GENETICALLY MODIFIED FOODS IN NIGERIA: A long-lasting solution to hunger?

Alimentos geneticamente modificados na Nigéria: uma solução duradoura para a fome?

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Abstract

The application of biotechnology in the genetic modification of plants in food production has led to the appearance of genetically modified foods (GMFs) in the marketplace. From inception, the subject of GMFs food has been controversial. The use of biotechnology to enhance nutritional value has raised a number of fundamental questions about genetically modified foods or plants all over the world. In spite of these controversies, GMF has been presented as the ultimate weapon against hunger in Africa, and other developing countries. While the world debates on whether or not to endorse genetically modified food in most of Western Europe and give it the acceptance it already enjoys in the United States, we are totally oblivious of the fact that genetically modified food has crept into Nigeria. Nigeria has been a recipient of food aid from countries like the United States, that are renowned for producing genetically modified foods. In 2004, Nigeria signed a Memorandum of Understanding (MoU) with the United States government agreeing to support GM crops. Are GMFs really a good substitute for the natural and traditional foods? Are the benefits of GM crops as strong as claimed by pro-biotech interests? If GM crops are safe, economically profitable, and environmentally friendly, why then has there been so much opposition, concern and controversy in recent years? If the scenario is so good, if so many millions of farmers and consumers are benefiting, if the increase in GM crops is so impressive, and if poverty, malnutrition and hunger have been alleviated in developing countries, why then have some governments imposed bans and why are consumers opposing those products in many places around the world? Is there any substance in these arguments against GMFs? This paper discusses these issues using Nigeria as a case study. We concluded that GMFs may not be the ultimate solution to hunger and poverty in a developing country like Nigeria.

Keywords: Benefits and risks; Genetic engineering; Food aid; Developing countries; Nigeria.

Resumo

A aplicação da biotecnologia na modificação genética de plantas para a produção de alimentos tem levado ao surgimento de alimentos geneticamente modificados (OGMs) no mercado. O tema é controverso, a utilização da biotecnologia para aumentar o valor nutritivo dos alimentos (e de plantas) tem suscitado uma série de questões fundamentais em todo o mundo. Apesar dessas controvérsias, os OGMs têm sido apresentados como a grande arma contra a fome na África, e de outros países em desenvolvimento. Enquanto o mundo debate sobre aprovar ou não alimentos geneticamente modificados, a maior parte da Europa Ocidental e os Estados Unidos já aceitam sua utilização. Aqui na Nigéria é irreversível o seu crescimento e utilização. Temos recebido ajuda alimentar de vários países, como por exemplo, os Estados Unidos, reconhecido pela produção de alimentos geneticamente modificados. Em 2004, assinamos um tratado com o governo dos Estados Unidos concordando em apoiar as culturas geneticamente modificadas. Mas será que os alimentos geneticamente modificados são realmente bons substitutos para os alimentos tradicionais? Os benefícios das culturas GM são tão fortes como alegado pelos interesses da biotecnologia? Se as culturas GM são seguras, economicamente rentáveis e ambientalmente compatíveis, então por que razão tem havido tanta oposição, preocupação e polêmica nos últimos anos? O cenário é bom, muitas pessoas se beneficiam dos OGMs; nos países em desenvolvimento o aumento das culturas geneticamente modificadas é impressionante, atenuando a pobreza, a desnutrição e a fome. Mas, então, por que governos impõem restrições e proibições? Isso provoca a queda de seu consumo em diferentes partes do mundo. Este artigo discutiu estas questões, utilizando a Nigéria como um grande cenário. Concluímos que OGMs podem não ser a solução final para a fome e a pobreza em um país em desenvolvimento como o nosso.

Palavras-chave: *Riscos e benefícios; Engenharia genética; Ajuda alimentar; Países em desenvolvimento; Nigéria.*

INTRODUCTION

Genetically modified foods (GMFs) are most commonly used to refer to crop plants created for human or animal consumption using the latest molecular biology techniques (1). These plants have been modified in the laboratory to enhance desired traits such as increased resistance to herbicides or improved nutritional content (2). The enhancement of desired traits has traditionally been undertaken through breeding, but conventional plant breeding methods can be very time consuming and are often not very accurate. Genetic engineering, on the other hand, can create plants with the exact desired trait very rapidly with great accuracy (2). Genetically modified products include medicines and vaccines, foods and food ingredients, feeds and fibres.

