International Workshop for Islamic Scholars on Agribiotechnology: Shariah Compliance

Georgetown, Penang, Malaysia
1-2 December 2010

Edited by:

Shaikh Mohd Saifuddeen Shaikh Mohd Salleh

MABIC
MALAYSIAN BIOTECHNOLOGY INFORMATION CENTRE

ISAAA

International Workshop for Islamic Scholars on Agribiotechnology: Shariah Compliance

Georgetown, Penang, Malaysia
1-2 December 2010

MABIC
MALAYSIAN BIOTECHNOLOGY INFORMATION CENTRE

ISAAA
INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

Published by: Malaysia Biotechnology Information Center (MABIC)
The International Service for the Acquisition of Agri-biotech Applications (ISAAA)

Citation: International Workshop for Islamic Scholars on Agribiotechnology: *Shariah* Compliance. Georgetown, Penang, Malaysia (1-2 December 2010). Malaysia Biotechnology Information Center: Selangor, Malaysia; International Service for the Acquisition of Agri-biotech Applications: Los Baños, Laguna, Philippines.

ISBN: 978-967-11160-0-5

ISBN 978-967-11160-0-5

9 789671 116005

Table of Contents

Foreword

Religious scholars have great potential to play an instrumental role in the public understanding of biotechnology. In most countries, they enjoy tremendous public trust and become a credible source of information during time of crisis or when emerging technologies such as recombinant technology, nanotechnology, stem cell research, gene therapy, xenotransplantation, and cloning start to have impact on everyday life. Mosques and churches often become platforms for discussion and deliberation of such issues. Religious scholars are also often consulted by the government on issues related to bioethics and *halal* status of biotechnology products.

However, there is limited dialogue and discussion between scientists and religious scholars which creates a knowledge and communication barrier between these two groups. For religious scholars to play an effective role in addressing public concerns and ethical issues related to modern biotechnology, consultation between scientists and religious scholars has to be an ongoing process.

This workshop was organized with a focus on agribiotechnology and Muslim scholars to kick start the engagement of religious scholars with modern biotechnology. With Malaysia being a predominantly Muslim country and with *Shariah* law governing the life of every Muslim, this was an obvious choice. All Muslim countries are far from being self-sufficient in terms of food production. Being net importers of food and with the yearly increase in the cultivation of genetically modified (GM) crops, the *halal* status of foods from GM crops becomes a topical issue. A record of 15.4 million farmers in 29 countries planted GM crops on 148 million hectares of land. The four main crops are soybean, cotton, canola and corn. These four crops give rise to hundreds of products that are used in almost every food we consume. Therefore, there is a strong and valid need to evaluate the *halal* status of products that comes from GM technology. The scientists involved in agricultural biotechnology too, have to understand the concerns and needs of the Muslim community who make up more than 20 per cent of the global population.

Religious scholars and Muslim scientists from Malaysia, Indonesia, Philippines, Iran, Saudi Arabia, Egypt, and the USA converged to discuss agribiotechnology and its permissibility in Islam. High level discussion on the technicality of recombinant technology and principles of *shariah* took place which resulted in the adoption of a resolution that states the *halal* status of GM products, the need for modern biotechnology in the Muslim world and the obligation of Muslim community in harnessing this beneficial technology.

Malaysia Biotechnology Information Center (MABIC) would like to express its greatest appreciation to International Halal Integrity Alliance (IHIA) for co-organizing this workshop and to all learned religious scholars and scientists who contributed towards this discourse. Special thank you to the International Service for the Acquisition of Agri-biotech Applications (ISAAA) for publishing this proceedings.

Mahaletchumy Arujanan
MABIC Executive Director

The Science of GM Technology in Agriculture

Dr. Wayne Parrott
Department of Crop and Soil Science, University of Georgia, Athens, GA 30605, USA

Abstract
The adoption of GM crops in Organization of Islamic Conference (OIC) countries has lagged behind adoption in other regions of the world. Inasmuch as there is a shortage of data on the applications of GM technology in OIC country agriculture, it is necessary to extrapolate from the information collected in countries where GM crops are legally grown, in order to determine the impact this technology could have in OIC countries. Across the globe, the cultivation of GM crops around the world has helped prevent yield losses, while reducing costs of production and environmental impact. Most importantly, over 90% of the farmers growing GM crops are resource-poor farmers, a group that has found GM crops particularly profitable and easy to manage. Given the prevalence of resource-poor farmers in OIC countries in Africa and southeast Asia, GM crops could be an especially useful tool with which these countries can meet the challenges of sustainably feeding their current and future populations.

Introduction

The use of genetically modified (GM), or more accurately genetically engineered or transgenic crops, has become a reality in international agriculture. During the past 14 years, use of these crops has increased dramatically, and by now these crops have been planted in over a billion hectares in some 29 countries throughout the world (James, 2010). As a consequence, it is possible to evaluate these crops based on the experience of their widespread use.

Like crops, many microbes are used in the food industry, but these are not controversial. Although their use has become almost universal, there are no labeling requirements (GMO Compass), and their use is essentially not perceived by the general population.

In contrast, the population is increasingly aware of GM crops, primarily as a consequence of propaganda and misinformation on the Internet. Given that the majority of people with access to the Internet are urbanites with little to no knowledge of agriculture, any misinformation from the Internet appears more realistic than it really is.

Barring carnations and roses with altered flower color, GM crops are usually indistinguishable from their conventional counterparts. The other traits that are currently commercialized are resistance to viruses, insects, or herbicides (James 2010).

Virus-resistant crops are limited to squash and papaya, and were among the original GM crops placed on the market. Both of these are only grown regionally in the USA (James, 2010).

Herbicides came into use after World War II. However, only a few of them are able to discriminate between the crop and the weeds, which complicates the application of herbicides, as they have to be directed towards the weeds and away from the crop. Thus, the premise behind engineering for herbicide tolerance is simple. If a crop can tolerate an herbicide, then non-directed sprays can be applied in a field, obviating the need for specialized equipment. Though the herbicide may fall on both crops and weeds, only the latter are affected. Thus far, herbicide tolerant soybean, canola, cotton and maize are on the market (James 2010), with rice expected sometime in the future.

The second category is for insect-resistant crops. The premise is to have plants produce a protein, called Bt, originally produced by the bacterium, *Bacillus thuringiensis*, which is toxic to certain types of insects. By so doing, the need to apply traditional types of insecticides is reduced. Furthermore, the Bt proteins discriminate between the target pest and other beneficial insects. In contrast, traditional pesticides seldom do. Thus, so far, the use of Bt is limited to cotton and maize. In maize, different Bt proteins are used to control both lepidopteran and coleopteran pests. Historically, coleopteran larvae damage maize roots, and plants with damaged root systems are not as able to extract moisture from the soil (Sanahuja et al., 2011).

Finally, a new generation of GM crops is starting to reach the market, which emphasizes quality traits targeted to the consumer, as opposed to agronomic traits targeted to the farmer. Among the first of this group is a soybean with oil quality comparable to that of olive oil (CERA, 2010).

How does GM breeding differ from traditional breeding?

One goal of breeding is to accumulate several different traits into one crop variety. In traditional breeding, these traits usually come from wild relatives or other varieties of the same crop. In some cases, techniques such as embryo rescue or protoplast fusion may be necessary to move genes into a crop from its close relatives. In contrast, GM breeding can acquire traits from any other living organism, at least theoretically.

Plant genetic modification has been going on since the start of agriculture, though the vast majority of the population today is not aware of it. While the population at large is that our current fruits and vegetables were found in nature in their current state, the truth is they were domesticated from wild ancestors. Charles Darwin noted in his *Origin of Species* that our crops which been domesticated the longest are so altered in appearance that few people can still recognize their wild relatives. The point is that there is nothing new about the concept of genetic modification.

Even then, few people associate changes in appearance with changes in DNA. However, barring epigenetic phenomena, it is impossible to change the phenotypic appearance of a plant without altering its DNA. In some cases, the DNA changes are orders of magnitude more extensive (Kato et al., 2004) than anything that can be done via genetic engineering.

Mutation breeding is another technology that causes large changes at the DNA level, including deletions, rearrangements and insertions. According to the IAEA (http://www-infocris.iaea.org/MVD/), there are over 2543 known varieties of crops developed through mutation breeding, and these have not presented any safety problems even if they were never tested for safety.

So to summarize, a hallmark of traditional breeding is that the genetic or biochemical basis behind altered traits is seldom known, or it comes to be understood years or decades after a new variety has been commercialized. Traditional breeding changes the DNA, but is a very safe technology, with a long history of safe use. In some cases, levels of previously known toxicants have been increased, but novel, unknown toxicants in the genus have never arisen *de novo* from a traditional breeding program. Because of its safety, traditional breeding is largely unregulated around the world, except in Canada, which regulates all novel traits, regardless of the method used to obtain them.

GM crop development also boasts an outstanding safety record- no problems have been confirmed that are uniquely attributable to any commercialized GM crop. Furthermore, because genes must be thoroughly studied before they can be used, the type of change conferred by the gene is known. Yet, GM crops are among the most highly regulated entities around the world.

Why use engineering?

While conventional breeding has been and continues to be spectacularly successful, it is not without limitations. It can only use traits that can be incorporated via sexual crosses, which limits traits to those available in the species itself and perhaps its close relatives. Furthermore, many crops are propagated vegetatively, as they are either sterile, or do not breed true. Conventional breeding is out of the question for this group of crops. Thus, genetic engineering is what is done when all the conventional approaches to add a needed trait to a crop have not been successful.

The ability to mix and match different gene parts adds to the flexibility of genetic engineering. Promoters from one organism can be spliced with a coding sequence from another organism, and a terminator sequence from yet another. The use of different promoters permits the transgene to be expressed in all or in just certain parts of a plant, or just a certain times in a plant's development.

Thus far, all commercialized genes for food and feed crops have come from other crops, bacteria or viruses, or have been synthesized in a laboratory (CERA, 2010). Currently commercialized food and feed crops have not used genes from fungi or from animals of any kind. Furthermore, although the genetic code is universal, the punctuation codes and the reading machinery are not. Thus, it is not always possible to take a gene from one species and express it successfully in another. Thus, it has become customary to optimize the DNA codons for the recipient species prior to transformation. The net result is that few, if any, genes are used as found in nature.

There are additional criteria that must be met when selecting a gene for use in a transgenic program. The gene product must not be toxic to the humans or animals eating the food, it must not cause allergies (OECD, 1993), and for food and feed crops, the genes do not come from humans. Additional safeguards are in place to ensure that the transgenic plant has not been impaired in its nutrient value or have increased amounts of antinutrients (OECD 1993).

While there are no animal genes in any crop commercialized for food and feed, animal genes have been used for experiments in the laboratory—for example, antifreeze genes from fish have been tried in fruit such as tomato (Hightower et al., 1991). Such laboratory products have become immortalized in the public media and Internet, even if they never were commercialized. The use of human and other animal genes is limited to pharmaceutical crops to produce high-value proteins (Davies, 2010), such as anticoagulants or milk antimicrobial proteins. Nevertheless, any transgenes approved for commercialization in food or feed crops are a matter of public record, and the information may be obtained from web sites such as the Biosafety Clearing House (http://bch.cbd.int/) or the Center for Environmental Risk Assessment (http://cera-gmc.org/).

The number of engineered crops will continue to expand as technology continues to advance. Crops with more complex traits, such as drought tolerance or improved nitrogen use efficiency, can be expected, which will facilitate more sustainable crop production under adverse conditions. Likewise, crops with improved nutritional profiles can be expected, with vitamin enhanced rice expected to be one of the first in this category (Goldenrice.org).

References

CERA. 2010. GM Crop Database. Center for Environmental Risk Assessment (CERA), ILSI Research Foundation, Washington D.C. http://cera-gmc.org/index.php?action=gm_crop_database.

Davies MH. 2010. Commercialization of whole-plant systems for biomanufacturing of protein products: evolution and prospects. Plant Biotechnology Journal 8: 845-861.

GMO Compass. http://www.gmo-compass.org/eng/grocery_shopping/ingredients_additives/36.gm_microorganisms_taking_place_chemical_factories.html. Accessed 30 Oct 2010.

Hightower R, C Baden, E Penzes, P Lund and P Dunsmuir. 1991. Expression of antifreeze proteins in transgenic plants. Plant Molecular Biology 17:1013-1021.

James C. 2009. ISAAA Brief 41-2009. Global Status of Commercialized Biotech/GM Crops: 2009. http://www.isaaa.org/resources/publications/briefs/41/download/isaaa-brief-41-2009.pdf

Kato A., JC Lamb and JA Birchler. 2004. Chromosome painting using repetitive DNA sequences as probes for somatic chromosome identification in maize. Proceedings of the National Academy of Sciences of the United States of America 101:13554-13559.

OECD. 1993. Safety evaluation of foods derived by modern biotechnology – concepts and principles. OECD Publishing, Paris.

Sanahuja G, R Banakar, RM Twyman, T Capell, and P Christou. 2011. *Bacillus thuringiensis*: a century of research, development and commercial applications. Plant Biotechnology Journal 9:283-300.

Applications of GM Technology in Agriculture in OIC Countries

Dr. Wayne Parrott
Department of Crop and Soil Sciences, University of Georgia, Athens, GA 30605, USA

Abstract
The use of GM organisms has become prevalent around the world. In contrast to the use of GM microbes, the use of GM crops is controversial. Nevertheless, the land area planted to GM crops has increased rapidly since their introduction in agriculture. Available products include virus-resistant fruits and vegetables and novel ornamentals. However, these are minor compared to herbicide-tolerant and insect-resistant crops. Future crops will have consumer-oriented traits, such as healthier oils; others will have stress-resistance. Thus, genetic engineering technology has emerged as an important complement to traditional breeding and selection and mutagenesis technologies, by making it possible to obtain crops with traits that are otherwise very difficult or impossible to achieve, by using genes from viruses or bacteria or other plants. After 14 years of large-scale use around the world, GM crops have solved many agricultural problems; at the same time, they have not caused any new problems.

The worlds'population has been in an exponential growth phase during the past century, and it doubled between 1960 and 2000. It is expected to reach 7.8 billion by the end of the decade, and should eventually level out at somewhere between 9 and 10 billion in mid-century. In contrast, the amount of arable land is fixed. Thus, while there were 3 ha on which to raise food per person in 1980, there were only 2.2 by 2000, and there will only be 1.7 by 2020. It is against this background of population growth that developments in agricultural biotechnology must be measured. Food production per hectare must increase 40% between 2000 and 2020 just to keep up with growth. They will need to increase far more to meet the demand at mid century. As supply struggles to keep up with demand, food prices have started increasing around the world.

A look at the world's hungry reveals geographical inequities. A full 26% of them live in mostly Islamic countries of Sub-Saharan Africa, and 63% in Afghanistan, Pakistan, India, Bangladesh, and Indonesia (Butler, 2010). While India is not an OIC member, it is home to the world's second-largest Muslim population. The point is that since malnutrition and hunger affects OIC countries disproportionately, it is these countries that should benefit disproportionately from judicious applications of agricultural biotechnology.

As of this writing, GM agriculture is legal in only three OIC countries, providing a very limited database from which to draw conclusions. Nevertheless, there are vast amounts of data from non-OIC countries, and these data can be used to predict the impact of biotechnology in OIC countries. Specifically, agricultural biotechnology has made important contributions in the areas of food security, economic security, environmental health, and human health and safety.

At the present time, about a fifth of the wheat, soy and maize crops, a third of the rice and potato crops, are lost to pests prior to harvest (Mark Halsey, Donald Danforth Center, Personal Communication). Thus, it is not immediately necessary to increase the yield potential of our current crops. Simply avoiding preharvest losses will contribute significantly to food security. Accordingly, results with Bt crops show that yield increases ranging from 15% in South Africa to 25% in the Philippines have been achieved simply by preventing losses due to insects. The results in cotton are even more dramatic. By controlling insects, yield increases have been about 10% in China, 25% in South Africa, 30% in Argentina and parts of Colombia, and almost 50% in India (Brookes and Barfoot, 2010).

