Genetically Modified Microorganisms (GMM): Development, Application & Effect

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CHALLENGES OF THE MALAYSIAN AGRICULTURE INDUSTRY

• Food security / increase in productivity:
  Sufficient amount of food to meet the national needs
  Reducing import of food

• Wealth creation:
  production of value-added food & food products that are more competitive in the open market
Definition of Biotechnology

The use of living organisms (microbes, plants, or animals) or their products (DNA, protein, metabolites) as tools to foster:

• better understanding of biological mechanisms
• for the improvement and creation of products
• **Genetically Modified Organisms**: Any organism in which the genetic material has been altered in a way that does not occur naturally by mating or natural recombination or by a combination of both.

• **Plants, Animals & Microorganisms.**
Genetically Modified Microorganism

Bacteria: 1st organism to be modified in laboratory
GMO Development: Tools for Microorganism via Genetic Engineering

- Gene Transfer Method
- Vectors
- Promoter, Terminators & Selection Markers
- Unique Restriction Site
DNA Cloning: Overview

- Prepare foreign DNA and vector
- Ligate target and vector
- Introduce rDNA to host
- Select for transformants via antibiotic selection
- Screen for rDNA of interest
Improvement of Microbes

- Microbes: Supermicrobes
- Improved Expression of Beneficial Trait
- Value Added Product
- High & Controlled Production
Why is it GMM relevant?

- Fast
- Easy way to make a lot of a selected gene.
- Used to cure and prevent sicknesses, to create medicines
- Can be used to improve the environment
BIOREACTOR / CELL CULTURE TECHNOLOGY

Large scale, controlled production
GMM & GMM_DERIVED PRODUCTS APPLICATION

- Human Health
- Animal
- Agriculture
- Industry
- Bioremediation
Medical/Human Health Applications:
Production of Hormone & Vaccines

- Insulin: Diabetes
- Clotting Factor: Haemophilia
- Growth Factor: Dwarfism
- Hepatitis B surface antigen (vaccine)
GM Bacteria Research:

**GM bacteria eats cancer**

- The genetically modified *C. novyi*-NT bacterium thrives in these oxygen-deficient areas, which are unique to cancerous growths, and starts to kill the tumour from the inside out. Normal surrounding cells were largely unaffected as were the exterior of the tumours as the bacteria don't like the more oxygen rich conditions.

**Genetically Altered Bacteria Could Block Malaria Transmission**

Scientists have discovered a way to help stop the spread of malaria by genetically altering a bacterium that infects about 80 percent of the world’s insects. Malaria is primarily transmitted through mosquito bites and kills more than a million people every year.

The ubiquitous Wolbachia bacteria are able to alter male insects so that they can only reproduce with female insects also infected with the bacteria, resulting in more infected offspring. Researchers believe that by using genetically altered Wolbachia bacteria, they could spread genes that leave mosquitoes unable to transmit the malaria parasite.
GMM Agriculture Application

- Biocontrol of insect pest: BT genes into species eg *Clavibacter & Ancioloabacter*
- Bio fertilizer: Induced Plant growth by enhancing the availability of nutrient eg Sinuhizobium GM bacteria that fix nitrogen more efficiently
- Biological control of frost injury: GM *pseudomonas* that competes with naturally ice nucleating *pseudomonas*
- Biological control of plant disease: Microrganism modified to deliver chemicals eg bacteriocin, oomycin that kills unwanted plant pathogen
Bioremediation is a waste management technique that involves the use of organisms to remove or neutralize pollutants from a contaminated site.

GMM: Potential for bioremediation in soil, groundwater, activated sludge environment.

