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University Students' Views about Genetically Modified Organisms: A Case Study

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Abstract

Today, Genetically Modified Organism (GMO) is a popular socio-scientific issue and views on this issue directly shape people's behaviors. This study aims to investigate university students' views about GMOs. A total of 200 university students from different faculties of a state university participated in the study. For data collection purposes face-to-face interviews developed by the researchers were conducted with the participant students. The convenience sampling technique and the maximum variation sampling technique were systematically used together to determine the participants of the study. The study was designed as a holistic single-case study. The data were analyzed using descriptive analysis and the content analysis. NVivo12 software, a qualitative analysis software, was used to organize the data and the results of the analyses were presented via frequencies and percentages. Quotes from the themes were also included. The results revealed that the university students' sources of information regarding the issue were mainly news, social media, and the school courses. It was nonetheless found out that they did not rely on news and social media. They indicated many food products with GMOs were plants in particular. However, they are confused about situations like growing the aforementioned products in periods different than seasonal periods and using hormones and additives with modifying genetics. In accordance with the content analysis the views of the participants were collected under five different themes: Genetically Modified Products, Purposes of GMO Use, GMO's differences from other products, advantages of GMOs, and damages of GMOs.

Keywords: Genetically modified organisms (GMO); products; university students; views

1. Introduction

The term Biotechnology was first defined by Karl Ereky in 1919 as "all production procedures performed with the help of living organisms" (Fári & Kralovánszky 2006; Hosseini, 2019). Nonetheless, it is not actually a new science. For thousands of years, human beings have been practicing this science such as the production of food like wine, yogurt, or cheese, the domestication of plants and animals, and the production of medicine (Harzevili, 2018; Choudhury, Kumar & Sandeep 2017). Over the past century, there have

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been enormous developments in genomics and recombinant DNA technologies, which lead to a change in the definition of biotechnology. Modern biotechnology is defined today as a multidisciplinary science that changes living creatures and their products, or enables new production, to solve direct or indirect problems of human beings (FAO, 2004; Raju, 2016; Gahlawat, Duhan, Salar, Siwach, Kumar, & Kaur, 2018). It is today possible with recombinant DNA technology, to create changes in the genetic material (DNA) of organisms which do not appear with natural recombination/fertilization (WHO, 2016; FAO, 2016). The current characteristics can be changed by playing with the gene sequences in the genetic material and the organism can be equipped with new characteristics by adding new genes, as a result of these changes. The organisms formed are called as a genetically modified organism (GMO) or transgenic organism, and their products are called genetically modified (GM) or transgene (Zhang, Wohlhueter, & Zhang, 2016).

These genetically modified microorganisms obtained through recombinant DNA Technologies, and products prepared by plants and animals are used in many fields today. The most common fields of usage are agriculture and livestock practices and medicine applications.

The reasons like increasing population, decrease in cultivable areas and long periods of time depending on the generation of livestock practices in traditional agriculture have more directed scientists to studies on GMOs. The economic effect of GM products is increasing exponentially. Furthermore, the cost of products has also decreased due to GM plants that are resistant to weeds and pests (Brookes & Barfoot, 2014; James, 2013). Another advantage of GM products is producing GM plants that are supported by vitamins A, C, or E or by changing protein and carbohydrates. GM plants are also known to have a therapeutic effect. Eatable vaccines can be obtained with GM plants and the immune system can be stimulated (Nicolia, Manzo, Veronesi & Rosellini, 2014). In addition to the benefits of biotechnological GMO production on food for people's future with the help of controlled and smart technologies, it may have some potential damages and risks. For example, GM products cause some concerns regarding the continuation of biodiversity and human health since it may create allergen and toxic effects.

