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Detection of Genetically Modified Organisms in Crops, Food and Feed: A Malaysian Perspective

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Abstract

Genetically modified crops have been identified as one of the important alternative ways to increase global food production to cater to the demands of population growth. GM crops that can withstand drought, pests, herbicides, and unfavourable soil conditions have been developed to aid in achieving food security. As important as GM crops are for sustainable food production, monitoring and regulation of GM food and crops is vital to ensure consumer confidence and ensure the safety of animal/humans and the environment. The Biosafety Act 2007 was enacted to regulate the activity of GM products including but not limited to research, distribution, transportation, and consumption. There are currently 54 events from the common crops (soybean, maize, potato, cotton, canola, sugar beet) that have been approved for import in Malaysia to be used for food, feed and processing. The National Reference laboratory in Malaysia has been the primary laboratory for development of new detections methods and to carry out GMO testing for monitoring and enforcement of the Biosafety Act 2007. The most common food crop and its products received by the NRL are maize, rice and soybean, consisting of more than 50% of all samples received. Almost 100% of animal feed, followed by about 50% of soybean and 30% of maize products were detected to contain at least one GM event. With more and more new GM events being developed globally, the laboratory is stretched in terms of resources, and would need to find new ways to adapt to the challenges faced.

Introduction

Genetically Modified (GM) crops have been commercially available for more than 10 years. Several studies have shown the contribution of GM crops to a significant rise in food production across the globe [1]. According to the United Nations, the world population currently at 7.7 billion is estimated to reach 9.7 billion by 2050 [2]. As the world population continues to increase drastically, the demand for food also increases. However, the total agricultural land globally remains the same, therefore, finding alternative ways to increase global food production is important to maintain sustainability and full fill the needs of a growing population. Many developed countries across the world have realised this problem and opted for Genetically Modified Food to improve agriculture productivity [3]. Research carried out globally on the application of gene technology on food crops resulted in improvement of product quality and agronomic traits such as drought resistance, herbicide tolerance, salt tolerance and development of resistance to pests offering great technical potential [4]. As of 2018, 70 countries around the world had adopted GM crops through cultivation and importation indicating the importance of these crops towards achieving global food security [5].

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Currently, the development of GM crops has raised many new legal and ethical issues in the field of agriculture [6]. Although GM technologies are found to be novel technologies compared to conventional methods, the production of GM crops are bound to specific legislations. The GM regulations are commonly categorised as either process or product oriented [2]. In recent years, new legislations were enacted to regulate the presence of Genetically Modified Organisms (GMOs) in crops, food and ingredients present in processed food through many rapid and reliable methods for GMO detection [4]. Over the last 2 years, there were 26 countries that grew around 190 million hectares of biotech crop which included developing and industrial countries.

The UN Cartagena Protocol on Biosafety which was approved in January 2000 provides a framework of regulations on international trade in GMOs and their products. This arrangement is an addition to the Convention of Biological Diversity which focus at the safe transport, handling and use of living modified organisms (LMOs) which is the outcome of modern biotechnology [7]. The Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety was adopted in October 2010 in Nagoya, Japan. There were 51 Parties which signed this protocol and as of March 2013, however, Malaysia is not a party to the KL-Nagoya Supplementary Protocol on Liability and Redress [8]. In addition to that, the Regulation on Safety of Agri-GMOs was issued in June 2002 with a priority to limit foreign GMOs importing by safety certification and labelling system. There were outlined considering policies adopted in western countries such as the green barrier to international trade [9]. Till date, there were approximately 32 GM crops approved globally. Some of the approved GM crops are eggplant, cowpea, maize, papaya, potato, rice, pineapple, soybean, tomato and wheat [10].

Studies have shown that crops with genetically modified (GM) traits was grown and commercialised since 1996. Evidence shows that there was a significant increase in the economic impact of developed countries especially in the production of four main crops such as soybeans, corn, cotton and canola [11].

