# Investigation of Science and Primary Education Teacher Candidates' Knowledge, Attitudes and Risk Perceptions about GMO Foods

**Aygun Karcı**
*Fırat University, Turkey*
https://orcid.org/0009-0005-8677-748X

**Erol Asiltürk**
*Fırat University, Turkey*
https://orcid.org/0000-0001-8126-7812

**Gülen Önal Karakoyun**
*Van Yüzüncü Yıl University, Turkey*
https://orcid.org/0000-0002-7675-0006

**Mehmet Polat**
*Fırat University, Turkey*
https://orcid.org/0000-0002-5955-5620

**Abstract**

*This study aimed to compare the knowledge levels, attitudes, and risk perceptions of pre-service science education (PSTs) and primary education (PETs) teachers toward genetically modified organism (GMO). Within the scope of the study, quantitative data were collected from 318 teacher candidates (1st-4th grade students) enrolled in universities in the Eastern and Southeastern Anatolia Regions of Turkey. Genetically Modified Organisms Knowledge Test (GMOKT), Genetically Modified Organisms Attitude Scale (GMOAS) and Genetically Modified Organisms Risk Perception Scale (GMORPS) were used as data collection tools. The data were evaluated with descriptive and comparative analysis methods using the SPSS package program. The findings showed that the knowledge levels of PETs regarding GMO were significantly higher compared to PSTs (p<0.05). In terms of risk perception, PETs scored higher on the overall scale (p<0.05). However, when personal and general risk perception sub-dimensions were examined, no statistically significant differences were found. Both groups perceived GMO foods as highly risky. The majority of participants have a common belief that GMO products carry risks at both individual and societal levels. The results reveal that teacher candidates' knowledge, attitudes and risk perceptions about GMO are affected by socio-cultural experiences as well as field education. It is recommended that GMO and biotechnology-based content in teacher training programs be restructured with an interdisciplinary approach and that practices focusing on critical thinking, risk assessment and science-society interaction be included.*

Keywords: Science Education, Primary Education, Genetically Modified Foods, Attitude, Risk Perception

## Introduction

The rapid growth of the world's population has brought about a dramatic surge in food demand (Dag & Akbay, 2022; Koca & Somuncu, 2021; Sisman & Sisman, 2025), while climate change, soil pollution, the misappropriation of agricultural lands, and unsustainable farming practices threaten global food supply (Gokirmakli & Bayram, 2018; Kahraman & Senol, 2018; Tian et al., 2021). In this context, advances in biotechnology

and genetic engineering provide innovative solutions aimed at increasing agricultural productivity (Alotaibi, 2017; Verma et al., 2011). Organisms produced through genetic-modification technologies (GMO) are promoted for advantages such as enhanced disease resistance, improved nutritional value, and greater tolerance to environmental stressors such as drought; nevertheless, they also provoke debate about potential risks to human health and ecosystems (Sivaji et al., 2020; Kaur & Singh, 2022; Zhang et al., 2016). Within the literature on GMO' role in agricultural production, a clear dichotomy emerges between the opportunities and risks associated with this technology. On one side, scholars highlight positive effects such as reduced pesticide use, increased crop yields, and enriched nutritional content (Evenson & Terri, 2007). On the other, concerns have been raised about long-term risks, including biodiversity loss, allergic reactions, and genetic contamination (Zhang et al., 2016). For instance, Faisal et al. (2019) acknowledge the potential of GMO to enhance nutritional value yet underscore uncertainties related to toxicity and gastrointestinal complications. Similarly, Catalbas et al. (2017) reported that religious and cultural concerns, along with perceived health risks, fuel resistance to this technology within society. These conflicting findings render a multidisciplinary evaluation of GMO' place in the global food system indispensable.

