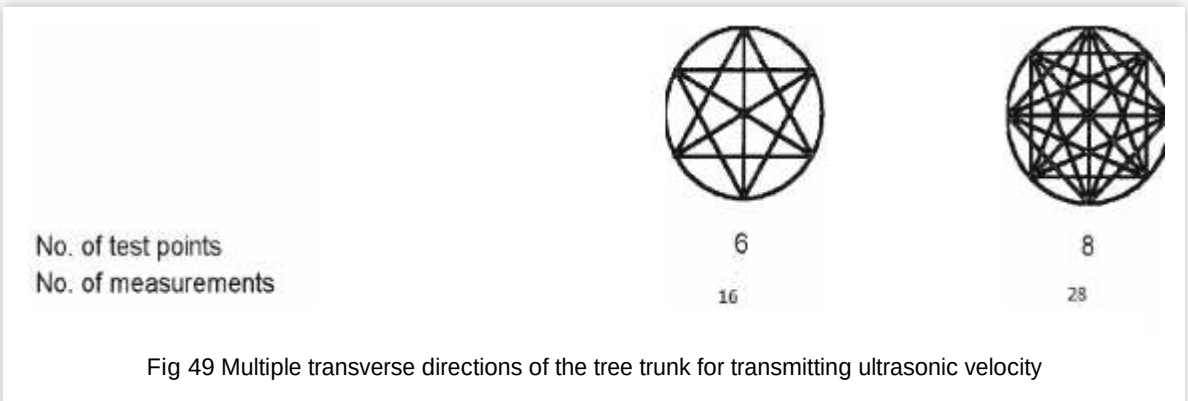


Fig 49 Multiple transverse directions of the tree trunk for transmitting ultrasonic velocity

&1-6 points) on the tree. Total twenty eight (8 points) or sixteen readings (6 points) are recorded. Ultrasonic velocity is determined for each position of transmitter and receiver (eqn. 1). Thereafter the value is computed in the software to find the hollowness presence (Fig. 50).

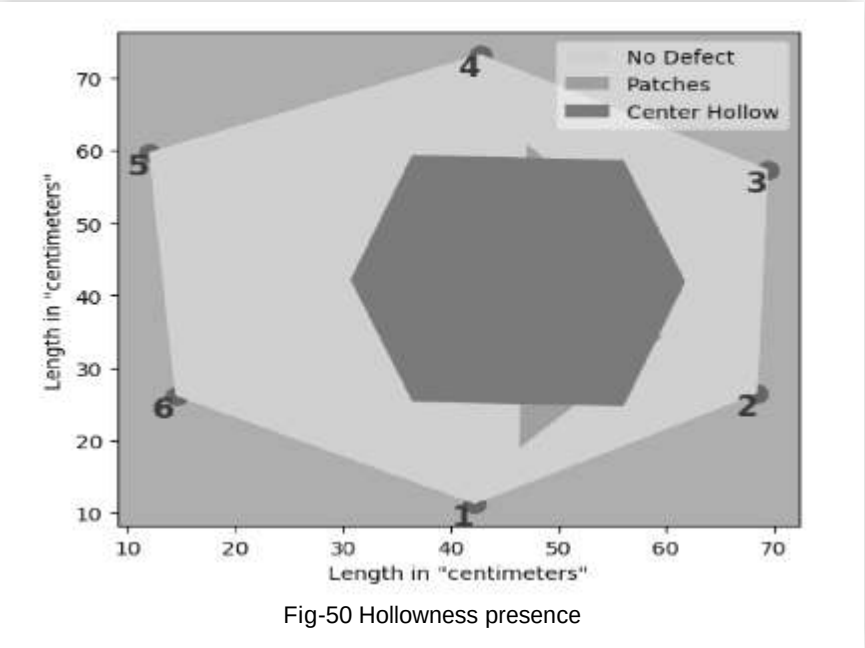


Fig-50 Hollowness presence

Salient features

Defects in standing or living trees can be detected easily.

Defects can be detected within 15 to 20 minutes.

Equipments are handy and very easily operated by any trained person

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Equipments:

(i) Commercially available anultrasonic equipment with two probes for producing ultrasonic frequency up to 50 Hz.

(ii) A battery operated drilling machine for removing the bark form the tree so that ultrasonic probes can be placed properly

- Manpower: Two skilled people for recording reading of the equipment and one labor for cleaning and hole making and plugging of that hole in the tree by use of wax.

- Materials:

Small stools (02). One for keeping the ultrasonic machine and the other for sitting the person to take the reading from the machine

Honey wax to plug the tree hole

A computer, and a software (available with the FRI, Dehradun) to process the data.

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Sometime equipments won't get reading if the tree is branched inside. In that case reading is taken from little upper side of the tree Probes of the equipment should be placed properly to avoid the erratic reading. Drilling should be done up to the trunk to record the proper reading. Sufficient amount of silica gel should be applied to the probes and to the reading points to get the uniform wave diffusion.

6. IMPACT OF THE INNOVATION

In the year 2019, Fani cyclone killed at least 89 people in eastern India and Bangladesh and caused damages estimated to be US$8.1 billion in both India and Bangladesh, mostly in Odisha. In India over one million trees that once stood tall and provided green cover to the Odisha capital were uprooted by the raging winds of Cyclone Fani and also it damaged the property. Developed technique is an effective diagnostic technology for decay detection in trees and timely prediction of their hollowness saving thereby people and their property loss. Use of this technique doesn't require high inputs in terms of cost, energy, or any other materials and can be adopted by the forest departments and City Municipal Corporations and others with minimum input cost.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Developed technique, being effective, non destructive and inexpensive, is highly suitable in diagnosing hollowness in the trees grown in the forest, rural and urban are as there by enabling the state forest departments to take corrective measures for their protection. This technology can easily be upscaled. Ultrasonic defect detection process can be made more users friendly if it is digitized and made functional with mobile application.

8. ECONOMIC VIABILITY

Cyclonic tree falling have devastating effect in rural and urban areas, especially in coastal areas, every year. The developed technology enables to monitor the trees regularly and to detect their decay timely thereby minimizing the cyclonic damage to the life and property. It is a simple technique which can be handled by a technician with one helper. Cost of the equipment is about Rs. 4.75 lakhs (Rs. 2.50 lakhs for equipment with accessories and Rs. 2.25 lakhs for Software developed by FRI, Dehradun).

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

This ultrasonic hollowness detection technique has problem solving orientation and thus focuses on policy issues desired in urban forestry.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

The officials of the forest departments and City Municipal Corporations can easily build their capacity to use this technology. Capacity building to artisans, youth and women in use of this technique would create employment opportunities to them.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Forest Product Division, Forest Research Institute, Dehradun is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE), Dehradun. ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

20 PERSONAL AND HOME CARE PRODUCTS FROM PLANT SAPONINS

1. GENERAL INFORMATION

- Title of Innovation

  Personal and home care products from plant saponins.

- Brief Description : Saponins represent a diverse group of chemicals possessing surface active or detergent properties and named so on account of their ability to form soap like foams in water. Saponins occur in many plant species, in both wild plants and cultivated crops. Saponins containing wild plants are traditionally used in India especially by rural communities in the hill areas of Uttarakhand and Himachal Pradesh for body/hair care and washing clothes. There are numerous commercial products containing plant extracts in different proportions in the market, and are becoming increasingly popular. However, rural areas barely benefit from this commerce, and rural communities hardly figure in the value chain which is dominated by traders. Many so-called herbal products in the Indian market have dubious ingredients and lack appropriate certification or standards. Utilizing DST's Core Support 2008-13, Centre for Technology and Development (CTD), a unit of Society for Economic and Social Studies (SESS), Delhi developed a processing system and protocols for preparing saponin bearing aqueous extracts that could be used as intermediates, and a range of finished products for personal and home care. The system has capacity to process about 250 kg of Reetha/Soapnuts (*Sapindus mukorossi*) pericarp or Bhimal (*Grewia optiva*) stems per batch for production of saponin-bearing aqueous extracts which have shelf-life of over 12 months. Saponin extract containing finished products (liquid hairwash or shampoo and liquid detergent) are all-natural, fully bio-degradable containing 95% or higher Eco-Certified additives and conform to Food and Drugs Administration (FDA)standards.

- Name and contact details of person or institution responsible for the innovation : Centre for Technology and Development (CTD), Under Society for Economic and Social Studies (Regd.), Khasra No. 275, Westend Marg, Said-ul-ajaib, New Delhi 110030, Email: ctd.delhi@gmail.com; Mobile: +919810098621/+919958200572

- Name and position of key or relevant persons or officials associated : D. Raghunandan, Director, CTD

  Dr. Kalpana Arora, Programme Leader, CTD

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

With modernization and industrialization, personal and home care products like soaps, toiletries, detergents, dishwash, etc. have become a basic consumer needs. Total market of synthetic soaps and detergents is estimated to be about Rs.150 billion. Almost 50% of these sold in rural areas are primarily economy soaps and low grade synthetic detergents which are high in non-biodegradable phosphates and sulphates. When discharged in water bodies from industries or households, these ingredients are of serious environmental and

public health concerns. Many plants have traditionally been used for washing and bathing purposes. There are commercial products containing plant extracts available in the market and gaining popularity but tribal / rural communities engaged in collection of plant materials get barely any benefit for collection of these materials. Plant products such as Ritha, but in raw form, are also exported. Developed technology was, therefore, aimed to add value to the traditionally used local plant materials such as Reetha and Bhimal using rural people usable simple methods for production of all natural products for personal and home care as effective and eco-friendly substitutes of synthetic chemicals.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 Saponin Extracts (Intermediate)

3.1.1 Soapnut extract

Fig.51: Soapnuts

Soapnuts (Fig. 51) are broken into small pieces manually, seeds are removed and then extracted with demineralized (DM) water in a proportion of 1: 100. Initially 1 Kg of the Soapnuts is boiled with 20Kg of DM water into a stainless steel kettle connected to a boiler for 30 minutes. Again 20 Kg of DM water is added to it and boiled for another 30 minutes. This process is repeated for three times with stepwise addition of 20 Kg of DM water and boiling each time for 30 minutes. Temperature should not exceed to 60°C. The extract is filtered through muslin cloth and concentrated to 50 Kg by boiling. After cooling, the extract is filtered, if needed, then added 0.5% potassium sorbate and stored in HDPE Jerrycanes in a cool and dry place away from sunlight.

3.1.2 Bhimal extract

Stems of Bhimal are cut into small pieces of 2" size and extracted with DM water in a proportion of 1: 100. Initially 1 kg of the stems is boiled with 20Kg of DM water into a stainless steel kettle connected to a boiler for 30 minutes. Again 20Kg of DM water is added to it and boiled for another 30 minutes. This process is repeated for three times with stepwise addition of 20Kg of DM water and boiling each time for 30 minutes. Temperature should not exceed to 60°C. The extract is filtered through muslin cloth and concentrated to 50 Kg by boiling. After cooling, the extract is filtered, if needed, then added 0.5% potassium sorbate and stored in HDPE Jerrycanes in a cool and dry place away from sunlight.