Abiotic stresses, such as drought, also take their toll on crop yield. Resistance to abiotic stress has been one of the most difficult traits to achieve using conventional breeding techniques. Yet, transgenic approaches to drought are very promising, and the first maize engineered for drought resistance is expected to reach the market in the near future.

Erosion prevention and the maintenance of soil quality are key elements of agricultural sustainability, itself a prerequisite for lasting food security. A key contribution from transgenic crops has been to facilitate no-till agriculture. When soil does not have to be tilled to control weeds, it accumulates organic matter, stores carbon, and helps prevent soil erosion. Furthermore, expenses are reduced, as labor and fuel requirements are diminished when tillage is reduced or becomes unnecessary (Brookes and Barfoot, 2010).

Transgenic agriculture has been extraordinarily successful on the economic front. It should be intuitive that GM agriculture would not be the most quickly adopted technology in the history of agriculture if it did not offer real advantages to farmers, both economic and practical, such as ease of management. About half of the added economic value at the farm gate came from higher yields which obtained by lowering losses to pests, and the other half comes from decreased inputs. By 2008, twelve years after the advent of GM agriculture, farmers had obtained $52 billion in added value from GM crops (Brookes and Barfoot, 2010).

It is noteworthy that of the 14 million farmers growing GM crops in 2008, some 13 million of these were small farmers of limited resources (James 2009). These figures reflect the fact that GM technology is very flexible, and does not require highly mechanized technology to be successful. For example, small farmers in Paraguay have access to low-cost seed drills, which can be pulled by oxen (INBIO-Paraguay, Personal Communication). Some cotton farmers in India still rely predominantly on hand labor, yet the GM technology remains effective.

While increased profitability and ease of management drive farmers to adopt the technology, its use also has resulted in environmental benefits. In fact, GM crops must meet with stringent environmental standards prior to being authorized for commercialization, which are evaluated on a case by case basis. For example, there must be a reasonable certainty that gene flow from a GM crop will not lead to enhancement of weediness in wild relatives or the destruction of biological diversity (USDA, 1987). Likewise, when a crop is engineered to express compounds that defend them from pests, these expressed compounds must not damage other organisms. Thus, if the target organism to be controlled is something like a corn earworm, non-target organisms, such as earthworms, birds and bees, must not be damaged. This assurance is achieved by evaluating the GM crop for toxicity to non target organisms and by field monitoring prior to commercialization (EPA, 2001).

Likewise, the engineering process must not confer weedy characteristics upon the GM crop, nor must outcrossing confer weedy characteristics to cross compatible relatives. The period of field trials prior to commercialization serves to ensure that there is no novel weediness associated with the GM trait (USDA, 1987). The issue of herbicide-resistant-weeds is closely related to the use of herbicide-tolerant crops, and the number of weed species resistant to glyphosate (the main herbicide used in transgenic agriculture) is steadily increasing. However, the issue of herbicide-resistant weeds is not unique to transgenic agriculture, and has been a well established problem in conventional agriculture (Heap 2010). This example serves to highlight that an important criterion for GM crops is that they pose no novel problems for agriculture. In this regard, weed resistance is a problem, but it is not a novel problem. This example also serves to illustrate the fact that good agronomic practices, such as crop or chemical rotations, must always be observed to prevent problems, regardless of whether a crop is GM or conventional.

In the case of insect resistance, good agronomic practices are actively pursued and in many countries are mandated by regulations. The objective of these practices is to prevent insects from overcoming the resistance in Bt crops. Accordingly, a percentage of a crop field must be planted in a non-Bt variety of the crop. This insect-susceptible section of the field thus serves as a refuge for susceptible insects. Should a Bt resistant insect emerge from the Bt crop, its most likely mates will come from the refuge, and effectively breed out the resistance. Thus far, this strategy has been very successful in maintaining the effectiveness of Bt crops.

Management issues aside, it is possible to examine the impact of GM technology on agrichemical use in agriculture, as data for the first 12 years of use have been published. The use of insect resistant maize and cotton has resulted in major decreases in insecticide use (35 and 22%, respectively). In contrast, the use of herbicide tolerant soybean, maize and cotton has resulted in a very modest (7% or less) reduction in herbicide use, and the advent of herbicide-tolerant sugarbeet has actually increased herbicide use, as measured by the amount of active ingredient used (Brookes and Barfoot, 2010).

Nevertheless, the amount of active ingredient used is not a good determination of environmental impact, as different chemicals differ greatly according to their toxicity and residual activity. Thus, the notion of Environmental Impact Quotient (EIQ) was developed at Cornell University (Kovach et al., 1992). The EIQ integrates the overall impact of each chemical and multiplies it by the amount used. When EIQ is used to measure the impact of GM crops over the first 12 years of GM agriculture, a significant positive impact is noticeable for herbicide tolerant crops (Brookes and Barfoot, 2010). Nevertheless, the benefit of herbicide-tolerant crops has been less than that of insect resistant crops. The reason is that for the former, GM technology has led to the substitution of one class of herbicides with another; in contrast, the use of insect-resistant crops has led to a decrease in the amount of insecticides used.

Not surprisingly, a decrease in insecticide use contributes to habitat quality. For example, in the United States, the number of bird species in cotton fields increased between 10 and 37% following the introduction of GM cotton (USGA BBS, 2008). Likewise, endosulfan levels in a river in Australia's cotton region decreased to nearly undetectable levels (Mawhinney, 2004).

Just as the extensive use of GM crops over the past 12 years has made it possible to evaluate the impact of GM agriculture on the environment, it is beginning to be possible to evaluate the contributions to human health as well.

It was noted early on that Bt maize tended to suffer less contamination from *Fusarium* fungi, as a result of suffering less insect damage. As insect damage serves as a point of infection for *Fusarium*, the less damage, the less infection there is (Wu, 2007). As the incidence of *Fusarium* decreases, so does the prevalence of fumonisin. Fumonisins are toxins produced by the fungus and which are known to cause liver cancer in humans. More recently, it is becoming clear that they also interfere with nutrient uptake, suppress the immune system, and contribute to the incidence of neural tube defects (Wild and Gong, 2010). Thus, there are health benefits simply from reducing the fumonisin content of maize. This reduction is particularly important in parts of Africa, Asia and Latin America that depend on maize, and which thus suffer disproportionately from fumonisins.

Though the benefits have yet to materialize, GM crops could play a role in helping to ameliorate Vitamin A Deficiency (VAD). According to the World Health Organization (2009), approximately 200 million school-age children suffer from VAD. The majority of these are in OIC states in Africa and Asia. For an estimated 5 million children, the VAD is so severe so as to cause night blindness. Up to 500,000 of these become permanently blind, and half of these die within a year of becoming blind. No single solution can hope to solve a problem as vast as VAD, but there is no doubt that GM crops expressing pro-vitamin A could be part of the solution. Accordingly, Golden Rice, which is rice engineered to express pro-vitamin A, is being developed specifically to help alleviate VAD (goldenrice.org). Just 50 g (uncooked weight) of Golden Rice per day is enough to prevent VAD in children (Ingo Potrykus, Personal Communication).

To summarize, there is a paucity of data on the impact of GM crops in OIC countries, as only 3 countries allow their cultivation. Nevertheless, there is abundant data from many other countries. As there is no reason to believe that GM crops would perform differently in OIC countries, the benefits of GM crops to OIC countries is easy to infer. The greatest benefits would come from decreased losses to pests and decreased need for inputs, resulting in higher income and greater food security for farmers. If the experience from other countries holds out in OIC countries, the majority of the beneficiaries will be small farmers.

In addition, it should be possible to expect a reduction in pesticide use, and a concomitant decrease in environmental impact from agrochemicals. Furthermore, a decrease in the erosion rate can be expected to the extent to which herbicide-tolerant crops are adopted. From a human health perspective, there should be an immediate benefit from reduced fumonisins due to Bt maize, as many OIC African countries depend on maize as a stable. Finally, once Golden Rice is approved, it should contribute towards alleviating VAD issues in many countries. The impact should be even greater once the technology behind Golden Rice is applied to other crops of importance in OIC countries.

References

Borlaug NE. 2005. From the Green to the Gene Revolution: A 21st Century Challenge. USDA Agricultural Outlook Forum. http://ageconsearch.umn.edu/bitstream/32849/1/f005b001.pdf

Brookes G and P Barfoot. 2010. GM crops: global socio-economic and environmental impacts 1996-2008. PG Economics Ltd, UK. http://www.pgeconomics.co.uk/pdf/2010-global-gm-crop-impact-study-final-April-2010.pdf

Butler D. 2010. Food: The growing problem. Nature 466: 546-547. http://www.nature.com/news/2010/100728/full/466546a.html

EPA. 2001. Bt Plant-Incorporated Protectants October 15, 2001 Biopesticides Registration Action Document. http://www.epa.gov/oppbppd1/biopesticides/pips/bt_brad.htm

Heap I. 2010. The international survey of herbicide resistant weeds. http://www.weedscience.org.

James C. 2009. ISAAA Brief 41-2009. Global Status of Commercialized Biotech/GM Crops: 2009. http://www.isaaa.org/resources/publications/briefs/41/download/isaaa-brief-41-2009.pdf

Kovach J, C Petzoldt, J Degnil and J Tette. 1992. A method to measure the environmental impact of pesticides. New York's Food and Life Sciences Bulletin. 139:1-8.

Mawhinney W. 2004. A case study - Catchment water quality and cotton: northern NSW, DIPNR, Tamworth. In WATERpak, published by the Cotton Research and Development Corporation and the Australian Cotton CRC., Narrabri..

USDA. 1987. Introduction of organisms and products altered or produced through genetic engineering which are plant pests or which there is a reason to believe are plant pests. Federal Register 52: 22908-22915

USGS North American Bird Breeding Survey, 2008; Characterization of Avian Species On and Around Cotton Fields in the Cotton Belt of the Southern United States," American Cyanamid and Wildlife International 1/15/1998.

Wild CP and YY Gong. 2010. Mycotoxins and human disease: a largely ignored global health issue. Carcinogenesis 31:71-82.

WHO. 2009. Global prevalence of vitamin A deficiency in populations at risk 1995–2005. WHO Global Database on Vitamin A Deficiency. Geneva, World Health Organization. http://whqlibdoc.who.int/publications/2009/9789241598019_eng.pdf

Wu F. 2007. Bt corn and impact on mycotoxins. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 2:1-8.

A Background on Halal Industry and Principles

Darhim Hashimi[1] and Shaikh Mohd Saifuddeen Shaikh Mohd Salleh[2]

[1] *Chief Executive Officer, International Halal Integrity Alliance, Kuala Lumpur*
[2] *Executive Director, Yayasan Ilmuwan, Kuala Lumpur*

Abstract

The Halal industry is growing at a rapid pace worldwide. The growing demand for Halal products have shifted the focus of Halal from merely meat and poultry to non-meat products. This has given rise to the concept of Halal logistics that include Shariah-compliant business practices and financing. This paper looks at two major issues, namely the growing Halal industry as a global economic force with a number of multinational corporations as some of its major players, and the issue of food security in the Islamic world. It is imperative that the disparity in the Islamic world vis-à-vis food supply and poverty is addressed in the light of the growing importance of food trade, in particular Halal food trade.

Introduction

Over the past six years, an evolving pattern can be discerned within the global halal industry as it develops and matures into a dynamic market with its own specific set of parameters.

The inaugural World Halal Forum held in Kuala Lumpur in May 2006 marked the beginning of a new era for this developing market:

- The term 'Halal industry' was coined and henceforth was accorded an identity and stature as an economic force;
- For the first time, corporate giants such as Tesco UK, McDonalds International and Nestlé delivered papers on Halal market topics, confirming their commitment to the industry;
- The entire value chain, from farm to fork to finance, was assembled to represent all aspects of the industry;

- The world's media, including the business media, started to appreciate the scope and depth of the Halal sector;
- The delegates expressed a desire to see an industry association formed, particularly to take on the task of developing Halal standards.

Economic Force

The size of the global halal food market was quantified for the first time. Based on an assumption of 1.6 billion (CIA Factbook) Muslims worldwide and taking into account the varied purchasing power in these countries, the annual global Halal food market would be US$ 634 billion in 2010. The attraction of this market is even more compelling when one considers that this figure is merely a conservative estimate with a tremendous upside when taking into account:

- The non-food consumables sector such as pharmaceuticals, toiletries, healthcare and cosmetics;
- The services sector especially finance and banking, travel and tourism;
- The spin-off and ancillary activities such as research and development, logistics and handling, audit and certification etc;
- The cross-over market of targeting the non-Muslim consumers leveraging on the universal quality attributes encompassed by *Halal* and *Tayyiban* (good, wholesome);
- The potential increase in purchasing power of Muslims, most of whom live in emerging market countries with high growth prospects;
- Muslim consumers becoming more discerning with wealth, especially those residing in non-Muslim countries, hence demanding more variety of products and services;
- The rate of growth in the Muslim population due to a higher than average birth rate as well as record numbers of converts to Islam.

Multi-National Corporations ("MNCs")

The Halal market has been elevated from being a niche sector to one commanding a significant consumer voice. Marketers are already coining the term "Islamic dollars" to signify the strength of Muslims' buying power.

Previously in non-Muslim majority countries, Halal products could only be found in "corner shops" and specialized ethnic stores. Nowadays, they can be found on the shelves of leading hypermarkets such as Tesco's and Carrefour. Halal certification logos are found on a vast range of packaged products from confectionary to ready-to-eat pre-packed meals.

Nestle SA, the biggest food and beverage manufacturer in the world boasts sales of halal certified products amounting to US$3.5 billion annually. Selected McDonald's outlets in Australia and the

United Kingdom that have "gone halal" have seen exponential growth in customers, reaching out for perhaps the first time to a generation of Muslims born in their adopted countries. It is quite evident that Halal has in fact become mainstream.

From Farm to Fork to Finance

Traditionally, Halal was considered merely as a method of slaughter and the realm of Halal products was confined to just meat and poultry. With the unabated advancement in food technology led predominantly by non-Muslims, *haram* (forbidden) substances (mainly by-products of pork) have found their way into food that was previously intrinsically Halal. Commonly used ingredients include porcine bone based gelatine and lard, which are often used in confectionery and bakery products. Hence, the realm of Halal food has since extended to non-meat based foods. A similar development has taken place in the non-food consumable sector as mentioned above.

The realm of Halal standards has also extended upstream to the livestock sector. Good animal welfare practices are consistent with Halal guidelines, whose principles are based on minimising cruelty and suffering by livestock. Saudi Arabia has taken the lead in applying Halal to include the feed given to livestock i.e. that the livestock must not be fed with *najis* (filth) or *haram* substances. Such substances include bone-meal made from waste products of the same ruminants and even pigs, which empirically has proven to lead to outbreaks of diseases like salmonella and bovine spongiform encephalopathy (BSE), more commonly known as mad cow disease.

One often overlooks what happens in between the various stages from production to the store shelf. Logistics is an invisible service that we tend to take for granted. With increased global trade, there is added risk of Halal products being cross-contaminated with *haram* goods or even with goods whose source and status are doubtful. This is particularly the case with wet goods and meat products. Thus, the concept of Halal logistics was born.

The practices engaged by businesses producing Halal products ought to also be halal and *Shariah*-compliant (Islamic law). It can be argued that *Riba*-based (usury) financing used by the business would negate the efforts of producing halal goods hence the need for *Shariah*-compliant finance or Islamic Banking.

Another related issue that we should note is that while focus on the issue of permissibility of food in Islam has always been on the halal criterion, many people forget that in the Holy Qur'an the concept of 'halal' always come together with the concept of 'tayyib'. In the Holy Qur'an, it is stated clearly that: *"O ye people! Eat of what is on earth, lawful and good; and do not follow the footsteps of the Evil One, for he is to you an avowed enemy"* (Qur'an, Surah al-Baqarah, verse 144).

The Holy Qur'an uses the phrase 'halalan tayyiban' which is translated into 'lawful' and 'good'. In other words, when we discuss about the Islamic perspective on food and other products, it must be remembered that there are two criteria being given the emphasis, namely: (i) Halal (must be lawful or permissible according to Islamic law, and (ii) Tayyib (must be of good quality and safe).