Development of novel strains with desirable properties through pathway construction and the modification of enzyme specificity and affinity:
- New metabolic pathway into bacteria strain
- Rate limiting step engineered to increase degradation rate

Singh et al. 2011
GMM for Bioremediation

- Eg: Engineering of bacteria using bacterial hemoglobin (VHb) for the treatment of aromatic organic compounds under hypoxic conditions, remediation of heavy metals

- GM Deinococcus radiodurans to absorb radioactive waste

- Pseudomonas sp : Oil spillage

Singh et al. 2011
Modified bacteria turn waste into fat for fuel

Rice University process is part of USDA project to develop energy from biomass

HOUSTON – (Feb. 28, 2013) – “Green” chemistry developed at Rice University is at the center of a new government effort to turn plant waste into fatty acids, and then into fuel.

The Rice lab of bioengineer Ka-Yiu San is part of a recently announced $25 million United States Department of Agriculture project to develop a new generation of renewable energy and bio-based products from switchgrass and forestry residues and from a new hybrid of sorghum being developed at Texas A&M University.

Patent-pending fermentation processes created by San and his colleagues use genetically modified E. coli bacteria to produce fatty acids from hydrolysates.

“The sugary, carbon-rich hydrolysate is extracted from cellulose, the tough, inedible part of plants that is usually thrown away. San said his lab already gets an 80-to-90 percent yield of fatty acids from model sugars and hopes to improve that over the next few years.

“Adding another 1 or 2 percent doesn’t seem like much,” said San, based at Rice’s BioScience Research Collaborative. “But when you’re talking about making several million tons per year, it’s huge.”
• GM Microbes for value added products
CONCERN

- Harmful & Dangerous organism will be created
- Displacement of wild species. Irreparable species diversity
- Transgenes Escaped to other species
- Destruction habitat and environment
- Lack of knowledge on the effects of introduced strain

Harm to non target species in soil
Effect of GMM

- Impact of GM micro-organisms released into soil have been less well studied

- Ecological effects: Survival, spread, persistence
  i. The ability of the GM micro-organisms to compete successfully with the indigenous microbiota;
  ii. Transfer of genes to new hosts;
  iii. Changes in biomass turnover;
  iv. Changes in community structure and function of the indigenous microbiota

- GM micro-organisms carrying genetic markers which allow the selective recovery of the released strain from the environment.
Effect of GMM

- Laboratory and limited field experimentation has shown that transgenic microorganisms introduced into soil have sometimes caused statistically significant changes in the structure and function of indigenous soil biota.

- Transient changes in composition of the indigenous soil microflora but often changes have not been significantly different from responses to inoculation of the wildtype strain.

- Movement of plasmids from GM micro-organisms to indigenous soil bacteria has been demonstrated and uptake of plasmids by GM micro-organisms from indigenous bacteria has also been observed.

- Clear need for robust experimental design to overcome some of the complexities associated with soil biota assessments. Long term implication must be assessed.
Risk Assessment

1. Identification of environmental stresses which may cause adverse effects on GE bacteria
2. Evaluation of the potential consequences of each adverse effects, if it occurs
3. Assessment of the likelihood of the occurrence of each identified potential adverse effects
4. Assessment of the risk posed by each identified characteristics of the GE bacteria
5. Application of management strategies for environmental risks from the deliberate field release of GE bacteria
6. Determination of the overall risk of the GE bacteria in natural environment
Govern and regulate the release and import of living modified organisms (LMOs) and products of such organisms in Malaysia
GMM Work Requirement
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- Eye wash station,
- Ceilings, wall, floor easily cleaned and resistant to common reagent/disinfectant
- Windows cleaned & Sealed,
- Biosafety cabinets as needed,
- Well ventilated
GMM Work Practices

- Lab coat
- Gloves
- Protective eye wear
- No food or drink sign
- Closed footwear
- Hand washing after removing gloves
DETECTION FOR GMM?
CONCLUSION

- GMM: Many Useful application

- GMM: To be developed, used safely and designed to reduce risks.

- Continuing Regulatory oversight as well as long term research and monitoring and development of tools for detection

- More extensive studies of the environmental benefits and risks associated with GMMs are needed.
THANK YOU