The enormous advances in biotechnology also underline the need to raise public awareness in the social, ethical, and economic fields where the effect of biotechnology is observed, to investigate the advantages and disadvantages of the use of GM products, a genetic engineering practice. Studies are particularly needed to inform school-age children and young people. Objectives determined regarding the issue in formal education play a crucial role to equip students with a scientific perspective (Sinan, 2015). Therefore, biotechnology topics are becoming more and more common in the national education program in many countries (Steele & Aubusson, 2004). Studies on GMO mostly focus on individuals' knowledge and attitudes regarding GMOs (e.g., Balemen, 2009; Çiçekçi, 2008; Dawson, 2007; Gillian, 2009; Gürkan, & Kahraman, 2018; Öcal, 2012; Jiménez- Salas, Campos- Góngora, González- Martínez, Tijerina- Sáenz, Escamilla- Méndez &Ramírez- López, 2017; López Montesinos, Pérez, Fuentes, Luna-Espinoza, & Cuevas, 2016; Yüce & Yalçın, 2012). As a result, it was found that knowledge and attitudes of individuals whose information sources are based on formal education are significantly improved (Gürkan &

Kahraman, 2018; Yüce & Yalçın, 2012). Studies also show that students have some difficulties in expressing GMO concepts (Sıcaker & Öz Aydın, 2015), which are among the factors affecting negatively students' perspectives. In order to prevent this situation, education programs, textbooks, and methods used while teaching the GMO concept should be considered. In fact, Çıngıl Barış, and Kırbaşlar (2015) investigated the biotechnology concepts in middle and high school textbooks and the sufficiency of those books and found striking deficiencies in the books. Altun, Çelik, and Elçin (2011) studied the effect of guide materials regarding biotechnology and molecular biology on student achievement and reported that the use of materials is effective to learn the concept. Demirci and Yüce (2018) applied a lab-supported education program to teach Biotechnology and Genetic Engineering Topics and increased students' achievement and attitudes, and ensured the permanence of learning. However, most of the studies have a result-oriented perspective with a quantitative approach. Researchers stated that qualitative analysis of the cases investigated may not cover the entire picture; therefore, qualitative studies can deepen the understanding (Christensen, Burke Johnson, & Turner, 2015).

This study aimed to explore the views of university students, who were the prospective teachers, scientists, administrators, politicians, and most importantly parents, with a qualitative approach. The results of this study are thought to have a supportive effect on future studies made on GMOs and the development of curriculum and textbooks, in particular.

2. Method

2.1. Design of the Study

This study investigated university students' views about GMOs and utilized the case study design, a qualitative research design. In case studies, the categories of events and behaviors are discovered by nature (Yin, 1984; Hancock & Algozzine, 2006). This study addressed all aspects of the issue through the interviews (Merriam, 1998). The study used the holistic single-case study design where a single analysis unit is considered, whose frameworks are set forth by Yin (1984) (Yıldırım & Şimşek, 2013).

2.2. Participants

The sampling technique of convenience sampling, a purposeful sampling technique, and the maximum variation sampling technique were used together. The convenience sampling was used to accelerate the study and to make the study more practical (Yıldırım & Şimşek, 2013) and the maximum diversity sampling was used to reveal different perspectives regarding the issue (Patton, 2014). The participants were 200 university students from a state university. Information about the participants was presented in Table 1.

Table 1. Demographic information about participants

Faculty			Grade Level			Gender		
	f	%		f	%		f	%
Faculty of Dentistry	3	1.5%	1	3	1.5%			
			2	-	-	Female	2	1.0%
			3	-	-	Male	1	0.5%
			4	-	-			
			Other	-	-			
Faculty of Pharmacy	4	2.0%	1	-	-			
			2	-	-	Female	1	0.5%
			3	1	0.5%	Male	3	1.5%
			4	3	1.5%			
			Other	-	-			
Faculty of Letters	20	10.0%	1	5	2.5%			
			2	3	1.5%	Female	18	9.0%
			3	-	-	Male	2	1.0%
			4	10	5.0%			
			Other	2	1%			
Faculty of Education	53	26.5%	1	9	4.5%			
			2	14	7.0%	Female	49	24.5%
			3	10	5.0%	Male	4	2.0%
			4	19	9.5%			
			Other	1	0.5%			
Faculty of Science	23	11.5%	1	3	1,5%			
			2	3	1,5%	Female	16	8.0%
			3	9	4,5%	Male	7	3.5%
			4	6	3,0%			
			Other	2	1,0%			
Faculty of Law	7	3.5%	1	2	1,0%			
			2	3	1,5%	Female	3	1.5%
			3	1	0.5%	Male	4	2.0%
			4	1	0.5%			
			Other	-	-			
Faculty of Economics and Administrative Sciences	30	15.0%	1	11	5.5%			
			2	3	1.5%	Female	24	12.0%
			3	6	3.0%	Male	6	3.0%
			4	5	2.5%			
			Other	5	2.5%			

