



# VISION 2030

Biotechnology Research and Innovation for  
Food and Nutritional Security

National Agri-Food Biotechnology Institute  
(Department of Biotechnology, Govt. of India)

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# FOREWORD

**Dr. K. VijayRaghvan**  
Secretary

Government of India  
Ministry of Science and technology  
Department of Biotechnology  
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The Green revolution has provided India with much needed food security. However, the current challenge the country needs to address is achieving domestic food and nutritional security. This demands a constant assessment in formulating and in implementing Agricultural, Food and Nutritional research programs. Undernourishment is primarily because of poor diet diversification, lower quality and quantity of protein intake, and poor micronutrient availability. Post-harvest food losses contributed by poor handling of farm produce, transport and storage, inadequate processing infrastructure further aggravate the problem. Biotechnology can make a significant contribution in ensuring food and nutritional security through domestic resource mobilization and building partnerships. This necessitates agencies such as the DBT to have a perspective, which should be translated through proactive, innovative and novel research approach based on cutting edge technologies. In this endeavour, NABI has formulated a vision 2030 document to highlight the current and future issues involved in nutritional security of the country and strategies to address them.

The major research areas identified at NABI include bio-fortification of crop plants and development of novel technologies for food and nutritional security. It is envisioned that NABI would provide multiple innovative biotechnological solutions and inventive products in agriculture and food sector.

It is envisaged that a forward looking concept and analytical approach presented in the vision 2030 document will help NABI to emerge as a center of excellence in agri-food biotechnology research. It will prove useful for researchers, policy makers and stakeholders improve their efficiency and effectiveness to address the future challenge of food and nutrition security of ever increasing Indian population and help the country in achieving sustainable development goals.



**K. VIJAYRAGHVAN**

# MESSAGE

Former Secretary DARE and DG ICAR  
Chairman, SAC, NABI  
Founder Chairman  
Trust for Advancement of Agricultural Sciences  
Avenue-II, Indian Agricultural Research Institute,  
New Delhi-110012



**Dr. R. S. Paroda**  
Chairman, SAC, NABI

National Agri-Food Biotechnology Institute (NABI), Mohali is an autonomous organization of the Department of Biotechnology, Ministry of Science & Technology, Government of India. This institute has a unique mandate of providing innovative and sustainable technology oriented solutions for food and nutritional security of ever increasing Indian population. The present document "NABI VISION 2030" highlights the need, challenges and issues related to the food and nutritional security of the country. In the VISION document, it is proposed to develop and utilize state-of-the-art research facilities, with highly trained professional manpower to carry out research in the areas of crop biofortification, quality processing and post-harvest improvement of food crops, including development of functional foods to mitigate malnutrition. Also, the focus will be on human resource development, capacity building, societal outreach and policy advocacy in the areas of agribiotechnology, food and nutritional security. This VISION document, highlights number of strategies using novel, proactive and innovative biotechnological interventions in the areas of agriculture, food and nutrition and also an interface

between them for providing future Road Map for effective implementation.

I am happy to be associated with NABI in shaping its scientific agenda that is relevant to the current needs and future growth of agriculture sector through innovative use of biotechnology both for pre and post-production of agricultural commodities. I wish NABI scientists all the best in their endeavours to achieve household food and nutritional security being important sustainable development goals (SDGs).

A handwritten signature in black ink, appearing to read 'R. S. Paroda'.

**R. S. PARODA**

# PREFACE



**G**reen revolution made India self-sufficient in food grain production, but sustainable food and nutrition security is yet to be achieved in the country. Biotechnology provides powerful tools for improvement in the quantity and quality of food crops hence, can play a significant role in the development of the nutritionally secure country. NABI is committed to provide leadership in a demand-driven biotechnology-led research at the interface of agriculture, food and nutrition. This NABI-VISION-2030 is based on the objectives of the institute, including crop biofortification, quality processing and post -harvest improvement of food and fruit crops, and development of functional foods to mitigate malnutrition, human resource development, social outreach and policy advocacy.

