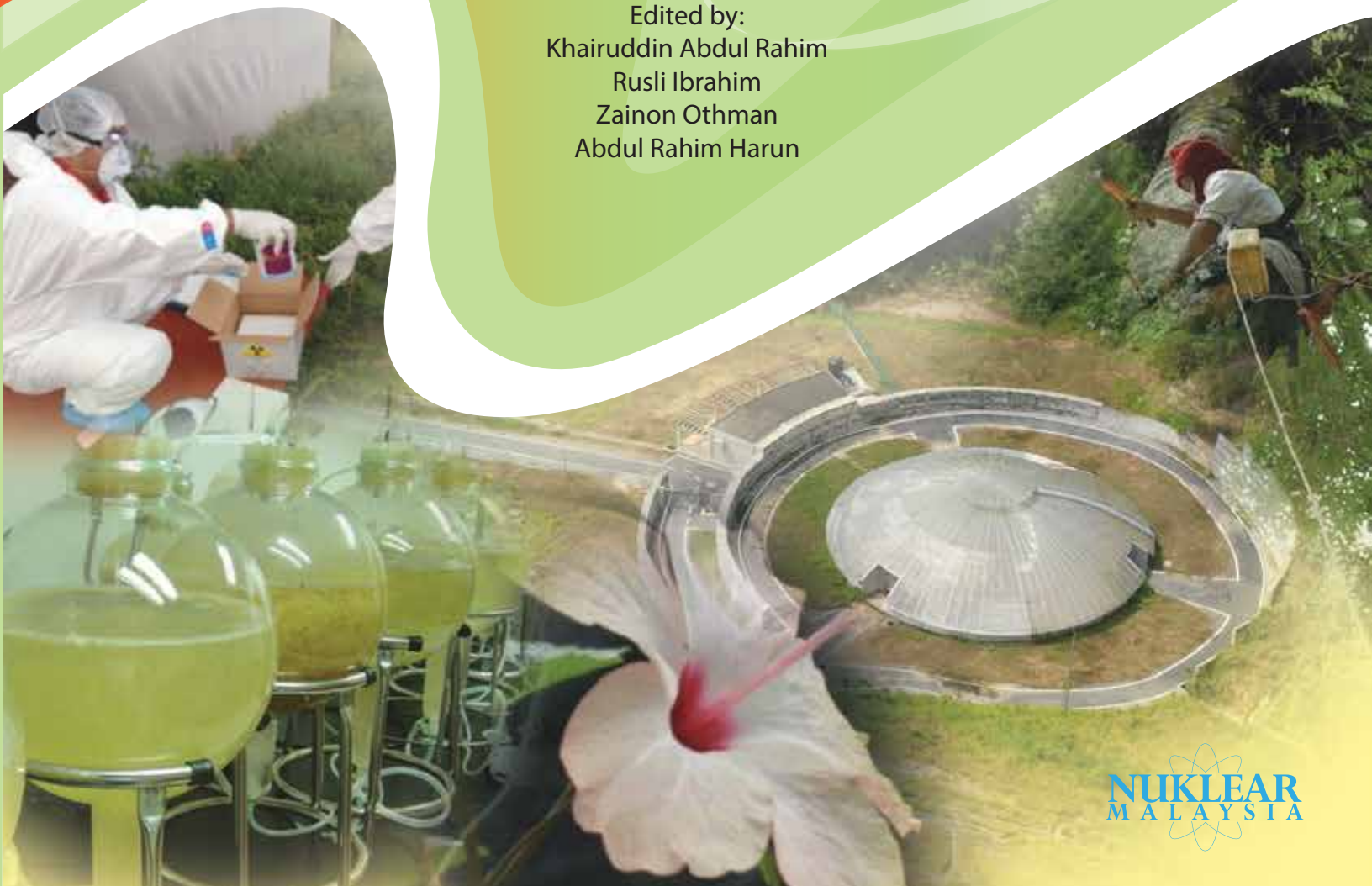
A Compendium of

R&D on NUCLEAR TECHNOLOGY APPLICATIONS

in Agriculture & Biosciences

1984–2014

Edited by:
Khairuddin Abdul Rahim
Rusli Ibrahim
Zainon Othman
Abdul Rahim Harun



NUKLEAR MALAYSIA

A Compendium of

R&D on Nuclear Technology Applications in Agriculture and Biosciences (1984-2014)

Editors

Khairuddin Abdul Rahim, Rusli Ibrahim, Zainon Othman, Abdul Rahim Harun

Authors

Abdul Rahim Harun, Affrida Abu Hassan, Ahamad Sahali Mardi, Ahmad Nazrul Abd Wahid Ahmad Zainuri Mohd Dzomir, Azhar Mohamad, Chong Saw Peng, Jong Bor Chyan, Khairuddin Abdul Rahim, Mat Rasol Awang, Mohd Fajri Osman, Mohd Zaidan Kandar, Norazlina Noordin, Norimah Yusof, Nur Humaira' Lau Abdullah, Pauline Liew Woan Ying, Phua Choo Kwai Hoe, Ros Anita Ahmad Ramli, Rosnani Abdul Rashid, Rusli Ibrahim, Salahbiah Abdul Majid, Salmah Moosa, Seri Chempaka Mohd Yusof, Shaiful Azuar Mohamad, Shakinah Salleh, Shyful Azizi Abdul Rahman, Sobri Hussein, Tengku Ahbrizal Farizal Tengku Ahmad, Zainon Othman, Zaiton Ahmad

Publication Advisor

Iberahim Ali

Publication Coordinator

Sakinah Ariffin

Publication Officer

Normazlin Ismail

Graphics & Layout Designer

Marizan Mahmud

FOREWORD FROM THE DIRECTOR GENERAL

The great collective effort by the writers of "Compendium of R&D on Nuclear Technology Applications in Agriculture and Biosciences (1984-2014)" is highly commendable, commemorating the works by Malaysian Nuclear Agency (Nuclear Malaysia) scientists spanning three decades. When Nuclear Malaysia was established in 1972, at the time known as Pusat Penyelidikan Atom Tun Ismail (PUSPATI), it was for the planning and development of the country's nuclear power programme. However, with the realignment of PUSPATI's function when oil and gas were discovered in the waters of Malaysia, thus changing the face of the country's energy sector, the focus of the institution becomes nuclear technology applications in the various socio-economic sectors, such as industry, healthcare and environment, as well as agriculture and the life sciences.

The International Atomic Energy Agency (IAEA) has given much support over the years to Malaysia, through various programmes including the Technical Cooperation Programme, to build the country's capacity in R&D and human capital development in nuclear application, enabling Nuclear Malaysia to be at the forefront on its own right, and currently providing technical support and expertise in various fields to other developing countries. From studies conducted the world over we have been shown proven records where nuclear technology have indeed increase world agricultural production.

It is indeed an honour when Malaysia, through Malaysian Nuclear Agency, was accorded international recognition when it became a recipient of the FAO/IAEA Achievement Award in Mutation Breeding in 2014. This shows that the outputs of scientists from Malaysia have standing in the realm of nuclear science and technology in the agriculture sector, contributing to certain measures of knowledge generation, wealth creation and societal wellbeing.

It is hoped that this book will enlighten readers on the uses of ionising radiation and isotopic tracers in agriculture, and together with researchers from various institutions our own pool of researchers have worked together for the common cause to elucidate the unknown and help solve common problems faced by the agriculture sector. While this treatise enriches our knowledge it is also our fervent hope that the findings from the three decades of R&D will be of greater use, viz. taking R&D from the laboratories to the market, reaching the right users, especially the communities.

Thank you and best wishes.

Dato' Dr. Muhamad Lebai Juri
Director General
Malaysian Nuclear Agency
Ministry of Science, Technology and Innovation Malaysia

2014

FOREWORD FROM THE DEPUTY DIRECTOR GENERAL (RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAMME)

The “Compendium of R&D on Nuclear Technology Applications in Agriculture and Biosciences (1984-2014)” is but one example of Knowledge Management (KM) in motion. In it are embedded the elements of identifying, capturing, evaluating, retrieving, and sharing of information assets of Malaysian Nuclear Agency (Nuclear Malaysia). These assets include databases, documents, procedures, and previously uncaptured expertise and experience in individual workers, including those that have left this agency.

If one were to analyse the compendium as a whole one would realise that the elements of lessons learned or best practices, expertise location and harnessing of the community of practice, are being utilized optimally. Key personnel who have left the agency, either through retirement or moving to new institutions or enterprises have been consulted for verification of data and for enhancement of the quality of information presented. The time taken may be long but this has to be done if the desired standard is to be achieved.

International recognition on the contribution of Malaysia in the advancement of nuclear technology in agriculture, including in mutation breeding of crops, is embedded in this publication; the role of Nuclear Malaysia as the “game changer” is evident from the various achievements.

I must congratulate the writers and contributors to this publication for their sheer dedication and commitment. Their determination to ensure information and knowledge are preserved, appreciated and perpetuated are indeed commendable, thus, manifesting that KM is here to stay.

Best wishes.

Thank you.

Dr. Muhd Noor Muhd Yunus
Deputy Director General (Research and Technology Development Programme)
Malaysian Nuclear Agency
Ministry of Science, Technology and Innovation Malaysia

2014

PREFACE FROM THE EDITORS

This publication is a compendium of R&D outputs by Malaysian Nuclear Agency (Nuclear Malaysia) researchers in the areas of agriculture and biosciences, spanning 30 years, since early 1980s. Central to these R&D activities are the utilisation of nuclear technologies as research tools, viz. application of ionising radiation and isotopic tracers, and utilisation of nuclear instrumentation to generate new variants, elucidate pathways and fate of agrochemicals or to analyse biological and chemical compounds. Nuclear techniques have long been used by scientists worldwide in the areas of crop varietal improvement, through radiation mutagenesis; food and agricultural produce irradiation for prolonging shelf-life and phytosanitary measures; agromanagement systems for higher productivity through efficient management of soil, water and agricultural inputs; radiation modification of biopolymers for healthcare and agroindustrial application; and radiation biology at cellular up to biotic ecosystem levels.

The R&D outputs reported here are products, including mutant varieties of food crops, fruit trees, ornamental plants, and also herbal plants and forest species. Other outputs are processes, procedures and technologies developed through R&D. Another important facet of R&D is publication, and where available awards received and other recognitions are listed too.

It is hoped that this compendium will be a source of reference to research scientists, not only within Nuclear Malaysia but to peers outside, too, especially when intending to embark on new research involving nuclear technology in agriculture and the life sciences.

Our heartfelt thanks to all contributors to this publication. It is our hope that the efforts of all contributors will become a legacy that brings benefit to many.

Editors
Khairuddin Abdul Rahim, Ph.D.
Rusli Ibrahim, Ph.D.
Zainon Othman, Ph.D.
Abdul Rahim Harun, Ph.D.

Division of Agrotechnology and Biosciences
Malaysian Nuclear Agency (Nuclear Malaysia)
Ministry of Science, Technology and Innovation Malaysia

2014

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RICE - MA03 ('TONGKAT ALI')

RESEARCH TEAM

Leader:	Ramli Othman, Dr
Members:	Rusli Ibrahim, Dr Mohd. Nazir Basiran, Dr Chi Gek Lan, Dr Mohd. Farazi Johari, Dr Abdul Rahim Harun, Dr Asnah Hassan Rokiah Abas Shuhaimi Shamsudin Othman Abu Sari Khairuddin Abdul Rahman Rossalim Jaafar Omar Masiran
Collaborators:	Kamaruddin Dahuli (MADA) Mohamad Osman, Dr (MARDI)
Year:	1985-1990

SYNOPSIS

The first application of nuclear technology in mutation breeding for the improvement of rice was conducted in 1984 for a Coordinated Research Programme under RCA/IAEA/FAO entitled 'Semi-Dwarf Mutants for Rice Improvement in Asia and Pacific'. The main objectives were to generate semi-dwarf mutants in both traditional and improved varieties as new mutant varieties or as potential parents in cross breeding programme. Within 5 years, 101 semi-dwarf mutant lines have been identified. Twenty-nine of the semi-dwarf mutant lines had grain yield of 6,000-7,300 kg/ha which were higher than the parent variety, Manik, which yielded 5,700 kg/ha thus classified as potentially good yielding mutants. Forty-seven mutant lines had grain yields of 5,000-6,000 kg/ha and 25 mutant lines yielded in the range of 4,300-5,000 kg/ha. Twelve mutant lines were resistant to brown plant-hopper (BPH) but only one mutant line, ML15, had high grain yield of 6,300 kg/ha, which was better than the parent. One of the most striking effects of gamma irradiation was the production of glutinous rice (Manik 817) with both good yield and head recovery. It is also interesting to note that one of the mutant lines (MA03) showed a drastic change in its characteristics and performed better than the parent and other mutant lines. MA03 was popularly known as rice mutant 'Tongkat Ali' because of its outstanding agronomic traits with erect panicle even after grain-filling, had strong culm and resistant to lodging. This mutant 'Tongkat Ali' was not officially released; however, it has been planted on a fairly large scale by several farmers especially in the northern parts of Malaysia for several seasons. Although high yielding, MA03 had rounded grains, a trait less favourably accepted by local consumers.

'Tongkat Ali' mutant rice (MA03) with erect panicles

Grower of 'Tongkat Ali' mutant rice in Kedah

Demonstrating Mutant Germplasm to the Minister of MOSTE

Demonstrating Mutant Germplasm to the Deputy Minister of MOSTE

COMMERCIALIZATION STATUS

101 semi-dwarf mutant lines generated from this project have been deposited at Seed Bank in MARDI Research Station, Bertam, Seberang Perai. These mutant lines have potential as commercial planting materials and as genetic materials for cross-breeding programme.

OTHERS

Related project:

- Semi-Dwarf Mutants for Rice Improvement in Asia and Pacific; RCA/IAEA/FAO Coordinated Research Programme.

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

RICE - MR219-4 AND MR219-9

RESEARCH TEAM

Leader:	Abdul Rahim Harun, Dr
Members:	Rusli Ibrahim, Dr Sobri Husein, Dr Khairuddin Abdul Rahim, Dr
Collaborators:	Abdullah Mat Zin, Hj (MARDI) Marziah Mahmood, Prof (UPM) Sariam Othman, Dr (UPM)
Year:	2003-2006

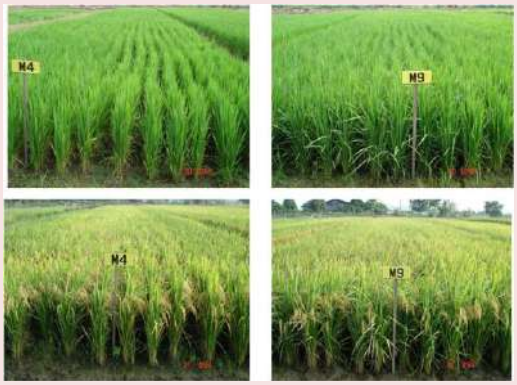
SYNOPSIS

Mutation induction project was started in 2008, whereby seeds from popular local variety MR219 were irradiated with 300 Gy using gamma rays. Main objectives were to screen and select for potential mutant lines suitable for minimal water condition with improved agronomic traits such as high yielding and resistance to blast disease. M_2 generation was screened for water stress under simulated non-flooded water regime under glasshouse and field conditions to identify superior genotypes for minimal water requirement. A total of 55 potential mutant lines have been evaluated at M_4 generation, of which 38 have been selected for having high percentage of grain filling. However, only two potential lines designated as MR219-4 and MR219-9, were selected at the later stage, in M_7. The lines were evaluated under replicated yield trial in KETARA under normal flooded conditions. In KETARA, the yields of MR219-4 and MR219-9 were 4.8 t/ha and 5.5 t/ha, respectively, as compared to the 5.8 t/ha of the original variety MR219. The lines have been evaluated in MADA too under saturated soil and flooded conditions. The yield obtained for MR219-4 was 5.9 t/ha under saturated soil condition and 7.2 t/ha under flooded condition. For MR219-9, the yield was 6.8 t/ha and 6.1 t/ha under saturated and flooded condition, respectively. The lines also performed satisfactorily when grown under aerobic soil condition in MARDI Seberang Perai. Grain yield as high as 6.3 t/ha for MR219-4 and 3.4 t/ha for MR219-9 were achieved under aerobic condition. Efforts had been geared in collaboration with MARDI, UPM and DOA to register these mutant lines as new varieties.

Glass house screening of rice mutant lines

Field screening of rice mutant lines under simulated low water regime

Demonstrating mutant lines grown under aerobic condition



Demonstrating mutant lines MR219-4 and MR219-9

AWARDS

- Nuclear Malaysia Innovation Day 2011 – MR219-4, An Efficient Water Use Mutant Developed Through Mutation Breeding - Gold Medal.
- BioInnovation Awards 2011 - MR219-4, An Efficient Water Use Mutant Developed Through Mutation Breeding - Gold Medal.
- UMT Research Day 2011 – An Efficient Water Use Mutant Developed Through Mutation Breeding - Gold Medal.
- Pencipta 2011 – An Efficient Water Use Mutant Developed Through Mutation Breeding – Silver Medal.

COMMERCIALIZATION STATUS

Seeds of mutant lines of MR219-4 and MR219-9 have been deposited at Seed Bank in MARDI Research Station, Bertam, Seberang Perai. They have potential for commercial planting or as genetic materials for cross-breeding programme.

OTHERS

Related projects:

- Varietal Improvement of Irrigated Rice Under Minimal Water Condition. IRPA (01-01-03-0000/PR0068/0504).
- Development of Advanced and Promising Mutant Lines Derived from Mutagenesis of *Oryza sativa* MR219 for Drought-Tolerant, Blast Resistant and Quality Traits. Science Fund (06-03-01-SF0110).
- Applying Mutation Breeding and Optimized Soil, Water and Nutrient Management for Enhanced and Suitable Rice Production. IAEA Technical Cooperation Project MAL5029.
- Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change. IAEA Regional Project RAS/5/056.

CONTACT

Abdul Rahim Harun, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1339
Fax: 603-89112157
E-mail: rahim@nuclearmalaysia.gov.my

BANANA - ‘NOVARIA’

RESEARCH TEAM

Leader:	Rusli Ibrahim, Dr
Member:	Norimah Yusof, Dr Mohd. Farazi Johari, Dr
Collaborators	Mak Chai, Prof Dr (UM) Ho Yuk Wah (UPB) Frank Novak, Dr (IAEA)
Year:	1990-1995

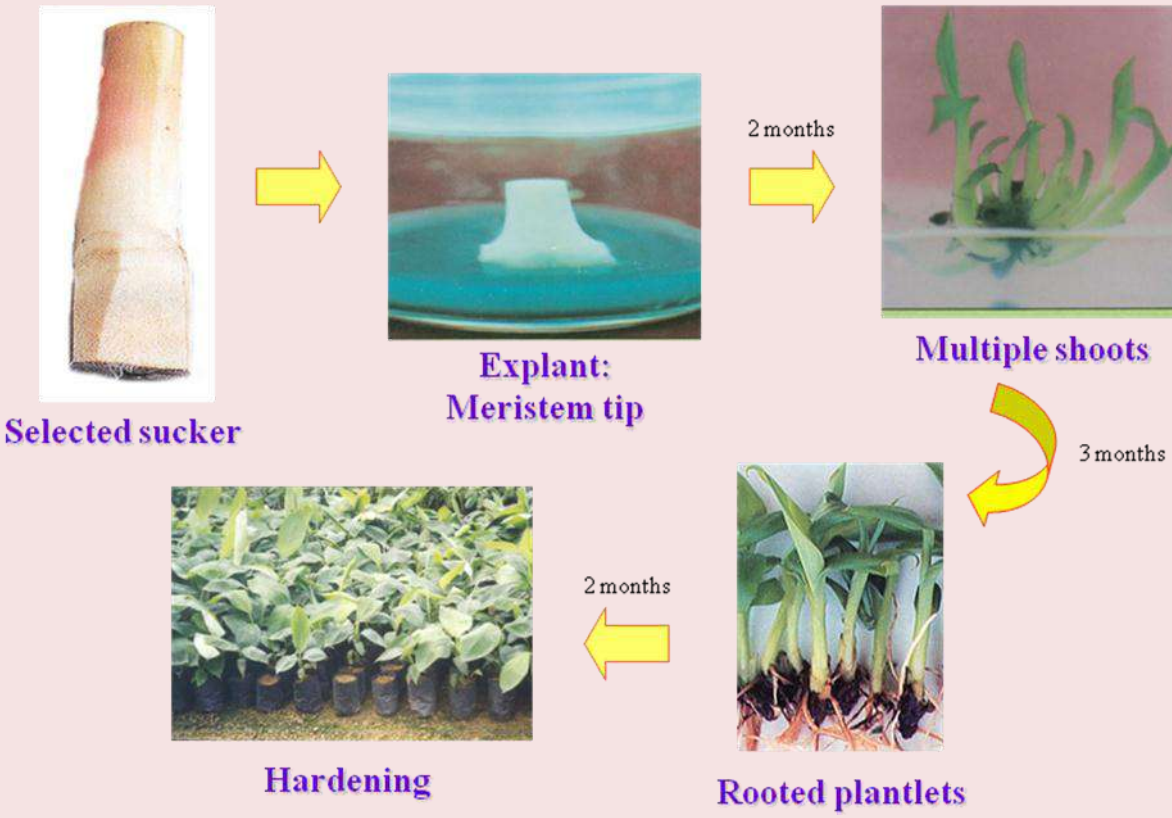
SYNOPSIS

Novaria is a banana mutant variety that originated from IAEA banana mutation breeding programme. It was officially released as a new cultivar in 1995 with improved characteristics of early flowering, short stature, high yielding with strong fruit pedicel and had good flavour and pulp texture. It was widely planted by farmers in Peninsula Malaysia, especially in Perak and also in East Malaysia in the state of Sarawak.

Meristem from original cultivar of Cavendish-type banana called Grande Nain was first irradiated with gamma rays at FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf, Austria. An early flowering putative mutant designated as 'GN-60A' was identified among the regenerated plants in the glasshouses. In vitro shoots of GN-60A clone were sent to Malaysian Nuclear Agency for field testing. With the collaboration of University of Malaya and United Plantations Sdn. Bhd., GN-60A clones were micropropagated for multiplication. Micropropagated plants of GN-60A were sub-cultured until M_1V_5 stage to minimize chimerism and they were field planted at United Plantations Sdn. Bhd. in Teluk Intan, Perak. Early flowering plants obtained in the field are tissue cultured again for further screening. In September 1993, a total of 2000 plants were planted to evaluate the performance of GN-60A in terms of earliness and other agronomic traits. From this population, a selection was made for mutated plants which flowers about 10 weeks earlier than the original parental clone, Grande Naine with other improved agronomic traits. This mutant selection was later launched under the name of Novaria in 1995. United Plantations Sdn. Bhd. produces about 200,000 per year of tissue culture plantlets and seedlings of Novaria for sale to growers in Malaysia.

Field plantation of Novaria at United Plantations Berhad in Teluk Intan, Perak

Fruit bunch of Novaria



Tissue culture technique for production of banana mutant variety Novaria

COMMERCIALIZATION STATUS

Commercial production of rooted tissue culture plantlets and seedlings in poly-bags was carried out by United Plantations Sdn. Bhd., Nuclear Malaysia's industrial collaborator in Teluk Intan, Perak. Yearly production is about 200,00 to cater for buyers from Peninsula Malaysia, Sabah and Sarawak.

OTHERS

Collaborative project with University of Malaya, United Plantations Sdn. Bhd. and International Atomic Energy Agency for ‘Screening and selection of 'GN-60A' irradiated clones for resistance to *Fusarium* wilt disease with improved agronomic traits.

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

BERANGAN BANANA

RESEARCH TEAM

Leader:	Rusli Ibrahim, Dr
Members:	Norazlina Noordin Siti Hajar Mohd. Nahar Siti Mariam Mohd. Nahar
Collaborators:	Siti Hawa Jamaluddin, Datin Dr (MARDI) Maziah Mahmood, Prof (UPM) Nor Zulaani Khalid, Prof (UM)
Year:	Phase I: 2004-2006 Phase II: 2007-2010

SYNOPSIS

Meristem cultures of popular local banana cultivar Berangan (*Musa* spp. AAA) were irradiated with gamma rays with doses ranging from 0 to 100 Gy. Based on the percentage survival of irradiated explants, LD_{50} and LD_{100} obtained were 50 Gy and 80 Gy, respectively. Using selected effective doses of 20, 30, and 40 Gy, cultures were micropropagated from M1V1 to M1V5 stage for multiplication and also to minimize chimerism. Four artificial disease screening techniques have been developed, which can be used effectively for nursery and field screening against *Fusarium* wilt disease. Three potential mutant lines tolerant to *Fusarium* wilt with improved agronomic traits such as high yield, early fruiting and short stature have been selected. These selected mutant lines need to be further tested in multi-location trials.

