From President's Desk……

Bioprospecting: way forward for sustainable utilization of Natural Resins and Gums

Self-reliability and sustainability are important to cope up with the adverse situations like we have been experiencing during the present Covid-19 pandemic. Therefore, focus on '*Atmanirbhar Bharat*' requires us to emphasize on conservation and sustainable use of natural resources of the nation. India is home to over 7% of the world's biodiversity on a mere 2.5% of the world surface. Our country, one of the mega diversity countries is ranked ninth in terms of plant species richness. This biodiversity needs to be efficiently conserved and sustainably utilized for the benefit of present and future generations. Bioprospecting translates biodiversity into product of commerce with ultimate benefits to the society.

The Convention on Biological Diversity defines bioprospecting as the exploration of biodiversity for commercially valuable genetic and biochemical resources. In a wider perspective, bioprospecting is the systematic and organized search for genes, chemical compounds, etc. from plants, animals and microbes with potential for product development. Bioprospecting has three important facets such as 'chemical prospecting, gene prospecting and bionic prospecting'.

Chemical prospecting is search for novel chemical compounds from natural resources. It is becoming increasingly applicable in agriculture pharmaceuticals, cosmetics, proteins, enzymes, food additives and other industrially valuable chemical products. Gene prospecting includes identification, isolation, manipulation and utilization of genes for the benefit of mankind. Bionic prospecting deals with studying and evolving new designs, patterns, models and techniques based on natural biodiversity. New sensor technologies, architecture, bio-engineering and bio-modelling are some of the interesting fields in bionic prospecting.

Extraction and commercialization of active chemical components from Natural Resins and Gums (NRGs) and NRG yielding plants and mining chemo-diversity from biodiversity have unlimited applications. Modern technologies such as high-throughput chemical screening, automated bioassay programmes would facilitate activity-guided screening for identifying, isolating characterizing novel bioactive compounds from NRGs. Gene bioprospecting for the commercial products from NRGs and bionic prospecting of NRGs need more emphasis in the coming days. Indigenous Traditional Knowledge on NRGs are one of the important sources of information to be relied upon. For instance, lac is being used by some of the tribal communities in NE India as a pain reliever since long time. However, its scientific basis and further product development can be explored tactically by the scientific community. Genomic and transcriptome databases, the most reliable source of information for bioprospecting. are booming in the recent years. These databases reveal information on functional genes and metabolic diversity which would aid in enzyme bioprospecting for improving the overall pathway of products of commerce in NRGs and NRG yielding plants. Besides these, manipulation of enzymes through random mutagenesis for improvement in desirable traits such as catalytic activity, thermo-stability and pH tolerance (directed evolution) is also widely practiced. It has a great potential in the genetic improvement of NRGs especially in microbial gums because microbes are more amenable for such techniques.

However, bioprospecting should not lead to biopiracy especially in terms of biodepletion and extinction of NRGs which are high value bio-resources of the country. Hence, bioprospecting should go hand in hand with biodiversity conservation.

National Scenario of Plant exudates based Natural Gums: An outlook

Procurement data available with Odisha Forest Development Corporation Ltd, Rajasthan Tribal Areas Development Coop Federation Ltd, Maharashtra State Cooperative Tribal Development Corporation Ltd, Jharkhand State Minor Forest Produce Cooperative Development Marketing Federation Ltd, Girijan Co-operative Corporation Limited, Vishakhapatnam, Andhra Pradesh, Chhattisgarh M.F.P. (T&D) Fed. Ltd., Raipur, Chhattisgarh, Gujarat State Forest Development Corporation Limited (GSFDCL), Vadodara were recorded and compiled. Gum tapping is mainly done in the schedule areas where tribal populations exist. Collection charges to the collectors at collection centres are paid by the purchaser at the rate fixed by the Govt. After making the payment of the collection charges and the difference amount of sale rate and collection rate in the District Union, the purchasers are allowed to transport the collected gums wherever they desire. India produces mainly gums such as gum *karaya* (*Sterculia urens*), *dhawada* gum (*Anogeissus latifolia*), *prosopis* gum (*Prosopis juliflora*), *khair* gum (*Acacia catechu*), *babool/babul* gum (*Acacia nilotica*), *Jhingan* (*Lannea coromandelica*), *palas* (*Butea monosperma*), *char* (*Buchanania lanzan*) and *guggul* gum (*Commiphora wightii*).

More than 85 % of natural gum production in the country is contributed by M.P (31.67 %), Maharashtra (22.14 %), Jharkhand (20.41 %), Gujarat (7.37 %), Chhattisgarh (3.37 %), A.P (2.14%) and Telengana (0.58 %). Rest of the natural gums comes from Rajasthan and other minor gum producing states (12.32%). In parts of Jaipur, Ajmer and Jodhpur districts *A. senegal* is common. *A. catechu* forests are common in the South-eastern regions *e.g.* Baran, Jhalawar, Kota, Tonk, Chittorgarh and Alwar. Year wise gum production during 2009-10 to 2018-19 is illustrated in Figure 1.