Global Impact

The impact of the World Halal Forum was not only felt in the region but reached the shores as far as South America and Australasia. Around 730 delegates attended (70% of whom were from the business sector) representing almost 30 different countries. 93 different international media companies were represented.

Industry Solidarity

On the last day of the World Halal Forum ("WHF") 2006 in Kuala Lumpur, leading experts and leaders from all over the world from various sectors of the Halal industry passed a resolution to form its own industry organisation. As a direct response to this resolution, International Halal Integrity Alliance Ltd (IHI Alliance) was officially registered on 30th April 2007 in Labuan, an offshore financial centre. This is a first-of its kind organisation whose members will consist of major halal manufacturers and service providers from all over the world.

It is fair to say that the primary movers within the Halal market come from several distinct market sub-sectors:

- South East Asia is where Halal standards, auditing and certification procedures have been most fully developed by government and semi/government agencies, with Malaysia taking the strongest position. This is partly due to the fact that Muslims in South East Asia live in a predominantly multi-cultural society and are more sensitive toward halal products and services in the market.
- Major meat/poultry exporting countries such as Australia, New Zealand, Brazil, Uruguay and some European Union ("EU") countries. Certification is problematic in most of these countries, and is generally pragmatic rather than rigorous; the important issue is the sale.
- Muslim minorities in non-Muslim countries, especially in the EU and USA have emerged as important niche markets in their own right, and also are home to many highly motivated Muslim-owned small business enterprises producing halal products.
- The Arabian heartland is the largest Muslim consumer market, but has been slow to recognize the power of Halal as a market force, and has only limited food production. Halal standards are just now becoming a topic of discussion.
- Several multinationals involved in manufacturing, retail and restaurant chains are already well established in the Halal market, and are steadily increasing their presence and strengthening their position.

Industry Analysis

The international Halal industry is devoid of a significant non-government organization (“NGO”) presence or position that can provide accreditation to certification bodies. The main reason for this is due to the absence of a constructive platform for the industries to communicate and network. The absence of a credible reference centre for information has resulted in industries and consumers being bombarded with various interpretations of the meaning and application of Halal which often contradict each other. Initial feedback has indicated that there is a significant need for a neutral platform established based on studies carried out at various World Halal Forum dialogues held worldwide.

The Muslim consumer market has experienced exponential growth as a result of heightened awareness of Halal, increased purchasing power, more frequent travel and tourism by Muslims and cross-migration into non-Muslim majority countries. The need then for products to be differentiated for Muslim consumption has brought about a proliferation of Halal certification bodies. The types of organizations that perform such certification services range from Government departments, Islamic associations, charities, local mosques to private companies.

A large number of these organizations have sincere intentions to serve their communities but may lack the resources and expertise to implement a comprehensive certification system. The fact that the majority of food producers are controlled by non-Muslims further compounds the situation as the *amanah* (trust) is easily broken along the supply chain.

Furthermore, certification typically centers on the product only at the point of manufacture. The risk of cross-contamination with or adulteration by ingredients containing *haram* products outside of the manufacturing plant has not been addressed. In addition to the physical contact with haram, we need to consider its intangible forms such as *riba*, unfair and unethical practices. At the end of the day, the Muslim consumer is faced with a dilemma as to which products to consume not being able to determine which certification logo to trust and wondering whether the processes to make the product was *Shariah*-compliant.

Clearly, the Global Halal industry has tremendous potential but is currently wrought by numerous issues such as fragmented standards with little or no mutual recognition, a lack of regulatory framework in most countries and an uneven level of awareness even amongst Muslim consumers. Inevitably, these issues will have to be resolved as they become more compelling in the light of threats to food security especially in Muslim majority countries.

Food Security in the Muslim World

According to the World Food Summit 1996, food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle. Hence, it is not only a question of food availability, but also the ability of the population to have access to food, which is related to the distribution system, ability to pay, and so on.

Some of the food security requirements can be satisfied by market forces through domestic agriculture, food production and importation. Other aspects of food security however are effectively what economists refer to as "public goods", such as the assured and secured feeling of a certain level of self-sufficiency or the provision of national strategic needs, for example food safety and balanced nutrition.

Many Muslim-majority countries after gaining independence became dependent on agriculture and food production. They became the producers and suppliers to the world food market, particularly in terms of primary agriculture and food products. However, the value added activity on these raw materials remains very little resulting in the need to import back processed food products at a premium to satisfy domestic consumption.

In addition, many Muslim countries face problems of inadequate food production due to insufficient resources such as arable land or water and inefficient food distribution systems. This has led to increased dependency on massive imports from other countries (typically non-Muslim majority) to meet their basic requirements. Overdependence on food imports rendered some of the poorer countries into a vicious debt cycle.

In the global context, the negative consequence of food security is staggering. The number of people without enough food to eat on a regular basis is estimated to be more than 800 million out of a 6.4 billion world population. With the prospect of commodity prices increasing, the impoverishing effect will be further compounded.

Over 60 per cent of the world's undernourished people live in Asia, and a quarter in Africa, most of which are Muslim-majority countries. The latest FAO figures indicate that there are 22 countries, 16 of which are in Africa, in which the rate of malnutrition is over 35 per cent.

The Islamic Concept of Food Security

Many scholars such as Nik Mustapha Nik Hassan [1991] have reiterated the Islamic position on food security. There is no doubt that food, clothing and shelter are bare necessities for survival and form the basic needs of a human being.

Prophet Muhammad *p.b.u.h* prayed: *"Allah, I ask thy refuge from apostasy, scarcity and ignominy"* (reported in Bukhari); and *"Allah, I ask thy refuge from hunger for it is the worst bed fellow"* (reported in Nasa'i).

The vision of an organized nation consistent with Islamic principles is among others, the guarantee to every human being the fulfilment of their basic needs, which would include food security. The state or government leaders bear the ultimate responsibility of ensuring basic needs are met including creating a policy to overcome food security issues. In reality, this represents a daunting task for many Muslim countries at present given the lack of a clear and consistent economic and food production policy. In the context of state leadership, as stated by Nik Hassan [2001], the Prophet *p.b.u.h* said that: *"The Ruler is the guardian of one who has no guardian"* (reported in Tirmidzi). Therefore, it is clear that the role of state leadership is important to ensure that food security can be achieved.

The Holy Qur'an highlights the necessity of ensuring food security through the advice of Prophet Yusuf: *"(Yusuf said): 'For seven years shall ye diligently sow as in your wont, and the harvest that ye reap, ye shall leave them in the ear, except a little of which ye shall eat'"* (Qur'an, Surah Yusuf, verse 47).

Further to this, there is also ample evidence from the Holy Qur'an encouraging man to be involved in food production: *"He it is has made the earth a cradle for you, and has traced out for you ways (of livelihood) thereon and (who) send down waters from the sky; and by this means We bring forth various kinds of plants"* (Qur'an, Surah Ta'Ha, verse 53).

If we look at the history of the Islamic civilization, we will notice that emphasis on food production (and hence, food security) was given a priority. It was this emphasis that brought about the globalization of crops where crops from different parts of the world were introduced to other parts. So huge was the stride made in agriculture during the time of the Islamic civilization that by the 11th century, there was hardly a stream, oasis, spring, known aquifer or predictable flood that went unused.

The Paradox of Muslim Countries: Diverging Wealth

The paradox of the problem is demonstrated by the fact that many Muslim countries are experiencing food shortages and poverty whilst some enjoy tremendous wealth in money and resources but the Muslim nations as a whole suffer a deficit in food trade balance. Production factors are plenty; population and labor supply is enormous and at the same time cheap, and land is abundant while Islamic banking and finance as a result of petrodollars are flourishing.

The six member countries of the Gulf Cooperation Council (GCC) alone have a combined size of their Sovereign Wealth Funds exceeding USD 1.2 trillion. But on the other hand, numerous Muslim countries are experiencing tragic conditions of food shortages and widespread poverty. It is really shocking to note that the three major food famines in recent history in which millions of people died of starvation occurred in Muslim countries.

In the early 1940s for example, widespread famine and hunger in Bengal (currently known as Bangladesh and the state of West Bengal in India), which existed due to economic malfunction, resulted in the deaths of more than four million people. This happened when the food production in that area was actually high, but most of the food was exported leaving the domestic population to face famine and starvation.

Food as the New Weapon for Global Dominance

Nowadays, we can see that global dominance can be achieved in various ways other than conventional warfare. Indeed, food trade is an effective weapon in attempting to achieve economic and political domination, as well as political subservience of poor countries.

The simple reality is, even though we, as emerging countries are progressing well economically at face value, we will always be internally unstable and externally vulnerable so long as food security is a threat. Although self-sufficiency in all food products is neither desirable nor economically justifiable, we should, at a considerable degree, have a certain 'safety level' and 'group accessibility' to food products, especially those that constitute our staple diet.

Overcoming Food Security

We are now at a juncture of mindset change. We have been constantly bombarded by the notion that as resources are limited we have produce and export only those things in which we have a comparative advantage and import the rest from other countries who can produce them more cheaply. This convention in economic theory is flawed in that goods are valued superficially and that their strategic intrinsic value is not taken into account.

First and foremost, we must understand that our resources are not limited. It is our ability as humankind to use resources at an efficient and productive manner that is limited, and not the resources itself. Increasing food supply within a country is the most favorable option, although it does not guarantee that poor people will have access to it. Hence, accessibility to food and the objective of food security can only be achieved if the economic status of the lower income groups are upgraded or a comprehensive welfare system is in place to ensure that food is distributed either free or at an affordable price to those most in need.

In the Islamic approach to economic development, every person in a community must contribute to the development of the community. A good example of such a mechanism is Zakat (tithes), which is one of the Five Pillars of Islam and is compulsory on all Muslims. Through effective collection and distribution of Zakat, the wealth of communities could be improved. Another mechanism is through waqf (endowment) where economic assets can be designated for agriculture purposes to sell food at cost without any profit margin for example.

Collectively within the Muslim world, we have the resources, land, human capital and Islamic mechanisms to overcome food security issues both in the more developed but food-poor countries as well as in the impoverished nations. Policy makers are now re-adjusting their priorities and trying to find the delicate balance between being globally competitive and yet being able to feed one's own people.

The key to achieving food security for the Muslim world is to harness all these qualities and implement Zakat, Waqf and other mechanisms effectively. A combined population of 1.6 billion is meaningless if they cannot act in cohesion to fulfil the most basic of human needs.

References

ASEAN Secretariat. 2006. Country Case Studies on Multi-functionality of Agriculture in ASEAN Countries.

The ASEAN Secretariat and Ministry of Agriculture, Forestry and Fisheries of Japan. Jakarta, Indonesia.

Nik Hassan, Nik Mustapha. 2001. The Concept of Food Security in Islam. Institute of Islamic Understanding of Malaysia (IKIM), Kuala Lumpur, Malaysia.

Halal Concept and Products Derived from Modern Biotechnology

Mohammad Taghi Malboobi[1]* and Mohammad Ali Malboobi[2]

[1] Research Department, Islamic Relation and Culture Organization
Resalat Highway, Tehran, I.R. Iran; alimalboobi@gmail.com
[2] National Institute of Genetic Engineering and Biotechnology, P.O. Box 14965/161, Tehran, I.R. Iran
**Corresponding author*

Abstract

The concept of "Halal" is a very important from the perspective of science and religion that encompasses many other concerns such as cleanliness, ethical values and food safety not only in Islamic world but also in other societies. Conceptually, "Halal" term means "permitted" – in opposite to "Haram" which means forbidden – and to do what is called permissible and legitimate and is not in contrary to the God's instructions. From the perspective of Holy Quran, everything is permissible or Halal unless it is explicitly determined to be Haram. Basically, Halal has been summarized in certain criteria such as to be Tayyib (clean), not to be Khabis (dirty), and reasonably cause no harm to human or other creatures. Genetic engineering is considered as a tool for production of food, medicine and industrial products and services for human welfare. Concerns have been raised about the safety of these activities as well as their conformity with Shariah. Some have even considered genetic manipulation as an attempt to play God. In terms of legitimacy, the available methods of genetic manipulation of animal and plants are not the instances of interference with "creation", but also they are cases of human efforts like cultivation or reproduction to progenies as permitted in Shariah, though such matters must follow legal and social norms and social conventions. For consumption of genetic engineering products, the basic principle of Ebahah is applied which declares "all food products are Halal and permissible unless stated explicitly". Indeed, unreasonable rejection of food products as Haram is prohibited in Islam. All food products derived from application of new scientific methods such as genetic engineering and biotechnology are subject to the following principles. If the produced material preserves the original Haram characteristics with no change in the nature, then it remains Haram. However, if the derived product has a new nature and has no characteristic of the Haram origin, it is considered as Istihalah (entirely changed from one nature or state to another, i.e. subject is changed), Intiqal (shifted from one subject to another, i.e. become another subject) and Inqilab (transformed to another subject). In such cases, the products derived from modern biotechnology are "Halal" and there is no objection in the use of derived food products and they are permissible and could be labeled as "Halal".

Introduction

In the new era of science, applied sciences are advanced towards the introduction of modern technologies with the goal to improve human welfare and capabilities in various areas. With the emergence of new technologies, particularly in Modern Biotechnology, ethical, social and religious concerns are raised as expected. In Islamic societies, the convergence of science and religion as complementary languages of thinking are always sought. With advances in genetic engineering, the Halal concept from both the legitimacy point of view and consumption of products derived from modern biotechnology require faithful re-examination. In this paper, concepts and definitions, the nature of the subject, the view of Holy Quran and lawful orders of Shariah on Modern Biotechnology practices and consumption of the derived products are deliberately reexamined.

Halal Concept

Looking at the root of the word “Halal”, it means “opening a node or resolving something”. In Islamic context, Halal is permissible and legitimate conduct or food in opposite to “Haram” which means forbidden. Halal act is to do what is not in contrary to the God’s will and instruction. Practically, it has also accommodated several other attributes and values such as cleanliness and purity.

Basic principles for Halal products are:

1. Being Halal or Haram products is the function of being lawful or unlawful with respect to Divine orders.
2. Assigning Halal or Haram depends on being beneficial or harmful, respectively.
3. In the context of the above concepts, assigned orders in Shariah are both fixed and variable rules based on the state of subjects on specific times and places.
4. Orders in Shariah are ranked based on the degree of being beneficial or harmful while the best choice is preferred whenever it is necessary.
5. Some controls and governing regulations such as “La zirar” (no harm to human), Haraj (the existence of serious threat and/or constraints), and urgency rules occasionally disapprove the orders.

Halal and Haram in Qur’an

From the perspective of Holy Quran, everything is Halal and permissible unless it is explicitly announced as Haram. Fundamentally, determining Halal and Haram have been summarized in certain criteria such as to be Tayyib (clean), not to be Khabis (dirty), and to be reasonable with no clear and measurable harm to environment, human and other creatures.

A review of verses in which Halal activities and objects are described, it is found that Haram materials and affairs are restricted to certain instances, such as: dead bodies (except for permissible animal that are slaughtered in special way), blood, sperm, wine, dog and pig, possession of other’s properties without permission and foods offered by tyrant rulers. Therefore, by determining of Haram cases, Holy Quran has strongly discouraged prohibition of what Allah has blessed human being for as clearly stated in the following verse:

"O you who have believed, do not prohibit the good things which Allah has made lawful to you and do not transgress. Indeed, Allah does not like transgressors" (1).

Halal and genetic engineering

Despite subtle differences in verdicts, Muslim Ulama have cleared out the limits of Halal and Haram for type of conducts as well as objects, plants and animals derivative from time to time. However, the progress in modern sciences necessitates re-examination of the nature of the subject from this point of view.

Genetic engineering involves production of new food material through manipulating or fabricating and then transferring genes to convey genetic data from one organism to another. The result is eventually the production of food material with scientifically predefined characteristics and qualities. In other words, genetic engineering in living organisms deals with new products aimed at improvement of food and medicinal products to fulfill the increasing human demands for food and cure from accessible biological resources. Hence, modern biotechnology introduces new topics in religion, moral and value fields as highlighted here from two points of views, legitimacy of genetic engineering per se, and the Halal or Haram state of the products derived from genetic engineering to be consumed by human.