3.2 Saponin based Liquid Hairwash/ Shampoo

In a stainless steel vessel, DM (25 parts) and glycerine (2 parts) are mixed with continuous stirring at the temperature between 45°C to 50°C. Then xanthan gum is dispersed into it through gentle stirring followed by addition of ecocertified potassium sorbate (0.5%) and decyl glucocide (13 parts) as per manufacturer requirement. All these ingredients are mixed well. The vessel is cooled at room temperature. Cationic polyelectrolyte (0.5 parts) and a blend (2 parts) of essential oils (basil oil, tea tree oil and rosemary oil) are mixed separately and added to the vessel. Finally Soapnut extract (57 parts) is added with slow stirring to avoid

excessive foaming. The product is allowed to settle for 24 hrs and packaged.

3.3 Saponin based liquid detergent

In a stainless steel vessel, DM (25 parts) and ecocertified chelating agent disodium ehtylenediamine tetraacetic acid (EDTA) (0.01 parts) are mixed with continuous stirring at the temperature between 45°C to 50°C. Then xanthan gum is dispersed into it through gentle stirring followed by addition of ecocertified potassium sorbate (0.5%) and decylglucocide (13 parts) as per manufacturer requirement. All these ingredients are mixed well. The vessel is cooled at room temperature. Cationic polyelectrolyte (0.5 parts) and a blend (2 parts) of essential oils (basil oil, tea tree oil and rosemary oil) are mixed separately and added to the vessel. Finally Soapnut /Bhimal extract (57 parts) is added with slow stirring to avoid excessive foaming. The product is allowed to settle for 24 hrs and packaged

- Products (Fig. 52) are free from harmful chemicals and preservatives and contain natural and eco-certified ingredients conforming to FDA standards.
- Technology adds value to traditionally used local produce to benefit the rural economy.
- Technology links rural enterprises with markets for sustainable pro-poor livelihood options.

Fig.52: Plant saponin based Personal care and Home care products

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Machineries:
  - Saponin Extract Unit (designed by CTD) (200 L capacity) (Fig. 53)
  - Boiler/Steam Generator (Capacity: 100 Kg/hr to 250 Kg/hr; Pressure: 10.5 Kg/cm² to 32 Kg/cm²)
  - Colloidal Mill(30 L/hr capacity, particle size reduction up to 5 microns) (Fig. 54)
  - Weighing Balance (1g-2 Kg)
  - Glass Wares and Stainless Steel Utensils
- Raw Materials:
  - Saponin containing plant materials such as Soapnuts and Bhimal stem
  - DM water
  - Eco-certified thickening agents such as natural gums and pectins

Fig.53: Saponin extract unit

Fig.54: Colloidal Mill

- Eco-certified surfactants such as alkylglucosides, alkylglucamides

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

- Users must obtain regulatory permits and clearances as applicable.
- Prescribed protocols should be strictly observed for quality control and shelf life of the products.
- Working capital and other credit arrangements must be tied up.
- Appropriate branding, packaging and sales strategies must be adopted.
- Marketing and sales are crucial to this project, especially since buyers are likely to be non-local urban consumers: The entrepreneur or NGO taking up this project must take responsibility for the same

6. IMPACT OF THE INNOVATION

Approximately 10-15 beneficiaries will get full-time employment in the envisaged enterprise. Alternatively, the beneficiary organization may decide that 3 Self-Help Groups of 10-15 members will share this responsibility and related incomes. An additional 100-150 small farmers would also be benefited directly by supplying raw materials to the enterprise and receiving better and fair price for the same. Retailers, stockists and others in the market chain would also earn from the new products range. Production and use of the products, being made of natural and eco-certified ingredients, is ecofriendly.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

The organization 'hub and spoke' model of rural enterprise envisaged is well suited for modular scaling-up through addition of more satellite units. The extract would be prepared in the "Satellite unit" at the cluster-of-villages level. Finishing, packaging and marketing will be done at "Mother unit" which will receive intermediates from all satellite Units.

8. ECONOMIC VIABILITY

The current business model, when further enhanced with scaled-up operations, expected to result in greater benefits to the target population. Following is the business plan (Table 1) for the sustainability of the enterprise:

Table 1. Business plan for processing of saponin based material for 200 days per year per unit

Cost of Material	Rs. 5,76,000.00
Cost of Packaging	Rs. 8,06,400.00
Marketing Cost	Rs. 7,39,200.00
Amortisation Cost	Rs. 1,47,840.00
Depriciation	Rs. 1,47,840.00
Labour	Rs. 1,80,000.00
Utilities	Rs. 5,760.00
Total Cost	Rs. 26,03,040.00
Provision for Taxation	Rs. 80,000.00
Contingencies	Rs. 2,60,304.00
Total Expenses	Rs. 29,43,344.00
Total Sales	Rs. 33,76,608.00
Surplus Generation (estimated)	Rs. 4,33,264.00

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Though substantial plants of Soapnut and Bhimal are available in the forest, economic importance of their produce is not well understood. Proper utilization of these plants can create additional employment and income opportunities for forest dependent communities, tribals, farmers, rural women and youth. Saponin extraction can be promoted at cluster level where the members can own jointly the required infrastructure facilities for saponin extraction, value addition and marketing. Policy interventions with regard to promotion of Soapnut and Bhimal plantations and their sustainable harvesting practices, skill development for making personal and home care products and establishment of producer-market linkage may result in developing rural bio-industries, and value added utilization of renewable sources

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

Setting up a rural enterprise and ensuring good benefits to rural partners are the basic objectives of this innovation. This requires adoption of beneficiary network and appropriate participatory ownership and management practices with suitable organizational set up such as self-help groups, farmer producer organizations etc. For long-term sustainability, systematic capacity-building, motivation and gradual transfer of ownership and management to their own organization will be required. In addition, linkages will need to be forged between the enterprise and relevant development and financial Agencies such as KVIC and NABARD for financial and enterprise support.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

SESS/CTD having an impressive track-record of almost 35 years is a multi-disciplinary group of dedicated and experienced professionals with the mandate to nurture and promote the entire innovation chain covering field investigations and surveys, assessment of felt needs and market potential, technology development and demonstration, production and commercialization, training and capacity-building, dissemination and hand holding, thus enabling conversion of an innovative technology/process into a viable business. It has developed and demonstrated 50+ viable, replicable technologies and business models, and helped set up and sustain over 250 such rural enterprises pan India, with the support from National/State S&T Departments and Development Agencies as well as UN agencies.It has wide experience of working with FPOs, SHGs and Co-operatives, and has on-going collaboration with many CSIR Labs and other S&T Institutions, as well as linkages with financial institutions such as NABARD, KVIC etc. SESS/CTD has newly settled an Enterprise for all-Natural Personal and Home Care products under the 'Wild Roots'™ brand name developed earlier for 'lifestyle products.'

21 A SIMPLE AND COST EFFECTIVE UNIT FOR MAKING HERBAL OILS

1. GENERAL INFORMATION

- Title of Innovation

  A simple and cost effective unit for making herbal oils

- Brief Description : This Oil Processing Unit is a simple and easy to operate machine for extracting variety of oils from herbs like Nirgudi, Maka, Aloe, Shatavari, Bala, etc. The unit is easy to maintain and helps the user in income generation.
- Name and contact details of person or institution responsible for the innovation : Rural Communes, Mumbai & DST –RC Core support team. Email: ruralcommunes@gmail.com; Mobile: +919869001965
- Name and position of key or relevant persons or officials associated : Salma Alavi and Dr. Ramchandra Hanbar Deshmuk, Technical Advisor, Rural Communes, Mumbai .

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Traditional method of processing of oils from herbs is a labour and time consuming process. Very poor heat exchange and varied processing conditions lead to the increased cost and inconsistent yield and quality of the product. Handling of the raw material and its processing by several laborers causes its wastage. Heavy weight load, improper gas burners and continuous sitting in front of gas / heat for stirring of the processing materials make the operation risky. These limitations do not allow processing of the bulk quantity of the oil and hence traditional method of oil processing is not popular among the local people and Ayurveda practioners. These limitations are overcome in the developed processing unit.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Developed technology is suitable for processing of oil from various herbs such as Nirgudi, Maka, Aloe, Shatavari, Bala, etc. The leaves (approx. 40kg to make 20 liters Oil) are collected, cleaned, crushed in a crusher, weighed and minced with same proportion of water in a grinder to make their juice. The juice is filtered using cotton /muslin cloth. Sesame oil equal to the quantity of juice is heated in the developed kettle having a stirrer on a LPG flame at 60°C for 15 -20 minutes. After turning off the flame, the juice is added to the oil and heated at 80°C for 2-3 hrs depending upon the herb under constant stirring. The extracted

Fig.55: Processing of herbal oil

herbal oil is collected in bottles through the drain valve provided in the unit (Fig. 55).

Salient features of the Unit:

Stainless Steel body of the heating kettle is convenient to women to clean and handle and also the ingredients are not adversely affected due to heat.

Convex shaped bottom with drain valve reduces wastage during filtration of the product.

Increased heat exchange efficiency due to convex shaped bottom and hence reduced fuel consumption.

Electronically controlled stirrer fitted in the kettle eliminates labourers requirement for continuous stirring of the material and hence their exposure to heat during stirring.

Heat sensor with buzzer helps in reducing heat consumption thereby saving fuel.

Baffles and adjustable stirrer fans enable to vary oil rpm according to different product formulations.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Raw materials: Sesame oil, Water, Plant (Herbs) material, Muslin / Cotton cloth.

Machinery: The oil processing unit (Fig.56) made up of stainless steel which can be fabricated according to the following parts and specifications:

Parts and their Specifications:

- Open steel vessel with attached outlet port of ball valve and socket for drain out the oil; Capacity: 90 liter.
- Stand for holding vessel of 90 liter volume
- LPG Cylinder, valve to adjust flame, Burner and Gas Pipe for heating
- Stirrer consist of a shaft (Stainless Steel Rod), Sleeve with 6205 Bearings and Bush, blades with threaded rod and steel thick plates. Stirrer blades are fixed in a bush for rotating shaft and for vortexing the mixture of the oil and plant decoction

Fig.56: Herbal oil processing unit

- Motor containing stirrer shaft in a sleeve with bearings should be fixed.
- S.S. plates frame consisting of 4 mm hollow pipe, Nut and Bolts, and Washer for supporting motor.
- Box with temperature programming. At 60°C, buzzer will buzz two times and green LED will blink. At 80°C buzzer will sound four times and yellow LED will blink. From 110°C to 125°C buzzer will beep continuously and red LED will blink continuously until gas is turned off and heating is stopped.

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

During the last phase of oil preparation when oil and water is heated together, oil may splatter a little while boiling so the flame should be kept low at this stage and stayed away from the kettle till all water is evaporated and oil becomes stable. Complete evaporation of the water should be ensured as the residual water will make oil to smell bad resulted from microbial contamination. Some small particles may remain during straining of oil resulting into non acceptance of the product by the customer. To overcome this issue, the oil is first strained carefully into bottles of 1 lit or 2 lit and kept for few hours till all the particles settle down at the bottom then oil is filled into smaller bottles.