Approval process of GM crops in Malaysia

Malaysia largely imports its GM crops for food, feed and processing and currently does not produce any GM crops of its own. Malaysia is considered one of the 17 mega diverse countries in the world, one of only three ASEAN countries being in the list, thus biodiversity degradation is considered as the most important risk of cultivation of GM crops [12]. Regulation of GM food products and crops are carried out to ensure that the potential impact of these products on human/animal health and the environment is assessed scientifically before release and consumption. This is also to promote consumer confidence in GM food and crops which had undergone risk and safety assessment prior to be given approval. For this reason, Malaysia enacted the Biosafety Act of 2007, one of the numerous biosafety policies to be enacted from 2000 to 2010, to monitor the activities pertaining to GMO such as the release, importation and exportation of Living Modified Organisms and its products [13]. These activities include but not limited to conducting R&D (contained use) involving developing LMOs, importing LMOs for contained use and supply for sale or placing in the market. All activities involving LMO requires the approval from the National Biosafety Board (NBB). The NBB reviews the new GM product for safety before allowing it to be sold and distributed in the local market. The Genetic Modification Advisory Committee (GMAC) is an entity within the NBB that provides technical, legal and regulatory expertise during the review process. Figure 2 depicts the approval process of GM products by the National Biosafety Board which indicates a time frame of 180 days, from application to approval. To date, no approval has been obtained in the country for cultivation of GM crops for commercialisation.

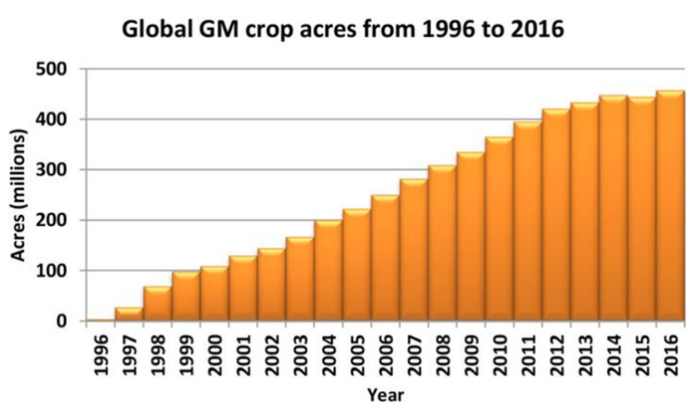

Figure 1: *Global GM crop acres from year 1996 to 2016 (Source: International Service for the Acquisition of Agri-Biotech Applications).*

There are currently 54 events from the common crops (soybean, maize, potato, cotton, canola, sugar beet) that have been approved for import in Malaysia to be used for food, feed and processing [8]. As part of the approval process, the National Reference Laboratory is required to develop detection methods for the identification of these newly approved GMO events. Development of detection methods are important to assess if a product contains GMO which have been approved in Malaysia.

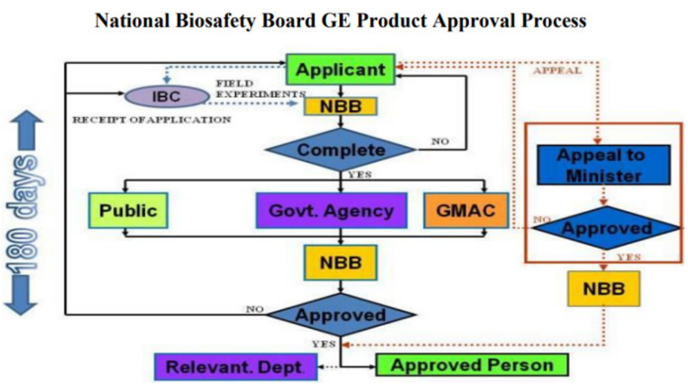

Figure 2: *The National Biosafety Board Genetically Modified crops approval process [14].*

GMO detection for crops and its products

Unlike procedures adopted in the EU, GMO detection in Malaysia is accomplished by carrying out species/taxon specific, element-specific, construct-specific and event specific methods using quantitative PCR (qPCR) techniques [15]. Typical genetic elements found in majority of the classic GMOs are detected using the matrix based screening approach [16,17]. Detection methods are either obtained from the GMOMETHODS database that is hosted by the European Union Reference Laboratory for Genetically Modified Food and Feed (EURL GMFF) [18] or from various other publications, and is validated or verified in-house according to the guidance document on minimum performance requirement [19]. The National Reference Laboratory (NRL) in Malaysia is an MS ISO/IEC 17025 accredited laboratory, and hence requires respective methods employed for enforcement to be accredited according to international standards.

