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Knowledge and attitudes towards genetically modified food among life sciences university students

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Author: Bc. Petr Veselský

Chief supervisor: Ing. Petra Chaloupková, PhD., dr. h.c.

Second (specialist) supervisor: prof. Dr. Ing. Eloy Fernández Cusimamani

Declaration

I hereby declare that I have done this thesis entitled Knowledge and attitudes towards genetically modified food among life sciences university students independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague

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Abstract

Genetically modified (GM) foods have the potential to provide solution in ensuring food security, however GM food acceptance is closely dependent on the perception of risks and benefits that can be generated through an individual's knowledge, available information, and trust to information. Therefore, the main aim of the study is to analyse the attitudes to GM food among life sciences university students.

A cross-sectional survey-based study was conducted to explore the knowledge and attitudes of students toward GM foods. In total, 420 students from Bolivia and the Czech Republic participated in the study via online survey.

The majority of the Czech students (88 %) self-reported positive subjective knowledge about GM food, while only 19 % of Bolivian students recognised themselves as knowledgeable about GM food production. A significant difference was found toward the willingness to consume GM food among the students from both countries ($p < 0.001$). Only 5 % of Bolivian students considered trustworthy the information about GM in food production provided by the government, while almost 55 % of Czech students have confidence in provided information.

Based on the results there is a need to increase awareness particularly among Bolivian students about GM in food production, particularly both positive aspects and health risks connected to consumption.

Keywords: Willingness to Consume; Risk and benefits perception; Trusted source of information ; Knowledge and education; Importance of source of information

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List of the abbreviations used in the thesis

EU European Union

CZ the Czech Republic

USA the United States of America

UK United Kingdom of Great Britain and Northern Ireland

GMO Genetically Modified Organism

GM Genetically Modified

GE Genetically Engineered

Mha million hectares

GRMAU Gabriel René Moreno Autonomous University

USFX University of Saint Fracis Xavier

CZU Czech University of Life Sciences Prague

UK Charles University

1. Introduction

The global human population is estimated to grow to 9 billion over the next decade (UN 2021; World vision 2020; WFP 2020), with this growing population, humanity will be forced to address the lack of arable land and food to ensure food security (Le Mouël & Forslund 2017). An estimated 690 million people in developing countries currently suffer from hunger due to a lack of arable land, instability and other vices and it is also being estimated that this number will increase rapidly by the end of 2030 (UN 2021; World vision 2020; WFP 2020). GM foods are experiencing an increase in production and imports worldwide, mainly in developing countries, where strict rules and restrictions do not apply, such as in the EU, and is also welcomed by farmers (ISAAA 2018;2017; GeneWatch 2015; James 2015). this provides one of the possibilities to ensure food security by increasing GM food availability on the market (Muzhinji 2020; Nilsen & Anderson 2011), but the expansion of GM in food development and production is determined by consumers attitudes (Nilsen & Anderson 2011). These attitudes are formed by several factors, including knowledge, education, perception of risks, and benefits connected to consumption of GM in food and feed production, trust in science and institutions, moral values, and reference groups (Boccaletti and Moro 2015; Traill et al. 2006; Gaskell et al. 2003; Lusk et al. 2004). Research up to date has shown that the general public's attitudes towards GM foods are rather negative, also, that consumers attitudes in countries with higher GM food and feed production are more positive in comparison with consumers from countries with lower GM food and feed production. When comparing between the general public and the scientific community, it has been found that the scientific community has a more positive approach to GM foods. These studies were mostly carried out within one country, union (EU, USA) or continent. Most studies focused on the population with ended education only, with little or no inclusion of students. This brings us to the question: What are the attitudes of students? What are the differences about attitudes of students about GM food in comparison between low-income countries with GM food history and high-income countries without GM food history?. This study, therefore, focuses on comparing the attitudes of students at life science universities in selected countries, particularly Bolivia and the Czech Republic.

2. Literature review

2.1. Genetically modified food and genetically modified organism

The modification process of the genetic makeup of an organism for specific objectives (e.g., to favour the expression of desired physiological traits or the generation of desired biological products) is the end result of a product called Genetically Modified Organism (GMO) (Halford & Shewry 2000; FAO 2011; WHO 2014; FSAI 2019; MZ 2021).

According to FAO, GMO is defined as 'an organism in which one or more genes (called transgenes) have been introduced into its genetic material from another organism using recombinant DNA technology' (FAO 2011). While the Cartagena Protocol on Biosafety defines GMO as a 'living modified organism' or as 'any living organism that possesses a new combination of genetic material obtained through an alteration by the use of modern biotechnology' (Cartagena Protocol on Biosafety 2000).

In agriculture, some of the main objectives of genetic modification include upsetting genetically linked diseases in organisms (i.e., resistance to pests, disease, and drought), reduced need for pesticides, increased crop yields, reduced costs for food production, and enhanced nutrient composition and food quality (Phillips 2008). In addition, efforts have been made to develop crops that are tolerant to various environmental and climatic conditions such as drought, salt, frost, boron, and other environmental stressors (Phillips 2008). In genetic modification, genes can be deleted, silenced, knocked out, added, and transferred to and from related and non-related species.

The technology that allows the alteration of the genetical material (DNA) and the insertion of external agent such as viruses, bacteria, animals, or plants into related and / or non – related species in GMO is called "genetic engineering", "recombinant DNA technology", "gene technology" or "modern biotechnology" (Halford & Shewry 2000; WHO 2014). This technology allows us to overcome naturally insurmountable physiological barriers and to transfer selected individual genes among all living organisms. This provides us with the potential to allow the creation of an organism which is desired and designed by human (Halford & Shewry 2000; WHO 2014), leading to creating new property to the organism, such as; plant´s resistance to disease, insect, drought, tolerance to herbicide, improving a food´s quality or nutritional values and increasing yield (EC 2021; Clive 2016; Klümper & Qaim 2014).

2.2. Global production of genetically modified crops

Although genetically modified organisms (GMO) in agriculture have been available for about 26 years now, their commercial use has expanded exponentially. Recent estimation of food products on the store shelves contains at least a small amount of crops produced with this new technology. The major crop plants produced by genetic engineering techniques have been so welcomed by farmers that currently a third of the corn and about three-quarters of the soybean and cotton grown in the USA are varieties developed through genetic engineering. GM crops were first introduced on the USA market in 1994 with the Flavr Savr tomato, which was genetically modified to slow its ripening process, softening, and rotting. The popularity of GM crops is on the rise since the 1990s and in 1996, just 1.7 million hectares of arable soil were used to plant GM crops globally (Clive 2016). There is a trend of increasing arable land used for GM crops for the last 23 years. Since 1996 this area accumulated from 1.7 million to 2.5 billion hectares (ISAAA 2018) (Figure 1). In 2015 the number of countries producing GM crops has increased from 6, in 1996 – USA, China, Canada, Argentina, Australia and Mexico- to 28 and GM crops were grown on 179.7 million hectares and then, in 2018 arable land designated to GM production reached 191.7 million hectares –that is over 10 % of the world's arable land and equivalent to seven times the land area of the UK. The USA, Brazil and Argentina are the leading producers. There are currently no GM crops being grown commercially in the UK although scientists are carrying out controlled trials (Clive 2016; ISAAA 2018; 2017). The number of countries planting GM crops decreased to 26 in 2018; 21 of these countries were less income countries and 5 were high income countries (ISAAA 2018; GeneWatch 2015; James 2015/2007/2005). Meanwhile from 1998 to 2018 arable land dedicated to GM crops increased by 163.9 million hectares globally (ISAAA 2018) and since 2012 less income countries are using more arable land for biotech crop, outperforming high income countries. Prior to 2011, high income countries steadily exceeded the acceptance of GM crops over less income countries as new countries began to join in, and by the end of 2012, GM crops had been evenly distributed among high income and less income world (ISAAA 2018;2017; GeneWatch 2015; James 2015). After 2012, less income countries were consistently increasing in the usage of arable land used in GM crops and by 2018 there was a difference of 14.5 million hectares between less income and high-income countries.