6. IMPACT OF THE INNOVATION

Developed herbal oil processing unit has several advantages over the conventional method. This unit is easy to handle by women without affecting their health. Bulk quantity of the oil can be efficiently processed resulted from improved design of the heating kettle. There is significant reduction in processing time, labour and wastage of the raw material resulting into the product of low cost, and improved yield and quality. There is increased demand of herbal oils, because of their immense medicinal properties, in Ayurveda, cosmetics, and wellness industries. SHGs, NGOs and Farmer Producer Organizations (FPOs) can readily adopt this technology in producing various herbal oils and their marketing into to cities and towns.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Developed unit is a small and low cost unit and is useful for small scale industries. This unit can be upgraded to any higher scale depending upon the availability of the plant material and product requirement.

8. ECONOMIC VIABILITY

The unit can be easily fabricated with one time investment of around Rs.1.25 lakhs. Various types of herbs can be processed within the same unit. Almost 40% cost of processing of the oil is reduced using this unit as compared to the traditional method.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The low-cost herbal oil making unit can be a promising addition in national missions on sustainable livelihood.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/ COMMUNITIES/ INDUSTRIES, ETC.)

There is high possibility and scope of extension because of abundance of availability of NTFPS and demand of various herbal oils for skin, hair, and beauty products in national and international markets. Rural Communes is ready to sell this unit as per requirement including training programme of processing of oils (three types of hair oils, two types of massage oils). Scientific training on processing and marketing of NTFPs along with the

utilization of by products for composting, mulching and making fuel cakes can also be imparted to the rural communities.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Rural Communes (RC) was founded in 1974 and registered in 1976, both under the Societies Registration Act - 1860 (No. Bom. 137/1976 G.B.B.S.D.) and the Bombay Public Trusts Act, 1950 (No. F - 3978 (Bom.). Since its inception, RC has been actively involved in Skill Training and Capacity Building of various target groups such as women, small & marginal farmers, landless, youths and field officials of various government departments. Further, RC is actively involved in implementing Comprehensive Sustainable Development Programme for the direct benefit of rural poor and the local communities in the field of Water, Watershed & Rainwater Harvesting; Sustainable Agriculture; Conservation, Protection & Sustainable Utilization of Medicinal Plants and Biodiversity; Micro Enterprise Development, Promotion of Appropriate Low Cost Rural Technologies. The stated Mission of RC is to work for the development of the marginalized and deprived sections of society - landless, marginal, small farmers, women and Tribals.

22 PROCESS FOR MAKING EDIBLE PRODUCTS FROM UNDERUTILIZED FRUITS OF ARID AND SEMI ARID ZONES

1. GENERAL INFORMATION

- Title of Innovation

  Process for making edible products from underutilized fruits of arid and semi arid zones.

- Brief Description : Wild fruits of *Leptadenia reticulata, Cordia gharaf, Grewia tenax* and *Momordica dioica* occurring in the arid areas of Rajasthan remain underutilized. Simple and low cost processing techniques developed by the Arid Forest Research Institute(AFRI), Jodhpur have made possible to transform these fruits into marketable products such as pickle, murabba, candy, and squash. Adoption of these processes will lead to preservation, improved utilization and increased marketability of these fruits enhancing thereby livelihood opportunities for rural / tribal communities living in and around the habitats of these fruit bearing trees.

- Name and contact details of person or institution responsible for the innovation : Dr. Mala Rathore, Scientist E, Silviculture & Forest Management Division, Arid Forest Research Institute, Jodhpur. Email: mala@icfre.org; Mobile: + 919828070369

  Smt. SangeetaTripathi, ACTO, Silviculture & Forest Management Division, Arid Forest Research Institute, Jodhpur; Email: sangeeta@icfre.org; Mobile: + 91 9352652639

- Name and position of key or relevant persons or officials associated : Dr. Hemant Sharma, ACTO, Silviculture & Forest Management Division, Arid Forest Research Institute, Jodhpur; Mob. 9413320161

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

2.1 *Leptadenia reticulata* pods

Leptadenia reticulata (Family: Asclepiadaceae) also known as 'dodi' or jivanti (Fig. 57a) is a branched twining shrub which is found in semi arid regions of Rajasthan. Flowering occurs in May and June (Fig.57 b), while fruiting begins in October and continues up to November–December. The plant has great demand in local as well as in the

(a) (b) (c)

Figure 57 : (a) *Leptadenia reticulata*; (b) Flowers; (c) Pods

international market owing to its medicinal and edible uses. The Pods are dark green, slender and horn shaped (Fig. 57c).

2.2 *Cordia gharaf* fruits

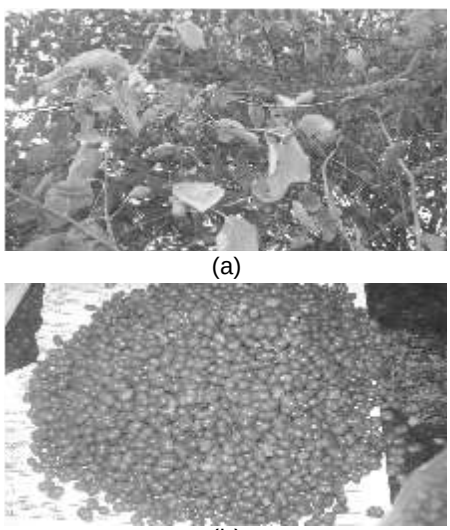
Cordia gharaf (Family: Boraginaceae), commonly known as ' Ghondi'is a tall, erect, compact, densely growing multi-stemmed branched shrub or tree up to 4 -8 m in height (Fig 58 a). Flowering and fruiting occur in March-June. The plant is commonly utilized locally as source of food and medicine. It is occasionally cultivated for its fruit. Fruits are yellow colored berries (Fig.58b;Fig.58c) and contribute significantly to the food and energy needs of rural populations. The sweet and sticky tasty pulp of the fruit is eaten fresh and often put in porridge as a sugar substitute. Nutritional properties of the fruits have been determined at the AFRI, Jodhpur. Fruits have been found to be a good source of vitamin C (94.44 mg/100g).

(a) (b) (c)

Fig. 58 (a) *Cordia gharaf*; (b) Fruits (c) Plucked fruits

2.3 *Grewia tenax* fruits

Grewia tenax (Family: Tiliaceae), commonly known as 'Gondni' is a small leaved white cross berry fruit producing deciduous shrub or small tree of widespread occurrence in semi-arid climates (Fig. 59a). In Rajasthan, it occurs in Jodhpur, Barmer and Jaisalmer. Ecologically, it can withstand environmental stress and thus is an ideal tree for sustainable production without needing expensive inputs of water or fertilizer. Flowering and fruiting occur from August to October. Yellow orange colored fruits (Fig. 59b) are used for edible purpose.



(a)

(b)

Fig: 59 (a) *Grewia tenax*; (b) Fruits

2.4 *Momordica dioica* fruits

Momordica dioica (Family: Cucurbitaceous) is a perennial, dioceous climbing creeper (Fig. 60 a) and is commonly known as Parora, Kankoda. Fruits (1.0 cm - 2.7 cm long and 0.5 cm thick) are shortly beaked and tapered at one end, obtuse with inner red kernel, densely covered with soft spines, and become green at maturity (Fig. 60 b). Fruits contain high amount of carotene among the cucurbitaceous vegetables, protein and fair amount of vitamins and minerals. Tribals of Abu road area in Sirohi district of Rajasthan on an average annually collect 30 ton of these fruits and the prevailing selling price of the fruits is Rs.40-80/kg.

Above wild edible fruits are of high nutritional value and become important economic commodity to the rural communities. However, they remain underutilized because of seasonal occurrence and perishable nature. Further, techniques for their preservation and value addition are not known. If such techniques are developed and extended to the local communities, utilization of these fruits will be increased for gainful income generation.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 Edible products from Leptadenia reticulata pods

3.1.1. Preparation of Pickle (Fig. 60 a)

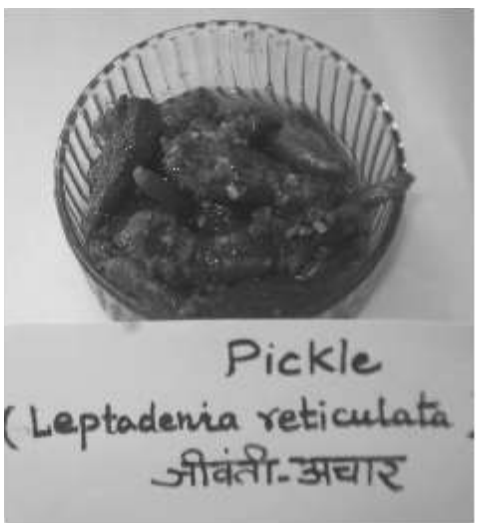


Fig. 60 a : Pickle

Ingredients

Fresh fruits – 500g

Turmeric powder –10 g

Salt –10 g

Red chilly powder –5g

Methi (fenugreek) seeds- 5g

Yellow mustard seeds- 5g

Mango powder- 20 g or according to taste

Sugar- 250 g or according to taste (for sweet pickle)

Ajwain, -10 g

Red chilly powder 5 g

Heeng (asafoetida) -pinch

Cooking oil- 500mL.

Procedure

Washed fresh pods are cut from centre longitudinally. Water (enough to submerge all the fruits) is taken in a utensil to boil. After the water comes to boil the pods are put into it and gas is turned off, fruits are covered and kept aside. Once they cool down the entire water is thrown and the fruits are taken out and kept overnight at room temperature in a muslin cloth to remove excessive water. Oil is heated in a pan and to it salt, mango powder and ground spices viz. turmeric powder, methi seeds, yellow mustard seeds, ajwain, red chilly powder

and heeng are added. Mixture is cooled and the pods are mixed with this mixture. Keep them in the sun for 8-10 days. For khatta-meetha pickle sugar is added to it. Pickle is ready.

Fig. 60 b Mangodi

3.1.2 Preparation of Mangodi (Fig. 60 b)

Ingredients

Moong Dal 250g

Pods 100-200g

Green Chilli -5-6pc medium size

Coriander -50 g

Salt to taste

Procedure

Moong dal is soaked overnight and ground in the morning. To it grated pods are mixed. Then salt, coriander, chilli are added and the mixture is applied on a plastic sheet in the form of mangodi. After drying these can be cooked with potatoes as vegetable.

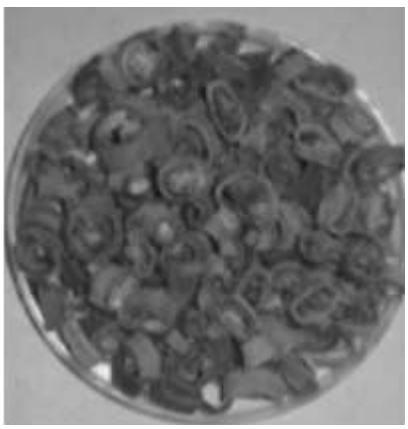


Fig. 60 c : Dried pods

3.1.3 Preparation of dried pods (Fig. 60 c)

The pods are washed, dried and then cut horizontally into small pieces. These are then put in boiled water for 5 minutes and then immediately put in cold water. After taking them out, salt is sprinkled over these and then dried in shade. Dried pods are stored in airtight container for future use.

3.2 Edible products from *Cordia gharaf* fruits

3.2.1 Preparation of Murabba (61 a)


Fig. 61 a: Murraba

Ingredients

Fresh fruits 250 gram.

Sugar 750 grams.

Green cardamom seeds crushed 1/2 teaspoon.