Genetic engineering technology has revolutionary potential in agriculture, for it allows one to design a plant to one's desire. In this way, it may seem entirely different from previously existing agricultural technologies. However, this is not quite true, for humans have practiced selective breeding for thousands of years (3). One aspect of genetic engineering which has been used for centuries is the selective breeding of crop plants and farm animals to produce improved food (4). Clearly, genetic engineering is merely a refined version of selective breeding, just another step in the long tradition of improvements in agriculture. The only real difference between the two methods is the possibility in genetic engineering of mixing genes between species (5).

Genetic engineering offers a way to quickly improve crop characteristics such as yield, resistance or herbicide tolerance to a degree not often possible with traditional methods (6). GMFs can be manipulated to produce completely artificial substances, from the precursors to plastics to consumable vaccines. They are developed and marketed because there are some perceived advantages either to the producer or consumer of these foods (7). However, the production of GMF raises the possibility of human health,

environmental and economic problems, including unanticipated allergic responses to novel substances in foods, the spread of pest resistance or herbicide tolerance to wild plants, inadvertent toxicity to benign wildlife, and increasing control of agriculture by biotechnology corporations. This review provides an overview of risks and benefits of GMFs in Nigeria. The effect(s) of genetic modification as a technique for food production is considered. The possibility of using GMF as a tool for alleviating hunger in Nigeria is weighed against using agricultural approaches to produce food. The possibility of introducing bio-safety regulations into the food industry is also considered. This paper concludes with a perspective and highlights a few suggestions that are likely to lead to major advances in the food industry in the country.

Genetic modification

Genetic modification can be defined as a set of technologies that alter the genetic make up of living organisms such as animals, plants or bacteria (8). Although 'biotechnology' and 'genetic modification' are commonly used interchangeably, biotechnology is a more general term, which refers to using living organisms or their components such as enzymes, to make products that include wine, cheese, beer and yougurt (9). The aim of genetic modification is "to isolate single genes of known functions from one organism and transfer copies to a new host (in this case plant or food crops) to introduce desirable characteristics" (10). The increased power of genetic breeding over selective breeding allows a large number of applications, some of which are still in development (11). One of the common uses of genetic engineering is to introduce herbicide resistance into plants. Another is in making plants hardier or more productive; in particular, one can insert disease resistance or the ability to grow in harsh environments (12). A third use is in the modification of crops so that their produce lasts longer on the shelf (13).

DNA is extracted from an organism and a specific gene isolated through the use of restriction endonucleases, which cut DNA at specific points (14). The resulting food produced through the process of genetic modification is said to be "genetically modified", "genetically engineered" or "transgenic" (9). The process of genetic modification is known by many names such as gene manipulation, gene splicing, etc. There are basically two methods of genetic modification which are the traditional breeding, and recombinant DNA technology methods.

The traditional breeding method has been used for many years to improve food supply since the first cultivation of crops such as wheat and barley in Mesopotamia in 6000 BC and the domestication of animals such as sheep and goats in southwestern Asia over 10,000 years ago (15). More recently, improvement of food supply through genetic manipulation by breeding was accelerated through the development of hybrid crop varieties in the 1960s and 1970s (3). Selective plant breeding, one of the traditional breeding methods was seen as a practice of chance selection rather than scientific application of principles (16). The plant breeder has several purposes for producing new strains or varieties of plants (17). One of the key objectives is the production of more desirable varieties. Such plant characteristics as large fruit, large and abundant seeds, vigorous growth, early maturation of fruit, large leaf area in leafy vegetables and vigorous root growth in root crops are highly profitable (16). By means of hybridization, different kinds of plants have been developed. Many fresh fruits and vegetables have long been produced through breeding from parent stock of differing background by genetically altering them (5).

The traditional breeding method has been used for many domesticated animal species that are food sources (15). A good example is chicken, which was one of the more expensive meats in the 1940s, and now one of the least expensive sources of meat (18). However, the traditional method of breeding plants and animals may take several generations to obtain results and bad results may occur at least as often as good ones (11).

Recombinant DNA method involves the introduction of DNA into cells where they are expressed in form of proteins. In most cases, only minute amounts of DNA is needd to be introduced to obtain the desired trait in the foods (15). A range of techniques is used for transferring an isolated gene into the host, which in this case could be a plant or animal (10). These techniques include bacterial carriers, microinjection, biolistics, calcium phosphate precipitation, gene silencing and gene splicing, lipofection, vectors and protoplast transformation among others.

