Exploring attitudes towards GMO labelling: a study on the Czech population

David Broz, Inna Cabelkova, Martin Hlavacek, Lubos Smutka, Petr Prochazka

Czech University of Life Sciences Prague, Prague, Czech Republic

Keywords:

GMO
Food
Labelling
Czech
Nutritional profile
Proteins

Article history:

Received 20.04.2023
Received in revised form 17.06.2023
Accepted 29.12.2023

Corresponding author:

Inna Cabelkova
E-mail: cabelkova@pef.czu.cz

DOI: 10.24263/2304-974X-2023-12-4-3

Abstract

Introduction. The debate surrounding the labeling of genetically modified organisms (GMOs) has largely shifted from whether to label to understanding the various reasons behind supporting or opposing such labeling.

Materials and methods. This paper studies factors influencing attitudes towards GMO labeling employing a representative sample of the Czech population (N=884). We examine the impact of information about genetically modified foods (GMFs), environmental concerns, perceived health effects, dietary habits, factors considered important when purchasing, and sociodemographic characteristics on GMO labeling preferences in the framework of ordinal regression analysis.

Results and discussion. Our findings reveal that almost one third of the respondents is not familiar with genetically modified foods (GMF). Another third confirm that they are familiar with the GMF, but does not know what it refers to. Almost eighty percent of the respondents do not express interest in GMF. On the other hand, the results suggest that the health concerns and the level of interest and information about GMO significantly predict the propensity to check GMO labels and the belief that the GMO products should be labelled. The current subjective state of health was not related to the attitudes to GMO labelling. Environmental considerations, such as the subjective effect of food production on the environment and the current environmentally conscious behavior (recycling and environmental waste management at home) positively predicted the need for labelling and the propensity to check labels. Additionally, individual dietary habits, such as shopping habits showed to affect the subjective proportion of GMO products the respondent eats. The results will be interested to marketing specialists and policy makers.

Conclusion. This research contributes to understanding the multifaceted dynamics underlying public attitudes toward GMO labeling and provides valuable insights for policymakers and stakeholders in the ongoing debate about genetically modified products.

Introduction

The ongoing debate over the labeling of genetically modified foods (GMFs) reflects a complex interplay of public interest, health concerns and the availability of information. Discourse on genetically modified foods (GMFs) is shaped by various sources, including mass media, websites and informal communication channels (Gibson et al., 2022). Considering the above pros and cons, this public discourse can be encapsulated in five overarching themes: the basic science of biotechnology, food and feed safety assessment (including labelling), environmental safety assessment (including pest control, use of pesticides or chemicals, biodiversity, mitigating climate change and environmental degradation), government regulations and global trade in GM crops (Arcelo-Villena, 2019).

Despite unanimous conclusions from several risk assessments confirming the safety equivalence of genetically modified foods with conventional crops in terms of human and animal health (Smyth et al., 2021), the public still tends to take GMFs with apprehension due to the perceived potential risks. As a result, regulatory measures have been introduced, particularly in Europe, with parallel developments observed in developing countries across Africa and Asia, regions that may gain significant benefits from the adoption of GM products (Qaim, 2020).

In the European Union, the European Food Safety Authority (EFSA) plays a key role in conducting risk assessments for regulated food and feed, including GM crops. EFSA's approach is based on a comprehensive framework of legal and methodological guidelines that govern the decision whether to authorize a particular food or feed for the European market (Garcia-Alonso et al., 2022; Hilbeck et al., 2020). However, the regulatory process is not without problems, as evidenced by the estimated cost of approving genetically modified food and feed in the EU ranging from €11 to €16.7 million (EuropaBio, 2019).

As the discourse has evolved beyond the mere question of whether to label GMO products, understanding the factors that drive the public to label GMFs has become essential. This paper aims to contribute to this discourse by examining the influence of environmental concerns, perceived health risks associated with GMOs, and the availability of information on the public's demand for GMF labeling, as well as their propensity to read such labels. This investigation is conducted on a representative sample of the Czech population, including 884 individuals aged 18 to 90 years (M ± SD: 48.17 ± 17.72; 53.40% women, 18.04% with higher education).

