International Journal of Agriculture, Environment and Food Sciences
e-ISSN : 2618-5946
www.jaefs.com
JAEFS
edit PUBLISHING

Research Article
Int J Agric Environ Food Sci 6 (1): 121-129 (2022)

Genetically modified organisms and biosafety as perceived by professionals according to their sociodemographic characteristics

Selda Turkoglu Coskun[1,*] **Emine Olhan**[2]

[1]Ankara University, Biotechnology Inst. Socioeconomical Dev. and Biotechnology Dept., Ankara, Türkiye
[1]Ankara University, Agriculture Faculty, Agriculture Economics Department, Ankara, Türkiye

[*]Corresponding Author: seldaturkoglu@gmail.com

Citation
Turkoglu Coskun, S. and Olhan, E. (2022). Genetically modified organisms and biosafety as perceived by professionals according to their sociodemographic characteristics. Journal of Agriculture, Environment and Food Sciences, 6 (1), 121-129.
Doi
https://doi.org/10.31015/jaefs.2022.1.16

Received: 04 February 2022
Accepted: 25 March 2022
Published Online: 02 April 2022

Year: 2022
Volume: 6
Issue: 1 (March)
Pages: 121-129

Available online
http://www.jaefs.com
https://dergipark.org.tr/jaefs

Abstract

While the cultivation of modern biotechnology products was adopted by producers very fast, the consumer acceptance of these products has not evolved at the same pace. Despite multiple benefits associated with genetically modified organisms (GMO), some potential risks related to the environment, health and economy have increased concerns and affected consumer confidence. This article examines the relationship between knowledge and confidence levels for biosafety and GMOs, and the sociodemographic characteristics of professionals working in the fields of food, agriculture and veterinary medicine, with a view to assess their perception. Questionnaires were applied to 261 individuals, selected by the proportional sampling method among professionals, the numbers of whom were obtained from the relevant unions and chambers. Then frequency, percentage distribution and factor analyses were carried out on data obtained. In conclusion food engineering professionals, men and more knowledgeable participants in biotechnology were found to have a more positive approach towards GMOs and more confidence in the biosafety system. It is indisputable that the scientific knowledge is essential for a reliable biosafety mechanism. Therefore, the inclusion of courses on GMOs and biosafety into curricula and planning in-service trainings may significantly contribute to the development of scientific knowledge thus, improving attitudes towards GMOs.

Keywords

Biosafety, Food biotechnology, GMO trust and confidence, GMO knowledge, Consumer perception

Introduction

As of the late 20th century, given its highly advanced level and scope of application, modern biotechnology has become an added value of leading edge technologies. While having brought about favourable economic and social transformations in many sectors, it has also raised question marks (Yilmaz, 2014). Although biotechnology products are offered as a solution to the global hunger problem and are claimed to be more efficient, more economical and environmentally friendly, discussions continue on their adverse impact on the environment and biodiversity, as well as the potential health risks they pose, including allergies, antibiotic resistance and toxicity (Cebi & Olhan, 2019).

Existing regulations on GMOs across the world are handled as either non-binding, guide-based international regulations or binding legal regulations. Among them, the United Nations Convention on Biodiversity and the Cartagena Biosafety Protocol are the main internationally binding texts to which Türkiye is also a party (Soykan, 2007). Whereas Türkiye is not a party yet in the Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the Convention on Biological Diversity and entered in force in 2018. (Karakoc Yildiz, 2019).

There are also contextual differences between texts regulating the trade of GMOs such as the Cartagena Biosafety Protocol and the World Trade Organization (WTO) agreements. The main purpose of the WTO is to support free trade (Aksu, 2019), while in the Cartagena Biosafety Protocol, which is an annex to the Biodiversity Convention, the main objective is to

prevent the adverse effects of GMOs on biodiversity, such that the precautionary principle has been adopted (Ates, 2020).

Two different perceptions of GMOs have created different legal frameworks in countries. While the USA implements its policies and regulations based on the principle of "basic equivalence", considering GMO and traditional products to be similar, the EU is more cautious and considers GMO products to be different from traditional ones, based on the precautionary principle (Karakoc Yildiz, 2019). Differences reflected in the legal regulations are also came out in the production and trade of these products. While countries such as the USA, Brazil, Canada and Argentina are the leaders in the production of GMO products, EU countries do not favour the production and trade of these products, with a few exceptions. The top ten countries producing GMOs in the world produced transgenic plants on an area of more than 1 million hectares in 2019. As can be seen in Table 1, among these top ten countries, only the USA and Canada are classified as developed countries, while the rest are classified as developing (ISAAA, 2019).