Genetically modified foods

The advent of GMFs came with the birth of genetic engineering (11). In the 1960s, a lot of breakthroughs were recorded in the field of genetics. It was proven that this new knowledge had the potential to revolutionalize food production, thus creating huge benefits for the world (11). By 1972, another scientific breakthrough was recorded by Paul Berg, who joined together DNA from two different organisms, to create the first recombinant DNA molecule (9). This breakthrough was followed by a pioneer study in which Stanley Cohen and Robert Boyer inserted DNA from an African clawed toad into the *Escherichia coli* bacterium (19). Shortly, after then, some companies realized that this fledging technology could open up new highly profitable markets (11).

The first field trial of genetically modified organism was in 1986 when Frost ban, a spray containing genetically modified bacteria was sprayed over strawberry crops to protect them from frost damage (20). Frost ban was designed to stop the growth of other bacteria that catalyze the formation of ice. In 1992, a Supreme Court ruling in the United States made the patenting of life-forms of genetically modified foods legal (21). Following this, the first genetically engineered products became available in the US markets in 1994. The Flavr Savr tomato that had been gene-altered for longer shelf-life and milk from dairy cows injected with recombinant Bovine Growth Hormone (rBGH or rBST) causing them to produce more milk were two of the first GMFs available to consumers. In the case of the slow-ripening Flavr Savr™, scientists knew that a type of enzyme causes tomatoes to soften as they ripen. When they isolated the gene responsible for the softening enzyme and insets it backwards into the tomato's genetic code, the resulting tomato maintained good eating quality for a longer time than regular tomatoes (4). Hence the Flavr Savr™ tomato was genetically engineered to keep it firm for a long period of time and it was a big hit with the consumers. Calgene®, the company that produced the genetically modified tomato was overcome by a flawed business plan and the Flavr Savr™ tomato eventually disappeared from supermarket shelves. Despite this, the Flavr Savr tomato helped the United States consumers to accept genetically modified foods (3). By the year 2000, as much as 75% of the foods in American supermarkets had ingredients from GE crops. Such foods include cereals, baby foods, corn and soy products, cooking oils, squash and tomatoes.

Herbicide-tolerant crops are engineered to survive the application of a powerful herbicide that would kill a non-engineered crop, making it easier for farmers to use more herbicide to control nearby weeds. Insect-resistant crops are engineered with an insecticidal protein from a soil bacterium, *Bacillus thuringiensis* that kills certain insect pests when they eat the leaves or grain of the plant. Four crops that have been genetically engineered for insect-resistance and herbicide tolerance include corn, cotton, canola and soybean (22). Crops in development include soybeans with higher protein content; potatoes with more nutritionally available starch and with improved amino acid content; pulses such as beans which have been altered to produce essential amino acids; crops which produce beta-carotene; and crops with a modified fatty acid profile (4). Different types of peppers and melons with improved flavour are currently in field trials. Flavour can also be improved by enhancing the activity of plant enzymes which transform aroma precursors into flavouring compounds (23).

In addition to the use of biotechnology in the production of GM crops, the technique can also be used to create genetically modified animals (4). But developments of this application may be slow due to the greater difficulties in animal genetic engineering and to the social and ethical concerns of consumers about the animal food applications of biotechnology. Nevertheless, some genetically modified food animals are under consideration for approval and marketing. An example is a salmon that that grows to marketable size more rapidly than regular salmon (4). Most GM animal research is for medical applications, as in the case of the cloned sheep "Dolly", where scientists are investigating cystic fibrosis disease (23, 24).

Today, GM foods are common, especially in the United States (25). In many parts of the world, farmers have embraced genetically modified crops so enthusiastically that the global area of genetically modified crops has increased 30-folds in six years (20). Only five countries have embraced and introduced genetically modified crops, they include Argentina, Brazil, Canada, China and the United States (6).