Establishment of effective screening techniques for *Fusarium* wilt disease

a) Dipping method: Dipping the root parts of 1-2 month old rooted in vitro plantlets in spore suspension cultures of *Fusarium* oxysporum, FOC race 4 (10 6 spores/ml) for 1-2 hours. Treated plants were transferred to sand/soil in a nursery and observe for symptoms of *Fusarium* infection.

b) Double tray method: Rooted in vitro plantlets which had been hardened for 4 weeks are planted in sterile sand media placed in a plastic tray. *Fusarium* oxysporum, FOC race 4 (10 6 spores/ml) suspension is poured into the tray containing test plants. Treated plants were watered daily and observe for symptoms of *Fusarium* infection. Excess *Fusarium* spores were collected in the second tray which is placed below the first tray.

c) Nursery screening method: Plants are hardened for 4-8 weeks in individual polybags and later transferred to tray containing coir dust which had been inoculated with *Fusarium* oxysporum (FOC race 4) for 2 weeks. Evaluation for *Fusarium* infection is done 4-6 weeks after planting.

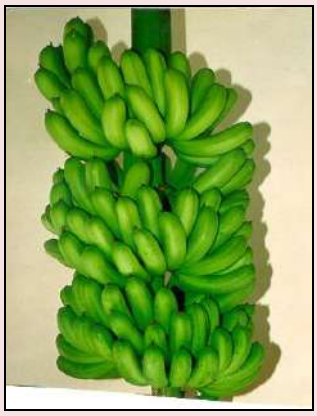
d) Field screening: Those treated plants that survived from the above screening methods are transferred to hot spot. Plants which showed signs of tolerance or resistance selected and micropropagated for further testing.

Regenerated *in vitro* shoots from meristem

Rooted *in vitro* plantlets

Hardening of rooted *in vitro* plantlets under cover for 2 months

Banana seedlings ready for field planting



Fruit bunch of pisang Berangan

AWARDS

- Malaysian Technology Expo MTE 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal and Best Award.
- BioInno Award and Bio Malaysia Exposition 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal.
- Seoul International Invention Fair 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology -Gold Medal and Semi Grand Prize Winner.
- i-Innova Expo, Universiti Sains Islam Malaysia (USIM) 2010. Synthetic Seeds - Gold Medal.
- Nuclear Malaysia Innovation Day 2002. Temporary Immersion Bioreactor for Mass Propagation of Tissue Culture - Gold Medal.
- S & T Expo 2002. Temporary Immersion Bioreactor for Mass Propagation of Tissue Culture - Bronze Medal.

COMMERCIALIZATION STATUS

Technology Transfer to Selamat Indah Sdn. Bhd. for the commercialization of tissue culture technique and bioreactor system for mass propagation of *in vitro* plantlets of banana.

OTHERS

Related projects:

- Projek Kerjasama Pengeluaran Anak Benih Pisang dan Kelapa Sawit dengan Menggunakan Teknik Kultur Tisu dan Bioreaktor. Non Disclosure Agreement No: NM BKT NDA 12/2008.
- Pengeluaran Anak Benih *In Vitro* Pisang Tanduk Menggunakan Teknik Kultur Tisu dan Sistem Bioeaktor. Memorandum of Agreement No: BKT/2012/(03).
- Improvement of Bananas for *Fusarium* Wilt Resistance and High Fruit Quality through Mutation Induction. PR IRPA 01-02-04-0000-PR0010/04-03 (2004-2006).
- Improvement of Bananas for *Fusarium* Wilt Tolerance and High Fruit Quality through Mutation Induction. FNCA Mutation Breeding Project (2007-2010).
- Pre Commercialisation of Bioreactor Technology for Mass Production of *In Vitro* Plantlets of Banana Cv Tanduk. Techno Fund TF0911B222 (RMK 10) (2012-2015).

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

GROUNDNUTS – 'KARISMA SWEET' & 'KARISMA SERENE'

RESEARCH TEAM

Leader:	Rusli Ibrahim, Dr
Members:	Abdul Rahim Harun, Dr Khairuddin Abdul Rahim, Dr Shuhaimi Shamsudin Khairuddin Abdul Rahman
Collaborator:	Faizah Abdul Wahab, Dr (RRIM)

Year:	1985-2005

SYNOPSIS

Malaysian Nuclear Agency first started a mutation breeding programme for the improvement of groundnut in 1985 under FAO/IAEA Coordinated Research Project and later funded by MOSTI under Intensified Research Priority Areas (IRPA) in 1987. Main objectives were to induce new mutant varieties resistant to *Cercosora* leaf spot disease with high yield as well as high N_2 fixation. Mutation was induced by irradiation of seeds of the original variety called Matjan with gamma rays. After a few generation of field screening and multi-location trials, two advanced mutant lines were selected with improved agronomic traits such as resistance to *Cercospora* leaf spot, high yield (5,000-6,000 t/ha) and early flowering. These two advanced mutant lines were officially launched as new mutant varieties by the Minister of Science, Technology and Innovation in 2005. The pods of KARISMA Sweet has a sweeter taste while KARISMA Serene has high N_2 fixation abilities (>70%). Seed multiplication of these two mutants has commenced and seeds have been distributed to the farmers, especially in Kelantan for large-scale planting as part of the initiatives by the government to identify potential alternative crops to replace tobacco. Preliminary study has identified groundnut as one of the potential crops for cultivation under BRIS soil and in addition there is a high demand for groundnuts in Malaysia.

Seeds of Karisma Sweet and
Karisma Serene

COMMERCIALIZATION STATUS

Mutant varieties generated from this project have been grown in large scale area in Taiping, Kelantan and Johor at farmers plots. These mutant varieties had also been distributed to MARDI Kelantan for further evalutaion and use as genetic materials for cross-breeding programme.

OTHERS

Related project:

- IAEA Research Contract on Evaluation of Yield and N_2 Fixation of Mutant Lines of Groundnut in Malaysia.

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

FLOWERING PLANT

RESEARCH TEAM

Leader:	Zaiton Ahmad, Dr
Members:	Affrida Abu Hassan Shakinah Salleh Mohd. Nazir Basiran, Dr Sakinah Ariffin Shuhaimi Shamsudin Salim Othman Mohamed Najli Mohamed Yasin Nurul Hidayah Mahmud Norimah Yusof, Dr
Collaborators:	Yutaka Oono, Dr (JAEA) Yoshihiro Hase, Dr (JAEA) Naoya Shikazono, Dr (JAEA) Issay Narumi, Dr (JAEA) Atsushi Tanaka, Dr (JAEA) National Landscape Department Department of Agriculture, Serdang. Stesen MARDI Cameron Highlands Ramlan Mat Janor (RMJ) Delilah Bani Hashim(RMJ) Mohd. Hashim Kamaruddin (RMJ)
Year:	1990-2012

SYNOPSIS

Malaysian Nuclear Agency has started research on mutagenesis of flowering plants since 1990. The main objective of this research is to create new varieties of flowering plants with attractive colour and long lasting flower for landscaping purposes. Most of the ornamental plants in Malaysia are vegetatively propagated and some are sterile (have no seed or extremely low seed set). In order to widen genetic variations of these plants, *in vitro* culture was used in combination with mutation induction. *In vitro* cultures of selected flowering plants such as alpinia, petunia, amaryllis and orchid were established and irradiated with gamma rays at respective optimum doses for each species. Irradiated seedlings were then hardened and planted for morphological screening.

In early 1995, a memorandum of understanding (MoU) was signed between Malaysian Nuclear Agency and RMJ Management Sdn. Bhd. This company was responsible to promote the nuclear application in agriculture especially in mutagenesis of ornamental plants. In 2012, new mutant varieties of turnera with longer bloom period and canna with new flower colours were generated through a collaborative project with National Landscape Department, Ministry of Housing and Local Government. Through a bilateral project collaboration with JAEA on “Generating New Ornamental Plant Varieties using Ion Beams” (2008-2012), and a ScienceFund project entitled “Development of

New Chrysanthemum Varieties for Cut Flower Production Through Irradiation Technology" (2010-2012), several new mutants of chrysanthemum (of Reagan Red and Pink varieties) were developed. The flowering mutants that have been developed are as featured below;

2002

Alpinia purpurata (Parent)

Alpinia purpurata (Mutant)

2004

Petunia hybrida (Parent)

Petunia hybrida 'NK Tropicana' (Mutant)

2009

Hippeastrum puniceum (Parent)

Hippeastrum puniceum 'Orange BioGamma' (Mutant)

2012

Turnera subulata parent (left) and mutant with blooming flowers at 1 pm (right)

2012

Canna generalis pink parent (left) and pink-orange mutant (right)

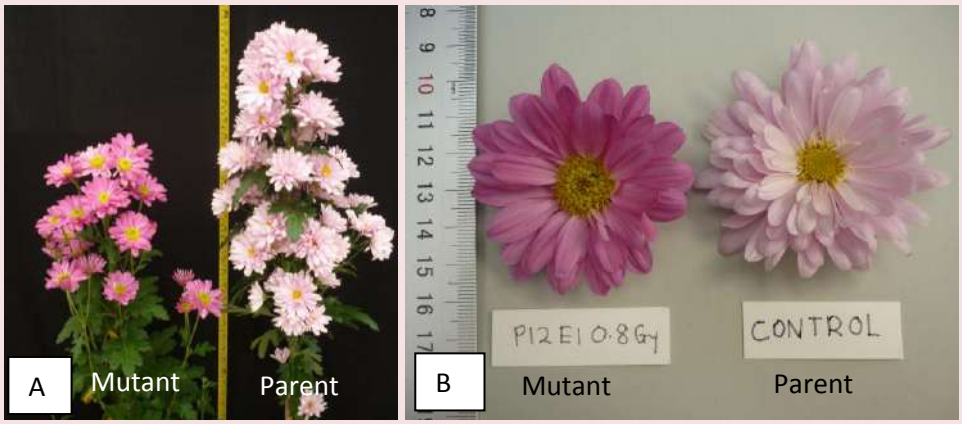
2012

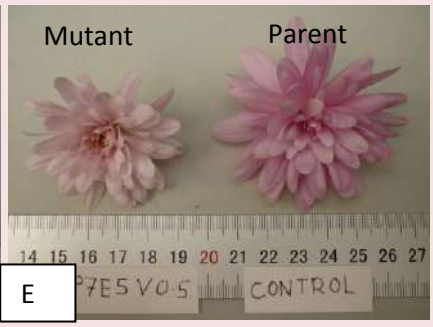
Canna generalis red-orange parent (left) and orange-yellow mutant (right)

2012

Among the mutants of *Chrysanthemum morifolium* cv. Reagan Red generated through ion beam irradiation; (A) parent, (B) purplish red mutant (TIARA Red), (C) small orangish red ray floret, and (D) red with small orange stripes. Another mutant, (E) *Chrysanthemum* Cream Marble was developed through gamma irradiation with green and yellowish cream leaf variegation.

2014





Two new mutant varieties of *Chrysanthemum morifolium* Pink generated through ion beam irradiation; (A-B) purple flower mutant and (C-E) light pink flower with variegated leaves, both originated from the pink variety.

AWARDS

- Nuclear Malaysia Innovation Day 2009. Amaryllis “Orange BioGamma” :Biotechnology-Gamma Generated Plants - Silver Medal.
- Malaysia Technology Expo 2010. Amaryllis “Orange BioGamma” :Biotechnology-Gamma Generated Plants (2010) - Bronze Medal.
- Nuclear Malaysia Innovation Day 2012. Chrysanthemum Cream Marble - Bronze Medal.

COMMERCIALIZATION STATUS

- MoU with RMJ Management Sdn. Bhd.
- Amaryllis and chrysanthemum mutants are in the process of registration for Plant New Variety with Department of Agriculture

OTHERS

Related projects:

- Improvement of Selected Ornamental Plants through Induced Mutation; IRPA Top Down, 01-03-03-0073 (1995-2000).
- Kajian Penghasilan Jenis / Varieti Baru Tanaman Renek Melalui Kejuruteraan Genetik; Consultancy Services for National Landscape Department, Ministry of Housing and Local Government, NM-R&D-10-04 (2009 – 2012).

- Development of New Chrysanthemum Varieties for Cut Flower Production through Irradiation Technology; ScienceFund (Agriculture), 05-03-01-SF1001 (2010 – 2012).

- Generating New Varieties of Ornamental Plants using Ion Beams; Nuclear Malaysia – JAEA Bilateral Project (2008-2012).

CONTACT

Zaiton Ahmad, Dr.
Agrotechnology & Biosciences Division
Tel: +603-89112000 ext: 1335
Fax: +603-89112157
E-mail: zaitonahmad@nuclearmalaysia.gov.my

ORNAMENTAL FOLIAGE

RESEARCHER TEAM

Leader:	Mohd. Nazir Basiran, Dr
Members:	Sakinah Ariffin Affrida Abu Hassan Shuhaimi Shamsudin Mohamed Najli Mohamed Yasin Murizal Zainol Khairuddin Abdul Rahman Rengasamy a/l Ratnam Rohayu Othman Rabaatuladawiyah Zainal Abidin
Collaborators	Ramlan Mohd. Janor (RMJ) Delilah Bani Hashim(RMJ) Mohd. Hashim Kamaruddin (RMJ)
Year:	1994 – 2000

SYNOPSIS

Research on mutagenesis using gamma irradiation to induce morphological variations in foliage plants was started in 1994. The work has successfully generated several mutant plants as follows; three new mutant varieties of *Cordylines terminalis* namely *Cordylines terminalis* 'Jaguh', *Cordylines terminalis* 'Teguh' and *Cordylines terminalis* 'Mantap', one mutant varieties of *Cordylines fruticosa* namely *Cordylines fruticosa* 'Shuhaii' and two new mutant varieties of *Duranta repens* namely *Duranta repens* 'Marginata'and *Duranta repens* 'Variegata' . These new mutant varieties were officially launched in 2000 by YABhg. Tun Dr Siti Hasmah Hj. Mohd. Ali during MINT Flora Day. Another attractive cultivar, *Tradescantia spathacea* 'Sobrii' was obtained from irradiated stem cuttings of *Tradescantia spathacea* and was officially launched in 2001 by YBhg. Dato' Dr Ahmad Sobri Hj. Hashim (former Director General of Malaysian Nuclear Agency). Currently, these new cultivars are propagated and maintained at 'Laman Flora GENETIKA' for decoration and landscaping purposes.

Cordylines fruticosa (Parent)

Cordylines fruticosa 'Shuhaii'

Tradescantia spathacea (Parent)

Tradescantia spathacea 'Sobrii'

Cordylines terminalis (Parent)

Cordylines terminalis 'Teguh'

Cordylines terminalis 'Jaguh'

Cordylines terminalis 'Mantap'

Duranta repens (Parent)

Duranta repens 'Marginata'

Duranta repens 'Variegata'

COMMERCIALIZATION STATUS

Memorandum of Understanding (MOU) - A Collaboration Project Between MINT-RMJ Management Sdn. Bhd. Entitled *'In Vitro Mutagenesis of Ornamental Plants'* (UPP/95/02) -14 March 1995 -12 March 1998.

OTHERS

Related project:

- Improvement of Selected Ornamental Plants through Induced Mutation; IRPA (01-03-03-0073) (1996-1998).

CONTACT

Shakinah Salleh
Agrotechnology & Biosciences Division,
Tel: 603-89112000 ext: 1449
Fax: 603-89112157
E-mail: shakinah@nuclearmalaysia.gov.my

Hibiscus rosa sinensis – 'Siti Hasmah RedShine' , 'Siti Hasmah PinkBeauty' & 'Nori'

RESEARCH TEAM

Leader:	Mohd. Nazir Basiran, Dr
Members:	Zaiton Ahmad, Dr Norimah Yusof, Dr Shakinah Salleh Affrida Abu Hassan Sakinah Ariffin Shuhaimi Shamsudin Suhaimi Musa Salim Othman Sazali Daud Mustafa Tak
Collaborators:	Ramlan Mohd Janor (RMJ) Delilah Bani Hashim(RMJ) Mohd Hashim Kamaruddin (RMJ) National Landscape Department Department of Agriculture, Serdang
Year:	1991 - 2012

SYNOPSIS

Hibiscus rosa-sinensis or 'bunga raya' is a national flower of Malaysia and a popular plant in Malaysian landscapes as clusters, hedges or topiary. Malaysian Nuclear Agency has started research on the use of mutagenesis technology to change plant characteristics such as flower colour and shape in *Hibiscus* since 1991. Stem cuttings were irradiated using gamma irradiation at dose 20.0 Gy, and subsequent clonal propagation and selection has led to the development of three new attractive cultivars from two different mother plants. *Hibiscus rosa-sinensis* 'Siti Hasmah RedShine' and *Hibiscus rosa-sinensis* 'Siti Hasmah PinkBeauty' were officially launched during MINT Flora Day 2000 by YABhg. Tun Dr Siti Hasmah Mohd. Ali. *Hibiscus rosa-sinensis* 'Nori' was launched by the former Prime Minister YAB Tun Abdullah Ahmad Badawi during the National Landscape Day on 3 March 2005 at the Hibiscus Garden Kuala Lumpur. The cultivar was named *Hibiscus rosa-sinensis* 'Nori' after the name of the former Prime Minister's daughter, Pn. Nori Abdullah.

A research grant was awarded in 2009 from National Landscape Department, Ministry of Housing and Local Government for improving flower characteristics of several landscaping plants, including hibiscus, through mutagenesis. The main objective was to produce new varieties with desired characters, such as longer bloom period, unique and prominent petal colours and larger flower size that are suitable for landscapes in Malaysia. Through this project, one hibiscus mutant with compact curly petal was identified and will be registered as a new variety with Department of Agriculture.

Parent
Hibiscus rosa-sinensis (Pink)

New mutant variety
Hibiscus rosa-sinensis
'Siti Hasmah RedShine'

New mutant variety
Hibiscus rosa-sinensis
'Siti Hasmah PinkBeauty'

New mutant variety
Hibiscus rosa-sinensis 'Nori'
(multiple petal layers)

Parent
Hibiscus rosa-sinensis
(Striking red)

New mutant variety
Hibiscus with compact
curly petal

AWARDS

- Nuclear Malaysia Innovation Day 2005. Bunga Raya Nuklear: *Hibiscus rosa-sinensis* 'Siti Hasmah RedShine' and 'Siti Hasmah PinkBeauty' - Bronze Medal.

OTHERS

Related projects:

- Generating New Varieties of Ornamental Plants; PQRD, MINT-R&D-6-014 (2002 - 2012).
- Kajian Penghasilan Jenis / Varieti Baru Tanaman Renek Melalui Kejuruteraan Genetik ; Consultancy Services for National Landscape Department, Ministry of Housing and Local Government, NM-R&D-10-04 (2009 - 2012).

CONTACT

Zaiton Ahmad, Dr.
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1335
Fax: 603-89112157
E-mail: zaitonahmad@nuclearmalaysia.gov.my

ORCHID

RESEARCH TEAM

Project Leader:	Sakinah Ariffin
Members:	Affrida Abu Hassan Zaiton Ahmad, Dr Mohd. Nazir Basiran, Dr Shuhaimi Shamsuddin Suhaimi Musa Mohamed Najli Mohamed Yasin Othman Abu Sari Salim Othman Ahmad Fauzi Ahmad Nadzri Sazali Daud Rengasamy a/l Ratenam Siti Mazlina Mustafa Nasasni Nasrul Rosnah Mohd. Nayan
Collaborators:	Md. Yusof Husin, Dr (HGSB) Norani Abdul Samad, Dr (HGSB) MARDI, UPM, UM
Year:	1996-present

SYNOPSIS

Irradiation using gamma rays on *in vitro* culture of protocorm-like bodies (PLBs) from a commercial hybrid *Dendrobium* Sonia at dose 35 Gy has resulted in variability on phenotypic characteristics of the flowers, inflorescenses, shelf life and growth habit. Research on mutation induction at Malaysian Nuclear Agency has successfully generated 11 new orchid mutant varieties with commercial potentials; 5 mutant varieties have been officially released and another 6 are being selected for further commercialization studies. The first two mutant varieties namely *Dendrobium* 'Sonia KeenaOval' and *Dendrobium* 'Sonia KeenaRadiant' were launched in 2000 by YABhg. Tun Dr Siti Hasmah Hj Mohd. Ali during MINT Flora Day. In the following years, another two mutant varieties were launched during the same event: *Dendrobium* 'Sonia KeenaAhmadSobri' in 2001 by YBhg. Dato' Dr. Ahmad Sobri Hj. Hashim (former Director General of Malaysian Nuclear Agency) and *Dendrobium* 'Sonia KeenaHiengDing' in 2002 by YB Datuk Seri Law Hieng Ding (former Minister of MOSTI). *Dendrobium* 'Sonia KeenaPearl' and has won silver medal Nuclear Malaysia Innovation Day 2012 and BioInnovation Awards 2012. was launched by Datuk Dr Abu Bakar Mohd Diah in 2014. All mutant plants were mass-propagated at Hexagon Green Sdn. Bhd. pilot farm at Taman Agroteknologi Bukit Changgang, Banting, Selangor under a TechnoFund project entitled 'Pre-commercialization of Mutant Orchids for Cut Flower Industry'. This project focuses on observation and determination of stalk length, floral architecture, flower quality and quantity, pest disease susceptibility/damages, post-harvest evaluation and quality control compliance for cut flower market

Dendrobium Sonia (Parent)

Dendrobium ‘Sonia KeenaPearl’

Dendrobium ‘Sonia KeenaOval’

Dendrobium ‘Sonia KeenaRadiant’

Dendrobium ‘Sonia KeenaAhmadSobri’

Dendrobium ‘Sonia KeenaHiengDing’






New mutant varieties of *Dendrobium* Sonia with different shades of colour and flower morphology ready for commercialization trials.

AWARDS

- Nuclear Malaysia Innovation Day 2012. Development Of New Orchid Variety Through Nuclear Technology *Dendrobium* 'Sonia KeenaPearl' - Silver Medal and Women Inventor Award.

- BioInno Awards and Bio Malaysia Exposition 2012. Development Of New Orchid Variety Through Nuclear Technology *Dendrobium* 'Sonia KeenaPearl' - Silver Medal.

COMMERCIALIZATION STATUS

Collaborative agreement between Nuclear Malaysia and Hexagon Green Sdn. Bhd.(HGSB) under TechnoFund programme for pre-commercialization studies of orchid mutant varieties for export market.

OTHERS

Related projects:

- Improvement of Commercially Important Orchids Using Biotechnology. Orchid Top Down NBD (01-03-03-007/BTK/ER/014) (1996-2000).
- Pre-commercialization of Mutant Orchids for Cut Flower Industry. TF 00110C033 (2012-2014).

CONTACT

Sakinah Ariffin
Agrotechnology & Biosciences Division
Tel: +603-89112000 ext: 1307
Fax: +603-89112157
E-mail:sakinah@nuclearmalaysia.gov.my

SIGNAL GRASS -'KLUANG COMEL'

RESEARCH TEAM

Leader:	Abdul Rahim Harun, Dr
Member:	Shuhami Shamsuddin
Collaborator:	Ghazali Hussin (JPH)
Year:	1996-2003

SYNOPSIS

Signal grass mutant variety 'Kluang Comel' was derived from mutagenesis of *Brachiaria decumbens* Stapf using gamma irradiation. Mutagenesis study commenced in 1996 with the main objective to obtain new genotypes with improved nutritional values and free from toxicity in grazing sheep. *Brachiaria decumbens* seeds were exposed to gamma radiation at 900 Gy for induction of mutation. Irradiated seeds were planted in experimental plot at Institut Haiwan Kluang to raise M1 population. Cutting back technique was applied in sebsequent generations to eliminate chimera in mutated sector of the plants. Selected mutant lines were transplanted to the field for yield and plant growth performance. One mutant was observed to be different in plant type compared to the original parental variety with bushy leaves and erect stems. Other distinctive morphological traits that were different from the parent were higher stem ratio, broader leaf blade, short internodes, more tiny hairs on the leavers and dark green leaf colour. Nutritional value of the mutant is better than the parent since it contains higher contents of crude protein, calcium, posphorus, total digestible nutrient and energy. The mutant plant comprises 80% leaves and 20% of stem. At 7 weeks after planting the yield was recorded at 15 t/ha. The spreading rate of the mutant is 16.7 cm/month as compared to the parent at 25 cm/month. The slow spreading rate implies that the mutant has a potential to be used as mix grass-legume pature. The mutant was officially lunched in 2003 by the Deputy Minister of Agriculture.