			1	2	1.0%			
			2	12	6.0%	Female	12	6.0%
Faculty of Engineering	31	15.5%	3	3	1.5%	Male	19	9.5%
			4	12	6.0%			
			Other	2	1.0%			
			1	8	4.0%			
			2	4	2.0%	Female	14	7.0%
Faculty of Health Sciences	18	9.0%	3	6	3.0%	Male	4	2.0%
			4	-	-			
			Other	-	-			
			1	-	-			
			2	1	0.5%	Female	1	0.5%
Faculty of Sport Science	3	1.5%	3	2	1.0%	Male	2	1.0%
			4	-	-			
			Other	-	-			
			1	-	-			
			2	2	1.0%	Female	6	3.0%
Faculty of Medicine	8	4.0%	3	2	1.0%	Male	2	1.0%
			4	2	1.0%			
			Other	2	1.0%			
			1	43	21.5%			
			2	45	22.5%	Female	146	73.0%
Total	200	100%	3	40	20.0%	Male	54	27.0%
			4	58	29.0%			
			Other	14	7.0%			

As Table 1 indicates, the 200 university students were from 11 different faculties: Faculty of Dentistry, Faculty of Pharmacy, Faculty of Letters, Faculty of Education, Faculty of Science, Faculty of Law, Faculty of Economics and Administrative Sciences, Faculty of Engineering, Faculty of Health Sciences, Faculty of Sport Science, and Faculty of Medicine. Of the participants, 146 (73.0%) were females and 54 (27.0%)) were males. The distribution of the participants was: 43 (21.5%) are first-grade, 45 (22.5%) are second-grade, 40 (20.0%) are third-grade, 58 (29.0%) are fourth-grade, and 14 (7.0%) are at different grade levels (5th- 6th-, and extended etc.).

2.3. Data Collection Tools

The data of the study were collected using the interview questions formed through the review of the current literature and the Exchange of ideas with the experts. The reason for choosing the interview technique was to make an in-depth investigation of the knowledge and experience of the university students and to reveal their perspectives regarding the

issue (Best & Kahn, 2017). Opinions of two field experts and one assessment and evaluation expert were consulted while preparing the interview form. The criteria of determining the experts were: a) Conducting studies on GMOs (field experts), and b) having expertise in qualitative studies (the expert of the assessment and evaluation). These experts were consulted throughout the study.

Some examples of the interview questions posed to the participants are as follows:

- Where did you hear about genetically modified organisms? Do you trust these sources?
- Do you think that genetically modified organisms are necessary?
- How does a genetically modified product differ from genetically not modified products?

2.4. Data Collection

The data of the study were collected via face-to-face interviews. The participants took part in the interviews on a voluntary basis. They were informed about the fundamental points like the topic and the average duration of the interview. The confidentiality of the data was further underlined. It was also emphasized that the participants have the chance to end the interview at any time they wish. During the interviews, a voice recorder was used following the permission of the participants. The interviews lasted between 7–12 minutes.

2.5. Data Analysis

Descriptive and content analyses were used together to analyze the data obtained in the interviews. Content analysis is an initiative aiming for the basic consistency and sense-making of a voluminous qualitative material (Patton, 2014). In the data analysis, the recordings were first transcribed and codes like P1, P2, P3, … were assigned to each participant. Later, the students' views were analyzed using NVivo software, and themes and categories were created. To demonstrate the results clearly, the data were digitized and the results were presented in tables using percentages and frequencies. All views were included in the study without any frequency limitation. Yıldırım and Şimşek (2011) stated that excerpts should be included to determine whether the views accurately represent the themes.

To provide the reliability of coding, three different experts, of whom one is one of the researchers of this study, coded the data separately. The consistency of the coding was calculated using the formula by Miles and Huberman (1994) as "Agreement / (Agreement + Disagreement) x 100" and it was calculated as .89, which is considered as sufficient according to Miles and Huberman (1994).