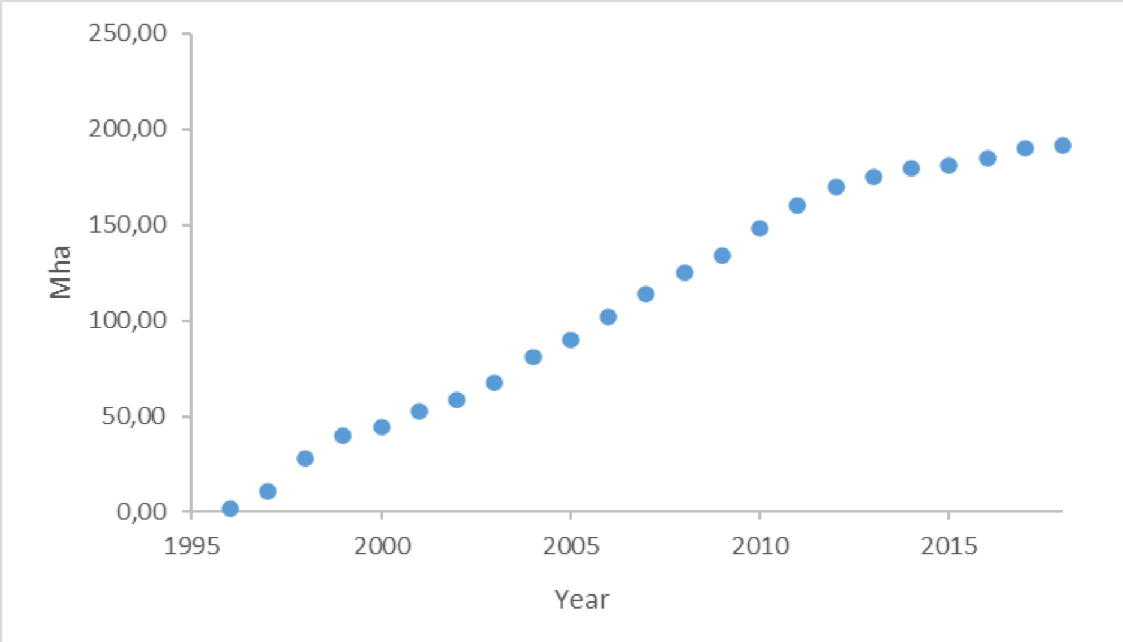

Figure 1: Arable land (Mha) used worldwide for GM crops production

Source: ISAAA 2018

With this increase in arable land usage, less income countries grew by 54 % of the global GM crop per hectares compared to 46 % for high income countries in 2018. Also, there was an increase for less income countries that are joining in with GM crop production, meanwhile numbers of high income countries that grew GM crops began to decline (ISAAA 2018; 2017). The countries that increased in arable land designated for GM crops in 2018 were: Brazil (1.1 million hectares), Paraguay (800,000 hectares), Argentina (300,000 hectares), India, and Uruguay (200,000 hectares respectively), China, and Mexico (100,000 hectares respectively) (ISAAA 2018). While less income countries such as; Mexico expanded by 100 % in GM cotton area, followed by Paraguay and Sudan (27 %), Uruguay (18 %), a small increase in arable land occurred in China (4 %), India and Brazil (2 % respectively), and Argentina (1 %), meanwhile high income countries were decreasing areas used for GM crops: Canada (4 %), Australia (1 %), and small decline in Spain and Portugal (ISAAA 2018). It is expected that the trend of increasing GM crops production in less income countries is going to continue due to more countries in Africa and Asia are adopting GM crops (ISAAA 2018). In 2018, a total of 26 countries, 21 less income and 5 high income countries, planted GM crops. USA grew GM crops on 75 million hectares (39 % of global total), Brazil grew GM crops on 51.3 million hectares (27 %), Argentina grew GM crops on 23.9 million hectares (12 %), Canada grew GM crops on 12.7 million hectares (7 %), India grew GM crops on 11.6 million hectares (6 %), Paraguay grew GM crops on 3.8 million hectares (2 %), China grew 2.9 million hectares GM crops on (2 %), Pakistan grew GM crops on 2.8 million hectares (1 %), South Africa grew GM crops on 2.7 million hectares (1%), and Uruguay grew GM crops on 1.3 million hectares (1 %) (Table 2) (ISAAA 2018). Indonesia and Eswatini planted GM sugarcane as the two new less income countries in 2018, adding 1,565 hectares to global arable soil used for GM crops. From high income countries, only USA and Canda used 1,0 Mha for GM crops growing, while from less income countries, same amount of arable land for GM crops was designated in Brazil, Argentina, India, Paraguay, China, South Africa, Pakistan, and Uruguay. A total of 18 GM mega-countries (countries which grew 50,000 hectares, or more, of GM crops) was recorded in 2018 (ISAAA 2018). Even if Europe have some representation in the GM crops production, it does not stand as a major producer of GM crops, in contrast with other world areas. The EU grows only GM maize (MONO810) with Spain being the largest producer, however, there is also trend of new countries joining in with GM crops production, as the Czech Republic started its GM crops cultivation in the year 2005 (Moschini 2008; ISAAA 2018). The reason EU have low impact on GM crops production can be explained by its restrictive regulations which can also have an impact on the future potential of biotechnology in EU (Moschini 2008). The table below shows top 5 countries that are producers of GM crop in 2018 (Table 2).

Table 1: TOP 5 countries producing GMO crops on global market in 2018

Country	**Mha**	**Share (%) from globally used arable land for GM crops production.**	**Crops**
USA	75.00	39	maize, soybean, cotton, canola, sugar beet, alfalfa
Brazil	51.00	21	papaya, squash, potato
Argentina	23.90	12	soybean, maize, cotton
Canada	12.70	7	canola, maize, soybean, sugar beet
India	11.60	6	cotton

Sources: ISAAA 2018

2.3. Global import and newly accepted genetically modified crops

Since 1996, total of 70 countries (26 actively growing GM crops and 44 that do not grow GM crops) adopted 30 GM crops for food, feed, and cultivation in 2018. Japan adopted the highest number of new crops (11) for import for food, feed, and processing (Table 4). There is increase in approvals for GM crops granted. From total of 4,349 in 1992 to 2,063 of GM food crops, 1,461 of GM feed crops and 852 of GM cultivation crops approvals in 2018. (ISAAA 2018, GMOA 2021).

The most imported GM crops were maize (14 countries), soybean (11 countries), cotton (8 countries) and canola (7 countries). 7 countries also approved newly created variations of GM crops, such as DHA canola, stacked IR and IR/HT cotton, drought resistant potato, DHA safflower, HT and PQ soybean, IR sugarcane, single IR cotton, and IR/HT maize (ISAAA 2018, GMOA 2021).

The new countries from less income world which approved and planted GM crops in 2018 were Indonesia (drought tolerant sugarcane) and Eswatini (IR cotton). Also, Ethiopia approved GM cotton for planting in 2020, and Nigeria approved 17 GM crops variations (1 cotton, 20 maize, and 6 soybean) for food, feed, and processing imports. From high income world, in Australia, Canada, New Zealand and the USA the hemipteran insect resistance cotton was approved and isoxaflutole herbicide tolerance cotton GHB811 was approved in Australia, Canada, Japan, New Zealand and in the USA (ISAAA 2018, GMOA 2021).

2.4. Legislative of genetically modified organism

Policymaking in the Agro-biotech field is a paradigmatic area in which substantial uncertainty constrains new technology developments. Indeed, when risks are unknown, risk regulation becomes complex and risk analysts often search for simple rules to guide decision-making. One of those rules is that of "*erring on the side of caution*" or "*absence of risk is not the same as risk of absence*" (ERSC 1999). Production, sale and safety of GM food and feed on market is regulated by both international and national laws. These laws are ensuring, that no health or environmental risks are present when GM is presented in food and feed production. Countries have set up their own biosafety regulations in order to facilitate production and entry of biotech crops from outside sources. Biotech crop approval is not synchronised in international scale (ISAAA 2018).

The European Union implemented several Directives and Regulations. Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC. (OJ L 106, 17.4.2001, p. 1) is specifying conditions under which GMO or GM food can be produced and sold on market within EU. These conditions are assuring that there is no health risk to the consumers nor risk for the environment. Regulation (EU) 2019/1381 of the European Parliament and of the Council of 20 June 2019 on the transparency and sustainability of the EU risk assessment in the food chain (OJ L 231, 6.9.2019, p. 1) is specifying the conditions of the environmental risk assessment and considering the experience gained in the environmental risk assessment of genetically modified plants (Eur-Lex 2021). Commission Directive (EU) 2018/350 of 8 March 2018 amending Directive 2001/18/EC of the European Parliament and of the Council as regards the environmental risk assessment of genetically modified organisms (OJ L 67, 9.3.2018, p. 30) is allowing to EU member states to restrict or ban GMO cultivation in their territory (Eur-Lex 2021). Directive (EU) 2015/412 of the European Parliament and of the Council of 11 March 2015 amending Directive 2001/18/EC as regards the possibility for the Member States to restrict or prohibit the cultivation of genetically modified organisms (GMOs) in their territory. (OJ L 68, 13.3.2015, p. 1) is establishing legal provisions for ensuring the traceability of GMOs through the food and feed chains (Eur-Lex 2021). Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC. (OJ L 268, 18.10.2003, p. 24) establishing precise identification of each GMO product available at EU market (Eur-Lex 2021).

The Czech Republic, as an EU Member State, applies the applicable EU laws concerning GM in food and feed production and also implements its own laws: "Zákon č. 78/2004 Sb." this law incorporates the relevant regulations of the European Union, at the same time follows the directly applicable regulations of the European Union and regulates the rights and obligations of persons and the powers of administrative authorities in the handling of genetically modified organisms and genetic products; than the decree "Vyhláška č. 89/2006 Sb." specifying the distances between parts of soil blocks in the cultivation of genetically modified varieties, the minimum distance from the state border when growing a genetically modified variety; the deadline for providing information before the cultivation of genetically modified varieties is expected to start; the scope of providing information on the cultivation of the genetically modified variety and the extent of sowing of the genetically modified variety with the same non-genetically modified crop; followed by decree "Vyhláška č. 209/2004 Sb." specifying the requirements and risk assessment procedures for the introduction of GMOs into agriculture (eAgri 2021; PK ČR 2021; ICBP 2021).

In 2010 Bolivian president proposed a 5-year program to completely ban GMO production in Bolivia and in 2012 Bolivian government implemented the Mother Earth law banning GMO seeds but only for crops indigenous to Bolivia (such as potatoes and quinoa) but allows transgenic varieties for non-native crops (GRICCE 2012.). In 2016 Supreme Decree 2735 is instructing that all food which includes genetically modified organisms (GMOs) must be labelled with a symbol and a warning that it contains transgenic food. Article Four of the decree declares: "All foods that are produced, manufactured, imported and commercialized inside the country which contain or are derived from GMOs are obligated to show a notice that they were transformed." A symbol (red triangle with the letters GMO and the text: "Genetically modified organism") to notify consumer that package contain GM food (Lexi Vox 2021). Furthermore in 2020 the Supreme Decree 4232 was issued which authorises National Biosafety Committee to establish an abbreviated evaluation procedure for GM crops to address the country's internal food supply as well as agricultural products for export. This decree also authorises ministries of Environment and Water, and of Rural Development and Lands to consider the actions and measures taken by Bolivia's neighbouring countries when developing agricultural and food products using the GM technology (Lexi Vox 2021).

2.5. Genetically modified food and food security

Food security implies the physical, social and economic access to sufficient, safe, nutritious food to maintain a healthy and active life and to cover dietary needs and food preferences by all people at all times (World Food Summit 1996; Pinstrup-Andersen 2009).

Human population is predicted to reach 9 billion within next decades (UN 2021) which is of urgent concern as already populations in developing countries are facing hunger and starvation; 690 million people suffer from hunger (UN 2021; World vision 2020; WFP 2020) and it is estimated that this number will increase to 840 million by 2030 (WFP 2020). In 2019 10.5% (more than 780,000,000 people) of global population was threatened by severe food insecurity. This number increased by 2.3% compared to 2015 and is still growing (WB 2021).

The solution for keeping up with feeding the increased global demand for crops is to boost the crop yields on currently cultivated land. So far, the rate of increase in crop-yield is less than 1.7 %, but the annual increase in yield needs to be 2.4 % to meet the demands of population growth and improved nutritional standards, but this is highly limited by availability of arable land and water resources (Ray et al. 2013; Le Mouël & Forslund 2017; FAO 2021) as modern intensive agriculture; as primary source of food, is the burden on environment, causing drinking water contamination, soil degradation, erosion, air pollution and biodiversity reduction (Frison et al. 2011; FAO 2021). These problems are caused as large farms are specialising in few livestock breeds and few species of crops which are grown or bred in monoculture of genetically uniform individuals. Large fields reducing the extent of field margins and, also hedgerows with reserves of biodiversity. This also leads to loss of soil organic matter that degrades the productivity of the soil. Further increase loss of genetic material is expected due to the increase in monocultural production of biofuels; such as sugarcane, maize, and soybean and, also oil crops such as oil palm and by increased production of non-food products like coffee (Jacobsen et al. 2003; Jacobsen 2011).

Increased access to genetic resources will be caused by increased food production to cover demand for food by expanding human population while being faced with anticipated climate changes (Marrone 2013). It is expected that further changes in agriculture will lead to increasing demand for non-food crops and breeds, including their wild relatives, to provide genes necessary to cope with changes in agricultural production (Huang et al. 2002; Welch &

Graham 2004; Conner & Mercer 2007), as conventional breeding relies on sexual crossing of one parental line with another parental line, in hopes of expressing some desired property (e.g. higher yield) (Oliver 2014) which means that conventional breeding relies on genetic pool resources, which are being depleted and decreased due to environmental destruction. The process of conventional breeding also takes several years before desired gene expression is achieved (Oliver 2014).