Methodologically, our approach involves hierarchical ordinal regression analysis to examine the relative impact of these key factors on public attitudes towards GMF labelling. In the first stage of our analysis, we examine the overall predictive power of environmental issues, health risks, and information availability. Acknowledging the paramount importance of GMF-induced health effects, we then delve into a second-stage hierarchical regression to discern the predictive power of GMO-induced negative health effects relative to other factors influencing labeling attitudes.

By focusing on these aspects, the present study aims to offer a detailed understanding of the factors that shape public opinion on GMF labeling and to provide insights that can inform both academic discourse and policy decisions on GM products.

The organization of the paper develops as follows: The introductory sections provide an overview of the public discourse on genetically modified foods and offer a synthesis of the existing discussion on GMF. The following segments detail the literature review, data collection process, and chosen methodology. Subsequently, we present the findings, engage in a comprehensive discussion and draw conclusions.

Genetically modified foods: a review of health, ecological and ethical aspects

Genetically modified foods (GMF) have become the focus of intense scrutiny, leading to a comprehensive examination of their multifaceted implications. This review delves into three primary dimensions – health, ecology and ethics – to provide a detailed understanding of the challenges and opportunities that GMF presents. Health considerations include potential risks associated with consumption, examination of issues such as toxicity and allergenicity, as well as examination of claims of changes to human DNA. On the environmental front, the assessment reviews both negative concerns, including reduced biodiversity and potential contamination, and positive aspects, such as reduced reliance on harmful chemicals in agriculture. In addition, ethical considerations are explored that deal with moral objections and cultural perspectives that view genetic modification of food as a violation of the natural order and a violation of fundamental principles. By synthesizing these aspects, this review aims to contribute to a balanced discourse on GMFs and to inform discussions about their cultivation, regulation and adoption in our global food systems.

Health risks associated with genetically modified foods

The introduction of genetically modified foods (GMFs) has sparked extensive debate with a primary focus on health risks. Researchers such as Ozkok (2015), Gizaw (2019), and Krimsky (2019) have highlighted concerns related to GMF. Among the prevalent health problems associated with GM foods, toxicity and allergenicity are often highlighted (Zhang et al., 2016). Consumer reports following the introduction of transgenic corn revealed an association between GM corn consumption and food allergy symptoms, including headaches, diarrhea, nausea, and vomiting (Bernstein et al., 2003; Dona and Arvanitoyannis, 2009).

Another major health issue revolves around the potential alteration of human DNA as a result of substantial modifications to our diet through GM foods. The change can occur through the insertion of foreign genes into the human genome or through cumulative changes in metabolic processes resulting from modified food intake. However, current evidence as reported by Nawaz et al. (2019), does not conclusively demonstrate a causal link between GM foods and changes in human genetics. Despite two decades of widespread GM food consumption, no confirmed cases of gene insertion in humans directly linked to GM food intake have been reported.

Environmental impacts of GMOs

Genetically modified organisms bring a spectrum of potential environmental impacts and generate both concerns and potential benefits. Tsatsakis et al. (2017) elaborate on the negative consequences, including the reduction of biodiversity, potential contamination by non-genetically modified organisms, disruption of natural ecosystems due to the widespread introduction of GMOs, and the potential reduction in the effectiveness of some pest deterrents. The risk of unintended gene transfer between species is another threat that leads to unpredictable impacts on the environment and food webs.

Conversely, GM crops offer positive environmental effects by reducing the need for herbicides, pesticides and other chemicals in food production. This reduction is in line with environmental sustainability goals and contributes to reducing the environmental impact associated with traditional agricultural practices. As the complexities surrounding GMOs develop, it becomes essential to consider both potential risks and benefits in order to make informed decisions about their cultivation and use in agricultural systems.

Moral and ethical dimensions of GMF

Criticism of GMF goes beyond scientific concerns and includes moral and ethical dimensions. Knight (2009), Kumar and Yadav (2021) and Green (2023) highlight the prevailing moral objections, particularly regarding the perception that GMFs disrupt the natural order of food production. Genetic modification of foods involves changing their DNA to increase nutritional content or resistance to disease, pests or environmental stressors. Many individuals find this manipulation morally objectionable and see it as a violation of the fundamental principles of nature. There are also concerns about potential long-term health risks and unintended environmental consequences through cross-pollination.