Potassium metabisulphite 1/2 pinch

Procedure

The fruits are washed, dried in shade in a jar and added sugar and potassiummetabisulphite. The jar is kept in sun for 10-15 days. The

fruits will release water and the sugar will change into syrup. Now cardamom seed powder is added. The murabba is ready.

3.2.2 Preparation of Pickle (Fig. 61 b)

Ingredients

Fresh fruits – ½ kg

Turmeric powder –5 g (tablespoonful)

Salt –10g

Red chilly powder –2 g

Methi (fenugreek) seeds- 2 g

Yellow mustard seeds- 5 g

Mango powder- 10 g or according to taste

Sugar- 250 g or according to taste (for sweet pickle)

Cooking oil-1/2 lit.

Fig. 61b: Pickle

Procedure

Fruits are washed. Water (enough to submerge all the fruits) in a utensil is taken and boiled. After the water comes to boil fresh fruits are put into it and gas is turned off . The fruits are cooled down and taken out and kept overnight at room temperature in a muslin cloth to remove excessive water. Now salt, turmeric powder, methi seeds, yellow mustard seeds, ajwain, red chilly powder and heeng are ground to a coarse powder and mixed with the fruits. For Khatta-Meetha pickle add sugar to it. Mustard oil in a pan is heated and then cooled and poured on the fruits, so that they remain submerged. Muslin cloth is tightened on the mouth of container and kept in sunlight for 4-5 days. The pickle is ready.

3.2.3 Preparation of Squash (Fig. 61 c)

Ingredients

Fruit Juice 100ml

Lemon juice 2g

Water 50 ml

Sugar 30g

Citric acid 4g

Fig. 61c: Squash

Procedure

Water is brought to simmer and sugar is dissolved into it. To the sweetened water are added citric acid and the lemon juice and simmer for another 10 minutes. After cooling the zest is sieved

out for a clear squash. Now the fruit juice (obtained by mildly grinding fresh fruits) is added to the sweet citric syup. The cooled squash is poured into a sterilized bottle and seal. The bottle is left for a couple of weeks to allow the ingredients to get matured.

Fig. 61d: Candy

3.2.4 Preparation of Candy (Fig. 61 d)

Ingredients

Fruit Juice: 100ml

Sugar 10g

Procedure

The fruits are taken and washed with warm water. They are then grounded on a low speed in a grinder or mixer so that their seeds are not crushed. Now the juice is separated from the seeds and fibres with the help of a muslin cloth. It is now heated in a pan and sugar in the proportion is added after 10 minutes. Juice is allowed to boil and the froth formed is removed. The juice is boiled until slightly thick. Now it is poured in a plate in which oil has been previously applied and allowed to dry in shade. Dried juice in the form of candy is ready for use.

3.3 Edible products from *Grewia tenax* fruits

3.3.1 Preparation of pickle (Fig. 62 a)

Fig. 62a: Pickle

Ingredients

Fresh fruits – 500 g

Turmeric powder –5g

Salt –10g

Red chilly powder –2 g

Methi (fenugreek) seeds- 2 g

Yellow mustard seeds- 5 g

Mango powder- 10g or according to taste

Sugar- 250 gm or according to taste (for sweet pickle)

Cooking oil- 500 ml.

Procedure

Fruits are washed. Water (enough to submerge all the fruits) in a utensil is taken and boiled. After the water comes to boil fresh fruits are put into it and gas is turned off . The fruits are cooled down and taken out and kept overnight at room temperature in a muslin cloth to remove excessive water. Now salt, turmeric powder, methi seeds, yellow mustard seeds, ajwain, red chilly powder and heeng are grounded to a coarse powder and mixed with the fruits. For khatta-meetha pickle sugar is added to it. Mustard oil in a pan is heated and then

cooled and poured on the fruits, so that they remain submerged. Muslin cloth is tightened on the mouth of container and kept in sunlight for 4-5 days. The pickle is ready.

3.3.2 Preparation of Fruit drink (Fig. 62 b)

Ingredients

Fresh fruits - 250 grams (1.5 cup)

Sugar – 250 g

Rock salt – 3 g

Ice cubes - 4-5 pc

Sodium/ Potassium metabisulphite -1 g

Fig. 62b: Fruit drink

Procedure

Fresh fruits are washed and put inside the mixing jar. Water (half cup) is added and mixer is turned on. In this way the pulp leaves the seeds at the bottom and gets mixed with the water. The seeds are left as it is. Now three cups of chilled water are added to this mixture, and the mixer is turned on once again for half a minute. The pulp will get mixed into the water. Now it is taken out of the mixer, filtered and 3 table spoon of sugar is added to it. The juice is poured into a glass and to make it more chill, some ice cubes are added. Squash is ready to serve and drink. For preserving long time a pinch of sodium / potassium meta bisulphite is added to the preparation. For storage, the squash is poured in dried glass bottles.

3.4 Pickle from *Momordica dioica* fruits

Preparation

Ingredients

Fresh fruits – 1kg

Turmeric powder –15g

Coriander Powder-10 g

Salt –10g

Red chilly powder –20 g

Methi (fenugreek) seeds- 20 g

Yellow mustard seeds- 5g

Mango powder- 10g or according to taste

Cooking oil- 1 lit.

Pickle Masala- 500 g

Fresh fruits are collected, washed thoroughly, cut into four pieces and weighed. Then, they are rinsed with boiling water. Excess water is removed through sieves. Sieves with fruits were are then kept in slanting position

for fifteen minutes to remove excess water if any. The fruits are then left for overnight in open air in a muslin cloth to remove residual moisture. In case of excess moisture, the fruits can be left for overnight drying for next 24 hours. Proper drying of fruits is essential to avoid any microbial growth in pickle. Next day pickle is prepared by the usual method described above, kept for one year with no deterioration in quality, taste, colour and consistency.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Stainless steel utensils for preparation of products

Mixer grinder, Knife, cooking gas, spatula/ spoon for preparation.

Glass containers of different capacilities for storage of the products.

5. SPECIFIC PROBLEMS / OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

The fruits should be harvested directly from plants/trees and cleaned, washed and dried before use. Rotten fruits and those fallen on the ground should be discarded. In preparation of pickle and dehydrated products care should be taken to keep the products well in sun so that no fungal/microbial growth occurs. Glass containers used for storing of the products should be washed with hot water and dried in sun. Ingredients viz. spices and oil should be of standard quality. The prepared product such as pickle, murabba should be kept in sun for 8-10 days and stored in dry place to avoid fungal infestation.

6. IMPACT OF THE INNOVATION

The processes developed for value addition of the lesser known wild edible fruits are simple, cost effective and of high potential not only to increase their utilization into various edible products but also to enhance the income of the communities including tribals who are engaged in their collection and sale. Increased utilization of these fruits will lead to promote their cultivation.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Methods developed are facile, economic and adoptable. Ingredients required for value addition are common and available at affordable prices in the market. Products developed belong to the category of the high demand eatables. Therefore, these methods are suitable for up scaling at any scale depending upon the availability of the raw materials and product requirements. However, certification from Food Safety and Standards Authority of India (FSSAI) will be required for these products before commercialization. Also these have to be tested on Hedonic scale for consumer acceptability.

8. ECONOMIC VIABILITY

The edible products can be prepared using simple methods and ingredients available easily in the market at cheap rates. Market for these product is also available within a periphery of 5-10 km. Therefore, developed methods are easily adoptable by tribals and rural people as their income improvement activity.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

The pods of *Leptadenia reticulata*, and fruits of *Cordia gharaf, Grewia tenax* and *Momordica dioica* should be promoted for value added utilization and economic gains for rural communities. Silviculture, management and utilization aspects of these fruit trees should become an essential part of JFM activities to maximize benefits from multiple uses with the inputs of traditional and developed technical knowledge. Forward and backward linkages of such wild fruit trees should be developed for upgrading their value chain.

9. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDS/ COMMUNITIES/ INDUSTRIES, ETC.)

Developed know how will promote an economically viable option for income generation for tribal community and local people. Various stakeholders including tree growers, and workers involved in gathering, selling, transporting and packaging of raw forest produce can be benefitted by extending the developed know how for their capacity building. Processes for making pickle from *Momordica dioica* fruits were introduced to the Bhurki Devi Self Help Group (BDSHG), Jamboori. Two training cum demonstration programmes were organized for the members of the BDSHG in the year of 2016 and 2017 (Fig. 63). These members adopted the practices and started production of pickle for selling it in the nearby market. Five training programmes were also organized in five villages namely Siyawa, Surpagla, Jamboori, Nichlagarh and Uplagarh of Abu Road Block of Sirohi district in Rajasthan in the year 2017 under Skill India Development Programme sponsored by Ministry of Environment, Forest & Climate Change, New Delhi (Fig. 64) wherein members of the self help groups were imparted training for making pickle from *Momordica dioica*, murraba from *Cordia gharaf* fruits, squash from *Greweia tenax* fruits pickle and mangodi from *Leptadenia reticulata*.

Fig. 63: Training to the members of the BDSHG for making pickle from *Momordica dioica* fruits

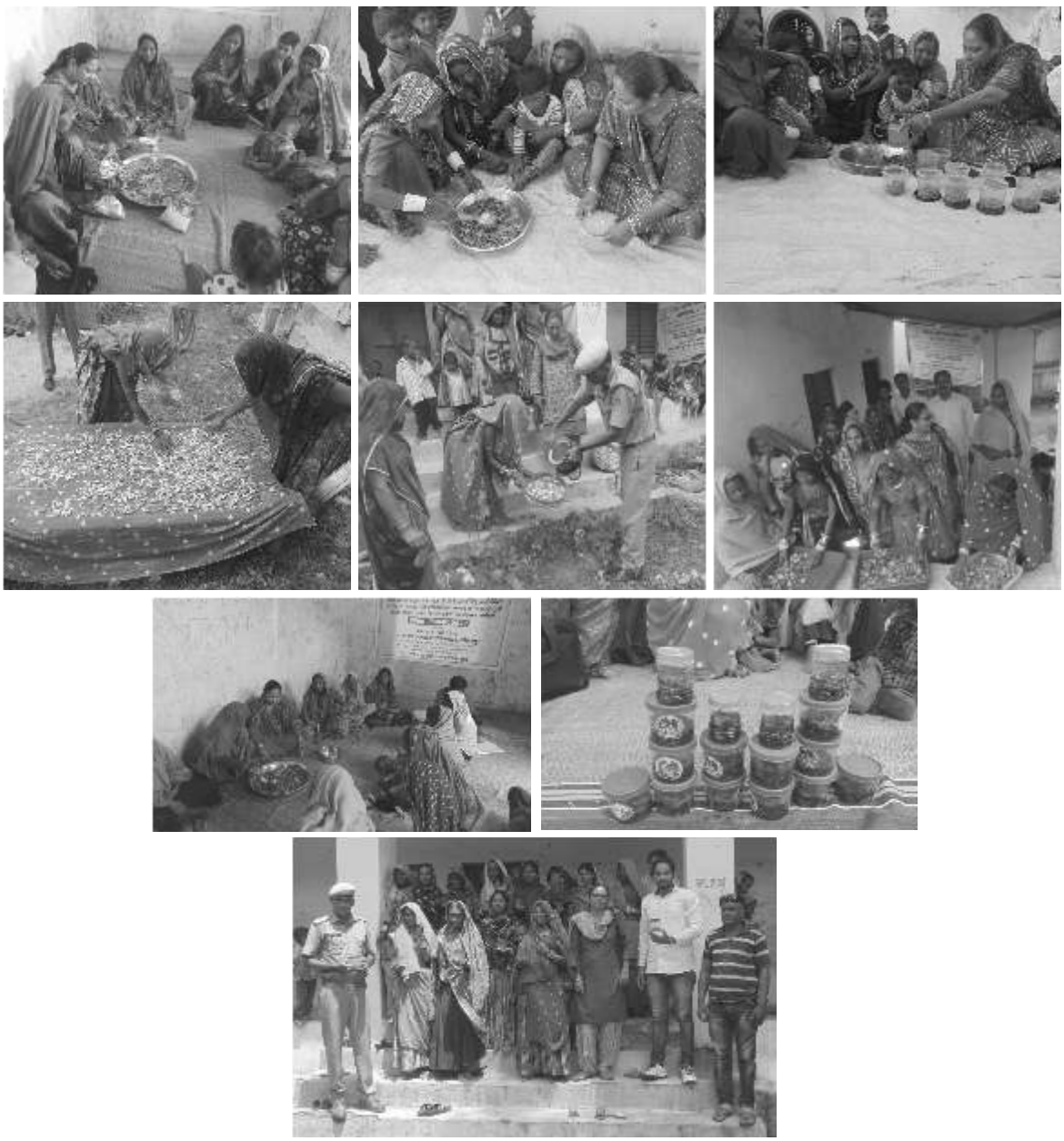


Fig. 64: Training to members of the SHGs of Abu Road Block of Sirohi district for making edible products

