Vision 2050

Indian Institute of Natural Resins and Gums

Indian Council of Agricultural Research

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Vision 2050

Indian Institute of Natural Resins and Gums
(Indian Council of Agricultural Research)
Namkum, Ranchi 834 010

http://ilri.ernet.in

Printed : July 2015

संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अत: खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)
केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Indian Institute of Natural Resins and Gums (IINRG), Ranchi has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
Krishi Bhavan, Dr Rajendra Prasad Road,
New Delhi 110 001

Preface

Preparing Vision 2050 for the Institute was a highly challenging task. Visualizing how the sector is likely to evolve during the time frame set, based on a sound projection of the overall local, national and global scenario, is sine qua non for developing an appropriate strategy. We also had to consider the factors which would directly influence the production and consumption of the NRGs based on the current and emerging trends. Envisioning the projected demand of the commodities addressed will be the obvious basis for developing the road map of vision document. The task is relatively easier with regard to food commodities which could be based on projections of population growth as well as changes in food preferences. Envisaging demand for non-food produce like natural resins and gums (NRGs) after about four decades is rather complex. Consumption of NRGs is linked to quality of human life, as their strong areas of consumption are in food, cosmetics and pharmaceutics. Safety considerations are expected to positively impact on the demand for NRGs; development of novel areas of consumption will also push it up further. Thus a multifold increase in demand is envisaged necessitating concomitant increase in NRG production.

India is a major global player in NRG production at present and a substantial portion of its production is exported to various countries. The estimated production of NRGs in the country during 2013-14 was around 8.9 lakh tonnes. It is hoped that the demand would grow stronger due to increased worldwide interest on use of natural products. The world would move towards environment-friendly production technologies and safer raw materials that are renewable and can be produced on sustainable basis. NRGs like seed gums and lac have immense potential for production enhancement as per demand growth, whereas for exudate gums it is limited. Lac, derived from specific lac insect species, is unique, as it is a source of multiple products of commercial value, such as resin, dye and wax and can be used for versatile applications.

NRG production is inherently vulnerable to climatic conditions, leading to fluctuations in supply and price, both of which are vital for maintaining a sustainable demand. All the R&D efforts should be to achieve higher and sustainable productivity with optimal inputs,

ensuring high quality of NRGs and development of novel and specialty applications especially in low-volume high-value products; emergence of new frontier areas would trigger paradigm shift in application domains. Biotechnological tools would enable harnessing genes for mass production of useful molecules in bio-factories. Such production systems would complement rather than replace the conventional production systems; drastic changes are nevertheless foreseen with introduction of highly organized plantations with advanced parameter monitoring, automated management systems for precision farming for sustainable production. IT-enabled advanced information and communication systems would lead to management of production systems at national level, for demand-production matching, on annual basis. Strong linkages and partnerships with stakeholders: farmers; domestic and overseas industries related to processing and consumption and production counterparts, is cardinal for the Institute to achieve the goals being set.

Growth of NRGs can't be achieved solely by technology development and therefore R&D institutions have only a limited role to play in this regard. The key domains that contribute to state and growth of any such sector are: i) production strategy, mechanism and status; ii) procurement and price management; iii) commodity value chain including supply and quality assurance; iv) innovative application development and consumption promotion. All these components are like the links of a chain; a chain is only as strong as its weakest link. Therefore, realization of goals set in this vision would entail involvement of stakeholders in unison with coordination as a consortium. The pace of technological strides has tremendously increased in recent decades and this trend would continue during the forthcoming decades as well. Barriers of distance would be broken by ICT. Inter-country marketing channels would become more open, globalizing the markets, which would tremendously impact such export-oriented commodities.

Besides, the institute could in future move on to related area such as biopolymers, derived especially from agrowastes, ushering new domains of research. Thus, even a realistic portrayal of the roadmap and sector scenario by 2050 in the NRG sector is likely to read like a science fiction. This document may therefore be viewed as rather a conservative picturization of NRG sector by 2050 and R&D framework to a meet the requirements that would emerge.

I would like to acknowledge the valuable inputs provided by all the scientists of the Institute and Dr. K.K. Sharma, Head, Lac Production Division; Dr. N. Prasad, Head, Processing and Product Development

Division; Dr. A.K. Jaiswal, Head, Transfer of Technology Division. The critical inputs by the RAC especially Dr. N. Krishnamurthy, Chairman are gratefully acknowledged.