Religious beliefs further contribute to ethical discourse, particularly in cultures where religion strongly influences dietary practices. Streiffer and Hedemann (2005) and Chen and Li (2007) note that the introduction of genetically modified foods may conflict with established religious doctrines, reducing their acceptance in the general population. Individuals express concern about GMOs as interfering with natural processes and disrupting nature's delicate balance, leading to fears of unforeseeable consequences and the ethical dilemma of "playing god". Even those without religious objections may reject GMFs out of a broader respect for nature or fear of potential unknown dangers associated with their consumption. The intersection of ethical considerations and belief systems plays a critical role in shaping public policy decisions and influencing consumer decisions as GMOs continue to evolve and affect our food systems.

Public awareness challenges and the role of knowledge

A significant gap in public awareness of the scientific evidence surrounding genetically modified technologies contributes to confusion among the general population. Sikora and Rzymski (2021) highlight the polarization evident in media debates between proponents and opponents of GM, further fueled by deliberate anti-GM actions led by non-governmental organizations (NGOs). The dissemination of information through social media, which often lacks a scientific basis, increases the complexity of public understanding (Jiang and Fang, 2019). Individuals with limited knowledge, including parents, play a key role in shaping perceptions of GMOs (Shtulman et al., 2020).

Empirical evidence from studies such as Moon and Balasubramanian (2004), Moerbeek and Casimir (2005), and Vilella-Vila et al. (2005) highlights a direct and positive relationship between increasing knowledge of GM technologies and increased support for their applications (Costa-Font et al., 2008). Targeted information campaigns have the potential to cultivate an informed public and promote a more objective understanding of the risks and benefits associated with GM products. However, the impact of knowledge is varied, influenced by perceptions of the morality of genetic modification, rather than simply dependent on political or religious views (Hasell and Stroud, 2020).

Conversely, some studies question the assumed direct link between scientific knowledge and attitudes, suggesting that the correlation between science-based information about GMF and public perception remains weak and in some cases non-existent (Diamond et al., 2020). Government regulatory policies and laws regarding the cultivation and sale of genetically modified products are important determinants of public acceptance. Consumers who do not agree with these policies can express their disapproval by protesting GM products, even if they are not directly affected. As the debate on GM technologies continues to evolve, the multifaceted interplay between knowledge, perception and regulatory

frameworks will play a key role in shaping public attitudes and influencing wider societal acceptance of genetically modified products.

GMF labelling

In many countries, the absence of clear regulations governing the labeling of genetically modified foods has left consumers uncertain about the products they buy and consume, contributing significantly to the prevailing sense of mistrust of the technology. The introduction of mandatory labeling of genetically modified organisms represents a potential solution to alleviate the lack of information on GMFs. The issue of GMO labeling has been central to political and public discourse since the beginning of commercialized GM technology (Adalja et al., 2023). Consumers express a critical need to be informed about the presence of transgenic ingredients in their food in order to make informed consumption decisions (Delgado-Zegarra et al., 2022).

Voluntary labeling initiatives, particularly for non-GMO (third party verified) products, have gained traction in the United States to address consumer preferences. This approach resonated with consumers and increased sales of non-GMO products to over $26 billion in 2019 (Food Business News, 2019). Such labeling is particularly important for consumers who are concerned about safety and show resistance to GM technologies (Zheng and Wang, 2021). Research also shows that consumer demand for GM foods is influenced by labeling schemes adopted by policy makers (Kim et al., 2022). As a result, mandatory labeling requirements are emerging as an essential tool to provide transparent information to consumers and enable them to make informed decisions about food choices.

While some studies suggest that the cultivation and production of modified products can lead to lower production costs (Azadi and Ho, 2010; Ekici and Sancak, 2012), a significant segment of consumers choose more expensive non-GMO alternatives for reasons of principle rather than for functional reasons. . This preference is consistent with a broader pattern of low public acceptance of GM foods, with consumers having subjective knowledge and limited objective understanding demonstrating a greater willingness to pay for non-GMO variants (Rihn et al., 2021). As debates about GMOs and labeling evolve, the dynamic interplay between regulatory frameworks, consumer preferences, and the principles that guide food choices will continue to shape the landscape of GM food acceptance and consumption.

This paper concentrates on two main discourses: the effects of environment protection and supposed health risks on GMF acceptance. As the consumer preferences are highly impacted by the available information, we also research the effect of information availability on the GMO acceptance.