Genetically modified foods on the market

The most important GM crop in terms of acreage planted is soybean, followed by corn, cotton and canola (26). Soybeans and corn are the top two most widely grown crops (82% of all GM crops harvested in 2000), with cotton, rapeseed (or canola) trailing behind (2). 74% of these GM crops were modified for herbicide tolerance, 19% were modified for pest resistance, and 7% were modified for both herbicide tolerance and pest tolerance (2). Figure 1 shows the global adoption of GMFs from 1996 to 2002. Between 1996 and 2005, GM crops have been adopted by farmers in many areas of the world. Presently, GM varieties have a significant share of the four major agricultural crops for which they are commercially available (maize, canola, soybean and cotton). Figure 2 shows the share of GM varieties for these major crops globally.

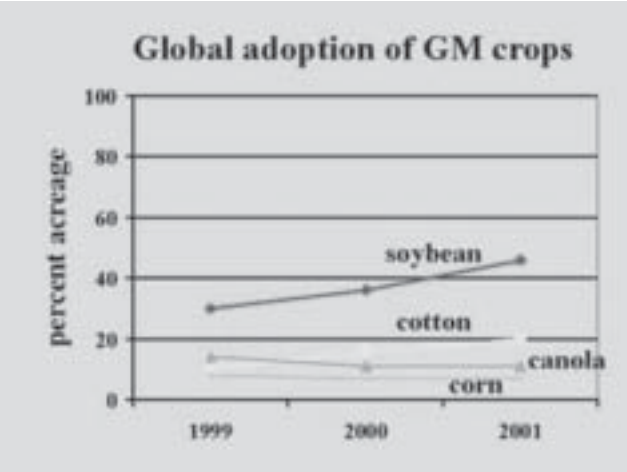

FIGURE 1 - Global Adoption of GM crops (James, 2002)

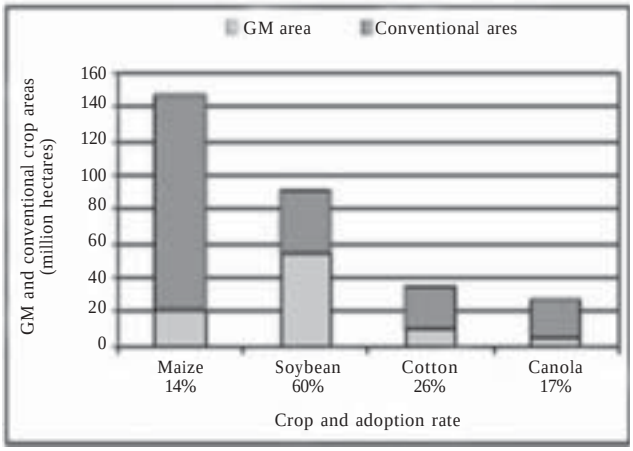

FIGURE 2 - Global Adoption Rates for Major GM crops in 2005 (FAOSTAT, 2006; James, 2005)

The benefits and risks of GMFs

With such great potential benefits came also potential harms and the debate over whether or not to pursue genetic modification of foods is a passionate one. The potential harms of genetically modified foods include its impact on human health (allergens, transfer of antibiotic resistance markers), potential environmental impact (unintended transfer of transgenes through pollination, loss of flora and fauna diversity), tampering with nature by mixing genes among species, violation of natural organisms' intrinsic values, biopiracy, among others (11).

HEALTH

According to Hammer (11), GMFs have great potential as a relatively cheap source of human therapeutics, especially for developing countries. Researchers believe that banana or any fruit that is eaten raw could be genetically engineered to vaccinate against a wide range of diseases, providing cheap sources of protection (27). A good example is the production of a blood anticoagulant in canola fruit. Scientists have genetically engineered a variety of rice (golden rice) that could prevent a form of blindness (28). Over 250million people worldwide are exposed to the risk of permanent blindness caused by vitamin A deficiency (20). Golden rice could remedy this risk because it contains a daffodil gene that produces beta-carotene. This pigment forms vitamin A when absorbed by the human body and gives the rice its yellowish colour – hence the name "Golden Rice" (28). Monsanto ®, a multinational corporation and the world's leading producer of GM crops asserts that the biofortification of rice with beta-carotene (a precursor to vitamin A) and iron will reduce the incidence of malnutrition and blindness due to vitamin A deficiency as well as reduce infant mortality in developing countries (29). The Agri-biotech industry also purports that agriceutical vaccines currently being developed will be much easier and less expensive to administer via vaccine-containing food and will therefore facilitate the protection of millions of people in developing countries against virulent life-threatening diseases. A recent study demonstrated that when mice were fed potato tubers genetically modified to express

Hepatitis B surface antigen, they (the mice) showed a primary immune response by producing the antibody specific to that antigen (30). Hence the desired effect of improved immunity may have been achieved through genetic engineering.

