Chapter 1:

Introduction
1.1 Islamic Republic of IRAN

According World Bank database IRAN is the 18\textsuperscript{th} largest country in the world after Libya and before Mongolia. Its area roughly equals that of the United Kingdom, France, Spain, and Germany combined. In terms of area it is 1,648,195 km\(^2\), 0.7\% of which is water, It has a population of over seventy million (70,472,846) with density of about 42/km\(^2\). Tehran is the capital, largest city and the political, cultural, commercial, and industrial center of the nation (World bank 2009).

1.1.1 Economy of IRAN

Economy of Iran is a mixture of central planning, Public ownership of oil and other large enterprises, village agriculture, and small-scale private trading and service ventures. Its economic infrastructure has been improving steadily over the past two decades but continues to be affected by inflation and unemployment. The economic indicators for IRAN are listed below;

- Total GDP(PPP) (2010 estimated) = $863.5 billion (18\textsuperscript{th} rank in the world)
- Per capita GDP(PPP) (2010 estimated) = $11200 (87\textsuperscript{st} rank in the world) (CIA, 2011)
- Human development index (HDI) = 0.759 (medium) (94th) and ranking of the country is 16\textsuperscript{th} among 177 developing countries of the world (Tehran Times, 2011).
According to World Bank report (2008), in the early 21st century the service sector contributed the largest percentage of the GDP, followed by industry (mining and manufacturing) and agriculture. In 2006, about 45% of the government's budget came from oil and natural gas revenues, and 31% came from taxes and fees. Government spending contributed to an average annual inflation rate of 14% in the period 2000–2004. IRAN has earned $70 billion in foreign exchange reserves mostly (80%) from crude oil exports (2007). In 2007, the GDP was estimated at $206 billion ($852 billion at PPP), or $3,160 per capita ($12,300 at PPP). IRAN's official annual growth rate is at 6%. Because of these figures and the country’s diversified but small industrial base, the United Nations Organization classifies IRAN’s economy as semi-developed.

The services sector has seen the greatest long-term growth in terms of its share of GDP, but the sector remains volatile. State investment has boosted agriculture with the liberalization of production and the improvement of packaging and marketing helping to develop new export markets. Thanks to the construction of many dams throughout the country in recent years, large-scale irrigation schemes, and the wider production of export-based agricultural items like dates, flowers, and pistachios, produced the fastest economic growth of any sector in IRAN during the 1990s (UNIDO, 2009).

Roughly one-third of IRAN's total surface area is suited for farmland, but because of poor soil and lack of adequate water distribution in many areas, most of it is not under cultivation. Only 12% of the total land area is under cultivation but less than one-third of the cultivated area is irrigated; the rest is devoted to dry farming. One third of the total farmland area (35%) is used for grazing and small fodder production. Most of the grazing is done on mostly semi-dry rangeland in mountain areas and on areas surrounding the large deserts of Central IRAN. (The ministry of Jehad-e-Agriculture 2009)

In data base of UNIDO (2009) about Iran’s agriculture is written that at the end of the 20th century, agricultural activities accounted for about one-fifth of
IRAN's gross domestic product (GDP) and employed a comparable proportion of the workforce. Most farms are small, less than 25 acres (10 hectares), and thus are not economically viable, which has contributed to the wide-scale migration to cities. In addition to water scarcity and areas of poor soil, seed is of low quality and farming techniques are antiquated.

All these factors have contributed to low crop yields and poverty in rural areas. Further, after the 1979 revolution many agricultural workers claimed ownership rights and forcibly occupied large, privately owned farms where they had been employed. The legal disputes that arose from this situation remained unresolved through the 1980s, and many owners put off making large capital investments that would have improved farm productivity, further deteriorating production. Progressive government efforts and incentives during the 1990s, however, improved agricultural productivity marginally, helping IRAN toward its goal of reestablishing national self-sufficiency in food production.

1.1.2 Agriculture in IRAN

As defined by FAO agriculture in Iran can be divided in following sub titles:

- Crops & Plants

The wide range of temperature fluctuation in different parts of the country and the multiplicity of climatic zones make it possible to cultivate a diverse variety of crops, including cereals (wheat, barley, rice, and maize (corn)), fruits (figs, pomegranates, melons, and grapes), vegetables, cotton, sugar beets and sugarcane, pistachios (World's largest producer with 40% of the world's output in 2005), nuts, olives, spices e.g. saffron (World's largest producer with 81% of the world's total output), tea, tobacco, and medicinal herbs. More than 2,000 plant species are grown in IRAN; only 100 of which are being used in
pharmaceutical industries. The land covered by IRAN’s natural flora is four times that of the Europe’s.

- **Forestry**

IRAN's forests cover approximately the same amount of land as its agricultural crops—about one-ninth of its total surface area. The largest and most valuable woodland areas are in the Caspian region and the northern slopes of the Elburz Mts.; where many of the forests are commercially exploitable and include both hardwoods and softwoods. Forest products include plywood, fiberboard, and lumber for the construction and furniture industries. The cutting of trees is rigidly controlled by the government, which also has a reforestation program.

- **Fishing**

Fishing is also important, and IRAN harvests fish both for domestic consumption and for export, marketing their products fresh, salted, smoked, or canned. Sturgeon (yielding its roe for caviar), bream, whitefish, salmon, mullet, carp, catfish, perch, and roach are caught in the Caspian Sea, IRAN's most important fishery. More than 200 species of fish are found in the Persian Gulf, 150 of which are edible, including shrimps and prawns.