R Ramani
Director
ICAR-IINRG, Ranchi

Contents

Context

The ICAR-Indian Institute of Natural Resins and Gums (ICAR-IINRG) was founded on September 20, 1924 in Ranchi, as Indian Lac Research Institute during the colonial era of India. The Institute was established by the Indian Lac Association for Research, on the basis of the report Lindsay-Harlow Committee, constituted for development of lac in the country. Subsequently it came under the control of Indian Lac Cess Committee before ICAR took over in 1966.

Ever since establishment, the Institute had made tremendous contributions towards development of lac in the country. Recently, the lacuna for R&D of other natural resins and gums produced was realized due to lack of any dedicated institutional support to these commodities. Responding to the ICAR initiative, the Institute transformed itself by expanding its mandate to encompass all the natural resins and gums (NRGs), in 2007, during the XI Plan, adding a network project on harvesting, processing and value-additions of NRGS especially to address the expanded mandate.

In the era of value-chain and holistic approach in research, the Institute is already future ready, addressing the research and development needs of natural resins and gums, at various stages, starting from production to processing and application development through the institutional programmes and in network mode. The IINRG plays a definitive role in technology development, popularization and dissemination; human resource development in production, processing and utilization and providing inputs in policy-related issues of the sector. The institute thus provides the R&D backbone besides playing a catalytic role in health and development of the sector.

The NRGs could be considered as low volume – high value commodities. They are used in a broad spectrum of areas. At present, the important NRG-producing countries in the world are: USA, China, Russia, Indonesia, Thailand, India for resins; India, Nigeria and Sudan for gums and Afghanistan, Iran, Spain, Ethiopia and Somalia for gum-resins. India is traditionally the largest producer of guar and karaya gums as well as lac. Besides these, a large number of other minor gums are also produced in India. One of the important facets of NRGs in the economic context is their role in livelihood of the farmers. Out of the 150 disadvantaged districts identified by the Planning Commission,

NRGs are important source of subsidiary income to farmers in around seventy of these districts. But, it is envisaged that the economic, educational and social picture of such farmers would undergo a vast improvement in the forthcoming years. Looking forward, the income pattern of various sections of Indian population would have undergone sea change by the middle of present century. Therefore, sustenance of interest in production systems of NRGs would necessitate proper tuning of production economics coupled with appropriate operation scales.

Tribal farmer carrying harvested lac crop

Globalization of various activities would touch new heights during the next four decades, the period under consideration in this document, and this would make a tremendous impact on the research as well as functional components of the programmes of R&D institutions; ICAR institutes will be no exception to this. ICAR needs to look beyond production and ideate broader catalytic role for the holistic growth of agricultural commodities under its purview. Growth of any commodity or sector is unimaginable without healthy forward and backward integrations.

A paradigm shift would be needed in the priorities and functioning style of the institution, backed by concomitant changes in the rules and regulations of the system, providing required powers and freedom to the constituent institutions. There should be special drive to reduce the time needed in decision making at various levels. The ICAR-IINRG will have to think global and develop linkages with international bodies and industry to tune the R&D programmes as per the needs and industrial dynamics and global perspectives.

The relative contribution of different types of NRGs to the total production of the country is about 80 per cent gums, 19 per cent resins and a small fraction of gum-resins. The gums are basically water-soluble whereas the resins are soluble only in non-aqueous solvents. The

variations in molecular size, structure and other functional groups, which confer unique properties to them, have to be advantageously harnessed for development of different applications of NRGs.

In the forthcoming decades, greater emphasis will be laid on quality of human life with enhanced stress on human and environmental safety of products and technologies. The production and application of natural resins and gums would receive tremendously more attention than in the past and it may be really challenging task to meet the demand potential, which is likely to emerge in future.

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Challenges

The NRG sector is envisaged to confront challenges from several fronts. In the production front, the climate change would throw newer threats affecting productivity and sustainability. At the same time, elevated temperatures could be expected to have positive impact on the production of plant exudates: resins as well as gums. Towards the middle of this century the agricultural production systems including NRG production would have to evolve as economically highly viable option, rather than livelihood agriculture. Thus economic returns have to be substantially increased through higher productivity and enhanced scale of production systems. We have to work towards production technology transition with a negative relationship between the manpower involved, over the period. The production systems would have to be made highly efficient for resource utilization and pest management need to be highly environment-friendly.