**Review of Literature**

Purbosari and Ma'rifah (2021), as a result of their study aiming to examine the knowledge and attitudes of pre-service biology teachers towards GMO foods, found that there was a positive relationship between the knowledge and attitudes of pre-service biology teachers towards GMO foods. Sorgo and Ambrozis-Dolinsek (2009) examined the knowledge, attitude, opinion and acceptance of biology teachers towards GMO foods in their study. As a result of their research, they found that pre-service teachers had low-level knowledge in modern subjects of biotechnology and high-level knowledge in classical subjects. As a result of their study, they also found that pre-service teachers' attitudes towards GMO foods were not high. In addition, they found that there was no relationship between knowledge and

attitude regarding GMO foods, a weak relationship between knowledge and acceptance, and a strong relationship between attitude and acceptance. Jiménez-Salas et al., (2017) found that more than 60% of basic education teachers thought that GMO foods would prevent hunger in the world; They concluded that 39.2% of them think that GMO foods threaten future generations; 47% of them do not have enough knowledge about biotechnology; and 90.3% of them want to be informed. Mohapatra et al. (2010) examined the knowledge and attitudes of teachers and students about genetically modified foods in their study. The findings showed that there was a significant difference between science teachers and high school students in understanding the concepts related to GMO foods. Most of the teachers stated that they found GMO foods dangerous for the environment, while most of the students stated that they were cautious about the benefits of GMO foods.

Public attitudes toward scientific developments are closely linked to individuals' scientific literacy. Scientifically literate individuals can analyse the risks and benefits of technological innovations and make informed decisions. At this juncture, teachers particularly pre-service teachers play a critical role, as they will guide future generations and foster critical thinking by conveying the socio-scientific dimensions of biotechnological applications.

**Objectives**

Studies examining pre-service teachers' knowledge and attitudes toward socio-scientific issues such as GMO remain limited, and comparative research exploring differences between PSTs and PETs is notably scarce.

Addressing this gap, the present study compares PSTs' and PETs' knowledge levels, attitudes, and risk perceptions concerning GMO foods. The core research questions are:

- Do the groups differ significantly in their knowledge levels regarding GMO foods?
- Do the groups differ significantly in their attitudes toward GMO foods?
- Do the groups differ significantly in their risk perceptions of GMO foods?

## Methodology
### Research Model

This descriptive study adopted the survey model, one of the quantitative research designs, to compare pre-service teachers' knowledge, attitudes and risk perceptions regarding foods that contain genetically modified organisms (GMO). In survey models, events, phenomena or situations are portrayed as they exist, without any intervention by the researcher; consequently, the researcher neither influences the outcome nor makes deliberate changes to the data. The principal aim is to determine relationships among variables on the basis of the data obtained and to arrive at generalisations.

### Study Group

The study group consisted of 318 pre-service teachers enrolled in various year groups of Science Teacher Education and Primary Education Teacher Education programmes at education faculties in six provinces of Turkiye's Eastern and Southeastern Anatolia regions.

**Table 1 Information on the Demographic Characteristics of Pre-service Teachers**

| Variable | | (n) | (%) |
|---|---|---|---|
| Gender | Female | 233 | 73,3 |
| | Male | 85 | 26,7 |
| | Total | 318 | 100,0 |
| Department | PSTs | 134 | 42,2 |
| | PETs | 184 | 57,8 |
| | Total | 318 | 100,0 |
| Year of study | 1st year | 198 | 62,2 |
| | 2st year | 53 | 16,7 |
| | 3st year | 35 | 11,1 |
| | 4st year | 32 | 10,0 |
| | Total | 318 | 100,0 |

PSTs: Pre-service science teacher; PETs: Pre-service primary education teacher

An inspection of Table 3 reveals that 73.3% of the participants were female and 26.7% were male; 57.8% were enrolled in the PETs programme, whereas 42.2% were in the PSTs programme. In terms of year of study, 62.2% were first-year students, 16.7% second-year, 11.1% third-year and 10.0% fourth-year.

### Data Collection Tools

In the study, three different measurement tools were used to determine pre-service teachers' knowledge, attitudes and risk perceptions about GMO foods.

**Genetically Modified Organisms Knowledge Test (GMOKT)**: This test, developed by Sönmez, aims to measure the basic knowledge level of prospective teachers about GMO foods. In the test, there are 8 multiple-choice items consisting of three options as "true, don't know and false". In order to determine the reliability level of the scale, KR-20 coefficient was calculated and this value was determined as 0.72.