H1: GMF labelling requirements are predicted by environmental concerns

H2: GMF labeling requirements are negatively predicted by perceived health risks

H3: GMF labelling requirements are predicted by availability of relevant information including the interest in the subject.

Material and methods

Data

The survey data was collected in July 2021 through a study called "Food 2021" conducted by the Czech Sociological Institute. A total of 884 participants, reflecting the population of the Czech Republic, answered the questionnaire voluntarily and anonymously (age 18–90 years, M ± SD: 48.17 ± 17.72; 53.40% women, 18.04% with higher education). The survey was conducted under the supervision of 139 experienced interviewers who used a combination of Paper and Pencil Interview (PAPI) and Computer-Assisted Personal Interview (CAPI) methods. Due to the high quality of completed questionnaires, all collected data were included in the sample. Participants, native speakers residing in the Czech Republic, were selected using quota sampling by region (NUTS 3), size of place of residence, gender, age and education. This dataset, provided by the Czech Social Science Data Archive (Institute of Sociology. Academy of Sciences of the Czech Republic. 2021), is representative of the Czech Republic.

Method

We apply hierarchical ordinal regression analysis to test the following hypotheses (Graph 1):

Graph 1

Hypotheses

GMF Labelling	Are predicted by ⇐	Information about GMF
		GMF effects on health
		Environmental concerns

Additionally, we incorporate controls for the significance of food and food-related habits, as well as socio-demographic factors.

The hierarchical ordinal regression analysis consists of two sequential steps. Initially, we assessed the model with all explanatory variables based on the specified formula (Formula 1).

$$GMF\ Labelling = Logit\ (a_0 + a_{1\text{-}3}\ Information + a_{4\text{-}8}\ Health + a_{9\text{-}12}\ Environment + a_{13\text{-}17}\ Food\ Purchasing + a_{18\text{-}20}\ Food\ habits + a_{21\text{-}27}\ Socio\text{-}demographics + e) \quad (1)$$

In the second stage, we omitted the set of variables associated with health effects and performed ordinal regression using the following formula (2):

$$GMF\ Labelling = Logit\ (a_0 + a_{1\text{-}3}\ Information + a_{9\text{-}12}\ Environment + a_{13\text{-}17}\ Food\ Purchasing + a_{18\text{-}20}\ Food\ habits + a_{21\text{-}27}\ Socio\text{-}demographics + e) \quad (2)$$

It was contrasted the pseudo R-squared values between both models and drew conclusions regarding the moderation effects of the excluded variables.

Indicators

GMF labelling needs

Examining GMO labeling needs includes three dimensions: perceived importance of having GMO information on labels, frequency of checking GMO labels when shopping, and current perception of GMO content in consumed foods. The survey questions were formulated as follows:

- "To what extent do you agree or disagree with the following statements? Foods containing ingredients from genetically modified crops should have this information in the description or on the label.
- How many of the foods you normally eat do you think contain ingredients from genetically modified crops?
- When you buy food, how often do you check the label for ingredients from genetically modified crops?" (Sociologicky ustav, 2021)

Table 1 shows that approximately 74% of participants agree that genetically modified foods should be labelled. Conversely, 60% of respondents said they never checked information about GM ingredients on food labels. Data on the actual consumption of GMFs is quite limited, almost 40% of the participants did not express any opinion about the share of GMFs in their total food intake.

Table 1

Distribution of respondents (%) based on attitudinal indicators for genetically modified foods (GMF)

Question	Definitely agree	Rather agree	Undecided	Rather disagree	Definitely disagree	No opinion
Food items containing genetically modified ingredients should carry labels indicating their genetic modification status.	51.1	23.2	9.3	2.9	1.6	11.9
What proportion of the foods you consume contains genetically modified (GM) ingredients?	Almost none	Rather a minority	About half	Rather the majority	Almost all	No opinion
	14.9	27.8	13	4.6	0.8	38.8
	20.4	41.7	15	12.4	10.4	
Examine food labels for genetic modification information during your purchases.	Always	Often	Rarely	Never		
	3.1	10.9	25.7	60.4		

Note: Due to a notable number of individuals expressing no opinion on the perception questions, we included these respondents in the "undecided" category wherever applicable (category 3 on the 5-point Likert scale).