- **Livestock**

Of the country's livestock, sheep are by far the most numerous, followed by goats, cattle, donkeys, horses, water buffalo, and mules. The raising of poultry for eggs and meat is prevalent, and camels are still raised and bred for use in transport. IRAN has also a large dairy industry and imported close to two million tons of feed grain annually in 2006. The raising of swine is forbidden in IRAN due to Islamic law. (FAO country profiles 2009)
1.1.3 Role of Agriculture in IRAN’s Economy

According to website of Ministry of Jehad-e-Agriculture in Iran Since 1979 commercial farming has replaced subsistence farming as the dominant mode of agricultural production. Some northern and western areas support rain-fed agriculture, while other areas require irrigation for successful crop production. Wheat, rice, and barley are the country’s major crops.

Overall, the soil is not well suited for large scale agriculture. About 11-12 percent of the country's total land area of 1,636,000 km² is cultivated. Still, 63% of the cultivable lands have not been used, and 185,000 km² of the present farms are being used with 50 to 60% capacity. (The Ministry of Jehad-e-Agriculture 2009)

After achieving agricultural self-sufficiency in the 1960s, IRAN reached the point in 1979 where 65 percent of its food had to be imported. Declining productivity was blamed on the use of modern fertilizers, which had inadvertently scorched the thin Iranian soil. Unresolved land reform issues, a lack of economic incentives to raise surplus crops, and low profit ratios combined to drive increasingly large segments of the farm population into urban areas. (Ilias, 2008)

The 1979 revolution sought self-sufficiency in foodstuffs as part of its overall goal of decreased economic dependence on the West. Higher government subsidies for grain and other staples and expanded short-term credit and tax exemptions for farmers complying with government quotas were intended by the new regime to promote self-sufficiency. But by early 1987, IRAN was actually more dependent on agricultural imports than in the 1970s (Agriculture in Iran, 2009).

By 1997, the gross value of products in IRAN's agricultural sector had reached $25 billion. In 2000, the Construction Jihad Organization and the Ministry of Agriculture were merged by national legislation, to form the new Ministry of
Agricultural Jihad. By 2003, a quarter of IRAN's non-oil exports were agricultural based. In 2004 an agricultural bourse started trading agricultural and related products in the country (BBC persian.com, 2004). Presently IRAN has attained 94 percent self-sufficiency in essential agricultural products.

Mechanized agriculture has had a slow but steady growth in IRAN. Industrial facilities in Tabriz and Arak are IRAN's largest producers of machinery and equipment for the agricultural sector. 12,000 combine harvesters and 300,000 tractors are currently used in this sector (2007) (Iran daily 2007).

While the Iranian Government policy is aimed at self-sufficiency for even more products, it’s unlikely the country will produce enough agricultural products in the short- to medium-term to meet that goal. IRAN has struggled to provide enough basic food commodities to its local market demands, following a significant population increase over the past two decades (Iran daily, 2009).

In 2007 IRAN exported close to 600,000 tons of wheat (production 15 million tons) (domestic economy 2007 and 2008). Another important agricultural export item is pistachio of which IRAN exported more than 140,000 tons for $823 million in 2005. IRAN ranks the world's largest pistachio producer and exporter followed by USA and Turkey (domestic economis 2008).

1.1.4 Trade and Environment Dimensions in the Food and Food Processing in IRAN

A glance at The Food Industry Business:

- The total value of food industry = 7.8 million US $
- The share of food industry in total value of industry production = 9.5 percent
- The industry food export = 566000 ton
- The value of industry food export = 359 million US $
• The share in total non-oil export = 3.4 percent
• The total value of industry food import = 1.2 billion US $
• The share of industry food import in total import = 3 percent (Rezvan Rahnavard and Alani 2006)

1.1.5 Consumption and Import of Inputs of Production in Agriculture in IRAN
• The total agriculture production = 85,000,000 ton
• The chemical fertilizers consumption = 4,500,000 ton
• The total chemical agriculture insecticides used 25,000 ton
• The chemical fertilizers imports = 1,800,000 ton
• The chemical agriculture insecticides import = 4000 ton (Rezvan Rahnavard, Faridoun Alani 2006)

1.1.6 Agriculture in 5 Year Development Plan of IRAN

The 5-year development plan of IRAN about Environment and sustainable development (2005-2009):

1. Provision for banking facilities (Loans) and other governmental resources for the investors in food Processing industries

2. Provision for coverage of insurance for at least 50 percent of total agricultural products

3. Preventing the uncontrolled use of chemical insecticides, chemical fertilizers, and replacing them gradually by composts and application of biological control for plant pests

4. Implementing programs concerning the self-assertion in production units for controlling the pollutant sources of the environment
5. Preparing the necessary programs for the management of residuals of the country and provision for governmental credits for sewage system, canals and recycling process, especially in industrial complexes

6. Provision for national environmental fund in order to reduce the incoming pollutant to the environment and prevention of further destruction and erosion

7. Environmental Evaluations and appraisal for all projects and plans within production and services before operation and in the process of implementing the surveys

8. Rational use of inputs and the factors of production in agriculture in order to attain a sustainable agriculture while protecting the environment

9. Application of biotechnology for reducing the loss, producing the outputs with a higher added value and better quality in accordance with the international standards

10. Expanding and updating the preservation technology, processing, packing and distribution of the products, exploiting biotechnology and nano technology, considering the environmental issues, and optimization of energy use

11. Provision for prizes and low interest credits for exporters who follow the environmental rules and regulations (Rahnavard and Alani, 2006).

Five year development plans of Iran show that the government is keen for betterment of agriculture by using modern technologies like biotechnology.

1.2 Genetically Modified Foods

1.2.1 What Are GM Foods?

Genetic experiments have been done by human for centuries in the forms of crossing plants and animals with the purpose of making them better for use and consume. At the present time, the genetic modifications are being done in a
scientific way, by the use of more developed techniques capable of permitting the identification, manipulation and multiplication of genes in organisms, regardless of species borders. This new branch of science is known as biotechnology. One of the strongest performances of biotechnology is found in agriculture where the transgenic foods are produced. These genetically modified (GM) products are making many controversies among scientists (Sheikhha et al., 2006).