**Genetically Modified Organisms Attitude Scale (GMOAS)**: This test, developed by Sönmez, aims to measure the attitudes of prospective teachers towards GMO foods. The reliability level of the 5-point Likert-type scale with 12 items was evaluated with Cronbach's alpha coefficient and this value was determined as 0.87.

**Genetically Modified Organisms Risk Perception Scale (GMORPS)**: This test, developed by Sönmez and Kılınç, aims to measure the risk perceptions of prospective teachers regarding GMO foods. The reliability level of the scale, which includes 26 6-point Likert-type items, was evaluated with Cronbach's alpha coefficient and this value was determined as 0.92.

### Research Process

In the first stage of the research process, all measurement tools and demographic information forms regarding teacher candidates were transferred to the Google Forms digital platform and an access link was created. The pre-service teachers were asked to answer the questions in the scales sincerely and were promised that their answers would be kept confidential and used only for research purposes. In the introduction section of the digital platform, pre-service teachers were informed by including a voluntary participation form and an information text about the research. Survey links were sent to the participants through the deanships and department heads of the faculties of education of the universities where the research was conducted, and a total of 318 pre-service teachers participated in the study.

## Data Analysis

In the data analysis phase of the study, the data collected with the measurement tools were transferred to the SPSS statistical package. In this context, arithmetic mean and standard deviation values were calculated to reveal the central tendency and distribution characteristics of the data. Skewness and kurtosis measures were used to examine the form of the distribution. Obtaining skewness and kurtosis values within the limits of -2 and +2 suggested by George and Mallery established the assumption that the variables showed a normal distribution. Based on this assumption, parametric test methods were preferred; independent sample t-tests were applied to determine the differences between the knowledge levels, attitudes and risk perceptions of the teacher candidates.

## Results

The central tendency measures (mean), distribution spread (standard deviation) and normality assumptions (skewness-kurtosis) of the GMOKT, GMOAS and GMORPS scores of the prospective teachers were examined in detail and the obtained data are presented in Table 2.

**Table 2 Descriptive Statistical Analysis of PSTs' and PETs'GMOKT, GMOAS and GMORPS**

| Grup | Measurement Tool | n | Mean | ss | Skewness | ss | Kurtosis | ss | Min | Max |
|------|------------------|-----|------|------|----------|------|----------|------|-----|-----|
| PSTs | GMOKT | 134 | 1,86 | 0,43 | ,812 | ,209 | ,877 | ,416 | 1 | 3 |
| | GMOAS | 134 | 3,00 | 0,29 | ,127 | ,209 | -,687 | ,416 | 1 | 5 |
| | GMORPS | 134 | 4,49 | 0,50 | -,284 | ,209 | -,172 | ,416 | 1 | 6 |
| PETs | GMOKT | 184 | 2,09 | 0,43 | ,389 | ,179 | -,523 | ,356 | 1 | 3 |
| | GMOAS | 184 | 3,01 | 0,33 | -,797 | ,179 | 2,377 | ,356 | 1 | 5 |
| | GMORPS | 184 | 4,71 | 0,45 | -,454 | ,179 | 1,450 | ,356 | 1 | 6 |
| Total | GMOKT | 184 | 1,99 | 0,45 | ,501 | ,137 | -,162 | ,273 | 1 | 3 |
| | GMOAS | 184 | 3,01 | 0,31 | -,474 | ,137 | 1,382 | ,273 | 1 | 5 |
| | GMORPS | 184 | 4,62 | 0,48 | -,410 | ,137 | ,537 | ,273 | 1 | 6 |

Examination of Table 2 shows that the mean GMOKT score of PETs ($\bar{X}$=2.09) is comparable to that of PSTs ($\bar{X}$=1.86), the difference between the two group means being $\bar{X}$ difference=0.23. Likewise, the mean GMOAS score of PETs ($\bar{X}$=3.01) is essentially the same as that of PSTs ($\bar{X}$=3.00), with a difference of $\bar{X}$ difference = 0.01. Similarly, the mean GMORPS score of PETs ($\bar{X}$=4.71) is close to that of PSTs ($\bar{X}$=4.49), yielding a mean difference of $\bar{X}$ difference = 0.22.