The model figure regarding the views about GMOs is depicted in Figure 1.

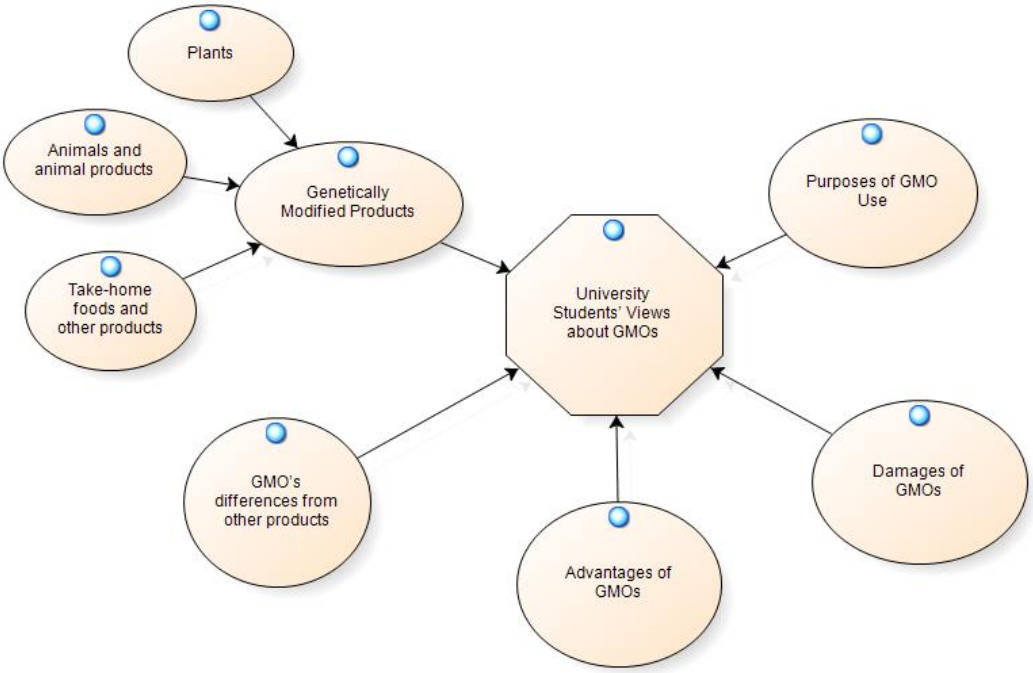

Figure 1. University Students' Views about GMOs

The analysis made revealed five different themes: Genetically Modified Products, Purposes of GMO Use, GMO's differences from other products, Advantages of GMOs, and Damages of GMOs. The codes of the views of the university students about GMOs are detailed in the findings section.

3. Results

Results on the distribution of the university students' sources of information about GMOs are presented in Table 2.

Table 2. University students' sources of information about GMOs and their trust levels in these sources.

Source of information			Trust levels		
	*f	%		f	%
News	153	76.5%	Yes	16	8.0%
			Partially	23	11.5%
			No	114	57.0%
Social media	56	28.0%	Yes	17	8.5%
			Partially	22	11.0%
			No	27	13.5%
School and course	54	27.0%	Yes	41	20.5%
			Partially	10	5.0%
			No	3	1.5%
Family and group of friends	17	8.5%	Yes	1	0.5%
			Partially	4	2.0%
			No	12	6.0%
Have no idea	11	5.5%	Yes	-	-
			Partially	-	-
			No	-	-
Scientific journals	9	4.5%	Yes	9	4.5%
			Partially	-	-
			No	-	-

*Students were able to indicate more than one source.

As Table 2 indicated, the sources with the highest frequencies were News (f=153, 76.5%), Social Media (f = 56, 28.0%), and Lessons and Schools (f = 54, 27.0%). Some students who indicated that they have no knowledge regarding GMOs were also identified. It is however seen that the university students' trust levels in the sources of News and Social Media, which are the main sources, were quite low. However, it is also seen that the university students who acquire knowledge regarding GMOs in the formal learning process have a higher level of trust in sources of information.

The following is an excerpt of one of the students regarding the issue:

P17: I heard about GMOs from lessons and on news. I trust them because the lessons on GMOs were scientific but I do not trust the news.