Genetic modification (GM) refers to all modern techniques in cellular and molecular biology used to alter the genetic composition of foods or food ingredients, including in vitro nucleic acid, recombinant DNA, genetic modification, and genetic engineering. GM is different from traditional breeding techniques in three principal ways:

i) It reduces the random nature of classical breeding; ii) It accomplishes the desired results much more quickly and predictably; and iii) It makes it possible to cross the species barrier (Harlander and Roller, 1998)

1.2.2 Why GM Foods?

The dependency of the agricultural production on a fixed factor, land, and the nature of the agricultural products markets are at the source of its relevance. At the farmer’s level, income is dependent directly on the productivity of available resources, given the fact that, for each individual farmer, price is an exogenous variable of his economic equation, non-modifiable from his perspective. In words of Eduardo et al. (2006), this lack of flexibility is an incentive for the constant incorporation of technology as the only means to achieve a sustained income increase. This behavior also reflects in the sector aggregates and becomes an important determinant of its evolution and participation in the economy. Technological change is one of the key elements for the agricultural development and the improvement of farmers’ income. As it has come in the report of Economic and Social council of UN (2001) GM crops have provided
producers with opportunities to lower production costs, enhance crop production, and increase profits by using inputs more efficiently.

1.3 Scenario of GM Crops in the World: Past, Present and Future

In 1973, genes were transferred for the first time from one bacterium to another and later on, in 1977 the soil bacterium *Agrobacterium tumefaciens* was used to transfer alien genes into the plant cells. Large scale farming of GM crops started in 1986 in USA with soy bean, maize, rapeseed and cotton. The large numbers of GM plants which have been grown so far and the lack of any reported side effect indicate that biotechnology cause no immediate or significant risks (Stewart *et al.*, 2000).

Most of the GM products already available contain small modifications (one or more genes) that confer one or more specific characteristics that the original variety does not have. This way, the genetic modification can induce resistance to herbicides, tolerance to insects, virus and fungi, etc. Among these products, the more widely known (and currently used) are Monsanto’s Roundup Ready corn, soybean, and cotton, BT corn, etc. These types of GM products, commonly referred to as first-generation, were developed to improve their agronomic performance.

Second-generation GM products have been genetically modified to improve their nutritional value and could offer direct benefits to the consumers. Golden Rice, which by genetic modification produces beta-carotene, a precursor to vitamin A, is one of the emblematic cases of second-generation GM products. Even though second-generation genetically modified organisms (GMO) are not currently available for consumers, because research is still being done, given the high consumers’ demand for other non-GM functional food products they are expected to be soon available in the market.

GM crops have provided producers with opportunities to lower production costs, enhance crop production, and increase profits by using inputs more efficiently. For example, Bacillus thuringiensis (Bt) kills insects with alkaline digestive
systems through the action of a crystalline protein toxin called Cry proteins. Bt transgenic corn is genetically engineered to resist the European corn borer (ECB), which causes reduction in yield (Thomas, 1999). Thus, BT transgenic corn lowers input costs and improves productivity. GM crops also offer other potential benefits, such as using fewer chemicals and pesticides, enhanced taste and quality of some foods, increased nutrients, as well as improved resistance to disease and pests. Animal performance can also be improved through genetic engineering. For example, bovine somatotropin (BST) or bovine growth hormone is a naturally occurring protein made in the pituitary gland of the cow. Recombinant bovine somatotrophin (rBST) is BST produced by GM bacteria in the laboratory. A cow administered rBST can increase milk by more than 20%. (Aldrich and Blisard, 1998).

In 1996, when the first biotech crops were commercially grown, the coverage of these crops was on seven million acres worldwide.

The biggest surprise in 2005 was IRAN's entry with 4,000 hectares of BT rice to produce seed supplies for full commercialization in 2006. IRAN is a small step ahead of China which is expected to register its own insect resistant BT rice¹(CropLife Canada, 2008).

In 2006, the global area of GM crops continued to climb for the tenth consecutive year at a sustained double-digit growth rate of 13 per cent. The major GM crops being grown and traded around the world were soybean occupying 58.6 million hectares, followed by corn (25.2 million hectares), cotton (13.4 million hectares) and canola (4.8 million hectares), as per South Australian GM Crop Advisory committee, (2007). In 2006, countries that grew 97% of the global transgenic crops were the United States (53%), Argentina (17%), Brazil (11%), Canada (6%), India (4%), China (3%), Paraguay (2%) and South Africa (1%)²(human genome project information, 2008).

¹ (http://www.croplife.ca/english/pdf/biocropnews/BiocropNewsVol5Issue12006.pdf)
² (http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml)
In 2006, a total of 252 million acres of transgenic crops were planted in 22 countries (both developed and developing) by 10.3 million farmers (human genome project information 2008). These countries, in order of hectarage were, USA, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Romania, Mexico, Spain, Colombia, France, Iran, Honduras, Czech Republic, Portugal, Germany, and Slovakia, which includes small GM crop plantings in six European Union countries (South Australian GM Crop Advisory committee, 2007). ISAAA report (2007) states; Genetically modified (GM) crops produced by genetic engineering continue to increase in production worldwide. Global biotech crop area increased by 12 percent over 2006, in 2007, when 23 countries produced 282.3 million acres of GM crops, up by 30.3 million acres in 2006. The US ranks first in GM crop production, followed by Argentina, Brazil and Canada, in that order (James, 2007). These 382 million acres were planted by 12 million farmers. Notably, 90 percent or 11 million are resource-poor farmers in 12 developing countries (Bio, 2008 and 2009). The potential for economic and social gain from the production of GM crops is generally greater in developing countries/economies, since there is usually a higher incidence of disease/pests and larger potential for yield increase (Abdalla et al. 2003 and Qaim 2005). According to Nossal et al. (2008), GM crop production in 2007 increased by 20% in countries with emerging economies versus 6% in developed countries. Africa is considered the “final frontier” for biotech crops as it has perhaps the greatest need and most to gain (Bio, 2010).