10.DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Arid Forest Research Institute, Jodhpur is one of the 9 institutes of Indian Council of Forestry Research & Education (ICFRE). ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

23 PROCESS FOR MAKING EDIBLE PRODUCTS FROM UNDERUTILIZED FRUITS OF KUSUM

1. GENERAL INFORMATION

- Title of Innovation

  Process for making edible products from underutilized fruits of Kusum.

- Brief Description : *Schleichera oleosa* (Lour.) Oken., commonly known as Kusum or Lac tree, is a forest tree species of tropical and subtropical regions. It is a medium-sized to large deciduous or nearly evergreen tree attaining upto 40 m height and 2 - 4 m in girth usually with a dense and spreading shady crown. The tree is commonly known to host Lac insects (*Kerria lacca* Kerr) for production of natural, biodegradable and commercially important Lac resin which is a livelihood support to millions of poor farmers in states like Jharkhand, Madhya Pradesh, Chhattisgarh, Odisha, Andhra Pradesh and West Bengal. The fruits (Fig.65) of this tree are edible. Raw fruits are reported to be pickled and the ripe ones contain yellowish and pleasant pulp which is sour in taste and often eaten during summer. Fruit pulp has been shown to contain minerals such as sodium, potassium, calcium, magnesium, phosphorus, copper, iron, nickel, zinc and manganese. However, the fruits remain underutilized as the major use of the tree is for cultivation of Lac. Tropical Forest Research Institute (TFRI), Jabalpur developed processes has made it possible to make value added products such as Kusumvati, Kusum Jam, Kusum Chutney, KusumThandai, Kusum Squash, Kusum Sharbat and Kusum Murabba from pulp of these fruits (Fig. 66). Based on sensory and nutritional properties, these products have consumer acceptability and can help to maintain a healthy weight. These value added products are also economically cheaper than their equivalent products in the market.

- Name and contact details of person or institution responsible for the innovation : Dr. Hari Om Saxena, Scientist – D, Tropical Forest Research Institute, P.O. – R.F.R.C., Mandla Road, Jabalpur (M.P.); Email: hariomsaxena81@gmail.com, Mobile: +919479843256

Fig. 65. Various edible products from Kusum pulp

- Name and position of key or relevant persons or officials associated : Shri Ratan Kumar Gupta, Technical Officer, Forest Research Centre for Social Forestry & Eco-rehabilitation (FRCSFER), Praygraj (U.P.)

  Shri Ganesh Pawar, Technician, Tropical Forest Research Institute, P.O. – R.F.R.C., Mandla Road, Jabalpur (M.P.).

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Fruits from Kusum tree are eaten during summer by rural and tribal communities. Though the fruits have some economical value due to their seeds which yield a fatty oil called 'Kusum oil' for use in culinary, traditional medicines, and for lighting, but the practice of oil extraction is uncommon and. uneconomical Further, during depulping required for separation of the seeds for oil extraction, edible pulp goes waste. Fruit pulp is digestive, appetite stimulant, astringent, antihelmintic and coolant. In Ayurveda, the pulp is known to have Keshavardhaka, Vatanashaka, Snigdha and Kaphanashaka properties. Fruit juice has also been reported to stimulate hair growth. Despite of edibility and various medicinal properties of the fruit pulp, the fruits remain underutilized. This necessitated value addition of the fruits for their increased utilization and marketability.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 Processing of Kusum fruits

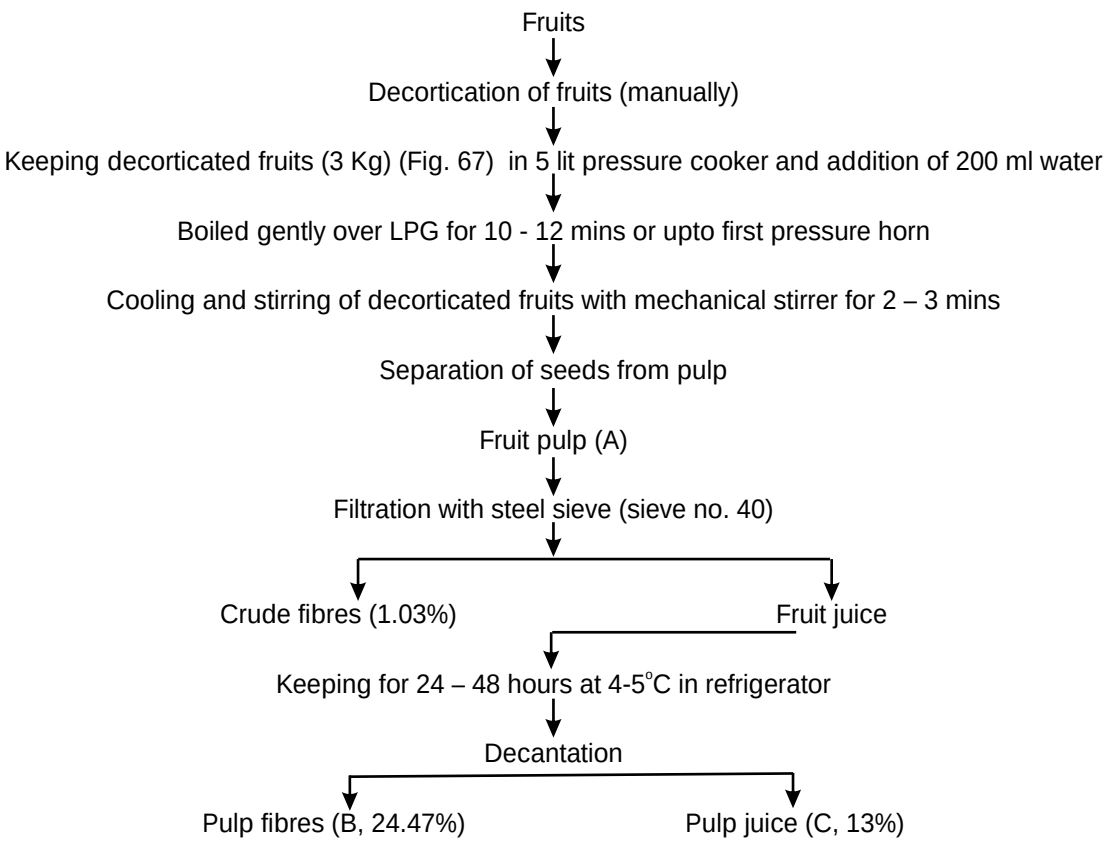


Fig. 66. Flow – chart for processing of Kusum fruits

Fig. 67. Decorticated Kusum fruits

(a)

(b)

(c)

Fig. 68. (a) Fruit Pulp; (b) Pulp fibre; (c) Pulp Juice

3.2 Preparation of edible products

3.2.1 Sharbat

Fruit juice (1 kg)
↓
Addition of sugar (1 kg)
↓
Boiling in non-stick pan (with continuous stirring until sugar dissolved completely)
↓
Addition of sodium benzoate (2 g) as preservative
↓
Filling hot into sterilized in an autoclaveglass bottles (air tight, 1 litre capacity)
↓
Cooling at room temperature for 15 – 20 mins
↓
Capping manually
↓
Storage at 4 - 5°C in refrigerator

Fig. 69. Flow – chart for preparation of sharbat

3.2.2 Thandai

Sugar (1.5 kg) + Water (750 ml)
↓
Boiling (10 – 15 mins with continuous stirring)
↓
Fruit pulp fibres (1 kg)
↓
Addition of spices (45 g)
↓
(Black pepper- 10 g, Dry ginger- 10 g, Chhoti Elaichi- 5 g, Cloves- 10 g, Fennel- 10 g)
↓
Boiled gently in a non-stick pan for 5- 6 mins
↓
Addition of sodium benzoate (2 g) as preservative
↓
Filling hot into sterilized bottles (air tight, 1 litre capacity)
↓
Cooling at room temperature for 15 – 20 mins
↓
Capping manually
↓
Storage at 4-5°C in refrigerator

Fig. 70 Flow – chart for preparation of thandai

3.2.3 Squash

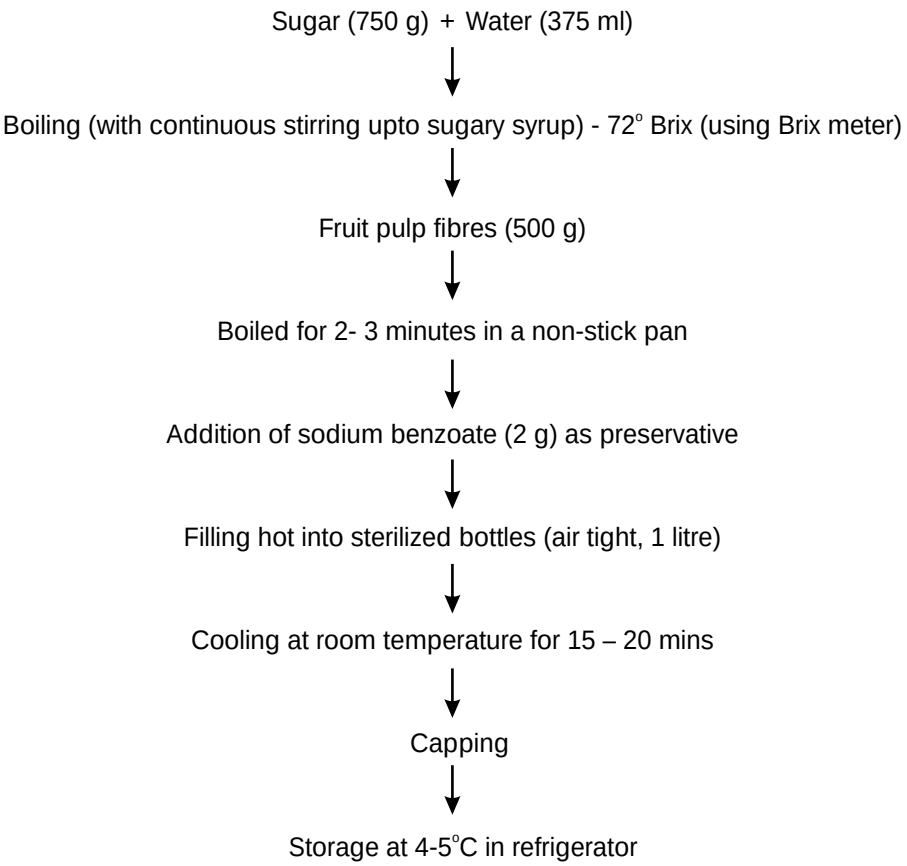


Fig. 71 Flow – chart for preparation of squash

3.2.4 Chutney

Sugar (1.25 kg) + Water (1 lit)