The university students' perspectives about GM products are presented in Table 3.

Table 3. University students' examples of GM Products

Categories	f	Examples of GM Products	f
Plants	393	Tomato	91
		Corn	51
		Watermelon	42
		Strawberry	32
		Eggplant	28
		Soybean	24
		Banana	13
		Rice	10
		Apple	9
		Orange	8
		Sugar beet	7
		Pepper	6
		Plum	6
		Wheat	5
		White mulberry	5
		Melon	5
		Peach	5
		Cucumber	4
		Sour cherry	4
		Lemon	3
		Grapefruit	2
		Green squash	2
		Potato	2
		Grape	1
		Apricot	1
Animals and animal products	58	Chicken	19
		Milk and milk products	12
		Egg	11
		Cattle	7
		Butter	5
		Sheep	4
Take-home foods and other products	89	Canned foods	34
		Packaged products	23
		Margarine	9
		Beverages	8

	Meds	6
	Cosmetics	4
	Chocolate	2
	Chewing gum	2
	Hamburger	1

Table 3 includes university students' examples of GM products. The content analysis made indicated that there are three different categories: Plants, Animals, and Animal Products, and Take-home foods and other products. The highest frequencies for each category were tomato (f=91), corn (f=51), and watermelon (f=42) in the Plants theme; chicken (f=19), milk and milk products (f=12), and egg (f=11) in the Animal and Animal Products; and canned foods (f=34), packaged products (f=23), and margarine (f=9).

A quote from the interview with one of the participants is as follows:

P103: GMOs are applied to many plants such as tomato, cucumber, and eggplant to increase efficiency. I also think that the canned food we buy from markets includes GMOs.

The university students' views about the purposes of GMO use are presented in Table 4.

Table 4. University students' views about the purposes of GMO use

	Codes	f	%
Purposes of GMO use	To produce more products in a shorter time	39	19.5%
	Growing long-lasting products	27	13.5%
	Producing hormonal foods	17	8.5%
	Producing off-season vegetables and fruits	12	6.0%
	Creating new products by grafting	10	5.0%
	To give resistance to species	9	4.5%
	Make products look more beautiful	7	3.5%

As Table 4 shows, the university students mainly indicated "producing more products in a shorter time" (f=39, 19.5%), "growing long-lasting products" (f=27, 13.5%), and producing hormonal foods (f=17, 8.5%) as the purposes of GMO use.

An excerpt from the interview with one of the participants is as follows: P71: Growing and harvesting processes that take a long time are completed with GMOs in a shorter time.

The university students' views about the differences between GM products and other products were presented in Table 5.

Table 5. University students' views about the differences between GM products and other products

	Codes	f	%
Differences between GM products and other products	No decay and deterioration	52	26.0%
	Difference appearance	45	22.5%
	Different smell	28	14.0%
	Different taste	26	13.0%
	Production outside the season	14	7.0%
	Contains preservatives and colorants	11	5.5%
	No cores	7	3.5%
	Indication on the product label	5	2.5%

As Table 5 shows, the university students primarily listed these points among the differences between GM products and other products: "No decay or deterioration" (f=52, 26.0%), "different appearance" (f=45, 22.5%), and "different smell" (f=28, 14.0%).

An excerpt from the interview with one of the participants is as follows:

P23: Vegetables and fruits with GMOs are bigger and brighter. It does not smell at all. It doesn't taste good.

The university students' views about the advantages of GMOs were listed in Table 6.

Table 6. University students' views about the advantages of GMOs

	Codes	f	%
Advantages of GMOs	Longer shelf life	62	31.0%
	More production	29	14.5%
	Faster production	23	11.5%
	Cheaper prices	18	9.0%
	Supporting development	8	4.0%
	Use in treatments	7	3.5%
	Help to prevent hunger	7	3.5%
	Improving the quality of products	5	2.5%
	Aesthetically adds beauty	2	1.0%

As Table 6 shows, the university students mainly listed "longer shelf life" (f=62, 31.0%), "more production" (f=29, 14,5%), and "faster production" (f=23, 11,5%) among the advantages of GMOs.