This document is the outcome of many formal and informal discussions with the Scientific Advisory Committee (SAC) and Program Advisory committee (PAC) members and all major stakeholders in Agricultural, Food and Nutritional Biotechnology. I extend my sincere thanks to them. I am personally thankful to Dr. R.S. Paroda, President TAAS, former Secretary DARE and Director General, ICAR and the Chairman, Scientific Advisory Committee of NABI for his continuous support, innovative ideas and guidance throughout the preparation of NABI VISION 2030. I am also grateful to Dr. J.L. Karihaloo, Coordinator-Asia-Pacific Consortium on Agricultural Biotechnology for his valuable suggestions during the preparation of this document. I am grateful to Prof. K VijayRaghavan, Secretary, Department of Biotechnology, Govt. of India for his critical suggestions on this document.

All the formers Directors of NABI, Dr. Rakesh Tuli, Prof. Akhilesh Kumar Tyagi, Dr. Rajender Singh Sangwan have provided valuable input to identify various goals for the institute which has immensely helped us to structure this NABI VISION document. I sincerely acknowledge their help. I am thankful to all the Scientists of NABI for providing new ideas during preparation of this document. Special thanks are due to Dr. Mahendra Bishnoi, Dr. Monika Garg and Dr. Koushik Mazumder, members of VISION committee-NABI. They have put considerable thoughts and efforts to shape NABI Vision 2030.

I am sure this document will provide future directions to the Scientists of NABI and will act as an important guide to shape their research programs. I hope and wish that by 2030, NABI will be able to provide multiple biotechnological and innovative products in agriculture and food sector that will lead to household food and nutritional security for achieving the sustainable development goals.



**DR. T. R. SHARMA**

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# PREAMBLE

Article 47 of the Constitution of India, states that, “The State shall regard raising the level of nutrition and standard of living of its people and improvement in public health among its primary duties”. Although, since the days of green revolution, India is self-sufficient in food grain production, yet it is obvious that achieving household food and nutritional security for the expanding population is going to be an enormous task and will need another revolution directed towards sustainable food and nutrition security with technological advancements based innovative solutions at its forefront. At the United Nations Sustainable Development Summit-2015, all 193 member states adopted the “Agenda 2030” for Sustainable Development, which includes a set of 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030. Under Goal 2, “to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture,” it will be critical to ensure that all people should have household food and quality nutrition security. If this goal is to be more than aspiration, we need to find innovative and lasting solutions to eliminate the food and nutritional insecurity across the world. Agri-Food biotechnology provides powerful tools for improvement in quantity and quality of food crops, minimize pre and post-harvest losses, prevent malnutrition related diseases, limit health care costs and enhance economic growth and hence, can play a significant role in the development of the nutritionally secure country. This NABI-VISION document is built on the premise that agriculture, food and nutrition are strongly interrelated and have a critical role in the economy, growth and development of the nation. It identifies vision, mission and goals while outlining certain long-term flagship projects and strategies to implement them to achieve desired research outputs into products and processes for the national public good.

# BACKGROUND

India is home for the 17.8% of the total world population. The United Nations (2017) report has projected that with the current annual population increase of 1.2% that India will be most populous country after 2024<sup>1</sup>. Since the days of green revolution, India is self-sufficient in food grain production with 1.9% total factor productivity growth rate in agriculture and allied sector between 1980 and 2008<sup>2</sup>. Having attained food security in terms of physical access by producing sufficient, India needs to address socioeconomic and ecological access of food for all. India is ranked 75th in the Global Food Security Index<sup>3</sup>. On a scale of 0-100, Global Hunger Index-2015 (GHI) has ranked India at 55th position with a hunger index score of 29, suggesting serious challenges ahead<sup>4</sup>. By this, it is obvious that the continuous task of meeting the consumption needs (food security) of the projected population is going to be enormous and more so with newer goal of quality nutritional food for all for better health and well-being.