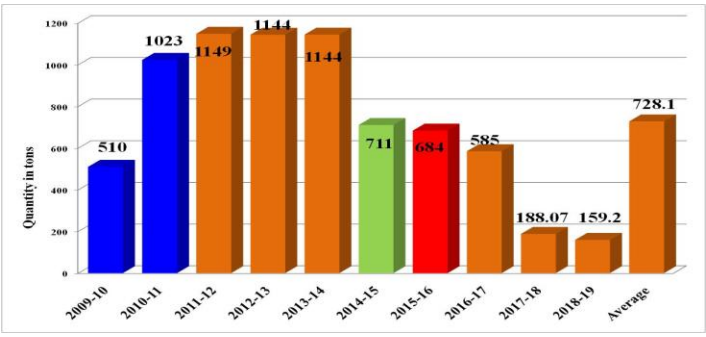

Fig. 1: Trends in production of natural gums in India

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Commodity outlook on gum *karaya* in India and abroad

Gum *karaya* is the dry exudate of *Sterculia urens* and *Sterculia villosa*. It is also known by the name Indian tragacanth, as it resembles gum tragacanth produced by *Astragalus spp.* Gum *karaya* is one of the least soluble gums used for many industries including pharmaceutical, food, paper, textiles, cosmetic industry, *etc*. Overall production has decreased from 387 tons in 2009–10 to 21 tons in 2018-19. During this period price increased from ₹7.4/kg to ₹110/kg. Average gum *karaya* production during 2009-10 to 2018-19 across various states is presented in Figure 2.

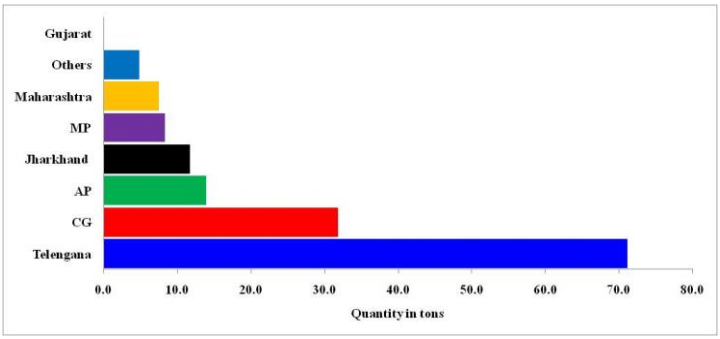


Fig. 2: State-wise average production of *karaya* gum

Gum producing forest divisions in Chhattisgarh are Bilaspur (Mugeli, Dindori, Ratanpur, Takhatpur, Lormi), Raipur, E. Surguja (Balarampur), Marvahi (Kota), S. Surguja, Raigarh (Khamariya,), Dharmajaygarh, Rajnandgaon, Mahasamund, Dhamtari, Korea, Sukma, Bijapur, Dantewada and W. Bhanupratapur. In Jharkhand, *karaya* gum is produced in Latehar (Garu, Mahuadar, Herhanj, Balumath, Barwadih, Lesliganj, Chhipadohar and Richughutu), Chatra (Lawalang, Pratappur and Kanti), Garhwa (Ramkanda and Bhandaria), Daltonganj (Panki and Chhatarpur) and West Singhbhum (Chakradharpur). A trend in annual production of gum *karaya* in India is illustrated in Figure 3.

Collection and grading of gum *karaya*

During 2017-18, a Minimum Support Price (MSP) of ₹11600/qt for gum *karaya* was declared by Pricing Cell, TRIFED, Ministry of tribal affairs, Govt. of India. However, prevailing market price of gum *karaya* is ranged from ₹350/kg to ₹450/kg. The scheme is initially being implemented in the states having scheduled areas and scheduled tribes in the fifth schedule of the Constitution of India (except Himachal Pradesh). Now, it is extended over the country.