Further scrutiny of Table 2 indicates that the skewness and kurtosis coefficients for all test results obtained from PSTs and PETs fall within the −2 to +2 interval, confirming that the data conform to a distribution consistent with normality.

The t-test results between the GMOKT, GMOAS and GMORPS scores of the prospective teachers and the branch variable are given in Table 3.

**Table 3 Independent-samples t-test Results between the GMOKT, GMOAS and GMORPS Scores of the Prospective Teachers and the Branch Variable**

| Test | Branch | n | X | ss | Levene Test | | sd | t | p |
|------|--------|-----|------|------|------|------|-----|-------|------|
| | | | | | F | p | | | |
| GMOKT | PSTs | 134 | 1,86 | ,043 | 2,327 | 0,128 | 316 | -4,765 | ,000* |
| | PETs | 184 | 2,09 | 0,43 | | | | | |
| GMOAS | PSTs | 134 | 3,00 | 0,29 | ,077 | 0,782 | 316 | -,288 | ,774 |
| | PETs | 184 | 3,01 | 0,33 | | | | | |
| GMORPS | PSTs | 134 | 4,49 | 0,50 | 6,817 | 0,009 | 316 | -4,016 | ,000* |
| | PETs | 184 | 4,71 | 0,45 | | | | | |

As seen in Table 3, the PST (X̄=1.86) and PET (X̄=2.09) groups' knowledge test scores are at the "incorrect" level. This level indicates that most prospective teachers answered the test items incorrectly. This result suggests that they lack accurate knowledge about GMOs and have misconceptions.

The independent-samples t-test in Table 3 showed that pre-service teachers' knowledge levels concerning genetically modified foods differed statistically significantly by branch [t(316) = –4.765; p<.05]. PSTs (X̄ = 1.86) and PETs (X̄ = 2.09) both responded at the "incorrect" level. This finding indicates that candidates in both branches judged the item claiming that GM foods are a beneficial practice to be incorrect. The same test indicated that

attitudes toward genetically modified foods did not differ significantly by branch [t(316) = –0.288; p> .05]. PSTs (X̄ = 3.00) and PETs (X̄ = 3.01) both responded at the "neither agree nor disagree" level, suggesting a moderate attitude toward the statement that genetically modified foods are beneficial. Risk perceptions of genetically modified foods, however, differed significantly by branch [t(316) = –4.016; p<.05]. PSTs (X̄ = 4.49) and PETs (X̄ = 4.71) answered at the "high" level, indicating that both groups perceive genetically modified foods as highly risky.

The t-test results for the levels at which pre-service teachers deem genetically modified foods risky according to branch are provided in Table 4.

**Table 4 Independent-samples t-test Results for Pre-service Teachers' Levels of Perceiving Genetically Modified Foods as Risky According to Branch**

| Test | Branch | n | X | ss | Levene Test | | sd | t | p |
|------|--------|---|---|-----|------|------|----|----|----|
| | | | | | F | p | | | |
| GMOKT | PSTs | 134 | 1,86 | ,043 | 2,327 | 0,128 | 316 | -4,765 | ,000* |
| | PETs | 184 | 2,09 | 0,43 | | | | | |
| GMOAS | PSTs | 134 | 3,00 | 0,29 | ,077 | 0,782 | 316 | -,288 | ,774 |
| | PETs | 184 | 3,01 | 0,33 | | | | | |
| GMORPS | PSTs | 134 | 4,49 | 0,50 | 6,817 | 0,009 | 316 | -4,016 | ,000* |
| | PETs | 184 | 4,71 | 0,45 | | | | | |

As a result of the independent groups t-test conducted according to the branch variable, it was determined that the level of personal risk perception of GMO foods by teacher candidates did not differ statistically significantly according to the branch variable [t(316) = 1.519; p<.05].From the answers given to the question where the risk level was scored between 1-10, it is understood that both science teacher candidates (X = 7.12) and classroom teacher candidates (X = 6.74) consider genetically modified foods to be highly risky for themselves. However, no statistically significant difference was found between the two teacher groups. As a result of the independent groups t-test conducted according to the branch variable, it was determined that the level of teacher candidates' perception of GMO foods as risky for humans did not show a statistically significant difference according to the branch variable. [t(316) = 1.519; p<.05]. From the answers given to the question where the risk level was scored

between 1-10, it is understood that both science teacher candidates (X = 7.42) and classroom teacher candidates (X = 7.51) consider genetically modified foods to be highly risky for humans. However, no statistically significant difference was found between the two teacher groups.