Parental variety of *Brachiaria decumbens* with spreading plant type

Mutant variety 'Kluang Comel' with bushy plant type

Demonstrating Mutant Germplasm to the Deputy Minister of MOA

Demonstration plot at Institut Haiwan Kluang, Johor

AWARDS

- Nuclear Malaysia Innovation Day 2004. Kluang Comel - Silver Medal.
- MOSTI Quality Award 2004. Kluang Comel - Third Place.
- S&TI Expo 2004. “Kluang Comel”: New Variety of Grazing Pasture - Bronze Medal.
- Salon International Des Inventions, Geneva 2005. Kluang Comel - Bronze Medal.
- 26th Malaysian Society of Animal Production Conference 2005 - Best Poster Presentation.

COMMERCIALIZATION STATUS

New mutant variety of Kluang Comel had been grown in large-scale area at MARDI Research Station, Kluang Johor and Institut Haiwan Kluang. These mutant lines are potential for commercial planting or as genetic materials for cross-breeding programme.

CONTACT

Abdul Rahim Harun, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1339
Fax: 603-89112157
E-mail: rahim@nuclearmalaysia.gov.my

EKSOTIKA PAPAYA

RESEARCH TEAM

Leader:	Rusli Ibrahim, Dr
Members:	Alvina Lindsay Mijen Amir Hamzah Zulfadzli Jan Jam Siti Hajar Mohd. Nahar Siti Mariam Mohd. Nahar
Collaborators:	Chan Yin Kwok, Dr (MARDI) Mohamad Bahagia Ab. Ghaffar, Dr (MARDI) Yasmin Othman, Prof. Dr (UM)
Year:	2004-2006

SYNOPSIS

Malaysian Nuclear Agency initiated a breeding programme for the improvement of Eksotika papaya with resistance to Papaya Ring Spot Virus (PRSV). Induction of mutation was carried out using irradiation of seeds with gamma-ray doses ranging from 0 to 400 Gy. Dose response curve plotted against total shoot length observed after 3 weeks showed that LD_{50} (Lethal Dose that kills 50% of the irradiated seeds) was 100 Gy and LD_{100} (Lethal Dose that kills 100% of the irradiated seeds) was 400 Gy. Data on radiosensitivity test indicated useful information on dose range for induction of mutation for breeders to work with radiation in order to create a wide range of genetic variations. Three doses were selected for field planting; 150, 200 and 250 Gy. Before field planting, plants were treated using artificial inoculation of papaya ring spot virus (PRSV) in the nursery for preliminary screening. A total of 1,500 M1 mutant plants were planted and screened in the field. Data were collected on plant morphology, early flowering, yield and symptoms for PRSV. Based on the results obtained after M3 field screening, three potential mutant lines have been identified with the following characteristics: 1) High sugar content, 2) High fruit weight and 3) Early flowering.

Seedlings derived from Eksotika papaya seeds irradiated with gamma rays

Hardening of irradiated papaya seedlings in the nursery

Field planting

Field screening and selection for improved agronomic traits

Ripened fruits of Eksotika papaya

High-yielding mutant of Eksotika papaya

AWARDS

- Malaysian Technology Expo MTE 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal and Best Award.
- BioInnovation Award and Bio Malaysia Exposition 2009. Biotechnology Improved Synthetic Seeds -Low Cost Seed Production Technology - Gold Medal.
- Seoul International Invention Fair 2009. Biotechnology Improved Synthetic Seeds -Low Cost Seed Production Technology - Gold Medal and Semi Grand Prize Winner.
- i-Innova Expo, Universiti Sains Islam Malaysia (USIM) 2010. Synthetic Seeds - Gold Medal.

COMMERCIALIZATION STATUS

- Application of gamma radiation to create genetic variations for the production of potential mutants with improved desired traits
- Seeds of selected mutant lines were kept at MARDI Research Station in Pontian Johor for further evaluation.

OTHERS

Related project:

- Gamma irradiation-induced mutation for papaya ring spot virus resistance in Eksotika variety IRPA 01-03-03-0000-PR0051/06 (2004-2006).

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

JOSAPINE PINEAPPLE

RESEARCHER TEAM

Leader:	Rusli Ibrahim, Dr
Members:	Alvina Lindsay Mijen Amir Hamzah Zulfadzli Jan Jam Siti Hajar Mohd. Nahar Siti Mariam Mohd. Nahar
Collaborators:	Siti Hawa Jamaluddin, Datin Dr (MARDI) Mohamad Bahagia Ab. Ghaffar, Dr (MARDI)
Year:	2004 - 2006

SYNOPSIS

Popular local variety Josapine pineapple was first micropropagated and multiplied through tissue culture technique using suckers. Shoot buds were irradiated using gamma rays with doses ranging from 0 to 100 Gy. LD_{50} value for multiplication rate was obtained at 40 Gy. For mutation induction, explants from meristems were treated with gamma rays at selected doses of 10, 20, 30 and 40 Gy. Irradiated explants were micropropagated up to M_1V_5 to minimize chimerism and then hardened for acclimatization in the nursery at MARDI Research Station in Pontian, Johor for 2-3 months before field planting. Preliminary screening in the nursery was first carried out in order to select for potential mutants with desired characters such as vigorous growth and smooth leaves. A total of 15,000 irradiated plants have been selected and planted in bacterial heart rot disease hot spot area at MARDI Research Station in Pontian to screen for bacterial heart rot disease with improved agronomic traits. In M3 generation, three potential mutant lines resistance to bacterial heart rot disease were selected with improved agronomic traits such cylindrical fruit shape with bigger fruit size between 800 and 900 g (highest recorded 1,160 g in comparison to control at 300-500 g) and higher sugar content (20-25 sugar index as compared to control at only 18).

Besides selection of three potential mutant lines with improved traits, an efficient tissue culture protocol for micropropagation and Temporary Immersion Bioreactor System for mass propagation of *in vitro* plantlets of pineapple has been established. These propagation techniques have been transferred through project collaboration to an industrial partner, Koperasi Serbaguna Anak-Anak Selangor (KOSAS) for commercial production of tissue culture plantlets of pineapple using bioreactor technology.

Regenerated *in vitro* shoots of pineapple from suckers

Scaling-up using Temporary Immersion Bioreactor System

Scaling-up using Air-lift Bioreactor System

Pineapple seedlings from Air-lift Bioreactor System

Field planting

Field screening and selection

Ripened fruit of Josapine pineapple

AWARDS

- Malaysian Technology Expo MTE 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal and Best Award.
- BioInno Award and Bio Malaysia Exposition 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal.
- Seoul International Invention Fair 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology -Gold Medal and Semi Grand Prize Winner.
- i-Innova Expo, Universiti Sains Islam Malaysia (USIM) 2010. Synthetic Seeds - Gold Medal.

COMMERCIALIZATION STATUS

- Tissue culture protocol and bioreactor system were transferred to Koperasi Berhad Anak-Anak Selangor (KOSAS) for commercial production of planting materials of MD2 pineapple.

OTHERS

Related projects:

- Production of Tissue Culture Plantlets of Pineapple Variety MD2 using Bioreactor System. Non Disclosure Agreement. No: NM BKT NDA 1/2008.
- Gamma Irradiation Induced Mutation for Bacterial Heart Rot Disease Resistance in Josapine Pineapple. PR IRPA 01-01-03-0003-PR0050/05-03 (2004-2006).

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

WATER MANAGEMENT STUDY USING NUCLEAR AND OTHER RELATED TECHNIQUES

RESEARCH TEAM

Leader :	Khairuddin Abdul Rahim, Dr.
Members :	Asiah Ahmad, Datin Dr. Shyful Azizi Abdul Rahman Jaafar Abdullah, Dr Juhari Mohd. Yusof
Collaborators :	UPM MARDI IAEA
Year:	1984 - 2012

SYNOPSIS

Isotopic and nuclear techniques are useful and effective tools to assess the soil water status, particularly in the immediate vicinity of crop roots, to trace soil water and nutrient movement and to identify hot spots of land degradation that deliver sediments and affect downstream water quality. Such information assists in developing strategies for sustainable agricultural water management.

To date, more than 50 related to soil water management projects have been conducted in Nuclear Malaysia, including research and development, technical and advisory services, laboratory support, training in the use of nuclear techniques and assistance in collecting, analyzing and disseminating the derived information and technology.

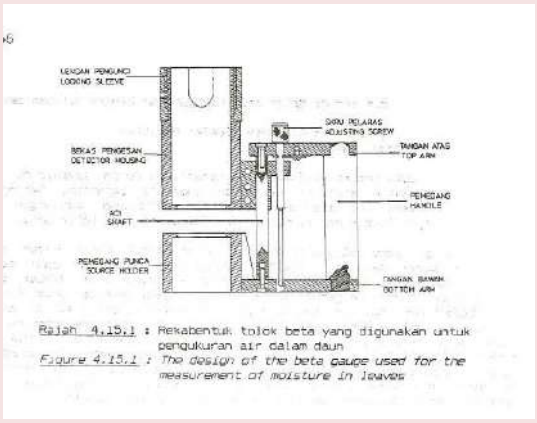
In soil water and nutrient management projects, most of the research works were conducted to evaluate uptake efficiency and utilization of fertilizer input (w.r.t nitrogen, phosphorus and potassium) under different water condition of industrial and food crops such as rubber, oil palm, pineapple, rice, groundnut, banana, cocoa plantation and others. Two main nuclear techniques were used, viz isotopic technique (N-15, P-32 etc) as tracer and soil moisture neutron probe (SMNP) for soil moisture measurement. Results from the research works provided recommendation on water application strategy for sufficient crop water management subject to meteorological prediction.

The soil moisture neutron probe is ideal for the measurement of soil water in the immediate vicinity of the crop roots, and providing accurate data on the accessibility to the crop of available water to establish optimal irrigation schedules. The SMNP is currently the most suitable instrument to accurately measure soil moisture under saline conditions. It is also widely used to calibrate conventional moisture sensors for direct use in farmers' fields.

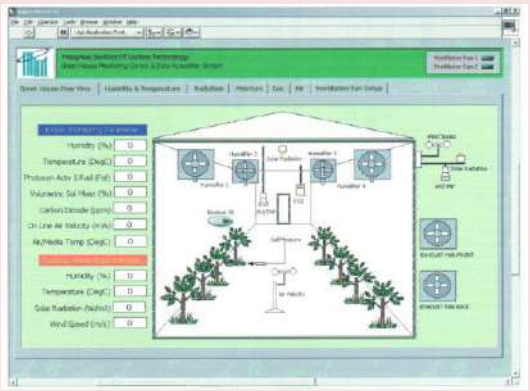
Recently, isotopic technique using carbon isotope was introduced for agricultural research in Nuclear Malaysia. Carbon is an important building component of plants. Green plants assimilate carbon from atmospheric carbon dioxide through the process of photosynthesis. Carbon dioxide is

composed of two stable isotopes, the less abundant ^{13}C and the lighter ^{12}C. During photosynthesis the plant discriminates against the heavier isotope in favour of the lighter one. The extent of this discrimination depends on environmental factors, such as water availability and salts in the soil. The variation in the relative abundance of the carbon isotopes can therefore be used as a surrogate marker of water stress, water use efficiency and crop tolerance to drought and salinity.

Research team also involved in some product/system development such as “Beta-Gauge” and automatic fertigation system. Beta-gauge is a technique using beta radiation attenuation for measuring changes in water status of plants. The technique is a non-destructive, rapid and very accurate (sensitive to small water changes). The beta-gauge was successfully fabricated and tested on young shoots of a rubber seedling.



Rajah 4.15.1 : Rekabentuk tolok beta yang digunakan untuk pengukuran air dalam daun
Figure 4.15.1 : The design of the beta gauge used for the measurement of moisture in leaves



OTHERS

The oil palm study was related to project code JKP/PP(15-f)/86.

CONTACT

Khairuddin Abdul Rahim, Dr.
Director
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1611
Fax: 603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

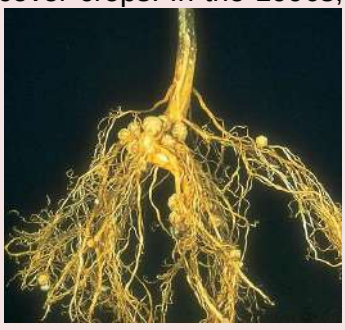
ASSESSMENT OF BIOLOGICAL NITROGEN FIXATION IN LEGUMES USING ^{15}N ISOTOPE TECHNIQUE

RESEARCH TEAM

Leader:	Khairuddin Abdul Rahim, Dr
Members:	Bajuri Kadmin, Dr Asiah Ahmad, Datin Dr. Nashriyah Mat, Dr. Phua Choo Kwai Hoe Pauline Liew Woan Ying, Dr. Ahmad Nazrul Abd. Wahid Ahamad Sahali Mardi Rusli Ibrahim, Dr. Abdul Rahim Harun Latiffah Norddin Abdul Razak Ruslan Hazlina Abdullah Maizatul Akmam Mhd. Nasir
Collaborators:	MRB, MARDI, UPM, Jabatan Pertanian, MYAGRI
Year:	1984-2014

SYNOPSIS

Nitrogen fixation is a process by which atmospheric nitrogen (N_2) is converted into ammonia (NH_3). Malaysian Nuclear Agency (Nuclear Malaysia) has conducted many studies since the 1980's, on nitrogen fixation by nitrogen fixing bacteria on leguminous crops such as groundnut, soybean and cover crops. In the 1990s, the study of nitrogen fixation was involving the use of selected N_2 fixing bacteria. It was targeted that from these studies, the application of chemical nitrogen fertilizers can be minimized.



The ^{15}N isotope dilution technique is used to quantify N_2 fixation by legume crops and N-fixing bacteria. The advantage of the 15N isotope dilution method is that it makes it possible to separate N taken up by the plant from fertilizer and soil from that fixed in the plant. Many researchers have described the ^{15}N isotope dilution method as the most reliable measure of N_2 fixation. Nuclear Malaysia often collaborated with other agencies such as MRB, MARDI, Department of Agriculture, UPM and Malaysian Agri Hi-Tech Sdn. Bhd. (MYAGRI). A variety of crops and area were used in the study. If in the 1980s the study only focused on leguminous crops, at present the study has focused on evaluation of biofertilizer products, containing N_2 fixing microorganisms, on crops such as rice, oil palm, vegetables, vanilla orchids and groundnut. Nuclear Malaysia has been consulted on BNF for its ^{15}N isotopic analysis services and expertise on the research.

Experiment of N_2-fixing bacteria evaluation on vegetable and vanilla crops.

CONTACT

Khairuddin Abdul Rahim, Dr.
Agrotechnology & Biosciences Division,
Tel: +603-89112000 ext:1611
Fax: +603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

ROOT ACTIVITY AND PHOSPHORUS FERTILIZER EFFICIENCY STUDIES USING ^{32}P AND ^{33}P RADIOISOTOPES

RESEARCH TEAM

Leader:	Ahamad Sahali Mardi
Members:	Bajuri Kadmin, Dr Khairuddin Abdul Rahim, Dr Shyful Azizi Abdul Rahman Ahmad Nazrul Abd Wahid Latiffah Norddin Misman Sumin Abdul Razak Ruslan Hazlina Abdullah
Collaborators:	Universiti Putra Malaysia Malaysian Rubber Board MARDI FRIM FELDA CRAUN Research Sdn Bhd
Year:	1986-2009

SYNOPSIS

The root is the organ of a plant that typically lies below the surface of the soil. The function of plant roots is to absorb water and uptake the nutrients from the soil. Basically, the growth of plant roots is due to the presence of phosphate element. Phosphate will stimulate the growth of plant roots, particularly in the initial stages of growth. To study the activities and distribution in the plant root, the tracing of ^{32}P radioactive isotope is a method that has been used. Since the 1980's this method has been used by the researchers to observe and evaluate the activities and mapping of plant roots. A major breakthrough was in the study where Nuclear Malaysia was part of a team of researchers from UPM and a major plantation industry investigated the active root zones of mature oil palm under plantation cultivation. The findings from the study led to a transformation of the methods of fertilizer application – from fertilizing at each stand to fertilizer application along every alternate row. Delineation of active root zones of fruit crops such as mango, starfruit (carambola) guava and dokong trees were also conducted . Active root studies lead to fertilizer use efficiency studies, e.g. effectiveness of phosphate fertilizers on crops. Different formulations of phosphorus fertilizers and different phosphate rock fertilizer from all over the world (e.g. China, USA, Morroco, Christmas Island) was evaluated on their efficiency of utilisation by different crops using the phosphorus radioisotopes of

P-32 and P-33. ^{32}P and radioactive isotopes of P that emit beta particles. The researchers involved in the study are highly trained in handling these isotopes. ^{32}P radioactive isotope in plant samples can be detected by using liquid scintillation counter (LSC).

In 1994, studies on manau rattan (*Calamus manan*) was conducted in collaboration with Universiti Putra Malaysia (UPM) and Forest Research Institute of Malaysia (FRIM). In the 1990s and late 2000s, Nuclear Malaysia collaborated with CRAUN Research Sdn Bhd, Sarawak to study the root activity of different sago planting materials at different locations in Mukah and Dalat, using ^{32}P radioactive isotope. The study aimed to investigate and evaluate the active root zone delineation and effectiveness of phosphate intake by the sago plant roots. Through the expertise and other resources including equipment on plant roots study using ^{32}P radioactive isotope, Malaysian Nuclear Agency has become a source of references from other organisations.

Sago palm active root delineation using ^{32}P radioactive isotope tracer technique

Liquid scintillation counter (LSC)

CONTACT

Khairuddin Abdul Rahim, Dr.
Agrotechnology & Biosciences Division,
Tel: +603-89112000 ext:1611
Fax: +603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

NITROGEN USE EFFICIENCY STUDY IN SOIL/PLANT SYSTEM USING ^{15}N ISOTOPE TECHNIQUE

RESEARCH TEAM

Leader:	Khairuddin Abdul Rahim, Dr
Members:	Bajuri Kadmin, Dr Asiah Ahmad, Datin Dr Nashriyah Mat, Dr. Ahamad Sahali Mardi Ahmad Nazrul Abd Wahid Phua Choo Kwai Hoe Latiffah Norddin Abdul Razak Ruslan Hazlina Abdullah
Collaborators:	MARDI, UPM, MADA, KADA, Jabatan Pertanian.
Year:	1986 - 2014

SYNOPSIS

Nitrogen, N is an essential macronutrient needed by all plants to thrive. It is an important component of many structural, genetic and metabolic compounds in plant cells. In the dynamic study of nitrogen, the elements are always given attention are related to fertilization technique, loss of nitrogen, nitrogen treatment, nitrogen placement, nitrogen rate, nitrogen source, nitrogen use efficiency and nutrient utilization. Since the 80's, Malaysian Nuclear Agency (Nuklear Malaysia) has been engaged in research in nitrogen dynamic in soil/plant system nitrogen using ^{15}N isotope technique. The ^{15}N isotope technique is the tool of obtaining estimates on fertilizer nitrogen in soil/plant system. A variety of crops and regions were used to study the dynamics of nitrogen in the soil and plants. Study the efficiency use of nitrogen fertilizer is the most significant and well known studies in the use of ^{15}N isotope technique in Malaysian Nuclear Agency.

Nitrogen use efficiency refers to the ratio of nitrogen fertilizer uptake by crops to nitrogen fertilizer applied to the plants. Since from past to present, study the efficiency use of nitrogen fertilizer is still conducted by the researchers at the Division of Agrotechnology and Bioscience. In the 80's, a study of fertilizer use efficiency is much focused on fruit crops such as mango, guava, and dokong and others. It is also focused on tobacco crops, where in 1986 study the effect of nitrogen source and placement on nitrogen uptake by tobacco is conducted. However, after entering the era of 90's, most of the studies are focused on cereal crops such as corn and rice. Then, this study is expanded up to the major crops such as oil palm and cocoa and vegetable crops. Malaysian Nuclear Agency has work with many other collaborators in the implementation of the study such as MARDI, MADA, KADA, Department of Agriculture, University Putra Malaysia and others. Through the collaboration, it can give the advantages between both parties in ensuring the success of the study. Generally Malaysian

Nuclear Agency has an expertise ^{15}N isotope technique for nitrogen dynamic study. Therefore, most of the collaborators will offer their research area or demonstration plot and their expertise especially on the crop interest. Malaysian Nuclear Agency also provides service and consultancy to any agency wishing to undertake study of nitrogen fertilizer use efficiency using ^{15}N isotopic technique.

Use of emission spectrometer to analyse ^{15}N isotope in plant and soil samples

CONTACT

Khairuddin Abdul Rahim, Dr
Agrotechnology & Biosciences Division
Malaysian Nuclear Agency
Tel: +603-89112000 ext:1611
Fax: +603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

PESTICIDE BEHAVIOR AND FATE STUDIES USING CARBON-14 RADIOISOTOPE

RESEARCH TEAM

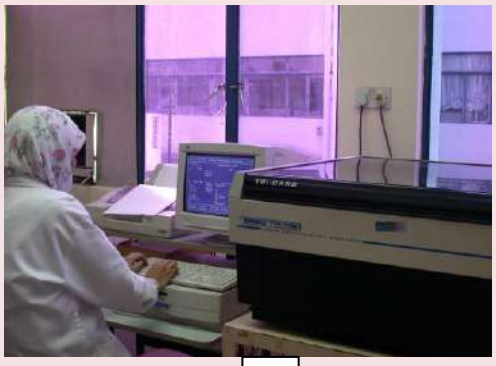
Leader :	Nashriyah Mat, Dr.
Members :	Mazleha Maskin Misman Sumin Maizatul Akmam Mohd. Nasir Juhari Abd. Latiff
Collaborators :	Roland Kubiak (Staatliche Lehr-und Forschungsanstalt fur Landwirtschaft, Weinbau und Gartenbau, Breitenweg, Neustadt an der Weinstrase, Germany) Kenji Nambu T. Miyashita M. Ohshima S. Sakata T. Fujisawa T. Kumada (Sumitomo Chemical Co. Ltd. Environmental health Science laboratory Takarazuka research Centre, Japan)

Year : 1990-1998

SYNOPSIS

In the environment, pesticide applied to agroecosystem would undergo different fate processes that include adsorption, transfer and degradation. Transfer includes processes that move the pesticide away from target site which include volatilization, spray driff, runoff, leaching, absorption and crop removal. Application of carbon-14 labelled molecules to plants, soil, animal, water and etc. can be used to study the metabolism in plant and animal, environmental fate, behavior and mobility of pesticides in ecosystem and agroecosystem. This technique allows compound to be followed in experimental systems and for the unambiguous identification and quantification of transformation products at very low concentrations. Because only radioactive carbon is measured, for many purposes, sample clean-up is less rigorous than that required by other techniques such as chromatography. Consequently, a large number of samples can be processed rapidly an dmeasured with standard liquid scintillation equipment at low cost. During the 1990s, several pesticide studies using carbon-14 radioisotope had been carried out in MINT: (1) leaching of ^{14}C-carbofuran into sub-surface water through Bungor series sandy loam soil in vegetable agroecosystem; (2) outdoor lysimeter studies on the effect of soil and application rate on ^{14}C-carbofuran insecticide leaching in the

Brassica sp. vegetable agroecosytem; (3)soil plant transfer coefficient of ^{14}C-carbofuran studies under field condition, using outdoor lysimeter consisting of *Brassica* sp. vegetable crop, riverine alluvial clayey soil and undisturbed Bungor series sandy loam soil columns; (4) metabolic fate and degradation of fenitrothion using the ^{14}C-ring labeled fenitrothion in a model ecosystem consisting of Takarazuka paddy field soil, rice plant (*Oryza sativa* var *nihonbare*), carp fish (*Cyprinus carpio* L.) and dechlorinated water; (5) distribution of ^{14}C-lindane in a simulative mudflat microecosystem; in sea water, sediment and cockle (*Anadara granosa*) compartments; (6) adsorption-desorption and degradation of glyphosate (Roundup^{R}) studies using ^{14}C-glyphosate in two soils, namely Serdang Series and Sungai Buloh Series; (7) behavior and fate of ^{14}C-2,4-Dichlorophenoxyacetic acid herbicide in ricefield water.



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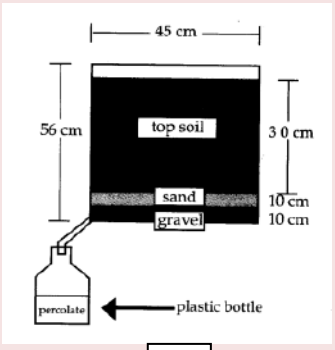

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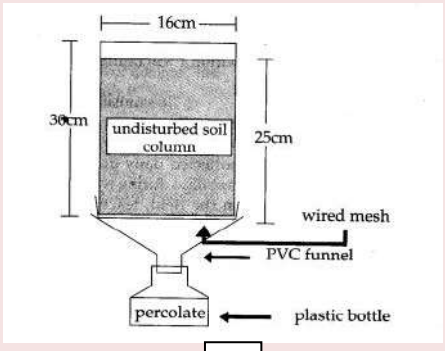


C

(A) ^{14}C-carbofuran leaching study: radioactivity measeurement using LSC, (B) An indoor lysimeter setup using homogenous and packed disturbed soil column, and (C) An outdoor lysimeter setup using undisturbed soil column.