Table 1. Global transgenic plant cultivation in 2019

Rank	Country	Area (million hectare)	Commercial Transgenic Products
1	USA	71.5	Maize, soybean, cotton, alfalfa, canola, sugar beet, potato, papaya, squash, apple
2	Brazil	52.8	Soybean, maize, cotton, alfalfa
3	Argentina	24.0	Soybean, maize, cotton, alfalfa
4	Canada	12.5	Canola, soybean, maize, sugar beet, alfalfa, potato
5	India	11.9	Cotton
6	Paraguay	4.1	Soybean, maize, cotton
7	China	3.2	Cotton
8	South Africa	2.7	Maize, soybean, cotton
9	Pakistan	2.5	Cotton
10	Bolivia	1.4	Soybean

Source: (ISAAA, 2019)

In recent years, some new breeding techniques, such as genome editing, have allowed scientists to improve the characteristics of living organisms. The technologies most commonly used in genome editing are clustered regularly interspaced short palindromic repeats (CRISPR)-CRISPR-associated protein 9 (Cas9), transcription activator-like effector nucleases (TALENs), zinc-finger nucleases (ZFNs), and homing endonucleases or mega nucleases (ISAAA, 2022). CRISPR-Cas technology allows making changes in targeted regions of human, animal, plant and microorganism's genetic material (Tastan, 2018). The two types of legal approaches mentioned above also come to the fore in determining whether or not to extend the controls applied to GMOs to commercial varieties obtained with novel methods such as CRISPR. While the techniques used in the development of new varieties have been taken into account with a process-based approach in the EU, Argentina, Brazil and several other countries, a product-based approach has been adopted by the USA and Canada (Akbudak & Kontbay, 2017).

In addition to all these regulatory studies on GMOs, several scientific studies have aimed to assess the consumers' perspectives on GMOs. In a study dating back to 2003, it was stated that consumers' perspectives and attitudes towards GMOs changed positively in direct proportion to their education and knowledge level (Hossain et al., 2003). Aleksejeva (2014) again, showed that EU Experts, who have a high level of knowledge about GMOs and are involved in the decision-making process, support the use of GMOs in food and feed. There are also studies showing that consumers' attitudes towards GMO foods vary among countries and individuals (Rodríguez-Entrena & Salazar-Ordóñez, 2013). For example, the attitude of US citizens towards GMOs is more positive than that of Canadians, European Union citizens and Irish. (Gaskell, 2005; Wolf at all., 2004; Tukelman, 2017). In a study conducted in the rural areas of China in 2015, it was determined that consumer attitudes towards GMOs were shaped by subjective comments rather than objective information, and beneficial perspectives on these products positively affected purchasing behaviour (Liu & Zhang, 2015). On the otherhand, the research conducted with approximately thirty thousand participants in the EU in April 2019 showed that the Europeans' concerns about GMOs had decreased, such that the percentage of respondents identifying 'genetically modified ingredients in food or drinks' as a concern, which was 66% in a 2010 survey, had fallen to 27% in the 2019 (EFSA, 2019).

Legislation on GMOs in Türkiye consists of the Convention on Biological Diversity, the Cartagena Biosafety Protocol and the Biosafety Law with three regulations at the national level (Civgin, 2013). According to the Biosafety Law numbered 5977 (2010), which prohibits the entry of genetically modified seeds into Türkiye, it is forbidden to place GMOs and their products on the market without approval, to use or make use of GMOs and their products in violation of prevailing decisions, to cultivate genetically modified plants and produce genetically modified animals, to use GMOs and their products outside their defined scope and purpose, and to use GMOs and products in baby foods and infant formulas, follow-up formulas, follow-on formulas and supplementary foods for infants and young children. In addition, with amendments made to the Biosafety Law over time, the Biosafety Board was abolished and the Ministry of Agriculture and Forestry assumed its duties (TBBDM, 2022). In a study

conducted by Civgin (2013), it is stated that the current GMO legislation in Türkiye is overall compatible with the Convention on Biological Diversity and the Cartagena Biosafety Protocol.