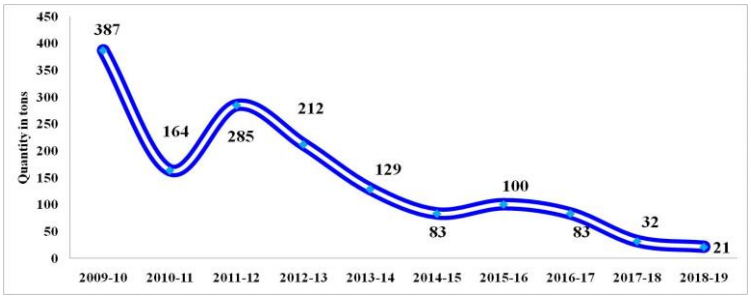
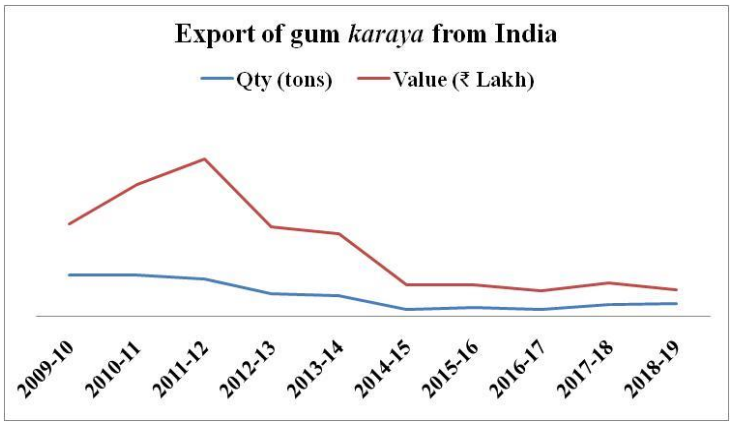


Fig. 3: Trends in production *of* gum *karaya* in India

International trade of gum *karaya*

Export and import of gum *karaya* from India during previous years have been depicted in Figure 4.



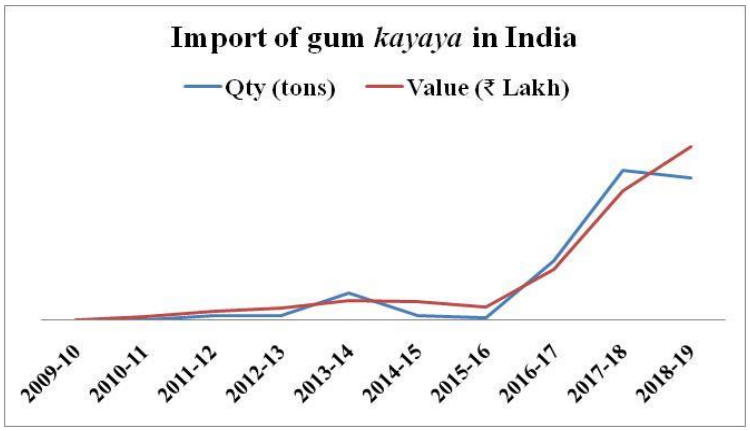


Fig. 4: Trends in export and import of gum *karaya*

India has now become a net importer of gum *karaya* with an import of worth ₹ 21.8 crores (31.9 lakh US Dollars) and export of ₹ 6.6 Crores (9.6 lakh US Dollars) during 2018-19. France (32.85%), Japan (21.01%), China (15.88%), Vietnam (6.25%), Pakistan (5.28%), UK (2.95%), USA (2.84%), UAE (2.33%), Germany (2.26%), Nepal (1.54%), Syria (1.33%), Russia (1.28%), Thailand (0.99%) and Indonesia (0.55%) remained as major export destinations during 2018-19.

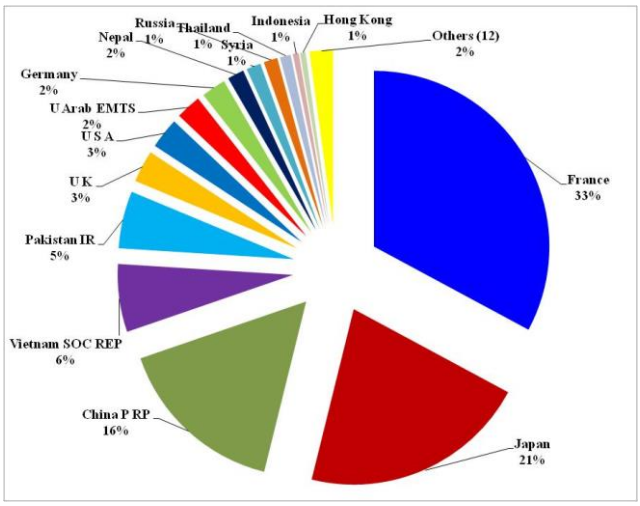


Fig. 5: Destination wise export scenario of gum *karaya* during 2018-19

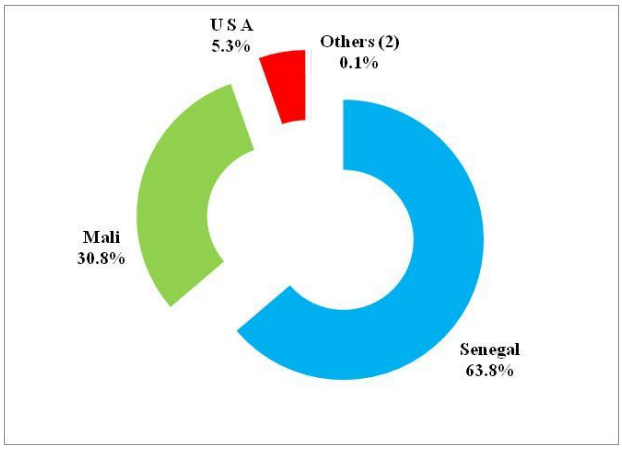


Fig. 6: Source wise scenario of gum *karaya* during 2018-19

Due to decline in production and comparatively cheaper rates in international market, a total of 2664.39 tons of gum *karaya* was supplied from Senegal (63.75%), Mali (30.85%), USA (5.36%), France (0.03%) and Germany (0.001%) to India. Destination Source wise overseas trade is presented in Figure 5 & Figure 6. Scientific gum tapping techniques need to be promoted among the forest dwellers for gum collection through extension functionaries. This will ensure the livelihood security as well as sustainable domestic production of natural gums.