↓

Boiling in non-stick pan (10 – 15 mins with continuous stirring)

↓

Dipped spice's packet (mixture of Black salt-15 g, Black pepper- 5 g, Cumin-5 g, Bay leaf-5 g, Dry ginger-15 g, Chhoti Elaichi-5 g, Cloves-5 g in a muslin cloth)

↓

Boiled gently for 10 - 12 mins

↓

Addition of fruit pulp fibre (1 kg)

↓

Boiled upto chutney texture

↓

Addition of sodium benzoate (2 g) as preservative

↓

Filling hot into sterilized bottles (air tight, 1 litre capacity)

↓

Cooling at room temperature for 15 – 20 minus and capping manually

↓

Storage at 4-5°C in refrigerator

Fig. 72 Flow – chart for preparation of chutney

3.2.5 Vati (laddoo)

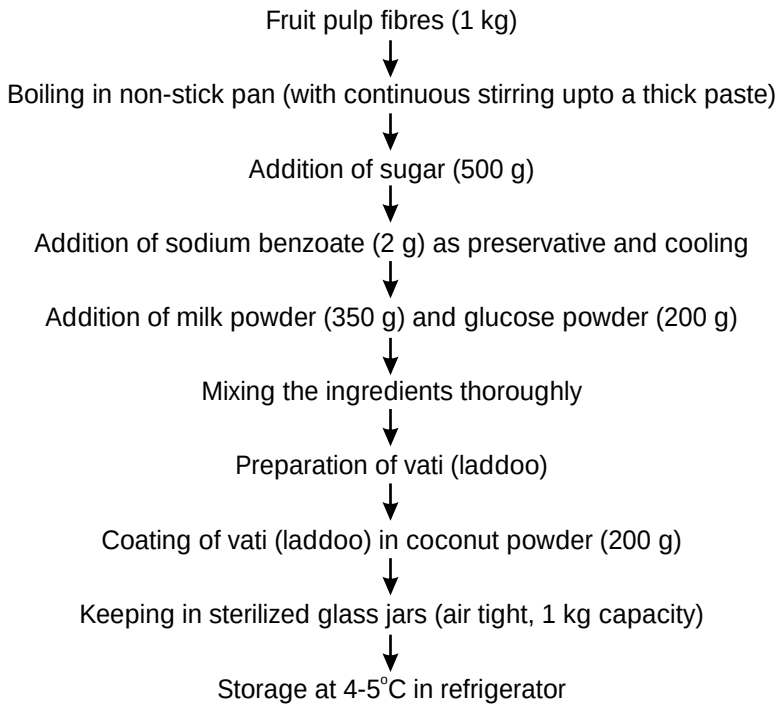


Fig. 73 Flow – chart for preparation of vati (laddoo)

3.2.6 Jam

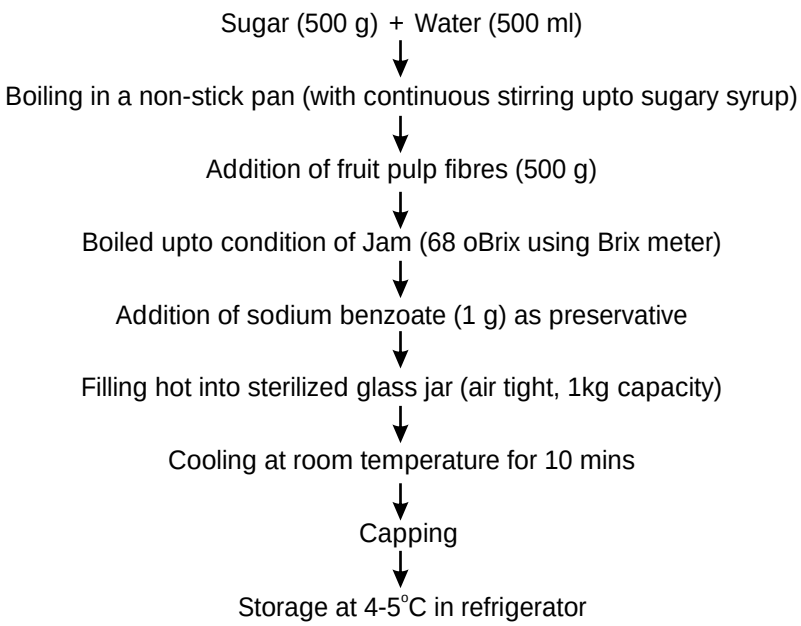


Fig. 74 Flow – chart for preparation of jam

3.2.7 Murabba

Sugar (685 g) + Water (500 ml)

↓

Boiling in non-stick pan (with continuous stirring upto sugary syrup)

↓

Addition of decorticated fruits with seeds (685 g)

↓

Boiled gently over gas flame in non-stick pan upto dehydration of fruits

↓

Leaving for overnight (for 12 hrs)

↓

Boiling gently over gas flame for 10 – 15 mins

↓

Addition of sodium benzoate (1 g) as preservative

↓

Filling hot into sterilized glass jar (air tight, 1 kg capacity)

↓

Cooling for 15 – 20 mins at room temperature

↓

Capping manually

↓

Storage at 4-5°C in refrigerator

Fig. 75 Flow – Chart for preparation of murabba

Evaluation of the prepared products by a group of qualified panelists for their sensory properties including colour, appearance, aroma, taste, texture, mouth feeling and overall acceptability showed their suitability for human consumption.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Raw materials: Kusum fruits (as main ingredient) and other ingredients mentioned in the flow charts (Fig. 66,69,70,71,72,73,74,75) for preparation of the value added products. Air tight bottles and Glass jars for storage of products etc.
- Equipments/ Utensils: Electronic weighing balance, Brix meter, Mixer grinder, Kitchen utensils, LPG

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Mature and ripened fruits contain more than 80% moisture, hence should be processed immediately to prevent deterioration. Besides, pulp and fibres should be stored in refrigerator at 4 – 5°C after adding preservative, if not used immediately. However, it is suggested to utilize the pulp and fibres as soon as possible. Moreover, the products should be stored in refrigerator for longer time.

6. IMPACT OF THE INNOVATION

Developed processes transformed underutilized raw Kusum fruits to marketable value added products. Since the wild edible fruits are of high economic importance to the tribal communities residing in forest areas, their access to the developed processes will enable them to use the value added products for their health benefits and livelihood generation at their doorsteps. Altogether, use of the processes will lead to the increased utilization and marketability of underutilized Kusum fruits. These processes also have potential to be replicated for value addition of other wild edible fruits.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

Processes for making marketable value added products from Kusum fruits being easy to adopt and cost effective in terms of readily available low cost machinery and raw materials can be upscaled at any level depending upon availability of the fruits and product requirement.

8. ECONOMIC VIABILITY

The developed processes could be effectively disseminated to the user target groups particularly to the rural and tribal communities residing nearby species rich forest areas which will help them in getting additional source of nutrient rich food as well as in generating income on a sustainable basis by selling the products in local market. The scope for value addition by the forest fringe dwellers is high because the pulp of Kusum fruit is totally underutilized and goes waste only due to unawareness about the economic use of this fruit. The prepared value added products are economically cheaper than the equivalent popular products available in the market. Economics of the each value addition process has been worked out and given in Table 1. The cost of fruit pulp including the collection and processing charges is Rs. 60.34/- per kg. Overhead charges included the cost of additives and labour charges etc.

Table 1. Economics of making edible products from Kusum fruits

S. No.	Name of Products	Fruit pulp		Overhead charges (approx. in Rs.)	Approx. Cost for Total weight generated	Cost of product per kg (approx. in Rs.)	Packaging charges per kg (approx. in Rs.)	Total cost per kg (approx. in Rs.)
		Quantity (kg)	Cost (approx. in Rs.)					
1.	Vati (*laddoo*)	1.0	60.34	235	295.34 for 1.6 kg	185/ -	60/-	245/ -
2.	Jam	0.5	30.17	21.75	51.92 for- 0.75 kg	69/-	60/-	129/-
3.	Murabba	0.68	41.33	27.49	86.56 for 0.80 kg	87/-	60/-	147/-
4.	Sharbat	1.0	60.34	38.50	98.84 for 1.7 kg	58/-	20/-	78/-
5.	Squash	0.5	30.14	29.50	59.67/- for 1 kg	60/-	20/-	80/-
6.	Chutney	1.0	60.34	66.50	126.84 for 1.95 kg	65/-	20/-	85/-
7.	Thandai	1.0	60.34	80.80	141.14/- for 2.2 kg	64/-	20/-	84/-

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Population of Kusum trees is available in patches and is decreasing. There is a need to incorporate the species in the afforestation programmes of State Forest Departments for its increased promotion and utilization for gainful employment to the rural / tribal communities.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDS/ COMMUNITIES/ INDUSTRIES, ETC.)

Methods for processing of Kusum fruits and making value added products thereof are suitable to be extended to the stakeholders including SFDs, rural communities, SHGs, NGOs, farmers, tree growers, and small scale food industries etc., for their popularization. TFRI, Jabalpur will provide hands on training to the interested users of the technology for their skill development.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Tropical Forest Research Institute, Jabalpur is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE). ICFRE is an autonomous Council of Ministry of Environment, Forest & Climate Change, Govt. of India.

24 PROCESS FOR MAKING EDIBLE PRODUCTS FROM MAHUA FLOWERS

1. GENERAL INFORMATION

- Title of Innovation

  Process for making edible products from Mahua flowers.

- Brief Description : *Madhuca indica* (Mahua) a large deciduous tree belonging to family Sapotaceae, is found in the forests of Madhya Pradesh Odisha, Maharashtra, Uttar Pradesh, Andhra Pradesh and Gujarat. It is one of the important forest trees because of its delicious and nutritive flowers. The flowers are fleshy, off white in colour and emit attractive sweet fragrance when plant is in full bloom and shed their corollas during April-May. Flowers also possess several medicinal properties and are used in cough heart diseases and burnings etc. Mahua flowers are eaten by tribals as a food in various forms. After collection, they are spread outdoors, drying in the courtyards or housetops. During this process the flowers shrink in size and turn reddish brown in colour, resembling raisins and get contaminated by dust particles. Forest Research Centre for Skill Development (FRCSD), Chhindwara developed improved processes for collection and drying of the flowers. Processes for production of three edible products viz. Mahua Jam, Mahua Squash and Mahua Chutneys using dried flowers were also developed as per Food Product Order (FPO) specifications. Consumer acceptability tests for all these products were conducted by trained panelist and approved for their consumption.