In line with all these developments, the perspectives of both consumers and experts on biotechnological advancements have been investigated through many studies in Türkiye. The research conducted in three different regions of Türkiye (Southeast/Eastern Anatolia, Aegean and Black Sea) in 2012 found that while 73% of the participants stated that they had heard of the concept of GMO, 27% stated that they had never heard the term before (Baykan & Ertunc, 2012). On the other hand, Temelli and Kurt (2011) concluded that students did not have adequate scientific knowledge on GMOs, and were therefore cautious about the use of GMOs, which highlighted the need to increase their information level. Adana et al. (2014) found that nursing and midwifery students did not have sufficient knowledge about genetically modified organisms. Merdan (2019) conducted a study revealing that the socioeconomic characteristics of students significantly defined their level of knowledge about GMO products.

The hypothesis "the level of knowledge and confidence of professionals working in the fields of food, agriculture and veterinary medicine about biosafety and GMOs is high" was aimed to be set out in this study. The attitudes of food engineering, agricultural engineering and veterinary medicine professionals, who are thought to have a high level of knowledge about biosafety and GMOs, were determined and differences in the knowledge and confidence levels of these professionals in relation to their sociodemographic characteristics were demonstrated. This research contributes to determining the need for the development of training programs addressing public concerns over GMOs by the relevant authorities for a reliable and effective biosafety mechanism.

Materials and Methods

In order to identify the main population of the research, the numbers of food engineers, veterinarians and agricultural engineers working in the Ankara Province were obtained from the Chamber of Food Engineers, the Chamber of Agricultural Engineers and the Veterinary Medical Association on August 4, 2015. The proportional sampling approach was used to determine the number of subjects to be sampled (Aksoy & Yavuz, 2012). Accordingly, 261 individuals were selected among 8570 professionals working in Ankara with the proportional sampling method with a confidence level of 90% and a 5% margin of error.

Questionnaires were applied to professionals working for the Ministry of Agriculture and Forestry in Ankara Province and responses were obtained through software after preliminary interviews with the individuals. Collection of all questionnaires were completed in 2021. Accordingly, the official figures obtained are shown in Table 2.

Table 2. Sample Distribution

Group of Profession	Number of Professionals	Rate in Total	Number of Professionals to be Surveyed
Food Engineering	1224	14%	37
Veterinary Medicine	2031	25%	64
Agricultural Engineer	5315	61%	160
Total	8570	100%	261

The first part of the questionnaire applied in the present study comprised of questions to measure the sociodemographic characteristics of the participants, and the second part included the statements to determine their general thoughts on biosafety and GMOs. The SPSS26 software was used in the analyses of the obtained data. A 3-point Likert attitude scale (1 = disagree, 2= indecisive, 3= agree) was used, frequency and percentage analyses of the questionnaire responses were performed, followed by an explanatory factor analysis (Kline., 1994; Buyukozturk, 2002).

The Kayser-Meyer-Olkin (KMO) value, comparing the magnitudes of the observed correlation coefficients in relation to the magnitudes of the partial correlation coefficients was used to measure the sampling adequacy and the Bartlett spherical value was used to test the hypothesis that the correlation matrix is an identity matrix. In determining the number of factors in this research, the sum of the squares of the factor loads of each factor, the eigenvalues (coefficient used in calculating the ratio of the variance explained by each factor and deciding the number of important factors) were taken into account. In the factor analysis, in which the variance explained by the factor increases as the eigenvalue increases, the factors with an eigenvalue of 1 were taken as important factors. The naming of the factors was based on the common characteristics of several factors. The Cronbach alpha coefficient was used for the internal consistency of the data set and the Kolmogorov Smirnov test was used to determine the distribution of the variables and showed that they did not exhibit a normal distribution (Tabachnick, B. G., & Fidell, L. S., 2007; Buyukozturk, 2002). The Mann-Whitney U test was used for the comparison of two groups, and the Kruskall-Wallis H-test was used for the comparison of three or more groups, as non-parametric analysis techniques (Akdag, 2011).

Results

Descriptive Statistics on the Sociodemographic Characteristics

The first part of the questionnaire aimed to determine the sociodemographic characteristics including socioeconomic statistics of the participants. According to the frequency and percentage distributions of the sample from which the data were obtained, the ages of the participants, whose male and female ratios were similar, varied between 31-51 years and above. Nearly half of the participants held master of science degrees in either agricultural engineering, veterinary medicine or food engineering. It was determined that the attendance

of the participants to biotechnology courses was at a level higher than that to GMO-specific courses. Furthermore, about half of the participants had also attended biotechnology trainings due to their job. The percentage distribution of the data obtained in the research is shown in Table 3.