GM food provide an option how to fulfil increasing demands for food (Muzhinji 2020; Nilsen & Anderson 2011) as agricultural biotechnologies offer a possibility to improve crops especially traits that are lacking in crop genomes, and significantly fasten the process of breeding new crops (Philips 2008; WHO 2014; Muzhinji 2020; Wieczorek 2003; Singh 2011). The primary support for agricultural biotechnology itself is the identification 'progress' that is, universally, there is a historical claim that genomic technology and transgenic crops represent 'progress for humanity'" (Bridge et al. 2003). Therefore, the adaptation of GM crops globally has had enormous benefits to the environment, health of humans, animals, and contributions to the improvement of socio-economic conditions of farmers and the general public. The global economic gains contributed by biotech crops in the last 21 years (1996-2016) have amounted to US$186.1 billion economic benefits to more than 16 to 17 million farmers. GM crops have contributed to food security by increasing crop productivity by 657.6 million tons valued at US$186.1 billion in 1996 2016; and 82.2 million tons valued at US$18.2 billion in 2016 alone; conserving biodiversity in 1996 to 2016 by saving 183 million hectares of land, and 22.5 million hectares of land in 2016 alone; providing a better environment – by saving on 671 million kg. of pesticides in 1996-2016, and by 48.5 million kg in 2016 alone from being released into the environment; – by saving on pesticide use by 8.2 % in 1996-2016, and by 8.1 % in 2016 alone; – by reducing EIQ (Environmental Impact Quotient) by 18.4 % in 1996-2016, and by 18.3 % in 2016 alone 95 % of whom come from developing countries. Helping alleviate poverty through uplifting the economic situation of 16-17 million small farmers, and their families totalling 65 million people, who are some of the poorest people in the world (Brookes and Barfoot, 2018). Thus, GM crops can contribute to a "sustainable intensification" strategy favoured by many science academies worldwide, which allows productivity and production to be increased on the current 1.5 billion hectares only of global crop land, thereby saving forests and biodiversity. GM crops are essential but are not a solution, and adherence to good farming practices such as rotations and resistance management, are a must for GM crops as they are for conventional crops (ISAAA 2018).

As the prevalence of food insecurity in the global population continues to increase, this only paves way for more research in the field of GM foods and products to aid in food security with the growing population. When all these facts are taken into account, GM in food production do have a potential to provide an optional strategy to achieve sustainable global food security.

2.6. Benefits and risks of genetically modified food

The growing use of GM products in the food market confirms that GM plants and animals brings benefits. Improving the agronomic, technological, or utilitarian properties of food is increasing the use of GM food (Kondratowicz et al. 2009; Kosicka-Gębska & Gebskij 2009; Mickiewicz et al. 2009; Yonekura & Saito 2006).

Benefits

Changing the chemical composition of food products through GM enriches transgenic foods with specific food products, which leads to a much higher utility value than traditional foods. Foods modified in this way provide a concentrated source of nutraceuticals, or substances with high therapeutic and health value, which are a desirable element of a differentiated diet. These are mainly vitamins A, C, E, plant pigments, essential unsaturated fatty acids, alimentary cellulose, pre - and probiotics (Kosicka-Gębska & Gebskij 2009; WHO 2014; Wieczorek 2003; Singh 2011; Nilsen & Anderson 2011; USDA 2021). A well-known example of such enhanced GM food is the Golden Rice, the genome of which was modified by the introduction of additional copies of genes conditioning the synthesis of provitamin A, Carotenoids, including, among other, β-carotene, vitamin A and its provitamin, represent a group of biologically active compounds responsible for normal sight and body resistance (Hug 2008; Qaim 2010; Key et al. 2008). Subsequently, adjustments were made to increase the level and bioavailability of iron in the Golden Rice. As a result, the Golden Rice has helped reduce malnutrition due to its high nutritional value and low price (Yonekura & Saito 2006; Falk et al. 2002; Brookes & Barfoot 2020). Other modifications of traits have been made in transgenic foods, especially with a focus on changing the content of specific proteins, lipids, and carbohydrates. The enrichment of these food components in GM foods has led to an improvement in the nutritional value of individual products. In particular, the altered profile of amino acids, lysine, methionine, cysteine and tryptophan has made plant varieties with low levels of these nutrients a source of exogenous proteins. This can be demonstrated in sweet lupine cultures enriched with other methionine molecules (Kondratowicz et al. 2009). GM also improved the structure of alimentary lipids. An increasing share of saturated fatty acids, paralleled by a decreasing consumption of mono- and polyunsaturated fatty acids, led to enhancing the natural composition of oil plants. For example, soybean varieties with a few-fold increased content of oleic acid and varieties of rape rich in stearic acid free of unfavourable effects for health (Kondratowicz et al. 2009; EMBO 2004). GM in products also influence changes in the composition of carbohydrates. Such example is the GM potato variety; Amflora. This potato has increased production of amylopectin, saccharide used widely in the production of starch, paper, and in the processing of textiles. Although the Amflora potato was permitted to be grown in European countries exclusively for industrial purposes, nevertheless it induced a widespread protest from society (Bagwan et al. 2010; Zeeman et al. 2010).

Farmers in 1996–2012 generated more than 370 million tons of food crops. One-seventh of the yield was generated by GM crops in the USA. To generate same increase in yield as produced by GM crops, it is estimated that an addition of more than 300 million acres of conventional crops would have been needed (Brookes & Barfoot 2020; James 2005). These additional 300 million acres would necessarily be lands requiring more fertilizer or irrigation or carved out tropical forests. Such conversion of land would generate serious ecological and environmental stress to the world (Brookes & Barfoot 2020). Economical gain from GM crops generated by first 21 years (1996 – 2016) of GM crops commercialization generated a total of US$186.1 billion (Brookes and Barfoot, 2018). In 2016 alone, the six countries that gained the most economically from GM crops were: the USA (US$7.3 billion), Brazil (US$3.8 billion), India (US$1.5 billion), Argentina (US$2.1 billion), China (US$1 billion), Canada (US$0.82 billion), and others (US$1.8 billion) for a total of US$18.2 billion (Brookes and Barfoot, 2018). Less income countries benefited from GM crops' production by US$8 in 2016 (Brookes and Barfoot, 2018).

Genetic engineering techniques enable the expression of viral or bacterial antigens in the edible portion of plant cells (Ellstrand & Hancock 1999; Hare & Chua 2002; Schafer et al. 2011). Therefore, in theory, GM foods could serve as oral vaccines, capable of stimulating the immune system, via mucosal immunity, to produce antibodies. A variety of crops (e.g., rice, maize, soybean, and potatoes) are under study as potential bearers of edible vaccines against different infections, including *Escherichia coli* toxins, rabies virus, *Helicobacter pylor*i bacteria, and type B viral hepatitis (Nicolia et al. 2014; Ellstrand & Hancock 1999; Hare & Chua 2002; Schafer et al. 2011; Aggarwal 2012; Reichman et al. 2006).

Crops modified to pests and diseases resistance reduced pesticide usage by 37 % and environmental impact (insecticide and herbicide use) by 18 % (Klümper & Qaim 2014; Brookes & Barfoot 2020). It also reduces farmer pesticide poisonings, an example of this reduction of farmer pesticide poisonings have been quantified in China, India, Pakistan, and

South Africa. In South Africa, farmers reduced pesticide applications from 11.2 per year to 3.8, with reported cases of pesticide poisoning declining from over 50 poisoned farmers per year to less than 10 poisoned farmers over the first 4 years of GM cotton adoption (Bennet et al. 2003). One third of non-GM cotton farmers in China reported cases of pesticide poisoning, compared with 9 % of GM cotton-producing farmers (Hossain et al. 2004). Data in India revealed a reduction in cases of pesticide poisoning of 2.4 – 9 million cases of poisoned farmers per year from minimum of 38 million poisoned farmers per year, with upper potential to 144 million poisoned farmers per year (Kouser and Qaim 2011).

Risks

Although there is little to no evidence from scientifical studies, that these risks are real (Wieczorek 2003), concerns about the risks of GM foods are raised by uncertainties concerning the potential hazardous effect of GM foods on human health and environmental safety in wider society. This can be attributed to difficult explanations provided by scientific community; concerns about the improper distribution of GM foods, ethical principles, and adequacy of evaluation of the GM foods (Domingo 2007; Ekici & Sancak 2012).

One of the concerned threat of GM foods is the possibility of gene escaping and crossbreeding, which can lead to creation of super weeds, which will become difficult to control and, also creating ecological imbalances or disasters. The probability of this happening is extremely low, but it is not inconceivable. The resistance to a specific herbicide does not mean that the plant is resistant to other herbicides, so such weeds could still be controlled with other products. Besides, lot of crops are not capable to survive without human interfering by providing fertilizers to plant (WHO 2014; Wieczorek 2003; Singh 2011; USDA 2021).

Another concern is loss of biodiversity by introduction of GM crops. Similar concerns were raised in the past century, which led to extensive efforts to collect and store seeds of as many varieties as possible for all major crops. Collected samples were then maintained and used by plant breeders globally. Modern biotechnology increased knowledge of genes expression and importance of preserving of genetic material, therefore agricultural biotechnologists also want to make sure that there is maintenance of genetic diversity of crop plants needed for future. While concerns are that GM crops will push other crops from market due to low prices, the USA markets for specialty crop varieties and locally grown produce appear to be expanding rather than diminishing. Thus the use of GM crops is unlikely to negatively impact biodiversity (WHO 2014; Wieczorek 2003; Singh 2011; USDA 2021).

An additional concern is about the possibility of insect-resistant plants might increase the number of minor pests while reducing the major type of pest. This mean that the pest population might shift from those put-off by the engineered plants to other, undaunted species. This shift might start a pervasive disruption of the entire food chain, with new predators of the new insect species (Bawa & Anilakumar 2013). Other concerns are about increased risk of allergies connected to consumption of GM foods due to increased production of secondary metabolites in crops or introduction of new allergens into another crops or food. Also, proteins obtained due to GM are thought to carry an allergizing potential if its sequence is homologous to another, defined allergen, inducing unfavourable immune body reactions (Bernstein et al. 2003; Ladics et al. 2011). This can lead to triggering immune system response in case of exposure to enormous amount of these secondary metabolites (WHO 2014; Wieczorek 2003; Singh 2011; USDA 2021). Another concern is antibiotic resistance, as antibiotic resistance genes are used to identify and trace a trait of interest that has been introduced into plant cells. These genes are used to prove that gene insertion was successful, but it also creates concerns about possibility to enhance antibiotic resistance in bacteria, even though possibility of transferring plant genes into bacteria itself is quiet low (WHO 2014; Wieczorek 2003; Singh 2011; USDA 2021). Most farmers using hybrid varieties (mostly in high income world) are buying fresh seeds each season, as anyone who is growing hybrid varieties must buy new seeds annually as seeds from last year´s hybrids grown on the farm will not produce plants identical to the parental line, which could lead to a decrease in production quality. Therefore, hybrid seeds are genetically engineered to have seeds with poor germination. This is forcing farmers to buy new seeds for each season, instead of saving them from previous season. This is a serious issue among farmers practicing saving seeds from last season, such as organic farmers or farmers in less income countries. As farmers cannot use newly grown seeds and thus take advantage of improvements brought by genetic engineering without being brought into the economic cycle that profits the seed companies, but without profit, these companies are unlikely to invest in crops improvements such as better seeds germination (WHO 2014; Wieczorek 2003; Singh 2011; USDA 2021).