The current major challenge for the country is to achieve household nutritional security for all. High levels of undernutrition is a major problem that is determinantal, especially in children and women. According to Global Food Security Index 2016, 15.2% of the Indian population is undernourished, primarily because of lower quality protein consumption (38.6% compared to world average of 57.8%), micronutrient availability (26.5% compared to 57.3%) and diet diversification (41% compared to 51.6%)<sup>5</sup>. According to Global Nutrition Report 2016 of International Food Policy Research Institute (IFPRI), average annual GDP losses from low weight, poor child growth, and micronutrient deficiencies are 11% in Asia and Africa<sup>6</sup>. The economic survey-2016 of the Ministry of Finance, Government of India, shows that “maternal and early-life health and nutrition programs offer very high returns on investment”<sup>7</sup>. India is home to more than one third (around 200 million) of world’s stunted children. Undernutrition is a serious challenge, but on the contrary, there are positives too, due to the various food and nutrition schemes, rate of reduction in stunting has doubled in the past 10 years compared with the previous decade<sup>4</sup>.

There is hope to further increase nutritional security through judicious application of biotechnology tools for improving the nutritional quality of food crops. India must also pay attention to its growing incidence of over-nutrition leading to problems of overweight and, in particular, high rate of diabetes (diabetes prevalence 9.5%). SMART (Specific, Measurable, Achievable, Relevant, and Time bound) national targets and their technology driven solution are required for reducing stunting, wasting, low birth weight, anemia, childhood overweight, adult obesity and diabetes.