Table 3. Statistics of sociodemographic characteristics

Criteria	**Category**	**Total**	**%**
Age	26-30	10	3.8
	31-40	120	46
	40-50	48	16.5
	51 +	88	33.7
	Category	**Total**	**%**
Gender	Male	135	51.7
	Female	126	48.3
	Category	**Total**	**%**
Occupation	Agricultural Engineer	160	61.3
	Veterinarian	64	24.5
	Food Engineer	37	14.2
	Category	**Total**	**%**
Household Size	1-3	149	57.1
	4-6	111	42.5
	6 +	1	0.4
	Category	**Total**	**%**
Who do you live with right now?	Alone	17	6.5
	With spouse	43	16.5
	Elementary family	110	42.1
	Extended family	74	28.4
	Others	17	6.5
	Category	**Total**	**%**
If you have children, their age?	No child	25	9.5
	0-24 mounth-old child	47	18
	2-13 year-old child	141	54
	13-18 year-old child	38	14.5
	18 +	**10**	**4**
	Category	**Total**	**%**
Educational background	Undergraduate	97	37.2
	Graduate	120	46
	Doctorate	44	16.9
	Category	**Total**	**%**
Monthly salary (%)	4000-5000 TL	11	4.2
	5001-7000 TL	57	21.8
	7000 TL +	193	73.9
	Category	**Total**	**%**
Budget for food	500 TL and below	6	2.3
	500-1000 TL	37	14.2
	1000-2000 TL	112	42.9
	2000 TL +	106	40.6
	Category	**Total**	**%**
Have you taken a course on biotechnology?	Yes	156	59.8
	No	105	40.2
	Category	**Total**	**%**
Have you taken a course on GMOs and GMO products?	Yes	99	37.9
	No	162	62.1
	Category	**Total**	**%**
Have you attended trainings on biotechnology?	Yes	120	46
	No	141	54

Statistics on the Participants' Perspectives on Biosafety and GMOs

Frequency and percentage analyses of the expressions of the participants on GMOs and the current biosafety policy were performed using a 3-point Likert attitude scale. Accordingly, it was determined that half of the participants were misinformed on the presence of GMOs on the national market, but the majority of them knew that GMOs were available for feed purposes on the national market. Again, nearly half of the participants didn't support the consumption of products such as meat, milk and eggs from animals fed on GMO feed. The development of GMO products (e.g., foods with increased nutritional value), despite proven positive effects on the consumer was also not supported by half of the participants. On the other hand, it was shown that most of the participants were disinclined to consume GMOs or GMO products as food, even if they were cheaper than the non-GMO equivalent of the same product, and were opposed to the production of genetically modified animals (such as cattle with increased milk yield). More than half of the participants were in favour of the production of health products such as vaccines. Again, according to the aforementioned data, more than half of these participants, who had the habit of checking product labels, had not come across with food products labelled as a GMO or GMO product, but stated that they may have consumed a GMO or its product for food purposes unwittingly. When the question about biosafety and the level of knowledge about GMOs and their products was asked, the participants gave three different answers, and no clear distinction was observed between agreeing, disagreeing and being indecisive. The opinions of the participants regarding all statements are shown in Table 4.

Table 4. Opinions of the Participants on Biosafety and GMOs

Expressions	Disagree		Indecisive		Agree		Total	
	Frequency (*f*)	Rate (%)	Frequency (*f*)	Rate (%)	Frequency (*f*)	Rate (%)	Frequency (*f*)	Rate (%)
There are GMOs and/or their products for use as food on the national market.	96	36.8	35	13.4	130	49.8	261	100
There are GMOs or products for use as feed on the national market.	8	3.1	14	5.4	239	91.6	261	100
There is no harm in consuming products such as meat, milk, eggs obtained from animals fed with GMO feed.	116	44.4	95	36.4	50	17.2	261	100
I support the development of GMO products (e.g., nutritionally enhanced foods) with proven positive effects on the consumer.	135	50.8	72	27.6	54	20.7	261	100
If a GMO or GMO product is cheaper than its non-GMO equivalent, I would consume it as food.	197	75.4	42	16.1	22	8.4	261	100
In Türkiye, genetically modified animals (such as cattle with increased milk yield) should be produced, if permitted by law.	157	60.2	56	21.5	48	18.4	261	100
Health products such as vaccines should be produced using gene technology in Türkiye.	35	13.4	52	19.9	174	66.6	261	100
I check the labels of the products I buy.	12	4.5	3	1.1	246	94.2	261	100
While shopping at the market, I came across with products sold for food purposes with a label stating that the product was a GMO or GMO product.	160	61.3	63	24.1	38	14.5	261	100
In Türkiye, I may have consumed a GMO or its product for food purposes unwittingly.	40	15.3	51	19.5	170	65.2	261	100
I think that the chicken whose meat I consumed was fed with GMO feed.	18	6.8	51	19.5	192	73.5	261	100
I have sufficient knowledge of biosafety and GMOs and their products.	84	32.2	90	34.5	87	33.3	261	100