2.7. Attitudes towards genetically modified food and genetically modified organism

Allport (1935) stated that "the concept of attitude is probably the most distinctive and indispensable concept" in social psychology. An attitude refers to a set of emotions, beliefs, and behaviours toward a particular object, person, thing, or event, often as the result of experience or upbringing; it is a learned tendency to evaluate things in a certain way. Such evaluations are often positive or negative, but they can also be uncertain at times (Albarracin et al. 2021; Cherry 2021). Attitudes are proven to have a powerful influence over behaviour. While attitudes are enduring, they can also change (Albarracin et al. 2021; Cherry 2021).

Consumers attitudes determine the extent of expansion of GM in the food development and production (Nilsen & Anderson 2011). The attitude formation towards the product is based on knowledge about the product itself and its attributes, which is referred to as the so-called "bottom-up" formation of attitudes (Grunert et al. 2003). However, attitudes do not depend only on one specific belief alone but rather in a handful of them. A more detailed model of how attitudes are formed by consumers towards GMO and GM foods has been developed recently (Bredahl et al 1998). This model considers that GMO and GM food technology is defined by a weighted sum of attitudes towards each product and its corresponding process. Therefore, each attitude also depends on the overall perceived risk and benefit associated with the product and process (Bredahl et al 1998). Studies about factors influencing consumers attitudes towards GMO and GM food are mentioned in Table 5.

Knowledge and education

Knowledge about a specific GM product and the underlying production process are important during creating consumers attitudes. There is a direct and positive relation between an increasing knowledge of GM technology and an increasing support to GM applications (Li et al. 2002; Moerbeek & Casimir 2005; Boccaletti & Moro 2015; Hwang & Nam 2021; House et al. 2004; Onyango et al. 2004). Also, when comparing knowledge of experts with wider public, results shows that experts perceive less or different risk for all GM applications than the public (Savadori et al. 2004; Madsen & Sandøe 2005). One of the main reasons for the low acceptance of GM food products is the "scarce knowledge" that individuals have about this topic. Those with a higher knowledge are more likely to buy these products (Boccaletti & Moro 2015; Li et al. 2002). The consumers' knowledge of the science of genetic engineering influences the formation of attitudes about GM foods. The general public has little information about genetic engineering. In a nationally representative survey in the USA in 2013, 54 % of people said they knew "very little" or "nothing at all" about GM foods, and 25 % were unaware of the existence of GM foods prior to the survey (Hallman et al. 2013). It has been confirmed that increasing specific knowledge is increasing the acceptance of genetic engineering among the general public, as the general public opposes new technologies, such as genetic engineering, mainly because they do not understand them (Hallman et al. 2003; House et al. 2004; Klerk & Sweeney 2007). Some studies distinguish between two types of knowledge: objective and subjective. Objective knowledge can be defined as the real knowledge people have about GMO while subjective knowledge refers to what consumers think they know about GMO. Subjective knowledge is clearly related to general attitudes and values. Both types of knowledge are important in the process of creating attitudes towards GMO. Although both subjective and objective knowledge are measured, each type of knowledge exerts different influences (House et al. 2004). Some studies find effects only through subjective knowledge (House et al. 2004) and others only through objective knowledge (Zhang & Liu 2015). Subjective knowledge appears to be related to acceptance and objective knowledge seems to be less related (House et al. 2004; Lusk et al. 2004). In terms of being influenced by new information, individuals with higher levels of subjective knowledge were less likely to be influenced (Lusk et al. 2004). Subjective knowledge is also related to consumer location (House et al. 2004). Results of some studies suggests that consumers with higher education (university/college) are most likely to consume GM foods due to higher level of knowledge about GM foods (Hwang & Nam 2021; Onyango 2004). Also, a potentially negative relationship between biology knowledge and attitudes towards GM foods have been identified, suggesting that the relationship between knowledge and attitudes is complex and context-specific (Allum et al. 2011).

Perceived risks and benefits

Research on attitudes towards GM foods has focused on rational predictors of resistance to GM foods, including perceived risks and benefits, (lack of) knowledge, (lack of) confidence in science and (lack of) trust in institutions (Siegrist 1999; Gaskell et al. 2004; Moon & Balasubramanian 2004; Costa-Font et al. 2008). Consumers tend to develop what is known as a lexicographic process, where a product attribute (risk or no-risk) dominates the decision. Respondents use so called expected utility method, which consists of a combination of all the possible costs and benefits to create attitudes towards GM technology and products

(Gaskell et al. 2004). A large body of research has focused on perceived risks, which are likely to give rise to anti-GMO attitudes. The general public perceives GM foods as very risky (Gaskell et al. 2010; Hallman et al. 2013) which is contrary to the scientific consensus (Wieczorek 2003; Kramkowska et al 2013). The perceived risk was repeatedly the reason for the emergence of negative attitudes towards GM foods by the general public (Siegrist 2000; Moon & Balasubramanian 2001, 2004). Some studies have found that the general public's risk perception of GM foods outweighs the perception of benefits (Moon & Balasubramanian 2001, 2004), perceived risk is the reason for negative attitudes towards GMO´s (Siegrist 2000; Moon & Balasubramanian 2001, 2004). The absence of benefits from GM foods directly for the consumer is also linked to the emergence of negative attitudes towards GM foods (Siegrist 2000; Bruce Traill et al. 2006). Consumers are more likely to reject GM crops if not provided with any direct, tangible benefits, so perceiving the benefits may predict consumers' attitudes toward GM foods (Moerbeek & Casimir 2005; Bruce Traill et al. 2006; Gaskell et al. 2004). Also, according to meta-analysis of consumers´ willingness to pay valuations, the consumers are interested in buying GM foods if offered direct benefits to the consumer (Lusk et al. 2005). There is also suggestion, that risk and benefit perceptions are negatively, but not perfectly correlated, and that benefits are more important than risks in the determination of consumers´ willingness to consume GM foods (Traill et al. 2006). On the other hand, benefits connected with consumption positively influences the attitudes of consumers towards GMO´s (Siegrist 2000; Bruce Traill et al. 2006).

Trust in science and institutions

Another important predictor of attitudes is trust in the institutions handling genetic engineering technology and providing information, such as industry, government regulatory bodies, and scientific institutions. In this case, the effect of trust on attitudes is likely to be indirect, via risk and benefit judgments. That is, if laypeople feel that they know little about gene technology, they may rely on other institutions to manage the risks. If those institutions are trusted, the technology is not considered risky. Some empirical support for this indirect role of trust comes from models suggesting that trust alters risk and benefit perceptions, which in turn affect overall attitudes toward GM foods (Siegrist 1999, 2000). GM crop industry and government are considered less trustworthy than consumer organisations, environmental groups, and scientists by wider society (Bredahl et al., 1998; Onyango et al., 2003; Savadori et al., 2004). In the EU, the most trusted are doctors, university scientists, consumer organisations and patients' organisations, followed by scientists working in the industry, newspapers and magazines, environmental groups, shops, and farmers. Governments and industry are the least trusted (Gaskell et al., 2003). A cross-country comparisons between the USA and the EU revealed that Americans have more favourable and trusting attitudes towards GM technology than Europeans (Traill et al. 2004). Individuals seem to more strongly accept the risks reported by environmentalists than the benefits reported by industry and government (Traill et al. 2004).

Moral Values

Personal attitudes towards risks and benefits of genetic engineering may follow from pre-existing general attitudes toward genetic engineering or toward scientific innovations in general, rather than just independently determining them (Finucane 2000; Siegrist 2006; Costa 2007). Evidence shows that for some people, GM food is a moralized issue for which individuals base their opposition on moral convictions about the process of genetic engineering. Studies about moral values that influences attitudes toward GM foods have found that most Americans (64 %) were opposed to GM plants and animals and that a majority of these opponents (71 % of those opposed, i.e., 46 % of the entire sample) were moral absolutists. Moral absolutists thought genetic engineering should be prohibited "no matter how great the benefits and minor the risks from allowing it"—that is, they treated their opposition as absolute, a hallmark of moral values (Scott 2016). Moral judgments about genetic engineering (e.g., it is an immoral risk, the degree of moral acceptability) help account for overall risk perceptions and attitudes even when accounting for demographics and other risk-perception variables (Sjöberg 2004; Tanaka 2004).

For these opponents, the process of GM itself appears to violate some basic moral principles such that it is unacceptable regardless of the consequences, quantity, or context (Scott 2016). Nevertheless, whenever consumers are given correct information, they are more willing to pay higher prices in order to benefit from quality improvements, which may indicate that, regarding the acceptance of GM foods, practical reasons often prevail over ethical considerations (Boccaletti &Moro 2015). However, it is not clear, how moral values are predicting attitudes towards GM foods. Some investigators have found that moral concerns do not predict attitudes, when applied with other factors (Spence & Townsend 2006), or that moral concerns and risks perception should be considered as the same (Moon et al. 2007).

Reference group

Reference group also create and shape consumers attitudes toward GM foods. Most consumers hear about GM foods through media sources (Kahan 2011). These communication channels may attenuate or amplify risk perceptions (Kahan 2011) through different processes, such as framing; the spiral of silence, in which the minority is less willing to express opinions for fear of isolation, which over time establishes the majority opinion as the social norm (Nisbet 2006; Scheufele 2007). Another important referent group is family and friends. In study from the Czech Republic (Brosig & Bavorova 2019), respondents from the Czech Republic, Ukraine and Russia were examined. Results showed that young adults are influenced by the perceived attitudes of their parents and friends. Parents have more important role in creating of young adults attitudes about GM foods, than their best friends (Brosig & Bavorova 2019).

Place of living

Social influence is a key aspect that is relevant in the formation of personalities across the globe. Social influence is the concept of how traditions, customs, lifestyles, and daily practices in a locality can directly impact societal norms. These aspects of society can affect people's attitudes and behaviours (Rentfrow & Jokela 2016). Evidence from study by Trail et al. (2006) proves that geolocation do influence consumers attitudes towards GM food, as nearly half of respondents overall and in each region except Grenoble see GM technology as having both high benefits and high risks. The percentage of respondents that had sceptical opinions (high risks, low benefits) was high in France, moderate in Reading and Long Beach, and lowest in Lubbock (Texas) (Trail et al. 2006) and respondents from EU have higher objective knowledge than respondents from USA (Gaskell 200). Significant relationship between subjective knowledge and location was reported in study comparing EU and USA (House et al. 2004).