In addition to method development, the role of the NRL for GMO analysis include carrying out analysis for GMO samples collected for monitoring and enforcement purposes. In the first few years since its inception, the laboratory only received grains such as maize, soya, rice and wheat. As the global GMO development increased and diversified to various other crops, different types of samples were increasingly sent as a consequence. Figure 3 shows the types of samples that were sent from 2019 to 2021 to the NRL. The samples that were sent to the laboratory were those that were sampled at ports of entry, markets and stores, and farms. Rice, maize, fruits such as papaya, and vegetables such as brinjal are grown locally as well as imported, hence contribute to the number of samples sent for testing.

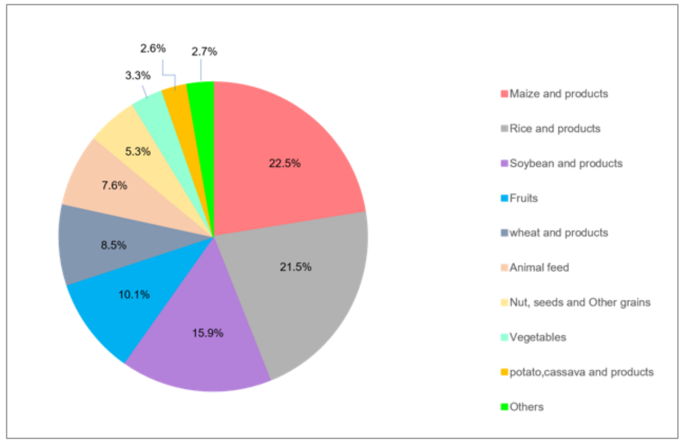

Figure 3: *Percentage of crops and its products that were sent to the National Reference Laboratory for testing for the period of 2019-2021.*

Maize, rice grains and their products make up about 44% of the total samples that were sent to the National Reference Laboratory in the past 3 years (Figure 3). Rice is a main commodity in Malaysia and is a staple food for the majority of Malaysians, hence the frequent monitoring by law enforcement agencies. Although Malaysia grows the majority of its rice locally, it is still a nett importer of rice with most imports coming from Thailand and Vietnam [20]. No GM rice has been detected locally so far from the monitoring activities carried out by the enforcement agencies. Although the majority of maize sent to the laboratory for testing are grains that have been imported, monitoring of maize farms around Malaysia is also frequently carried out to determine if GM maize are cultivated illegally. More than 30% of the total samples of maize grains and its products sent to the laboratory were detected to contain at least one GM maize event as shown in Figure 4.

Malaysia imported a nett value of more than 500 million USD of soybeans and soybean meal in 2019, the majority of it from Argentina and the US [21]. About 15% of the total imports of soybean are processed into local products such as tofu, tempeh, soy milk and bean curd while the rest used for animal feed [21]. More than 50% of the soybean grains and products sent to the NRL were tested positive for at least one GM soy event (Figure 4).

About 5% of the total samples sent to the laboratory for testing were in the form of nuts, seeds and other grains (Figure 3). These include samples such as legumes, cowpea, sesame, peanut, canola, oat, barley, flaxseed, and millet. Some of the crops such as cowpea and flaxseed were sent because they have been approved for food, feed and processing in at least one country globally [10] but have not been approved in Malaysia. Others such as peanut, oats, barley, sesame have yet to be approved globally but have reports of successful transformation of its seeds, hence the monitoring of these crops [22–25]. Of these, only GM canola grains has been detected so far with the approved events GT73, RF3 and MS8 canola.