Participants' GMO Perception According to their Sociodemographic Characteristics

In line with the information obtained, four different types of scores were created for the following statements: "positive view on GMOs", "need to be informed on GMOs", "trust in the biosafety system" and "legislative knowledge". A factor analysis, based on dimension reduction, was used for the creation of these scores. The results obtained by factor analysis are shown in Table 5. For the data set to be considered suitable for factor analysis, the KMO value should be above 0.50 and the Bartlett Sphericity Test result should be statistically significant ($p<0.05$) (Buyukozturk, 2002).

The calculation of the KMO value as 0.755 showed that the sample size was sufficient for factor analysis. On the other hand, as a result of the Sphericity Test, the

p-value=0.00 <0.05. Accordingly, the data were suitable for factor analysis. As seen in Table 5, the total variance explained by these four factors regarding the scale was 56.3%. Since Cronbach's alpha values indicated high, rather high or very high reliability levels for all the questions collected under the factors, overall the scale was found to be highly reliable. The factor loads, Cronbach's alpha reliability coefficients, the total explained variance, which is an indicator of the related concept or structure having been measured well, and the data of the KMO and Bartlett Sphericity Tests are shown in Table 5.

Table 5. Factor Loads and Alpha Confidence Coefficients

Dimensions	Cronbach Alpha	Factor Loads
positive view on GMOs	**0.752**	
I support the development of GMO products (e.g., nutritionally enhanced foods) with proven positive effects on the consumer.		0.835
If a GMO or GMO product is cheaper than its non-GMO equivalent, I would consume it as food.		0.782
In Türkiye, genetically modified animals (such as cattle with increased milk yield) should be produced, if allowed by law.		0.757
There is no harm in consuming products such as meat, milk, eggs obtained from animals fed with GMO feed.		0.717
need to be informed on GMOs	**0.927**	
There are GMOs or GMO products for use as food on the national market.		0.794
In Türkiye, I may have consumed a GMO or its product for food purposes unwittingly.		0.618
While shopping at the market, I came across with products sold for food purposes with a label stating that the product was a GMO or GMO product.		0.611
trust in the biosafety system	**0.854**	
The Biosafety Board can take impartial decisions.		0.732
Criminal sanctions in our Biosafety Law are deterrent.		0.693
The Biosafety Law ensures the protection of our biodiversity.		0.692
legislative knowledge	**0.821**	
According to our biosafety legislation, there is a labelling requirement for GMOs and their products.		0.671
According to our Biosafety Law, experimental GMO production is allowed.		0.582
According to our Biosafety Law, the production of genetically modified plants and animals is prohibited.		0.568
All questions	**0.836**	
Eigenvalue		**1**
Factor Variance (%)		**56.348**
KMO Value		**0.755**
Bartlett Sphericity Test		**p =0.00 < 0.05**
Cronbach Alpha=		**0.836**

Subsequently the Kolmogorov-Smirnov test was applied to the four different scores to determine whether the sample in question came from a normal distribution. According to the results obtained for the need for information on GMOs, a positive view of GMOs, trust in the biosafety system and legislative knowledge, it was determined that the variables did not have a normal distribution. At this point, the non-parametric Mann-Whitney and Kruskal-Wallis tests were used (Buyukozturk, 2002). In the score types created, the differences were tested for gender, occupation, education level (taking biotechnology courses, taking GMO courses, attending biotechnology trainings for work), people with whom they live, income level, and the budget allocated for food. The differences for each of the mentioned score types are summarized in Table 6, such that situations, in which no difference in all variable types was observed, were not included in the table.