Legitimacy of genetic engineering

Considering that genetic engineering manipulate organism characteristics as a result of gene transfer from one organism to others, the first topic is whether this conduct is religiously allowed or not. There are two main views in this regard:

1. Genetic engineering manipulate the creation which means interfering in Divine work (playing God); and, thus, is illegitimate.
2. Genetic engineering is a scientific practice in compliance with god's instruction to human, as the god's successor on earth, to make use of creatures; and, thus, is legitimate.

The first view objects genetic engineering in three ways:

First: interfering with Divine work;
Second: causing harm and corruption;
Third: committing the use of Haram methods.

Regarding the above objections, we should keep in mind by definition genetic engineering and biotechnology as *"transferring one or more genes or DNA elements from one organism into the genome of another one"*. In this way, the recipient gains a gene that it lacked previously and now it can express the transgene which confers a new trait or modified product. In fact, gene transfer is a kind of data transfer and copying what already existed in nature. Based on this point, the objections could be resolved as below.

First: interfering with Divine work

1. Genetic engineering is not meddling with Divine creation, since human is the "Khalifatollah (successor of God)" on the earth in many religions, especially in Islam. God has created him with tendency for creativity and innovation by nature to make use of its beings. For instance, human is allowed to cultivate seeds for farming to produce food as needed that may disturb natural forests and ranges. Similarly, he is also allowed to rearrange genes or DNA elements to have a better life.
2. Genetic engineering is based on modification and cloning towards human welfare, although in some cases may make trouble. Therefore, the basics of genetic engineering for production and cloning, which is similar to propagation of plants through cuttings, are permissible in Islamic Fiqh. Such works are Halal only if done for Halal purposes and like any other thing it become Haram if it is for Haram purposes, e.g. making wine from grape in Islam.
3. Holy Quran generally shows human had no limits in using creatures via different methods including genetic engineering except those limits that are explicitly mentioned. There are several sets of verses in this regard:
    - Verses elaborating that things in earth, heaven and so on are for the human welfare,
    - Verses about creation and reproduction of human or other creatures,
    - Verses about developing, creativity and innovation by human,
    - Verses about thinking of the creation of the universe
4. Reasoning on devil saying:
   "And I will mislead them, and I will arouse in them [sinful] desires, and I will command them so they will slit the ears of cattle, and I will command them so they will change the creation of Allah. And whoever takes Satan as an ally instead of Allah has certainly sustained a clear loss" (2).

   Change of creation in this verse is not about genetic modification. Because based on it we should prevent many things that are not Haram including transplantation, beauty surgeries or producing plants through grafting for all of which there is no verdict to be Haram. Based on this verse, devil states that it will deviate human from its nature with tendency toward god, designated as *"fitrah of Allah"* in Holy Quran. Indeed, this verse refers to monotheism and polytheism as cleared in another verse:

   "So direct your face toward the religion, inclining to truth. [Adhere to] the fitrah of Allah upon which He has created [all] people. No change should there be in the creation of Allah. That is the correct religion, but most of the people do not know" (3).

Basically, changes in *"fitrah of Allah"* would lead to polytheism and infidelity which are totally irrelevant to cloning or genetic engineering.

Second: causing harm and corruption

Another issue could be possible harms of genetic engineering products to human health that provides a basis for prohibiting biotechnology utilization. However, we should consider the following matters:

1. Biotechnology includes several specialized field where the benefits or harms should be defined by experts. Since most of the experts, except for social and environmental activists, believe defects could be during the research phase before reaching people, society or environment, through pre-marketing risk assessments as required by authorizing bodies. In Islam anything that cause harm to human health is forbidden. In case any biotech product is scientifically proven to cause damage, then that product only is forbidden, but one has no right to extend that specific and or hypothetical case to all biotechnology products. To the knowledge of the authors there is no verifiable report on any harm caused by biotech crops/foods in spite of growing more than 148 million hectares of biotech crops in the 15th year of their cultivation. In Islamic Fiqh it is not permissible to use a loose reason for prohibition and prevention, particularly if it is necessary for one's life. Even in case of uncertainty, one should consider the questioned product as Halal based on *"Ibahah"* principle. Ibahah principle declares that "everything is Halal and permissible unless stated explicitly". The benefits of this technology for human, on the other hand, prove that it should be even favored, particularly when it comes to food security and survival.
2. Some may reason that genetic engineering may lead to species extinction which is not scientifically proven. On the other hand, many species have gone extinct because of natural causes and no one has issued a verdict against them.

Third: committing the use of Haram methods

The principle of legitimacy is a distinct concept from using or committing Haram or Halal. Gene transfer, cloning and reproduction, as the main issues of biotechnology, have never been prohibited in Islam. Indeed, Islam encourages science and scientific progress and do not want to impose limitation upon sciences and scientists.

Using or committing Haram is a secondary issue which should be discussed in its own place. If an activity is Haram, the relevant part should be prohibited and this has nothing to do with legitimacy of the main subject. Both Sunni and Shiite Ulama have always ruled something as Haram only based on corruption or prohibitory reasons. Therefore, if the Haram reason is omitted, then, the prohibition is abandoned. For example, as one of the eminent Ulama, Garzavi, stated "animal cloning is eligible provided that it is beneficial for human and no greater harm is caused".

Having rejected the above objections, the second view upon which genetic engineering is a scientific practice in compliance with god's instruction to human is considered legitimate.

Halal issues in Genetic Engineering

Hypothetically, foods derived from modern biotechnology can be categorized as followings:

1. Products derived from transferring genes from Halal origins into Halal recipients; e.g. products

of transferring genes from wheat to rice where all the elements used during genetic engineering process are considered “Halal”.

2. Products derived from transferring genes from Haram origin into a Halal recipient; e.g. products of transferring genes from pig, or other Haram animal, or Halal animal not properly slaughtered into a Halal entity such as rice or wheat.
3. Products derived from transferring genes into Haram recipients; e.g. the product of transferring gene from rice into any Haram animal, such as pig.
4. Products with mixed Halal and Haram origins

1. Products derived from transferring genes from Halal origins into Halal recipient

These products are Halal and permissible to use, since:

a. Based on generalities in Holy Quran and traditions, these are not included as Haram and Khbays (unclean materials).
b. Rationally, as confirmed in tradition and by experts, these materials comply with religious principles and human needs.
c. The principles of authenticity of Halal and Ibahah apply to all issues if there is no reason for prohibition.
d. There is no Haram work or object in their production process.
e. There is no verifiable harm on human and environment
f. The principle permissibility applies on genetic engineering technology as there is no religious objection for either gene transfer or cloning.

Therefore, genetically engineered food products with Halal origins are Halal. This decree, of course, is acceptable if no harm to human or animals are involved during the process as proven for experts in the field.

2. Products derived from a transgene of Haram origins into Halal recipient

This category essentially includes the use of genetic data of a Haram animal copied or transferred for scientifically beneficial purposes without preservation of the original materials. Although this has never been done in practice and the authors failed to identify any project of this kind, this class of products could not be readily ruled as Haram since the original material (e.g. the DNA) and the subject or title for prohibition is altered. In other words, only genetic “data” and not “the material” or “characteristics” are left in the final product such that there is no reason for prohibition.

In such cases (Hukmiah Tahrimiah objection), we should refer to Shariah principles for which two views exist. Some believe in precaution and rule it as Haram while others disagree and believe due to lack of the prohibition verdict, the principle of authenticity of Ibahah applies, i.e. the products are Halal.

These products could be divided into two groups:

I. Products that are not similar to the Haram origin but save its Haram and harmful characteristics after gene transfer, e.g. producing cow meat with characteristics of pig meat. This group falls into Haram category and the principle of caution applies as already shown in similar verdicts.

II. Products with certain beneficial characteristics of the Haram material which are transferred to biotech crops or human body for health, sanitation or pharmaceutical purpose with no harm. This group is not considered Haram and the principle of authenticity of Ibahah applies, since in these cases:
   a. The Haram material does not exist practically and the subject of Haram is detached from it.
   b. By transferring genetic material, new products with distinct identity are obtained. For example, a dead body is changed to dust. In such cases, the characteristics of Haram origin are transformed into other materials. These are considered either as Istihalah (changing from one nature or state to another, i.e. subject is changed) or as Intiqal (shifted from one entity to another, i.e. become part of another entity's body).

This rationale applies at other levels like transplanting organs from a Haram animal to human body so that the part is no longer a part of the original being and considered as human organ and, thus, is sanitized. Sunni Ulama (4) in the 8th Islamic Fiqh Conference resolution (year 1405 HG) approved that "implanting organs of Zabihah (slaughtered in special way) animal, whether Halal or non-Halal, in case of necessity is permissible". Using these products is legitimate in both Halal and Haram cases, since:

1. The subject is changed and these materials are no longer identified as a part of Haram organism. The derived materials are also considered Halal and clean.
2. The benefits of drugs or food products are applicable here; meaning that based on rationality and reasoning of experts, these products are beneficial for public.
3. The principle of authenticity of Ibahah applies here since the Haram titles that are explicitly mentioned in Holy Quran or tradition do not cover these products.
4. In the case of necessity (Iztirar), using the needed amounts of these materials is Halal.

3. Products derived from transferring genes into Haram recipients

These products are produced through propagation, cloning or transfer of genes from a Haram origin to produce that same Haram material in a modified form in which the Haram material preserves its original characteristics. These materials are certainly Haram due to their Haram or unclean origin. In fact, this category includes improvement of Haram products like genetic engineering or cloning pig from pig cells.

4. Products with mixed Halal and Haram origins

These products are divided in two groups:

1. Haram materials are mixed with Halal materials to produce vital medications (in case of Iztirar) for which both Shiite and Sunni Ulama believe in their legitimacy and consider them as Halal.

2. Halal products that are mixed with Haram ones in the final food products is considered as Haram by all Ulama of different sects in Islam since Haram identity is preserved no matter how small it remains in the final food.

Conclusion

In summary, genetically engineered food products are:

1. Halal, if they are derived from Halal origins.
2. Haram, if with Haram origins and the Haram material preserve its characteristics or they are in obvious Haram nature.
3. Halal, if the original Haram materials have changed their identity and are beneficial to human being.
4. Halal, if derived from Haram origins but there is a necessity in consuming them.
5. Haram, if food product is a mixture of Halal and Haram material with no alteration in its nature.

Acknowledgement

Authors wish to acknowledge Malaysia Biotechnology Information Center (MABIC) for organizing the meeting. We are also deeply grateful to all scholars and scientists who participated in the discussion of this subject and helped in the production of this paper. Also, we would like to acknowledge critical revisions done by Dr. Behzad Ghareyazie.

References

1. Holy Quran, Maidah: 87.
2. Holy Quran, Nisa: 119.
3. Holy Quran, Alrum 30.
4. Al-Tohid Journal, Vol. 46:47.

Food and Environmental Safety of Biotech Crops: Islamic Perspective

Behzad Ghareyazie
President, Biosafety Society of Iran and Head, New Technologies Division of Center for Strategic Research, Tehran, Iran. E-mail: ghareyazie@yahoo.com

Abstract

Intrinsic and extrinsic concerns have been raised about the environmental release of crops developed through "Modern Biotechnology" and their use as food. Currently more than 134 million hectares of biotech crops are grown in 25 countries in the world and the products are consumed almost in the whole world. Both intrinsic and extrinsic concerns about biotech crops are evaluated and Islamic perspective is presented. "Playing God" and "crossing the natural borders" as the main intrinsic concerns about modern biotechnology and genetic engineering are evaluated from Islamic point of view. From the extrinsic concerns food safety and environmental concerns including the effect on biodiversity including non-target organisms are reviewed. It is concluded that biotech crops are safer for human consumption and useful for the environment. Islam does not consider genetic engineering as playing God and has no other intrinsic concern in this regard. Islam considers biotech crops as "Halal" as long as the sources for production of these crops are Halal.

Introduction

Another roughly 3 billion people will be added to the planet's population by the mid-21st century. To feed this population, food production must be increased by 70 percent (Federrof *et al.,* 2010). Production of "safe" food will be more challenging. The amount of arable land has not changed appreciably in more than half a century. No more increase in arable land is expected since we are losing land to urbanization, salinization, and desertification. On the other hand, devoting more land for agriculture will put more pressure on rangelands and forests and will result in the loss of biodiversity and increased environmental pollution. Therefore increased food should be produced from almost the same land under cultivation today.

Climate change and in particular global warming will bring more sophistication to the food production. The yields of our most important crops decline significantly at higher temperatures. In 2003, Europe experienced an unusual heat wave that was about 3.5°C above the average for the last century. There was a 20 to 36% decrease in the yields of grains and fruits in that summer (Federrof *et al.,* 2010). We are expecting more hot summers to come.

High temperature is only one of the problems. Salinization, desertification, water scarcity, biotic stresses (increased damage caused by insect pests, diseases and weeds), food loss and the quality of produced food are also part of the challenges that food security faces in the 21st century.

These signify the application of new tools that promise to improve the productivity in parallel with the quality and safety of the produced food. Biotechnology provides powerful tools for the sustainable development of agriculture, fisheries and forestry, as well as the food industry (FAO 2000). Biotechnology is referred to several technologies that use living organisms or parts of them for the production of goods and services to improve human welfare. Application of tissue culture, microbiology and molecular markers to produce agricultural products with higher quality and productivity with lower input has been in practice for more than half century. Modern biotechnology is however a new branch of biotechnology that is referred mainly to the application of "in vitro nucleic acid techniques, including DNA and direct injection of nucleic acid into cells or organelles that overcome natural physiological reproductive or recombination barriers" (Cartagena Protocol on Biosafety). The products of modern biotechnology are frequently referred to as "biotech crops", "transgenic crops", Leaving Modified Organisms (LMOs) and/or Genetically Modified Organisms (GMOs). The latter two are the same except the fact that GMO may or may not be a leaving organism, but LMO is used only when a GMO in question is a live entity.

Biotech crops are produced to improve their desired characteristics such as productivity, increased resistance against insect pests or diseases (and hence the reduction in the application of chemical pesticides), increased tolerance against more environmentally friendly herbicides, improved abiotic stress tolerance such as drought and salinity tolerance, improved nutrition such as vitamin A, zinc and iron and production of "plant made pharmaceuticals" (PMPs) such as edible vaccines and antibodies.

The major goals of modern biotechnology are to help 1) attain food security, 2) attain sustainable development, 3) save environment and biological diversity, 4) facilitate farm practices and 5) produce industrial molecules including enzymes and PMPs.

Products of modern biotechnology have been in market place since 1995-1996. In 2009 more than 14 million small and large farmers in 25 countries planted 134 million hectares of biotech crops (James 2009). Of the 90 million hectares of soybean grown globally three-quarters are biotech soybean; almost half of the 33 million hectares of global cotton is also biotech cotton. Biotech maize occupied over one-quarter of the 158 million hectares of global maize and biotech canola more than one-fifth of the 31 million hectares of global canola (James 2009). These biotech crops are cultivated in both industrial and developing countries. Biotech crops are so appreciated by farmers that they adopt these crops immediately after their availability in the market. For example, in three years after release of herbicide tolerant biotech sugar beet in USA and Canada, about 95 percent of the cultivated sugar beet in these two countries was transgenic herbicide tolerant. In 2009, 13 biotech crop plants including Soybean, Maize, Cotton, Canola, Sugarbeet, Alfalfa, Squash, Papaya, Sweet pepper, Tomato, Poplar, Rice and Roses were grown globally. Insect resistant Brinjal (Eggplant) will be the next biotech crop in the “food basket”. Biotech rice was first commercialized in Iran in the year 2004, but the cultivation area is very limited. China has approved commercial cultivation of insect resistant (Bt) rice in 2009. It will take 2 to 3 years before full commercialization of this important food crop that is considered as the main staple food of the world population.