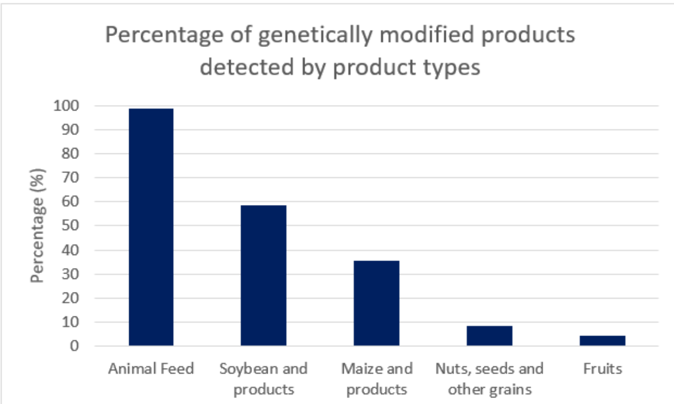

Figure 4: *Percentage of genetically modified products based on type detected by the National Reference laboratory from 2019 to 2021.*

From 2019 to 2021, there were two types of fruits that were sent to the NRL for testing, which were apples and papayas. Of these fruits, only papayas were detected positive for GMO. There are currently four GM papaya events that have been approved for food, feed or cultivation in the US [10]. In Malaysia, no approval has been obtained for cultivation or distribution of GM papaya, hence any GM papaya are classified as unauthorised GMO in the country. Due to this reason, monitoring of farms and local markets for unauthorised GM papaya was heavily carried out in 2020 and 2021 by the Department of Biosafety. The NRL is currently developing event specific detection methods for the identification of GM papaya.

Animal feed is a product which is frequently sent to the laboratory for testing. From 2019 to 2021, more than 7% of the samples sent were comprised of animal feed (Figure 3) of which almost 100% (Figure 4) of these samples were produced from GM maize and/or soya. Most of the feed samples sent for testing were those that have been processed locally for the consumption of domestic animals, although some were grains and meal imported as animal feed. Soybean meal base animal feed is currently the preferred choice due to high protein content and the availability in large quantities.

Vegetable and vegetable seeds, potato and cassava products, and other types of samples make up about 9% of the total samples submitted to the NRL for analysis from 2019 to 2021. The most common vegetable and its seeds sent were brinjal, squash and beans. These are the types of vegetables that have been genetically modified and approved in at least one country but has yet to be approved in Malaysia [26–28]. Potato and cassava products are usually obtained as raw materials and chips, and although there are 3 potato events that have been approved so far in Malaysia [8], no GM potato has been detected so far. Other products which were sent less frequently and could not be classified under any of the other classifications were included in 'others' category, such as cocoa, coffee, eucalyptus and highly processed food containing a mixture of raw ingredients.

Conclusion

Over the years, there has been an increasing trend of new GM crops and GM crop products produced globally. GM crops can mitigate several economic and social challenges globally especially in developing countries. Extensive research has been carried out that shows a positive and fast-growing market trend in the global agricultural industry which not only benefits farmers but also the growing population.

Studies have shown that GM foods are predicted to be important for the biotechnology industry and can contribute towards sustainable food production and improved food security in Malaysia. Although Malaysia does not have any GM crop grown for commercialisation, Malaysia has been an importer of crops such as corn, soya and animal feed from many GM producing countries. Till date, a limited number of GM crops have been approved in Malaysia and are currently restricted for the purposes of food, feed and processing only.

The approval of GMO foods in Malaysia is controlled by regulations under the Malaysian Biosafety Act. Malaysia, however, still faces challenges in many other aspects such the laboratory testing constraints, strict regulations and policies in handling of GMO products and crops and limited funding for GM research. Although there may be a need for GM technology to undergo strict regulation and monitoring by government bodies to minimise issues of unethical research and introduce improved risk mitigation strategies, these regulations should be in such a way as not be restrictive to research activities carried out by the various institutes.

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