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Field evaluation of antifungal efficacy of *Acacia nilotica* gum-induced silver nanoparticles against powdery mildew of pea

The field evaluation of the synthesized *Acacia nilotica* gum-induced silver formulations (AgNPs) against powdery mildew of pea (Arkel), caused by *Erysiphe pisi* (a plant pathogen), along with controls (distilled water, gum solution and silver nitrate ($AgNO_3$) solution) and commercial sulfur fungicides Sulfex® (80WP @ 2g/lit) and Haru® (sulphur 65% and tebuconazole 10%) was conducted following standard procedures. The concentration of the commercial sulfur fungicides used was 0.25%. All the set of experiments were laid down in more than five replicates. Disease scoring was recorded periodically after 24 hrs interval. After seven days of treatment, it was found that the *A. nilotica* gum-induced AgNPs protected the plants to the level of 48.51% in comparison to commercial fungicides Sulfex® and Haru®, which protected to the level of 11.19% and 31.85, respectively (Table 1 & Fig. 7).

Therefore, *A. nilotica* gum-induced AgNPs formulation could be used as potent anti-fungal agents in crop protection.

Table 1: Field evaluation of *Acacia nilotica* gum-induced AgNPs and commercial fungicides against powdery mildew of pea

Treatment	Disease Index Mean±S.E.	% Plant protection
Acacia nilotica gum solution (2%)	75.000±6.191	4.46
$AgNO_3$ solution (0.5 mM)	63.130±11.118	19.58
Acacia nilotica- AgNPs	40.418±9.256	**48.51**
Commercial Sulfex®	80.67±7.88	11.19
Commercial Haru®	53.500±9.430	31.85
Control (water)	78.500±6.035	0.00
C.D.	18.202	
SE (m)	6.425	
C.V.	31.292	

Before Treatment

After Treatment

A **B** **C** **D**

Fig. 7: Result of field experiment. A. *Acacia nilotica* control B. $AgNO_3$ C. Commercial fungicide D. *A. nilotica* - AgNPs

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Partially hydrolyzed guar gum-A potential source of dietary fibre

American Association of Cereal Chemists (AACC) defined dietary fibre as the edible parts of plant or carbohydrates that are resistant to digestion in the intestine. The dietary fibres are classified on the basis of water solubility and fermentability (Fig. 8). There are two types of dietary fibres: Water insoluble/ less fermented fibres (Cellulose, Hemicellulose and Lignin) Water soluble/well fermented fibres (Pectin, Natural Gums, Mucilages). Dietary fibre intake provides many health benefits. Individuals with high intakes of dietary fibre appear to be at significantly lower risk for developing heart disease, stroke, hypertension, diabetes, obesity and certain gastrointestinal diseases. Increased intake of soluble fibre decreases glycemia and improves insulin sensitivity in non-diabetic and diabetic individuals. Fibre supplementation in obese individuals significantly enhances weight loss.

Guar gum is a polysaccharide made of galactomanan which composed of long chain galactose and mannose. Guar gum as such is used as an emulsifier, thickener and stabilizer in a wide range of foods and comprises of soluble dietary fibres (SDF). However, guar gum is extremely viscous in aqueous solution when it is added at a physiologically effective concentration; thereby its utilization may be restricted for dietary fibre supplementation in actual food products, especially for liquid products. It also interferes with absorption of nutrient and decreases the protein and lipid utilization. This results in slow movement of food in intestine and creates gastric problems.

These problems can be easily overcome by using Partially Hydrolyzed Guar Gum (PHGG). PHGG produced from guar gum by enzymatic process has the same chemical structure with intact guar gum but less than one-tenth of the original molecular length of guar gum (Fig. 9). The viscosity of the product is substantially reduced and greatly stable against low pH, heat, acid and digestive enzymes. It is now being used commercially in various beverages, food products and medicinal foods as a functional dietary fibre. SDF are also finding wide application in beverage industry as they act as a sugar replacement and have prebiotic properties. The growing awareness towards health and fitness among consumers is further expected to fuel the demand of SDF in the coming years.