Table 6. Differences in the score types according to sociodemographic characteristics

Variable	The need to be informed on GMOs	Positive view on GMOs	Trust in the Biosafety System	Legislative Knowledge
Gender	No difference	Men scored higher (p=0.018)	No difference	No difference
Occupation	Food engineers scored lower (p=0.00)	No difference	Food engineers scored higher (p=0.01)	Food engineers scored higher (p=0.00)
Level of Education	No difference	No difference	Those holding a doctorate degree scored higher (p=0.051)	No difference
Status of Prior Attendance to Biotech. Course	No difference	Those who had taken courses scored higher (p=0.061)	Those who had taken courses scored higher (p=0.059)	Those who had taken courses scored higher (p=0.004)
Status of Prior Attendance to Courses on GMOs	No difference	No difference	Those who had taken courses scored higher (0.033)	No difference
Status of Prior Attendance to Biotech. Course for Work	Those without prior training scored higher (p=0.06)	Those with prior training scored higher (p=0.008)	Those with prior training scored higher (p=0.076)	Those with prior training scored higher (p=0.000)

Discussion

This study investigated the knowledge and confidence levels of food engineering, agricultural engineering and veterinary medicine professionals for GMOs and the national biosafety policy, and the sociodemographic factors affecting their perceptions. It was determined that, overall, almost half of the participants showed a supportive approach to GMOs in their statements. However, more than half of the participants were sceptical of the statements based on trust. Previous research has shown that the people of different countries develop prejudices due to lack of information about GMOs and various psychosocial and economic reasons, and since no definite judgement can be made about the knowledge levels of these societies, it has been concluded that the determinants of the attitudes and behaviours of the people are the psychosocial priorities of that society and the individual (Atikcan et al., 2011).

In this study men showed a higher percentage of positive viewpoint towards GMO than women. In fact, similar to our findings, in previous studies women were found to be more concerned about GMO ethics and health aspects than men (Subrahmanyan and Cheng, 2000; Tukelman, 2017).This study also revealed that the need for information about GMOs is less and the positive point of view is higher of food engineers. It has also been determined that the scores of food engineers are high in the dimensions of trust in the biosafety system and knowing the legislation. Atikcan et al. (2011) examined the awareness of students in food engineering and other faculties in Türkiye in terms of demographic characteristics such as gender and determined that men were more aware of GMOs and food engineering students were more knowledgeable since they are educated on this subject. Furthermore, in this study, it was determined that those holding a doctorate degree had a higher level of trust in the biosafety system. It has already been determined that a high level of scientific understanding leads to fewer negative opinions, higher acceptance rates, and less discrimination among types of genetic modification (McComas et al., 2014). In this study, it was proved that the participants who had taken courses on biotechnology had a more positive attitude towards GMOs, were more confident in the biosafety system, and had more knowledge on legislation. Participants who had taken a course on GMOs trusted these products more. Statistically significant differences were observed for all score types for professionals had participated in biotechnology trainings for work. In fact, as mentioned above, it is known that participants with a high level of scientific knowledge have less negative thoughts about GMOs (Wunderlich & Gatto, 2015). In a study conducted to measure the knowledge and attitudes of nursing students about GMOs, it was determined that they considered GMOs to be very risky despite their low knowledge levels, and it was stated that adding GMO-related courses to the curriculum would contribute to improving their knowledge and attitude (Turker et al., 2013). In another study conducted on consumers in 2003, it was stated that their perspectives and attitudes towards biotechnological applications and products changed in direct proportion to their education and knowledge levels (Hossain et al., 2003). Yet in Aleksejeva's (2014) research, highly knowledgeable EU experts, who are involved in the decision-making process for GMOs, support the use of GMOs in food and feed. Thus, as Yilmaz V. (2020) stated a reliable and effective biosafety mechanism is essential for addressing the concerns of the society over GMO products.

Conclusion

Among the population of the present study food engineering professionals, men and more knowledgeable participants in biotechnology were found to have a more positive perception of GMOs and be more confident in the biosafety system. Increasing trust in the biosafety system depends on eliminating information pollution and increasing the level of scientific knowledge. Thus, inclusion of courses on GMOs and biosafety into curricula and planning in-service trainings may significantly contribute to the reliability of the biosafety mechanism.