In the words of Clive James “As a result of the consistent and substantial economic, environmental and welfare benefits offered by biotech crops, millions of small and resource-poor farmers around the world continued to plant more hectares of biotech crops in 2008, the thirteenth year of commercialization. Progress was made on several important fronts in 2008 with: significant increase in hectarage of biotech crops; increase in both the number of countries and

3 (http://www.bio.org/ataglance/acreage.asp)
farmers planting biotech crops globally; substantial progress in Africa, where the challenges are greatest; increased adoption of stacked traits and the introduction of a new biotech crop. These are very important developments given that biotech crops can contribute to some of the major challenges facing global society, including: food security, high price of food, sustainability, alleviation of poverty and hunger, and help mitigate some of the challenges associated with climate change.” (James, 2008). Figure 1.1 presents an apparent increase of 9.4% of 10.7 hectares between 2007 and 2008, equivalent to “real” increase of 15% or 22 million trait hectares. 

In 2009 farmers around the world continued to enthusiastically embrace genetically engineered (GE) crops according to the ISAAA report for 2009. Till the time more than 2.4 billion acres (1 billion hectares) of biotech crops have been planted globally since 1996. After a dozen years of commercialization, the global adoption of biotech crops continues to rise with new countries realizing the benefits, according to a report released by the “International Service for the
Acquisition of Agri-biotech Applications (ISAAA)”. In 2009, biotech crop area grew seven percent or by 9 million hectares (22.23 million acres) to reach 134 million hectares (330 million acres). Fourteen million farmers (up from 13.3 million in 2008) in 25 countries are using agricultural biotechnology. Ninety percent (13 million) of these are resource-poor farmers in developing countries. (Bio 2010) In 2009, global biotech acreage grew to 330 million acres (134 million hectares) versus 309 million acres (125 million hectares) in 2008. This is a 22 million acre (9 million hectare) increase, an increase of seven percent. In 2009, biotech crops were grown in 25 countries; this number remained the same from 2008 and represents the addition of Costa Rica. Costa Rica is growing biotech crops for the first time, exclusively for the seed export market, while Germany discontinued cultivation of genetically engineered (Bt) maize at the end of the 2008 growing season.

It is noteworthy that Accumulated acreage of biotech crops (for the period 1996 to 2009) exceeded 1 billion hectares in 2009 for the first time (Bio, 2010).

Clive James, ISAAA chairman, said the most significant event in 2009 was the “landmark November decision” by China to issue biosafety certificates for insect-resistant rice and phytase maize, the latter of which has a gene that enables pigs and chickens to digest the grains more efficiently in animal feed. Both crops will have to complete two or three years of successful field trials before commercialization. “China’s global leadership in approving biotech rice and maize will likely become a positive role model and influence acceptance and speed of biotech food and feed crop adoption throughout Asia and globally,” said James, a strong advocate of GM technology. Like China, India has rapidly adopted insect-resistant cotton but not approved any GM foods (FT, 2010). Table 1.1 shows Global Area of Biotech Crops in 2009, by Country and Figure 1.2 shows Mega biotech countries of the world and the area under cultivation of GM crops in each country. Figure 1.3 and 1.4 show the growth of biotech farming in five different countries and in different periods of the time.
The important point is positive growth of biotech farming in all these five countries till 2009.

Table 1.1 Global Area of Biotech Crops in 2009: by Country (Million Hectares)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Area (million hectares)</th>
<th>Biotech Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>USA*</td>
<td>64</td>
<td>Soybean, maize, cotton, canola, squash, papaya, alfalfa, sugarbeet</td>
</tr>
<tr>
<td>2*</td>
<td>Brazil*</td>
<td>21.4</td>
<td>Soybean, maize, cotton</td>
</tr>
<tr>
<td>3*</td>
<td>Argentina*</td>
<td>21.3</td>
<td>Soybean, maize, cotton</td>
</tr>
<tr>
<td>4*</td>
<td>India*</td>
<td>8.4</td>
<td>Cotton</td>
</tr>
<tr>
<td>5*</td>
<td>Canada*</td>
<td>8.2</td>
<td>Canola, maize, soybean, sugarbeet</td>
</tr>
<tr>
<td>6*</td>
<td>China*</td>
<td>3.7</td>
<td>Cotton, tomato, poplar, papaya, sweet pepper</td>
</tr>
<tr>
<td>7*</td>
<td>Paraguay*</td>
<td>2.2</td>
<td>Soybean</td>
</tr>
<tr>
<td>8*</td>
<td>South Africa*</td>
<td>2.1</td>
<td>Maize, soybean, cotton</td>
</tr>
<tr>
<td>9*</td>
<td>Uruguay*</td>
<td>0.8</td>
<td>Soybean, maize</td>
</tr>
<tr>
<td>10*</td>
<td>Bolivia*</td>
<td>0.8</td>
<td>Soybean</td>
</tr>
<tr>
<td>11*</td>
<td>Philippines*</td>
<td>0.5</td>
<td>Maize</td>
</tr>
<tr>
<td>12*</td>
<td>Australia*</td>
<td>0.2</td>
<td>Cotton, canola</td>
</tr>
<tr>
<td>13*</td>
<td>Burkina Faso</td>
<td>0.1</td>
<td>Cotton</td>
</tr>
<tr>
<td>14*</td>
<td>Spain*</td>
<td>0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>15*</td>
<td>Mexico*</td>
<td>0.1</td>
<td>Cotton, soybean</td>
</tr>
<tr>
<td>16</td>
<td>Chile</td>
<td>&lt;0.1</td>
<td>Maize, soybean, canola</td>
</tr>
<tr>
<td>17</td>
<td>Colombia</td>
<td>&lt;0.1</td>
<td>Cotton</td>
</tr>
<tr>
<td>18</td>
<td>Honduras</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>19</td>
<td>Czech Republic</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
<tr>
<td></td>
<td>Country</td>
<td>Hectares</td>
<td>Crop(s)</td>
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<tr>
<td>---</td>
<td>---------------</td>
<td>----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>20</td>
<td>Portugal</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>21</td>
<td>Romania</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>22</td>
<td>Poland</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>23</td>
<td>Costa Rica</td>
<td>&lt;0.1</td>
<td>Cotton, Soybean</td>
</tr>
<tr>
<td>24</td>
<td>Egypt</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
<tr>
<td>25</td>
<td>Slovakia</td>
<td>&lt;0.1</td>
<td>Maize</td>
</tr>
</tbody>
</table>