The share of Muslim Ummah in production of biotech crops

Global value of the biotech seed market alone was valued at US$10.5 billion in 2009. The global value for the corresponding commercial biotech maize, soybean grain and cotton was valued at US$130 billion for 2008, and projected to be US$ 143-150 billion in 2009 (James 2009).

Many Islamic countries including Iran, Pakistan, Egypt have strong biotechnology research and development program in place. But as of 2009, Egypt is the only one that is included among the 25 mega biotech crop growing countries. Egypt grows less than 50000 hectares of insect resistant Bt maize. Iran was the first Islamic country to commercialize a biotech crop plant. Pakistan is thought to grow millions of hectares of Bt cotton since 2007; but no official confirmation is available to date. No other Islamic country is expected to grow biotech crops at commercial; scale in the next 2-3 years. The share of Islamic Countries in production of biotech crops and hence their share from the export of about US$ 150 billion is therefore nearly zero.

Although there are 25 countries producing biotech crops in the world but additional 57 countries have approved the importation and use of these commodities. In addition, almost all Islamic countries import and consume large quantities of biotech crops from major biotech crop producing countries (USA, Argentina, Brazil and Canada) directly or indirectly. Table 1 shows some of the Islamic countries and the source of their imported oil seed, edible oil and maize. Most of the Islamic countries import major part of their edible vegetable oil and animal feed (Maize). They import significant part of these commodities either directly or indirectly from the four mentioned mega biotech crop producers. For example, Iran imports about three million metric tons of oil seeds (soybean, canola, etc) and about additional 3 million metric tons of animal feed (mainly maize) annually. This constitutes more than 90 percent of the annual consumption of edible oil and animal feed of the country. The source of these oil seed is mainly Argentina and Brazil (directly) and USA and Canada (indirectly). Since almost the entire soybean production of USA and Argentina and significant portion of oil seed crops and maize in Brazil and canola in Canada are biotech crops, it is therefore concluded that most of the above mentioned imported commodities by Iran are transgenic. There are also scientific reports confirming that imported soybean and maize in Iran include GMO (Sarikhan, 2006). Islamic countries are therefore considered as huge market for the biotech crops that are safer and better in their quality but are produced elsewhere.

Table 1. Source of vegetable oil, oil seed and maize imported by selected Islamic countries.

Country	Oil and oil seeds	Cereal
Iran	Argentina, Brazil, second hand	
Egypt	USA, Argentina, Canada, Brazil	
Turkey	Argentina, USA, Brazil…	
Saudi Arabia	Brazil, USA, Second hand	USA, Argentina
Syria	Argentina	
Jordan	USA and second hand	USA, Argentina, Brazil
Sudan	Second hand	USA (corn) and Second hand
Oman	Argentina, UAE, USA, Saudi Arabia, Brazil	USA, Argentina Brazil
Algeria	Argentina, USA, Brazil	Canada, Argentina, USA, Brazil
Malaysia*	Indonesia, Argentina	Vietnam, Australia, Brazil

*Malaysia is a net vegetable oil (Palm oil) exporter, but still imports some.
Source: http://www.trademap.org/tradestat/

Concerns raised about biotech crops

In spite of 15 years of experience in cultivation and safe consumption of billions of tons of biotech crops, there are still concerns about the application of this technology for food production. These concerns are either of "intrinsic" or "extrinsic" nature. Intrinsic concerns include the "playing God" argument that considers genetic engineering as interference in God's authority and may be thought to be morally wrong in *itself*. However, only some sects in Christian Religion consider genetic engineering as interference with God. This belief however, has no basis in the Bible. Muslim clerics and Ulama do not buy this argument. They believe whatever scientists are doing is under the natural rules and regulation set by Allah himself and therefore, no one can cross the red lines (intrinsically) and no one can "play God". There is no single "Fatwa" stating that genetic engineering is forbidden or is "Haram". Fatwa is a religious declaration set by highest ranking Ulama that is considered obligatory for the followers of those Ulama. Islam does not intrinsically disapprove any branch of science and technology. In fact Islam encourages human kind to seek for science from birth to death (Ghareyazie 2008).

Some "naturalists" may also be intrinsically against genetic engineering since they believe it is not "natural" or it is interfering with nature. Naturalists who are concerned with crossing the "boundaries" set by the "nature" are also disarmed when genetic engineering involves genes coming from the same species. The problem with intrinsic concerns is that it is not clear who and how defines what is "boundaries". For example why are other methods of plant breeding such as mutation breeding not considered as crossing the boundaries?

According to the second group of concerns (extrinsic), although the procedure of genetic engineering by itself is not considered "wrong", but the *consequences* of this technology is considered potentially unacceptable (Kaiser, 2005). The extrinsic group of concerns can be categorized in four major groups:

I) Human Health (food safety), II) Environment and biological diversity, III) Agriculture and animal welfare and IV) Socio-economic concerns. This paper addresses the concerns related to food and environmental safety of biotech crops only.

Human Health

Concerns have been raised about the safety of foods derived from GMO for human health. Toxicity and/or allergenicity of the newly expressed protein and the possibility of occurrence of "unintended effects" were among the concerns raised about the safety of this type of food. After 16 years of consumption of billions of tons of foods derived from biotech crops, with no single verifiable evidence of any "damage" or negative impact on human health, this concern is fading away. However, a few points are made in here.

Biotech crops are safer than their traditional counterparts since:

- New plants developed through traditional breeding techniques may not be evaluated rigorously using risk assessment techniques whilst "specific systems have been set up for the rigorous evaluation of GM organisms and GM foods relative to both human health and the environment" (WHO).
- For example, a new celery (*Apium graveolens*) cultivar that was produced through traditional plant breeding for enhanced insect resistance contains high amounts of psoralen that was linked with significant incidences of phytophotodermatitis of grocery employees (Beier 1990).
- Another example is a new Lenape potato that had to be withdrawn from market due to its high content of solanine. This cultivar was developed using conventional breeding methods (Akeley *et al.,* 1968). It was removed from the market after finding dangerously elevated solanine content in the marketed and heavily consumed potato tubers (Zitnak and Johnston, 1970). More recently, a similar high-solanine potato variety "Magnum Bonum" was detected and withdrawn from the market in Sweden after decades of consumption by people (Hellanäs *et al.,* 1995).
- Tomatine is another glycoalkaloid that is naturally present in tomatoes. Tomatine can be produced in hazardous quantities in certain conventionally bred varieties (NRC 2004).
- Several other crops consumed as food may also contain toxins, allergens and anti-nutrients. That includes soybean and other beans (tripsin inhibitors), bamboo shoot (hydrogen cyanide), and tree nuts (allergens). These crops that are sometimes produced by organic farming and are sometimes called "natural" food are in human food basket for centuries.
- Cassava (*Manihot esculenta*) as the third-largest source of carbohydrates for meal in the world contains two cyanogenic glucosides, linamarin and lotaustralin in its root and leaves. One cow may die if it takes only 40 mg of these glucosides. Improper preparation of Cassava may lead to vomiting, paralysis and even death in few hours.
- In contrast, the newly expressed proteins in biotech crops and foods derived from these crops are safe since they are rigorously examined for their safety prior to marketing. For example crystallized proteins of *Bacillus thuringiensis* have been used for insect control during more

than the last 3 quarters of the century. These proteins are commonly referred to as *Bt* proteins or sometimes "*Bt* toxin" since they are toxic against certain insects. The *Bt* proteins of different kind have been expressed in biotech crops for enhanced insect resistance and hence reduced chemical insecticide application. *Bt* protected plants provide a safe and highly effective method of insect control. *Bt*-protected corn, cotton, and potato were introduced into the United States in 1995/1996 and are currently grown on more than 50 millions of hectares globally (Betz 2000). These proteins are practically non-toxic to human and animals. No adverse effects were observed among humans exposed orally to 1000 mg/day of *Bt* (EPA 1986). The highest dose tested was 4.7 x 1011 spores per Kg of rats with no evidence of toxicity (EPA 1986 and McClintock *et al.*, 1995). *Bt* was not acutely toxic in tests conducted on birds, dogs, guinea pigs, mice, rats, and human. No oral toxicity was found in rats, or mice fed protein crystals from *Bt*. Single oral dosages of up to 10,000 mg/kg did not produce toxicity in mice, rats, or dogs. There was no significant difference between the live animals and their weight in 42 days and 48 days feeding trial between broiler chickens fed by a transgenic *Bt* protected rice variety Tarom Molaii or its traditional non transgenic counterpart (Afraz *et al.,* 2009).

- Pesticide residue in foods derived from insect resistant biotech crops are much lower than that in foods derived from crops raised by traditional methods of insect control using toxic chemical insecticides.
- It has been shown that insect resistant biotech corn, through the pest protection that it confers, has significantly lower levels of mycotoxins: toxic and carcinogenic chemicals produced as secondary metabolites of fungi that colonize crops (Wu, 2006).
- Considering these and enormous other evidences, World Health Organization has concluded that: "GM foods currently available on the international market have passed risk assessments and are not likely to present risks for human health" (WHO).

Food Allergenicity

Food allergies are adverse reactions to specific proteins in foods generally referred to as "allergens". True food allergies may involve several types of immunological responses including allergen-specific IgE antibodies and cell-mediated reactions, which involve sensitized tissue bound lymphocytes rather than antibodies. Both IgE mediated food allergies and cell-mediated reactions are treated with specific avoidance diets. Eight most common food allergens cause more than 90 percent of all food allergenic reactions. These top eight food allergens are: milk, eggs, fish, soy, shellfish, wheat, peanuts and tree nuts (e.g. walnuts). Allergens are therefore part of the daily food consumption of human. Those who are sensitive to these allergens have to simply avoid them. Food allergens are prevalent in non GM food, but no newly expressed proteins in the foods derived from GMO that is currently available in the market are food allergen. When a crop variety is modified using transgenic approach, allergenicity of the newly expressed protein is fully examined. Care is taken not to express proteins from known allergenic source unless the protein is proven not to be allergen by itself. Reports of allergenicity of the donor organism are therefore part of the risk assessment conducted by the developer of the GM food. Amino acid sequence homology is also performed to avoid 35% or more identity of the newly expressed protein with a known allergen in a segment of 80 or more amino acids. Pepsin resistance and sometimes heat stability (e.g. in Japan) tests are conducted and immunoreactivity of proteins are evaluated after cooking. Specific serum screening methods using sera from individuals with a clinical validated allergy to the source of the protein are also used to the specific binding to IgE class antibodies of the protein in vitro assays. Finally skin test and ex vivo protocols are used to ascertain the safety of the food derived from a recombinant source prior to commercialization. These steps are not mandatory when a crop plant is developed using traditional methods of plant breeding. None of the newly expressed proteins in currently available biotech crops in the market are considered allergenic. Allergens are stable to gastric digestion and are typically prevalent in food. In contrast the newly expressed proteins in biotech cops are rapidly degraded and present at low levels in food. Table 2 shows the share (percentage) of the introduced genes in total protein in the same plant and the time required for their digestion. The selected genes/proteins represent more than 90 percent of the biotech crops in the market as of 2009. Moreover, genetic engineering can be used to reduce allergenicity of a certain food crop. Matsuda *et al.,* (1996) reported the reduction of rice allergens using genetic engineering.

Table 2. Selected proteins introduced into biotech crops, their share in total protein and their stability to gastric digestion.

Stability	% Total Protein	Trait	Gene/Protein
<30 sec	<.01	Insect resistance	*B.t.t*
30 sec	<.01	Insect resistance	*B.t.k.* HD-73
30 sec	<.01	Insect resistance	*B.t.k.* HD-1
<15 sec	<.1	Herbicide tolerance	CP4 EPSPS
<15 sec	.01	Reporter protein	GUS
<10 sec	<.01	Selectable marker	NPTII

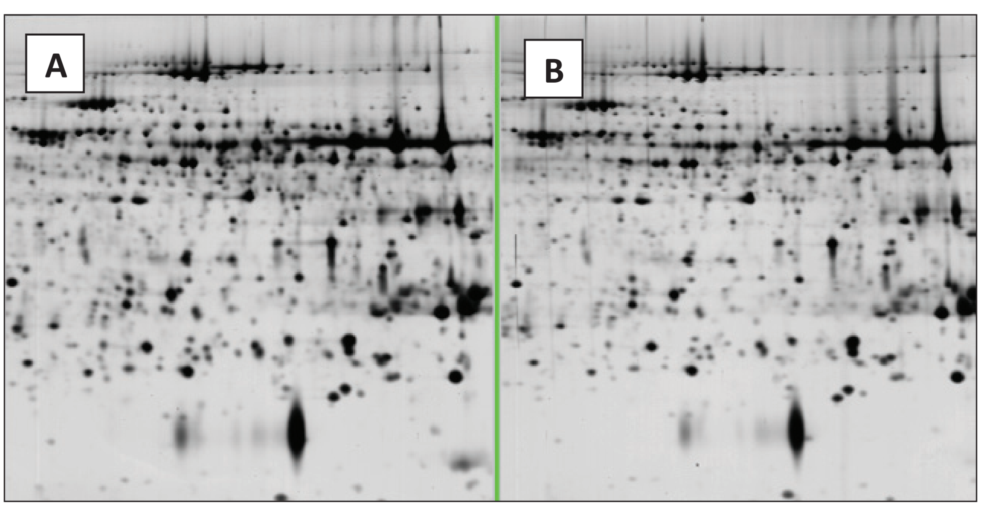
Unintended effects and their association with all plant breeding methods

One of the concerns raised about the safety of the biotech crops is the possibility that in achieving the objective of conferring a specific trait (intended effect) to a plant by the insertion of a known DNA sequence, additional traits may also be acquired or some of the existing traits may be lost or modified (unintended effects). But this is important to note that the potential occurrence of unintended effects is not restricted to biotech crops. It is an inherent and general phenomenon that can also occur in conventional plant breeding. Safety assessment of biotech crops (and not the conventionally bred crops), include data and information to reduce the possibility that a food derived from a recombinant-DNA plant would have an unexpected, adverse effect on human health (Codex Guideline Para 14). Molecular, biological and biochemical techniques can be used to analyze potential changes at the level of gene transcription and message translation that could lead to unintended effects. Several studies show that potential of occurrence of unintended effect is several folds more in conventional methods of plant breeding including mutation breeding than that expected from using transgenic approach. Batista *et al.,* (2008) evaluated the extent of transcriptome modification occurring during rice improvement through transgenesis versus mutation breeding. Using microarray analyses, they showed that plant mutagenesis may induce more transcriptomic changes than transgene insertion. Another research group working on wheat, compared the detailed gene expression profiles obtained for a series of transgenic and conventionally bred wheat lines expressing additional genes encoding high molecular weight subunits of gluten (Baudo *et al.,* 2006). Differences in endosperm and leaf transcriptome profiles between untransformed and derived transgenic lines were consistently extremely small. Differences observed in gene expression in the endosperm between conventionally bred materials were much larger in comparison to differences between transgenic and untransformed lines exhibiting the same complements of gluten subunits. They concluded that the presence of the transgenes did not significantly alter gene expression and that, at this level of investigation, transgenic plants could be considered substantially equivalent to untransformed parental lines (Baudo *et al.,* 2006). Using two dimensional gel electrophoresis no detectable difference among the number of proteins and their quantity extracted from a biotech rice cultivar Tarom Molaii expressing a Cry1Ab protein and its parental conventional wild type plant was observed (Ghareyazie *et al.,* 2005) (Fig 1). Significant number of differences was however observed in both number and quantity of the expressed proteins among different conventionally bred rice cultivars (data not shown).

Environmental impact of Biotech crops

Un-naturalness, horizontal gene transfer, effect on non target organisms, resistance generation in target organisms and the reduction in biological diversity are some of the environmental concerns raised about the ever expanding environmental release of biotech crops.

Figure 1. Two-dimensional gel electrophoresis of proteins extracted from seeds of A) transgenic rice expressing a Cry1Ab protein and B) non transgenic parental rice cultivar Tarom Molaii. Gels are silver stained.



Food crops: Natural/un-natural?