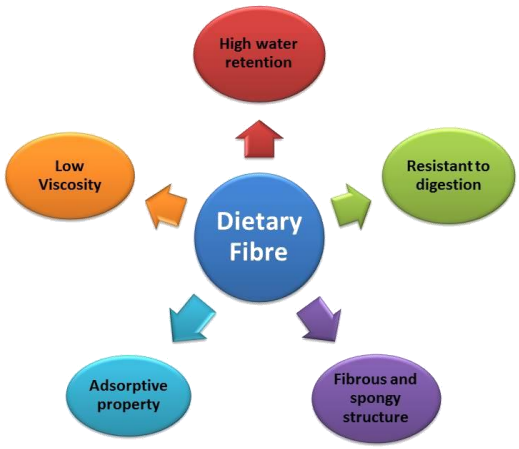

Fig. 8: Properties of dietary fibre

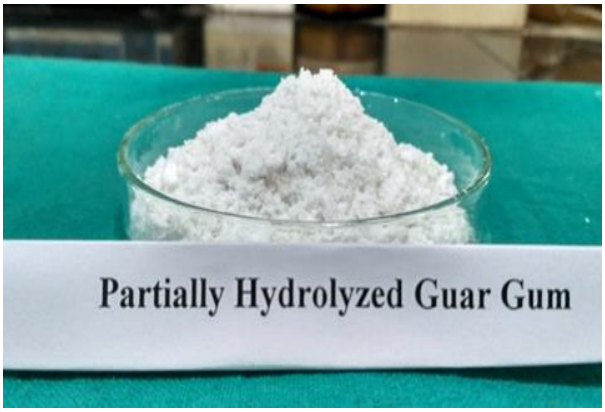

Fig. 9: PHGG developed at ICAR-IINRG

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Peach gum: Its uses and benefits

Peach gum is one among the dozens of organic products that we classify as natural gums. Peach-gum exudates are mainly produced on the trunks and fruit of peach trees in response to mechanical injury and pathogenic fungi invasion (Fig.10). The peach (*Prunus persica*) belonging to family Rosaceae is a deciduous tree that grows up to 7 m tall, but trees are usually 3-4 m tall when pruned properly (Fig. 11). It bears edible juicy fruits which are rich in protein, minerals and vitamins. It is native to the region of Northwest China, where it was first domesticated and cultivated. Peach is grown commercially and as home fruit in most of the temperate countries of the world. In India, peach is grown on a commercial scale in the mid-hills of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, and on a limited scale in North-Eastern states. Other low chill varieties of peaches are commercially grown in Punjab, Haryana, and Eastern U.P.

Fig. 10: Peach gum exudates on the trunk of peach tree (*Source: guide.michelin.com*)

Peach gum is mainly used in Chinese sweet soups, desserts and vegetable fries. Chinese people are using it as medicine in curing urinal infections, thirst-quenching and relieving stress. It is also used to nourish skin or as an emollient to rejuvenate the skin as it is rich in collagen. Studies showed that peach-gum coating reduced ethylene production and fruit softening in postharvest peach fruit. It has antibacterial properties and an efficient, low-cost adsorbent for environmental cleanup. In India, peach gum is documented, but its scientific studies are unexplored; therefore, there is a wide scope in exploring the potential application of peach gum in numerous fields.

Fig. 11: Peach tree

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***Eublemma amabilis* Moore: A major threat to lac culture in Assam**

Assam is one of the largest eight states in North East India which falls in Eastern Himalayan biodiversity hotspot. Lac culture is traditionally practised in some pockets of East Karbi Anglong West Karbi Anglong, Dima Hasao, Tinsukia districts of Assam. The lac species predominant in Assam is *Kerria chinensis* (Mahd.), which is vulnerable to variety of biotic and abiotic factors leading to lower yield. Among the biotic factors, two Lepidopteron predators, *Eublemma amabilis* Moore and *Pseudohypatopa pulverea Mayr* are the key pests of lac insect causing 30-40% damage. The emergence of adult *E. amabilis* from lac culture is shown in Fig. 12.

An experiment on the incidence of *E. amabilis* was carried out in Regional Lac Insect Field Gene Bank, Assam Agricultural University, Jorhat during summer and winter crop of *K. chinensis* (Mahd.). Population of natural enemies were recorded from a few randomly selected host plants of *Flemingia semialata* Roxb. The observations were based on the hollow lac cell caused by *E. amabilis* larvae.

Fig. 12: *Eublemma amabilis* adult on *F. semialata*

After 21 days of inoculation, the *phunki* lac were removed and brought into the Lac laboratory, Department of Entomology, Assam Agricultural University, Jorhat and the samples (approx. 250 grams) were placed in natural enemy emergence cage fitted with glass tubes to study the emergence of adult *E. amabilis* Moore (Fig. 13).