Information about GMF

Access to information plays a crucial role in shaping opinions. This study utilizes indicators to assess the availability and adequacy of information, while also accounting for the respondents' level of interest in the subject. Table 2 provides an overview of the indicators, scales, and the distribution of respondents regarding information about GMF.

Table 2

Distribution of Respondents (%) Based on Indicators of Genetically Modified Foods (GMF) Information

Are you familiar with genetically modified crops?	No	Yes, but does not know what it refers to	Yes, and roughly knows what it involves	Yes, and knows well what it involves	
	27.7	31.9	33.4	6.8	
Do you have an interest in Genetically Modified Products (GMP)?	definitely yes	rather yes	rather no	no	does not know
	3.3	12.7	32.9	48.4	2.6
Do you possess sufficient information about Genetically Modified Foods (GMF)?	definitely enough	rather enough	rather not enough	definitely not enough	does not know
	3.1	14.1	32.5	40.8	9.4

Respondents who answered, "do not know", were excluded from subsequent analysis.

Perceived GMF effects on health

The existing literature indicates that perceived health effects are among the most significant informational challenges influencing legislation and public acceptance of Genetically Modified Foods.

Environmental concerns

The initial indicator of environmental concerns determined the degree of subjective importance of the impact of food production on the environment (Definitely important: 11.10% of respondents; Rather important: 37.30%; Rather unimportant: 30.10%; Definitely unimportant: 11.00%; No opinion: 3.70%.

We then assessed environmental concerns based on the frequency of participation in pro-environmental behaviors. The descriptive statistics is presented in Table 4.

Table 3

Distribution of Respondents (%) Based on Indicators of Perceived Effects of Genetically Modified Foods (GMF) on Health

Self-assessment of personal health	Very good	Good	Average	Bad	Very bad	
	20.00	42.30	29.30	7.50	0.90	
Consuming Genetically Modified Foods (GMF) is safe	Definitely agree	Rather agree	Undecided	Rather disagree	Definitely disagree	No opinion
	4.30	18.40	26.80	16.20	8.90	25.10
Research on the Health Effects of Genetically Modified Products (GMP) is sufficient	Definitely agree	Rather agree	Undecided	Rather disagree	Definitely disagree	No opinion
	5.90	22.50	21.60	15.50	7.90	26.50
Consuming GMP can change human DNA	Definitely agree	Rather agree	Rather disagree	Definitely disagree	No opinion	
	5.40	15.70	21.20	21.40	36.20	
GMF can endanger human health	Definitely agree	Rather agree	Rather disagree	Definitely disagree	No opinion	
	10.30	24.70	24.40	7.00	33.60	

Note: Respondents with no opinion were combined with the "Undecided" group for subsequent analysis.

Table 4

Indicators of environmental concerns. Descriptive statistics

How frequently does the respondent:	Mean	Std. Deviation
Utilize their own reusable shopping bag	3.98	1.182
Use reusable bags for purchasing fruits and vegetables	2.35	1.410
Use reusable bottle for drinks	2.71	1.428
Use environmentally friendly detergents	2.72	1.204
Prefer purchasing czech-made foods	3.35	1.088
Pack the food into reusable boxes	2.71	1.353
Avoid single-use plastic products	3.21	1.301
Limit car trips to protect the environment	2.15	1.195
Conserve energy and water to protect the environment	2.92	1.266
Practice waste sorting	3.96	1.159
Engage in composting	2.58	1.618

Note: N=727. The respondents with No opinion were excluded from further analysis

To simplify the model, we employed Principal Component Analysis (PCA) on the indicators outlined in Table 4, utilizing regression-based factor scores for subsequent analysis. The outcomes of the PCA are detailed in the Data Transformation section, where three components were identified: inclination toward waste reduction and sorting, resource conservation, and engagement in recycling.

Significance of food characteristics in purchase decisions

Consumers evaluate several characteristics to varying extents when making food purchases, including consideration of ingredients, package material and size, origin, and, notably, price (refer to Table 5). We posit that these factors serve as crucial predictors for attitudes towards Genetically Modified Foods (GMF).