D

E

(D) Rice ecosystem model used in fenitrothion metabolic rate study, and (E) and whole plant autoradiography of rice plant after treated with ^{14}C-Fenitrothion.

OTHERS

Related projects:

- Behavior and Fate of Pesticide in Vegetable Agroecosystem; IAEA-Technical Cooperation Project, MAL/5/022 (1995 -1998).
- Metabolic Rate of ^{14}C-fenitrothion in Rice-Fish Model Ecosystem: Collaboration with Sumitomo Chemical Co. Ltd. Environmental Health Science Laboratory Takarazuka Research Centre, Japan (1990 - 1991).

CONTACT

Khairuddin Abdul Rahim, Dr
Director
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1611
Fax: 603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

IMPACT OF BIOCIDE ON BIOTIC AND ABIOTIC COMPONENTS OF RICE ECOSYSTEM

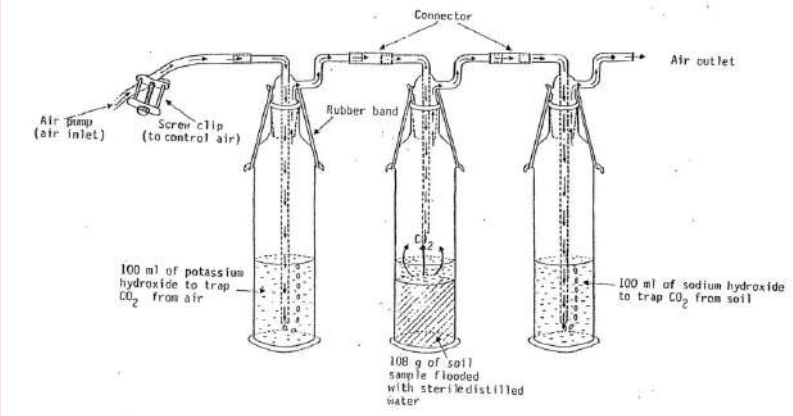
RESEARCH TEAM

Leader :	Nashriyah Mat, Dr.
Members :	Khairuddin Abdul Rahim, Dr. Mohd. Suhaimi Hamzah, Dr. Zaini Hamzah, Dr Abd. Khalik Wood, Dr Shaparudin Abd. Rahman Normala Shamsuddin Sabri Junoh Junainah Jusoh Shamsiah Abdul Rahman Abdul Aziz Basri Ramli Ishak Fouzi Ali Nuriati Nurdin
Collaborators :	Azimahtol Hawariah L. Pihie, Dr. (UKM) Ismail Sahid, Prof. Madya Dr. (UKM) Yaakob Kasin, MARDI Tanjung Karang Ho Nai Kin (MADA) Zulkifli Romli (MADA) Zaifah Abdul Kadir (UKM) Jambari Ali, Dr (UPM)
Year :	1990 - 2000

SYNOPSIS

Several collaborative projects had been carried out during the 1990s with MARDI Tanjung Karang and MADA. The study areas consisted of Northwest Selangor Project (Projek Barat Laut Selangor, PBLS) rice granary area and Muda area. Most of the studies concentrated on the effect of the use of the different biocides such as carbofuran, molinate, endosulfan, 2,4-D dimethy amine and propanil herbicides on biotic and abiotic components of rice ecosystem. In the Muda area specifically, studies had been carried out to monitor the impact of water recycling and non-recycling practices on the different biodiversity in the rice field agroecosystem. The molinate residue level and its accumulation in rice and aquatic weeds in the Muda rice agroecosystem were studied. A different study was carried out to determine the endosulfan (insecticide) residue level in ricefield fish in the same agroecosystem. For PBLS area, ricefield water quality study was carried out and compared with recommended value set by Food and Agriculture Organization (FAO) as well as standardized / optimum level for aquacultural activities in Malaysia and Japan. Metal distribution and uptake studies in rice and weedy/windy rice (padi angin) were also investigated. The half life of carbofuran under paddyfield conditions was investigated and the effect of carbofuran on soil microorganisms population in the

presence or absence of rice straw as substrate was monitored. Among the ecological indices measured were Simpson's Index of Diversity and Importance Value (I.V.).



Incubation system for measurement of microbial respiration.

Weed sampling using quadrat in ricefield.

(A) Sampling at Muda rice ecosystem, and (B) Samples analyzed using GC-ECD.

OTHERS

Related projects:

- Metabolic Fate, Exposure and Related Health Effects of Pesticides in Rice Farming Ecosystem; IRPA RM6 1-06-05-005 (1991-1995).
- Kajian Kesan Racun Perosak Terhadap Ekosistem Padi Di Kawasan MUDA, Kedah D.A. MINT-MADA Memorandum of Understanding (1992-2000).

CONTACT

Khairuddin Abdul Rahim, Dr.
Director
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1611
Fax: 603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

FOOD IRRADIATION

RESEARCH TEAM

Leaders :	Norimah Yusof, Dr / Muhamad Lebai Juri, Dato' Dr / Zainon Othman, Dr
Members :	Radziah Ariffin Ahmad Zainuri Mohd. Dzomir, Dr Ros Anita Mohd. Ramli Mohd. Sidek Othman Seri Chempaka Mohd. Yusof, Dr Ahsanulkhaliqin Abd. Wahab Rohaizah Ahmad Salmah Moosa Razley Mohd. Nordin, Dr Foziah Ali Zainab Harun Salahbiah Abdul Majid Rahmat Mardi Hassan Ramli Latifah Amin, Dr Rosmah Umam Shahrul Hizam Alias
Year:	1985-2013

SYNOPSIS

Malaysia experienced considerable post harvest losses in agricultural produce due to insect infestation, biochemical spoilage and microbial contamination during storage. Food irradiation (exposure of food to controlled amount of ionizing radiation) provides an alternative technology to minimize these losses and increase safety of food by destroying spoilage and pathogenic microorganisms in spices or poultry, disinfesting insect pests in grains, inhibiting sprouting of tuber crops or delaying maturity/ripening in fruits and vegetables. Beginning 1980s, research activities to determine the technical feasibility of food irradiation on local food and agricultural commodities were jointly conducted by Malaysian Nuclear Agency in collaboration with several institutions under the coordination of the National Committee on Food Irradiation. This Committee identified seven food products/ commodities of economic importance which have potential to benefit from this technology. The efficacy studies were completed in early 2000 with encouraging results. Research on other miscellaneous food products and economic feasibility of food irradiation was also conducted. The recommended radiation doses to achieve the desired objective for each food product are shown below. The application of irradiation as a phytosanitary treatment for the export of tropical fruits to USA is currently being developed by Malaysian Department of Agriculture as the National Plant Protection Authority with technical support from Malaysian Nuclear Agency.

Recommended dose for irradiation of local food products and agricultural commodities.

Types of food/commodity	Purpose of irradiation	Maximum dose (kGy)	Project Leader/Coordinator (duration)	Collaborators
Milled rice	Control insect infestation	1.0	Norimah Yusof, Dr (1982 -1989)	UPM MARDI UKM BERNAS (LPN)
Pepper (black and white)	i. Control insect infestation	1.0	Muhamad Lebai Juri, Dato' Dr (1985 -1992)	UPM UKM
	ii. Reduce microbial load	10.0		
Fresh ginger	Inhibit sprouting during storage	0.05	Norimah Yusof, Dr (1989 -1992)	MARDI UPM
Oyster mushroom	Eliminate molds and extend shelf life	1.0	Norimah Yusof, Dr (1989 -1992)	MARDI UPM
Fresh fruits	i.Control insect infestation (quarantine)	0.15 (minimum)	Norimah Yusof, Dr (1989 -1992)	MARDI – project leader UPM
	ii. Delay ripening (papaya)	0.75		
Papaya, jackfruit carambola, rambutan, pineapple	iii. Phytosanitary treatment for USA market	0.40 (minimum)	Ahmad Zainuri Mohd. Dzomir, Dr (2009 –present)	DOA – project leader MARDI FAMA USDA
Cocoa beans	i. Control stored insect infestation	1.0	Radziah Ariffin (1986-1991)	MARDI – project leader UKM UPM
	ii. Control fungi infection	6.0		
Chilled chicken	Eliminate pathogenic microorganisms and extend shelf life	3.0	Radziah Ariffin (1989-1997)	
Cut Flowers (roses, chrysanthemum, orchids, carnations)	Control insect infestation	0.30	Norimah Yusof, Dr & Zainon Othman, Dr (1989-2000)	MARDI - Project leader DOA ASEAN Planti UKM FAMA
Dried chillies for chilli sauce	Eliminate bacteria and mold and extend shelf life	5.0	Norimah Yusof, Dr (1987-1988)	Juliana Enterprise
Frozen shrimp	Eliminate pathogenic microorganisms	6.0	Zainon Othman, Dr (1986)	UKM - project leader

Types of food/commodity	Purpose of irradiation	Maximum dose (kGy)	Project Leader/Coordinator (duration)	Collaborators
Frozen beef	Eliminate pathogenic microorganisms	6-8	Muhamad Lebai Juri, Dato' Dr (1999-2002)	MOH DVS
Honey	i. Eliminate pathogenic microorganisms (for food use)	5-10	Norimah Yusof, Dr (2002)	UKM DOA UPM
	ii. Sterilize (for medical purpose)	25		
Herbs and spices	Decontaminate spoilage microorganisms	10	Norimah Yusof, Dr & Salmah Moosa (1995-2009)	Syarikat Nona Roguy NPCB MOH
Cream coconut	Decontaminate spoilage microorganisms	5	Norimah Yusof, Dr (2003-2007)	MOH

A: Microbial decontamination of black pepper; B: Insect disinfestation of stored rice
C: Shelf-life extension of mushroom; D: Sprout inhibition of fresh ginger
E: Insect disinfestation of carambola; F: Delay ripening of papaya
G: Cobalt-60 irradiator Sinagama

COMMERCIALIZATION STATUS

First commercial irradiation of spices for export was conducted in 1997 using the Cobalt-60 irradiator “Sinagama” at Nuclear Malaysia. The gradual acceptance by food industry has seen the volume of irradiated food products including herbs increased from 100 metric tons in 1999 to over 700 metric tons annually in 2010. Commercial application is expected to further increase with the approval of the Food Irradiation Regulation 2011 by the Malaysian Ministry of Health.

OTHERS

- Gamma Irradiation as a Quarantine of Carambola, Papaya, Mango and Guava; IAEA/RCA Coordinated Research Programme (CRP), 50412/RB (1988-1990).
- Irradiation of Cut Flowers and Ornamental for Quarantine Treatment against Mites and Thrips;. IAEA CRP, 6004/RB (1990-1991).
- Pengawetan Makanan Dengan Menggunakan Sinar Gamma Dan Alur Elektron; IRPA, 2-06-05-06 (1991-1992).
- Pilot Scale Irradiation Of Pepper For Export; IRPA, 2-06-05-06- J04 (1991-1992).
- Penyinaran Buah-Buahan Dan Tanaman Hiasan Bagi Tujuan Kuanrantin Dan Pemanjangan Tempoh Penyimpanan; IRPA, 2-06-05-016 J03 (1991-1992).
- Penyinaran Bunga Keratan; IRPA, 01-01-03-0006 (1996-1998).
- Public Acceptance Of Trade And Development In Irradiated Food In Asia And The Pacific; IAEA/RCA CRP: 8689 (1995-1999).
- Irradiation as a Pest Disinfestations Technique for Stored Cocoa Beans. IAEA Research Contract No: 4213/B. 1986.
- Irradiation As A Sanitary And Phytosanitary Treatment Of Foods; IAEA/RCA RAS/5/034
- Novel Applications Of Food Irradiation Technology For Improving Socioeconomic Development; IAEA/RCA/RAS/5/046 (2008 – 2010).
- Enhancing Sanitary and Phytosanitary Treatment Of Regional Products For Export By Irradiation; IAEA/RCA/ RAS 5/0/50 (2009 – 2011).

CONTACT

Zainon Othman, Dr
Agrotechnology & Biosciences Division
Tel: 603-89250510 ext: 1432
Fax: 603-89112157
E-mail: zainon@nuclearmalaysia.gov.my

ACCEPTANCE STUDIES ON FOOD IRRADIATION

RESEARCH TEAM

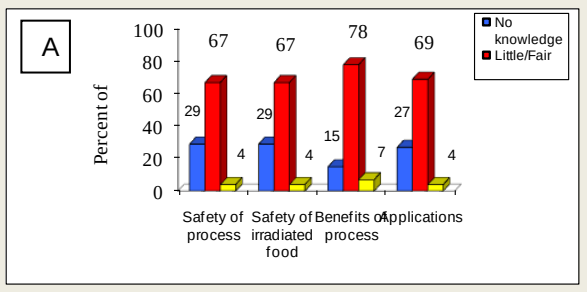
Leader : Zainon Othman, Dr

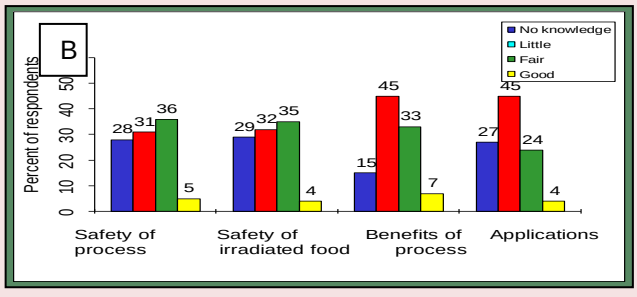
Members : Aminah Abdullah, Dr (UKM)
Rosmah Umam

Year: 1994-1998

SYNOPSIS

A survey was conducted on 1029 consumers in Klang valley region to obtain information related to awareness, understanding, perception and acceptance of food irradiation process and irradiated food. The survey indicated that majority of respondents interviewed were generally not aware or have little knowledge of the process. The frequency of awareness for the process showed significant differences between demographic categories of respondents. Irradiation process was perceived as somewhat dangerous by 52.1% of the respondents while 37.5% formed no opinion and only 10.4% were convinced that it is safe. Unwillingness to consume irradiated food by 84.9% of the respondents indicated low acceptance at present. However, safety endorsement from the Ministry of Health has strong positive influence on the consumer acceptance of irradiated food. Another survey was conducted on Malaysian food industries to determine the interest and potential application of food irradiation as an alternative or to complement existing food preservation treatments. A total of 37 food processors representing 5 subsectors of the food industry participated in the survey. Information collected showed that majority of respondents was aware of food irradiation but level of knowledge was low. Half of respondents perceived food irradiation as safe and 23% will consider using it for commercial purpose. Main concerns of the food processors are safety of the process, safety of irradiated food, efficacy of the process and consumer acceptance. The most potential application of food irradiation is in improving hygienic quality of food products. Respondents of both surveys strongly support the need to educate and promote food irradiation due to novelty of the technique in Malaysia. From the information gathered, the media (TV, radio, printing media) can play the leading role in conveying the information to the consumers effectively.





Level of knowledge on food irradiation for (A) consumers and (B) food industry

OTHERS

Related projects:

- Consumer Education and Acceptance of Food Irradiation Technology in Malaysia; IRPA: 07-01-03-0001 (1996-1998).
- Public Acceptance of Trade and Development in Irradiated Food in Asia and the Pacific; IAEA/RAC/CRP: 8689 (1994-1998).

CONTACT

Zainon Othman, Dr
Agrotechnology & Biosciences Division
Tel: 603-89250510 ext: 1432
Fax: 603-89112157
E-mail: zainon@nuclearmalaysia.gov.my

GAMMA IRRADIATION FOR STERILIZING TISSUE GRAFTS AND FOR VIRAL INACTIVATION

RESEARCH TEAM

Leader :	Norimah Yusof, Dr
Members :	Salahbiah Abdul Majid Asnah Hassan Selamat S. Nadir
Collaborators:	Hasim Mohamad, Dr (USM) Abd. Rani Shamsuddin, Prof (USM) Jamaludin Zainol, Dr (USM)
Year:	1990 -2000

SYNOPSIS

Ionizing radiation, namely gamma and electron beam, has been widely used for over 40 years to sterilize tissue allografts. Although their sterilizing efficacy has been widely studied, it is not in anyway to substitute proper screening of donor and proper tissue processing practices in tissue banking. There are two major concerns related to radiation sterilization in tissue banking practices; whether it evokes any undesireable effects in tissue and whether it effectively inactivates transmissible microorganisms particularly viruses such as HIV, HBV, and HCV. Ionizing radiation, like other sterilization methods, induces physical and chemical changes which may influence the biological properties of irradiated tissues. Some of these changes are desirable and some are not depending on the functional roles of the grafts. Effects of radiation sterilization are influenced by conditions during which the allografts are irradiated (temperature, moisture content) and also the processing techniques (air or freeze drying, deep-freezing). Gamma irradiation has been proven to be an efficient technique for inactivating viral and bacterial contaminants of allografts. Inactivation of microbes by irradiation is in dose dependent fashion. Sterilization dose depends on bioburdens (initial contamination) of the tissue and the resistance of microbial population to ionizing radiation. Radiation up to 30 kGy does not significantly alter the mechanical properties of many tissue alografts. Frozen tissues require higher doses up to 50 kGy before showing any degradation effect. Therefore, 25kGy, the universal sterilizing dose for medical products, is an acceptable dose for sterilization of allografts in order to achieve sterility assurance level (SAL) of 10^{-6}. Allografts that are processed under GMP and with extremely low bioburden can be sterilized even at lower dose of 15 kGy thus minimize any physical effects especially in soft tissues. Radiation, in combination with strict donor screening and proper processing technique, can sterilize tissues; minimize risk of disease transmission from donor to recipient and therefore safe for clinical application. Malaysian Nuclear Agency has developed protocols for processing and sterilizing tissues namely amnions and bones which have been adopted by many tissue banks locally and abroad.

Bone graft for orthopaedic surgery.

Procurement of amniotic membrane from human placenta

Superficial burn is covered by amnion for wound healing

AWARDS

- Malaysian Innovation and Design Exhibition/International Innovation and Technology Exhibition (MINDEX/INNOTEX) 1995. Production of Biomaterials for Clinical Applications - Bronze Medal.
- Quality Award YAB Menteri Besar Selangor 2001. Penghasilan Amnion Menggunakan Teknik Pengeringan Udara yang Berkesan Kos. First Winner (Innovation).

CONTACT

Khairuddin Abd. Rahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89250510 ext: 1611
Fax: 603-89112157
E-mail: khairuddin@nuclearmalaysia.gov.my

BIOLOGICAL DOSIMETERY USING CHROMOSOME ABERRATION ANALYSIS IN HUMAN BLOOD LYMPHOCYTE CELLS

RESEARCH TEAM

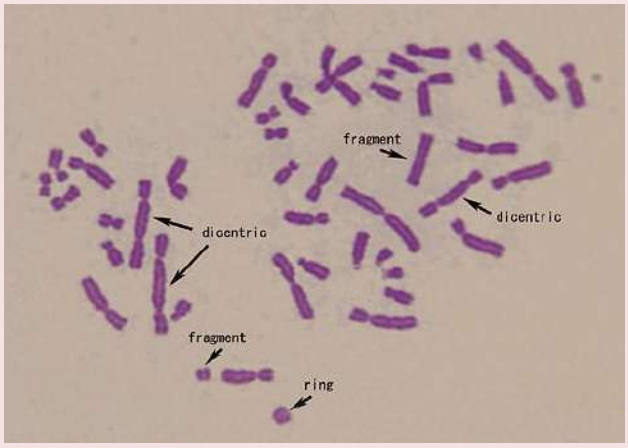
Leader :		Mohd. Zaidan Kandar
Members :		Zainon Ahmad Devaraj Muniandy
Collaborators	:	Ismail Bahari, Dr (UKM) Hamrah Mohd. Ali (AELB) Hasmadi Hassan (AELB)
Year	:	1990-1995

SYNOPSIS

Biodose laboratory which is now under the management of Medical Technology Division, was first initiated at the Division of Agrotechnology and Biosciences in 1988 by a small group of researchers and supporting staff. The laboratory was situated at block 44 and was known as Biological Dosimetry Laboratory. The laboratory was fully equipped with necessary equipment for cytogenetic analysis as well as a complete set of automatic chromosome spread metaphase finder to assist in the scoring of metaphase chromosomes.

Biological dosimetry is an alternative method to physical method in which absorbed radiation dose in human is determined by using chromosome aberration analysis in peripheral blood lymphocyte cells. The analysis involves sampling of blood, growing the lymphocyte cells in medium to allow for lymphocyte cells to divide. After metaphase arrest and various stages of cytogenetic procedure, cleansing and fixation procedure the cells suspension is fixed onto slide and stained with gymsa staining solution. Chromosome spreads are than examined and score under the light microscope manually or automatically. All aberrations is classified as dicentric (with associated fragment) (A), rings, acentric fragments and abnormal monocentric. The data are analysed using specially designed computer software based on the assumption that the distribution of chromosome aberrations among cells conforms to Poisson distribution. For dose estimation, standard in vitro dose-effect curve relating radiation dose with the induced aberration is established (B).

The role of biological dosimetry as an alternative method to physical dose estimation in case of workers not wearing film badge or overexposure was prominent. A number of overexposure cases that had been referred to the laboratory in solving radiation dose estimation problems as required by AELB. The usefulness of peripheral human lymphocytes as a bioindicator for ionizing radiation effect was also tested in a survey of Malaysian workers in industries producing technologically enhanced naturally occuring radioactive materials (TENORM).



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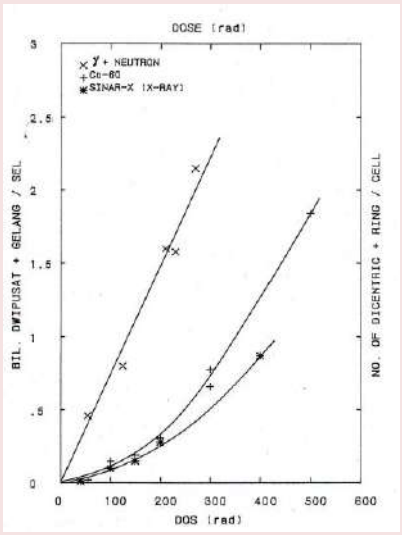

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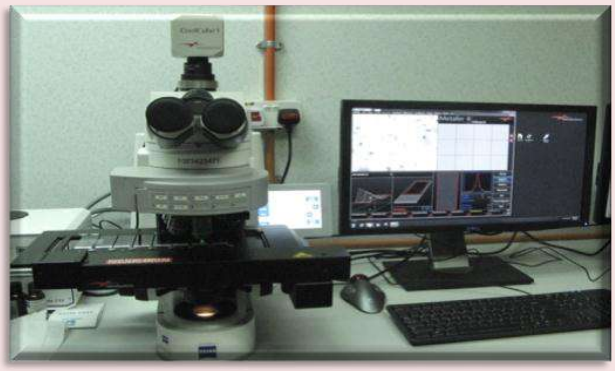


C

(A) Presence of dicentric, ring and fragment type of chromosome aberration in peripheral human blood lymphocytes cells as bioindicator for ionizing radiation effect, (B) Dose response relationship for the production of dicentric and ring percell for gamma, x-ray and mixed neutron-gamma radiation exposure, and (C) Automated metaphase finder used for scoring chromosomal aberration.

OTHERS

Related project:

- Radiation-induced Chromosomal Aberrations Among TENORM Workers: Amang and Ilmenite-processing Workers of Malaysia, IRPA 4-06-05-003-J06 (1990-1995).

CONTACT

Mohd. Zaidan Kandar
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1337
Fax: 603-89112157
E-mail: zaidan@nuclearmalaysia.gov.my

RADIATION AND FERMENTATION TECHNOLOGIES IN OIL PALM BY-PRODUCTS PROCESSING

RESEARCH TEAM

Leader :	Mat Rasol Awang, Dr
Members :	Muhamad Lebai Juri, Dato' Dr Zainon Othman, Dr Rosnani Abdul Rashid Foziah Ali Hassan Hamdani Hassan Mutaat
Collaborators:	Tamikazu Kume, Dr (JAEA) Shinpei Matsuhashi, Dr (JAEA) Tuan Syed Hussein Syed Abdullah (IHK) (JAEA, Japan Atomic Energy Agency)
Year:	1988- 2003

SYNOPSIS

Radiation processing is the processing of materials into a desired product or product intermediate utilizing controlled application of energy of short wave length radiations. Such radiation sources are electromagnetic radiation in nature, commonly known as ionizing radiations. Examples of such radiation are gamma rays, electrons beams and X-rays. Gamma-ray is a high energy ionising radiation, thus, highly penetrative into high density solid materials while electron beam is low penetrative, while X-ray is similar in nature to gamma-ray but slightly lower energy and lesser penetration to that of gamma. Due to high penetration, radiation is superior over the heat process for pasteurisation or sterilization purposes.