The total risk perception score varied by branch. However, this difference disappeared when the sub-dimensions were examined separately. There was no statistically significant difference between personal risk and general risk perception scores.

**Discussion and Conclusion**

In this study, the knowledge, attitudes and risk perceptions of science and classroom teacher candidates towards GMO foods were determined and compared according to their branches. In the analysis conducted in line with the question "Is there a significant difference between the knowledge levels of science and classroom teacher candidates

regarding GMO foods?", it was determined that the knowledge levels of science and classroom teacher candidates regarding GMO foods differed at a statistically significant level. It was concluded that the knowledge levels of classroom teacher candidates regarding GMO foods were higher than science teacher candidates, but that teacher candidates in both branches had limited knowledge and misconceptions regarding GMO foods. It was also revealed by this study that both science and classroom teacher candidates evaluated GMO foods as harmful. It can be said that the fact that classroom teaching programs, unlike the science curriculum, include an interdisciplinary curriculum regarding environmental education, social sciences and daily life problems is effective in the higher level of knowledge of students studying in these departments regarding GMO foods. It is thought that the intensive inclusion of basic theories, abstract concepts and experimental methods in science education programs is effective in having more limited knowledge and awareness levels regarding the socio-economic dimension of developments in the field of biotechnology. There are some studies in the literature that contain similar results to the results obtained in the current study. For example, Çankaya and İşçen (2015) conducted a study with 180 participants to determine the knowledge levels of science teacher candidates about GMO foods. As a result of the research, it was concluded that science teacher candidates have misconceptions about the effects of GMO foods and their knowledge is limited. In another research, Abacı and Abacı (2014) aimed to determine the knowledge and awareness levels of students studying in the Food Engineering and Biology departments about GMO foods. As a result of their research, they found that the majority of students studying in both departments had significant knowledge deficiencies about the basic principles, potential advantages and disadvantages of GMOs. Oğur et al. (2017) examined the knowledge and attitudes of university students about GMOs in their research. In the research in which 360 university students participated, they concluded that the general knowledge level of the students about GMOs was quite low. There are many different studies in the literature that concluded that the knowledge level

of university students and prospective teachers about GMO foods is low (Temelli & Kurt 2011; Yalmancı & Gözüm, 2016; Benzer & Civangönül, 2021; Sökülmez Kaya & Akar, 2016; Koçak et al. 2010). There are also studies in the literature that reached different findings than those mentioned above. For example, Arslan and Görgülü Arı (2020), in their research aimed to determine the knowledge and attitudes of science teachers about GMO foods, examined the knowledge levels of 30 science teachers. As a result of the research, they concluded that the knowledge level of science teachers about GMO foods was at a moderate level. Özdemir et al. (2010) determined that university students have a high level of verifiable knowledge about the production process, possible risks and prevalence of use of GMO foods as a result of their studies aimed at determining the knowledge and attitudes of university students towards GMO foods. It is thought that the existence of such different results in the literature is due to the different socio-cultural characteristics of the sample group, the difference in research designs, the professional profiles of the sample group and the difference in the curriculum of different departments.

Both groups scored low on the knowledge test. The majority of the answers were incorrect. This suggests that the prospective teachers lack accurate knowledge about GMOs. They have misconceptions, and students are confusing basic concepts. This result is consistent with similar studies in the literature.