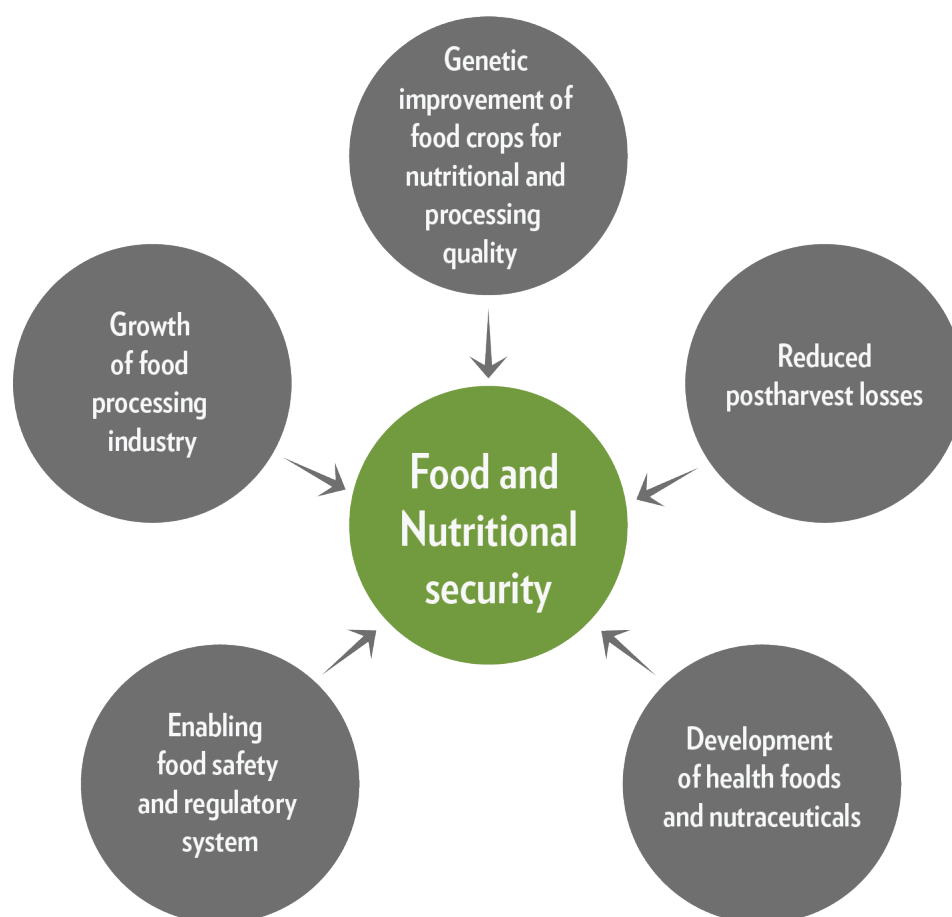


Fig 1: Cardinal pedestals to achieve national food and nutritional security

1. <http://www.un.org/en/development/desa/population/events/other/10/index.shtml>
2. 2014 GAP Report-Measuring Agricultural Productivity Growth in India
3. [Foodsecurityindex.eiu.com](http://Foodsecurityindex.eiu.com)
4. <http://www.ifpri.org/> Global Hunger Index

Post-harvest food losses (due to poor handling, transportation and storage, inadequate processing infrastructure and inefficient implementation of food safety regulation) are other challenges<sup>8</sup>. According to a study by the Indian Council of Agricultural Research-Central Institute of Post-harvest Engineering & Technology (ICAR-CIPHET) 2015 report, the annual loss of major agricultural produces at the national level due to harvest and post-harvest losses are about one lakh-crores. The maximum loss was found in fruits and vegetables (up to 16%). Pre-harvest physiology plays an important role in post-harvest characteristics of food crops with reference to storage and quality. Understanding pre-harvest physiology enables development of appropriate interventions to increase shelf life, storage and nutritional capacity of food crops. Development of novel food grade bio-preservatives, particularly against fungal spoilage as an alternative to chemicals to enhance shelf life and safety of raw and processed foods, is one of the priority research areas. The world over, there is a focus on enhancing processing qualities of cereals and non-cereals including fruits and vegetables. For example, disparate mixing of different varieties of wheat during storage is a limitation in producing good quality processed products. There is a need for the identification, development, validation and utilization of markers for each product type. This will enable scientists to breed more efficient cultivars with better processing quality. Further, there is a need for improving biosafety and toxicity standards in India, especially for genetically modified foods and wrong perception about their development.

Biotechnology can make a significant contribution in ensuring food and nutritional security in India. There are many success stories over the globe where biofortification both by conventional breeding and transgenic approaches has been remarkably successful. Based on joint efforts of HarvestPlus and International Potato Centre on vitamin-A rich, orange-fleshed sweet potato (OFSP), household food and nutritional security in sub-Saharan Africa has been addressed successfully, for which they have been recently awarded World Food Prize-2016.

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5. [Foodsecurityindex.eiu.com/Index](http://Foodsecurityindex.eiu.com/Index)
  6. [http://globalnutritionreport.org/Economist Intelligence, Unit \(EIU\) study](http://globalnutritionreport.org/Economist%20Intelligence,%20Unit%20(EIU)%20study)
  7. India, Minister of Finance, Economic survey- 2016
  8. ICAR-CIPHET report 2015

Also, crops such as iron and zinc fortified beans, rice, wheat and pearl millet, and Vitamin A-enriched cassava, maize are released or being tested in over 40 countries. Protein-biofortification of sorghum, maize (QPM, Quality Protein Maize) and cassava has also been successfully achieved and is at various stages of commercialization. Transgenic approaches have been successfully applied to develop various crops. A strain of “Golden Rice” that has more iron and beta carotene, later a precursor of Vitamin A might be in the market soon. The Bio Cassava Plus (BC+) program by HarvestPlus is a genetically engineered’ cassava with increased levels of iron and provitamin A along with increased shelf life, reduced cyanide levels, and improved disease resistance. These are few of many examples where biotechnology has shown its potential in addressing global hunger, household food and nutritional security. It is the way forward for development and implementation of innovative solutions for food and nutrition problems, thereby provide an opportunity to fulfil Sustainable Development Goal 2, envisaged by the United Nations and adopted by all its member nations including India.