- Name and contact details of person or institution responsible for the innovation : Dr. Vishakha Kumbhare, Scientist –E, Forest Research Centre for Skill Development, Chhindwara. Email: kumbharev@icfre.org

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Fresh Mahua flowers fallen on the ground are collected in forest areas / on farm bunds. Such collection practices being unhygienic limit utilization of Mahua flowers in making edible products. Also the traditional methods of drying of the collected flowers are unhygienic. Further, Mahua flowers are being used by the tribals in preparation of country liquor as they are rich in sugar content but it has deleterious effect on health. Thus, the tribal men earnings are used in liquor consumption which affects their economy. Hence, the processes were developed for collection and drying of the flowers and production of their marketable edible products as an alternative mean for utilization of Mahua flowers and livelihood improvement of the tribal people.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Flow – chart for preparation of Mahua Jam

Mahua Flowers

↓

Washing with tap water

↓

Boil in pressure cooker with water until flowers become soft (for 20 minutes) and cool to normal temperature and filter.

↓

Prepare smooth paste with the help of mixer (pulp)

↓

Addition of sugar

↓

Cook in an open pan with continuous stirring

↓

Addition of Pectin and citric acid slowly with agitation

↓

Checking of end point of jam preparation (it should contain not less than 68.5% soluble solids, as determined by the Refractometer)

↓

Pour hot into sterilized bottles through filling machine

↓

Cooling at room temperature

↓

Sealing by using a capping machine

↓

Store at room temperature for 3 months

Formulation of Mahua Jam: (Formula for 100 gms of Jam.)

Ingredients	Sample A
Mahua pulp	33 gm
Mango pulp	12 gm
Sugar	56 gm
Citric acid	0.51gm
Pectin	2 gm

Flow – Chart for preparation of Mahua squash

Mahua flowers

↓

Washing with tap water

↓

Soaking in Water (1:10 / 1:5)

↓

Juice Extraction through filter

↓

Juice collection (25%)

↓

Preparation of Sugar Syrup by addition of water (450 Brix)

↓

Mixing with Juice

↓

Addition of Citric Acid (1.5%)

↓

Addition of Preservative (Potassium Metabisulphite, 350 ppm)

↓

Filtering

↓

Storage (Refrigerate till six months)

Flow – Chart for preparation of Mahua - Tamarind chutney

Mahua flower

↓

Washing with tap water

↓

Cooking in pressure cooker by adding water (1:2 ratio of Mahua : water)

↓

Pulping through grinder

↓

Addition of Mahua pulp + Tamarind pulp (45 gm each, 1:1)

↓

Addition of all ingredients (spices - 2gm) cloves, blackpepper, cumin seeds, cinnamon, salt 2gm (Except vinegar, sugar)

↓

Cooking gently to desired consistency

↓

Addition of sugar (20gm) and cooking to thick consistency

↓

Addition of 5 % vinegar and sodium benzoate 250 ppm

Cooking for a while

↓

Filling hot into bottles using filling machine

↓

Cooling to room temperature

↓

Storage at room temperature for six months

Flow – Chart for preparation of Mahua -Tomato chutney

Mahua flower

↓

Washing with tap water

↓

Cooking in pressure cooker by adding water (1:2 ratio of Mahua : water)

↓

Pulping through grinder

↓

Addition of Mahua pulp + Tomato pulp (50 gm each, 1:1)

↓

Addition of all ingredients (spices - 2gm) cloves, black pepper, cumin seeds, cinnamon, salt 2gm (except vinegar, sugar)

↓

Cooking gently to desired consistency

↓

Addition of sugar (25gm) and cooking to thick consistency

↓

Addition of 5 % vinegar and sodium benzoate, 250 ppm
Cooking for a while

↓

Filling hot into bottles using filling machine

↓

Cooling to room temperature

↓

Storage at room temperature for six months

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

Dried mahua flowers (as main ingredient) and other readily available ingredients for preparation of Jam, Squash and Chutneys are required. Equipments required are Weighing balance, Brix meter, Mixer grinder, Bottle sealing machine and containers of varied capacity for storage of products.

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

A polythene sheet or any cotton sheet should be spread under the tree crown for collection of fresh flowers. The collected flowers should be shade dried or in light sunlight intensity to retain the original color and flavor of the flowers in the edible products.

6. IMPACT OF THE INNOVATION

The processes for collection and drying of Mahua flowers and making marketable edible products thereof, being simple and of low cost, can be adopted by the tribal people for their livelihood improvement.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING:

Processes developed are suitable for upscaling

8. ECONOMIC VIABILITY

Production of Jam, Squash and Chutney from Mahua flowers require common ingredients readily available in the market at low cost. These products, being edible and made from natural products, are easily sellable in the local market. Therefore, developed processes are economically viable for adoption of the tribal and other rural communities.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Technological and policy interventions are needed to utilize Mahua products to their full extent for enhancing the livelihood option of the local people without harming the natural ecosystem. The present invention aligns to this approach..

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDS/ COMMUNITIES/ INDUSTRIES, ETC.)

Being simple, economically viable and adoptable, developed processes for value addition of Mahua flowers are suitable for extension to tribal / rural communities. Demonstration cum training programmes should be organized for popularization of these processes and capacity building of the beneficiaries.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS

Forest Research Centre for Skill Development, Chhindwara is a satellite centre of Tropical Forest Research Institute (TFRI), Jabalpur. TFRI is one of the constituent institutes of the Indian Council of Forestry Research & Education (ICFRE). ICFRE is an autonomous council of Ministry of Environment, Forests & Climate Change, Govt. of India.

25 A PROCESS FOR PRODUCTION OF MORINGA LEAVES POWDER AS HEALTH SUPPLEMENT

1. GENERAL INFORMATION

- Title of Innovation

  A process for production of Moringa leaves powder as health supplement.

- Brief Description : Increased awareness of natural products for health benefits has accelerated the demand of herbal products. Herbal products for which raw material in rural / tribal areas is commonly available can be produced and marketed by small scale food processing units. Drying of agro-produce is one of the age old practices. Advancement made in drying technologies has made it possible to produce dried health mixes from naturally occurring plant materials keeping their vital nutrients intact. Production of these dried mixes can be an attractive enterprise for rural communities. In the areas where Moringa (*Moringa oleifera*) is readily available or can be planted in farms or homestead gardens, drying of Moringa leaves could be one of the profitable cottage scale enterprise. Moringa leaves powder, being a natural source of nutrients and bioactive compounds, and highly bioavailable, is a safer and effective alternate of synthetic supplements. Adding Moringa in our daily routine is an effective and natural way to prevent fatigue. High iron content of Moringa powder also makes it ideal for vegan, vegetarians and those suffering from anemia. Vigyan Ashram, Pune has developed a simple and economically viable drying process, for production of Moringa leaves powder which is suitable for making various ready-to-use health mixes, along with its business model for cottage scale enterprise.

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  Mr. Pramod Pansare, Research Fellow, Vigyan Ashram, Pabal, Tal- Shirur, Pune.

- Name and position of key or relevant persons or officials associated : Dr. Yogesh Kulkarni, Executive Director, Vigyan Ashram, Pabal, Tal- Shirur, Pune.

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

Moringa oliefera, a woody perennial, is very well known for its medicinal properties. Morgina leaves, pod, stem, seeds and even roots are used in Ayurveda for various purposes. Fresh leaves and Moringa pods are consumed traditionally in Indian recipes. Moringa leaves can be dried and preserved for longer shelf life. For better nutrients, and color and flavor retention Moringa leaves need to be dried scientifically. A solar dryer and drying protocol for Moringa leaves along with its business model have been developed by Vigyan Ashram under DST (SEED, Division) CORE support program during 2009-2013.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

Protocol for drying of Moringa leaves

Collection of Moringa leaves

↓

Sorting and grading

↓

Washing

↓

Drying

↓

Pulverizing

↓

Packing

Procedure of drying of Moringa leaves

3.1 Selection of leaves: Mature green leaves are selected for drying. Variety should be of edible Moringa ideally PKM-1.

3.2 Plucking of Moringa leaves: Green mature leaves are plucked manually and collected in a clean container.

3.3 Sorting and grading: Yellow and delicate leaves are removed.

3.4 Washing: The leaves are washed with plain water (Two times rinsing and draining).

3.5 Drying: Washed leaves are shade dried at the temperature ranges between 40 ^{0}C to 45 ^{0}C for 2 days. Exhaust fan in shade drying room gives best result. Leaves should be turned on regular interval at 2 hrs. for fast and uniform drying.

3.6 Pulverizing: Dried leaves are pulverized in a pulverizer to get dry fine powder.

3.7 Packing: Leaves powder is filled in plastic pouch, sealed and stored for further use.

Fig.76: Moring leaves powder

Solar Drying Technology

Moringa leaves can also be dried using solar dryers. In India low cost dryers are available in various shapes and specifications. Selection of dryer will depend on the cost of investment, quantity expected and quality of dried products. Based on field studies, Vigyan Ashram has

developed 'Solar Dome Dryer' for drying of Moringa leaves. This dryer is hemisphere or dome shaped with higher drying efficiency and lower capital cost. Smallest capacity dryer can process10 Kg of fresh leaves in 8 hrs to produce 1 Kg dried powder (Fig.76).

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

For adoption of the developed process beneficiary needs to have following :

- Availability of fresh Moringa leaves in 50 Km vicinity.
- Market demand analysis.
- FSSAI license compliance for food processing.
- Required capital cost investment.

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS.

Though the developed process is simple, following are few limiting factors in its adoption –

i. Lack of knowledge and skills in tribal community.

ii. Capital investment requirement for purchasing Dryer, Pulverizer. Weighing balance, Pouch sealing machine.

iii. Availability of fresh moringa leaves during production schedule.

iv. Maintaining quality parameters as per market feedback and marketing of processed product.

6. IMPACT OF THE INNOVATION

Many rural beneficiaries have been trained in processing Moringa leaves. Dried Moringa powder has been used to prepare various product mix. 4 Rural enterprises have been incubated during last 3 years for producing Moringa powder.

Dried Moringa leaves have good market potential and can be sold as dried leaves or in powdered form. Dried Moringa leaves powder can also be used for fortification of various traditional Indian processed food products or served in form of green-tea dip bags.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

As cottage scale enterprise Moringa drying unit is economical and sustainable. Due to increasing awareness and demand for health products, developed process can be upscaled in rural areas.

8. ECONOMIC VIABILITY

Following are the cost investments for starting cottage scale Moringa leaves drying business. These costs are for basic drying and powder selling business and for ready-to-use products.