* 15 biotech mega-countries growing 50,000 hectares, or more, of biotech crops. (James, C. 2009)
Figure 1.3 Percent adoption of GM crops in USA, (1996-2009) (USDA/NASS 2009)

Figure 1.4 Percent adoption of biotech crops in Brazil, Canada, China and India (James, 2009)
The biotech industry suffered a setback in India in February 2010 when the government rejected an application to commercialize an insect-resistant strain of brinjal (aubergine), one of the country’s most important vegetable crops, because more safety tests were needed. Even so, Mr James from ISAAA said he had had no doubt that GM plants worldwide were poised for a “second wave of growth”, driven particularly by biotech rice and the introduction of drought tolerance in several crops, starting with maize in 2012 (FT, 2010).

ISAAA said in 2010 that he expects the number of biotech farmers globally to reach 20 million or more in 40 countries on 200 million hectares in just more than five short years in 2015. ISAAA predicts future adoption increases will also come from:

- Significant expansion of biotech soybean, maize, and cotton in Brazil.
- Commercialization of Bt cotton in 2010 by Pakistan, the fourth-largest cotton growing country.
- Expansion of Bt cotton in Burkina Faso with potential adoption of biotech cotton and/or maize in other African countries including Malawi, Kenya, Uganda, and Mali.
- Adoption of golden rice by the Philippines in 2012 and Bangladesh and India before 2015.

In conclusion this fact has to be mentioned that every year, more European farmers grow GM crops, where they are allowed to European farmers grow GM crops because they offer significant economic advantages. Given the choice, many more European farmers would grow GM crops. Many farmers are blocked from benefiting from GM and other innovative crop cultivation. European farmers grow GM crops because they offer real environmental advantages. Four global trends pointing to more GM crops being grown in the future (EuropaBio 2010).

The analysis of the pipeline of new GM crops shows that a significant global increase in the number of individual commercial GM events can be expected (Stein and Rodríguez-Cerezo, 2010). While currently there are about 30
commercial GM events that are cultivated worldwide, the forecast is that by 2015 there will be more than 120 (Table 1.2); this development shows a particularly pronounced potential increase in the number of GM events in rice. When looking at the traits introduced into the new GM crops, it is clear that the currently dominant traits (herbicide tolerance and insect resistance) continue to play a major role in the upcoming GM crops. However, crop composition (mostly type and proportion of oil and starch content in the crop) becomes an important feature in new GM crops, and crops that are tolerant to abiotic stress (mostly drought) are also expected to become available (Figure 1.5).

Another development in the R&D of GM crops is the emergence of more players (Stein and Rodríguez-Cerezo, 2010); while currently it is private companies from the United States or Europe that develop most of the GM events and crops (which are generally first authorized and cultivated in the United States), over the next few years more GM crops will be supplied by private and public entities from Asia, in particular from China and India. (Stein, and Rodríguez-Cerezo, 2009), and in the longer term, even more developing countries may commercialize GM crops (Food and Agriculture Organization of the United Nations [FAO], 2009). Hence, while in the past GM crop adoption spread from North America to other parts of the world, in the future the adoption pattern may change fundamentally, with more new GM crops being adopted first in Asia and then potentially spreading from there (Stein and Rodríguez-Cerezo, 2010).
Table 1.2 Events in commercial GM crops and in pipelines worldwide, by crop

<table>
<thead>
<tr>
<th>Crop</th>
<th>Commercial in 2008</th>
<th>Commercial pipeline</th>
<th>Regulatory pipeline</th>
<th>Advanced development</th>
<th>Total by 2015*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybeans</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Maize</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Cotton</td>
<td>12</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Rice</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Potatoes</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Other crops</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>All crops</td>
<td>33</td>
<td>7</td>
<td>24</td>
<td>61</td>
<td>124</td>
</tr>
</tbody>
</table>

Source: (Stein and Rodríguez-Cerezo, 2009)

The total number of GM crops by 2015 represents an upper limit, given that by then some of the current GM crops may have been phased out (Stein and Rodríguez-Cerezo, 2009).
The ISAAA report further illustrates what we have known all along, that biotechnology is a key component contributing to sustainable agriculture. More and more farmers around the world are turning to biotechnology so they can grow plants that yield more per acre and reduce production costs while being resistant to disease and insect pests.