The statistical analysis comparing the perspectives of science and classroom teacher candidates towards foods containing genetically modified organisms did not reveal a significant difference in attitudes between the two groups. The findings show that both groups evaluated GMO products mostly in terms of their potential risks and therefore developed a clearly negative approach. This result is parallel to many studies in the literature. Studies conducted on classroom teachers (Aktaş, 2020; Özdemir, 2021; Uzunkol, 2012), science teachers (Benzer & Civangönül, 2021; Kışoğlu & Keleş, 2018; Yalmancı & Gözüm, 2016), university students (Koçak et al., 2010; Özdemir et al., 2010; Semiz & Yılmaz, 2019) and health professionals (Hıdıroğlu et al., 2013) report that participants have a cautious often negative

attitude towards GMO foods. Thus, the current study once again confirms the tendency towards caution and negativity that is widely observed in the social perception of GMO foods. It is thought that the emphasis on "organic food", the rumors that GMO foods increase cancer cases, and the popular culture of "traditional and natural nutrition" and the characterization of biotechnology studies as an element that disrupts this naturalness are effective in the emergence of negative attitudes.

The analyses conducted to answer the question "Do science and classroom teacher candidates' risk perceptions regarding GMO foods differ significantly?" show that classroom teacher candidates evaluate GMO foods at a higher threat level compared to science teacher candidates. However, it is seen that both groups already perceive the absolute risk level quite high. Participants agree that GMO products pose serious risks to both their personal health and the general well-being of society. This result is consistent with many studies in the literature. For example, studies conducted on medical school students (Koçak et al., 2010; Keskin et al., 2010), science teacher candidates (Arslan & Görgülü Arı, 2020; Benzer & Civangönül, 2021; Demiral & Türkmenoğlu, 2018; Kışoğlu & Keleş, 2018), adult individuals (Arı & Yılmaz, 2020), and hospital workers (Söyler et al., 2021) concluded that participants attribute a high level of risk to GMO foods. These results confirm once again that the widespread and intense risk perception towards GMO foods is not specific to teacher candidates, but an interdisciplinary and interprofessional phenomenon.

The total risk perception score was higher in the PET group. However, when the subscales were examined separately, this difference was not significant. This is due to the fact that the total score on the scale and the subscales can yield different results. In other words, students generally perceive GMOs as risky. However, they share similar views on whether the risk lies with them or society.

Prospective teachers have a low level of knowledge. Biotechnology and GMO topics should be added to curriculum. These topics should be included not only in science courses but also in social studies and environmental education courses.

Prospective teachers should be presented with case discussions and examples from daily life. Class discussion and problem-solving activities should be implemented. Practical work should be included to teach them how to conduct risk assessments. Activities should be designed to teach prospective teachers how to identify misinformation circulating in society.

## Acknowledgment

## References

Abaci, Z. M., & Abaci, Z. T. (2014). Genetically modified organism consciousness and information level in biology and food engineering students in Inonu University. *Inonu University Journal of the Institute of Science and Technology, 4*(2), 31-37.

Aktas, I. (2020). The relationship between knowledge of, attitudes toward, and acceptance of genetically modified organisms of pre-service elementary school teachers. *Trakya Journal of Education, 10*(3), 933-949.

Alotaibi, K. H. (2017). Globalization of genetically modified foods and their effect on human health. *International Journal of Advanced Research in Biological Sciences, 4*(11), 49-54.

Ari, E., & Yilmaz, V. (2020). Investigation of attitudes and behaviors for genetically changed products: Example of Eskisehir and Bursa. *Ankara Haci Bayram Veli University Journal of the Faculty of Economics and Administrative Sciences, 22*(2), 381-402.

Arslan, K., & Gorgulu Ari, A. (2020). Knowledge levels and attitudes of science teachers for GMO food. *The Journal of International Social Research, 13*(72), 567-578.

Ates, Z. G. (2020). The legal arrangements of European Union concerning the genetically modified organisms. *Insan & Insan, 7*(24), 9-29.

Benzer, S., & Civangonul, B. D. (2021). Pre-service science teachers' attitudes towards

genetically modified organisms. *Journal of Interdisciplinary Educational Research, 5*(9), 24-37.

Cankaya, C., & Iscen, C. F. (2015). Determining the knowledge and opinions about the Genetically Modified Organisms (GMO) of pre-service science teachers. *The Journal of Academic Social Science Studies, 2*(32), 537-554.

Catalbas, T., Savas, H. B., & Gultekin, F. (2017). Genetically modified foods and their effects on human health. *Acta Medica Alanya, 1*(3), 58-63.