Un-naturalness is one of the intrinsic concerns about the application of genetic engineering for food production from view point of some groups of naturalists. But it is not clear what is meant by being "natural". There is no consensus in defining what is natural. Is organic farming natural? What if one uses seeds developed by traditional methods of plant breeding, tissue culture or mutational breeding? The fact is that today, almost no food is found in the market that could be defined as true natural food. Moreover, it is not clear why nature or natural products should be always considered as "good". Charles Darwin for example, viewed the works of nature as "clumsy, wasteful, blundering, low and horribly cruel". Nature carries with it a number of characteristics and not all of them need to be unequivocally good (Kaiser, 2005). Many plants we consider them as "food" are toxic and cannot be used if they are in their "natural" status. Modification is required prior to their use as food. This justifies why Almighty Allah has given human the right to make changes and use everything in the space and on the earth (Holly Quran: Jathia, 13).

Biotech crops can increase biological diversity

This is a real threat that introduction of any "good cultivar" with improved traits such as better adoptability, higher yield, improved quality and enhanced resistance against biotic and abiotic stresses may result in disappearing several other cultivars with less adoptability or other "bad traits" and/or disadvantages. However, this is not a unique phenomenon related to biotechnology only. Replacement of high yielding resistant cultivars and reduction in the diversity of available cultivars of certain crops has been the concern since the realization of modern agriculture and green revolution. As an example, in spite of the registration of thousands of rice accession in National Gene Bank of Iran under the Ministry of Agriculture, currently there are only less than 40 rice cultivars in use. The rest are sitting in the gene bank. More than 90 percent of the paddy fields in Iran are devoted to 10 cultivars only. Points however should be made in this respect.

1) Food requirement for ever increasing population should be produced using either of the two major strategies, i.e. a) production of more food from unit area or b) production of more food from more land. There is no other alternative.
2) By growing high yielding cultivars requirement for land is reduced and hence the overall biological diversity is increased.
3) Biotechnology can return those cultivars resting in gene banks and even increase biological diversity. Many cultivars are out of production cycle for having only one or few "bad" traits such as hypersensitivity to insect pests or other stresses. If that specific trait is modified, those cultivars can find their way back to the field. A good example in here is the case of insect resistant biotech rice cultivar released in Iran. Tarom Molaii is a high quality aromatic Iranian rice variety. The area under the cultivation of this variety is steadily reduced due to its sensitivity to lepidopteran insect pests including striped stem borer (*Chilo suppressalis* L.). Transferring a bacterial gene *cry1Ab* to this variety enhanced its resistance against lepidopteran insect pests (Ghareyazie et a l., 1997; Alinia *et al.*, 2001). This cultivar is again back to the field. By

backcrossing the biotech Tarom Molaii with several local cultivars such as Khazar, Nemat, Neda, Sepid Rood, Sadri and Binam, they can still continue to be grown by farmers. This is a real example of how biotechnology can increase biological diversity.

4) Reduction in the use of chemical insecticides can lead to the increased population of non target organisms living under the field condition. Although "potential negative impact of living modified organisms" on biological diversity taking also into account human health has been a subject for international debate and an obstacle for the expansion of genetic engineering in some parts of the world, in particular Europe and some developing countries, but there are increasing evidence that biotech crops have many benefits for the conservation and sustainable use of biological diversity.

Environmental benefits of the reduction in the use of environmentally dangerous insecticides and herbicides

More than 95 percent of the biotech crops available in the market as of 2009 are either insect resistant crop plants such as insect resistant cotton and maize or they are herbicide tolerant crop plants such as herbicide tolerant soy bean and sugar beet. Insect resistant biotech crops require lesser amount and number of insecticide applications. During the period, 1996 to 2008, pesticide reduction was estimated at 356 million kg of active ingredient (a.i.), a saving of 8.4% in pesticides (James 2009).

Herbicide tolerant biotech crops, on the other hand, make it possible to use more environmentally friendly, relatively inexpensive and toxicologically safe herbicides. The herbicide resistance biotech crops also allow farmers to refrain from soil eroding and soil compacting tillage (zero tillage).

For the period 1996 to 2008 economic gains of US$51.9 billion were generated from two sources: firstly, reduced production costs (50%), and secondly, substantial yield gains (50%) of 167 million tons; the latter would have required 62.6 million additional hectares had biotech crops not been deployed, hence biotech crops are an important land saving technology (James 2009). In 2008 alone, the CO2 savings from biotech crops through sequestration was 14.4 billion kg of CO2 equivalent to removing 7 million cars from the road (James 2009).

Brookes & Barfoot (2006) distilled various environmental, human and animal health impacts of individual pesticides in different GM and conventional production systems into a single 'field value per hectare' called Environmental Impact Quotient (EIQ). They showed %15.3 reduction of EIQ on cropping area devoted for GM crops.

Gene flow (Horizontal Gene Transfer)

Horizontal gene transfer is a known phenomenon occurring for millions of years. This is however a concern recently raised about the transgene transfer from a biotech crop to its non transgenic wild relatives including the weeds. It is not however scientifically justified that a transgene flow has higher risk than non-transgene flow if both confer the same trait e.g. insect resistance.

Effect on non-target organisms

In spite of the fact that currently practiced methods of application of chemical insecticides for insect pest control are not specific and therefore do not differentiate between target organisms (pests) and non target organisms (e.g. natural enemies of the pests), concerns have been raised about the negative effects of biotech crops on non target organisms. Results of experiments conducted to evaluate the effect of biotech crops on non-target organisms are of varying types: a) no negative effects (Blumberg *et al.*, 1997; Jasinski *et al.*, 2003; and Romeis *et al.*, 2004), b) positive and synergistic effects between GM plants and the natural enemies (Head *et al.*, 2005; and Johnson, 1997) and negative effects (Atwood *et al.*, 1997; and Liu *et al.*, 2005). There is however no report indicating that the application of chemical insecticides has positive, synergistic or no effect on non-target organisms. Chemical insecticides are considered toxic and have negative effects on non-target organisms including natural enemies of pests and vertebrates including human being. Effects of Bt rice on *Andrallus spinidens* and *Trichogramma brassicae* were studied in a tritrophic system (GM rice-pest-natural enemy). *A. spinidense* is one of the most important natural enemies of the rice insect pests in Iran. *T. brassicae* is a parasitoid wasp of major rice insect pests such as striped stem borer (*Chilo suppressalis*). There was no significant difference between the number of live *A. spinidens* that fed on *N. aenescens* larvae, whether fed on on non GM rice or GM rice, in spite of the poor quality of the larvae fed on GM rice (Marzban *et al.*, 2007a). In field or simulated field condition in green house, no SSB larvae was able to survive and lay egg after feeding on Bt rice and therefore no "poor quality" egg will be available to the parasitoid wasp (Marzban *et al.*, 2007b). In another experiment, mature insects of *A. spinidens* were collected randomly from replicated transgenic and non transgenic plots with or without chemical applications. Population of *A. spinidense* was significantly higher (220%) in the GM plots compared to that in the non-GM plots with chemical application and not significantly different from plots with no chemical use (Ghareyazie *et al.*, unpublished data). It is therefore concluded that replacement of Bt rice with currently practiced, insecticide based insect control measures in Iranian paddy fields will have no significant negative effect on non-target organisms and will increase the population of the natural enemies of rice insect pests.

Conclusion

Continued and significant increase in the area under the cultivation of biotech crops during the past 15 years indicates that these crops are beneficial for the farmers and the countries where they are grown. These crops are safer than their traditional non-transgenic counterparts from both food safety and environmental sustainability point of view. In spite of the fact that the traditionally produced new varieties of crop plants are not systematically subjected to extensive food safety evaluation prior to marketing, biotech crops are subject to rigorous safety assessments prior to marketing. Foods derived from biotech crops are safer for human consumption and may also be more nutritious.

Biotech crops are also more environmentally friendly compared to non biotech crops since they reduce the need for the application of chemical insecticides and harmful herbicides and increase the population of useful non-target organisms.

Islam encourages all scientific innovations for human welfare. Islam has no intrinsic concern about the application of genetic engineering as a tool for crop improvement. Extrinsically also Islam has no reservation against products of modern biotechnology unless there is a verifiable scientific evidence for significant negative effect of these products for human health or the environment. Marketed products of biotechnology are therefore considered "Halal" since there is no report of transferring genes from "Haram" source into any crop plants.

Except in a few cases, Islamic countries are lagging behind in developing, accessing and using biotechnology for food and environment in spite of heavy importation of GM products from biotech crop producing countries. This is therefore considered as "Vajib Kefaii" or "Farz-ul-Kefaya" for all Muslim scientists to take all necessary measures to facilitate the access and use of biotech crops in the Islamic world and for the whole humanity.

References

Afraz F, Ghareyazie B, Khosh Kholgh Sima N, Lotfolahian H, Hosseini SA and Nemati SA. 2009. Evaluation the effects of transgenic Bt rice on growth, viability and blood biochemical parameters of broiler chickens. Journal of Biosafety. 1:2. 9-16.

Akeley RV, Mills WR, Cunningham CE, Watts J. 1968. Lenape: A new potato variety high in solids and chipping quality. *Am Potato J* 45:142-145.

Alinia F, Ghareyazie B, Rubia LG, Bennett J, and Cohen MB. 2000. Effect of plant age, larval age, and fertilizer treatment on resistance of a Cry IA (b) transformed aromatic rice to lepidopterous stem borers and foliage feeders. Econ. J. Econ. Entomol 93(2): 484-493.

Atwood, DW, Young, SY, Kring, TJ, 1997. Development of *Cotesia marginiventris* (Hymenoptera: Braconidae) in *Heliotis virescens* (Lepidoptera: Noctuidae) larvae treated with *Bacillus thuringiensis* and Thiodicaeb. J. Econ. Entomol. 90, 751–756.

Batista R, Saibo N, Lourenco T, and Oliveira MM. 2008. Microarray analyses reveal that plant mutagenesis may induce more transcriptomic changes than transgene insertion. PNAS. 105:9. 3640–3645.

Baudo MM, Lyons R, Powers S, Pastori GM, Edwards KJ, Holdsworth MJ and Shewry PR. 2006. Transgenesis has less impact on the transcriptome of wheat grain than conventional breeding. Plant Biotechnology Journal. 4. 369-380.

Beier RC. 1990. Natural pesticides and bioactive components in food. Rev Environ Contam Toxicol. 113:47-137.

Betz FS, Hammond BG and Fuchs RL. 2000. Safety and Advantages of *Bacillus thuringiensis*-Protected Plants to Control Insect Pests. Regulatory Toxicology and Pharmacology 32, 156–173.

Blumberg D, Navon A, Keren S, Goldenberg S, & Ferkovich SM, 1997. Interactions among *Helicoverpa armigera* (Lepidoptera: Noctuidae), its larval endoparasitoid *Microplitis croceipes* (Hymenoptera: Barconidae), and *Bacillus thuringiensis*. J. Econ. Entomol. 90, 1181-1185.

Brookes G, Barfoot P (2006) GM Crops: The First Ten Years - Global Socio-Economic and Environmental Impacts. ISAAA Brief No. 36. ISAAA: Ithaca, NY.

EPA. 1986. *EPA Fact Sheet for Bacillus thuringiensis Subspecies kurstaki, israelensis, and aizawai*, September 1986 (Abbott).

FAO. 2000. FAO statement on biotechnology. http://www.fao.org/biotech/fao-statement-on-biotechnology/en/

Fedoroff, NV, Battisti DS, Beachy RN, Cooper PJ M, Fischhoff DA, Hodges CN, Knauf VC, Lobell D, Mazur BJ, Molden D, Reynolds MP, Ronald PC, Rosegrant MW, Sanchez PA, Vonshak A, and J-K Zhu. 2010. Radically Rethinking Agriculture for the 21st Century. Science 327: 833-834.

Ghareyazie B, 2009. Global Status of Biotech Crops: Islamic Perspective and Benefits to Developing Countries. Biosafety Journal, 7: 25-32.

Ghareyazie B, Alinia F, Menguito CA, Rubia LG, De Palma JM, Liwanag E A, Cohen MB, Khush GS and Bennett J. 1997. Enhanced resistance to two stemborers in an aromatic rice containing a synthetic *cry1A b* gene. Molecular Breeding 3: 401-414.

Ghareyazie B, Karimi R, Hosseini Salekdeh Gh (2005) Establishment of substantial equivalence between a transgenic rice and its traditional counterpart variety Tarom Molaii. Proteomics Congress, Germany.

Head G, Moar W, Eubanks M, Freeman B, Ruberson J, Hagerty A, and Turnipseed S 2005. A multilayer, large-scale comparison of arthropod populations on commercially managed Bt and Non-Bt cotton fields. Environmental Entomology, 34: 1257-1266.

Hellanäs KE, Branzel C, Johnsson H, Slanina P. 1995. High levels of glycoalkaloids in the established Swedish potato variety Magnum Bonum. *J Sci Food Agric* 68: 249-255.

James C. 2009. Global Status of Commercialized Biotech/GM Crops: 2009. ISAAA Brief No. 41. ISAAA, Ithaca, NY.

Jasinski JR, Eisley JB, Young CE, Kovach J and Willson H. 2003. Select non-target arthropod abundance in transgenic and non-transgenic field crops in Ohio. Environ. Entomol. 32 407–413.

Johnson, MT, 1997. Interaction of resistant plants and wasp-parasitoids of tobacco budworm (Lepidoptera: Noctuidae). Environ. Entomol. 26 : 207–214.

Kaiser M, 2005. Assessing ethics and animal welfare in animal biotechnology for farm production. Rev. sci. tech. Off. int. Epiz. 24 (1), 75-87.

Liu XX, Zhang QW, Zhao JZ, Li JC, Xu BL, Ma XM 2005. Effects of Bt transgenic cotton lines on the cotton boll-worm parasitoid *Micropilitis mediator* in the laboratory. Biological Control 35:134-141.

Marzban R, Ghareyazie B and Najafi Navaii. 2007. Impacts of a Bt Rice on *Andrallus spinidens*. 5th Iranian Biotechnology Congress, Sept. 2007a, Tehran, Iran.

Marzban R, Ghareyazie B and Najafi Navaii. Impacts of a Bt Rice on *Trichogramma brassicae*. 5th Iranian Biotechnology Congress, Sept. 2007b, Tehran, Iran.

Matsuda T, Nakase M, Adachi T, Nakamura R, Tada Y, Shimamada H, Takahashi Fujimura T. 1996. Allergenic proteins in rice: Stategies for reduction and evaluation. In: food allergies and intolerances: Symposium (Eishenbrand G, Dayan AD, Ring J, Aulepp H, Elias PS, Grunow W, Schlatter J eds) pp 161-9 VCH Weinheim.

McClintock JT, Schaffer CR, and Sjoblad RD. 1995. A comparative review of the mammalian toxicity of *Bacillus thuringiensis*-based pesticides. *Pestic. Sci.* 45, 95–105.

NRC. 2004. Safety of Genetically Engineered Foods: Approaches to Assessing Unintended Health Effects Committee on Identifying and Assessing Unintended Effects of Genetically Engineered Foods on Human Health. National Research Council. ISBN: 0-309-53194-2, 256 National Academies Press at: http://www.nap.edu/catalog/10977.html.

Romeis J, Dutton A and Bigler F. 2004. *Bacillus thuringiensis toxin* (Cry1Ab) has no direct effect on larvae of the green lacewing *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae). J. Insect. Physiol. 50: 175–183.

Sarikhan S. 2006. GMO detection in foodstuffs imported into Iran's market. MsC thesis, University of Zanjan, Zanjan, Iran.

WHO: http://www.who.inf/foodsafety/publications/biotech/20questions/en/ (accessed: 20 July, 2011).

Wu F. 2006. Mycotoxin reduction in Bt corn: Potential economic, health and regulatory impacts. Transgenic Research 15, 277-289.

Zitnak A, Johnston GR. 1970. Glycoalkaloid content of B5141-6 potatoes. *Am Potato J*, 47: 256-260.