As a result of thrust towards greater harnessing of natural materials for achieving better quality of life and environment friendly approaches, the demand would become several-fold; ensuring adequate supply of desired quality at reasonable cost would have to be addressed. The availability of manpower would also diminish over the period under consideration and therefore novel techniques need to be developed to reduce labour requirement and higher yields. The processing sector will have to be geared for greater homogeneity and stringent quality criteria of finished products for industrial consumption.

From the application standpoint, there will be calls for more stringent quality requirement as well as safety information of NRGs, in view of their use in applications related human consumption and contact. There is need for preparedness in advance to be fully equipped for facing such challenges, in order to sustain and strengthen the demand.

Totally new application areas would emerge, which would require tinkering the molecules to achieve the desired characteristics for specific application. All the natural gums and resins are inherently heterogeneous; homogeneity requirement needs to be met through precise processing technologies. They also show exceptional versatility of their physico-chemical properties. In future, all the NRGs are likely to be modified before consumption to meet specific application requirements.

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Operating Environment

The institute addresses an important non-food commodity sector, which provides livelihood support to inhabitants in unfavourable and hilly regions especially in tribal areas. Therefore natural resins and gums could play a definitive complementary role in development of Indian agriculture.

Constraints of human labor, energy deficit and climate change are currently posing serious challenges to very sustenance of agriculture. Changes in the operating environment and opportunities, diverse challenges and constraints such as growing population; revival of preferences towards natural foods and food additives; climate change; slow growth in farm income; new global trade regulations; rising energy bills; evolution of softwares and ICT and preferences for clean energy are some of the factors which demand a paradigm shift in formulating and visualising new research programs for competitive age technology.

Resins are largely used in surface coating formulations for several applications like wood varnishes, paints, lacquers, food and pharmaceuticals, adhesives, cosmetics etc. The gums and gum-resins are mostly used in food (as stabilisers, emulsifiers and flavouring agent),

Lac crop on *kusum* tree

pharmaceuticals, cosmetics, textiles, chemical intermediates. In several application areas there are no substitutes for these natural products while in some cases synthetic alternatives are available. NRGs are one of the major components of NTFPs (Non Timber Forest Produces), which contribute an estimated value of Rs. 4139 crores, providing 70% employment of the forestry sector. It also provides opportunity for non-destructive utilisation for trees. In view of the revival of interest in NRGs sector, more attention is needed in this sector because of immense social, environmental and industrial development possibilities. Empowering the inhabitants to harness the forest trees for economic products under joint forest management would greatly help in providing income to the gum pickers/collectors. Reorientation of processing and product development with expanded mandate has now facilitated coverage of primary processing/value addition/quality control of all the natural gums and resins to strengthen this sector.

Processing and value addition of NRGs need to be boosted for enhanced returns and to carve new areas of consumption. Technological breakthroughs, especially in newer areas of science need to be reflected in the research programmes conceived in future to open up new frontiers in production, processing and application of NRGs. Playing a socially relevant role for poverty alleviation and income generation would involve collaborative development and application by the public organisations in partnership with producers, private sector and other stakeholders. Application of non-conventional sources of energy efficiently and strong

Tamarind gum powder

primary processing near production sites and its value addtion may be helpful in improving economics of processing.

In recent years, a renewed interest in deriving biologically active compounds from natural sources has been witnessed. This world-wide attention can be attributed to the low or no toxicity of the formulations based on natural products, their complete biodegradability,, availability from renewable sources and, in most cases, their lower cost, compared to those obtained by total chemical synthesis.

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New Opportunities

Production of microbe-derived gums through bioreactors would take a major leap contributing to a major chunk of total gum/resin production. Technological advancement would lead to use of genetically engineered organisms for production of NRGs.

Owing to this renewed attention to pharmaceuticals, agrochemicals and nutraceuticals (functional foods) involving use of natural resins and gums, the study of bioactive secondary metabolites, traditionally carried out mainly by chemists, has increasingly received the attention of pharmacologists, biologists, botanists, agronomists, and others, stimulating collaborative research.