Fixed Cost:

Sr. No.	Particulars	Qty	Rate (in Rs.) per unit	Amount (in Rs.)
1	Solar Dome dryer (10 Kg fresh leaves capacity)	1	40000.00	40000.00
2	Pulverizer	1	25000.00	25000.00
3	Cutting table & knife set	1	5000.00	5000.00
4	Weighing Balance	1	4500.00	4500.00
5	SS Utensils	1	5000.00	5000.00
6	Pouch sealer	1	3000.00	3000.00
7	Miscellaneous expenditure	-	-	2000.00
			Total	84500.00

Operational Cost:

Sr. No.	Particulars	Qty	Rate (in Rs.)	Amount (in Rs.)
1	Moringa Leaves (Daily 10 Kg for 150 Days)	1500Kg	20 / Kg	30000.00
2	Electricity@ 2 units / Day	300 Units	7 / Unit	2100.00
3	Labor @ 3 Hrs/ Day work	60 Man days	350/ Manday	21000.00
4	Miscellaneous expenditure			1000.00
			Total	54100.00

Total Cost:

Fixed Cost (in Rs.)	84,500.00
Operational Cost (in Rs.)	54,100.00
Selling of Moringa powder (wholesale) 150 Kg @ 600 Rs/ Kg	90,000.00
Total Profit (in Rs.)	35,900.00

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY-MAKING

Low cost solar drying process for making Moringa leaves powder should be promoted through various national missions.

10.POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (SFDs/COMMUNITIES/ INDUSTRIES, ETC.)

The process being simple, easy to use and cost effective can be adopted by community based organizations like Women Self Help Groups, NGOs, farmers, tree growers, herbal industries, Ayurveda practioners, SFDs etc. Vigyan ashram is providing all necessary support like technology adoption training, skill training, product formulation and validation, hand-holding and incubation support, etc., to needy beneficiaries in rural and tribal areas under DST, SEED Division CORE support program. In addition to this, the process is also available on open source platform for large scale awareness and dissemination.

11. DESCRIPTION OF THE INSTITUTION RESPONSIBLE AND ITS ORGANISATIONAL ASPECTS.

Vigyan Ashram located in village Pabal, Pune is a Center of Indian Institute of Education (IIE) Pune. This institution is supported by Department of Science and Technology (Govt. of India) through its Core Support Programme.

26 A PROCESS FOR PRODUCTION OF AMLA CANDY

1. GENERAL INFORMATION

- Title of Innovation

  A process for making Amla Candy.

- Brief Description : Amla or Indian gooseberry (*Phyllanthus emblica*) (Fig: 77) is one of the prominent vitamin C fruits having lots of health benefits. It not only improves the digestive system but also strengthens our immunity. Amla boosts the absorption of calcium, thus creating healthier bones, teeth, and nails. It also helps to prevent premature hair-fall, maintains hair color and retards premature graying. Because of vitamin C, it is a great detoxifying agent for a sluggish liver, and helps to make the skin clear and radiant. The Amla candies developed are another form of Amla murabba. In candy making process Amla pieces are sun dried and sweetened with sugar and can be stored throughout the year. Only two ingredients Amla and sugar are required for the preparation of the candy. Along with Amla sugar candy, Amla sharbat and Amla syrup can also be prepared as tasty Amla drink for consumption during summer.

Fig. 77 Amla fruits

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  Shri Pramod Pansare, Research fellow, Vigyan Ashram, Pabal, Tal-Shirur, Pune.

- Name and position of key or relevant persons or officials associated : Dr. Yogesh Kulkarni, Executive Director, Vigyan Ashram, Pabal, Tal-Shirur, Pune.

2. THE PROBLEM OR SITUATION BEING ADDRESSED BY THE INNOVATION

There is increased awareness of using the natural supplements to maintain health with the hactic lifestyle. Amla, besides a rich source of vitamin C, is known for its various health benefits since ages. Being of seasonal occurrence, it is not easy to reap on the benefits of Amla fruits. Amla candy is one of the healthiest candies. It is loaded with all the benefits of Amla. Use of Amla candy is a simple and healthy way to incorporate Vitamin C in the diet and making available to be used throughout the year.

3. DESCRIPTION OF THE INNOVATION AND ITS SALIENT FEATURES

3.1 Processing of Amla fruits

3.1.1 Washing

After proper selection and weighing, the surface dirt of fruits is removed by washing with plain running water.

3.1.2 Slicing

The washed fruits are sliced along their ridges by using sharp stainless steel knife.

3.1.3 Blanching and Drying

Amla slices are blanched with 0.5% potassium meta bisulphate for five minutes, then subjected to hot air oven drying at 70°C for 4-8 hrs to remove moisture which accelerates spoilage and reduces shelf life of fruits.

Fig 78: Amla candy

3.2 Preparation of Amla candy

Dried Amla slices are heated with equal quantity of sugar, steeped into it for 24 hrs, dried in a Trey drier followed by packing in suitable containers.

4. REQUIRED RESOURCES IN TERMS OF RAW MATERIALS, EQUIPMENTS, MACHINERIES, ETC.

- Raw materials: Fresh Amla fruits, Potassium meta bisulphate, Sugar
- Equipments: Hot air oven, Trey drier, Weighing balance, Packing machine, Refractometer, Gas stove

Containers of suitable size and utensils

FSSAI license compliance for food processing.

5. SPECIFIC PROBLEMS/ OBSTACLES LIKELY TO BE FACED BY THE USER DURING USE AND THEIR SOLUTIONS

Though making Amla candy is a simple process, following are the few limiting factors in its adoption –

i. Lack of scientific knowledge and skills in tribal community.
ii. Capital investment requirement for purchasing of equipments
iii. Availability of fresh Amla fruits during production schedule.
iv. Maintaining quality parameters as per market feedback.

6. IMPACT OF THE INNOVATION

Adoption of the process will generate livelihood opportunities to the rural communities.

7. SUITABILITY AND POSSIBILITY FOR UPSCALING

As cottage scale enterprise, Amla candy making unit is economical and sustainable. Due to increasing awareness and demand for health products there is always scope for upscaling this enterprise in rural area.

8. ECONOMIC VIABILITY

Following are the cost of investments for starting cottage scale Amla candy business. This cost is for basic drying of the fruits and for making ready-to-use products.

Fixed Cost:

Sr. No.	Particulars	Qty	Rate (in Rs.) per unit	Amount (in Rs.)
1	Food grade plastic drums	2	1000.00	2000.00
2	Stainless steel pots	4	2000.00	8000.00
3	Electronics weighing Balance	1	3500.00	3500.00
4	Stainless steel tray	5	400.00	2000.00
5	Packing Machine	1	2000.00	2000.00
6	Refractometer	1	1500.00	1500.00
7	Big Spoon	2	200.00	400.00
8	Gas stove	1	5000.00	5000.00
9	Trey Dryer	1	60000.00	60000.00
10	Others	1	2100.00	2400.00
			Total	**86800.00**

Operational Cost:

Sr. No.	Particulars	Qty	Rate (in Rs.) per unit	Amount (in Rs.)
1	Amla	1000 Kg	20.00 per Kg	20000.00
2	Sugar	1000 Kg	40.00 per Kg	40000.00
3	Salt	40 Kg	15.00 per Kg	600.00
4	Gas	40 Kg	100.00 per Kg	4000.00
5	Packing Cost (500 g per pack)	100 packs	1.00 per pack	100.00
6	Electricity	200 units	10.00 per unit	2000.00
7	Labour	03 Mandays	350.00 per Man day	1050.00
	Total			**67750.00**

Fixed Cost (in Rs.)	86800.00
Operational Cost (in Rs.)	67750.00
Misc. Expenses / Transport (in Rs.)	2000.00
Total Operating Cost (in Rs.)	**69750.00**
Average Selling Price (in Rs.)	**85000.00**
Total Profit (in Rs.)	**15250.00**

Operational profit per batch – Rs. 15250.00

Followings are not included in the above cost:

1. Land cost.
2. Legal cost (licensing).
3. Marketing expenses which may vary as per local conditions.

Note: -

In the cottage scale Amla processing unit, other Amla products like Amla supari, Amla juice, Amla syrup, Chavanprash, etc., can be manufactured with the same fixed investment. To earn sustainable income, enterprise needs to operate processing unit at least for 8 months / year by addition of other fruits / vegetables from local market.

9. SIGNIFICANCE FOR (AND IMPACT ON) POLICY MAKING

Low cost Amla candy technology should be promoted in various national missions for economic upliftment of the rural people.

10. POSSIBILITY AND SCOPE OF EXTENSION TO THE STAKEHOLDERS (S F D S / COMMUNITIES/ INDUSTRIES, ETC.)

The process can be adopted by community based organizations like Women Self Help Groups, NGOs, farmers, herbal and Ayurveda industries, Ayurveda practioners, etc. Vigyan Ashram is providing all necessary support like technology adoption training, skill development, product formulation and validation, hand-holding and incubation support, etc. to needy beneficiaries in rural and tribal areas under DST, SEED Division CORE support program. In addition to this, the process is available on open source platform for large scale awareness and dissemination.

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PLATE - 1

Fruit bodies of *G. lucidum*

Poplar Billets

Emergence of Primordia

Growing fruiting body

Sarpgandha seeds

Nursery raised Sarpgandha

Harvested roots of Sarpgandha

Mature plant of Kutki

Macroproliferated propagules of Kutki

macroproliferated plants of Kutki

Mature Plant of Mushakbala

Macro-proliferated propagules of Mushakbala

Macro-proliferated propagules of Mushakbala directly planted in the field

PLATE - 2

Chirata seed

Chirata at Harvesting stage

Harvested chirata

Air layering of *Vitex peduncularis*

Cleft grafting in Kusum (*Schleichera oleosa*)

PLATE - 3

Natural and processed Bamboo shoots

Shoots emerging from ground

Partly processed shoots

Pickled shoots

Dried shoots

Bark Shaving

Driling

Spraying

Fixing of Spout

Fixing of polythene to Spout

Collection of resin

Collected resin

PLATE - 4

Steps of making handmade paper from *Lantana camara*

Fruits of *Cordia gharaf*

Plucked fruits

Pickle

Murabba

Squash

Dried fruit juice

PLATE - 5






Training of members of the SHGs of Sirohi district (Rajasthan) for making edible products

PLATE - 6

Leptadenia reticulata and its products

Grewia tenax and its products

PLATE - 7

Various products of Kusum

Decorticated fruits

Various edible products from fruits

Fruit pulp

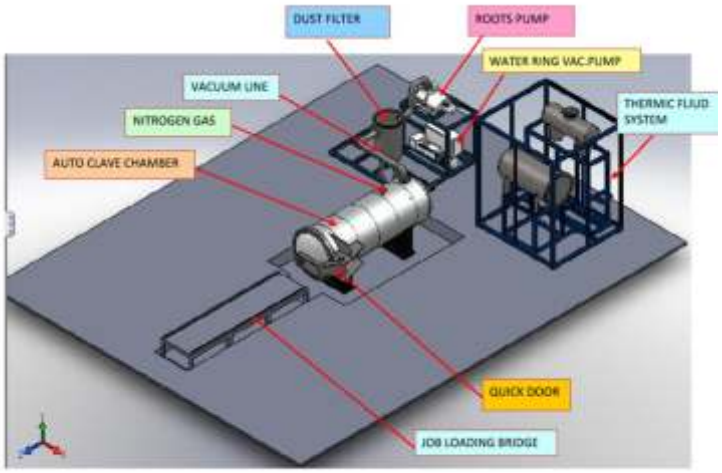
Fruit fibre

Pulp juice

In vitro propagation of *Embelia ribes*

PLATE - 8

Processing of herbal oil



Schematic diagram of pilot plant for thermal modification of wood

Herbal oil processing unit

Developed solar wood dryer

Microprocessor controlled vacuum chamber for heat treatment of wood

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