In the United States, more than 158 million acres of biotech crops were planted in 2009, up from 154 million acres in 2008. The primary biotech crops grown in the United States are corn, cotton, canola and soybean, but also squash, papaya, alfalfa, and sugar beet. At a time when the world is looking for science-based solutions to help feed a growing population, agricultural biotechnology is able to deliver heartier crops that produce more food, often in areas with less-than-perfect growing conditions. Agro-biotechnology also has environmental benefits because biotech crop varieties require less cultivation and fewer pesticide applications, thereby saving fuel and reducing carbon dioxide (CO2) emissions into the air. This also improves soil health and water retention. The
future of agricultural biotechnology is encouraging and promising as adoption rates continue to rise, especially as we learn about the promises of next generation crops. In the future, biotech crops will have resistance to additional diseases and increased tolerance for environmental stresses like drought and flooding. New developments such as nitrogen efficiency will further increase the yield potential of the world’s crop acreage, despite increasing pressure on natural resources. We’ll also see increased demand for biotech foods that have been nutritionally enhanced or engineered to help combat human disease. Agricultural biotechnology is helping to meet tomorrow’s challenges today in agriculture, food and energy production. Countries around the world are turning to science and technology to meet today’s challenges in agriculture, and food and energy production.

1.3.2 Status of IRAN in GM Crops Scenario

In a report by Dr. Behzad Ghareyazie about visit of supreme leader of Islamic Republic of Iran to “Ruyan Biotech” research institute position and importance of biotechnology and genetic engineering in overall policy of the government with regard to 20 yearly plan of Iran for 2024 has been highlighted. According the plan in 2024 Iran would be a developed country with a high economic and scientific rank among surrounding countries. As per this plan the government has to apply all the capacity and available resources of the country to increase share of Iran in scientific researches in the world for obtaining new technologies like nanotechnology and biotechnology and apply the same in agriculture, defense, pharmacy and industry to increase percentage of non-oil income of Iran from 2% to 6% (Gharehyazie, 2008).

In 2007 name of Iran was erased from the list of biotech crop producer countries due to issuance of some interviews of agriculture-Jehad minister about his objections toward biotech crops (Jonsen 2007).

Some of Iranian scientist’s valuable achievements in agro-biotech are listed bellow;
• Bioengineered pest resistant potato by Tohidfar, Ghareyazie.
• Bioengineered verticillium resistant potato by Rahnam et al.
• Molecular farming and production of bioengineered plants which can produce important molecules with medical benefits, by Jalali et al.
• Production of bioengineered animals in Ruyan institute.
• Production of biotech wheat by Habashi et al.
• Production of biotech rice resistant to saline soil and draught by Mortazavi, Ghareyazie et al.
• Production of biotech lentil and pea by Baghery, Moshtaghy, Zaker Tavallai, Ghareyazie et al.
• Transfer of non-biological tensions, resistance genes to rice by Alemzadeh et al.
• Production of biotech date palm by Moosavi, Habashi et al.
• Production of biotech farming plants by Alizadeh et al.
• Production of biotech colza, resistant to saline soil and draught by Dorani, Bagheri and Ghareyazi
• Pilot production of biotech colza with herbicide effect (Ghareyazi 2009)

In spite of all these scientific progresses, there is no Iranian biotech product officially commercialized so far.

1.4 Key to Success for GMF – Consumers

The characteristics of modern biotechnology provide both opportunities and challenges for developing countries. The new technologies have a wide range of potential applications, and many are knowledge rather than capital intensive. If countries are able to build capacity in their national innovation system, biotechnology has the potential to support national efforts towards food security, improved healthcare, increased export potential, and environmental sustainability. On the other hand, modern biotechnology is associated with
uncertain impacts on health and the environment, and has also raised some socio-economic and ethical concerns.

Based on the scientific reports, biotechnology techniques can solve a potential problem with food supply by producing new plants, which are resistant to dry or excessive wet weather or can reduce the need for pesticides and herbicides. But what is the opinion of ordinary people about these types of changes? The awareness of biotechnology was very low a decade ago in most countries. For example, surveys indicated that only about one-third of consumers in the USA have heard or read much about biotechnology. Similar results are obtained in Japan, France and the United Kingdom in 1995 (Hoban, 1997).

Consumers worldwide have been divided on the acceptability of GMF ever since, possibly affecting the success of this new technology. Because consumers have not reacted uniformly to GMF, uncertainty has arisen regarding GMF: whether it should be produced, whether new genetically modified (GM) crops should be pursued, and what role government has in the regulation of the agro-food system when it comes to GMF. A basic economic approach to these questions is outlined by Miranowski et al. (2004). They advised farmers considering adopting GM crops that the prices they could receive for their crops would depend on relative demand for GM and non-GM crops, the cost of segregating the two types of crops (and verifying that segregation), the relative supplies of the two types, and the alternative products available to the market. Thus, producing GMF is economically efficient when the marginal cost of production is equal to the marginal revenue from consumers willing to pay for the products. This discussion of possible impacts on the market for GM crops provides a useful overall perspective for describing a market already in equilibrium. However, uncertainty arises as the market tries to find an equilibrium in response to increasing rates of GM adoption by producers in many countries (James, 2003). Key to the market situation is consumer reaction to GMF.
1.5 Public Debate over GM Products

Genetic modification (GM) technology has been fairly recently introduced into the agro-food system. One of the first genetically modified food (GMF) products to be introduced was the Flavr Savr™ tomato (Martineau, 2001). This tomato, developed by Davis, California Company Calgene, was modified to delay rotting so that it could be harvested ripe off the vine and yet have a long shelf-life. This introduction of GMF was accompanied by interesting consumer reactions; Davis consumers were divided on the acceptability of this new tomato.

There have been many issues and controversies regarding biotechnology as discussed, and the public debate about biotechnology continues. Overall, while the biotech industry has emphasized the positive effects of biotechnology to society, some consumers and environmental groups have focused on the negative characteristics of biotechnology.