Table 5

Indicators of the importance of food characteristics when purchasing

Indicators	Mean	Std. Deviation
Origin	3.1	1.479
Package material	4.89	1.298
Price	2.22	1.438
Ingredients	2.78	1.412
Package size	3.48	1.472

N=799, Min=1 (very important), Max=6 (least important)

Significance of food and dietary practices

Table 6

Indicators of the importance of food and dietary practices. Distribution of respondents (%)

Food consumption important	Definitely important	Rather important	Rather unimportant	Definitely unimportant		
	43.30	43.00	9.80	3.40		
Frequency of food purchasing	Daily	Several times a week	Once a week	Once per 14 days	Less than once per 14 days	No answer
	9.80	50.80	23.50	5.50	3.50	6.70
Number of meals per day	One meal	Two meals	Three meals	Four meals	Five meals	More than five
	0.10	8.50	39.90	30.70	16.40	4.10

Socio-Demographic characteristics of the respondents and other factors

We consider variables such as gender, age, and education (ranging from 18 to 90 years, with a mean ± standard deviation of 48.17 ± 17.72; 53.40% women, 18.04% with higher education), subjective town size (from big city to small village), household standard of living (very good, 13.12%; rather good, 45.5%; neither good nor bad, 33.9%; rather bad, 6.4%; very bad, 0.9%), life satisfaction (very satisfied 20.8%; rather satisfied, 50%; neither satisfied nor dissatisfied, 21.3%; rather dissatisfied, 5.7%; very dissatisfied 1.2%), and belief in God (69.9% non-believers).

Data transformations and handling of missing values

Given the limited awareness about GMFs, certain survey questions recorded a notable proportion of respondents expressing no opinions. In line with the methodology discussed in preceding sections, respondents with no opinions were amalgamated with the Undecided group. It is essential to acknowledge that this data transformation is a recognized limitation of the study. In instances where an "Undecided" category was not available, respondents with no opinions were omitted from subsequent analyses. This approach ensures transparency in data interpretation, emphasizing the challenges associated with gauging public opinion in areas where information levels are inherently low.

Data transformations: analyzing environmental concerns through principal component analysis

To reduce the complexity of our model, we used a principal component analysis (PCA) on a set of variables representing respondents' environmental protection measures (Indicators of Environmental Concerns, Table 4). Factor extraction was determined by an eigenvalue of 1 or greater, and all variables were successfully extracted. Suitability of data for factor identification was confirmed by Bartlett's test of sphericity (chi-square value 1716.968, $p<0.001$) and Kaiser-Meyer-Olkin sampling rate of 0.852 (>0.8). Overall, these two extracted factors cumulatively explained 54.095% of the total variance. The rotated component matrix is shown in Table 7.

Table 7

Rotated Component Matrix for Indicators of Environmental Concerns

Action	Respondent's actions	Component		
		1	2	3
Waste Reduction	Sort waste	0.765	0.059	0.179
	Use own reusable shopping bag	0.623	0.138	0.055
	Prefer purchasing czech-made foods	0.614	0.326	0.125
Resource Conservation for Environmental Protection	Limit car trips to protect the environment	-0.062	0.842	0.113
	Save energy and water to protect the environment	0.394	0.637	0.136
	Avoid single-use plastic products	0.457	0.545	0.101
	Use environmentally friendly detergents	0.410	0.523	0.227
Recycling Efforts	Use own reusable bottle for drinks	0.018	0.127	0.796
	Pack the food into reusable boxes	0.177	0.155	0.760
	Compost	0.421	-0.078	0.500
	Use reusable bags for purchasing fruits and vegetables	0.105	0.367	0.495
% of Variance explained		34.25	10.593	9.252

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

The regression-based factor scores for all three components were computed and subsequently utilized for further analysis.

Results and discussion

The outcomes of the initial phase of hierarchical ordinal regression analyses are depicted in Tables 8 and 9 below, corresponding to formula 1.

Information and interest

The results, presented in the table 8 suggest, that

- The more the respondent is informed about GMF, (1) the more he believes GMF should be labelled, (2) the more often they check information on GM ingredients when buying food;
- The more often they check information on GM ingredients when buying food;
- The more are respondents confident that they have enough information about GMF the more often they check information on GM ingredients when buying food.