The following applications are suggestive of emerging areas to provide some insights rather than a comprehensive picture of new areas for NRGs in the forthcoming decades.

- Preparation of value added products from different natural resins and gums for food, surface coating, pharmaceutical and cosmetic industries and biomedical applications.
- Identification and process development for the isolation of potential phyto-chemicals from gums and resins for use in nutraceuticals, functional foods as an antioxidant.
- Natural gum based hot melt adhesive for packaging industries and also for baby diapers and sanitary napkins.
- New beverage innovations, such as wine coolers, novel confectionery coatings, high-fibre drinks and powders are some examples of new product formulations using gums and resins.
- Nanodelivery systems based on natural gums for targeted release.

India is endowed with wide range of climatic conditions for production of different gums and resins with varying climate requirements. For instance, guar gum requiring drier conditions, pine resin needing colder temperatures, lac demanding moderate temperature range. Thus, India holds ideal climatic conditions for all these commodities, which needs to be fully harnessed.

Strategically, while planning the development of natural resin and gum sector of the country, different approaches are needed in view of the production capabilities. Plant-derived gums/resins can be broadly classified under those produced from seeds and those obtained as tree exudates. While it is possible to increase the production to desired level

of seed gums, it is virtually impossible to achieve short-term increase in production of exudate gums, unless there is adequate number of untapped trees. Besides, unscientific tapping always puts the gum/resin yielding tree under risk of mortality. Lac also offers tremendous scope for considerably increasing the production levels concomitant with any spur in demand; there is a large reservoir of unutilized host trees in the country besides quick-growing plant host species identified for lac production.

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Goals and Targets

The Institute is mandated to undertake research on the complete commodity chain – from production to end products for the consumers. Therefore it has to respond to technological requirement for a whole range of areas including production, processing as well as application/product development of natural resins and gums. The R&D efforts have also to dynamically respond to meet various targets as a result of changed scenario outlined in the foregoing discussion.

With this backdrop, the Vision, Mission and Mandate of the Institute appropriately spelt out. These could undergo transformation subsequently, in view of enlarged role of this Institute envisaged in future, as discussed in another part of this document. The current Vision, Mission and Mandate of IINRG are as follows:

Vision

Harnessing natural gums and resins for livelihood support to resource-constrained farmers and promoting a healthier world, interlacing ecological development.

Mission

Accomplishing the vision through R&D and technology diffusion for sustainable lac production; processing, value-addition, quality management and application/product development of natural resins and gums.

Mandate

To translate the vision into reality and accomplish the mission, the IINRG has set the following mandate to bring about the desired change in the national natural resin and gum sector.

- To conduct basic and applied research on lac production technologies
- To conduct basic and applied research on processing and value addition of natural resins (including lac), gums and gum- resins
- Information dissemination and technology transfer to farmers, processors and entrepreneurs
- To conduct research on harvest and post-harvest processing and value addition of natural resins, gums and gum resins in network mode

- Conservation of lac insect genetic resources of the country in network mode

Production of NRGs

Major shifts are envisaged in the relative contribution of various sources of NRGs at the national and global level due to change in demand pattern and production forces and economics.

Major thrust in production systems would be to move towards ideal input-output efficiency, reduced labour requirement and long-term sustainability. Therefore greater attention would have to be laid on improving the efficiency of natural resources including water and nutrients, which would become increasingly limiting in future. Consolidation of land holdings would become inevitable in distant future due to paucity of manpower availability for agriculture. Therefore, tech-nology packages would have to be tuned towards higher scale of operations with higher-level of mechanization of operations.

Gum arabic

Lac Production strategy: The commercially important species in India, i.e., the Indian lac insect, *Kerria lacca* has two forms, *rangeeni* and *kusmi*, producing lac of different qualities, suitable for distinct applications. Lac production development should encompass identification and establishment of distinct *rangeeni* and *kusmi* lac producing clusters to facilitate better crop management and marketing besides staving off pest crossover from one crop to another. This is important in view of the need for the continuum of lac insect generations for sustained production. Sizeable production (about half of the total) should shift from scattered lac host trees to systematic plantations of bushy and tree hosts trained to shorter heights, including lac-agri-integrated systems. Broodlac (lac seed) should be under protected production systems to ensure desired quality and reduced pest risk.