Oil palm by-products especially oil palm empty fruit bunch contains high cellulose embedded with lignin; lignocelluloses material of highly recalcitrant to natural biodegradation. The materials would require at least three months to be degraded when they are naturally disposed to environment. The process of natural biodegradation so called fermentation occurs by the virtues of natural micro-organisms from the environment consuming the lignocelluloses of the oil palm by-products, mainly fungi and mushrooms. Over that period of biodegradation to compost, the material becomes a breeding ground to pests and in fact that nature of disposal created new solid wastes that pose threat to environmental pollution.

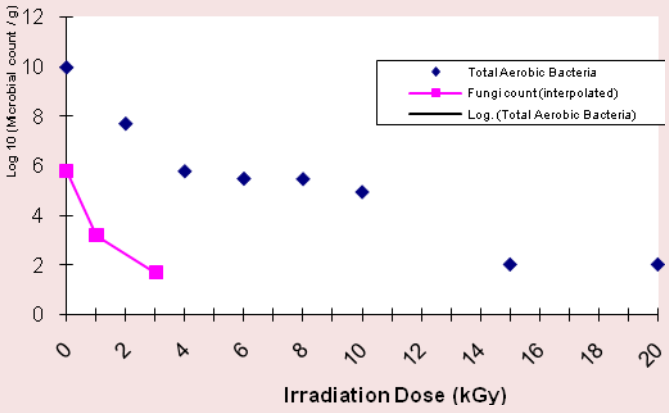
The availability of oil palm by-products are plentiful. It has been estimated on dry matter basis that their availability to be about 2.8 million tonnes oil palm empty fruit bunch, 2.2 million ton palm press fibre, 0.49 million ton oil palm trunk and 14.97 million ton oil palm fronds. Radiation and fermentation technology are combined technologies that utilise radiation source for pasteurisation or

sterilisation of oil palm by-products and application of microbes that grow and consumed on the pasteurised by-products. The mono-culture microbe applied in this process is the sole biodegradation agent which act on oil palm by products by secreting beta-glucosidase and xylanase enzymes to hydrolyse partially cellulose and lignin, in the fermentation process. The outputs from these processes are bioprocess products or bioproducts that could be directly used; typical examples are animal feed, compost and enzymes. The process for producing feed has been patented whereas process for producing radiation pasteurised substrates for mushroom cultivation has been recently filed for patent.

The value proposition of the technology lies in the fact that the process involves radiation pasteurisation using gamma-radiation at 10 kGy kills fungi and inactivates bacteria. Moreover, the level of radiation dose applied has not affected the physico-chemical properties of oil palm EFB and Palm Press Fibre. Thus, radiation pasteurisation has not change the original quality of the oil palm by-products. However, changes on physico-chemical properties of oil palm by product occur when they were exposed 50 kGy or higher dose irradiation dose.

In view of the available radiation processing technology and plentiful supply of oil palm by-product resources, the pasteurised oil palm by product resource could be produced in large quantity as feedstock for bio-industrial applications. This process could be the way forward for commercial production of animal feed, compost and enzymes in the future.

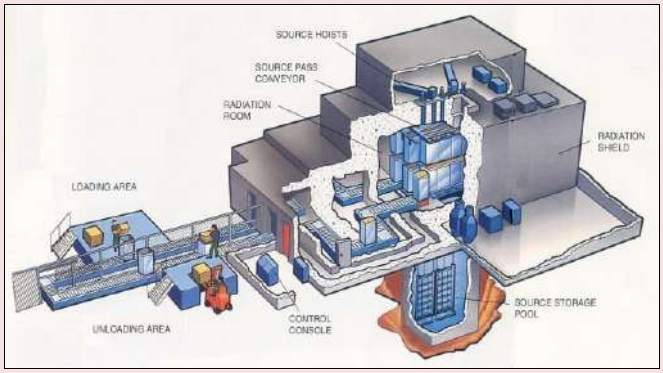
Fig. 1: Inactivation of typical fungi and aerobic bacteria on EFB from Mill 2



Reduction in bioburden by increasing dose

High bioburden oil palm EFB at the vicinity of palm oil mill

Oil palm EFB pasteurized by gamma radiation as mushroom cultivation substrate



Co – Irradiaiton Facility. MINTec SINAGAMA.

White Oyster

Shiitake Mushroom

Straw Mushroom

Grey Oyster

Pink Oyster

Cendawan Berangan

Edible mushrooms as oil palm by-product biodegradation agents

CONTACT

Mat Rasol Awang, Dr
Agrotechnology & Biosciences Division
Tel: 603-8911200 ext: 1362
Fax: 603-89112157
E-mail: rasol@nuclearmalaysia.gov.my

DEGRADATION OF OIL PALM EMPTY FRUIT BUNCHES (EFB) BY RADIATION AND MICROBES

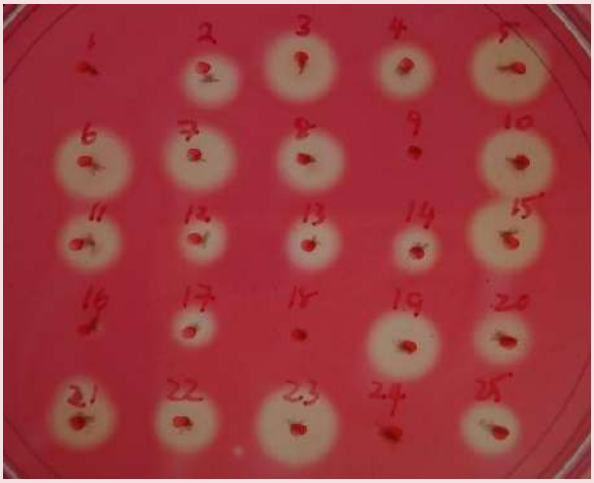
RESEARCH TEAM

Leader :	Jong Bor Chyan, Dr
Members :	Pauline Liew Woan Ying, Dr Ahmad Zainuri Mohd. Dzomir, Dr
Collaborator:	Narumi Issay, Dr Japan Atomic Energy Agency, Japan.
Year:	2003-2012

SYNOPSIS

The primary objective of this research was to convert the oil palm empty fruit bunch (EFB) into value-added product by bacterial isolates.The success of such conversion will not only be beneficial to the oil palm industry but will also have a significant impact in reducing the environmental problem. With the ultimate goal to add value to EFB, this research focused on an integrated, interdisciplinary approach in the degradation of EFB. Xylanolytic and cellulolytic bacterial isolates were obtained and their abilities to biodegrade EFB were successfully carried out in shake-flask fermentation system. Radiation approaches using gamma-rays and ion beams irradiation were employed to obtain bacterials mutants in degrading EFB. Recombinant biotechnology approach was carried out to identify the mechanism of biodgradation of EFB by bacterial isolates.

Bacterial isolate for EFB biodegradation.



Bacterial mutants with various cellulolytic activity obtained by irradiation approach.

OTHERS

Related projects:

- Degradation of Oil Palm Empty Fruit Bunches (EFB) by Radiation and Microbes; IRPA, 01-01-03-10002-EAR (2004-2007).
- Development of Bacterial Mutants Via Radiation Mutagenesis for Enhanced Bioconversion of Oil Palm Empty Fruit Bunches to Sugars; eScience Fund, 03-03-01-SF0040 (2010-2012).

CONTACT

Jong Bor Chyan, Dr
Agrotechnology & Biosciences Division
Tel: 60-3-8911 2000 ext. 1347
Fax: 60-3-8911 2157
E-mail: jongbc@nuclearmalaysia.gov.my

BIOENERGY GENERATION FROM AGRICULTURAL WASTEWATER USING MICROBIAL FUEL CELLS

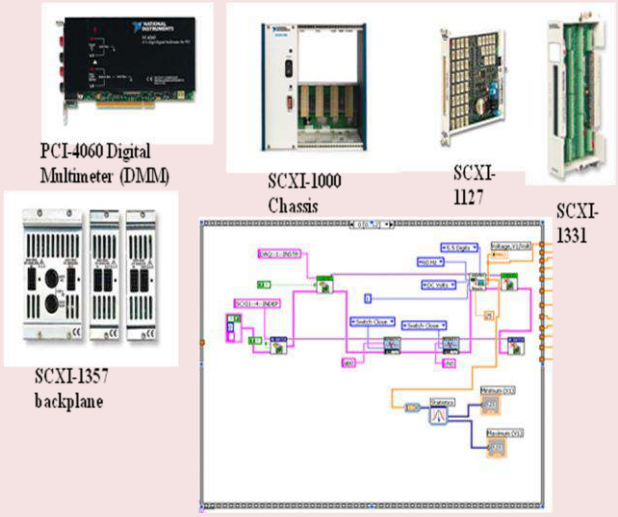
RESEARCH TEAM

Leader :	Jong Bor Chyan, Dr
Members :	Pauline Liew Woan Ying, Dr Muhamad Lebai Juri, Dato' Dr Leo Kwee Wah, Dr Ahmad Zainuri Mohd. Dzomir, Dr
Collaborator:	Kim Byung Hong, Dr Korea Institute of Science and Technology, South Korea
Year:	2006-2009

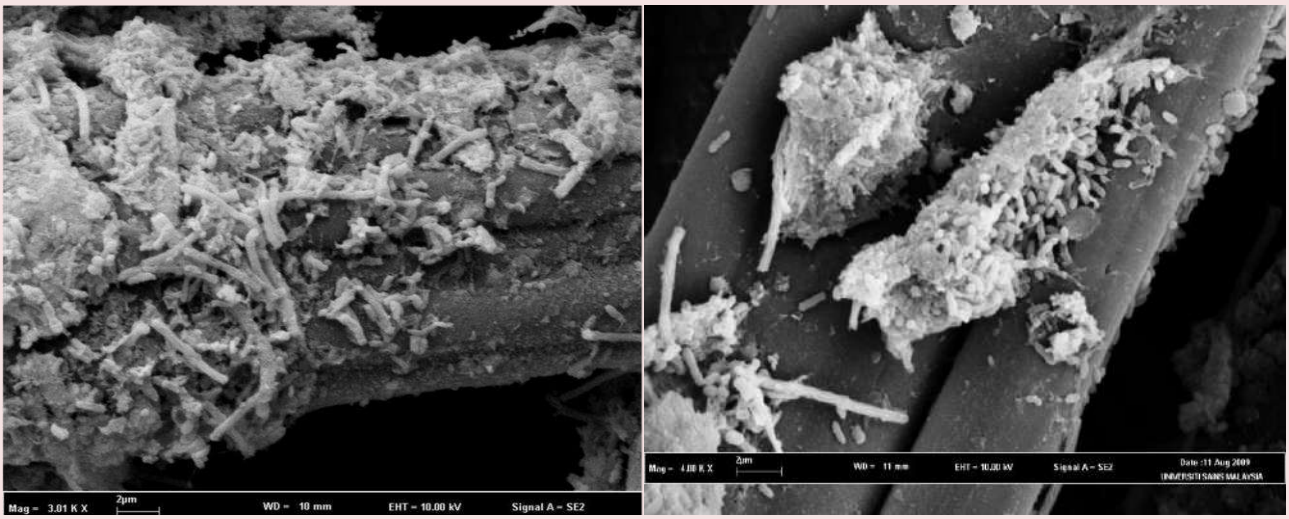
SYNOPSIS

The primary objective of this research is to generate bioenergy (electricity) from the oil palm processing wastewater. The success of such conversion will not only provide an alternative energy but have a significant impact in reducing the environmental problem caused by the oil palm processing industry. Besides electricity generation, the microbial fuel cell (MFC) process is able to reduce chemical content of wastewater. From this research, microbial fuel cell system was successfully developed from microbial consortium from POME and the effects of ionising radiation on bioenergy generation were also studied. We have shown that indigenous microbial consortium enriched from POME are able to generate power density of 3000 mW/m^2 while reducing the acetate artificial wastewater by 40% of its COD content in a MFC system. These findings suggest that there are encouraging potential economic benefits to convert the POME into electricity using a MFC system.

Microbial fuel cells for bioenergy generation



Real-time microbial fuel cell DAQ system



Microbial consortium for bioenergy generation

AWARDS

- Nuclear Malaysia Innovation Day 2009. Development of the microbial fuel cell measurement system. - Silver Medal.

OTHERS

Related project:

- Development and the Effects of Radiation on Microbial Fuel Cell in Generating Bioenergy from Agricultural Wastewater; eScience Fund, 03-03-01-SF0001 (2006-2009).

CONTACT

Jong Bor Chyan, Dr
Agrotechnology & Biosciences Division
Tel: 603-8911 2000 ext: 1347
Fax: 603-8911 2157
E-mail: jongbc@nuclearmalaysia.gov.my

DEVELOPMENT OF BIOPESTICIDE FROM *Lantana* spp. FOR THE CONTROL OF ORNAMENTAL PESTS

RESEARCH TEAM

Leader :		Nashriyah Mat, Dr.
Members :		Salmah Moosa Ros Anita Ahmad Ramli
Collaborators	:	Hamidah Sulaiman (MARDI) Ismail Sahid, Prof. Dr (UKM)
Year	:	2003 - 2006

SYNOPSIS

The flower eating yellow beetle *Oulema pectoralis* is one of the most important pests of orchid. As this beetle feeds on orchid flower, yield loss may reach 100% due to zero tolerance to damage. *Lantana camara* is one of the Malaysian weeds reported to have herbicidal and insecticidal properties. Leaf extract of *Lantana camara* was investigated for insecticidal and antifeedant activity against *Oulema pectoralis*. Ethanol and water extracts at 5-20% concentrations reduced the infestation of beetles on *Mokara* orchid flowers in glass beaker to 5-23%. Number of beetles reduced by 94% after 35 days of treatment with 10% *Lantana* water extracts. The orchid plants sprayed in the field with water extract of *Lantana camara* leaf, was effective in controlling *Oulema pectoralis* beetle on orchid flower. Work carried out at MARDI and UKM showed that crude extract of this plant is effective as insecticide and herbicide. The laboratory and field work done on *Lantana* spp. provide scientific evidence to support natural resources as biopesticide as an environmental friendly product for pest management and reduce environmental hazards.

Lantana camara sp.

Leaf extract of *Lantana camara* sp. to control *Oulema pectoralis*

Morkara Chark Kuan Pink

OTHERS

Related project:

- Development of Biopesticide from *Lantana* sp. for the Control of Ornamental (Orchid and Roses) Pests; MINT-R&D-05-028 (2003 - 2006).

CONTACT

Salmah Moosa
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1353
Fax: 603-89112157
E-mail: salmahmoosa@nuclearmalaysia.gov.my

DEVELOPMENT OF PLANT BIOREACTOR TECHNOLOGY FOR THE PRODUCTION OF FRAGRANCE COMPOUND FROM *Michelia alba* (CEMPAKA PUTIH)

RESEARCH TEAM

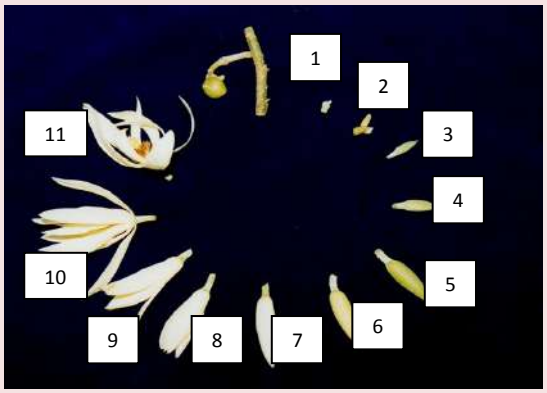
Leader :	Rusli Ibrahim, Dr
Members :	Sobri Hussein, Dr Norazlina Noordin Alvina Lindsay Mijen Salahbiah Abdul Majid Chong Saw Peng
Collaborators:	Sanimah Simoh, Dr (MARDI) Musa Al-Bakri Abdul Manan (MARDI) Hasniza Adnan (MARDI) Maheswary Vellupillai (MARDI) Radzali Muse, Dr (UPM)

Year:	2006-2009

SYNOPSIS

Michelia species is known to produce high value essential oil for perfumery industry. The essence of world's expensive perfumes, such as JOY and J'adore, is based on the oil of *Michelia* species. The content of fragrance compound from *M. alba* is 0.2% from flowers and 0.04% from the leaves. Studies have been conducted to develop an efficient cell culture system using somatic embryogenesis for the production of essential oils using bioreactor technology. Seven developmental stages of *Michelia alba*, flower namely stages 5 to 11 have been investigated for their volatile constituents. The essential oil was isolated by Simultaneous Distillation Extraction technique and the oil obtained was subjected to GC-MS analysis. In total, seventy-seven compounds representing 93-98% of the overall volatiles compounds have been identified on the basis of mass spectra and retention indices. Dihydrocarveol was one of the major fragrance compounds that contributed significantly during bud development through stage S5 to S8. However, linalool contributes significantly to the characteristic fragrance through stage S9 to S11 in which during these phases, the aroma of *M. alba* fragrance was intense. Extraction of cell cultures using Solid Phase Micro Extraction showed that linalool and dihydrocarveol were present in more than 10%, similar to those obtained from flowers.

This study has shown that plant cell cultures may serve as an alternative source of secondary metabolites such as fragrance compounds which are essential for various applications, especially in cosmetic industry. Improvement of culture media and selection of cell lines are particularly relevant in order to increase the production of fragrance compounds. The synthesis and accumulation of secondary metabolites can be endogenously controlled, development dependent differentiation process or can be regulated by various exogenous factors for production of valuable secondary metabolites in laboratory conditions.

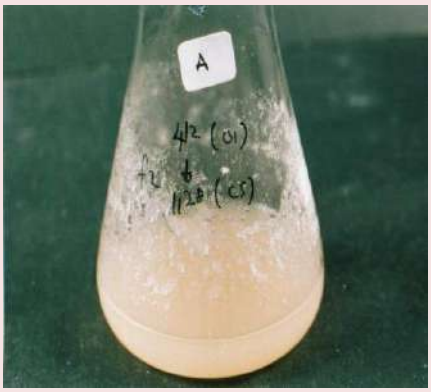


Development stages

Flower development

Full bloom flower

Callus from petals



Suspension cell culture

Scaling-up of cell cultures in Air-lift bioreactor

AWARDS

- Nuclear Malaysia Innovation Day 2004. Air-lift Bioreactor Technology for Mass Propagation and Cell Cultures - Gold Medal.
- S&TI Expo 2004. Air-lift Bioreactor Technology for Mass Propagation and Cell Cultures - Bronze Medal.

COMMERCIALIZATION STATUS

- Secondary metabolites in the form of fragrance compounds can be produced from cell cultures of *Michelia alba*.
- An alternative supply of essential raw materials for cosmetic industry
- Scaling-up can be done using laboratory bioreactor system and large-scale production using 1 ton Pilot Plant Bioreactor System.

OTHERS

Related projects:

- Development of Plant Bioreactor Technology for the Production of Fragrance Compounds from *Michelia alba* (Cempaka Putih). NBD Top Down (Biotechnology) 09-03-03-004/BTK/ER007 NBD (2004-2006).
- Development of Adventitious Roots and Scaling-up of Somatic Embryos for Plant Bioreactor System for the Production of Fragrance Compounds from *Michelia alba* (Cempaka Putih). NBD Top Down (Biotechnology) 09-03-03-004/BTK/ER007 NBD (2007-2008).

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

DEVELOPMENT OF GAHARU EXTRACTION AND DOWNSTREAM PROCESSING TECHNOLOGY

RESEARCH TEAM

Leader:	Mohd. Fajri Osman
Members:	Khairuddin Abdul Rahim, Dr Mat Rasol Awang, Dr Chong Saw Peng Rusli Zakaria Norellia Bahari Everina Ak Nuri
Collaborator:	Kedaik Agarwood Sdn Bhd
Year:	2003 - present

SYNOPSIS

Agarwood is a resin-impregnated wood produced from trees of *Aquilaria* spp. To obtain gaharu oil from the agarwood, the agarwood needs to be distilled via an extraction system.

Study on an innovative thermo-oil extraction system to enhance efficiency of gaharu oil extraction.

Development of a cost effective gaharu oil extraction technology suitable for use in the gaharu downstream industry.

COMMERCIALIZATION STATUS

Development of Gaharu Extraction Plant for Community

- Gaharu Oil Extraction Plant in Kg Kedaik, Rompin Pahang, 2007.
- Gaharu Oil Extraction Plant in Telupid, Sabah, 2010.
- Gaharu Oil Extraction Plant in Sg Asap, Belaga,Sarawak, 2013.

OTHERS

Involvement of Nuclear Malaysia in community projects to develop gaharu oil extraction facilities for rural communities and to facilitate the development of Malaysia's gaharu downstream industry.

Related projects:

- Pembangunan Loji Pemprosesan Minyak Gaharu; Community Innovation Fund (CIF), C0016 (2007-2008).
- Penghasilan Minyak Pati Resin *Aquilaria* sp. Menggunakan Sistem Ekstraksi Berinovasi MF-KARL-02; Community Innovation Fund (CIF), C0049 (2008-2010).
- Peningkatan Sosio-ekonomi Komuniti Sekitar Empangan Bakun Melalui Pembangunan Kemudahan Ekstraksi Produk Oleoresin Gaharu dan Aplikasi Teknologi Inokulasi Pokok Karas. Fasa 2: Pembangunan Kilang Ekstraksi Minyak Gaharu Berinovasi; Community Innovation Fund (CIF), C0284 (2011-2012).
- Peningkatan Sosio-ekonomi Komuniti Sekitar Empangan Bakun Melalui Pembangunan Kemudahan Ekstraksi Produk Oleoresin Gaharu dan Aplikasi Teknologi Inokulasi Pokok Karas. Fasa 3: Pemasangan Sistem Ekstraksi Minyak Gaharu; Community Innovation Fund (CIF), C0325 (2013-2014).

CONTACT

Mohd. Fajri Osman
Commercialization of Technology Division
Tel: 603-89112000 ext: 1372
Fax: 603-89252588
E-mail: fajri@nuclearmalaysia.gov.my

GAHARU INDUCER AND INDUCEMENT TECHNOLOGY

RESEARCH TEAM

Leader:	Chong Saw Peng
Members:	Khairuddin Abdul Rahim, Dr Mat Rasol Awang, Dr Mohd. Fajri Osman Rusli Zakaria Norellia Bahari Everina Ak Nuri
Collaborators:	Legenda Yakin Sdn Bhd Phyto Systemic Sdn Bhd Forestry Department Peninsular Malaysia (JPSM)
Year:	2004 - present

SYNOPSIS

Agarwood is a resin-impregnated wood produced from trees of *Aquilaria* spp. Under natural conditions, gaharu resin can only be produced by natural wounding such as injured by lightning or wounded by animals. However, the gaharu resin produced was very low in yield and only accumulated at certain spots where the injuries took place. Moreover, the natural process of gaharu resin accumulation is a time consuming process, it usually takes 10 to 20 years to accumulate enough gaharu resin for harvesting. To overcome this problem, gaharu inducement technology has been developed to enhance the gaharu resin production, which maximized the gaharu resin accumulation throughout the stem and shortened the oleoresin production time to 1 to 2 years.

Gaharu resin was formed inside the stem of the tree through inducement technology

Agarwood wood chips produced through inducement technology developed by Nuclear Malaysia and collaborator

COMMERCIALIZATION STATUS

A gaharu inducer product from Nuclear Malaysia had been ready for commercialization in 2009. An in house gaharu inducer production facility had been set up to provide the demand from the local market. In year 2012, Nuclear Malaysia has introduced a service package of gaharu inducer plus inducement service. The service is carried in collaboration with our industrial partner Legenda Yakin Sdn. Bhd., to serve Malaysia's gaharu industry.

OTHERS

Involvement in community projects on the inducement technology for gaharu resin development and to develop gaharu oil extraction facilities for the communities.

Related projects:

- Peningkatan Sosio-ekonomi Komuniti Sekitar Empangan Bakun Melalui Pembangunan Kemudahan Ekstraksi Produk Oleoresin Gaharu dan Aplikasi Teknologi Inokulasi Pokok Karas; Community Innovation Fund (CIF), C0173 (2010).

- The Study of The Gaharu Resin Production Via The Inducement Technology in *Aquilaria beccariana*; ScienceFund, 06-03-01-SF0060 (2012-2014).