Fig. 13: Adult emergence of *E. amabilis* from North East India in emerging cages under lab condition

The maximum emergence of *E. amabilis* adults were recorded during first week of June and third week of December in both summer and winter crop, respectively. The insect completes

its first generations within one month of inoculation and continues up to maturity with more than 4 generations. In Assam, *E. amabilis* is also considered as a major pest of lac insect. Therefore the farmers who are involved in lac farming should take proper care from the beginning and practice management strategies in order to avoid the threat caused by this pest.

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Longan gum immunomodulatory activity: potential for therapeutic use

Natural gums are the heterogenous mix of biomolecules of biological origin-plant, animal or microbes which have certain characteristics such as their ability to form gel-matrix, increase solution viscosity and stabilize emulsions. Largely polysaccharides are reported to have these activities either themselves or in complex with other biomolecules such as proteins. These natural gums have gained attention for their industrial as well as medicinal applications with added advantage of them being non- or low-toxic. Several well-known sources of gum have been identified in the past which have found applications in several industries and commercial sectors, while new sources of plant-based gums are being explored simultaneously. Recently it was reported that pulp and pericarp of Longan fruit (Fig. 14) have polysaccharide gums as their active biomolecules that potentially have therapeutic properties.

Dimocarpus longan commonly called Longan is a tropical fruit of Chinese origin where it has been used for long not just as food but for its pharmacological properties. They have been known by the traditional Chinese medicine for their antitumorogenic, antioxidant activity as well as hypoglycaemic activity. While investigating the biomolecules imparting these characters it was found that polysaccharides and polysaccharides-protein complexes were the key components comprising the gum. For their detailed study, oven-dried Longan fruit pulp and pericarp was extracted using hot water and ethanol precipitation to isolate the bioactive long polysaccharide. It is found to comprise monosaccharides such as galactose, arabinose, fructose, ribose, glucose, rhamnose, and xylose. Branched glucans with 1,6 linked at O-3, O-2,4 and O-3,4 branches forms the structure of these gums. The polysaccharides has weak gelling property and additional of sodium and calcium ionic forms showed to enhance its viscosity which is an essential rheological property for their use. The polysaccharides and polysaccharide-protein complexes have recently been reported to have immunomodulatory activities which potentially add a new tool to the medical kit for future applications.

Fig. 14: Longan fruit

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Proceedings of National Web Symposium on 'Recent Advances in Beneficial Insects and Natural Resins & Gums'

ICAR-Indian Institute of Natural Resins and Gums (IINRG) and Society for Advancement of Natural Resins and Gums (SANRAG) jointly organized the National Web Symposium on 'Recent Advances in Beneficial Insects and Natural Resins & Gums' virtually in partnership with Entomological Society of India, All India Coordinated Research Project on Honeybees and Pollinators and Dr. B. Vasantharaj David Foundation on 25-26 February 2021.

The inauguration of the symposium was graced by Dr. T Mohapatra, Secretary DARE and DG, ICAR, Dr. TR Sharma, DDG (Crop Science) and Dr. KK Singh, ADG (Farm Engineering). A total of 423 registered delegates attended the symposium wherein 17 lead papers by eminent workers of respective fields, 64 oral papers and 101 poster presentations were made.

Dr. T Mohapatra, Secretary DARE and DG, ICAR Chief Guest on the occasion emphasized upon the importance of beneficial insects and natural resins and gums especially lac and also the parasitoids and predators in organic agriculture. He urged the researchers, particularly, young investigators to take up the studies on biosystematics, genomics and epigenomics of pest resistance, evolution of the parasitoids and predators in relation with the pests, adaptation of the pests to withstand environmental changes. He highlighted few examples of beneficial insects such as control of papaya

mealy bugs by parasitoids, exploration of bumble bees in deploying them for pollination in natural field conditions and protected horticultural systems and possibility of utilizing the locusts as edible insects. He stressed the importance of habitat restoration for the conservation and deployment of beneficial insects and proper economic analysis to convince the policy makers for the promotion of beneficial insects. He insisted that this symposium would discuss the beneficial insects in totality, bring out newer insights in the unexplored areas of beneficial insect farming and utilization, understanding the various aspects of the biology of insects and bringing about policy dimensions in promoting beneficial insects.

Dr. TR Sharma, DDG (Crop Science) complemented IINRG on being a unique institute in dealing with lac. Internationally, 1200 insect genome projects are registered in National Center for Biotechnology Information (NCBI), comprising 401 genome assemblies and 155 gene sets of annotated protein coding genes. However, at national level these numbers are meager and there is a pressing demand to take insect genomics forward, which is very important for carrying out studies on molecular mechanism of evolutionary biology, immunology, adaptation and others. He stated to give a high priority in the present scenario to research on tritrophic interaction comprising of insect - crop plant - pathogen, molecular mechanism of insect resistance in crop plants, evolutionary biology of the insects, insect gut microbiome and genome sequencing of beneficial insects especially lac insects. To achieve laurels in these areas, collaboration across the divisions, domains, crops and systems is indispensable.