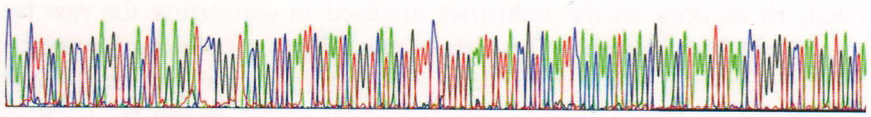
Deeper understanding of the mechanisms including the lac insect physiology, insect-host relationship, physiological aspects of plants producing exudate gums, factors influencing gum proportion of seed

gums, broader understanding and diversity of gum-yielding microbes would be some of the key areas which would be addressed through modern tools and equipment. Greater emphasis would be placed in basic and strategic research and its application for NRG production. Lac insect genome would be completely sequenced and functional genomics would lead to mining of useful genes related to resin, pigment production as well as other molecules for bioprospecting. NRG yielding plants would be linked with carbon sequestration and would thus complement the sector.

It is envisaged that there would be increased shift towards multispecies tree systems for enhanced stability. Therefore, suitable mix of systems would have to be developed based on deeper understanding of the nutrition requirements and complementarity of component species in the long run. Partially and fully controlled production systems would have to be developed for precision farming. Greater understanding of genetic diversity with regard to chemical composition is necessary to harness the full genetic potential. This would be coupled with conservation approaches positioning the Institute as a centre to reckon for genetic resources of NRGs.

In view of the foregoing considerations the following key areas are envisaged, which would receive special attention as move towards 2050. This list does not encompass all the programmes but provides insights into the newer areas and shift in thrust areas in view of future scenario.

- Identification of economically viable sources of production of NRGs and development of technologies for their commercial production. Use of microbes and industrial production through use of appropriate biotechnological approaches would get a major boost contributing to sustainability in gum-resin production.
- Harnessing the genetic variability of the lac insects their hosts and trees/plants/organisms producing resins/gums from different agro-climatic regions of the country by using conventional and biotechnological tools.
- Converting climate change impact to advantage by suitably geared strategic approaches, for enhanced production.
- Development of lac productions systems under protected conditions for better management of parameters and pest management to ensure high and sustainable production. Such systems would move towards automation with computer-controlled monitoring and management.
- Conservation of genetic resources and biodiversity would receive greater emphasis.
- Complete genome sequence knowledge of organisms (lac insect,



plant and microbes) producing NRGs and understanding the functional genomics for commercial gains.

- Gain deeper understanding of the lac insect- host interaction for manipulation of the host and insect related factors to achieve enhanced productivity.
- Mechanism and factors (plant physiological and climatic) influencing exudate gum/resin production for devising mechanised tapping methods.
- Development of exhaustive database of various sources gums/resins and identify means for harnessing them for specific applications.
- Documenting the environmental role of NRG trees and their development of national resource base gum/resin trees to meet the global demand, linking carbon sequestration and other beneficial functions. This would include resource mapping of important and potential NRG plants and development of national production strategy.

Processing equipment would have to be automated for least manpower requirement and enhanced quality of processed products. By-product utilization and effluent management would have to be fully addressed for minimal environmental pollution, especially in lac industry. Zero wastage should be the goal of processing industry for seed gums and lac.

Processing and Application Development

To maintain a healthy market environment, matching of demand and supply is primary, which is a challenging task that can be addressed only through concerted efforts of several agencies. Any R&D institution has only a definitive role to play in the overall sectoral development; it should gear its research programmes based on the current and emerging market scenario back-stopping technologies to facilitate demand-supply match. For those aspects needed for sectoral growth outside its scope, it could take up advisory, catalytic or facilitative role.

Lac, a source of multiple materials of commercial value and its development therefore offers multiple facets. The strategic approach for processing and application is as follows:

Value chain and quality assurance of basic materials from lac: Much

needs to be done to the industries involved in converting the raw lac into useful basic materials for various uses. There is considerable inertia in the processing sector to modernize the equipment as well as efficient conversion of materials including utilization of bye-products. There is also compelling requirement to place regulatory system to ensure the desired quality of lac-derived basic materials such as seedlac, shellac and aleuritic acid to overseas buyers, who often complain about the consistency and reliability of such products.