Compliance with Ethical Standards

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

References

Adana, F., Gezer, N., & Ogut, S. (2014). Knowledge and Opinions of the Health School Students About Genetically Modified Organisms (GMOs). *Acıbadem Üniversitesi Sağlık Bilimleri Dergisi*, *5*(September 2014), 276–280. (in Turkish)

Akbudak, M. A., & Kontbay, K. (2017). New Generation Genome Editing Techniques: ZFNs, TALENs, CRISPRs and Their Use in Plant Research Abstract. *Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi*, *26*(1), 111–111. Doi: https://doi.org/10.21566/tarbitderg.323614 (in Turkish)

Akdag M (2011). Statistical Analysis in SPSS. Lecture Notes, Malatya. İnonu.edu.tr. (Access Date: 04.12.2021). (in Turkish)

Aksoy, A., & Yavuz, F. (2012). Analysis on the Reasons for Quitting Sheep Aand Goat Rearing of Farmers: A Case of East Anatolia Region. *Anadolu Tarım Bilim. Derg.*, *27*(2), 76–79. Doi: https://doi.org/10.7161/anajas.2012.272.76 (in Turkish)

Aksu, S. (2019). *Legal Liability for a Genetically Modified Organism and Its Products* [Dokuz Eylül University Graduate]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=bQF6MSOhc5untxZ0AdqnBg&no=YNjdmC52k13iw8BkMMcurA PhD Thesis (in Turkish)

Aleksejeva, I. (2014). EU Experts' Attitude Towards Use of GMO in Food and Feed and Other Industries. *Procedia - Social and Behavioral Sciences*, *110*, 494–501. Doi: https://doi.org/10.1016/j.sbspro.2013.12.893

Ates, Z. G. (2020). *Biyogüvenlik Kanunu Çerçevesinde Hukuki Sorumluluk* (Issue February) [İstanbul Kültür Üniversitesi]. Ph.D thesis https://acikerisim.iku.edu.tr/bitstream/handle/11413/6443/ZehraGizemAteşDRTez.pdf?sequence=1&isAllowed=y (in Turkish)

Atikcan, D. T., Bulbul, A., Coskun, O., Cakmak, I. B., Ozkan, O. C., Tas, O., & Dnş:Durukan, E. (2011). Toplumun Genetiği Değiştirilmiş Ürünlerle İlgili Bilgi Düzeyleri ve Bu Ürünleri Kabul Ederlik Durumu. *Başkent Ünv. Sempozyumu*, *12–3*, 2015. https://silo.tips/download/toplumun-genet-detrlm-rnlerle-lgl-blg-dzey-ve-bu-rnler-kabul-ederlk-durumu (in Turkish)

Baykan, B. G., & Ertunc, B. (2012). Türkiye'nin Üç Bölgesinde GDO Farkındalığı. *Bahçeşehir Ünv. Ekonomik ve Toplumsal Araş. Merk. Betam Araştırma Notu 12/136*. (in Turkish)

Biosafety Law (2010). Biosafety Law 5977, 9 Official Gazette 76 (in Turkish)

Buyukozturk, Ş. (2002). Factor Analysis: Basic Concepts and Using to Development Scale. *Educational Administration in Theory and Practice*, *32*(32), 470–483. (in Turkish)

Cebi, S. Y., & Olhan, E. (2019). Possible Global Impacts of Genetically Modified Crops. *Journal of Agricultural Faculty of Bursa Uludag University*, 33(1), 179–196. (in Turkish) https://dergipark.org.tr/en/download/article-file/724416

Civgin, H. (2013). Biosafety Board Decisions According to International Conventions and to GMO Regulation in Türkiye. *Eğitim Bilim Toplum Üç Aylık Hakemli Dergi*, *9*(29), 9–38. (in Turkish)

EFSA. (2019). Food Safety in the EU. In *Special Eurobarometer Wave EB91.3 Food Safety İn the EU* (Issue June). https://doi.org/10.5040/9781472563880.ch-005

Gaskell G (2005). Europeans and biotechnology: Patterns and trends. Final Report on Eurobarometer, 64(3):1-87.