Dr. KK Singh, ADG (Farm Engineering) in his opening remarks mentioned that NRGs including lac form valuable means of subsistence, employment and cash flow to growers and collectors and serve as the raw materials for various industries and used in food, fodder and medicine. In 2016, India produced 8.43 lakh tons of NRGs, out of which 97% was guar gum and exported 2.72 lakh tons of NRGs worth 3440 Crore rupees. Guar gum was the third largest agricultural commodity exported after rice and buffalo meat. He informed that we carry out only primary process and export raw and semi refined forms of NRGs and import the value added products, which is a precarious situation. In the recent years, IINRG in collaboration with other institutes in Engineering SMD developed 50 cost effective and energy efficient tools, techniques and pilot plants for the production, processing and value addition of NRGs. Increase in sustainable livelihood security of rural and tribal people is possible through three pronged strategy that is (a) Promotion of NRG sector by the Govt., (b) declaring lac as an agricultural produce and (c) bringing all these under Minimum Support System of Government of India.

The deliberations of the symposium revolved under the following seven theme areas: (i) Systematics, conservation, insect behaviour and physiology Chaired by Dr. NK Krishna Kumar, former DDG (Horticultural Science), ICAR, New Delhi and Co-chaired by Dr. Chandish R Ballal, Former Director, National Bureau of Agriculturally Important Resources, Bengaluru; (ii) Host-plant, insect and environmental interaction Chaired by Dr. Pradyumn Kumar, Former Director, Indian Institute of Maize Research, New Delhi and Co-chaired by Dr. GK Mahapatro, Head, Indian Agricultural Research Institute, Regional Station, Pune; (iii) Crop improvement using innovative tools including biotechnology, nanotechnology, molecular approaches *etc*. Chaired by Dr. R. Ramani, Former Director, Indian Institute of Natural Resins and Gums, Ranchi and Co-chaired by Dr. S. Subramanian, Principal Scientist, Indian Agricultural Research Institute, New Delhi; (iv) Production system management and impact of climate change; Chaired by Dr. Subhash Chander, Director, National Research Center on Integrated Pest Management, New Delhi and Co-chaired by Dr. KK Sharma, Director, Indian Institute of Natural Resins and Gums, Ranchi (v) Potential of Insects as Food and Medicinal resources Chaired by Dr. Balraj Singh, Project Coordinator, All India Coordinated Research Project on Honeybees and Pollinators, New Delhi and Co-chaired by Dr. Badal Bhattacharyya, Professor, Assam Agricultural University, Jorhat; (vi) Processing, application, value addition and export potential of NRGs Chaired by Dr. Bangali Baboo, Former National Director, National Agricultural Innovation Project, New Delhi and Co-chaired by Dr. KK Singh, ADG (FE), ICAR, New Delhi and (vii) Role of beneficial insects and NRGs in sustainable livelihood security Chaired by Dr. CM Bajpey, Director, Central Tasar Research and Training Institute, Ranchi and Co-chaired by Dr. V Sivaprasad, Director, Central Sericultural Research and Training Institute, Berhampore.

Several recommendations emerged at the end of the two days' intense deliberations during the Plenary Session which was chaired by Dr. R Ramani, Former Director, Indian Institute of Natural Resins and Gums, Ranchi and Co-chaired by Dr. VV Ramamurthy, eminent taxonomist and Former Professor at Indian Institute of Agricultural Research, New Delhi. It was emphasized that successful completion of the shellac safety studies currently in progress elsewhere is critical so that the requirements laid down by European Food

Safety Authority are met for unhindered consumption and diversification of shellac in food and pharmaceutics.

Recommendations from all the theme areas were compiled area-wise for taking coherent action. These are:

A. Research thrust areas

- ✓ Elucidating the role of indigenous pollinators and solitary bees and studies on totality of pollinators including the effect of pollinators on yield and quality parameters, parasitism associated with pollinators particularly solitary bees are the need of the hour.
- ✓ Traditional and molecular techniques must go hand in hand in revealing the ecology of pollinators and other beneficial insects.
- ✓ Considering the scope of quality biocontrol agents in organic agriculture and the tremendous requirement, automation in the production of biocontrol agents shall be adopted and promoted.
- ✓ Identification of alternate host, water and soil management, selection of thermo tolerant varieties, crop insurance, weather based agro advisories, *etc*. are essential measures to mitigate the climate change effect in sericulture.
- ✓ The indigenous Muga silkworms may be explored and researched in a better way for their documentation, conservation and utilization.
- ✓ Whole genome sequencing of the Indian lac insect, *Kerria lacca* (Kerr) and its infra sub specific forms can be taken up on a priority basis for bioprospecting of genes of economic importance.
- ✓ Safety studies of edible insects and GI tags on indigenous edible insect species would take the edible insect industry to a new height.
- ✓ Potential of insect gut microbes for developing probiotics and microbiome consortium can be explored for improvement of insect farming and development of novel processing technologies for bioproducts from insects of commerce.
- ✓ Appropriate integration of productive insect cultivation comprising of lac, seri and api culture with the existing cropping pattern would enhance the income of farmers. Climate resilient lac host plants need to be assessed for their fitness and suitability under various agro climatic zones and promoted for lac cultivation in the wake of doubling farmers' income.
- ✓ There is an urging need to study the effect of climate change on productivity of beneficial insects and screen different beneficial insects to adopt under changing climate conditions for environmental sustainability and safety.
- ✓ Genetically engineered organisms may be appropriately explored to produce resins and gums under laboratory conditions which in turn would decrease the over exploitation of the gum yielding trees.
- ✓ Use of renewable energy for processing (eg. Solar dryer) and value addition of NRGs may be encouraged to save energy which in turn would help the resource poor farmers and tribes involved in this sector.
- ✓ Techno economic analysis of the research programmes on value addition of NRGs is indispensable for the success of any products or processes developed based on NRGs.
- ✓ Post Covid Scenario demands the ICT interventions in the period of new Normal to disseminate the Good Agricultural Practices (GAP) among different stakeholders of this secondary agriculture sector comprising of beneficial insects and NRGs for their improvement.