Food neophilia

The consumers are interested in new and interesting foods; therefore, market news might experience higher consumption stimulation for its novelty (Fenger et al. 2015). New foods have higher probability of being tried by the consumers to explore the taste, quality, and sensory attributes (Ha & Jang 2013). Such a tendency is recognised as a food neophilia (Giordano et al. 2018); it increases the consumers tendency to adopt market news (Tuncdogan

& Ar 2018) and support creation of an attitudes which can evolve the consumers interest to try the market news (Giordano et al. 2018). The neophilic consumer is considered to be a better judge of taste and hedonic perspectives of food as they search new and better food options for sensory and sensational satisfaction (Trijp & Kleef 2008; Fenger et al. 2015).

Gender

Several studies have shown that females are more likely to have more negative attitudes towards GM food compared to males (Costa & Mossialos 2005; Frewer et al. 2002; Hallman et al. 2003; Hwang et al. 2005). Some feminists have argued that because female bear responsibility for childbearing and rearing, they are somehow closer to nature, hence creating a more humane, subjective, and ‘empathetic’ science, sensitive to female’s values (Cutcliffe 2000). This theory was proven as when comparing masculinity index with the environmental sustainability index, negative relationship was found. Countries that scored high on masculinity index scored low on the environmental sustainability index (Hofstede 1998; Esty et al. 2002). Females were more likely to report avoiding foods with negative health image (Beasley et al 2004), female consumers are less willing to consume transgene food than males (Hossain & Onyango 2004).

Table 2:Factors influencing consumers attitudes towards GMO and GM food

Factors	Key findings	Author
Knowledge and education	GM food acceptance and knowledge of environmental science have potentially negative relationship.	Allum et al. 2011
	Consumers with higher knowledge are most likely to buy GM products.	Boccaletti & Moro 2015
	Attitudes of wider society towards GM products changed to more positive when receiving more information.	Hallman et al. 2003/2013
	Increased levels of subjective knowledge significantly increased willingness to accept GM products.	House et al. 2004
	Consumers who lack education and proper knowledge regarding GM foods may have a distorted perspective about them.	Hwang and Nam 2021
	Increased knowledge about the history, process, and scientific risks and benefits of GM foods seems to reduce concerns about the taste and quality benefits, as well as allay feelings of anxiety about the purchase of GM foods.	Klerk & Sweeney 2007
	Higher levels of consumers' self-reported knowledge increase their willingness to buy.	Li et al. 2002
	Subjective knowledge was a significant determinant of how willing consumers were to eat GM food products.	Lusk et al. 2004
	Experts generally tend to believe that there is to be no cause for concern about health issues connected to GM food consumption.	Madsen & Sandøe 2005
	More knowledge leads to more acceptance of GM food.	Moerbeek & Casimir 2005
	Consumer acceptance of GM food critically depends their education and actual knowledge on GM food.	Onyango 2004
	Consumers' objective knowledge rather than subjective knowledge plays an important role in the formation of consumer's attitudes to GM foods in urban China.	Zhang & Liu 2015
Trust in science and institutions	Consumer acceptance of GM food critically depends on their trust in the government, biotech industry, and medical professionals.	Onyango et al. 2003
	Biotech industry and government are considered les trustworthy than environmental groups and scientists by wider society.	Bredahl et al. 1998
	Information provided by research institutes and environmental groups was trusted the most.	Savadori et al. 2004
	Trust in institutions or persons doing genetic modification research or using modified products is the most important factor influencing perception of gene technology.	Siegrist 2000,1999
	Those who trusted government sources were more accepting towards GM food than those who trusted activist sources were less accepting.	Traill et al. 2004
	Government is the less trusted institution in providing information about GM food.	Gaskell et al. 2003

Table 3:Factors influencing consumers attitudes towards GMO and GM food, extension

Factors	Key findings	Author
Moral values	Practical reasons often prevail over ethical considerations about GMO.	Boccaletti & Moro 2015
	Moral values influence willingness to buy GM food.	Moon et al. 2007
	The use of gene technology in the food industry was judged as morally less acceptable than for medical use.	Sjöberg 2004
	High degree of correlation between the factor of trust in enterprises and researchers and the factor of sense of bioethics was found.	Tanaka 2004
Source of Information	Parents have important role in creating of young adults' attitudes about GM food.	Brosig & Bavorova 2019
	If consumers referred to online media more frequently, they had a high level of objective knowledge.	Hwang & Nam 2021
	Consumer attitudes towards GM foods are influenced by positive media coverage, those who trusted government sources were more accepting, those who trusted activist sources were less accepting.	Lusk et al. 2004
	Place of living influence respondents' acceptance of GM food.	Traill et al. 2006
	Place of living influences subjective knowledge about GM food.	House et al. 2004
	EU respondents have more objective knowledge about GM food than USA respondents.	Gaskell et al. 2000
Food neophilia	Consumers are interested in new foods.	Fenger et al. 2015
	New foods have high probability of being tried by consumers.	Ha & Jang 2013
	Food neophilia increases the consumers tendency to adopt market news.	Tuncdogan & Ar 2018
	Food neophilia support creation of an attitudes which can evolve the consumers interest to try the market news.	Giordano et al. 2018
Gender	Females are more likely to have more negative attitudes towards GM food compared to males.	Costa & Mossialos 2005
	Females were more likely to report avoiding foods with negative health image.	Beasley et al 2004
	Female consumers are less willing to consume transgene food than males.	Hossain & Onyango 2004

3. Aims of the thesis

The potential of genetically modified (GM) foods is to provide solutions to food safety, but the acceptance of GM foods by individuals depends closely on the perception of risks and benefits that can be generated through knowledge, available information, and confidence in information. The acceptance of GM foods by the general public is influenced by confidence in the information provided by scientists and institutions focusing on GM foods. Therefore, the main aim of the study is to analyse the attitudes to GM food among life sciences university students, particularly focused on comparing attitudes of students from the Bolivia and the Czech Republic. These two countries were selected based on the criteria of comparable number of population, number of tertiary students in population and quality of education. Moreover, both countries allow GM in feed production, however the Czech Republic, unlike Bolivia, is not providing GM in food production.

The study found out if willingness to consume GM food by university students is influenced by students' background particularly: subjective knowledge, their reference group and risks and benefits perception. This thesis intended to close the gap on lack of information about mentioned social influences which may likely influence the attitudes among the university students.

The specific objectives are:

1. To analyse the relationship between the students' knowledge to GMO and their educational background about GM foods.
2. To investigate if trust in science and institutions affects attitudes about GM food of university students.
3. To examine which source of information plays an important role in creating of attitudes about GM food among life sciences university students.

The main hypothesis for the thesis were identified based on previous studies as follows:

- H1: Students with higher self-reported subjective knowledge are most likely to buy GM products (Boccaletti & Moro 2015; Li et al. 2002; Hwang and Nam 2021).
- H2: Students perceive GM food as beneficial (Savadori et al. 2004; Gaskell et al. 2004).
- H3: Student´s acceptance of GM food is related to their trust in information provided by the government (Onyango et al. 2003, Siegrist 2000; 1999).
- H4: Parents as reference group have important role in creating of young adults´ attitudes about GM food (Brosig & Bavorova 2019).

4. Methods

4.1. Research design

This cross-sectional survey-based study was conducted among students at life sciences universities in Bolivia and the Czech Republic. A purposive sampling online questionnaire was distributed among students. Data collection took from November 2021 to January 2022. The study was conducted respecting the GDPR.

Data were collected from 4 universities: Gabriel René Moreno Autonomous University and, University of Saint Fracis Xavier from Bolivia, Czech University of Life Sciences Prague, and Charles University from the Czech Republic. Students that were enrolled in undergraduate and postgraduate programs; in various disciplines of the universities including animal production, plant production, veterinary studies, chemistry, biochemistry, botany, animal physiology and plant physiology were invited to participate in the survey. Life sciences university students were chosen especially for their supposedly high level of knowledge about topic of GMO and GM in food production obtained by the education in compared to other university students. As they most probably will become future specialists about this topic, it is assumed they will become authority in the eyes of wider society, therefore they could influence acceptance of GM in GM food production among lay people (Onyango et al. 2003; Savadori et al. 2004).

Countries participating in this study were based on several criteria such as similar number of populations: Bolivian population reached 11.8 million inhabitants (Nations online 2021), Czech population reaches 10.5 million inhabitants (ECZ 2021), number of tertiary students in population: nearly 9 % of Bolivian (UNESCO 2021) and nearly 5 % of Czech (UNESCO 2021) students are enrolled in tertiary education, and also GM in food and feed production. Law in both countries do allows GM in feed production, but only in Bolivia, GM is allowed in food production.

Based on literature review, factors such as trust, knowledge, and moral values were tested to obtain information how these factors influence willingness to consume GM food among Bolivian and Czech life sciences university students. Set of questions evaluating importance of source of information, trust to source of information, perceived risks and benefits, self-reported subjective knowledge about GM in food production and willingness to consume GM food products were compared among students from both countries (Figure 2).