Hossain, F., Onyango, B., Schilling, B., Hallman, W., & Adelaja, A. (2003). Product attributes, consumer benefits and public approval of genetically modified foods. *International Journal of Consumer Studies*, *27*(5), 353–365. https://doi.org/10.1046/j.1470-6431.2003.00303.x

ISAAA. (2019). *ISAAA Brief 55-2019*. https://www.isaaa.org/resources/publications/briefs/55/executivesummary/default.asp Access Date: 04.12.2021

ISAAA. (2022). *Genome Editing Resource*. https://www.isaaa.org/resources/genomeediting/default.asp Access Date: 20.02.2022

Karakoc Yildiz, D. (2019). *Genetiği Değiştirilmiş Tarımsal Ürünler ve Uluslararası Ticareti* [Ankara Üniversitesi]. Ph.D thesis https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=zOKMYGcgPe3KYwPb9ucW1g&no=bCE2UstFYYSAyZqiQpG (in Turkish)

Kline, P. (1994). An Easy Guide To Factor Analysis:. New York: Routledge.

Liu, G., & Zhang, M. (2015). The Effects of Consumer's Subjective and Objective Knowledge on Perceptions and Attitude Towards Genetically Modifies Foods: Objective Knowledge as a Determinant. *International Journal of*

Food Science and Technology, *50*, 1198–1205. https://doi.org/10.2495/MIIT132422
McComas, K. A., Besley, J. C., & Steinhardt, J. (2014). Factors influencing U.S. consumer support for genetic modification to prevent crop disease. *Appetite*, *78*, 8–14. https://doi.org/10.1016/j.appet.2014.02.006
Merdan, K. (2019). Determining the Level of Information and Perspective of Universıty Students Regarding Genetically Modified (Transgenic) Products: Gumushane University Sample. *Ufuk Üniversitesi Sosyal Bilimler Dergisi*, *8*(15), 343–365. (in Turkish)
Rodríguez-Entrena, M., & Salazar-Ordóñez, M. (2013). Influence of scientific-technical literacy on consumers' behavioural intentions regarding new food. *Appetite*, *60*(1), 193–202. https://doi.org/10.1016/j.appet.2012.09.028
Soykan, S. (2007). *European Union and Turkish Regulations on Biosafety*. Gazi University. MSc. thesis. (in Turkish)
Subrahmanyan S, Cheng P S (2000). Perceptions and attitudes of singaporeans towards genetically modified food. Journal of Consumer Affairs 34(2): 269-290.
Tabachnick, B. G., & Fidell, L. S. (2007). Using Multi-variate Statistics. Pearson, Boston.
Tastan, C. (2018). T101 CRISPR Genom Modifikasyonları (Issue February). (in Turkish)
TBBDM. (2022). *TBBDM*. http://www.tbbdm.gov.tr/ (in Turkish) Access Date:18.02.2022
Temelli, A., & Kurt, M. (2011). Determination of Information and Opinion of University Students about Transgenic Products (GMO) Abstract. *Kurumsal Eğitimbilim*, *4*(2), 247–261. (in Turkish)
Tukelman, E. O. (2017). *Awaraness of the Farmers to Genetically Modified Organisms*. Namık Kemal University. Ph.D thesis (in Turkish)
Turker, T., Kocak, N., Aydin, I., Istanbulluoglu, H., Yildiran, N., Turk, Y. Z., & Kilic, S. (2013). Determination of knowledge, attitude, behavior about genetically modified organisms in nursing school students. *Gulhane Medical Journal*, *55*(4), 297–304. https://doi.org/10.5455/gulhane.33326 (in Turkish)
Wolf M. C. G., Donell M., Domegan J., Yount H. (2004). Consumer attitudes towards GM food in Ireland and the USA. Consumer acceptance of genetically modified foods. Wallingford (UK): CABI Publishing, 143-54.
Wunderlich, S., & Gatto, K. A. (2015). Consumer perception of genetically modified organisms and sources of information. *Advances in Nutrition*, *6*(6), 842–851. https://doi.org/10.3945/an.115.008870
Yilmaz, V. A. E. (2020). Investigation of Attitudes and Behaviors for Genetically Changed Products: Example of Eskişehir and Bursa. *Ankara Hacı Bayram Veli Üniversitesi İktisadi ve İdari Bilimler Fak. Dergisi*, *22/2*(August), 381–402. (in Turkish)
Yilmaz, F. (2014). *Genetically Modified Organisms and Products with Biosafety in Plant Production* [Kalkınma Bakanlığı]. https://www.sbb.gov.tr/wp-content/uploads/2019/06/Bitkisel-Uretimde-Genetigi-Degistirilmis-Organizmalar-ve-Urunleri-ile-Biyoguvenlik.pdf (in Turkish)