Foods could also be engineered to be healthier for the consumer; for example, plant breeders have introduced a bacterial gene into potato plants which increases the proportion of starch in the tubers whilst reducing their water content. This means that the potatoes absorb less fat during frying, giving low-fat chips. Sweeter potatoes have also been produced which have higher sucrose content than traditional varieties (4). Both rapeseed and sunflower are being altered to produce more stable and nutritious oils, which contain linolenic acid and have lower saturated fat content. Rapeseed has also been modified to produce a high-temperature frying oil in low saturated fat (23, 31, 32, 33, 34).

However, genetically modifying foods can alter their nutritional value (10). The nutritional value of food could be diminished when the inserted genes interrupt the normal functioning of other genes in genetically modified plants (35). During genetic transformation, not all cells will undergo the desired modification and it is therefore necessary to select those that have been modified. To do this, a marker gene may be inserted along with the desired gene into the plant. The marker gene may confer resistance to specific antibiotics so that when these antibiotics are added to growth medium, only those cells with the desired modifications will grow. Fears are generated that live genetically modified foods could transfer antibiotic resistant genes to people (20). If this occurs, people could become resistant to commonly used antibiotics, and it may lead to the loss of ability to treat illnesses with antibiotic drugs (10).

Nestle (36) and Margulis (37) reported the possibility of genetically modified foods being toxic and allergenic. Hiefle and Taylor (38) noted that one of the theoretical concerns raised about food derived from genetically modified plants is that consumers might experience allergic reactions to them. Genetic engineering is imprecise and unpredictable. By inserting genes from organisms, which have never been eaten as food, new proteins are introduced into the human and animal food chains. There is concern that these could cause allergic reactions or other health effects (39).

Agriculture

Foods can be improved by making the process of producing them easier for the farmers or growers. This improvement can be achieved by providing the plants with genes for pest and disease resistance, reduced maturation time, increased yield, and increased tolerance to a wider range of climatic conditions or by making the foods more attractive to the consumers (11). Crops are difficult to raise for different reasons; for example, strawberries are not very frost hardy which makes them difficult to grow in certain climates. An anti-freeze gene from cold-water fish has been introduced into plants such as tobacco and potato. With this antifreeze gene, these plants are able to tolerate cold temperatures that normally would kill unmodified seedlings (2). Years ago it was discovered that the Arctic flounder produces an anti-freeze to protect itself in Arctic waters. Research is now underway to introduce the antifreeze gene into fruits and vegetables like strawberries and soybeans, which can be damaged or destroyed by frost (5).

Cultivation of genetically modified crops that are resistant to pests or diseases could reduce the reliance of agriculture on chemical sprays. While this makes the crop easier and cheaper to grow for the farmers, it also means that other indirect costs of spraying with chemical pesticides are eliminated. Another area of genetic modification is the introduction of herbicide resistance into plants (11). This allows the farmers to spray herbicides liberally on their crops, killing all the weeds but none of the crops. A good example of this is the "Round up Ready" soybeans, which is resistant to the herbicide 'Round up' (12). McGloughlin (40) reported that genetically modified crops allow the possibility of farming in poor soil or with much less use of fertilizer. Hence, there is conservation of soil and energy.

However, genetically modified crops may interbreed with closely related weedy species, thus making these weeds to become resistant to some of the specific herbicides (12). Such weeds are referred to as "super weeds". It is also speculated that the genetically modified crops for herbicide resistance may become weeds due to their resistance to herbicides if they are allowed to escape the confines of the paddock (40).