Celik, V., & Turgut-Balik, D. (2007). Genetically Modified Organisms (GMO). *Erciyes University Journal of the Institute of Science and Technology, 23*(1), 13-23.

Dag, M. M., & Akbay, C. (2022). Sustainable agricultural practices and alternative solutions against global food crisis. *The Journal of Agricultural Economics Researches, 8*(2), 182-194.

Demiral, U., & Turkmenoglu, H. (2018). Examining the relationship between preservice science teachers' risk perceptions and decision-making mechanisms about GMOs. *YYU Journal of Education Faculty, 15*(1), 1025-1053.

Evenson, R., & Terri, R. (2007). *The Political Economy of Genetically Modified Foods*. Edward Edgar Publishing.

Faisal, M., Saeed, M., Aslam, M., & Raheem, M. (2019). Impact of genetically modified food on human health. *Middle East Journal of Applied Science & Technology (MEJAST)*, *2*(3), 75-86.

Gokirmakli, C., & Bayram, M. (2018). Foresights for Future of Food: The Year 2050. *Academic Food Journal, 16*(3), 351-360.

Gorgulu Ari, A., & Kivanc, Z. (2019). Determination of the attitudes of science teacher candidates on biotechnology and genetically modified organism (GMO) subjects. *Adnan Menderes University Journal of Educational Sciences, 10*(1), 37-57.

Gunes, M. A. (2008). Genetically modified organisms and environmental law - International Regulations, European Union Law and

the current situation in Turkey. *Journal of Istanbul University Law Faculty, 66*(2), 49-90.

Hidiroglu, S., Onsuz, M. F., Kalafat, C. E., & Karavus, M. (2013). Knowledge, attitude and behaviours of patients applied to primary health care centers about genetically modified organisms in Umraniye. *Firat Medical Journal, 18*(3), 176-181.

Jiménez-Salas, Z., Campos-Góngora, E., González-Martínez, B. E., Tijerina-Sáenz, A., Escamilla-Méndez, A. D., & Ramírez-López, E. (2017). Basic-education Mexican teachers' knowledge of biotechnology and attitudes about the consumption of genetically modified foods. *Biochemistry and Molecular Biology Education, 45*(5), 396-402.

Kahraman, S., & Senol, P. (2018). Climate Change: Global, regional and urban impacts. *Akademia Journal of Social Sciences,* 353-370.

Kowalski, K. M. (2002). *The Debate over Genetically Engineered Food: Healthy or Harmful?*. Enslow Publishers.

Kaur, A., & Singh, K. (2022). A review on genetically modified food and their problems. *International Journal of Innovative Research in Engineering & Management, 9(1),* 225-229.

Keskin, Y., Luleci, N. E., Ozyaral, O., Altintas, O., Saglik, A., Lisar, H., Turan, A., & Top, Y. (2010). Knowledge attitude and behavior of the students in medical school of Maltepe University about genetically modified organisms. *Maltepe Medical Journal, 2*(1), 14-23.

Kisoglu, M., & Keles, O. (2018). Determination of pre-service science teachers' perceptions about genetically modified organisms (GMOs). *Abant Izzet Baysal University Journal of Faculty of Education, 18*(4), 2123-2147.

Koca, R., & Somuncu, M. (2021). An evaluation for Turkey on food security. *Ankara University Journal of Environmental Sciences, 8*(2), 1-11.

Kocak, N., Turker, T., Kilic, S., & Hasde, M. (2010). Assessment of knowledge, attitude and behavior level of medical school students

about genetically modified organisms. *Gulhane Medical Journal, 52*(3), 198-204.

Mohapatra, A. K., Priyadarshini, D., & Biswas, A. (2010). Genetically modified food: Knowledge and attitude of teachers and students. *Journal of Science Education and Technology, 19*, 489-497.

Ogur, S., Aksoy, A., & Yilmaz, Z. (2017). Knowledge levels and attitudes of university students about genetically modified organisms and foods: Bitlis Eren University example. *Journal of Food and Health Science, 3*(3).

Ozdemir, A. M. (2021). Primary school teacher candidates' attitudes of genetically modified organisms (GMOs). *Ahi Evran University Journal of Kırşehir Education Faculty, 22*(1), 521-541.

