

# ENHANCED PRESERVATION OF FRUITS USING NANOTECHNOLOGY

“GREEN NANOTECH” DELIVERS NATURAL WAY TO EXTEND HARVESTS AND SHELF LIFE FOR MANGOES AND OTHER FRUITS

## WHAT CANADIAN AND INTERNATIONAL COLLABORATORS DISCOVERED:

- ✓ Eco-friendly, affordable, and easy-to-use technologies that extend harvests and the shelf life of a wide variety of fruits and vegetables grown in tropical and temperate climates
- ✓ Improved resistance to diseases and pests in treated fruit
- ✓ Increased incomes for smallholder farmers from higher yields, better control of harvest and ripening, and improved fruit quality (e.g., colour, size, freshness)

## BY THE NUMBERS

- More than 12,000 farmers in India have adopted the Enhanced Freshness Formulation (EFF), which contains hexanal as an active ingredient; 80% reported benefiting from the delayed harvest and increased income
- Post-harvest losses to distant markets reduced by 10-12% in EFF sprayed fields
- Increased incomes of 10-15% (an additional to CAD\$494/hectare) among participating farmers; 51% of farmers fetched a premium price in the market for mango and banana in India
- 9 biodegradable nanotechnology solutions developed, tested, and proven to enhance the shelf life irrespective of the crop, variety, and location of the produce (demonstrations in 6 countries with 15 types of fruits). Among the results:
  - Pre-harvest sprays extended shelf life for mango (14-21 days), guava (5-6 days), and grapes (4-5 days), and retained fruits on trees longer (14-21 days)
  - Post-harvest dipping extended shelf life of bananas, mango, and papaya (12-18 days), and decreased disease incidence by 80%
  - The vapour form of hexanal (stickers, wrappers, and sachets) extended shelf life of mango and banana during transport (12-18 days)
- In India, pre-harvest spray in mango reached 14,164 hectares
- Huge quantities of fruit can be treated by smallholder farmers in 5 minutes, making adoption easy
- 7,245 farm advisory services provided (32% women)
- 44 value-added training provided to 1109 farmers (83% women), which resulted in additional income of CAD\$384 per hectare and 35% of the women becoming small entrepreneurs
- More than 2,000 model mango farms in India established to disseminate the technologies
- 2 patents for the hexanal smart delivery system (HSDS) filed in India

## THE IMPACT:

Thousands of smallholder farmers now have a natural and affordable way to reduce post-harvest losses from mangoes and other nutrient-rich fruits. Field trials using pre-harvest sprays and post-harvest dip applications of hexanal demonstrated two main benefits of the technology: its ability to retain fruits on trees longer, especially mango, and a longer shelf life, especially for banana. These innovations improve supply management by extending the growing and marketing season. This helps to prevent market glut, which enables farmers to sell their produce at a higher price. A



longer growing and marketing season has also increased employment, primarily for women who are involved in production and post-production activities (e.g., harvesting, sorting, packing, vending, and accounting). EFF has been added as a highly recommended practice to mango growers by the State Department of Agriculture in Tamil Nadu, India. Private sector companies and Tamil Nadu Agricultural University are working to commercialize hexanal products making them more readily available for small-scale farmers. Hexanal formulations have been authorized for commercialized by the private sector in Sri Lanka. The project's success has led thousands of small-scale farmers to request this safe and ecofriendly product, which evaporates within 24 hours, leaving no trace in the fruits.

## THE CHALLENGE

One of the biggest untapped business opportunities in agriculture is post-harvest losses—30-35% in Asia, particularly India and Sri Lanka; 80-85% in Africa; 15-20% in USA and Canada; and 25% in Europe. Fruits and vegetables are among the most highly perishable produce due to their tenderness. Previous methods to increase post-harvest shelf life and quality have had limited success and have not been economically and technologically viable for small-scale growers and packers. Canadian researchers and international collaborators have come up with a solution. They discovered that a key enzyme called phospholipase D (PLD) triggers the onset of membrane deterioration, which accelerates ripening. Further research led to the discovery of a bioactive molecule produced by plants, called hexanal, that significantly inhibits the action of PLD. Based on these discoveries, scientists from six countries (Tanzania, Kenya and Trinidad and Tobago in addition to India and Sri Lanka) developed and tested a package of nanotechnologies on fruit crops. Prototypes were then developed that could deliver hexanal at very small doses and in a sustained manner using 'green nanotechnology'. The next challenge is to scale up these solutions.

## TRANSLATING RESEARCH INTO ACTION

### Improving access to, and adoption of, improved agricultural solutions

*"Not only are my mangoes shinier, more colourful and sweet, but in addition, I can store them in my warehouse at room temperature for seven to 10 days longer without damaging them..."*

*For one rupee spent on EFF, my income increases by six rupees."*

*Madhavan, Farmer, Krishnagiri district, India*

- EFF technology produced approximately 5 kg of more fruit per tree, and delayed the harvest for about two weeks, which generated CAD\$280 in additional income for farmers.
- Post-harvest dipping of banana in EFF extended shelf life up to 2 weeks under ambient and 4 weeks under cold storage conditions, resulting in 15% fewer fruits being rejected at the pack houses.
- Continued availability of fruits for an extended time, because of EFF (spray or dip), resulted in 12-17 days of additional employment during each cropping season, especially for women.
- Farmers who were reluctant to grow highly perishable fruits like mango and banana are beginning to rethink and expand fruit growing as a result of EFF.
- In addition to EFF spray, farmers on 2,000 model farms have been trained to use nets and hooks to harvest fruits to minimize losses related to falling and bruising.
- In India, 3 Village Knowledge Resource Centers were established to train farmers on Good Agricultural Practices, EFF, collective marketing, and the formation of model farms.