The environment

Carpenter and Gianessi (27) reported that the opponents of biotechnology usually argue that the adoption of genetically modified crops will lead to decrease in plant biodiversity, thus reducing the sustainability of the planet. It is possible that if insect-resistant plants cause increased death in one particular pest, it may decrease competition and invite minor pests to become a major problem (41). In addition, it could cause the pest population to shift to another plant population that was once unthreatened. GM herbicide tolerant crops allow farmers to apply "broad spectrum" weed killers to their field, which kill other plants. There is the concern that this will continue the decline of farmland wildlife because the use of these GM crops could lead to the removal of weeds from all crops in the normal arable rotation (22). Another concern is that crop plants engineered for herbicide tolerance and weeds will cross-breed, resulting in the transfer of the herbicide resistance genes from the crops into the weeds. These "super weeds" would then be herbicide tolerant as well (2). Other introduced genes may cross over into non-modified crops planted next to GM crops. Another possible impact of GM foods on the environment is the possibility of residues from herbicides or pest resistant crops to harm key groups of organisms found in surrounding soil, such as bacteria, fungi, nematodes and other microorganisms (42).

The economy

Generally, GMFs are cheaper to produce than their natural counterparts. This is because the process of genetic modification has minimized some of the cost especially on pest control on the field and during storage. Since GMFs are produced by farmers at cheaper rates, the relief will be passed on to the consumers who will purchase the produce at cheaper rates (27). Another benefit of genetically modified plants is the reduction in the price of certain medicines that are produced from them. Unfortunately, the benefits of GMFs to the economy are not as great as they may seem. It is a well known fact in economics that, in a perfectly competitive market of agriculture, the high profits earned by farmers in the short run will eventually pass to the consumers, causing the farmers to earn less money in the long run (11). Consequently, the economic evaluation of the farmers' situation yields a number of potential costs and benefits but no conclusive recommendations. Hence, both consumers and farmers are at the mercy of the world market. Currently, the United States and Canada are by far the major producers of genetically modified foods, with very few other countries participating (20).

It is noteworthy that the companies producing genetically modified plants or foods enjoy power of monopoly (27). Many new plant genetic engineering technologies and GM plants have been patented, and patent infringement is a big concern of agri-business (2). Yet consumer advocates are worried that patenting these new plant varieties will raise the price of seeds so high that small farmers will not be able to afford seeds for GM crops, thus widening the gap between the wealthy and the poor (27, 40).

Social implications and ethics

Given the fact that genes can be transferred from one organism to another, some ethical concerns are generated. For example, when eating a vegetable, will a vegetarian be concerned to learn that the lettuce he is eating contains DNA copied from a pig's gene? If it were to contain copies of a human gene, does it mean that the person eating it is a cannibal? While people may be put off or even outraged by such possibilities, technologists point out that although there may be an ethical dilemma, which is likely to be debated emotively, the chemical structure of DNA is the same whether you are a human, a tree or an amoeba (5). It is only the sequence of the nucleotides within the DNA, which determines the genetic make up of the organism.

A commonly voiced concern in the general community is: "Does man have the right to play God?" People are worried about the fact that man is impatient to allow natural selection to take its course; instead we have decided to take laws into our hands to hasten things – through the process of genetic modification (5). "Just to think about all these makes us feel really scared about the food that is placed on our plates, and the seeds that we may be planting" (43). Hence, a lot of controversy has been generated on the acceptance of GM foods; thereby creating two schools of thoughts – those that are ready to embrace GM foods and those that are reluctant in accepting GM foods.

Long term effects

Genetic modification of foods has long-term effects. Unintended effects of genetic modification are likely to occur as a consequence of the imprecise nature of the technologies employed. The inability to predict the exact locations where transformations will take place, the unknown amounts of genetic material passed through, the effects of environmental conditions on the transfer and the potential DNA recombination and protein synthesis can produce unidentifiable outcomes. These long-term consequences cannot be completely predicted (11). Opponents of gene modification point to the example of nuclear technology as reasons to leave gene technology alone. Nuclear technology has had some ghastly health consequences for those working with it, with problems ranging from development of cancer to birth defects. These problems arose due to lack of knowledge at the time of the long-term effects these technology could have on the people and the environment (44). Most biotechnology companies use microorganisms rather than food plants as gene donors, even though the allergenic potential of these newly introduced microbial proteins is uncertain, unpredictable and untestable (37).

Genetically modified foods in Nigeria

Before the oil boom, Nigeria was generating foreign exchange from crops like cocoa, kola, groundnut e.t.c and farming was a factor part of productivity in the country. The oil boom saw agriculture decline over the years, leaving every citizen to depend on annual budget based on oil sales and depending on day-to-day expenditure based on the parallel market (45). Presently, Nigerian agriculture is facing the growing encroachment of urbanization, industrial expansion, and an expanding transport infrastructure. Deforestation and cultivation in fragile ecosystems is also leading to soil degradation (46). Consequent upon these challenges on agriculture, Nigeria imports a lot of things especially food from other countries.