Ozdemir, O., Gunes, M. H., & Demir, S. (2010). The level of knowledge and attitudes of students towards genetically modified organisms (GMO) and its evaluation according to sustainable consumption education. *Ondokuz Mayis University Journal of Education Faculty, 29*(1), 53-68.

Purbosari, P. P., & Ma'rifah, D. R. (2021). Knowledge and attitude of biology teacher candidate students towards genetically modified organisms (GMOs). *Scientiae Educatia: Journal of Science Education, 10*(2), 128-136.

Rathod, D., & Hedaoo, R. P. (2022). Assessment of knowledge and attitudes on genetically modified foods among students studying life sciences. *Cureus, 14*(12).

Semiz, M., & Yilmaz, E. (2019). Attitudes of university students towards GMO products: A structural equation modeling. *Journal of Quantitative Sciences, 1*(2), 1-20.

Sisman, D., & Sisman, M. (2025). Global food prices in the neoliberal era: The case of Turkiye. *International Journal of Social, Political and Financial Research, 5*(1), 46-62.

Sivaji, M., Pandiyan, M., Yuvaraj, M., Tilagavathi, T., Suganyadevi, M., & Sasmitha, R. (2020). Genetically modified food: Promises and Problems. *Biotica Research Today*, *2*, 312-315.

Sogukpinar, R., & Karisan, D. (2020). Investigation of preservice science teachers' attitudes towards genetic literacy issues and biotechnology. *Journal of Uludag University Faculty of Education, 33*(2), 410-445.

Sokulmez Kaya, P., & Akar, O. (2016). Health education of individuals with and without genetically modified foods' knowledge and attitudes about. *Journal of Samsun Health Sciences, 1*(1), 133-145.

Sorgo, A., & Ambrozis-Dolinsek, J. (2009). The relationship among knowledge of, attitudes toward, and acceptance of genetically modified organisms (GMOs) among Slovenian teachers. *Electronic Journal of Biotechnology, 12*(4).

Soyler, N., Ipar, M. S., & Kocatepe, D. (2021). Determination of the genetically modified organism (GMO) awareness levels of hospital workers: Example of Sinop. *Food and Health, 7*(1), 1-14.

Teitel, M., & Wilson, K. (2002). *Genetically Engineered Food: Changing the Nature of Nature*. Park Street Press.

Temelli, A., & Kurt, M. (2011). Determination of information and opinion of university students about transgenic products (GMO). *Journal of Theoretical Educational Science, 4*(2), 247-261.

Tian, X., Engel, B., Qian, H., Hua, E., Sun, S., & Wang, Y. (2021). Will reaching the maximum achievable yield potential meet future global food demand?. *Journal of Cleaner Production, 294*.

Uzunkol, E. (2012). Analysis of the primary school prospective teachers' perceptions about genetically modified organisms through metaphors. *Journal of Research in Education and Teaching, 1*(4), 94-101.

Verma, C., Nanda, S., Singh, R. K., Singh, R. B., & Mishra, S. (2011). A review on impacts of genetically modified food on human health. *The Open Nutraceuticals Journal, 4*, 3-11.

Yalmanci, S., & Gozum, A. I. C. (2016). Examination of research behaviours of pre-service science teachers on (GMO) socio-scientific issues. *Ahi Evran University Journal of Kirsehir*

*Education Faculty (KEFAD), 17*(1), 499-515.

Zhang, C., Wohlhueter, R., & Zhang, H. (2016). Genetically modified foods: A critical review

of their promise and problems. *Food Science and Human Wellness, 5*(3)*,* 116-123.

**Author Details**

**Aygun Karcı,** *Fırat University, Turkey,* **Email ID***: aygnkarc_2323@hotmail.com*

**Erol Asiltürk,** *Fırat University, Turkey,* **Email ID***: ecil@firat.edu.tr*

**Gülen Önal Karakoyun,** *Van Yüzüncü Yıl University, Turkey,* **Email ID***: gulenonal@yyu.edu.tr*

**Mehmet Polat,** *Fırat University, Turkey,* **Email ID***: hvpltyzbsmplt@gmail.com*