### Improving access to resources, markets, and income

*"Banana stem are a problematic agricultural waste product in our banana plantations.*

*Utilizing this as a raw material product and adding value to this waste not only resolves an environmental problem but also provides employment and income-generating opportunities*

*for women in banana producing areas.”*

*Mr. L.V. Randika Sanjeewa, Trainee Supervisor at Venture Industries (Pvt) Ltd., Embilipitiya, Sri Lanka*

- Sri Lankan farmers trained on banana cultivation and fibre production to generate additional income CAD\$370/hectare from banana fibre paper production – an ecofriendly alternative to Styrofoam used to protect fruits during storage and transport.
- Training provided to farmers, mostly women, on the commercial production of value-added products of mango, including pickles, chips, powders, bars, and jams.
- In Trinidad and Tobago, EFF spray allowed farmers to stagger harvesting times of papaya, which enabled them to better manage their harvesting time and labour availability.
- Higher yields are opening new export opportunities for fruit, particularly for farmers in India, Kenya, and Tanzania.
- A Canadian company, Smart Harvest, developed a business model and signed a Memorandum of Understanding with Tamil Nadu Agricultural University in India to commercially produce and distribute EFF at scale in India. In Sri Lanka, Hayleys Agriculture Pvt. Ltd. received Department of Agriculture clearance to launch their EFF products (Tree Fresh Formulation and Biowax) in March 2018.

### Informing policy

- EFF was incorporated into a state policy in Tamil Nadu, India.
- 160 registrants from 17 countries participated in a webinar on the project, organized by the Canadian chapter of the Inter-American Institute for Cooperation on Agriculture.
- Presentations made to diplomats and policymakers from several countries (e.g., UN General Assembly event, Trinidad and Tobago, Tanzania, Kenya).

### WHAT'S NEXT?

EFF is on track to be commercially available in India and Sri Lanka in 2018-19, with Canada and the United States expected to follow in late 2019 or 2020 once regulatory hurdles have been cleared. Regulatory approvals in Africa are expected to take longer as more data and a suitable partner are required. Patents have been filed in India for hexanal-impregnated nano-sachets and nano-stickers. Once issued, the technology will be commercially produced and made available to packers in India and other countries. Biowax has been approved and is expected to be commercially available in Sri Lanka in 2018. Uptake among farmers and packers in India is conservatively estimated to reach 100,000-150,000 once EFF products are widely available. Discussions have begun with prospective buyers in Canada for electrospun wrappers.

### LEARN MORE ABOUT THIS PROJECT:

Project abstract: <https://www.idrc.ca/en/project/enhanced-preservation-fruits-using-nanotechnology-cifsr-phase-2>

Research in action: <https://www.idrc.ca/en/research-in-action/enhancing-fruit-preservation-nanotechnology>

### KEY OUTPUTS

#### JOURNAL ARTICLES:

Special Issue: Journal of Tropical Agriculture: Volume 95 Special Issue 1, June 2018: *Enhanced Preservation of Fruits Using Nanotechnology*,. Includes 12 original articles. <https://idl-bnc-idrc.dspacedirect.org/handle/10625/57171>

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Hewajulige, I.G.N., Wilson Wijeratnam, R.S., Gunethilaka, R.M.S.I., Gunesekara, M.M.N.P., Perera, M.G.D.S., Paliyath, G. and Jayasankar, S. (2018). *Pre-harvest 'Tree Fresh' spray treatment reduces disease incidence and extends the harvesting season of 'TJC' mango grown in Sri Lanka*. Acta Hort. 1201, 49-54 <https://doi.org/10.17660/ActaHortic.2018.1201.8> .

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Krishna Kumar, S., El Kayal, W., Sullivan, J. A., Paliyath, G., Subramanian, J. (2018) *Pre-harvest application of hexanal formulation enhances shelf life and quality of 'Fantasia' nectarines by regulating membrane and cell wall catabolism-associated genes*. Scientia Horticulturae 229:117-124. <http://dx.doi.org/10.1016/j.scienta.2017.10.031>  
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El Kayal, W., Paliyath, G., Sullivan, J.A., Subramanian, J.(2017) *Phospholipase D inhibition by hexanal is associated with calcium signal transduction events in raspberry*. Horticultural Research, <https://www.nature.com/articles/hortres201742>.

## BOOK

*Biosafety of hexanal*. (2015) Gunasekaran, K.; Karthika, S.; Nandakumar, N.B.; Subramanian, K.S.; Paliyath, Gopinadhan; Subramanian, Jayasankar. <https://idl-bnc-idrc.dspacedirect.org/handle/10625/57313>

## PRESENTATIONS

Subramanian J, *Webinar by IICA* on October 20,2016 <http://www.iica.int/en/events/affordable-natural-product-extend-fruit-shelf-life>

## VIDEO

IDRC (2018) Reducing post-harvest losses through nanotechnology. <https://youtu.be/IFlmizUkdJE>

## VIEW ALL RELATED PROJECT OUTPUTS IN THE IDRC DIGITAL LIBRARY

<https://idl-bnc-idrc.dspacedirect.org/browse?type=project&value=107847>

## QUICK FACTS

**Project location(s):** India, Kenya, Sri Lanka, Tanzania, Trinidad and Tobago

**Institutions:** University of Guelph (Canada); Tamil Nadu Agricultural University (TNAU) (India); Industrial Technology Institute (ITI) (Sri Lanka)

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