GM Crops: The Socio-Economic Impacts

Mohammad Ali Malboobi
National Institute of Genetic Engineering and Biotechnology
P.O. Box 14155-6343, Tehran, Islamic Republic of Iran

Abstract

World population has already exceeded 6.5 billion, out of which about 850 million (13 percent) are undernourished. With the current growth rate, the world community faces even a greater challenge of hunger and food security as the estimated population will be 9 billion by the year 2050 with doubled requirements for food. At the same time, preservation of biodiversity, stopping deforestation and reduced environmental footprint caused by agricultural practices are the main concerns towards sustainable agriculture. The progressive adoption of genetically modified organisms (GMOs) including GM crops and trees can make a decisive contribution to improve harvest and alleviate hunger and poverty. In addition to the environmental benefits, the introduced GMOs can improve water use efficiency and reduce the need for fossil-based fuels and pesticide application and reduce thousands of tons of emissions of green house gases.

However, several social issues are still of concern. On one hand, many beneficial advantages of GMOs have encouraged a wide spectrum of large or small farmers to cultivate transgenic plants which is translated to food security and job opportunities. On the other hand, while ideological debates have hindered, or even ceased, technology provisions in developing countries, and GMO seed and food production are monopolized by a small number of transnational companies. For instance, seeds that were previously available at low or no cost, mainly through public institutes, international entities or seed exchange among farmers, would be offered at higher prices due to exclusive right of producers and additional cost of patent royalties.

Although the developing countries outnumbered developed nations in recent years, current statistic shows that around 84 percent of GMO crops are cultivated by only four countries, USA, Brazil, Argentina and Canada. Scientists and scholars, particularly in Islamic states, as well as decision makers are the major responsible bodies that must take roles for the current and future situations. They can discuss socio-economic issues and raise public awareness in order to harmonize their efforts towards proper utilization of biotech products in their society and towards a reliable point for food security and safety.

Introduction

Socio-economic (SE) and cultural considerations related to the use and release of genetically modified organisms (GMOs) have received more attention in recent years. Challenges based on possible health and environmental risk are fading out by massive experimental data as well as 15 years of consuming hundreds of tons of commercialized products containing GMOs and/or derived from GMOs with no verifiable negative report on human health. Now, new trends of old disputes are rationalized by showing SE impacts of any new technology can take several years when it has already become widespread and, in most cases, become deeply institutionalized. Therefore, it is argued that "even when the technology is withdrawn or people totally discontinue adopting the technology, its SE impacts may persist and leave a permanent imprint in society" (Dano, 2007).

SE concerns in Biotechnology takes into account a broad spectrum of aspects about the actual and potential consequences of biotechnology, such as impacts on farmers' incomes and welfare, cultural practices, community well-being, traditional crops and varieties, domestic science and technology, rural employment, trade and competition, the role of transnational corporations, indigenous peoples' rights, food security, ethics and religion, consumer benefits, and ideas about agriculture, technology and society (Garforth/WRI, 2004).

In this paper, I have attempted to bring up some possible SE aspects of GM crops and their extensions in the human livelihood. Of course, this issue highly depends on differences among societies with respect to culture, religion, social behavior and economic status as well as approach to food security and/or food safety.

Facts and realities

At present time, around 7000 species are cultivated as crops and trees by human beings. However, only 30 percent of these species constitute 90 percent of food. Green revolution in the sixties doubled food production with the use of high-yield varieties, chemical fertilizers and pesticide and mechanization. Despite this breakthrough, the number of undernourished people remained over 800 millions, reaching 900 millions in 2008 (Fig. 1). According to 2007 statistic, 835 million (98.6 percent) of the total of 847 million world undernourished population lived in the developing countries (Table 1). Based on an estimation given in the latest FAO report (2010), food production must be doubled by the year 2050 to meet the needs of an expected world population of 9.2 billion. Genetic uniformity, massive loss of topsoil, soil and water pollution by agrochemicals, and deforestation are the main problems to be pointed out as a result of mass cultivations.

Progressive utilization of GM crops

Following the Green Revolution, two major methods of genetic modifications were persuaded for

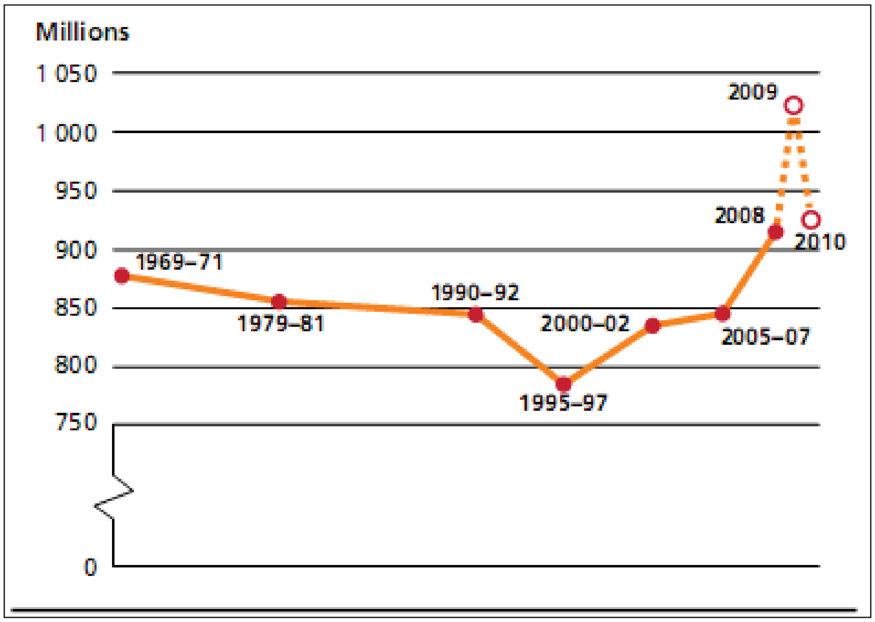


Figure 1. **Number of undernourished people in the world since 1969. Figures for years 2009 and 2010 are estimations (Source: FAO, 2010)**

Table 1. The distribution of undernourished people per population in the developing and developed countries (Source: FAO, 2010)

	Total population (2007)	Number of undernourished people	Undernourished per population (percent)
World	6,559.3	847.5	12.9
Developed countries	1,275.6	12.3	0.96
Developing countries	5,238.7	835.2	15.8

improvement of desired traits in crop plants for years: a) Collection of mutants introduced by radiation or active chemical materials; and, b) continued conventional plant breeding approach. However, the gained increase in the yield was very little and there was no success in improving some desired traits due to the limited gene pool. Therefore, there has been a great acceptance for GM crops produced through transfer of beneficial genes without gross differences with their corresponding traditional counterpart such as the parental plants. Having commercialized GM crops in six countries that cultivated 2.5 million hectare in 1996, progressive adoption reached 25 countries with 137 million hectare in the year 2009 (James, 2010). As such, about 55-fold increase in cultivated lands within 14 years made it one of the fastest adopted crop technology in recent history. The new technology has granted significant economic, environmental, health and social benefits to both small and large farmers in developing and industrial countries. Such that in the 15th year of GM crop commercialization, we witnessed increases in both the number of countries and farmers planting biotech crops globally plus adoption of stacked traits in newly produced biotech crop. It is noteworthy that the generated GM food products are consumed by almost all countries at present time.

SE concerns about GMOs at international arena

Owing to the strong lobby by activists particularly in the African countries, Cartagena Protocol has acknowledged that SE considerations for living modified organisms (LMOs) may also be taken into account during decision making for accepting a particular LMO. Based on Article 26 of Cartagena Protocol, "the parties may take into account, consistent with their international obligations, SE considerations arising from the impact of LMOs on the conservation and sustainable use of biological diversity, especially with regard to the value of biological diversity to indigenous and local communities. The parties are encouraged to cooperate on research and information exchange on any SE impacts of LMOs, especially on indigenous and local communities". Nevertheless, the pertinent decisions are all at recommendation or forum levels aiming at development of guidance documents to assist the parties in dealing with SE considerations.

GMOs are acceptable or not?

To be clear about what is argued by some social activists against GMOs as "contaminants" to the environment, it is a matter of what we compare them with. For instance, insect resistant GM crops expressing Cry proteins, known as Bt proteins, must be compared with the traditional method of insecticide-based pest control measures and the amounts of pesticides added to the soil, water and food products. One might claim that the fixed amounts of used chemical toxic compounds remain constant or even reduced by decomposition whereas transgenes are propagated thoroughly. We should not neglect the fact that the use of chemical toxin induces a strong selection force for or against certain genotypes of the target organism and non-target organisms, including microbial flora.

In fact, the improved products of biotechnology, GM crops in particular, are going to provide solutions for the food security versus food safety dilemma. This is because both increased yield and quality of the harvested products could be engineered deliberately. In this respect, several direct and indirect benefits of biotech crops as listed below:

1. Improving the nutritional quality of foods, e.g. golden rice containing pro-vitamin A;
2. Reducing the presence of toxic compound, e.g. cassava with less cyanide;
3. Reducing allergens in certain foods, e.g. groundnuts.
4. Reduced pesticide use, e.g. Bt crops;
5. Lower occurrence of mycotoxins (produced through fungal infections);
6. Increased availability of affordable food;
7. Reduced needed fossil fuels to disperse pesticides and so on;
8. Decreased emissions of green-house gases;
9. Reduced the accumulation of toxic compounds in soil and water.

Economic concerns

GMOs, GM crops in particular, have formed a major trend in a bio-based economy in the last decade and the coming years. Collectively, GM crops contributed US$60 billion during the period 1996-2009 due to substantial yield gains and reduction in production costs. Only in 2009, 29.6 million tons of GMO foods were produced by 14 million farmers. This is translated to added value of $9.2 billion globally, out of which $4.7 billion is the share of developing countries (James, 2010).

As a detailed case, the impacts of Bt corn on corn borer suppression was studied in a long term course (Hutchison et al, 2010). *Ostrinia nubilalis* insect readily disperses among farms at a distance of at least 800 m and colonizes over 200 host plants throughout their lifetime. There have been surges of the insect every 4 to 6 years as recorded since 1962. However, there was no such notable raise since the use of Bt corn during the period of 1996 to 2010. In addition, there has been at least 50 percent reduction in consumption of insecticides. As a result, US$4.3 billion of direct benefits plus $1.7 billion of indirect benefits were gained in 2009 because of *O. nubilalis* population suppression in 18.7 million hectare of corns in USA.

In another case study, Rao and Dev (2009) showed that the averaged cotton yields increased from 183 to 270 kg per hectare between 1996 to 2002 (before Bt-cotton adoption) to 306 to 470 kg per hectare between 2003 to 2008 (after Bt cotton adoption) in India. Considering both the reduced pesticide cost and elevated yield benefit, the average net income of cotton farmers (cumulative Bt and conventional cottons) increased three times. The interesting point was that both poor and non-poor farmers were benefited from Bt cotton adoption, although the extremely poor had lower earnings (Fig. 2).

Job analysis

The majority of farmers (over 11 millions) growing biotech crops are small-holder, poor farmers, mostly residing in developing countries (James, 2010). While the higher earning directly leads to job creation, however, GM crops affect the occupation level, particularly in developing countries where resistance against technology adoption is prominent. There are some obvious examples of GM crops challenging jobs in developing world. Growing rapeseed plants engineered to produce lauric acid (used in soaps and cosmetics) threaten 30 percent of jobs in the Philippines. New types of sweeteners, such as thaumatin, a protein derived from an African plant, which is 3000 time as sweet as sucrose, jeopardizes sugar beet and sugar cane cultivating farmers and sugar producing industries. It was even more alarming from a job point of view when a US Biotech company claimed it could produce thaumatin protein using recombinant DNA and fermentation technologies. These extreme examples evidently show that the developing countries can not step aside and watch the waves of technologies affecting people. As these countries accommodate the most of needy people, they are highly affected.

In developing countries, the problem must be considered from several points of views:

1. Historically, a strong resistance against new technologies are being imposed by state bodies that govern these nations.

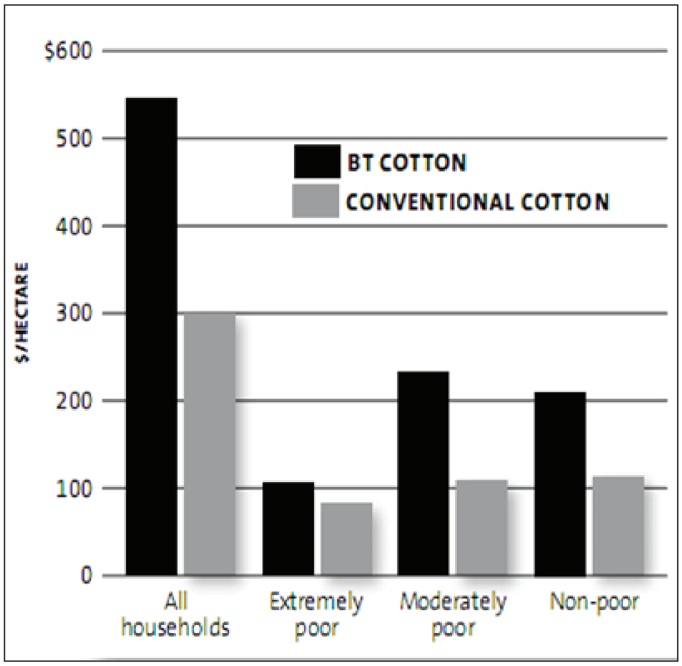


Figure 2. Comparing the net income of farmers cultivating Bt or conventional cotton. The increased incomes of the extremely poor, poor and non-poor farmers are also shown (Source: Rao and Dev, 2009).

2. These countries are mostly dependent on technologies transferred from developed countries which increase the cost of seeds, at least for the patent royalties.
3. By nature, GM crops are introduced by private sectors that are not strong enough in developing countries to compete with giant transnational companies.
4. Developed varieties via classic breeding were available though governmental and international agencies at nil prices while GM seeds are developed by private transnational companies.
5. The inability of developing countries to compete in the international market might threaten the job opportunities even within their own market. At present time, the lower costs of imported food products have already out-competed several domestic agricultural products. It would be harder for exportation. With stringent sanitary measures imposed internationally on exchanged food products, the better quality of GMO products in compare to conventional crops containing pesticides is alarming for competitive export market.

According to the recent statistics, around 84 percent of GMO crops are cultivated by only four countries, USA, Brazil, Argentina and Canada. Those developing countries (e.g. Brazil, India, China and Argentina) that were pioneers to explore GM crops benefitted remarkably (James, 2010). For example, cultivation of transgenic soybean has produced around one million jobs in Argentina from 1996 to 2005 which is about 36 percent of total created jobs during this period (Trigo and Cap, 2006).

Cost aspects

Seventy five percent of all poor people in the world are small farmers residing in developing countries. Despite the increased rice and corn production, Green Revolution imposed income inequality and wealth distribution in the rural areas in the past (Conway, 2003). It made poor farmers to become heavily dependent on the elite people who had better control over the new tools and technologies.

At present time, GM crops need lesser inputs (except for seeds, see below) and produce higher yield. Therefore, the products are sold at lower price making them affordable for larger markets. This is the good scenario for the big farmers while the small ones are affected differently. Companies that develop GMO products are determined to recover their investments on research and development through the intellectual property rights (IPR) system and marketing schemes. As a result, GM seeds are generally sold at a higher price to all farmers, no matter rich or poor. This is not in harmony with the traditional practice of farmers in saving, reusing, sharing, exchanging and selling farm-saved seeds. It must be noted that the traditional seed saving practices of farmers are widely regarded as the foundation of the immense genetic diversity in agriculture. Thus, any developments that limit this practice, such as the stringent application of the IPR on seeds, potentially threaten the preservation of crop biodiversity.

Indeed, the issue of IPR has received extensive attention and has been the subject of intense debates. The impacts of IPRs on public access to knowledge and technological innovations are far-reaching, especially in developing and underdeveloped countries. In addition, proprietary controls over useful technologies severely limit the access of the poor, under-developed or sanctioned countries, making undesired SE gaps among human communities.