Innovative application development and consumption promotion of lac: A number application areas are already vogue, which are often undermined by vagaries in price and supply. Robust supply mechanism needs to be developed by suitable buffer stocks to ensure steady supply and price. Lac is a treasure house of useful compounds and forms renewable source apart from contributing positively in carbon trading. Innovative approaches would indisputably generate hitherto unknown applications, opening novel areas of consumption, triggering demand. The strong areas for future consumption of lac are in food, pharmaceutics and cosmetics. We have to respond increasingly to stringent safety and quality requirement of materials linked to human consumption and contact. Recent call of safety data for shellac, as per specified OECD protocols, by European Food Safety Authority signals the kind of situations likely to arise in future. Generation of such safety data for all lac-derived materials is the call of the hour. Lac marketing is principally surviving on established channels of market; aggressive promotional initiatives to create newer channels would undoubtedly boost its consumption.

The gum and resin molecules would have to be suitably modified for specialty application and food, pharmaceutic and cosmetic segments are visualised as strong grounds for NRGs. The application of NRGs has to be appropriately modified to meet the emerging requirements as the products in these areas are expected to undergo sea change in terms of content and delivery systems in future. Nanotechnology would become inevitable tool in development of newer materials and systems of NRGs.

The following programmes provide insight into future direction to achieve the goals considered above.

Resins and exudate gums production and post-harvest management

- Development of tools, mechanization and optimization for collection/ tapping of exudates gums, resinoids.
- Developing of good handling practices, primary processing

techniques, packaging and storage protocols for better shelf life, economic and quality products.

Industrial processing, quality management, raw material engineering

- Processing technology modernization/modification including biotechnological approaches for improved efficiency and quality in lac processing with enhanced shelf life. By-product utilization to achieve zero wastage.
- Pilot plants for key processes/ products/by products/derivatives of natural resins and gums.
- Development of process know how for industrial processing, quality management and packaging of exudates/seed gums or resins in network mode aiming at better yield and good quality.
- Application of sources of non-conventional energy (Solar Energy) in primary processing of resins and gums/their by-products.

Dammar resin

Characterization and quality management

- Physico-chemical characterization of Natural resins and gums and their derivatives/by products.
- Characterization of lesser known resinoids and gums and application development with an aim to develop their application areas and serve as secondary source depending on their composition and suitability.
- Study of secondary source of resinoids (propolis from different bees) for their potential areas of application.
- To develop/refine national quality standards and testing protocols for important NRGs including minor gums. To provide testing support to buyers and sellers, up gradation of testing facility at the institute.

Raw material engineering

- Isolation/fractionation of potential components/constituents of NRGs for specialized applications (designer products as nutraceuticals, functional foods, pharmaceuticals, cosmetics, etc.)
- Derivatisation/modification of gums/resins for property enhancement.

- Synthesis of high value compounds/active ingredients, novel blends, nano delivery systems for specific applications.

Novel application and product development

- Preparation of value added products from different natural resins and gums for food, surface coating, pharmaceutical and cosmetic industries and biomedical applications.
- Natural gum based applications in specialty areas such as food packaging, diapers, sanitary napkins, etc.
- Use of NRGs in wine coolers, novel confectionery coatings, high fibre drinks and powders are some examples of novel product development areas.
- Use of advanced molecular modelling techniques for designing/ tinkering of molecules to confer desired properties for specific applications.
- Application of nanotechnology for manipulating gum/resin molecules for application in niche areas such as domestic appliances, drugs, food processing, cosmetics, etc.

Technological revolution and change in life style would lead to emergence of completely new application areas where NRGs could be used.

Technology Delivery System

There is need for achieving desired awareness among all stakeholders about the economic benefits of production to the growers/ collectors, industrial potential of the materials to the processors and advantages of using NRGs to consumers. The policy makers at the State and Central levels need to be sensitized from time to time about the sector for required policy and developmental support.

Multidimensional efforts are required to promote use of NRGs, which needs to be

Karaya gum tree

matched with production enhancement to ensure a healthy growth of industry. HRD is a paramount component of these efforts encompassing different components of this sector. The energies of all the stakeholders in the value-chain of NRGs are to be synergized to realize the vision set in this document.