VISION-2030 has been developed based on analysis of factors that contribute to food and nutrition security in Indian context and agriculture and food biotechnological options to address them. The major research areas identified are biofortification and improvement in the processing of staple cereals, legumes and fruits, post-harvest management of farm production and development of functional foods. Along with this, there will be an emphasis on creating state of the art infrastructure, networking through technology platforms and creating a pool of highly-trained human resources to attain the highest standards in biotechnology research. The vision also anticipates important roles for NABI in creating public awareness about the benefits and safety of the new technologies and in promoting policy advocacy at appropriate fora. It is envisaged that, NABI would provide multiple innovative biotechnological solutions and inventive products in agriculture and food sector. These products would include biofortified crop varieties with better nutritional qualities like improved micronutrients, vitamins, minerals and antioxidants and reduced anti-nutrients, improved shelf life of fruits/food products, health foods, nutraceuticals, new technologies and industrial processes.



# NATIONAL AGRI-FOOD BIOTECHNOLOGY INSTITUTE



# OD STITUTE

## NABI

National Agri - Food Biotechnology  
Institute (NABI) was established

as an autonomous institute, under the aegis  
of the Department of Biotechnology, Ministry  
of Science and Technology, Government of India.

Punjab government allotted 35 acres of land for its  
establishment in the Knowledge City at SAS Nagar (Mohali),  
Punjab. Further, it was registered under the Societies Registration  
Act, 1860 (XXI of 1860), on 27th November 2009. The institute was  
established to catalyze the transformation of agri-food sector in India  
and provide innovative and tangible solutions to the major scientific and  
technological problems in the areas of agriculture, food and nutrition and their  
interface like inadequate household food and nutritional security, malnourishment,  
high post-harvest losses, and limited processing capacity that the country is facing.

# VISION, MISSION & GOALS



## VISION

Food and nutritional security for all through agri-food biotechnology research and innovation

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## MISSION

To be a centre of excellence and provide leadership in agri-food biotechnology research

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## GOALS

Improving nutritional quality and availability of affordable agri-food and food products through innovations



# OBJECTIVES

1. To emerge as a centre of excellence in agri-food biotechnology research and innovation
2. To develop and employ biotechnological solutions for improvement of availability and nutritional quality of food and food products
3. To use biotechnology for reducing post-harvest losses and value addition
4. To build public-private partnership for up scaling and out scaling of biotechnological innovations
5. To provide support on policy advocacy and public awareness concerning agri-food biotech products and their regulatory aspects
6. To emerge as the primary centre for capacity development in the area of agri-food biotechnology

# CHALLENGES

- NABI faces a highly competitive international food processing industry in India. Inability to make significant R&D breakthroughs and developing partnerships with local industry may result in the continuation of the status quo.
- Lack of desired response from end users (local agri-food industries, farmers and medical fraternity) to the products developed by NABI may compromise its importance as lead national agri-food R&D centre.
- The diversity of NABI's programs while being its strength makes it a challenge to achieve all round high performance. Also, several of these overlap with similar programs operating at other agricultural R&D institutions. Inability to develop inter-institutional linkages and collaborative activities may lead to underperformance and duplication.



# OPPORTUNITIES

- With its unique mandate and expertise, NABI has the potential to emerge as a leading national institution in the area of agri-food biotechnology.
- Joint startups in the area of innovative food products, processing and management technologies can be initiated.
- With its well-trained research and technical staff, NABI can contribute in a major way to human resource development in agri-food biotechnology at national level.
- NABI can provide sustainable leadership as a nodal centre for agri-food policy, outreach and communication with farmers.
- NABI can form a meaningful bridge between agri-food producers and agri-food processing industries.
- NABI can build collaboration and partnership with national and International researchers in the areas of agri-food biotechnology.