Another important issue is that GM crops produced for the developed countries may not fulfill the needs in other regions as the situation is different in many developing countries. In the former, the expense and availability of labor are major production costs, while in the latter labors are abundant and often cheap. Therefore, GM crops like herbicide-resistant ones might be beneficial in the developed countries while it adds up the cost of GM seeds plus herbicide compounds for farmers in the other regions. Therefore, every country must be seriously involved in developing their own GM crops or be very selective to choose among them considering regional SE aspects.

Environmental and biodiversity aspects

Conserving biodiversity has been a great concern as experienced during the Green Revolution. Superiority of the seeds directs farmers toward monocropping leading to genetic uniformity and loss of endogenous germplasm, no matter if crops are produced through conventional breeding or genetic engineering. According to a FAO report in 1996, genetic erosion has already occurred in 154 countries where the replacements of local varieties were the main cause in over 80 of them. The proposed solution for this problem is to have as many as varieties carrying transgenes through conventional breeding.

As mentioned above, reduced chemical toxin usage is important to keep the distribution of non-target organism safe as deliberately engineered GM crops have specific pests targeted. In addition, the higher yield of GM crops means saving millions of hectare of natural forests and ranches away from being cultivated.

Social conflicts

Throughout the history, technological and scientific innovations have greatly impacted SE relations within and among communities directly and indirectly. The introduction of mechanized farming during the Green Revolution that increased the inequity between small-scale and large-scale farm communities is a known example of indirect impact of new technologies (Conway, 2003)

As an example of current direct conflicts, for unknown reasons, organic certification standards generally do not allow GMO content. Agricultural products containing even small traces of GMOs do not merit the organic label. In countries where GMOs are already legally commercialized, organic agriculture certification may be in trouble. This has been a controversial issue in the US and Canada where some organic farmers have filed legal suits demanding damages (Nature Biotechnology, 2002). Such a situation is expected to be much more complicated in most developing countries where landholdings are much smaller and distances between farms are much shorter. This problem necessitates establishment of regional policies to pave the way.

Freedom of choice

Freedom of choice is applicable to all food and agricultural products in general. However, as certification for labeling include several additional expenses such as isolation in field, separation in storage and shipping as well as the cost of analysis, the extra costs must be born by the end consumer. As a result, the needs for labeling become highly controversial in the case of GMOs. A declared meaningful label, instead of a certified one, may be more acceptable for all societies while a product with higher price would be primarily intended for markets that can afford them. Otherwise, GMOs could be channeled to markets with less capacity to pay or where such labeling is not legally required.

Cultural and religious concerns

Culture, ethics and religion are the major concerns in defining the way technologies are introduced and disseminated in any given society, particularly in countries where religion remains a strong societal force. For instance, in Islamic states debates on if GMO products are halal or haram sets their acceptability among Muslims. Such concerns must be deliberately resolved by dialogues among scholar and scientists considering culture, ethics, religion and social behavior in their society. Otherwise, false statement may obscure the reality and true verdicts.

Bodies involved in biotechnology implementation

When it comes to SE concerns of biotechnology products, not only scientists and scholars, but also national policy and decision makers have to take responsibility. However, a disturbing fact is that even the scientists who moved biotechnology forward, are not in a position to determine the route they are taking. To this, we may add exogenous influences, particularly by transnational companies, many of which have invested billions of dollars influencing the type and extend of research projects in universities and research institutes worldwide. With respect to profit-seeking nature of private companies, this contradicts with socialist approach of developing countries suffering from lower public awareness. Adopting appropriate legislation and policies could regulate the social behavior of stakeholders in this respect.

Scientists who develop and introduce technology into any society need to bear the moral and ethical responsibility for the impacts that their innovation may have on society. They are also required to ensure social acceptance and public awareness when GMOs are introduced in any given societal context.

Conclusions

Modern biotechnology can make decisive contributions to sustainable development in several ways to alleviate poverty and hunger, improve food security, reduce environmental damages and preserve endogenous genetic resources. Neglecting GMOs may lead to social crises due to higher food cost, job losses, higher farming expenditure, lower productivity, food insecurity, and economical and thus political dependency. Developing countries, including Islamic states, need to speed up the adoption of this technology more progressively while observing and managing social, religious and cultural concerns. These could be done through the following recommendations:

1) Define national goals and strategies,
2) Form proper structure for sharing resources,
3) Build up capacity by educating and training of required personnel,
4) Smoothen scientific collaborations,
5) Provide legislative and governmental support,
6) Raise public awareness,
7) Address sharia concerns consciously.
8) Allow transparency and public access to information

References

1. FAO report (1996) PR 96/9 - State of the world’s plant genetic resources. http://www.fao.org/WAICENT/OIS/PRESS_NE/PRESSENG/H8F.HTM
2. James C., 2010 Global Status of Commercialized Biotech/GM Crops: 2009 -The first fourteen years, 1996 to 2009. http://www.isaaa.org/resources/publications/briefs/41/default.asp

3. FAO (2010) The state of food insecurity in the world. ISBN 978-92-5-106610-2.
4. Elenita C. Daño (2007) Potential Socio-Economic, Cultural and Ethical Impacts of GMOs: Prospects for SE Impact Assessment. In Biosafety First – Holistic Approaches to Risk and Uncertainty in Genetic Engineering and Genetically Modified Organisms. Terje Traavik and Lim Li Ching (Eds.),Third World Network, Tapir Academic Press, Trondheim, ISBN: 9788251921138.
5. Hutchison et al (2010) Areawide Suppression of European Corn Borer with Bt Maize Reaps Savings to Non-Bt Maize Growers. Science 330: 222.
6. Chandrasekhara Rao and Mahendra Dev (2009) Agricultural Economics Research Review 22: 461-470.
7. Trigo EJ and Cap EJ (2006) Ten years of genetically modified crops in Argentine agriculture. ArgenBio report.
8. Conway, G. (2003). From the Green Revolution to the Biotechnology Revolution: Food for Poor People in the 21st Century, Woodrow Wilson International Center for Scholars Directors' Forum, March12.
9. Nature Biotechnology (2002). Organic Farmers Sue GMO Producers.
10. Paris, Thelma R. (1998). "Technology and Policy Needs of Poor Women in Asian Rice Farming", Gender, Technology and Development 2: 187-218.
11. Garforth, K. (2004). SE Considerations in Biosafety Decision-Making: An International Sustainable Development Law Perspective. CISDL Working Paper prepared for the World Conservation Union – International Development Research Center Meeting on Biosafety, Colombo, Sri Lanka. October 12-14.

Workshop Resolutions and Recommendations

International Workshop for Islamic Scholars and Experts of Modern Biotechnology

1-2 December, 2010
Penang, Malaysia

The world population has almost tripled since 1960 and the percentage of undernourished people has also increased steadily. Besides being net importers of food and agricultural products, Muslim countries [members of the Organization of the Islamic Conference (OIC)] are mostly least developed countries, characterized by rampant hunger and extreme poverty whereby close to 2.7 billion poor people spend 80% of their income on food. Food availability and accessibility for the Muslims should therefore be addressed to identify strategies to solve this problem in the midst of increased population, food and energy demand, decreasing food production resources and climate change.

Crops developed through modern methods of plant breeding termed as biotechnology (biotech) or genetically modified (GM) crops such as soybean, corn, canola and cotton with improved quality and quantity traits available in the market (biotic stress and herbicide tolerance) have been accepted and being cultivated globally in 25 countries (in 2009) and are being used as food and feed in a majority of other countries. The efforts for improvement of crop plants with tolerance to abiotic stresses such as drought and salinity (which are more relevant to the needs of OIC countries) are also ongoing. Records show that almost all members of the OIC have been importing these commodities from the large GM crop producing countries. In continuing promotion of global acceptance of biotech crops, OIC Members and Islamic scholars should be aware of genetic modification, GM crops and their benefits to accept the biotech agricultural products as Halal for the society.

With a focus on alleviating the existing food problems and poverty, the International Workshop of Islamic Scholars and Experts in Modern Biotechnolgy on “Agri-biotechnology: Shariah Compliance” held in Penang, Malaysia on 1-2 December 2010, agreed upon the following resolutions:

1. Islam and science are complementary and Islam supports beneficial scientific innovations for mankind. Modern biotechnology and genetic engineering are important developments that merit promotion in all OIC Members. Regulatory measures should facilitate the acceptance and use of GM products particularly by Muslims. Genetic modification and GM products are

Halal as long as the sources from which they originate are Halal. The only Haram cases are limited to products derived from Haram origin retaining their original characteristics that are not substantially changed.

2. Modern biotechnology and genetic engineering are methods of plant improvement and intrinsically are not different from other plant improvement techniques from the shariah point of view.

3. In ensuring food security, our Islamic obligations require us to urge all Muslim countries, governments, international organizations and research institutions, to support research and development and use of modern biotechnology, genetic engineering and their products.

4. Because of their positive impacts on agriculture and the urgency of food security for Muslim Ummah, promotion of modern biotechnology and genetic engineering are considered "Fardhu Kifayah" (collective obligation) and should not be neglected from the shariah point of view.

5. Public awareness and education on modern biotechnology and genetic engineering, demand continuous interaction between the Islamic scholars, scientists and the general public.

6. Transparent and complete scientific information should be available for the interested stakeholders for informed decision making.

International Workshop for Islamic Scholars
"Agribiotechnology: *Shariah* Compliance"

1-2 Dec 2010

Hotel Royal Penang (formerly Sheraton)
Georgetown, Penang, Malaysia

PROGRAM

Day 1: 1 Dec 2010 (Wednesday)

9.00am:	**Welcome and opening remarks by Darhim Hashim (IHIA)**
Session 1:	**Principles of Shariah (Chaired by Dr. Hashim Kamali, Afghanistan)**
9.15 am:	Talk 1: Principles of Shariah (Dr. Fahad Alkhodairy, Fiqh Council, Riyadh)
9.45 am:	Talk 2: Halal Concept (Dr. Hujat ul Islam Maboobi, Iran)
10.15 am:	Open Forum for discussion
10.45 am:	Tea break
Session 2:	**Agribiotechnology: Safety Issues (Chair: Dr Umi Kalsom Abu Bakar, MARDI)**
11.15 am:	Talk 3: The science of GM technology in agriculture (Prof. Wayne Parrot, University of Georgia)
11.45 am:	Talk 4: GM crops: Food and environmental safety (Dr. Behzad Ghareyazie, Iran)
12.45 pm:	Open Forum for discussion
1.15 pm:	Lunch/prayers
Session 3:	**Agribiotechnology: Benefits and Impact (Chair: Dr. Hisham El-Shishtawy)**
2.30 pm:	Talk 6: GM crops: The socioeconomic impact (Dr. Mohammad Ali Malboobi, Iran)
3.30 pm:	Open Forum for discussion
4.30 pm:	Tea break and end of Day 1
7.30 pm:	**Workshop Dinner**

Day 2: 2 Dec 2010 (Thursday)

Session 4: Agribiotechnology in OIC countries (Chair: Dr. Behzad Ghareyazie)

9.00 am: Talk 8: Applications of GM technology in agriculture in OIC countries (Prof. Wayne Parrot, University of Georgia)

9.30 am: Talk 9: GM Crops/foods: The benefits to the Ummah (Dr. Hisham El-Shishtawy)

10.00 am: Open Forum for discussion

10.30 am: Tea break

Session 5: Development of Resolution : Chaired by Mariam Abd Latif, MOH and Darhim Hashim, IHIA

11.00 am: Panel discussion

12.30 pm: Lunch/prayers

2.00 pm: Adoption of resolution/statement

3.30 pm: Tea and End of workshop

International Workshop for Islamic Scholars
"Agribiotechnology: *Shariah* Compliance"

1-2 Dec 2010

Hotel Royal Penang (formerly Sheraton)
Georgetown, Penang, Malaysia

LIST OF PARTICIPANTS

Afghanistan

1. Dr. Hashim Kamali
Senior Fellow
Afghanistan Academy of Sciences
Email: hkamali19@gmail.com

Egypt

2. Dr. Hisham El-Shishtawy
Secretariat of the National biosafety
Committee Agricultural Genetic Engineering
Research Institute (AGERI),
Agriculture Research Center (ARC),
Ministry of Agriculture & Land Reclamation
(MoLAR)
Egypt
Email: h.elshishtawy@gmail.com

3. Prof. Ghareeb Gad ElKareem
Prof. of Genetics and Biotechnology
Agricultural Genetic Engineering Research
Institute agricultural Research Center
9 Gamaa Street
Giza12619, Egypt

Indonesia

4. Prof. Dr. Umar Anggara Jenie
Lembaga Ilmu Pengetahuan Indonesia (LIPI)
Kantor Pusat, Sasana Widya Sarwono
Lt. II, Jl. Gatot Subroto 10 Jakarta 12710
Indonesia
Email: umar.anggara.jenie@mail.lipi.go.id

5. Dr. Suranto Human
Lecturer
Faculty of Science and Technology, State
Moslem University
Jl Haji Muchtar No 8, RT 01/01 Cinangka,
Sawangan 16516
Indonesia
Email: soeranto@batan.go.id

6. Ir. Adhi Siswaya Lukman
Chairman, Association of Indonesian Food
and Beverages (GAPPMI- Gabungan Asosiasi
Pengusaha Makanan dan Minuman Indonesia)
Kantor Pusat Departemen Pertanian,
Gedung F lt.2 R224-A. Jalan Harsono RM no 3.
Ragunan. Pasar Minggu,
Jakarta 12550
Email: adhi_s_lukman@yahoo.com.sg

Iran

7. Dr. Behzad Ghareyazie
Head
New Technologies Division
Iran's Centre for Strategis Research
Tehran, Iran
Email: ghareyazie@yahoo.com

8. Dr. Mohammad Ali Malboobi
Department of Plant Biotechnology
Natural Institute of Genetic Engineering &
Biotechnology
Iran, Tehran
Email: malboobi@nigeb.ac.ir

9. Mohammad Taghy Malboobi
Hujat ul Islam
Iran
Email: mtm4044@yahoo.com

Malaysia

10. Lokman Ab Rahman
Director
Islamic Development Department of Malaysia
JAKIM
Email: lokman@islam.gov.my

11. Dr. Umi Kalsom Abu Bakar
Director
Biotechnology Research Division
Malaysian Agricultural Research &
Development Institute (MARDI)
Email: uab@mardi.gov.my

12. Adrian Abdul Ghani
Vice President, Legal and Regulatory
Malaysian Biotechnology Corporation
Email: Adrian.abdghani@biotechcorp.com.my

13. Mariam Abdul Latif
Ministry of Health
Email: mariam.alatif@gmail.com

14. David W Cottrell
Agricultural Attaché
Embassy of the United States of America
Malaysia, Singapore and Brunei
E-mail: david.cottrell@usda.gov

15. Raymond Hoh Tuck Youen
Agriculture Specialist
Embassy of the United States of America
Email: Raymond.hoh@fas.usda.gov

Philippines

16. Dr. Mariechel Navarro
Manager
International Service for the Acquisition of
Agribiotech Applications (ISAAA)
Email: M.Navarro@cgiar.org

17. Dr. Abdulhadi T. Daguiit
Assistant Professor
University of the Philippines
Institute of Islamic Studies
Diliman, Quezon City
And Vice Chairman, National Halal
Accreditation Board of the Philippines, Inc.
Email: daguiit11@hotmail.com

Saudi Arabia

18. Dr. Fahad Al-Khodairy
Fiqh Council
Riyadh, Saudi Arab
Email: alkhodairy63@hotmail.com

USA

19. Prof. Dr. Wayne Parrott
Professor
Department of Crop and Soil Sciences
University of Georgia
Athens, USA
Email: wparrott@uga.edu

Organisers:

Mahaletchumy Arujanan
Executive Director
Malaysian Biotechnology Information Centre (MABIC)
Email: maha@bic.org.my

Thinakaran Chandran
Publication Officer, MABIC
Email: thinakaran@bic.org.my

Nicholas Boo Tzyy Guang
MABIC
Email: nicholas@bic.org.my

Darhim Hashim
Executive Director
International Halal Integrity Alliance (IHIA)
Email: darhim@ihialliance.org

ISBN 978-967-11160-0-5

9 789671 116005