Table 8

Predictive factors of attitudes toward gmf labeling. Results from ordinal regression analysis (formula 1)

	GMF labelled		Check lables on GMF		GMF content	
	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.
Threshold=1	-1.075	0.492	-0.14	0.937	0.962	0.584
Threshold=2	0.31	0.843	2.378	0.174	3.428	0.052
Threshold=3	2.188	0.163	4.853**	0.006	5.190**	0.003
Threshold=4	3.381*	0.033			7.045***	<.001
Information about GMF						
Heard of GMF	-0.662***	<.001	-0.435**	0.002	-0.146	0.309
Interested in GMF	-0.111	0.399	1.200***	<.001	-0.084	0.555
Enough Info about GMF	-0.001	0.988	0.453***	<.001	-0.183	0.055
GMF effects on health						
State of own Health	0.086	0.503	0.183	0.214	-0.212	0.15
GMF is safe	-0.206	0.094	0.067	0.615	-0.26	0.051
the effects of GMP on health are scientifically investigated	-0.113	0.332	-0.102	0.42	0.012	0.926
Consuming GMP can change DNA	0.06	0.466	0.285**	0.002	-0.025	0.782
GMP can endanger his health	0.188*	0.043	0.082	0.435	0.328**	0.002
Environmental concerns						
Effect of food production on environment important	-0.056	0.647	0.407**	0.004	0.141	0.325
Reduce Waste (component 1)	-0.543***	<.001	0.174	0.148	-0.218	0.076
Save Resources (component 2)	0.165	0.075	-0.171	0.109	0.173	0.128
Recycling (component 3)	0.227*	0.014	-0.238*	0.021	0.124	0.26
Aspects of food important when purchasing						
Origin	0.155	0.065	-0.02	0.825	0.271**	0.005
Packaging	-0.103	0.187	-0.023	0.795	0.249**	0.008
Price	-0.123	0.127	-0.159	0.055	0.231**	0.009
Ingredients	0.037	0.68	-0.161	0.11	0.308**	0.003
Package size	0.147	0.068	-0.078	0.357	0.091	0.311

Table 8 (*continue*)

	GMF labelled		Check lables on GMF		GMF content	
Food habits						
Number of meals per day	-0.005	0.959	-0.127	0.21	0.061	0.551
Importance of self-catering	0.036	0.772	0.098	0.521	0.328*	0.032
Frequency of food purchasing	-0.026	0.798	0.001	0.993	-0.268*	0.022
Socio-demographics						
Gender (men)	-0.123	0.485	0.072	0.727	-0.466*	0.027
Age	0.013*	0.022	-0.005	0.482	0	0.959
Education	0.054	0.587	0	0.997	-0.114	0.323
Town size	0.017	0.769	0.038	0.559	-0.076	0.252
Household standard of living	-0.084	0.521	0.097	0.522	0.032	0.834
Life satisfaction	-0.12	0.382	-0.295	0.054	0.341*	0.03
Non believer in God	0.244	0.221	-0.038	0.864	-0.239	0.311
Model Fitting Information						
Sig.		<.001		<.001		<.001
N	625		612		413	
Pseudo R-Square						
Cox and Snell	0.227		0.472		0.186	
Nagelkerke	0.251		0.537		0.202	
McFadden	0.11		0.302		0.082	

Note: Link function: Logit. ***-significant on 0.1% level. ** - significant on 1% level,
* - significant on 5% level.
Components 1, 2, 3 reflects the three components of PCA presented in Table 7.

The findings reveal a compelling relationship between the level of information individuals have about genetically modified foods (GMFs) and their attitudes and behaviors. A higher level of information is positively correlated with the belief that GMF should be labeled. This suggests that as individuals become more informed about GMFs, they tend to support the idea of clear labeling of these products. Moreover, increased interest in GMFs positively predicts a more frequent habit of checking information about GM ingredients when purchasing food. This underlines the role of personal interest as a motivating factor in seeking information about GMF. Moreover, respondents who express confidence in sufficient information about GMF are more likely to check for GM ingredients when purchasing food. This alignment suggests that perceived adequacy of knowledge plays a role in encouraging individuals to be more vigilant about the GM content of the products they consume.

Health risks

The results presented in the Table 8 suggest that

- The subjective assessment of own health condition proved unrelated to GM labelling attitudes.
- The more do the respondents believe, that GMF can change their DNA, the more they check information on GM ingredients when buying food

– The more do the respondents believe, that the GMF can endanger their health, (1) the more they believe GMF should be labelled (2) the less GM ingredients is contained in the food the respondent normally eats according to his perception.