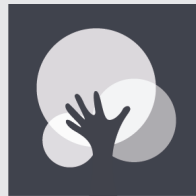


# IMPLEMENTATION STRATEGY

NABI vision will be implemented following 3 R principles;  
Research and development,  
Resource generation and Reach to community.



Research and  
Development



Resource  
Generation



Reach to  
Community



# RESEARCH AND DEVELOPMENT

Based on agri-food and nutrition issues at the national levels, NABI has identified programs at the inter-phase of agriculture, food and nutrition;

## AGRICULTURAL BIOTECHNOLOGY

- Development of designer crops with high nutrition, increased shelf life and processing quality
- Genomics and computational biology for marker and gene discovery
- Basic biology for crop improvement

## FOOD AND NUTRITIONAL BIOTECHNOLOGY

- Functional foods and nutraceuticals for better health
- Food and GM crops biosafety
- Nutrigenomics for health and human welfare
- Post-harvest biotechnology for value addition, increasing shelf life



Fig 2 : Implementation of NABI vision through research and development

# FLAGSHIP PROGRAMS

Flagship programs are the main thrust of the institute's developmental policy. Initially, two research and development programs are being proposed, that can be further expanded for attaining vision, mission and goals. These programs will address the important national challenges through intra- and inter institutional partnership.

## FLAGSHIP PROGRAM 1:

### Bio-fortification of crop plants for alleviating micronutrients and protein malnutrition

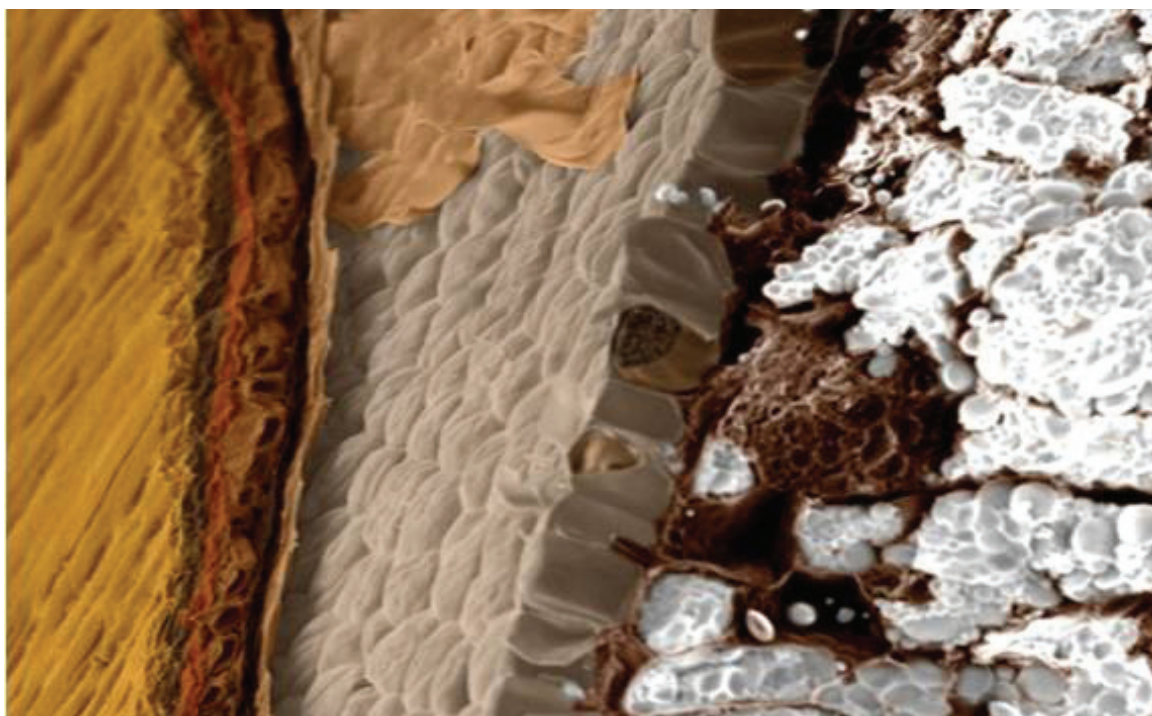
Bio-fortification of crop plants is a major research area with the potential of impacting food accessibility and improving nutritional and processing quality through the use of biotechnology and novel breeding approaches. It is considered to be better than fortification due to easy implementation, cost effectiveness and outreach. NABI will implement bio-fortification for micronutrients (e.g., iron, zinc, calcium, and selenium), vitamins (e.g., provitamin A and D), improve resistant starch and dietary fibers and reduce anti-nutrient in crops. Also, protein malnutrition problem is widespread in India and efforts are needed to address this concern. Staple crops like rice and wheat has low protein content and legumes and pulses such as Pigeon pea (Tur dal), Chickpea (Chana dal), Black gram (Urad dal) Moong bean (Moong Dal) and lentils have high protein content but lack quality and are marked by the presence of anti-nutrients (protease inhibitors, lipoxygenase, beany-flavour, neuro excitatory amino acid BOAA). Food processing adds value to the raw food materials by converting them into edible products with improved palatability, enhanced bioavailability, nutritional value and shelf-life. NABI will utilize different biotechnological approaches to develop designer crops with enhanced nutritional and processing quality, protein content and quality. Using biotechnology approaches, we have selected wheat and banana for genetic manipulation for improved quality. Similar strategies will be used in other crops like rice, pulses and minor millets.