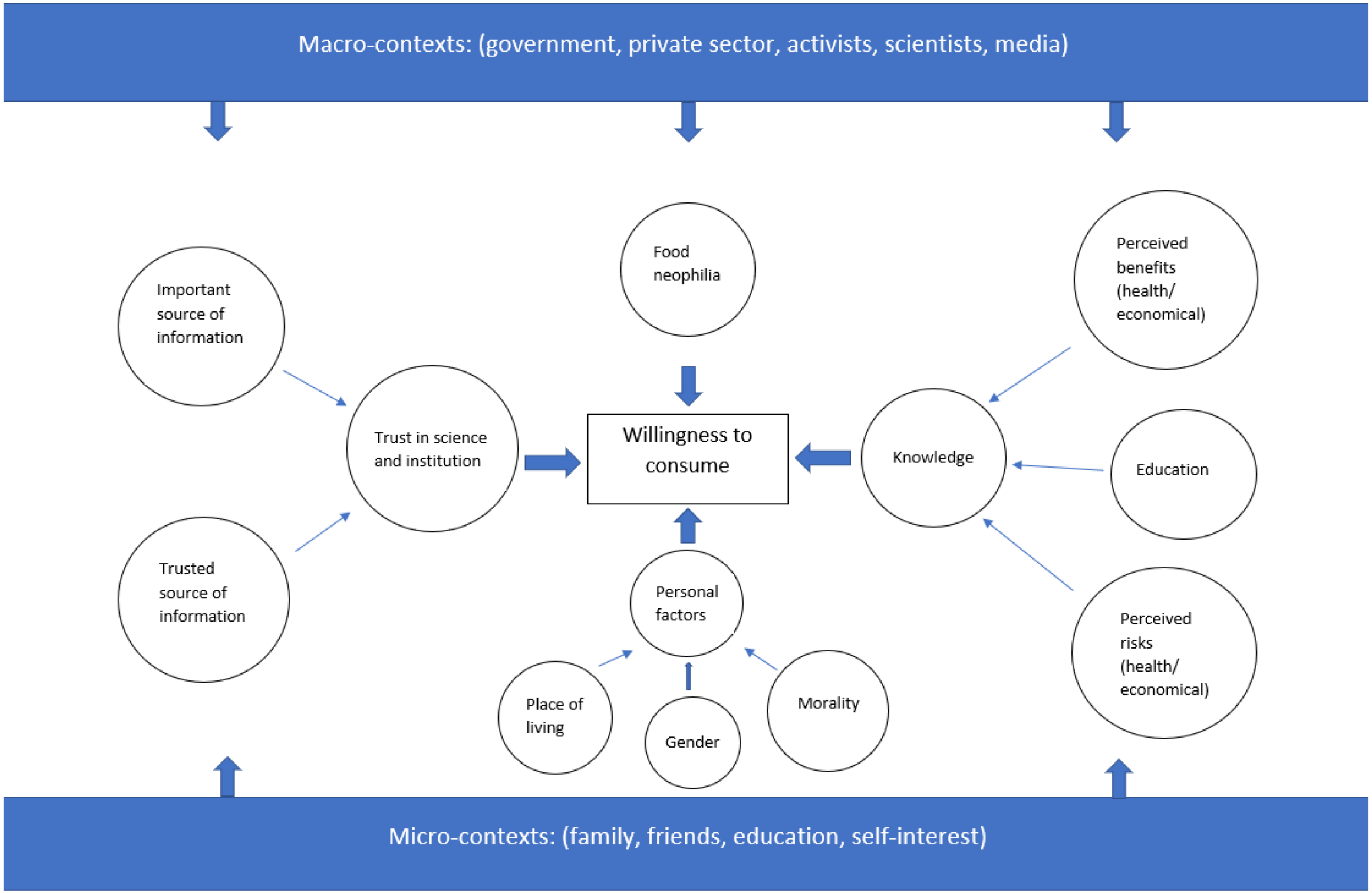

Figure 2: Research concept design

4.2. Questionnaire structure

The online questionnaire was developed using Survivo (for Bolivia) and Google questionnaire (for the Czech Republic) after a review of the current literature. The questionnaire was comprised of four sections. Section 1; which is the first part of the questionnaire; included information about subjective knowledge of participants about GM foods. Participant were asked to rate their awareness about facts and problems regarding GM in food production. Answers options were: ”extremely ignorant”, “ignorant”, “I do not know what it means”, “knowledgeable” and “extremely knowledgeable”. Next followed by set of questions focused on the attitudes and knowledge of participants about GM in food production. Participants were asked if they are willing to consume GM food, if they would welcome greater availability of GM food on the market, if they think that GM in food production is morally wrong and their opinions about the risks and benefits connected to GM in food production, such as: “farms and food businesses could benefit greatly from GM in food production”, “GM in food production will pose risks to agricultural and food businesses”, “GM is essential for improving the quality of food products”, “I am concerned about the lack of knowledge about the long-term effects of GM foods on human health in food production”, “GM food is one possible way to increase global food production”, “There is a high risk that GM in food production will result in new diseases for humans” and “The side effects of consuming GM produced foods are largely unknown”. For each question, participants were to use multiple choice answers. Answers options were: “I definitely do not agree”, “I do not agree”, “I rather do not agree”, “I don´t have a strong opinion”, “I rather agree”, “I agree” and “I definitely agree”. Participants were able to choose only one answer for each question.

Section 2 focused on the most trusted source of information about GM food. Options to choose from were: “activists”, “public sector”, “scientists”, “private companies” and “media”. Answers options were: “absolutely untrustworthy”, “untrustworthy”, “rather untrustworthy”, I do not have a reserved opinion”, “rather trustworthy” and “absolutely trustworthy”. Participants were able to choose only one answer for each question.

In section 3; participants were asked to state their sources of information about GM foods. List of options to choose from were: “family”, “friends”, “university(education)”, “self-interest” and “media”. Answers options were: “absolutely untrustworthy”, “untrustworthy”, “rather untrustworthy”, I do not have a reserved opinion”, “rather trustworthy” and “absolutely trustworthy”. Participants were able to choose only one answer for each question.

The fourth section included information on sociodemographic: gender, age, program of studies (Bc. MSc. /Ing., PhD.), year of studies, study focus, faculty, and university.

The questionnaire was pretested among ten students and two university pedagogues. Recommendations for changes to question and answers wording for the purposes of maximizing interpretation and understanding of questions were completed before data collection. The final survey was anticipated to take up to 15 minutes to complete and was available in Czech and Spanish language.

To minimise bias from outliners, participants were asked to shortly describe what GMO means, to ensure only valid responses are collected; invalid responses were filtered from this study.

4.3. Data analysis

The one-dimensional analysis looked at the answers to 21 questions from two countries: Bolivia and the Czech Republic. The individual answer variants were of the ordinal type and took on the values: "I definitely agree." through "I don't have a strong opinion." after "I definitely do not agree."

The Spider graph, which is a tool of multiple analysis, was used for visualization of subjective knowledge about GM food of university students in Bolivia and the Czech Republic. It is suitable for displaying multiple data and any differences can be read from it.

For further analysis, a good agreement test, Pearson's $\chi 2$ chi square test, was used to test the hypotheses. The interpretation of this test is of two types: if the frequencies within 1 random sample are compared (H0: There is no significant difference between the observed and expected frequencies; the expected frequencies are numbers that have a sum equal to 1), then we speak of the chi-square goodness of fit test; if we compare 2 data sets of the factor type, then we are talking about the Chi-Square test of independence. In this case, we are looking for an answer to the question of whether the 2 data sets being compared are related or not. The test result is expressed through P - value, which is the probability of obtaining results at least as extreme than the results already observed, assuming that the null hypothesis is correct. If the value of P. value is ≤ 0.05, then we reject H0 in favour of the alternative HA. If P - value > 0.05, then H0 cannot be rejected.

To analyse obtained data, programs program R and Excel 365 were used.

5. Results

5.1. Sociodemographic characteristics of the respondents

Out of the 420 respondents who participated in this study, 224 representatives were from Bolivia and 196 respondents were from the Czech Republic. For the variable gender, it can be seen that from Bolivia, both male (48.1 %) and female (51.8 %) were almost evenly represented. While from the Czech Republic female (60.2 %) participation prevailed compared to male (39.8 %). For the variable age, it can be said that the largest proportion (in Bolivia 49.1 % and in the Czech Republic 62.8 %) was the age, which was covered by an interval of 21-25 years. On the contrary, the age group 31+ had the smallest representation. In Bolivia it made up only 7.6 % of the respondents and in the Czech Republic only 6.6 % of the respondents. For the variable degree, data showed that in Bolivia the most numerous group of respondents were Ing. / Mgr. students with a representation of 64.3 % of the respondents. In the Czech Republic, on the other hand, the most numerous group of respondents were Bc. students (63.1 %). The smallest representation in both countries were Ph.D. students: in the Czech Republic they represented only 16 % of the respondents and in Bolivia only 4 % of the respondents. From the variable university, it shows that two universities in Bolivia participated: where 81.7 % of the respondents are the students at Gabriel René Moreno Autonomous University. The remaining respondents (18.3 %) were the students at University of Saint Fracis Xavier. A total of 2 universities took part in the Czech Republic. The Czech University of Life Sciences Prague had the largest representation in the sample, with 63.3 % of students; followed by 36.7 % of students from Charles University (Table 3).

Table 4:Sociodemographic characteristics of the respondents

		Bolivia		The Czech Republic	
N total = 420		**N=224**	**%**	**N=196**	**%**
Gender	Male	108	48.2	78	39.8
	Female	116	51.8	118	60.2
Age	18-20	68	30.	29	14.8
	21-25	110	49.1	123	62.8
	26-30	29	12.9	31	15.8
	>30	17	7.6	13	6.6
Degree	Bc.	71	31.7	123	63.1
	Ing. / Mgr.	144	64.3	40	20.5
	Ph.D.	9	4.0	32	16.4
University	GRMAU [1]	183	81.7	-	-
	UFSX [2]	41	18.3	-	-
	CZU [3]	-	-	124	63.3
	UK [4]	-	-	70	36.7

Note: [1] Gabriel René Moreno Autonomous University; [2] University of Saint Fracis Xavier; [3] Czech University of Life Sciences Prague; [4] Charles University

5.2. Subjective knowledge about genetically modified food

Testing the subjective knowledge about GM foods in dataset revealed that 4 % of Bolivians consider themselves as extremly ignorant, 39 % as ignorant, 37 % did not know what it means, only 14 % recognised themselves as knowledgeable and only 11% as extremly knowledgeable. This is in opposition with results from the Czech Republic, as 81 % of the students recognise themselves as knowledgeable, 7 % as extremly knowledgeable, 1 % did not know, what it means, 10 % as ignorant and only 2 % as extremly ignorant. (Figure 3).

Further testing self-reported subjective knowledge by Bolivian and Czech university students revealed, that significant difference between Czech and Bolivian students (p <0.05).

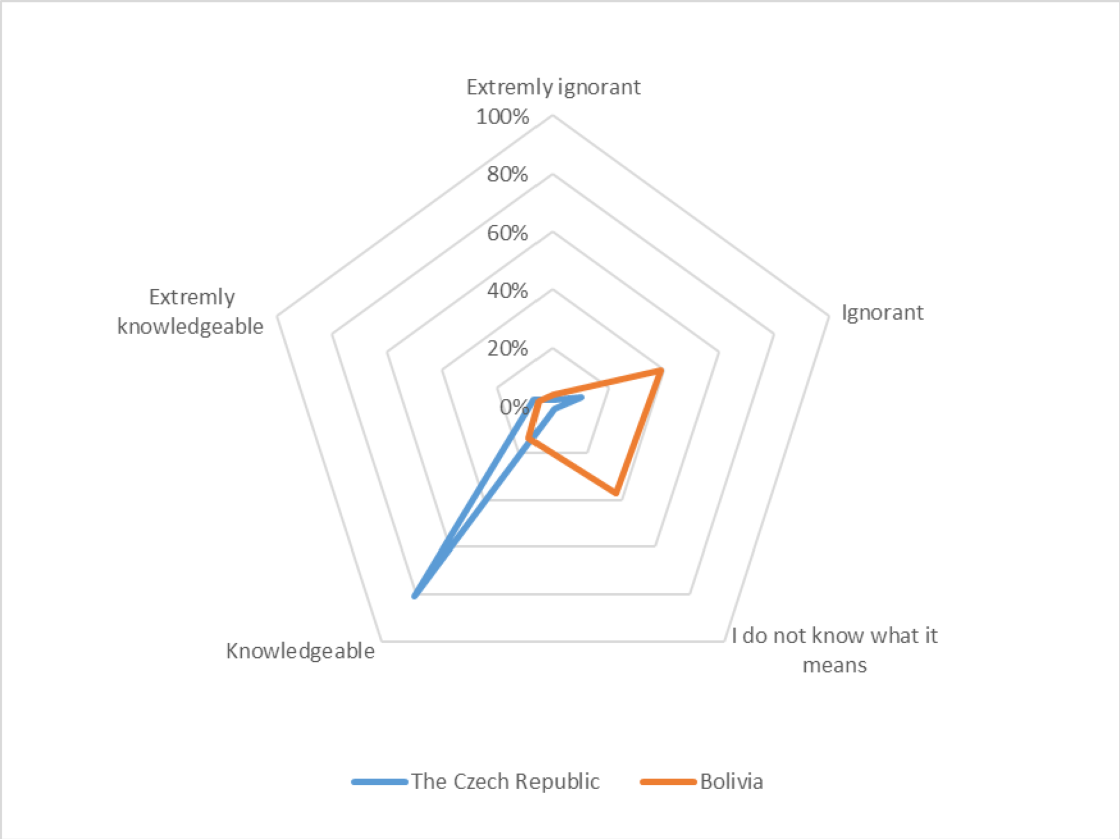

Figure 3: Comparison of subjective knowledge about GM food between Bolivian and Czech university students