- Demonstration, validation and refinement of lac production and resin and gum tapping/ primary processing technologies with farmer participation.
- Information dissemination, advisory services and promotion of technologies to stakeholders through publications such as promotional literature; technical bulletins; project profiles; reference book series; production and exim statistics, etc.; participation in rural and industrial exhibitions, kisan melas; liaison, information and advisory services on NRGs to stakeholders.
- Enhanced coverage on NRGs in the curricula in appropriate courses; supporting education modules related to NRGs to educational systems at different levels (schools and colleges).
- Impact assessment; lac crop surveillance; organising industrial consultations, conferences, academic symposia, brainstorming, etc.
- Socio-economic study of farmers and markets related to lac and other resin and gum production. Compilation of information and data on NRGs of commercial importance, in network mode.

Technology delivery system would undergo a sea change in the next half-century. IT would be instrumental in ushering new era of communications and information dissemination. Automated and networked monitoring system would enable remote management through expert advisory mechanisms.

Indian Frankincense

The technology delivery systems would be complemented by expert advisory support using IT tools. Remote monitoring of parameters would be developed providing advisory for timely interventions for production systems.

- Awareness and capacity building of farmers, industry (supply and consuming) and developmental machinery through structured and IT- complemented dissemination and delivery systems; web-based information and SMS services.

- IT-enabled real-time monitoring and advisory system in network mode, for providing solutions to production-related issues.
- On-line HRD programmes for the stakeholders.
- Monitoring of climatic parameters and other NRG-production related inputs, market information and timely intervention and advisory services.

India is already one of the leading NRG-producing countries in the world; the vision envisaged aims at leveraging this advantage and converts the opportunities in terms of the resource base and also the wide spectrum of climatic conditions suitable for producing different types of NRGs. An R&D institution has limited sphere of activity and therefore cannot single-handedly achieve this goal; it would basically aim to take up a catalytical role. Concerted efforts of the stakeholders with planning and execution of a sound road map would help realize this goal.

Way Forward

The period addressed in this document spans about four decades and would witness paradigm shifts in different spheres including scientific thinking, technological back drop, life style, etc, touching every sphere of life, which will greatly determine the demand and application of various food and non-food commodities including NRGs.

The R&D efforts and technology diffusion would provide the desired impetus to position the country as a global leader in production of NRGs. In this process it would emerge as the Centre of Excellence for research on NRGs.

Adequate emphasis on basic research would be extremely important for carving out novel applications in specialised areas. Industrial linkage right from conception stage would ensure better relevance and adoption of new technologies. In view of extremely specialized applications, linkages with overseas laboratories would be important for convergence of scientific expertise to develop new products, especially in frontier areas. The partnership between the Institute and others would emerge seamless with the involvement of other national and international labs as well as stakeholders—producers, industry and other related agencies including the line departments of State and Central govt.

It is envisaged that the Institute would have to emerge as an international centre for R&D of NRGs with scientists and laboratories across the borders as research partners; such networks would function in virtual and physical domains; the former would be through net-based systems for information sharing, whereas the latter will be establishing collaborative research efforts. This would enable relevant research driven by global needs and optimization R&D efforts, at global scale.

The R&D efforts should strategically aim at broad spectrum of consumption areas to buffer against erosion of any application. Continual development of newer products would ensure sustained demand for NRGs resulting in a sustained and healthy industry in the country.

A huge quantum of agricultural biomass is generated after recovery of food and other useful products. This agri-biowaste is a treasure-house of potentially useful products, the economic potential of which is yet to be optimally harnessed. They could also be a rich source a wide range of biopolymers with tremendous variations in the chemical structure and

properties which would be recovered through appropriate processing and suitably modified for different applications.

Evolution of any institution would be driven by its core competency. In view of the manpower composition and infrastructural facilities, the IINRG holds potential to take up research on development of agricultural biopolymers for various applications. Biopolymers would emerge as a strong sector needing attention in forthcoming decades and it is envisaged that the institute might undergo one more mandate revision to take up R&D on all agri-derived biopolymers. Therefore it may be prudent to start preparing the Institution for such anticipated transition.

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Laser typeset at M/s Print-O-World, 2568, Shadipur, New Delhi 110008 and printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028.

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