CONTACT

Chong Saw Peng
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1470
Fax: 603-89112157
E-mail: sawpeng@nuclearmalaysia.gov.my Bioprocess Group

PRODUCTION OF POLYSACCHARIDES FROM MUSHROOMS IN SUBMERGED CULTURE FERMENTATION

RESEARCH TEAM

Leader :	Shaiful Azuar Mohamad
Members :	Nurul Shahnadz Amir Hamzah Rusli Ibrahim, Dr. Mat Rasol Awang, Dr. Rosnani Abdul Rashid Hassan Hamdani Hassan Mutaat Mohd. Meswan Maskom
Collaborator :	Wan Mohtar Wan Yusoff, Prof. (UKM)

Year: 2008-present

SYNOPSIS

The polysaccharides obtained from local mushrooms have the potential to be used in radiotherapeutic applications in the forms of nutraceuticals or pharmaceuticals products. The polysaccharides with immunomudulation properties have an inhibitory effect on certain tumor growth in animal and human. The cultivation using solid state fermentation (SSF) took a long time; on the other hand, submerged culture fermentation (SCF) has the potential to lower the fermentation time, thus generating higher yield. The research includes methods to evaluating the productivity, as well as characterizing the compound, enhanced production via various technologies such as radiation, bioprocessing, and so on. Optimisation method such as response surface methodology (RSM) was employed and testing the products towards animal and human will be proceeded in stages as the research continues. Ultimately the aim is that the final solutions will be viable for commercialization and various other applications also will be explored to increase the potential entering the market.

Mycelium

Polysaccharides

AWARDS

- Nuclear Malaysia Innovation Day 2013. Productions of Polysaccharides from Mushrooms in Submerged Culture Fermentation - Bronze Medal.

COMMERCIALIZATION STATUS

The product is still in the R&D stages.

CONTACT

Shaiful Azuar Mohamad
Agrotechnology & Biosciences Division
Tel: +603-89112000 ext: 1404
Fax: +603-89112157
E-mail: azuar@nuclearmalaysia.gov.my

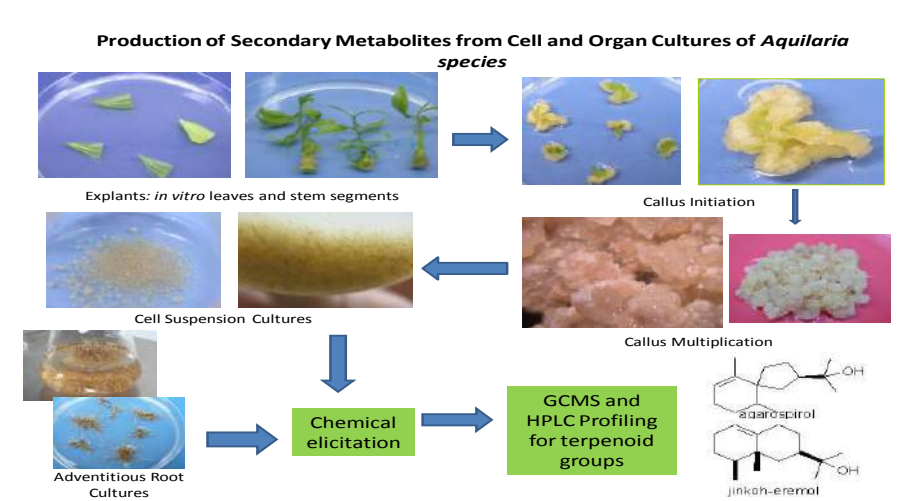
PRODUCTION OF SECONDARY METABOLITES FROM CELL AND ORGAN CULTURES OF *Aquilaria malaccensis*

RESEARCH TEAM

Leader :	Norazlina Noordin
Members:	Rusli Ibrahim, Dr. Alvina Lindsey Mijen
Year:	2009-Present

SYNOPSIS

Most bioactive compounds/secondary metabolites are obtained directly from plant tissue whose availability may be limited. The advantage of using plant cell culture as a model system for the study of biosynthetic pathways is because secondary metabolite formation can take place within a short cultivation time. Plant cell and organ cultures also provide alternative approaches when the source plant is difficult to cultivate, has a long cultivation period or has low metabolite yield. Thus, using this technology, the metabolites can be produced under controlled and reproducible conditions and from an engineering perspective and cell suspension culture has more immediate potential for industrial application than plant tissue cultures. This project was conducted to identify and produce secondary metabolites, namely sesquiterpens and 2-(2-phenylethyl) chromones compounds, in cell suspension cultures of *Aquilaria malaccensis* using chemical elicitation. This is a novel study involving *A. malaccensis,* in attempts to identify, induce and produce medicinally beneficial secondary metabolites using chemical elicitor in cell suspension and organ culture systems.



AWARDS

- Nuclear Malaysia Innovation Day 2009. Production of Gaharu Oil from Cell and Organ Cultures - Gold Medal.
- Malaysian Technology Expo 2010. Gaharu Oil production in Cell and Organ Cultures of *Aquilaria* spp. - Silver Medal.
- BioInno Awards, BioMalaysia 2010. Gaharu Oil production in Cell and Organ Cultures of *Aquilaria* spp. - Gold Medal.

CONTACT

Norazlina Noordin
Agrotechnology & Bioseciences Division
Tel: 603 – 89112000 ext: 1342
Fax: 603 - 89112157
E-maill: azlina@nuclearmalaysia.gov.my

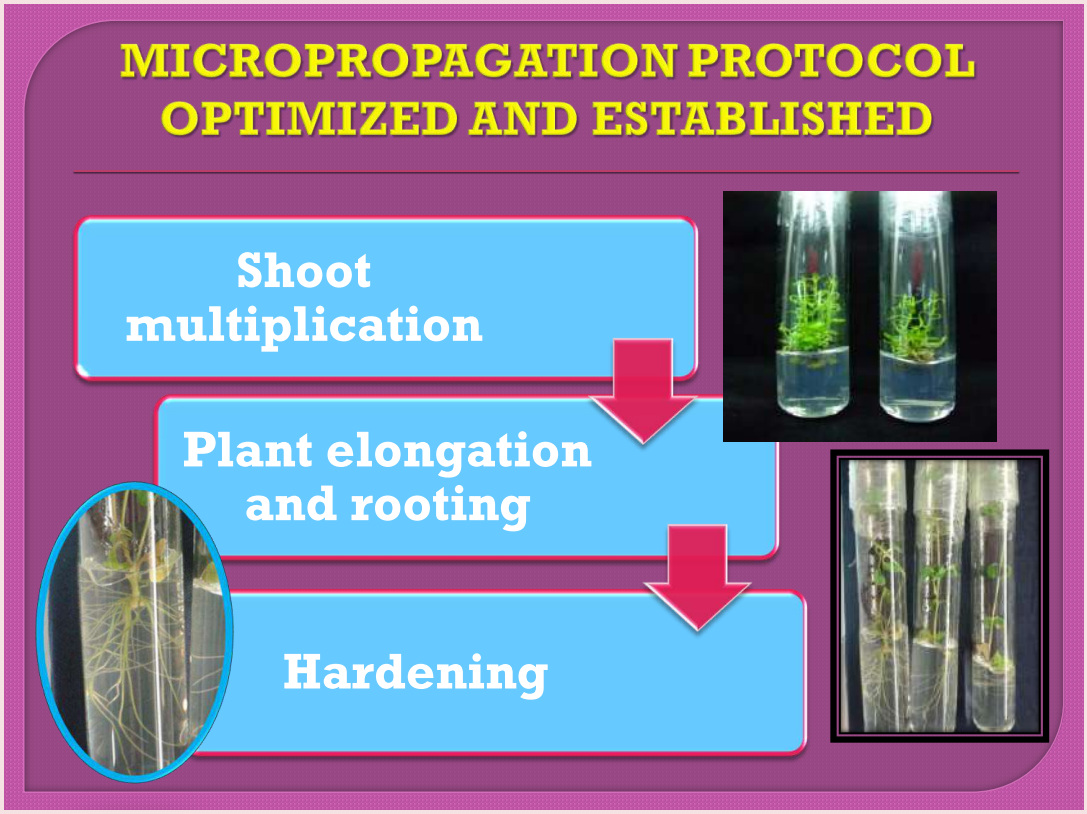
PRODUCTION OF STEVIOL GLYCOSIDES IN *Stevia rebaudiana* Bertoni.

RESEARCH TEAM

Leader :	Norazlina Noordin
Members :	Rusli Ibrahim, Dr Nurhidayah Sajahan Abdul Rahim Harun, Dr Sobri Hussein, Dr Salmah Moosa Ahmad Nazrul Abd. Wahid
Year:	2012-Present

SYNOPSIS

Stevia rebaudiana Bertoni is herbaceous tropical medicinal plant, belongs to the family Asteraceae. It is one of the 154 members of genus *Stevia* which produce sweet steviol glycosides and *Stevia* leaves are the source of diterpene glycosides, stevioside and rebaudioside. The study was conducted to establish a suitable protocol for *in vitro* propagation of *S. rebaudiana* Bertoni and to study the effects of chronic and acute gamma irradiation on growth and multiplication rate of in vitro shoots and enhancement of steviol glycosides in *Stevia rebaudiana*. With the introduction of a new variety of late-maturing/photo-insensitive *Stevia rebaudiana* with enhanced production of steviol glycosides, this could create an improvement of this source of natural sweetener and help to develop a sustainable stevia industry in Malaysia. To date, tissue culture protocol for multiple shoot formation has been successfully optimised, LD_{50} and effective gamma ray doses have been determined and *in vitro* mutagenesis has been successfully established.



OTHERS

Related projects:

- Effects of Chronic Gamma Irradiation on Growth and Multiplication Rate with Reference to Enhanced Production of Steviol Glycosides in *Stevia rebaudiana* Bertoni; ScienceFund (Biotechnology), 02-03-01-SF0163 (2012-2013).
- Effects of LED Light Technology for Development of Photo-Period Insensitive Stevia Variety; Collaboration with University of Gent, Belgium (2013-present).

CONTACT

Norazlina Noordin
Agrotechnology & Biosciences Division
Tel: 603- 89112000 ext: 1342
Fax: 603 - 89112157
E-mail: azlina@nuclearmalaysia.gov.my

PRODUCTION OF HIGH QUALITY PLANTING MATERIALS FOR *Labisia pumila* USING AIR-LIFT BIOREACTOR TECHNOLOGY

RESEARCH TEAM

Leader : Sobri Hussein, Dr

Members : Rusli Ibrahim, Dr
Aishah Hj. Hassan
Nurul Atiqah Yahya
Nur Atiqah Mohd. Anuar

Year: 2012

SYNOPSIS

Labisia pumila is one of the valuable medicinal plants and has been used by locals as protective medicine before and after childbirth. Interest in this plant was further enhanced due to its potential as a remedy for dysentery, flatulence, dysmennorhoea and gonorrhoea. It was also found to have a high flavonoids and phenolic contents that are responsible for pharmacological activities. Three different varieties of this species have been identified and found in Malaysia: viz *pumila*, *alata* and *lanceolata*. However, two of its varieties i.e *pumila* and *alata* have been commonly used in traditional medicine and researched as they are more readily available than *lanceolata*. The increase in logging activities and encroachment in forests caused a decline in the production of *L. pumila* from its natural habitats. This problem is further aggravated by its slow growth in natural forests. Moreover, it is difficult to obtain planting material from the wild. In order to address the demand of *L. pumila*, it is necessary to find alternative methods for mass production, specifically using *in vitro* methods to ensure regular supply of its planting stock.

Tissue culture plantlets of *Labisia pumila* can be regenerated through induction of callus and somatic embryogenesis using air-lift bioreactor system. Four different types of PGRs such as IBA, NAA, zeatin and kinetin were tested on explants such as *in vitro* leaf and stem cuttings of *L. pumila* var. *alata*. The explants responded differently towards the types of PGRs. Calli were induced in MS medium supplemented with IBA on leaf explants as well as in MS medium with IBA and zeatin on stem explants. These calli can be multiplied in air-lift bioreactor system for the production of somatic embryos which will be regenerated into shoots. *In vitro* shoots can be rooted in MS solid medium supplemented either with IBA or NAA. MS medium added with IBA, zeatin and kinetin promoted shoot induction from stem explants.

IN-VITRO CULTURE

Production of somatic embryos
using air-lift bioreactor

Tissue Culture Plantlets

CONTACT

Sobri Hussein, Dr
Agrotechnology & Biosciences Division
Tel:603-8911200 ext: 1330
Fax:603-89112157
Email:sobri@nuclearmalaysia.gov.my

PHYTOCHEMICAL SCREENING AND THE CHEMICAL CONSTITUENTS FROM LEAVES OF *Aquilaria malaccensis*

RESEARCH TEAM

Leader : Salmah Moosa

Collaborator : Khozirah Shaari, Prof (UPM)

Year: 2006 - 2011

SYNOPSIS

Aquilaria malaccensis is an endangered economic tropical forest tree producing valuable agarwood worldwide. The sequential maceration extraction methods utilizing solvents with different polarities namely hexane, ethyl acetate and methanol yielded the corresponding crude extract. The aqueous and methanol extracts along with dry powder of leaf of the plant was screened for the presence of phytochemicals. They were also tested for antioxidant activities. The result indicates the presence of alkaloids, flavanoids, triterpenoids, steroids and tannins. The phytochemical screening suggests that flavanoids present in this species might provide a great value of antioxidant activity. Determination on antioxidant activity of each crude extract showed that methanol crude extract had the highest IC_{50} value than others. This coincides with its traditional use through boiling of the leaves showing its potential as source of compounds with medicinal values. Several chromatographic method has been employed to the crude extract of the leaves which led to the isolation of eleven compounds namely stigmasterol, ß-sitosterol, lupeol acetate, luteolin, genkwanin, +7-hydroxy-5,4'-dimethoxyflavone, 3-fridelanol, fridelin, 2,4,6-trihydroxy-3-geranyl acetophenone, p-O-geranylcoumaric acid and 4-ethyl-4-methylheptyl-4-hydroxybenzoate. This work has resulted in the isolation and identification of triterpenes and flavanoid with the polar extracts showing potential antioxidant and cytotoxic activities proving the usefulness of agarwood tree for medicinal purposes and its potential as a source of medicinal or therapeitic drugs.




Aquilaria leaves are extracted through sequential maceration; several chromatographic techniques such as NMR, MS, UV and IR has been employed to identify isolated compounds.

CONTACT

Salmah Moosa
Agrotechnology & Biosciences Division
Tel: 03-89112000 ext:1353
Fax: 03-89112157
E-mail: salmahmoosa@nuclearmalaysia.gov.my

MUTAGENESIS of *Jatropha curcas*

RESEARCH TEAM

Leader :	Azhar Mohamad, Dr
Members:	Rusli Ibrahim, Dr Abdul Rahim Harun, Dr
Collaborators :	Mohd. Zaim Mohd. Nor (LKTN) Zulkefly Sulaiman, Dr (LGM) Zarawi Ab. Ghani (LGM)
Year:	2007-2010

SYNOPSIS

Jatropha plants in Malaysia has very low yield of around 3-4 t/yr/ha. Narrow genetic background of *Jatropha curcas* gives less selection to growers for better quality plant materials. Import of the high-yielding varieties may also mean importation of “unknown” bad traits, like susceptibility to pests and low adaptability. Main objectives are to obtain higher seed yield and oil content, earlier maturity, reduced plant height, resistance to pests and diseases, drought resistance/tolerance, higher ratio of female to male flowers and improved fuel properties.

Physical mutation by gamma-rays is one of the promising strategies for plant improvement which can alter one or more characteristics of plant cultivars while retaining other agronomic and quality traits of the original genotype. Through radiation mutagenesis, induction of new potential mutants with high fruiting yield is possible to achieve. The LD_{50} for seeds (germination rates) and cuttings (number of bud generates) were obtained at 297 Gy and 26 Gy, respectively.

Mutagenesis in *Jatropha* has opened a broad genetic pool to improve a high quality yielding fruit which can be utilized for bio-diesel industries. In vitro techniques through bioreactor propagation system can be utilized to support large-scale production of true-to-type plant materials. Integration of mutation breeding and tissue culture techniques could possibly contribute an important economic impact on agriculture especially in bio-diesel industries in the future.

(a)

(b) (c) (d)

Jatropha field (a). Mutagenesis of *Jatropha* resulted variance of plant traits such as (b) Dwarf, (c) High branching (e) Early flowering.

Jatropha fruits

Matured seed pods

Seeds

Male and female flower

OTHERS

Related project:

- Development of mutant lines in *Jatropha curcas* for high yield fruiting. NM-R&D-09-05. (2009-2010**).**

CONTACT

Azhar Mohamad, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1331
Fax: 603-89112157
E-mail: azhar_m@nuclearmalaysia.gov.my

MOLECULAR MARKERS FOR *AQUILARIA* AND MUSHROOMS

RESEARCH TEAM

Leader :	Azhar Mohamad, Dr
Members :	Mat Rasol Awang, Dr Rosnani Abdul Rashid Hassan Hamdani Hassan Mutaat Mohd. Meswan Maskom Mai'izzaty Mohd. Meswan Siti Khadijah Mohd. Nahar
Collaborators :	Rohaida Othman, Assoc. Prof. Dr (UKM) Sheila Nathan, Prof. Dr (MGI) Fauzi Daud, Assoc. Prof. Dr (UKM) Sahidan Senafi, Assoc. Prof. Dr (UKM)
Year:	2007-present

SYNOPSIS

Identification of karas tree (*Aquilaria* spp.*)* is important for cultivation of the right species and controlling trafficking of the products, especially wood chips and gaharu oil. Specificity of *Aquilaria* species is important in gaharu industry as the resin produced by the tree reflects the quality of the resin. At Malaysian Nuclear Malaysia, molecular markers based on targeted genes especially to stress genes had been developed for fingerprinting of *Aquilaria* spp.. The genes known as protein systemin is an 18-amino-acid polypeptide released from the wound sites of plant tissues caused by insects or mechanical damage. This protein systemically regulates the activation defensive genes in response to herbivore and pathogen attacks resulted in production of gaharu resin. Samples for DNA fingerprinting can be obtained from fresh leaves (field, nursery, tissue culture) or dried wood chips

There are many species of mushroom in Malaysia which requires their identification in order to understand diversity, locality and polymorphism. Good quality mushroom corresponds to large fruiting body, harder texture, higher yield production and produces early flush. Molecular marker based on ISSR (Inter Simple Sequence Repeat) had been tested to be useful for species identification and polymorphism in improving yield, seed production and quality traits.

ISSRs provide a powerful, rapid, simple, reproducible and inexpensive means to access genetic diversity among closely related species, characterization of accessions and identification of species. ISSR marker is found to be the best choice as it requires no information about the species. This technique provides more information in differentiating amongst species at molecular level, which provide an important milestone towards identification and characterization of plant and mushroom species in Malaysia.

 (a)  (b)  (c)  (d)

Samples for total genomic DNA of *Aquilaria* sp.: (a) field, (b) nursery, (c) tissue culture and (d) dried chips wood.

 (a)  (b)  (c)  (d)

Samples for total genomic DNA of *Pleurotus* sp.: (a) fruit body, (b) liquid seed, (c) mycelium and (d) dried mushroom.

AWARDS

- Nuclear Malaysia Innovation Day 2013. Method of Screening Local Oyster Mushroom Varieties using Inter Simple Sequence Repeat (ISSR) - Gold Medal.
- Malaysian Technology Expo MTE 2010. Biomolecular Markers of *Aquilaria sp*.: A quick and reliable fingerprinting - Silver Medal.
- Nuclear Malaysia Innovation Day2010. Gaharu Identification Kit: One stop solution *Aquilaria* Fingerprinting - Silver Medal.

OTHERS

Related projects:

- Elucidating the Gaharu Resin and Other Biosynthetic Pathways Using Large-Scale Transcriptome and Metabolite Profiling Via Comparison of Infected and Uninfected Trees. Nuclear Malaysia/UKM/MGI. 02-05-20-SF11116 (2012-present).
- Identification of *Pleurotus sajor caju* Using Molecular Marker Technique. NM-R&D-11-06. (2011-2013).

CONTACT

Azhar Mohamad, Dr.
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1331
Fax: 603-89112157
E-mail: azhar_m@nuclearmalaysia.gov.my

DEVELOPMENT OF FLORA, FAUNA, MICROFLORA AND AQUATIC ORGANISMS DATABASE AT THE VICINITY OF GAMMA GREENHOUSE IN MALAYSIAN NUCLEAR AGENCY

RESEARCH TEAM

Leader : Mohd. Zaidan Kandar

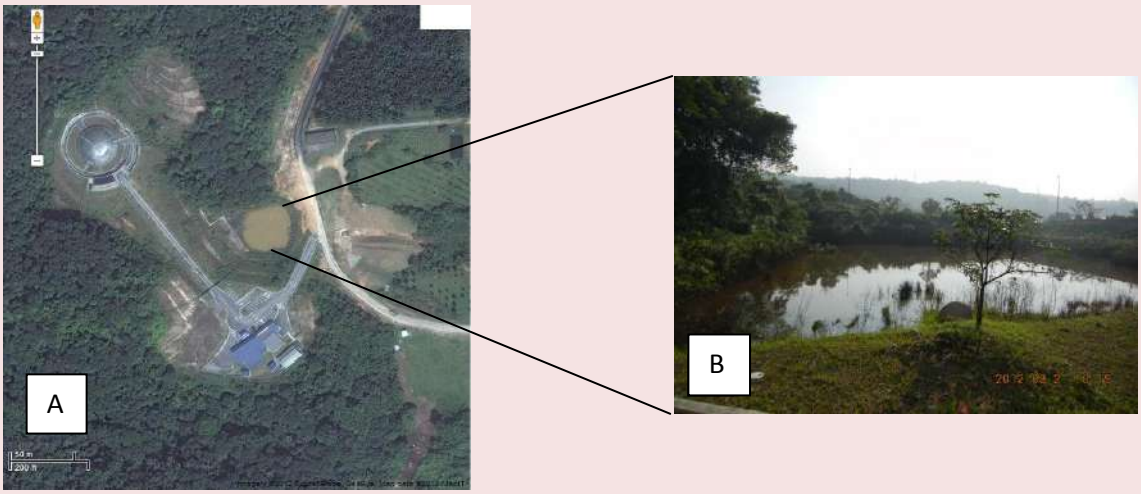
Members : Khairuddin Abdul Rahim, Dr
Mat Rasol Awang, Dr
Abdul Rahim Harun, Dr
Ahmad Zainuri Mohd. Dzomir, Dr
Seri Chempaka Mohd. Yusof, Dr
Azhar Mohamad, Dr
Sobri Hussein, Dr
Zaiton Ahmad, Dr
Affrida Abu Hassan
Phua Choo Kwai Hoe
Rosnani Abdul Rashid
Ros Anita Ahmad Ramli
Shakinah Salleh
Norazlina Noordin
Salmah Moosa
Sakinah Ariffin
Salahbiah Abdul Majid
Nur Humaira' Lau Abdullah
Zainab Harun
Maizatul Akmam Mhd. Nasir
Hassan Hamdani Hassan Mutaat
Foziah Ali
Latiffah Norddin
Shuhaimi Shamsuddin
Mohd. Meswan Maskom
Misman Sumin
Suhaimi Musa
Mohd. Hafiz Abd Nasir
Norhafiz Talib
Abdul Razak Ruslan
Salim Othman
Husni Ismail

Collaborators : Bahagian Keselamatan Sinaran & Kesihatan
Bahagian Teknologi Sisa & Alam Sekitar
Universiti Kebangsaan Malaysia
Universiti Putra Malaysia

Year : 2011-2013

SYNOPSIS

This project is a part of the programme of Nuclear Malaysia in preparation for Malaysia's first Nuclear Power Programme in the aspect of development of baseline data of flora and fauna at proposed power plant site/sites. The baseline data is needed in the EIA report as well as for future reference especially on the effect of ionising radiation to flora and fauna at the vicinity of a plant. In this project, Gamma Greenhouse at MINT-Tech Park is used as a model of a nuclear facility and standard procedure of ecological surveys are carried out to obtain data of the flora and fauna inhabiting areas around the facility. Ecological surveys have been conducted at the different ecosystems i.e. terrestrial and aquatic at the site. The species found from this work are continually screened to determine potential reference organisms (species) representing tropical region for environmental impact assessment in relation to radiation exposure. Besides ecological surveys, periodical dose mapping around the facility are conducted to relate any effect of radiation to the biodiversity. Ecological study is a new field in Malaysian Nuclear Agency and thus human capital development is essential and activities have been planned around the IAEA TC Project on Establishing a national database on Biodiversity and Radiology.



(A) Aerial map showing the location of the pond near GGH where sampling of aquatic organisms was carried out and (B) Close view of the pond where sampling of aquatic organisms was carried out.

Diverse organisms found at the vicinity of Nuclear Malaysia's Gamma Greenhouse.

OTHERS

Related projects:

- Establishing a National Database on Biodiversity and Radiology; IAEA Technical Cooperation Project, MAL/0/015 (2012-2013).
- Development of Baseline Data of Flora, Fauna and Microflora at the Gamma Greenhouse Vicinity; PDRD, NM-R&D-11-30 (2011-2013).