5.3. Percieved risks , benefits and willingness to consume

By testing positive attitudes in risk and benefit perception of GM foods in Bolivia and the Czech Republic, the data revealed that only 48.6 % of the students from Bolivia are willing to consume GM foods, while in the Czech Republic it is up to 78 % of the students. 50.4 % of Bolivian students and 56 % of Czech students would welcome greater availability of GM foods on the market. 71.4% of Bolivian and 82.6 % of Czech students agreed with statement that farms and food businesses could benefit greatly from GM in food production. The question "GM in food production will pose risks to agricultural and food businesses" shows that 48.6 % of Bolivian students and 55 % of Czech students have a positive attitude (therefore, they do not think there is a risk). 70.9 % of Bolivian students and 64 % of Czech students agree that "GM is essential for improving the quality of food products." 24.1 % of Bolivian students surveyed and 42% of Czech students disagree with the statement "I am concerned about the lack of knowledge about the long-term effects of GM foods on human health in food production." Probably the biggest agreement in the positive attitude within both countries came in connection with the statement "GM food is one of the possible way to increase global food production", while 76.7 % of Bolivian students and 89.7 % of Czech students agreed. Only 41.9 % of Bolivian students did not consider GM food production to be morally wrong. In contrast, almost 80 % of Czech students do not think that GM in food production is morally wrong. 30.3 % of Bolivian and 67 % of Czech students do not think that there is a high risk of developing new diseases through the production of GM foods. 17.4 % of Bolivian students and 47 % of Czech students disagree (therefore have a positive opinion) with the statement "The side effects of consuming GM-produced foods are largely unknown". Significant differencies in comparison of possitive attitudes towards percieved risks and benefits by university students in Bolivia and in the Czech Republic were not discovered only in statements: "I would welcome greater availability of GM foods on the market" (P - value 0.244); "GM in food production will pose risks to agricultural and food businesses (P - value 0.187)" and "GM is essential for improving the quality of food products" (P - value 0.142) (Table 5).

Table 5: Comparison of attitudes and risks and benefits perceived by life science university students

ti	Statement	Bolivia (N=224)	The Czech Republic (N=196)	P - value
		%	%	
Perceived benefits	Farms and food businesses could benefit greatly from GM in food production.	71.4	82.6	**0.014**
	GM is essential for improving the quality of food products.	70.9	64	0.142
	GM food is one possible way to increase global food production.	76.7	89.7	**$4*10^{-4}$**
Perceived risks	GM in food production will pose risks to agricultural and food businesses.	48.6	55	0.187
	I am concerned about the lack of knowledge about the long-term effects of GM foods on human health in food production.	24.1	42	**$6.95*10^{-5}$**
	There is a high risk that GM in food production will result in new diseases for humans.	30.3	67	**$3.664*10^{-14}$**
	The side effects of consuming GM-produced foods are largely unknown.	17.4	47	**$3.7*10^{-11}$**
Willingness to consume	I am willing to consume GM foods.	48.6	78	**$5.46*10^{-10}$**
	GM in food production is morally wrong.	41.9	79	**$1.125*10^{-14}$**
	I would welcome greater availability of GM foods on the market	50.4	56	0.244

*Note: Each column with answers represents % of positive responses given to that specific question. Significant P - value ($p < 0.05$) in bold.

5.4. Important source of information

When testing the importance of sources of information about GM foods, the percentage importance of the source was created. These percentages within Bolivia are sorted in descending order and the appropriate values have been assigned to this ranking (1 for the largest percentage and 5 for the lowest percentage). The percentage from the Czech Republic respects the sorting of data from Bolivia. The data show that students from both countries agree on the assignment of the three most important sources: university is considered the most important source (77.2 % in Bolivia, 85.7 % in the Czech Republic); self-interest took second place (67.8 % in Bolivia, 76 % in the Czech Republic); media is considered to be the third most important source of information (33 % in Bolivia, 28.5 % in the Czech Republic). The fourth source of information in Bolivia is family (28.5 %). In the Czech Republic, the fourth source of information is friends (15.3 %). Friends (23.3 %) received the least importance as a source in Bolivia. In the Czech Republic, family (7.6 %) was identified as the least important source. Significant differences were discovered by P - value in importance of family (P - value $4.43 \cdot 10^{-8}$) and university (P - value 0.026) as the source of information about GM food for students at universities in Boliva and the Czech Republic (Table 6).

Table 6: Importance of information sources about GM food perceived by the university students

Source	Bolivia (%)	Ranking	The Czech Republic (%)	Ranking	P - value
University (education)	77.2	1	85.7	1	**0.026**
Self interest	67.8	2	76	2	0.064
Media	33	3	28.5	3	0.323
Family (parents)	28.5	4	7.6	5	**$4.43 \cdot 10^{-8}$**
Friends	23.2	5	15.3	4	0.0575

Note: Significant P - value (p <0.05) in bold

5.5. Trust in source of information

While testing the credibility of the five potential sources of GM foods monitored, a trust percentage was created. These percentages within Bolivia are in descending order and have been assigned the appropriate values (1 for the largest percentage and 5 for the lowest percentage). The percentage from the Czech Republic respects the sorting of data from Bolivia. The data showed that scientists are considered the most trusted source of information about GM foods by students in both countries (77.6 % in Bolivia, 95.9 % in the Czech Republic). Private companies are considered the second most trusted source of information in Bolivia (49.5 %), in contrast to the Czech Republic, where the public sector is considered the second most trusted source of information (54.5 %). The third most trusted source of information in Bolivia is media (37.9 %), while in the Czech Republic activists took third place (21.4 %). The fourth most trusted source of information differed in both countries, and it is activists 37.9 % in Bolivia and private companies in the Czech Republic (18.3 %). The public sector is considered the least trustworthy source of information in Bolivia (34.3 %), while the media is considered the least trustworthy in the Czech Republic (13.2 %) (Table 7).

Table 7: Level of trust to received information about GM food by the university students.

Trust to	Bolivia (%)	Ranking	The Czech Republic (%)	Ranking	P - value
Scientists	77.6	1	95.9	1	**$6.466*10^{-8}$**
Private companies	49.5	2	18.3	4	**$2.295*10^{-9}$**
Media	37.9	3	13.2	5	**$1.148*10^{-8}$**
Activists (green peace etc.)	37.9	4	21.4	3	**$1.750*10^{-5}$**
Public sector (government)	34.3	5	54.5	2	**$3.099*10^{-5}$**

Note: Significant P - value (p <0.05) in bold

6. Discussion

6.1. Knowledge

Interestingly, the respondents from Bolivia mainly had a master level education, however, they self-reported lower level of subjective knowledge about GM food than the Czech students with bachelor's degree study program. This is in contrast with previous research that showed that the level of subjective knowledge is increased with obtained level of education (House et al. 2004; Li et al. 2002) but supports the findings of House et al. (2004) that consumers may underestimate their subjective knowledge about GM foods no matter the level of education. It could be due to different study programs background of students, as even though mostly students from plant production field of study participated from both countries. It seems like topic of GM in food production is taught in more detail in bachelor study programmes in the Czech Republic while in Bolivia this topic is maybe more of specialisation for PhD. students, or study programmes in Bolivia do not focus on this topic at all. When taking in consideration the self-reported subjective knowledge about GM in food production among life science university students and comparing their important source and most trusted source of information, data shows that as Bolivian students self-reported low level of subjective knowledge about this topic, they are also relatively more sceptical in information obtained by education and relatively less trusting to information provided by scientists, comparing with Czech students, even if in both countries, these sources of information came first. Subjective knowledge of students could be also influenced by place of living, as found by House et al. (2004), as Bolivia and the Czech Republic are two different countries from different continents, which is going to influence sociodemographic background of students participating in this study, even though a common element in both countries is studying at life sciences university; these influences can affect the way how learning and perception of information is obtained through study.

6.2. Perception of related risks and benefits

Attitudes about perceived benefits of GM in food production by Czech and Bolivian students are highly positive. Students from both countries do agree that farms and food businesses could benefit greatly from GM in food production and that GM food is one possible way to increase global food production. Interestingly, more Bolivian (almost 71 %) than Czech (64 %) students believe, that GM is essential for improving the quality of food products. This finding corresponds with the findings by Gaskell et al. (2004) that experts consider GM food as innovation with obvious benefits and also with Hallman et al. (2003) stating that attitudes of respondents are more positive when benefits from GM food products are stated. In the case of Bolivian students, these positive attitudes may be due to the existence of several decades of GM food and feed production in Bolivia, which gives them tangible results and experience with the benefits of GM food, both in terms of improving sensory and nutritional properties of food and economic benefits for farms; whereas in the case of Czech students, it could be due to trust to their own knowledge about GM in food production obtained by education and by trust to system. In terms of risk perceived by students towards GM in food production, Czech students showed less concerns about perceived risks of GM in food production, than Bolivian students in all cases of statements about negative impact of GM food on human health; almost 50 % of Czech students did not consider GM foods to be a risk to human health, in term of creation of new diseases by GM food production, almost 70 % of Czech students did not consider this as a risk. In terms of risks threatening food businesses and agriculture due to GM in food production, about 50 % of Bolivian and more than 50 % of Czech students did not consider this as a real threat. This finding is fully in line with previous findings by Madsen & Sandøe (2005) and Li et al. (2002) which argues that experts significantly and systematically perceived less risk for GM applications and also that experts perceived GM food as less harmful and more useful, also as they do perceive themselves having a high subjective knowledge, they do have high confidence to GM foods products (Hwang and Nam 2021). However Bolivian students do not perceive themselves as having high subjective knowledge, therefore they perceived risks of GM food on human health as relatively high threat, considering that only 30 % of Bolivian students agreed that GM in food production will not result in new disease for humans, only 17 % did not considered side effects of GM food consumption as largely unknown and just 24 % were not concerned about lack of knowledge about long term effect of GM food consumption on human health. With consideration of high level of underestimation in terms of subjective knowledge by Bolivian students, this findings can be explained as Bolivian students consider themselves not having a proper knowledge about this topic, therefore they might have distorted perspective about impact of GM in food production on human health (Hwang and Nam 2021). It could be that Bolivian students gain in depth knowledge about impact of GM food on human health in later levels of education than Czech students, or they depend on obtaining these information by external sources, considering the fact, that Bolivian students in this study mainly had master level of education and Czech students mostly had bachelor level of education.