B. Development domain

- ✓ Lac integrated agro-forestry system may be promoted by State Governments, SAUs and KVKs wherein there is a high scope for lac cultivation.
- ✓ The prospects of edible insect industry may be thoroughly explored by promoting their cultivation and commercialization through banking under start up schemes by *Bandhan*/*Mudra Bank Yojana* of the government. Trading of edible insects with South East Asian nations by the way of Act East Policy of Government of India would open new avenues for this potential yet less explored venture.

C. Policy interventions

- ✓ ***Declaration of lac as an agriculture produce:*** Lac production has been categorized as a Non-Wood Forest Produce and income generated from production of lac is taxable. It discourages the progressive farmers to take lac cultivation on a larger scale. However, lac is no longer a Non-Wood Forest Produce simply collected by the forest dwellers. Lac Integrated Farming System Models are becoming popular among the farmers which have led to 15-20 % increase in farming income through land use diversification. Agricultural and Village industry products including lac based value added products are presently covered under *Vishesh Krishi* and *Gram Udyog Yojna*

(VKGUY**)** in the Foreign Trade Policy 2015-2020. Hence, there is an urgent need to declare lac as an agricultural produce and MSP for lac can also be declared under Agricultural category to accelerate its growth and livelihood potential.

- ✓ ***Formation of National Lac Development Board:*** India is the leading lac producer, processor and exporter country in the world. There are policy differences in all the states regarding the cultivation and marketing of the lac. It has been classified as nationalized or non-nationalized or monopoly item in different states. Research on lac is mandate of IINRG (ICAR, Ministry of Agriculture); most of the lac production still comes from forest / sub-forest areas (ICFRE, Ministry of Environment and Forests); Promotion and export of lac is looked after by SHEFEXIL (Shellac and Forest Products Export Promotion Council, Ministry of Commerce) and cultivated mostly by tribals (Ministry of Tribal Affairs) which sometimes creates difficult situation in developing holistic approach for promotion and development of lac / NRGs. Hence, a policy intervention at national level is required to address this differentiation. Keeping in view of above scenario, the proposal of the National Lac Development Board (NLDB) under Ministry of Agriculture is proposed to replace the exploitation with empowerment, tradition with modernity, stagnation with growth, transforming lac cultivation into an instrument for the development of rural people, checking migration of tribals for livelihood and to provide the much needed fillip to accelerate the production of lac.
- ✓ The recent pandemic has taught us the importance of self-sustainability and our nation is also marching towards "*Atmanirbhar Bharat*". Conserving and utilizing our indigenous genetic resources is crucial in obtaining self-sustainability. The commercial insects such as lac insects, wild silk worms and honeybees are important not only in commercial aspects but also in ecosystem conservation. For instance, tribals resist deforestation wherever lac is cultivated on forest trees. There is a great scope for research of these tribal yet remunerative produces. Hence, a project proposal 'Tribal Produce Project' comprising of lac, wild silk, honey, edible insects and NTFPs including NRGs may be submitted to Government of India for funding the research projects and also for improvement of this indigenous agricultural sector.
- ✓ Beneficial insects face lot of challenges due to climate change, pollution and other anthropogenic activities. The ecological service provided by pollinators such as honey bees are under continuous threat due to climate change and extensive use of pesticides. Due emphasis may be given to the beneficial insects under a single umbrella for promoting research and addressing the problems of this sector. Hence, all the beneficial insects may be brought under the ambit of the SANRAG society or a new suitable forum be constituted for the purpose of better interaction of scientists working on these insects and improvement of these valuable insects.

Honorable DG, ICAR, Dr. T Mohapatra addressing the delegates during inaugural function of the web-symposium

Compiled and Edited by

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Published by

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