CONTACT

Mohd. Zaidan Kandar
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1337
Fax: 603-89112157
E-mail: zaidan@nuclearmalaysia.gov.my

ANIMAL FEED FROM OIL PALM WASTES

RESEARCH TEAM

Leader :	Mat Rasol Awang, Dr
Member :	Hassan Hamdani Hassan Mutaat
Collaborators:	Tamikazu Kume (JAEA) Shinpei Matsuhashi (JAEA) Tuan Syed Hussein Syed Abdullah (IHK) (JAEA, Japan Atomic Energy Agency; IHK, Institut Haiwan, Kluang, Johor)
Year:	1988- 2003

SYNOPSIS

Malaysia has abundant supply of agriculture waste or by-products, mainly lignocelluloses from palm oil extraction process that potentially be utilized as feed resources. Rich in cellulose, embedded with lignin, the materials is essentially energy rich resource for ruminant animal feed but less digestible due to the presence of lignin. The physico-chemical properties of the by-products indicated that, they are useful feedstock for ruminant animal feed production, but requiring some technological input to render materials into feed. This initiative has been identified as a potential venture in feed production. The animal feed product described herein was produced by upgrading of the solid wastes from oil palm industry into high protein roughage feed. It has been accomplished by treating the wastes with a combined radiation treatment and fermentation processing. The processing technology had improved the protein content twice over the original raw material and reduced the fiber content to a digestible level by ruminant animal. The feed material products can be used as a major component in production of complete feed. Assessment has been made that under appropriate commercial operation, this technology can produce a cost effective ruminant animal feed. The products have been forecasted to have an impact on local livestock industry, especially the ruminant sector. It would expect that the outcome of this initiative would have impacts on feed producing industries. The industries would be able to produce feed for local consumption. Consequently the livestock industries would be less dependent on imported feeds and feed components, hence reducing Malaysia's import bills. Besides the economic benefit of producing animal feed, the utilization of solid waste is also beneficial to the industry where, in the processing technology, the waste materials are being consumed in the processing and hence eliminate the potential threat of solid waste environmental pollution.

Oil palm fibres

Oil palm fibres fermented with mushroom In plastic bottles

Oil palm fibres fermented with mushroom In 1 Kg plastic bag

Oil palm fibres fermented with mushroom in 10 kg plastic bag

Cattle feeding on fermented oil palm fibres

Formulated feed pellets (complete feed) from oil palm EFB.

PATENT

Process for Producing Feeds from the Cellulosic Fibrous Wastes of Oil Palm (MY-130294 - A) -granted 29 June 2007.

CONTACT

Mat Rasol Awang, Dr
Agrotechnology & Biosciences Division
Tel: +603-89112000 ext: 1362
Fax: +603-89112157
Fax: 03-89112157
E-mail: rasol@nuclearmalaysia.gov.my

SYNTHETIC SEEDS

RESEARCH TEAM

Leader :	Rusli Ibrahim, Dr
Members :	Sobri Hussein, Dr Azhar Mohamad, Dr Siti Hajar Mohd. Nahar Siti Maryam Mohd. Nahar Wan Nazirah Wan Ali Hawa Abdul Aziz
Collaborators:	Dita Agisimanto (UKM) Sina Siavash Mogghadam (UPM)
Year:	1991 - 2012

SYNOPSIS

Synthetic seeds' refers to the encapsulation of somatic embryos (regenerative single cell) or meristem (adventitious buds, shoot tips) that functionally mimics the behaviors of true seeds and sprout into seedlings in *in-vitro* or *ex-vitro* under suitable conditions. The invention of synthetic seeds, or artificial seeds, involved improved development of encapsulation of somatic embryos or meristem using chemical formulation of radiation-treated alginate supplemented with other useful materials such as growth nutrients, fungicides, pesticides, antibiotics and beneficial microorganism such as *Mycorrhiza* supplemented with growth hormones. In addition, incorporation of activated charcoal improved vigour and regeneration of growing embryos to plantlets.

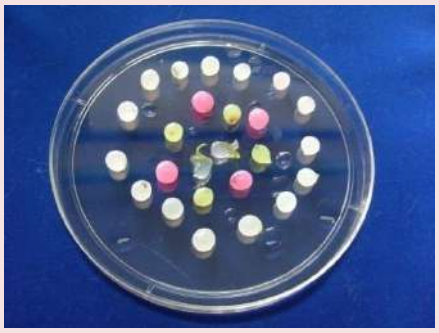
Radiation-treated alginate offers the advantage of longer shelf-life of coating materials for synthetic seeds. Radiation-treated alginate is an innovative step for coating matrix. In addition these synthetic seeds can be stored in air-tight containers filled with sterilized gamma-irradiated media for long storage. Gamma-irradiation treated media offers the advantage of keeping the synthetic seeds clean, free of bacterial and fungal contamination. Gamma-irradiation treated media for storage of synthetic seeds is another innovative step which is better and totally different from any other invention.

ADVANTAGES OF SYNTHETIC SEEDS

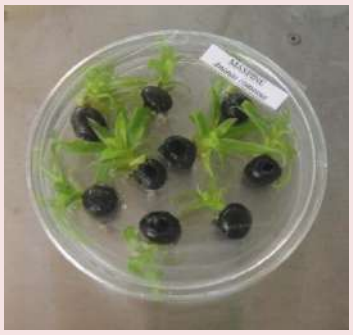
- Reduced cost of producing transplants
- Ease of handling while in storage and easy to transport
- Has potential for long term storage without losing viability
- Direct greenhouse and field delivery of selected genotypes and genetically engineered plants
- Allows economic mass propagation of elite plant varieties
- As a carrier for adjuvants such as microorganisms, plant growth regulators, pesticides, fungicides, nutrients and antibiotics.

- Protection of elite genotypes
- Simple to set-up the system and easy to use
- Practically no maintenance work

Somatic embryos

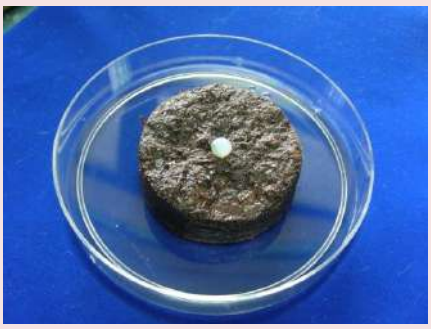


Synthetic seeds containing somatic embryos



Shoot-regenerated somatic embryos

In vitro shoots derived from synthetic seeds in multi-colour media for sales and decoration



Germinating synthetic seed on jiffy media

Synthetic seeds germinated into shoots

AWARDS

- Malaysian Technology Expo MTE 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal and Best Award.
- BioInno Award and Bio Malaysia Exposition 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology - Gold Medal.
- Seoul International Invention Fair 2009. Biotechnology Improved Synthetic Seeds-Low Cost Seed Production Technology -Gold Medal and Semi Grand Prize Winner.
- i-Innova Expo, Universiti Sains Islam Malaysia (USIM) 2010. Synthetic Seeds - Gold Medal.

- Nuclear Malaysia Innovation Day 2002. Temporary Immersion Bioreactor for mass propagation of tissue culture - Gold Medal.
- S & T Expo 2002. Temporary Immersion Bioreactor for Mass Propagation of Tissue Culture - Bronze Medal.

COMMERCIALIZATION STATUS

Established an agreement with a private company called Beta Eco Nature Solutions in Ipoh Perak for the supply of *in vitro* plantlets of pineapple, banana, orchids, roses, gaharu, Tongkat Ali, Kacip Patimah and Sambung Nyawa derived from Synthetic Seeds.

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

HYDROGEL WOUND DRESSING AND HYDROGEL BASED PRODUCTS

RESEARCH TEAM

Leader:	Norimah Yusof, Dr
Members :	Kamaruddin Hashim, Dr Tengku Ahbrizal Tengku Ahmad, Dr Asnah Hassan Salahbiah Abdul Majid Foziah Ali Mohd. Suhaimi Hamzah, Dr Shamsiah Abd. Rahman
Collaborators:	Ahmad Sukari Halim, Prof (USM) Ahmad Hazri Ab Rashid, Dr (SIRIM) T Kamarul Zaman, Prof (UM) Rozaini Mohd. Zohdi, Dr (UPM) Lee Si Yuen (UM) Haryati Jamaludin (Biological Industry, UTH) Zainal Romly
Year:	1995 - 2011

SYNOPSIS

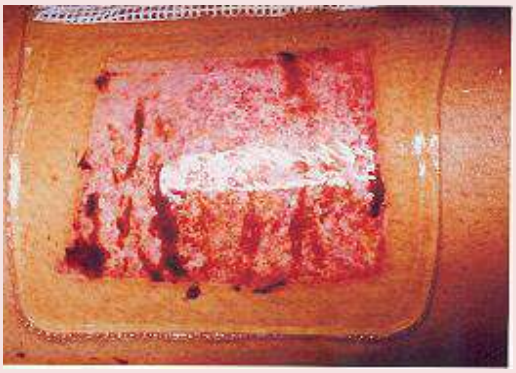
Hydrogel is a polymeric material that swells in water as it has the ability to retain water in its three dimensional network. Hydrogel can be prepared by radiation technology through induced crosslinking of hydrophilic polymers. Hydrogel based products have been widely used for wound management. It can absorb exudate from the wound bed and create/maintain a moist environment which enhances healing. Malaysian Nuclear Agency has developed a new process for production of hydrogel whereby irradiation either gamma or electron beam can be used to crosslink as well as sterilize the product. The dressing is designed for burn wound, ulceration, bedsore, abrasion and many other skin injuries. It covers skin contour or surface wound bed without strongly adhere to the wound therefore the removal of the dressing is usually painless. The product is recommended for wound dressing especially in children as its cooling sensation will soothe the wound. The dressing while keep the wound moist acts as a biological barrier to infection from outside without hindering air penetration. The dressing is transparent thus enable physicians to monitor wound healing process and assists in deciding further treatment or change dressing. In 2002, our patent of hydrogel sheet was licensed to Pharmaniaga Berhad to manufacture, market and distribute the Sterile Hydrogel Dressing.

Numerous hydrogel based products were then developed for health care and cosmetic industry. Natural components such as chitosan derivatives, honey, gamat, aloe vera and herbal extracts were then added to produce functional hydrogel that can enhance wound healing. A cooling pad for eyes, EyeFresh was developed by adding aloe vera juice, tomato juice or cucumber juice to give soothing effect as well as to rejuvenate the skin surrounding eyes and also to reduce dark circle. More innovative hydrogel in the form

of paste was also developed for treating cavity wound, suitable as filler for dry cavity wounds and management of partial- and full-thickness wounds such as pressure sores, leg ulcers, and diabetic ulcers. Any compounds with antioxidant and antimicrobial properties such as chitosan, honey and gamat can be added which can accelerate the healing process. Our product range also includes advanced material whereby hydrogel based scaffold has been successfully developed for proliferation and development of mesenchymal stem cells (MSC) which has gone through clinical trials.

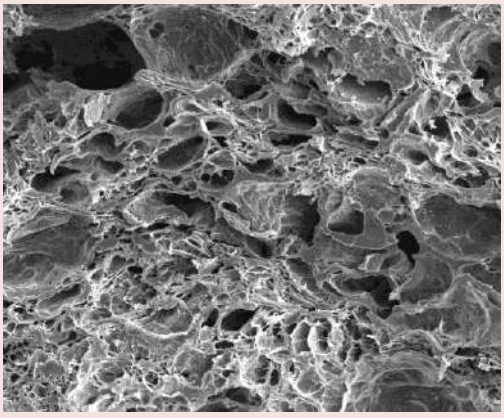
Lab-scale production of Hydrogel sheet.

Commercial production of hydrogel sheet.



Hydrogel sheet for treating surface wound.

Hydrogel paste suitable for cavity wound.



Hydrogel scaffold with porous structure.

AWARDS

- Malaysian Innovation and Design Exhibition/International Innovation and Technology Exhibition (MINDEX/INNOTEX) 1995. Production of Biomaterials for Clinical Applications - Bronze Medal.
- Sri Nona Award TV3 1999 – Trophy.
- Invention & Innovation MINT 2004. Eyefresh/ Functional Hydrogel - Gold Medal and Overall Winner.
- S&TI Expo 2004. Eyefresh/ Functional Hydrogel - Bronze Medal.
- Nuclear Malaysia Innovation Day 2009. Chitosan Paste: Flexible Wound Dressing Paste - Gold Medal
- Malaysia Technology Expo (MTE) 2010. Chitosan Paste – Wound Dressing Paste - Gold Medal and Women Inventor Award.
- Seoul International Invention Fair 2010 (SIIF 10). Chitosan Paste: Friendly Wound Dressing Paste - Silver Medal.

PATENTS

- Hydrogel Wound Dressing (MY-135416-A) – granted 30 January 2009.
- Chitosan Wound Dressing Paste (MY-145085) – granted 30 December 2011.
- Extracellular Hydrogel Scaffold (PI20081246) - Filed by Universiti Malaya April 2008.

CONTACT

Zainon Othman, Dr.
Agrotechnology & Biosciences Division
Tel:603-89112157 ext: 1432
Fax:603-89112157
E-mail: zainon@nuclearmalaysia.gov.my

SALAMED – INNOVATIVE PLANT TISSUE CULTURE MEDIUM

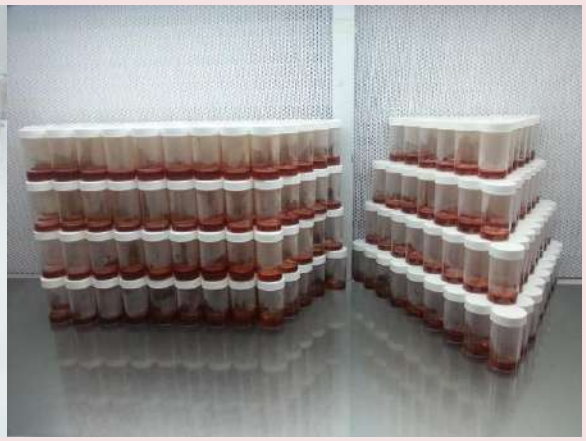
RESEARCH TEAM

Leader :	Salahbiah Abdul Majid
Members :	Norimah Yusof, Dr Rusli Ibrahim, Dr Seri Chempaka Mohd. Yusof, Dr Mohd. Rafaei Abdul Salam Norhayati Irwan
Year:	2000-present

SYNOPSIS

SALAMED™, an “easy-to-grow” *in vitro* plant growth medium has been developed suitable for various types of plant. With this, medium optimization is not needed for culture initiation. This stage is time-consuming as each species needs specific compositions of nitrogen source, macro and microelements, vitamins and hormones. SALAMED™ contains special supplements developed for growth and multiplication of various plant species. SALAMED™ has been tested on a number of plants such as *Rosa hybrida*, *Aquilaria malaccencis*, *Aquilaria crasna*, *Aquilaria subintegra*, *Dendrobium* hybrid, *Anthurium* sp*., Gynura procumbens*, *Labisia pumila*, *Centella asiatica*, *Musa* spp., *Bacopa monnieri*, *Drosera rotundifolia, Vanilla planifolia*, aquatic plants, chrysanthemum and pineapple “Maspine”. Our latest innovation, Tissue Culture Starter Kit containing sterile ready-to-use SALAMED™ medium in vials, for initiation and multiplication of shoots has recently been made available. It can be used as teaching kit for students and new tissue culturists.

Tissue Culture Starter Kit



Sterile SALAMED medium

Explants grown in SALAMED.

AWARDS

- Nuclear Malaysia Innovation Day 2008. “SALAMED” : Easy Used Medium For Cultured Tissue and Growing Plants - Bronze Medal.
- Malaysian Technology Expo (MTE 2009). “SALAMED” : Easy Used Medium For Cultured Tissue and Growing Plants - Silver Medal.

OTHERS

Pre-commercialization for laboratories studies of *Aquilaria* spp.

CONTACT

Salahbiah Abdul Majid
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1323
Fax: 603-89112157
E-mail: salahbiah@nuclearmalaysia.gov.my

PILOT PLANT OF ADVANCED BIOREACTOR SYSTEM

RESEARCH TEAM

Leader :	Rusli Ibrahim, Dr
Members :	Norimah Yusof, Dr Sobri Hussein, Dr Mohd. Azmi Sidid Omar Mohd. Jamil Hashim
Collaborators:	Norhalim Yunus, Dato' (MTDC) Mariamah Daud (MTDC) Mariatini Othman (MTDC) Rosliza Zulkafli (MTC) Hayati Taib (MyAgri) Elyana Shariff (MyAgri) Kee Yoeup Paek, Prof (Chungbuk National University, Korea) Keun-Young Song (Plantec, Korea)
Year:	Phase I: 2004-2007 Phase II: 2008-2013

SYNOPSIS

Malaysian Nuclear Agency has developed an advanced bioreactor technology facility for mass production of Tongkat Ali root cultures which is capable of reducing the maturing time from 7-10 years into months. From lab scale development started in 2004, a Pilot Plant of 1 ton had been established in 2011 with the collaborations of Malaysian Technology Development Corporation (MTDC), Malaysian Technology Consultants (MTC), Malaysian Agri Hi-Tech (MYAGRI), Chungbuk National University, Korea and bioreactor manufacturing company, Plantec, Korea. This project was supported by Commercialization of Research & Development Fund (CRDF), Project Code BF/010-MINT/05 (29) in the amount of RM6.3 million with the objective of commercialization of bioreactor technology for mass production of root cultures of Tongkat Ali (*Eurycoma longifolia* Jack). This is the first advanced bioreactor system constructed in Malaysia and South east Asia for large-scale production of root cultures of herbal and medicinal plants.

The system had also been successfully tested for ginseng, whereby instead of waiting 6 years for harvest in conventional breeding, root cultures can be harvested within 40 days. This advanced bioreactor technology is an excellent solution in ensuring continuous, reliable and steady supply of Tongkat Ali roots and other medicinal plants for bioactive compound extraction. The technology also enables the cultivation of Tongkat Ali to be conducted in a factory-based setting, incorporating mechanization and automation. This will improve production efficiency and product quality since the levels of secondary metabolites and bioactive compounds can be enhanced through chemical elicitation. Tongkat Ali roots and extract from are aimed to cater the herbal medicine, herbal dietary,

health supplement and herbal functional foods market. The system developed can be used as a Platform Technology for other local medicinal plants such as Kacip Patimah, Hempedu Bumi, Misai Kucing, Dukung Anak, Mengkudu and others. It can also be used for the production of mushroom mycelium for the extraction of secondary metabolites, especially beta-glucan which is an important anti-oxidant, production of bacteria, mycorrhiza, fungi and other micro-organisms used as biofertlizer.

Pilot Plant of 1 ton Advanced Bioreactor System

Seed-cultures in 20-litre bioreactors

Ceremony of handling over of Pilot Plant Bioreactor System located at Arab-Malaysian Industrial Park, Nilai, Negeri Sembilan from MTDC/MTC to Malaysian Nuclear Agency in 2011

AWARDS

- Malaysian Technology Expo MTE 2009. Biotechnology Improved Synthetic Seeds - Low Cost Seed Production Technology- Gold Medal and Best Award.
- BioInno Award and Bio Malaysia Exposition 2009. Biotechnology Improved Synthetic Seeds

- Low Cost Seed Production Technology- Gold Medal.
- Seoul International Invention Fair 2009. Biotechnology Improved Synthetic Seeds - Low Cost Seed Production Technology - Gold Medal and Semi Grand Prize Winner.
- i-Innova Expo, Universiti Sains Islam Malaysia (USIM) 2010. Synthetic Seeds - Gold Medal.
- Nuclear Malaysia Innovation Day 2010. Production of Gaharu Oil from Cell and Organ Cultures - Gold Medal.
- Malaysian Technology Expo MTE 2010. Production of Gaharu Oil from Cell and Organ Cultures - Silver Medal.
- BioInno Award and Bio Malaysia Exposition 2010. Production of Gaharu Oil from Cell and Organ Cultures - Gold Medal.
- i-Innova Expo, Universiti Sains Islam Malaysia (USIM) 2010. Production of Gaharu Oil from Cell and Organ Cultures - Gold Medal.
- Nuclear Malaysia Innovation Day 2006. Tongkat Ali – Perladangan Tanpa Tanah - Silver Medal.
- Malaysian Technology Expo MTE 2007. Tongkat Ali – Perladangan Tanpa Tanah - Bronze Medal.

POTENTIAL FOR COMMERCIALIZATION

- Production of root cultures of Tongkat Ali, Kacip Patimah, Ginseng and other herbal and medicinal plants as raw materials for herbal medicine, herbal dietary, health supplement, herbal functional foods and cosmetics.
- Production of mushroom mycelium for the extraction of useful secondary metabolites such as beta-glucan.
- Production of bacteria, mycorrhizal, fungi and microorganisms for biofertlizers.

OTHERS

Related projects:

- Commercialization of Bioreactor Technology for Mass Production of Cell Cultures of *Eurycoma longifolia* Jack (Tongkat Ali) CRDF BF/010-MINT/05(29) (2009-2013).
- Bioreactor Technology for Mass Propagation of Raw Materials of Tongkat Ali (*Eurycoma longifolia* Jack) in the form of Cell Cultures. Akaun Amanah MINT-R & D-06-035 (2004-2005).

CONTACT

Rusli Ibrahim, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1332
Fax: 603-89112157
E-mail: rusli_ibrahim@nuclearmalaysia.gov.my

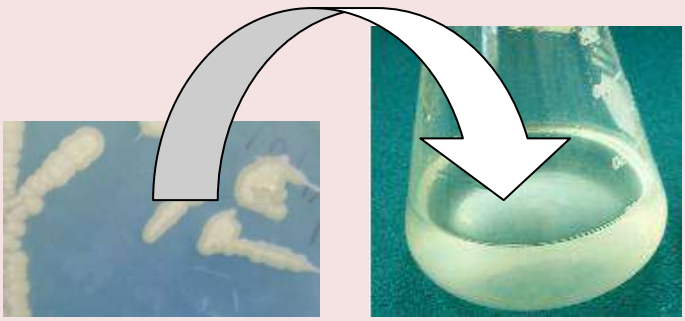
NITROGEN-PROVIDING BIOFERTILIZER MICROORGANISMS

RESEARCH TEAM

Leader :	Pauline Liew Woan Ying, Dr
Members :	Jong Bor Chyan, Dr Ahmad Nazrul Abd. Wahid Khairuddin Abdul Rahim, Dr Latiffah Norddin Abdul Razak Ruslan Hazlina Abdullah Zaharuddin Yaacob
Year:	2003-2007

SYNOPSIS

Biofertilizer microorganisms are bacteria and fungi that are able to produce plant nutrients and plant-growth-promoting substances. Important plant nutrients include nitrogen, phosphorus and potassium. Common substances that promote plant growth are plant hormones such as auxin (e.g. indole-3-acetic acid, IAA) and cytokinin which specialize in root and shoot developments, respectively. The nitrogen-providing (nitrogen-fixing) bacteria fix the N_2 molecules from the atmosphere and convert the N_2 molecules to ammonia (NH_3) and nitrate (NO_3^-). Both the NH_3 and NO_3^- are nitrogen fertilizers that are absorbed by plants. Through our research activities, three bacterial strains were isolated from local soil samples. Their abilities to fix N_2 molecules were determined using the ^{15}N isotope dilution method. The results showed the bacteria provide 7 – 15% of the plants' nitrogen compositions. In order to find out the identity of these bacteria, DNA method according to the 16S rRNA gene was adopted. The results matched the bacteria to genus *Bacillus*, *Rhodococcus* and *Pantoea*. The bacteria were deposited into the Nuclear Malaysia Culture Collection (NBCC).Field testing by applying the *Bacillus* sp. NBCC 20665 to paddy variety *Oryza sativa* MR 219 indicated shortened harvesting period from 2½ months to 2 months. The result illustrated the beneficial effect of N_2-fixing *Bacillus* to paddy growth.



Liquid bacterial culture of *Bacillus* sp. NBCC 20665 (picture at right). Left, bacterial colonies of *Bacillus* sp. NBCC 20665.

^{15}N isotope dilution method experimentation in a shade house. Left, planting of *Centella asiatica* (pegaga) in flower pot, right, application of ^{15}N-labeled urea and bacterial cultures.

COMMERCIALIZATION STATUS

One of the bacterial strains, namely *Bacillus* sp. NBCC 20665, was bought with exclusive right by a commercial company Malaysian Agric Hi-Tech (MAH) and used in formulation of their bioorganic products.

OTHERS

Related projects:

- Development of Nitrogen-Fixing Bacteria-based Biofertilizer for Herbal Farm; PQRD Nuclear Malaysia, MINT-06-20-02 or MINT-R&D-05-027(1) (2006-2007).
- Forum for Nuclear Coorperation in Asia (FNCA) Biofertilizer Project.