6.3. Information sources

Regarding the source of information used in this research, the most important source of information about GM food was chosen from both countries' universities, followed by self-interest and the media. Family played more important role as source of information over friends in Bolivia in compared with Czech Republic. It could be that Bolivians may be more likely to discuss important topics within the family circle than Czechs, who are more likely to prefer the advice and opinions of friends. However, this findings do not correspond with findings by Brosig & Bavorova (2019) stating that parents play slightly more important role over friends in creating attitudes of young adults about GM food in the Czech Republic. This difference could be due to fact that in our study more participants were involved or that we offered more options of source of information to choose from, not just mother, father and best friend, as Brosig & Bavorova (2019). In both cases, students reported media as third most important source of information, which corresponds with findings by Hwang & Nam (2021) that consumers with high objective knowledge referred to media as source of information.

When asked about the most trusted source of information, students in both countries correlated their response with the most important source and chose scientists. However, after that, we can identify distrust in the system by Bolivians as they put the least trust into public sector and the second most trusted source of information are the private sector, followed by media and activists. This is in line with the results of studies aimed at the general public, when the least trustworthy is the government (Gaskell et al. 2003; Bredahl et al. 1998) whereas activists or person or institution doing genetic modification research or using modified products gained the most important influence over GM products perception (Siegrist 2000,1999; Savadori et al. 2004). Unlike Bolivian, Czech students chose public sector as the second most trusted source of information, followed by activists, private companies and as the least trusted source were the media. This distrust to system by Bolivian students could be due to relatively rapid and frequent changes in GM food laws, that Bolivian government implemented within last decade, which can provoke distrust in both; the credibility of the delegated authorities and their adequate knowledge of the issue, while strengthening mistrust and questioning one's own knowledge gained through studies at public universities. When we compare previous findings about the high level of doubt about subjective knowledge about GM inf food production by Bolivians students and rapid changes in GMO laws in Bolivia with the stable environment of GM food laws within the EU and the Czech Republic, where Czech students also believe in the system and have confidence in the knowledge gained by studying in public universities, we can consider this as one of the reasons why Bolivian students doubt their knowledge and why they do not trust the system. Mistrust to the media by Czech university students could be explained as for last decade, whole EU is experiencing a massive increase in fake news portals that spread misinformation, try to create mistrust in any information disseminated in free media and thus influence individuals' decisions in favour of a false opinion (MVCR 2022). Rapid spread of fake news portals was seen during covid- 19 pandemic (Avast 2020; Figueiras 2021) and also due to Ukraine conflict (BBC 2022; MVCR 2022). It seems this influence plays a main role in distrust to media by Czech university students, as Bolivian university students placed media on third place in trust as Bolivian government implemented law to censor fake news portals (IPI 2020), therefore Bolivian students are not under massive influence of fake news campaign when searching information by media.

6.4. Willingness to consume

The practical reasons of GM in food production prevailed over ethical issues (Boccaletti & Moro 2015) within Czech students as nearly 80 % of them did not consider GM in food production as morally wrong. Situation within Bolivian students is different; just less than 42 % of the students did not consider GM in food production as morally wrong. This can be explained by lower trust to the system (Tanaka 2004) and also by religious background, as 92 % of the Bolivian population are Christians (Statista 2020) while more than 70 % of the Czech population are recognised as atheists (ČSÚ 2022), therefore perceptions of morality may be different through the sociological background of both groups.

As gender distribution in Bolivia in the study was almost evenly distributed among female and male students, while in the Czech Republic, the females' representation prevailed over male, but Czech students reported more positive attitudes towards GM food consumption over Bolivian students, gender most probably do not play a role in negatively affecting the willingness to consume GM food, as it was reported in previous studies (Costa & Mossialos 2005; Beasley et al 2004; Hossain & Onyango 2004). It seems that willingness to consume GM food among life science university students is rather influenced by other factors, as the willingness to consume GM foods was very low among Bolivian students; barely 49 % of students were willing to consume GM foods, while the willingness to consume GM foods among Czech students was quite high - almost 80 % of students were willing to consume such foods. If we take into consideration all previous findings of this study, the explanation for this, could be that willingness to consume GM food by Czech students is positively influenced by their self-reported high level of subjective knowledge (Boccaletti & Moro 2015; House et al. 2004; Hwang and Nam 2021; Li et al. 2002; Lusk et al. 2004; Madsen & Sandøe 2005) , perceived benefits from GM in food production (House et al. 2006; Traill et al. 2006), trust in system (Onyango et al., 2003; Traill et al. 2004; Lusk et al. 2004) and also by morality, as they did not considered GM in food production as morally wrong (Moon et al. 2007). On the other hand, Bolivian students reported low levels of subjective knowledge (House et al. 2004; Hwang and Nam 2021; Lusk et al. 2004; Moerbeek & Casimir 2005), consider GM in food production as risky (Li et al. 2002; Traill et al. 2004), showed distrust in the system (Onyango et al., 2003), they were more likely to trust more in activists than in the government (Traill et al. 2004; Lusk et al. 2004) and also considered GM in food production as morally wrong (Moon et al. 2007) due to belief perceptions. All of these factors mentioned above could positively influenced the willingness to consume GM food by Czech students and vice versa, negatively influence the willingness to consume GM food by Bolivian students. Roughly the same number of Czech (56 %) and Bolivian (50 %) students would welcome greater availability of GM foods on the market. This could be explained by the awareness of the benefits of GM foods such as improved food quality, taste, and accessibility, which is made possible because, the Bolivian government allows the production and importation of GM food on Bolivian market (Lexi Vox 2021). In the Czech Republic, the situation could be explained as interest towards novelty food by Czech students, as currently GM food is not available on the Czech market.

Limits of the study were due to the fact that the data were collected at selected two universities focused on life sciences in both countries, the results cannot be generalized for the entire population in a given country. However, the study provides interesting results and for further emphasis it is recommended to involve more universities in both countries, focusing on the differences in attitudes of students towards gm food between the years of the various study fields.

7. Conclusions

This study analysed subjective knowledge and attitudes towards genetically modified (GM) food among students at life sciences universities in Bolivia and the Czech Republic. Being a future specialists in agriculture, their perspectives are expected to have a major impact on acceptance of GMOs and GM food products. In a self-reported subjective knowledge, Bolivian students ranked themselves lower than Czech counterparts. Overall, Bolivian students have somewhat unfavourable views toward GM foods. They tend to be less willing to consume GM food and perceive health risks connected to GM food consumption more often than the Czech student. While Czech students are generally more positive in attitudes towards GM food. The major influence among the Bolivians students' negative attitudes is distrust to system as they do not trust information provided by government. To generate more favourable attitudes toward GM foods among Bolivian students, universities, agricultural producers, distributors, and food retailers will need to provide through education, corporate websites, news releases to media, and other avenues for sufficient information that alleviates students concerns about health safety of GM foods, as they played the most important role in obtaining information about GM food in food production and also scored higher than government in terms of trust to information obtained about GM food.

Further studies should focus on the importance of factors influencing attitudes and willingness to consume GM food among life sciences university students in Boliva and the Czech Republic, not just trust in information sources but in its reliability. The government in these two countries should make favourable policies regarding to GM in food production by creating awareness through research and ease in the accessibility of information.

In conclusion, GM in food production can aid alleviate the problems associated with food security and improve food safety. Nevertheless, there are few drawbacks associated with GM foods such as reliability in information sources, government policies and the influence on students and consumers by activists providing skewed information and biased opinions.

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Appendices

GM food and attitudes of students of agricultural/life sciences universities

This questionnaire is related to the research for the diploma thesis at the the Czech University of Life Sciences in Prague entitled "Attitudes of students of agricultural / life sciences Universities to GM foods; comparison of the Czech Republic, Spain, Mexico, Bolivia and India" focused on the attitudes of students of the Czech University of Life Sciences to GM food in comparison with students of agricultural/life sciences universities in other countries. All data will be anonymous and will only be used for research purposes. All data will be processed in accordance with the Personal Data Protection Act.

*Povinné pole

Your attitudes towards genetically modified (GM) foods

Genetically modified food means a food that contains, consists of or is produced from genetically modified organisms.

1. The rating scale continues to the right. *

Označte jen jednu elipsu na každém řádku.

	Extremely ignorant	Ignorant	I do not know what it means	Knowledgeable	Extremely knowledgeable
How would you say you are aware of the facts and problems regarding genetic modification in food production?	◯	◯	◯	◯	◯

2. GM stands for Genetically Modified in the following questions. The rating scale continues to the right. *

Označte jen jednu elipsu na každém řádku.

	I definitely do not agree	I do not agree	I rather do not agree	I don't have a strong opinion	I rather agree	I agree	I definitely agree
I am willing to consume GM foods.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
I would welcome greater availability of GM foods on the market.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
Farms and food businesses could benefit greatly from GM in food production.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
GM in food production will pose risks to agricultural and food businesses.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
GM is essential for improving the quality of food products.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
I am concerned about the lack of knowledge about the long-term effects of GM foods on human health in food production.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
GM food is one possible way to increase global food production.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
GM in food production is morally wrong.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
There is a high risk that GM in food production will result in new diseases for humans.	⬭	⬭	⬭	⬭	⬭	⬭	⬭
The side effects of consuming GM-produced foods are largely unknown.	⬭	⬭	⬭	⬭	⬭	⬭	⬭

3. Briefly describe what GMO mean. *

____

What do you think are the most trusted sources of information on GM foods?

4. The rating scale continues to the right *

Označte jen jednu elipsu na každém řádku.

	Absolutely untrustworthy	Untrustworthy	Rather untrustworthy	I do not have a reserved opinion	Rather trustworthy	Trustworhty	Absolutely trustworthy
Activists (eg Greenpeace)							
Public sector (government, ministry, agencies ...)							
Scientists							
Private companies							
Media (TV, Radio, News ...)							

You know about GM foods thanks to:

5. The rating scale continues to the right. *

Označte jen jednu elipsu na každém řádku.

	Definitely no	No	Rather no	50-50	Rather yes	Yes	Definitely yes
Family							
Friends							
University							
Self interest							
Media							

Questions related to demography:

6. Gender *

Zaškrtněte všechny platné možnosti.

- [ ] Male
- [ ] Female
- [ ] Other

7. Age *

____

8. Program *

Označte jen jednu elipsu.

- ( ) Bc.
- ( ) MSc./Ing. ...
- ( ) Ph.D.

9. Year *

Označte jen jednu elipsu.

- 1st
- 2nd
- 3rd
- 4th

10. Study focus (field) *

11. Faculty *

12. University *

Thank you for your answers.