We have selected wheat and banana as our first two crops which can be extended to other crops like rice, pulses and minor millets.

## FLAGSHIP PROGRAM 2:

### Development of novel technologies for food and nutritional security

Developing technologies to limit the post-harvest food losses in farm, during transport and storage and at the consumer level will play significant role in ensuring food and nutrition security. Biotechnological research can foster new approaches that will aid in understanding molecular and physiological mechanisms of post-harvest significance (like ripening, shelf-life, seedlessness, respiration, etc.) and can be applied in addressing challenges of postharvest losses of fresh produce. Agro-waste utilization for producing high value health promoting bioactives and technologies to enhance food safety are high priority research areas of NABI. It is essential to understand the mechanisms associated with malnutrition (under-nutrition and over-nutrition) using high throughput omics technologies and to identify novel biomarkers characteristic of Indian population and use them as diagnostic, preventive or therapeutic targets. Alternate and safe approaches (functional food, nutraceutical and nano-ceutical) to alleviate the malnutrition associated complications for a healthy living are essential. NABI will develop novel technologies to address these issues.



Scanning electron microscopy image of wheat seed showing outer seed coat, aleurone layer and endosperm

# ONGOING PROGRAMS

NABI has initiated multiple intramural and extramural projects which will complement and supplement its vision, mission and goals to achieve household food and nutrition security in India. The ongoing programs include improvement of processing and nutrition quality in wheat, addressing under- and overnutrition and chronic non-communicable diseases through food and bioactive based research, addressing post-harvest management and value addition concerns through innovative technologies, generating advanced technology platforms, capacity building and outreach.