CONTACT

Pauline Liew Woan Ying, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1441/1369
Fax: 603-89112157
E-mail: paulineliew@nuclearmalaysia.gov.my

MULTIFUNCTIONAL BIOORGANIC FERTILIZER

RESEARCH TEAM

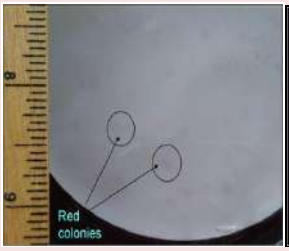
Leader : Phua Choo Kwai Hoe

Members : Ahmad Nazrul Abd. Wahid
Khairuddin Abdul Rahim, Dr.
Latiffah Norddin
Abdul Razak Ruslan
Hazlina Abdullah
Maizatul Akman Mhd. Nasir
Nor Fairul Azam Abd. Wahab

Year: 2007- 2011

SYNOPSIS

Biofertilizers are products containing living cells of microorganisms, which have the ability to convert nutritionally important elements from unavailable to available forms through biological processes. Biofertilizer is an alternative to chemical fertilizers to increase soil fertility and crop production in sustainable farming. Biofertilizer products normally consist of single-function microorganisms, such as N_2 fixing bacteria or phosphate-solubilising bacteria. Presently, three innovative biofertilizer products have been produced. The multifunctional biofertilizers, named PG & PA are based on indigenous microorganisms that have all the desired characteristics, including plant growth promoting, phosphate solubilizing and antagonistic towards plant pathogens, and the optimisation of the microorganisms present in a “Natural Farming” compost. Multifunctional Biofertilizer PG contains microorganism that is able to produce plant growth regulator (indol-acetic acid, IAA), which enhance plant growth and able to solubilise phosphate, hence making the insoluble phosphate to be available for plants, consequently enhancing plant growth and yield. Multifunctional Biofertilizer PA contains microorganisms that is able to solubilise phosphate and antagonistic against bacterial wilt disease, which known as the most destructive disease of tomato and affects more than 50 families of plants. MF-BioPellet: an innovative pelletised multifunctional biofertilizer. It is easy to handle, easy to store, has intrinsic controlled-release characteristic, and quality control feature. Furthermore, incorporation of microbes per pellet can standardised and has great potential for customisation for particular crops.



Advantages of Multifunctional Biofert PG & PA

- Enviromentally friendly
- 100 % Natural
- No chemical additives
- Enchance plant growth
- Easy to use
- Safe
- With beneficial microorganisms:
    - Plant-growth promoter
    - Phosphate solubilizer
    - Bacterial wilt disease antagonist

Advantages of MF-BioPellet

- Pelletised multifunctional biofertilizer product, consisting of microorganisms capable of:
- Enhancing plant growth;
- Solubilising “unavailable” phosphates in soil;
- Producing antagonistic effects to pathogenic bacteria e.g. bacterial wilt diseases.
- A ‘Green’ or environmental friendly product;
- Easy handling; easy storage; time-release and quality control;
- Can standardise incorporation of beneficial microbes in pellets;
- Easy to customise for particular crops.

AWARDS

- Nuclear Malaysia Innovation Day 2007. Multifunctional Biofert PG & PA - Bronze Medal.
- Malaysia Technology Expo 2008. Multifunctional Biofert PG & PA – Silver Medal.
- Nuclear Malaysia Innovation Day 2010. MF-Biopellet - Bronze Medal.
- I-Inova, USIM 2010. MF-Biopellet – Gold Medal.
- InnoBio, BioMalaysia 2010. MF-Biopellet - Silver Medal.
- Malaysia Technology Expo 2011. MF-Biopellet – Bronze Medal.

OTHERS

Related projects:

- Development of Natural Farming Multifunctional Biofertilizer Products for Sustainable Production of Short-Term Crops; PQRD, MINT-R&D-05-128 (2006-2008).
- Quantification of Improvement of Phosphorus and Nitrogen Nutrition of Vegetable Crops from Phosphate Solubilizing Bacteria and Rhizobacteria Interaction Using Isotopic Tracer Technology; ScienceFund, 02-03-01-SF0051 (2011-2013).
- Forum for Nuclear Coorperation in Asia (FNCA) Biofertilizer Project.

Biofertilizer Substrate Production

CONTACT

Phua Choo Kwai Hoe
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1383
Fax: 603-89112157
E-mail: phua@nuclearmalaysia.gov.my

PRE-COOKED SHELF STABLE IRRADIATED MEAT PRODUCTS

RESEARCH TEAM

Leader :	Seri Chempaka Mohd. Yusof, Dr
Members :	Foziah Ali Salahbiah Abdul Majid Mariani Deraman Muhamad Lebai Juri, Dato' Dr.
Year:	2006-2012

SYNOPSIS

The demand for ready-to-eat meals is growing due to their convenience such as easy to serve and can be directly eaten; and suitable for busy consumers with families, working people, school children and campers. Among food items, meat products are very popular. Sausages and burgers need to be cooked after been thawed from the frozen state before consumption.It would be very convenient if these products are easy to serve and can be eaten directly without any heating or cooked and displayed at chilled temperature on the shelves of retailers without frozen product facilities. Few studies were conducted to determine suitable sterilization dose and microbiological counts including of pathogens of pre-cooked chicken meat products stored at 0–3^{o}C. One of the technologies to ensure the microbiological safety of meat is radiation processing. Irradiated shelf stable pre-cooked meat sausages and burgers were produced for the convenience of the consumers, as ready-to-eat products after the removal of packaging. The products were hygienically safe; reduce time in the preparation and minimal heating needed before consumption. The highly penetrative ionising energy has the ability to inactivate spoilage and disease-causing microorganisms without causing harmful changes to the products. The ionising energy passes completely through the products and their packaging. Thus, the products can be irradiated in their final packaging ready for the end-user. This process is a cold treatment and suitable to retain the acceptability of the products. Other food preservation methods such as chemical and heat treatment can kill microorganisms including pathogens. However, chemical leaves residues and heating treatment can change the texture, colour and flavour of the products.

Pre-cooked chicken meat products gamma irradiated at doses of 3.5 and 5.5 kGy were most preferred for most of the attributes. For decontamination and prolonged their shelf-life in refrigerator/chilled storage, irradiation with dose 3.5 kGy was suitable for pre-cooked chicken sausages and dose 5.5 kGy for pre-cooked burgers. Irradiated pre-cooked meat sausages and burgers can be displayed at chilled temperature 0–3^{o}C in a chiller and also stored in a refrigerator at 0–3^{o}C without frozen storage for 3 months. This showed that irradiation in conjunction with chilled storage inhibits microbial growth and extends product shelf-life without compromising product safety and acceptability. These products shall contribute to expansion of utilisation of nuclear techniques in food technology that will lead to sustainable services for meat product industries in the future.

AWARDS

- The International Conference on Agricultural and Food Engineering for Life 2012 (CAFEi 2012). Radiation Decontamination of Ready-To-Eat Meat Products - Best Poster Award.

CONTACT

Seri Chempaka Mohd. Yusof, Dr
Agrotechnology & Biosciences Division
Tel:603-89112000 ext: 1492
Fax:603-89112157
E-mail: seri@nuclearmalaysia.gov.my

CONSUMER FRIENDLY LIP BALM

RESEARCH TEAM

Leader :	Seri Chempaka Mohd. Yusof, Dr
Member:	Foziah Ali
Year:	2008 - 2010

SYNOPSIS

New consumer 'friendly' lip balm product is a fully natural product with multifunctional uses namely to prevent chapped lips, freshen the breath, reduce mouth odour and hence, contribute to improving general health quality. The lip balm was formulated by substituting the base ingredient, i.e. petroleum jelly, with vegetable fats and incorporated with anthocyanin pigments as natural colourants. Petroleum jelly, the base ingredients of currently available lip balms is a preservative chemical harmful to users and the side effects from impurities in petroleum jelly in the manufacturing process have been implicated in causing cancer and long term damage to health. Anthocyanins, on the other hand, is a powerful antioxidant found in *Hibiscus sabdariffa* L. or roselle, known to prevent the formation of cancer-causing free radicals and cause cancer cells to break down and halts skin-cancer. Anthocyanin pigments, extracted from roselle and dragon fruit (*Hylocereus polyrhizus*) are used as natural colouring agent for this lip balm and have the ability in maintaining the intensity colours especially the redness after irradiation. Essential oils from spices and local herbs are also added to the products for flavours and aroma and have the potential as preservatives due to their antibacterial properties. Gamma ray is used to decontaminate the lip balm without heating process by reducing microbial and yeast and mold load present during the mixing process and filling in containers.

Benefits / Advantages of Consumer 'Friendly' Lip Balm:

1. Natural based product, using vegetable fats that are free from hazardous chemicals and preservatives
2. By incorporation with anthocyanin pigments and honey, the lip products are safe and enriched with antioxidants that have health promoting properties.
3. Halal and clean natural blending preparation free from animal sources and/or alcohol
4. Safe and attractive product, with multifunctional uses: prevent chapped lips, freshen the breath, reduce mouth odour, contribute to improving general health quality
5. Antimicrobial properties of herbal essential oils have potential as natural preservatives.

6. Suitable for everybody and 1 Malaysia product.
7. Low cost ingredients, since vegetable fats, anthocyanin pigments and herbal essential oils reduce the cost of production and reduce the selling price.
8. Promote demands for *Hibiscus sabdariffa L.* and *Hylocereus polyrhizus* production and increase demand for high production
9. Customers' satisfaction, since it does not create secondary risks to users.

Consumer 'Friendly' Lip Balm

Lip balms with pigments of *Hibiscus sabdariffa L.* and *Hylocereus polyrhizus*

AWARDS

- National Environment and Health Conference 2008. Gamma Irradiation In Developing Consumer 'Friendly' Lip Balm - First Poster Best Award.
- Exposition On Islamic Innovation (I-INOVA 2010). Development Of Consumer Friendly Herbal Lip Balm - Silver Medal.

CONTACT

Seri Chempaka Mohd. Yusof, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1492
Fax: 603-89112157
E-mail: seri@nuclearmalaysia.gov.my

GELAM HONEY AS RADIOPROTECTANT AGENT

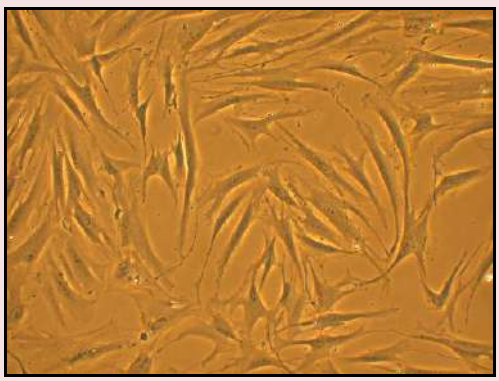
RESEARCH TEAM

Leader :	Tengku Ahbrizal Farizal Tengku Ahmad, Dr
Members :	Norimah Yusof, Dr Khairuddin Abdul Rahim, Dr
Collaborators:	Suzana Makpol, Prof. Dr.(UKM) Nor Fadilah Rajab, Dr. Assoc. Prof (UKM) Zakiah Jubri, Dr (UKM)
Year:	2009- 2012

SYNOPSIS

Ionizing radiation (IR) can trigger the formation of free radicals which induces biological damage in cells. Although our body posses antioxidant defense system, damage occurs when the radical production exceed the limitation of the system's ability. Thus, antioxidant supplement is required to protect our cells from radiation damage and to maintain cell functions. Gelam honey derived from nectar of Gelam tree (*Melaleuca* spp.) was studied to determine its ability in protecting human normal fibroblast skin cell against gamma radiation. Based on our findings, gamma-radiation induced DNA damage in fibroblast cells and activated mechanisms involved in cell defense system which leads to cell proliferation and survival inhibition. Studies on genes, proteins and antioxidant enzymes expression indicates that Gelam honey with antioxidant properties can protect DNA molecules against radiation damage and maintained cell functionality. Therefore, Gelam honey is a potential radioprotectant agent for radiation workers and cancer patient undergoing radiotherapy.

(A) Gelam tree, (B) Gelam flower, (C) Gelam honey



Fibroblast cells

CONTACT

Tengku Ahbrizal Tengku Ahmad, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1451
Fax:603-89112157
E-mail: ahbrizal@nuclearmalaysia.gov.my

GAHARU INNOVATIVE PRODUCTS

RESEARCH TEAM

Leader :	Chong Saw Peng
Members :	Mohd. Fajri Osman Rusli Zakaria Norellia Bahari Everina Ak Nuri
Year:	2011- present

SYNOPSIS

Development of the agarwood (gaharu) based products is one of the important activities in the agarwood industry value chain. There is a need to develop various agarwood based products to support the agarwood downstream industry, as the development and consistency of the agarwood industry highly dependent on the product range available in the market. In the traditional agarwood trade, the agarwood is marketed as wood chips and gaharu oil products. The lack of agarwood product diversification in the market limits the development of the agarwood industry and the need for the agarwood. Presently, with the rapid technological development, entry of new gaharu innovative products in the market directly increases the income and adds value to this industry.

Gaharu herbal tea product produced by Nuclear Malaysia.

Gaharu-based perfume formulated and blended by Nuclear Malaysia.

Gaharu oil rapid detection kit developed by Nuclear Malaysia

Gaharu pure oil extracted by Nuclear Malaysia

COMMERCIALIZATION STATUS

The gaharu herbal tea and gaharu perfume have been ready for commercialization in 2013. The gaharu oil rapid detection kit is in the process of patent filing.

OTHERS

Related project:

- Development of Gaharu Based Product to Enhance Gaharu Industries; PQRD, NM-R&D-11-11(2010-2011

CONTACT

Chong Saw Peng
Agrotechnology & Biosciences Division
Tel: +603-89112000 ext: 1470
Fax: 03-89112157
E-mail: sawpeng@nuclearmalaysia.gov.my

SINAROMA - GAHARU PELLETS

RESEARCH TEAM

Leader:	Seri Chempaka Mohd. Yusof, Dr
Research Team:	Mohd. Fajri Osman Salahbiah Abdul Majid Shyful Azizi Abdul Rahman Foziah Ali Nor Azli Mohd. Nor Azian Muhamad Lebai Juri, Dato' Dr
Year:	2010-2012

SYNOPSIS

SINAROMA-Gaharu Pellets from gaharu by-product are developed for use in aromatherapy and as deodorizer. These pellets can be used as substitution of expensive gaharu chips for aromatherapy and the cost is much lower and affordable. The gaharu by-product used in this new product is the light cream/brown powdery waste wood obtained from gaharu oil distillation (with little or no resin content). This by-product was obtained from an industrial scale gaharu oil extraction facility that has been developed by Nuclear Malaysia researchers in Kedaik, Rompin, Malaysia through MOSTI's Community Innovation Fund (CIF). This factory is capable in producing approximately one litre of gaharu pure oil per month to meet the needs of local and overseas market. From the operation of the facility, wastes such as extracted wood powder were generated. This accumulated waste can be reutilised as aromatherapy products that are similar to the gaharu chips when burnt in the burner and can function as a deodorizer with addition of essential oils or fragrances during the manufacturing process. The larger the diameter of the gaharu pellets, the longer is the time for the burning process. This gives connoiseurs longer time to enjoy the aroma of the exquisite essential oils. By using this innovative gaharu pellet product, the aroma of essential oils can be detected fast, at higher intensity than other products from ordinary heated equipment. These accumulated wastes can be re-utilized to form into high value added products. By maximizing the usage of the bioresources and waste of *Aquilaria* and turn it into valued product hope to help the gaharu industries to sustain and also open up a new market potential.

Benefits / Advantages of Sinaroma-Gaharu Pellets:

1. These gaharu pellets ensure continuous availability of such aromatherapy product for since gaharu/gaharu chips are high in price.
2. Reduce wastes from the gaharu industry.
3. Increase the value added products from recycling of the waste from the gaharu industry.
4. Increase the income of the gaharu product producers.
5. Affordable price of the pellets and enable consumers to enjoy the benefits of aromatherapy.
6. Natural deodorizer that is free from chemicals; the herbal essential oils and natural fragrances added are safe and harmless to consumers.
7. Low cost ingredients i.e. waste wood powders obtained from gaharu oil distillation, herbal essential oils and binders reduce the cost of production and reduce the selling price.

8. Customers' satisfaction, as the gaharu pellets do not create secondary risks to people.
9. Suitable for everybody and, thus, a 1Malaysia product.

Gaharu pellets for aromatherapy

Gaharu pellets as deodorizer

AWARDS

- Nuclear Malaysia Innovation Day 2010. Sinaroma - Gaharu Pellets from Gaharu by-Products for Aromatherapy and as Deodorizer – Bronze Medal.
- Malaysia Technology Expo 2011. Sinaroma - Gaharu Pellets from Gaharu by-Products for Aromatherapy and As Deodorizer – Bronze Medal.

CONTACT

Seri Chempaka Mohd. Yusof, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext:1492
Fax: 603-89112157
E-mail:seri@nuclearmalaysia.gov.my

GAWA - GAHARU PARTICLE BOARDS

RESEARCH TEAM

Leader :	Seri Chempaka Mohd. Yusof, Dr
Members :	Salahbiah Abdul Majid Siti Fatahiyah Mohamad Salmah Moosa Mohd. Fajri Osman Rusnah Mustaffa Nadira Kamarudin Chong Saw Peng Foziah Ali
Year:	2012

SYNOPSIS

Gaharu (agarwood) particle boards from gaharu by-product are developed for house decorations and indoor accessories. These particle boards can be used as a new product for wall panels, screens and indoor accessories such as tables, lamps, cabinets and others. The uniqueness of this particle board is due to its natural composites that consist of waste wood (with little resin content) obtained from gaharu oil distillation (Kg. Kedaik, Rompin, Pahang) using natural tannins as adhesives instead of synthetic resins and incorporation of essential oils and fragrances that can contribute to aromatherapy and as insecticides. This product is a new value-added product that has a niche in aromatherapy, as house decorations and indoor accessories that are safe, environmental friendly and free from chemical additives. Benefits of this product:

- Production of spent gaharu particle boards reduced wastes from the gaharu industry.
- Increase the value added products from recycling of the waste from the gaharu industry.
- Increase the income of the gaharu product producers.
- Affordable price of the particle boards and enable consumers to enjoy the benefits of aromatherapy.
- Natural materials used in spent gaharu particle boards that are free from chemicals; the herbal essential oils and natural fragrances added are safe and harmless to consumers.
- Customers' satisfaction, as the spent gaharu particle boards do not create secondary risks to people.
- Suitable for everybody and, thus, a 1 Malaysia product.

Gaharu (agarwood) particle boards from gaharu by-product - waste wood obtained from gaharu oil distillation (with little resin content).

Various house decorations and indoor accessories from gaharu (agarwood) particle boards. Left: clock from gaharu particle boards. Right: aromatherapy lamp using gaharu particle boards releasing natural fragrances and aroma from essential oils.

AWARDS

- Nuclear Malaysia Innovation Day 2012. GAWA: Gaharu Particle Boards from Gaharu By-Products for House Decorations and Indoor Accessories - Bronze Medal.

CONTACT

Seri Chempaka Mohd. Yusof, Dr
Agrotechnology & Biosciences Division
Tel:603-89250510 ext: 1492
Fax:603-89112157
E-mail:seri@nuclearmalaysia.gov.my

BIOGITA TEA

RESEARCH TEAM

Leader :	Sobri Hussein, Dr
Members :	Seri Chempaka Mohd. Yusof, Dr Salahbiah Abdul Majid Salmah Moosa Foziah Ali Rusli Ibrahim, Dr
Year:	2012

SYNOPSIS

In Malaysia, the consumption of Tongkat Ali and Ginseng were mostly through beverages and capsules. A simple, safer and easier consumption of the extracts is in the form of tea or energy drink. Incorporation with suitable carriers for tea can mask the bitter taste of Tongkat Ali and ginseng extracts whereby combination of the two herbal extracts gives the tea a unique and exotic taste. BioGita Tea is an energy beverage with Tongkat Ali and Ginseng extracts derived from root cultures which is produced by Pilot Plant Bioreactor System. BioGita Tea is easy to dissolve in water (hot or cold) and there is no waste left in sachets as compared to other teas sold in the markets. Tongkat Ali and Ginseng extracts from propagated roots derived from bioreactor system have similar chemical profiles as those extracts derived from raw materials obtained from the wild or cultivation. It has been tested to be safe for human consumption through cytotoxicity test using brine shrimp. BioGita Tea is one of the products produced from Pre-Commercialization Project titled 'Commercialization of bioreactor for mass production of cell cultures of *Eurycoma longifolia* Jack (Tongkat Ali)' under CRDF Grant awarded by MTDC. It was considered as the first herbal tea in Malaysia with unique combination Tongkat Ali and Ginseng extracts. The novelty of BioGita Tea is that the raw materials of Tongkat Ali and Ginseng were produced from bioreactor system and not harvested from cultivation. This tea is also targeted for adults especially men and the health conscious group. Efforts had been geared for promotion of BioGita Tea through exhibition for commercialization through technology transfer to suitable food industries.

Ginseng roots harvested from Bioreactor System Pilot Plant

BioGita Tea

AWARDS

- Nuclear Malaysia Innovation Day 2012. BioGita Tea – An Energy Drink with Tongkat Ali and Ginseng Extracts from Mass Propagated Roots Derived from Bioreactor Technology - Gold Medal.

- Exposition on Islamic Innovation (i-INOVA 2012). Biogita Tea – An Energy Drink Supplemented with Tongkat Ali and Ginseng Extracts from Mass propagated Roots Derived from Bioreactor Technology - Silver Medal.

CONTACT

Sobri Hussein, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1330
Fax: 603-89112157
E-mail: sobri@nuclearmalaysia.gov.my

GITACHOC DELIGHTS

RESEARCH TEAM

Leader :	Sobri Hussein, Dr
Members :	Rusli Ibrahim, Dr Seri Chempaka Mohd. Yusof, Dr Salahbiah Abdul Majid Salmah Moosa Foziah Ali
Year:	2012

SYNOPSIS

Malaysian Nuclear Agency first started Research & Development using incorporation of In Vitro Mutagenesis and Cell and Organ Cultures on Herbal and Medicinal Plants in 2005, particularly Tongkat Ali (*Eurycoma longifolia*), Kacip Patimah (*Labisia pumila*) and Korean Ginseng (*Panax ginseng*). The main objectives are to produce raw materials in the form of root cultures and enhancement of secondary metabolites using advanced bioreactor system for multiple industrial applications such as health food, cosmetics and pharmaceuticals. Ginseng is a slow-growing perennial plant with fleshy roots that usually takes 5-6 years before they can be harvested. While Tongkat Ali is a woody forest species that takes about 20 years to mature. With the establishment of 1-ton Pilot Plant Bioreactor System in 2011 from CRDF Grant awarded by MTDC, Ginseng roots can be harvested after 40 days and Tongkat Ali roots after 60 days of culture. The first product called 'Gitachoc Delights' which stands for 'Ginseng Tongkat Ali Chocolate Delights' was produced in 2012. It was the first kind of chocolate that contains extracts of Ginseng and Tongkat Ali that was derived from root cultures using bioreactor system and not raw materials harvested from the wild or plantations. Chocolate is a powerful antioxidant and with the addition of Ginseng and Tongkat Ali makes 'Gitachoc Delights' more effective in reducing the risk of blood clots, strokes, and coronary heart disease. Integration with herbal such as Ginseng and Tongkat Ali offers added-value to chocolate and promotes synergy beneficial impact to human health. Efforts had been geared for promotion of 'Gitachoc Delights' through exhibition for commercialization through technology transfer to suitable food industries.

Tongkat Ali root cultures

Harvesting

Raw materials harvested from bioreactor

Gitachoc Delights

AWARDS

- Nuclear Malaysia Innovation Day 2010. Gitachoc Delights - Ginseng Tongkat Ali Enriched Chocolate Delights - Bronze Medal.
- BioInnovation Awards, BioMalaysia 2011. Gitachoc Delights - Ginseng Tongkat Ali Enriched Chocolate Delights - Silver Medal.
- International Environment and Health Conference 2012. Development Energy Chocolate Confectionery Supplemented with Tongkat Ali and Ginseng Extracts from Mass Propagated Roots Derived from Bioreactor Technology - Best Poster Award.
- Exposition on Islamic Innovation (i-INOVA 2012). Gitachoc Delights: Ginseng Tongkat Ali Enriched Chocolate Delights - Gold Medal: i-INOVA 2012 Open Category and Special Award Gold Medal MINDS.

CONTACT

Sobri Hussein, Dr
Agrotechnology & Biosciences Division
Tel: 603-89112000 ext: 1330
Fax: 603-89112157
E-mail: sobri@nuclearmalaysia.gov.my

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