An issue that arises as economies develop is the challenge posed by the introduction of new products and new technologies. The agri-food system has seen many new products and technologies introduced since the rise of market economies. The success of these products and technologies can depend on consumer reactions, so that a product like margarine or a technology like food irradiation may have difficulties being adopted as a result of initial consumer resistance (Campbell et al., 2000). There are worldwide discussions on how to assess and to manage possible risks of GM foods and on the potential of biotechnology to improve global food security (McCullum et al., 2003). An increasing number of consumers expect food producers and retailers to assume a major role in providing safe food (Bruhn and Schutz, 1999). The important factor for risk assessment and management is obtaining a basic knowledge on GM food production, consumption and interaction with humans and environment. In addition, it needs availability of clear data that results from careful researches (Paparani and Romano-Spica, 2006).
1.5.1. Specific Issues Regarding GM Foods in Islamic Countries

To put in words of Hani Al-Mazeedi in Islamic countries, in addition to being concerned with the safety aspect of GMOs, consumers are more worried about the sources of their DNA material, whether they are Haram or Halal, and this lead to the importance of accurate labelling on GM food products (WORLD HALAL FORUM 2010). Al-Mazeedi provided the principles of Halal (lawful) and Haram (forbidden) on GMOs, as guided by the Qur’an and Hadith:

i) it does not contain any parts or products of animal origin which are forbidden in Islam, as well as of animals that are permissible in Islam but not slaughtered according to Islamic law;

ii) it does not contain any component of najis, or produced by tools or equipment contaminated by najis;

iii) it is safe and not harmful;

iv) its raw ingredients do not contain derivatives from human being; and

v) during preparation, processing, packaging, storage and transportation Halal products are separated from any other product that does not meet the conditions mentioned above.

Al-Mazeedi continued by stating that GMO products are lawful if they originate from lawful sources, and it is Haram, or highly questionable, if they originate from unlawful sources akin to genetic material from unlawful animals such as pigs or dogs. However, an unlawful GMO product may become lawful in times of emergency, such as to avoid starvation or an illness leading to death. At present, most food, cosmetics and medicinal products do not meet the emergency criteria, as there are alternative sources available.

1.5.2 Status of Debate over GM Products in IRAN

In spite of all scientific progresses there is no Iranian biotech product commercialized so far. In addition in IRAN, this subject has not been in hot discussion. However, there are some groups that are against many new technologies including GM foods, pleading that these foods are dangerous to
environment (Sheikhha et al., 2006). On the other hand the other groups are in favor of GM foods which say that there is evidence of damage to health and environment. The risks of using these technologies against their benefits must be weighted either by society as a whole or by the scientific community.

1.6 About the research

1.6.1 Research Objectives

Many surveys have been conducted in industrialized and developing countries to investigate the public perceptions regarding the risks and benefits of biotechnology, while in Middle Eastern countries hardly any studies have been done so far. The present study intends to contribute to a better understanding of public attitudes toward GM foods in IRAN as a Middle Eastern country. This study is undertaken with the following objectives;

1. To analyze the level of Iranian consumers’ subjective/objective knowledge about Genetically Modified (GM) foods and their level of risk/benefit perception toward GM foods and how these four factors can affect their “Willingness to Buy” (WTB) all four different types of GM products (first and second generation of GM crops and GM meat).

2. To test a causal relationship between Level of Iranian consumers’ “Trust” to GM institutions and their willingness to buy (WTB).

3. To demonstrate how some of major personal and demographic characteristics (gender, age, educational level, income, having bellow 7 years old kids, status of house ownership, health consciousness, habit of using food labels, demand for voluntary or mandatory labeling of GM foods, risk and benefit perception and knowledge) can affect consumers’ willingness to pay (WTP) a premium for GM foods after benefit disclosure.
1.6.2 Problem Statements for the Research

As applications of biotechnology in food products become more prevalent, consumers confront new opportunities, challenges, and risks/benefits associated with GM products. Some consumers, however, view biotechnology as a risky process. Acceptance of GM products is associated with the consumers’ risk/benefit beliefs about biotechnology. When consumers perceive benefits to themselves and society, they are expected to be more willing to buy GM foods, relative to consumers who perceive few benefits. On the other hand, if consumers perceive GM foods as a health risk, and risky for the environment, they would be less willing to purchase them. In this regard, consumers’ risk/benefit beliefs of GM foods are expected to play a significant role in determining their purchasing behavior for those foods.

- Problem Statement One

The first problem will be addressed in this study is to analyze the relationship between consumers’ risk/benefit beliefs and level of knowledge regarding GM foods and their willingness to buy foods that contain GM crops and animal products.

- Problem Statement Two

It is believed that consumers have little knowledge of GM foods (Hallman et al., 2004). Thus; they cannot assess GM foods by themselves, and need help from GM institutions providing information about them, such as government agencies, consumer and environmental groups, the food industry, and scientists and academics. It is assumed those consumers’ different levels of knowledge and trust toward GM institutions determine their purchase behavior for GM foods. The second problem will address is to test a causal relationship between trust toward GM institutions, and consumer purchase behavior of GM foods.
• Problem Statement Three

Compared to conventional products and the first generation of GM products, consumers would be willing to pay more for the second generation GM products with positive attribute and nutritional value, and also they are willing to pay more for GM crops compared to foods which are made by GM animals. Most of the literature has dealt with consumer willingness to pay (WTP) for non-GM foods. The first generation of GM foods offers benefits primarily for producers and the environment. However, the second generation of GM products providing direct benefits to consumers is just around corner.