# ACTIVE COLLABORATION

NABI is in strong partnership with its sister and common campus institute, Centre of Innovative and Applied Bioprocessing (CIAB). Indeed the two institutes constitute an agri-food partnership with respect to not only sharing facilities, but also with respect to active research and development collaborations and synergy. NABI is an active member of the group of institutions making Chandigarh Region Innovation and Knowledge Cluster (CRIKC). CRIKC would endeavour to foster and sustain close academic alliances between institutions of higher education and research in the Chandigarh region. NABI has also signed MOUs or has active research collaborations with following national and international institutes:

## National

- Post Graduate Institute of Medical Education and Research, Chandigarh
- National Institute of Pharmaceutical Education and Research, Mohali
- Indian Institute of Scientific Education and Research, Mohali
- Panjab University, Chandigarh
- Punjab Agriculture University, Ludhiana
- ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana
- Indian Institute of Technology, Ropar
- Indian Institute of Wheat and Barley Research, Karnal
- National Research Centre for Litchi, Muzaffarpur
- I. K. Gujral Punjab Technical University, Jalandhar
- Central University of Punjab, Bathinda
- Guru Jambheshwar University, Hisar

## International

- Queensland University of Technology (QUT), Brisbane, Australia
- National Institute of Agriculture Botany, Cambridge, UK
- Sheffield Hallam University, Sheffield, UK
- National Research Council, Plant Biotechnology Institute, Saskatoon, Canada
- Genome Prairie, Saskatoon, Canada

# FUTURE/PROSPECTIVE COLLABORATIONS

In addition to ongoing collaborations, newer strategic National partnerships will be developed along the way with leading institutions (e.g. IARI and other ICAR institutions, NIN, CFTRI, CDRI, NIFTEM, IIPH, NBPGR, medical institutes) having similar goals and objectives. Also, International collaboration with organizations having similar vision and mission (e.g. CGIAR, HarvestPlus, WHO) will be harnessed.

# RESOURCE GENERATION

Human resource development through:

- Training and skill courses in advanced technologies
- Academic courses at different levels (post graduate, doctorate and post doctorate)
- Meeting and courses for short term trainees, junior and senior research fellows, research associates, post-doctoral fellows, and project scientists to enhance the quality of higher education and research and prepare them to take up new and complex challenges
- Development of facilities for learning through technologies such as blended online, paper based and face to face learning and interactive video teaching
- NABI will be involved with the national institutional partners to initiate scientist exchange and sandwich courses for manpower training, education and research at the inter-phase of agriculture, food and nutrition
- Generation of products, technologies, Intellectual Property Rights (IPRs)
- Involvement in up scaling of agri-food biotech innovations and event organization
- NABI will act as affordable incubator, provide workspace resources, training and networking opportunities to public as well as private startups and small businesses in the areas of interest of its vision and mission

# REACH TO COMMUNITY

NABI will develop a strong outreach program as mentioned below:

- Technology development and industrial incubation
- Technology transfer under public-private- partnership mode
- To conduct “Scientist-Farmers-Industry” meet

- Organization of Awareness program on “Agri-Food Biotech for human welfare”
- To conduct visits of School Children’s to NABI labs
- NABI will act as think-tank of DBT for policy advocacy on the issues related to regulatory aspects, GM technology, biosafety, bio-security etc.

## EPILOGUE

NABI is committed to providing leadership in a demand-driven biotechnology-led research at the interface of agriculture, food and nutrition for improving food and nutrition status of Indian population. The Institute understands that the path of food and nutrition security is dependent on the enhancement of nutritional composition of produce using biotechnological measures, prevention of post-harvest food losses, answering the challenge of burden to human lives, economics and productivity due to undernutrition and life style disorders, stringent food/GM safety regulations and their implementation. Biotechnological interventions for pre- and post production for food and quality related innovations in agriculture and food sector can provide sustainable and meaningful answers for these. VISION-2030 is based majorly on biofortification, quality processing and post-harvest improvement of food crops, and development of functional foods to mitigate malnutrition, human resource development, social outreach and policy advocacy. The Institute would utilize and share requisite modern research facilities and professional manpower with other national and international agencies/institutions working for the cause of food and nutrition security in India. Continuous collaborative efforts would be made for time bound completion of projects. By 2030, NABI will be able to provide multiple biotechnological and innovative products in agriculture and food sector, which will aim at household food and nutritional security and a step closer to sustainable development goals.



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