An excerpt from the interview with one of the participants is as follows:

P186: With GMOs, the shelf life of products gets longer. Therefore, more products are obtained at a lower cost.

The university students' views about the damages of GMO use are presented in Table 7.

Table 7. University students' views about the damages of GMO use

	Codes	f	%
Damages of GMO Use	Harmful to health	182	91.0%
	Decreased nutritional value	36	18.0%
	Not natural	25	12.5%
	Damage to the ecosystem	16	8.0%

As Table 7 shows, the university students mainly pointed out "harmful to health" (f=182, 91.0%), "decreased nutritional value" (f=36, 18.0%), and "being not natural" (f=25, 12.5%) as the damages of GMO use.

A quote from the interview with one of the participants is as follows:
P42: It is very harmful to human health. I know that it causes cancer.

4. Discussion

This study investigated university students' views about GMOs. The results obtained revealed that the university students know GMOs mostly from the news (76.5%), social media (28%), and lessons and school (27%). The percentage of the students who stated that they do not have any knowledge regarding GMOs was found to be 5.5%.

The results showed that the information regarding GMOs was mostly gathered from the news and social media. A similar result by Öztürk and Erabdan (2019) was reported stating that science teachers use social media to follow the trends in socio-scientific issues and to teach them to their students. Similarly, media, as one of the main sources of information for people about GMOs, a socio-scientific issue, (Rzymski & Królczyk, 2016) is a functional communication tool. Furthermore, media is also an educational tool (Arslan, 2004). Mass media has the potential to directly affect and shape individuals' views on GMOs. However, it was also stated that university students do not trust their main sources of information. In the same vein, Jurkiewicz, Zagórski, Bujak, Lachowski, and Florek-Luszczkiet (2014) studied secondary scholl students in Poland and found that 64.1% of the students studied thought that media reports on GMOs are unreliable. Öcal (2012) examined science teachers' level of awareness in Biotechnology (Genetics Engineering) and put forward that teachers gain knowledge mostly from media communication tools such as the internet, TV, newspaper, and magazine. Similarly, Türker, Koçak, Aydın, İstanbulluoğlu, Yıldıran, Türk and Kılıç (2013) reported that only 13.6% of the information nursery students acquire regarding GMOs was from scientific books, and 54.9% of the information was from radio, magazine, newspaper, the internet, or TV. Tanır (2005) studied with freshmen preservice science teachers and found that their source of information was written and visual media rather than the school; however, they consider these sources unreliable, which might be explained with the late integration of biotechnology topics into the curricula in Turkey. Nevertheless, the media's general stance regarding GMOs (Bubela & Caulfield, 2004), which mainly emphasizes the negativities rather than reflecting the information objectively, clarifies that the views about GMOs are expressed more negatively.

The university students mainly indicated "producing more products in a shorter time" (f=39, 19.5%), "growing long-lasting products" (f=27, 13.5%), and producing hormonal foods (f=17, 8.5%) as the purposes of GMO use. When the students' responses were further examined, it was determined that their information on the purposes of GMO use is partially true; yet, they mostly focus on food production and quality but they do not put enough emphasis on health-related practices in their views. It is also found that they confuse hormone applications and GMO practices, which might stem from the university students' insufficient level of information regarding GMOs. In fact, studies on GMOs revealed that deficiencies in GMO definitions are observed in students who continue their education at university (Çiçekçi, 2008; Türker et al., 2013) as well as secondary education students (Dawson, 2007).

The university students' views about the GM organisms and products they use individually were collected under there different categories: Plants, animals and animal

products, and take-home foods and other products. Tomato, corn, and watermelon were among the responses with the highest frequencies in the GM plants category. Similarly, Türker et al., (2013) in their study stated that 32.4% of nursing students correctly identified the most cultivated GM plant like corn and cotton, while tomato and pepper were the leading products among GM products. Hallman et al. (2013) reported that in the United States, 59% of consumers know that soybeans are sold as GM and that of the consumers, 56%, 55%, and 50% thought that tomatoes, wheat, and corn, respectively, were not labeled as GM, despite the mandatory labeling policy in the USA.