The third problem which will be addressed is to examine linkages between a consumer’s risk/benefit beliefs, Knowledge about GM foods and Trust to GM institutions, and WTP for foods with some type of benefit disclosure. In addition, the effects of perceived morality and some personal and demographic characteristics would be determined on consumers’ purchase behavior of GM foods will be investigated.

1.6.3 Hypotheses

Because consumer reactions to GMF appear to be central to the market effects of GM technology, this thesis examines consumers’ decisions with respect to GMF. In doing so, this research considers several issues at once. One issue is whether consumers consider the type of benefit offered by GM technology when evaluating a specific product. If they do, then certain modifications, such as second-generation modifications, could be more valuable than others.

Hypotheses of this research are designed based on theoretical model of explaining purchase intention of GM foods as demonstrated in this figure;
The hypotheses are the following:

Hypothesis 1: Stakeholders’ Knowledge and risk/benefit beliefs regarding biotechnology (Significantly) influence their willingness to buy (WTB) GM foods

Hypothesis 2: Consumers’ level of trust toward reference groups like GM institutions, (Significantly) affects their level of willingness to buy (WTB) GM foods.

Hypothesis 3: Consumers’ knowledge, risk/benefit beliefs of GM foods and major personal and demographic characteristics (significantly) affect their purchase behavior as measured by WTP a premium for GM foods with benefit disclosure.

1.7 Statement of Purpose of This Survey

In conclusion, as an Introduction to the topic of this research, it can be said that; as economies develop, novel products are created and markets for these products arise. Genetically modified food (GMF) is an example of such a novel product and provides economists with the opportunity to investigate an infant market. The genetic modification of food is one of the most controversial scientific
developments in various societies. In spite of significant potential benefits, its acceptance hinges on the response of the broader community.

Of particular interest with GMF is the impact of consumer reactions on the market. The response of consumers to GMF and their willingness to pay for it has emerged as an important factor in the development of this technology. This thesis aims to gain a better understanding and thus, examine the impact of cultural/ethical background on consumer buying decisions for GM food products in Iran. The factors that provide exclusivity to this subject are discussed below.

Consumer acceptance of GM food appears to be highly affected by various (cultural/ethical/quality/monetary etc) issues. Most of the research regarding consumers’ willingness to pay (WTP) has focused on first-generation GM products, which have little or no direct benefit to consumers. It is believed that consumers will be more accepting of second-generation GM products that offer direct benefits to consumers (e.g., improved nutritional characteristics). Misinformation and/or lack of information are commonly reported to be the main reasons for low consumer’s acceptance of GM food products. Different interest groups, such as biotech companies and environmental groups disseminate information that endorses their own particular interests creating great levels of uncertainty for consumers.

Secondly, most of the research on consumer behavior on GM product conducted globally, has been more focused on the western & modern countries specific and small number of researches has been done on developing countries in recent years but none of the researcher has covered Middle East countries either due to lack of knowledge about this region or due to traditionally reserved nature of this culturally bound region of the world. The choice of a country such as IRAN provides the subject an exploratory scope and gives an opportunity to open a knowledge window for other nations to understand the consumer acceptance/rejection levels of a GM product.
The special geostrategic significance of IRAN, due to its central location in Eurasia makes it an ideal choice for conducting the research. It is a regional power, and occupies an important position in international energy security and world economy as a result of its large reserves of petroleum and natural gas. The situation of the present Iranian market may be unclear, but the future impact is even more uncertain.

1.8 Difficulties of This Study

The difficulties of studying Iranian consumers’ behavior and risk/Benefit perception regarding Genetically Modified (GM) foods are as following:

Consumers in Iran do not have much scope for expressing their opinion regarding Genetically Modified Foods (GMFs) through actual purchases. Because when they go for shopping do not face with any product which is called GM though, these products are available. It makes actual market data largely unavailable. There is no regulation for the labeling of Genetically Modified (GM) food and due to this fact, despite there are some GM foods available in the market, consumers are not informed as to which products are derived from Genetically Modified Organisms (GMOs).

Absence of regulations and labels make it difficult to have a real estimation about consumers’ reaction to GMF.

By the way there are still some hypothetical GM products, for which market research and data collection is possible. In conclusion these market data seem either unavailable or unsatisfactory.

Another problem with studying demand for GMF from existing products is that data about past or present products can’t exactly address the case of future products.

In addition Iranian consumer does not have any idea about these kinds of products and has not heard so much about them through media.

To eliminate effect of these difficulties from findings of the present study, the researcher decided to conduct the field work by trained questioners and at the
beginning of the interview with each participant a brief but useful information about GM foods and different labeling policies was given to him/her.

1.9 Differences of This Study from Previous Studies
The present study differs from other studies which mentioned in chapter (II), by determining consumers’ risk/benefit perception regarding GM foods and consumers willingness to pay (WTP) for GM foods and consumers’ perception regarding second generation of GM foods with benefit disclosure in a different type of society, middle eastern society, with different beliefs and attitudes toward life. This study would be valuable and noteworthy because gives this chance to researcher to compare Iranian consumers attitude as representative of other Middle Eastern consumers attitude with other countries consumers attitude regarding GM food. Comparing result of this study with previous similar studies gives the chance to learn more about effect of difference in culture, beliefs and attitude toward life in consumers’ perception and attitude regarding GM foods. In addition in this study effect of level of knowledge, risk and benefit perception and trust to GM institutions on intention of consumer to purchase four different categories of GM food (Veg-First generation, Veg-Second generation, Nonveg-First generation and Nonveg-Second generation) are compared, which gives this chance to researcher to compare effect of above mentioned factors on consumer intention to purchase all four categories of GM foods separately. This study also differs from previous studies by analyzing effect of personal and demographic characteristics of consumers on their WTP for these four different groups of GM products which makes it possible to compare the results in the hope of new findings in this field of study.
References


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