An investigation carried out by Environmental Rights Action / Friends of the Earth (39) on the potential presence of GM ingredients in Nigeria has found food aid as one of the potential channels. Nigeria is in principle not a food aid recipient, but continues to receive rice from the United States as food aid. In 2003, Nigeria received 11,000.6 metric tones of soy meal as food aid from the US Food for Progress programme (43). Taking into account that over 80% of soy beans in the US are genetically modified, it is therefore likely that Nigeria has been receiving GMFs without prior information to the government and the people (47). Another source of potential introduction of GMF is through commercial imports of food containing ingredients from corn and soy. It has been reported that China may release genetically modified rice into the market in 2006 (47). With the bulk of rice consumed in Nigeria coming from Asia, it is a matter of time before genetically modified rice from China floods Nigerian markets.

The International Institute for Tropical Agriculture (IITA) in Ibadan, Nigeria is making efforts to prevent the outbreak of virulent Cassava Mosaic Disease in Nigeria, which could lead to food shortages in the country (48). GM cassava was created at the Donald Danforth Centre in St. Louis, United States and sent to Nigeria for experimentation through IITA (49). However, the application to test the GM cassava was withdrawn by IITA due to its failure to achieve the required resistance to cassava mosaic disease (43).

The genetic modification of foods makes excellent economic sense for the major agribusiness and food corporations and has been strongly backed by them. Some of the biggest names in the food business openly use genetically modified components, while others will not disclose whether they use them or not. Such companies include Arnotts, Cadburys, Coca-cola, Coles and Woolworths' house brands, Golden Circle and Nestle (50). Already, Nigeria has drafted a biosafety law allowing the use of GMF technology, which the National legislature is yet to approve (49). The country also does not have any policy on the importation of GMF, unlike some African nations such as Angola, Ethiopia, Kenya, Lesotho and Zambia, which have banned the import of GMFs.

GMFs: the ultimate solution to hunger in Nigeria?

So much controversy has been generated over the adoption of genetically modified foods, so much that it calls for a serious appraisal. The

benefits and adverse effects of GMFs have been outlined in this review. The genetic modification of plants for food production stems from the challenges facing agriculture. The technology came about as a means of combating the problem of food shortage and hunger in the world. The United States of America has been giving genetically modified foods to developing countries like Nigeria to help alleviate the problem of hunger and poverty in the countries. However, anxieties have been raised over the genetic and health implications of consuming the GMFs. The issue of the long term effects of the GMFs on human populace and the ecosystem in general also needs to be addressed and properly researched to reveal and prevent any possible risks that may be associated with the consumption of the GMFs.

Agricultural practices in the developing countries need to be reviewed. More in-depth studies are needed to improve on the age-long practices, as a way of boosting food production. In one of the studies on commercial rice-growing fields, researchers found that thousands of Chinese farmers using agroecologic techniques experienced yield increase of 89% while completely eliminating some of their most common pesticides (51, 52, 53). If the Nigerian farmers are sufficiently mobilized, they have the capacity to grow food that will feed the population. Individuals could also be encouraged to engage in small-scale farming of native crops because it enhances food production. This is corroborated by UN figures; for instance, in Asia, figures for Syria showed farms between 1 and 2.5 acres being over 3 times as productive as farms over 35 acres (54). A similar study in Nigeria has the small farms being over 4 times as productive. This is because small farms tend to produce several crops at once, thus reducing nutrient depletion. They are more likely to compost any waste, they use all the land and a whole load of stuff that agri-business simply cannot effectively do.

Since GMF has found its way into Nigeria, there is need for caution. According to a report by the Centre for Food Safety (55, 56, 57), Nigeria still accepts GMFs as food aids, and the only condition for the importation is that the GMF food aid be milled. Presently, there is no law governing the production of food products by companies using genetically modified ingredients. There are many challenges ahead for the government, especially in the areas of safety testing, regulation and internal policy. Moreover, every citizen has a right to know what he is consuming. There is a need to enlighten the general public on what GMFs are, highlighting the advantages and disadvantages of accepting it as a source of food. It is our opinion that GMFs may not be the ultimate solution to hunger in a developing country like Nigeria.

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