They also indicated a watermelon grown in cages to give a square shape as a GMO. They, moreover, expressed GMOs as the grafting of a branch belonging to a blackberry called a grafting pen, by grafting it into the white lip called the rootstock. As an example of GM animals, chickens had the highest frequency, which is thought to be related to obtaining chicken breeds with high meat yield and rapid development as a result of breeding and selection today. The university students considered these breeding practices as GM chickens. The students also considered the long shelf life of cans due to GMOs, which is, in fact, because of the additives in cans. However, the production and import of foods involving GMOs are forbidden in Turkey, according to the regulation published in Turkey in 2014. However, as a result of analysis performed against gene contamination, it is reported that if GMOs are detected in products at 0.9% or below, this product will be considered as a GMO contaminant. It was concluded that if the genes detected as contaminants in products with GMO contamination are approved by the Biosafety Board, the products can be used in line with the purpose of approval (Yılmaz, 2014). Therefore, the examples set by university students as GM products in Turkey are, in fact, not GM products.

The university students' views about the differences between GM products between other products involves many misconceptions and knowledge deficiency. Genetics has been used to obtain higher productivity, large showy plants and animals by means of classical breeding practices for thousands of years in agriculture. Today, breeding studies have started to be carried out by using the advantages of biotechnology in shorter periods by considering the results of very long generations with classical crosses. In this study, the university students mistakenly thought that when they consume GM products, they are able to realize this with their sense organs. For example, the fact that an agricultural product looks beautiful in shape, has no crooked shape, has excellent taste and smell, or looks large from normal and has a long-lasting shelf life and does not decay easily, causes students to believe that the genetics of these products have been altered. Studies showed that products having eco-label on it has a psychological advantage over GM-label products (Sörqvist, Marsh, Holmgren, Hulme, Haga, & Seager, 2016). Since there is no GM production and import in Turkey, it is seen that students experience concept confusion about plants that are made of polyploid, plant growth regulator or hybrid plants with classical breeding.

The university students mainly listed "longer shelf life", "more production", and "faster production" among the advantages of GMOs. Furthermore, the university students stated that the fast and over-production will solve hunger problems of the age, cause a decrease

in prices, and support the development of countries. Jiménez- Salas, et al., (2017) in their study stated that the participants consider GMOs as an effective way to prevent hunger in the world. Similarly, Črne-Hladnik, Peklaj, Košmelj, Hladnik, and Javornik (2009) reported that their participants find the use of GM corn plants useful.

The university students were concerned about the fact that that the use of GM products can pose many health problems in both the short and long term, cause a decrease in nutrition values, vitamins in particular, and damage to the ecosystem. In particular, they said that they have learned from the media that GM products cause cancer. Bawa and Anilakumar (2013) stated that the transferred genes can have a toxic or allergic effect. Sanchis (2011) found that some people who consumed corn with insect resistance genes had allergic reactions. Herodotou, Kyzaa, Nicolaidoua, Hadjichambis, Kafouris, and Terzian (2012) in their study found that students are of the opinion that GMOs and GM products have some negative effects on environment and health. Jurkiewicz Zagórski et al., (2014) found that 57.4% of students studying in Poland do not find studies on GMOs reliable and think that they have negative effects on health. Aleksejeva (2014) concluded that 40.9% of students believe that their genes will also change after consumption of GM tomatoes. Mohapatra, Priyadarshini, and Biswas (2010) investigated teachers' knowledge and attitudes about GMOs and found that the vast majority of teachers found GMOs mistrustful for the environment. They also indicated that pesticide proteins in GMOs might have some indirect effects such as bioaccumulation on those who consume those products.

5. Conclusions

It is realized that the university students have some knowledge deficiencies and concept confusions stemming from their sources of information, and display an intense negative attitude regarding GMOs. GMOs and biotechnology do not only affect one or multiple disciplines but also have social, economic and ecological effects in medicine, law, ethics, and other fields; therefore, they have the potential to direct the future's world. For this reason, it is suggested to update curricula to equip students with direct and scientific knowledge regarding the issue and to integrate the related objectives in curricula. Media tools are quite effective to inform people about GMOs, as emphasized in this study. Presenting informative visuals, videos, and public service ads about GMOs in cooperation with scientists are thought to be effective to raise awareness among people regarding GMOs.

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