Examining health-related factors in relation to attitudes and behaviors around genetically modified foods (GMFs) reveals remarkable findings. Surprisingly, subjective evaluation of one's own health status does not appear to significantly influence attitudes toward GM labeling. This suggests that individuals' personal perception of health may not be a major factor in shaping their opinion on the necessity of GMF labeling. However, when considering beliefs about the potential health risks associated with GMFs, a compelling relationship emerges. Those who express a belief that GMF can change their DNA tend to check more frequently for information about GM ingredients when purchasing food. Similarly, respondents who believe that GMF may endanger their health are more likely to support the idea that GMF should be labeled. Interestingly, this group also tends to perceive a lower occurrence of GM ingredients in the foods they normally consume.

Environmental concerns

The results shown in Table 8 suggest that:

– The more important is the effect of food production on the environment, the more the respondents check the information about GM ingredients when purchasing food;
– The more the respondents recycle, (1) the more they check information on GMF ingredients when purchasing food; (2) the more they want GMF labelled.
– The more do the respondent engage in waste management including waste reduction and sorting, (1) the more they want GMF labelled

Examining the intersection of environmental concerns and attitudes toward genetically modified foods (GMFs) provides valuable insights into factors influencing consumer behavior. The findings reveal a remarkable relationship between the perceived importance of the environmental impact of food production and the frequency of checking information about GM ingredients when purchasing food. Individuals who prioritize the environmental effects of food production show a higher propensity to search for information about GM ingredients, suggesting a link between environmental awareness and food composition awareness.

In addition, the study suggests a positive association between pro-environmental behaviors such as recycling and waste management and preferences for GMFs. Respondents who actively engage in recycling practices are not only more likely to check information about GMF ingredients, but also express a stronger tendency to want to have a GMF label. Additionally, those involved in waste reduction and sorting show an increased desire for GMF labeling. This highlights the potential alignment between pro-environmental behavior and concerns related to the transparency of GMF information.

Important food characteristics and dietary habits

The results shown in Table 8 suggest that:

– The food characteristics and habits proved to be most significantly related to perceived content of GM ingredients in meals consumes. The more important are origin, packaging, price, ingredients of the food at the time of purchasing, and the lower is the content of GM ingredients in the food the respondent eats.

- The subjective importance of self-catering positively predicts the low GMF content in meals.
- The less often the respondent goes shopping for food items, the higher is the GM content in his meals.

Examining the importance attributed to different food attributes during the purchase process in conjunction with specific eating habits provides valuable insights into the factors influencing the perception of genetically modified foods (GMFs). The study reveals compelling links between individual preferences, purchasing behavior and the perceived content of GM ingredients in foods.

A key finding suggests that the perceived content of GM ingredients in consumed foods is significantly related to the importance placed on specific food characteristics at the time of purchase. Origin, packaging, price and ingredients emerge as crucial factors, with respondents who prioritize these factors reporting a lower perceived content of GM ingredients in food. This association underlines the impact of individual preferences during the purchase phase on the subsequent perception of GMF content in daily meals.

In addition, the study reveals interesting associations between dietary habits and perceived GMF content. Individuals who subjectively emphasize the importance of self-feeding demonstrate a positive association with lower GMF content in their meals. It follows that the preference for preparing one's own meals can contribute to reducing dependence on genetically modified ingredients.

Moreover, the frequency of grocery shopping appears to be a significant factor influencing the content of GMF in consumed foods. Respondents who buy food less often tend to report higher GM content in their food. This observation suggests that shopping frequency plays a role in shaping dietary choices and, consequently, the perceived prevalence of GM ingredients in the diet.

Sociodemographic characteristics of the respondents and other controls

The results shown in Table 8 suggest that:

- Women report lower GM content in their meals comparing to men.
- Age negatively predicts the necessity of GMF labelled.
- The bigger is the city the more people are willing to try GMF
- The more is the respondent satisfied in his life, the more he is willing to try GMF, but the lower proportion of the GM food in meals he reports.

Examining sociodemographic factors and other controls provides valuable insights into how individual characteristics shape perceptions and attitudes toward genetically modified foods (GMFs). Several notable findings emerged that shed light on the nuanced relationship between sociodemographic variables and attitudes toward GMF.

First, a gender difference is evident, as women tend to report a lower perceived content of GM ingredients in their foods compared to men. This gender difference suggests that women may have more conservative views on the inclusion of GM ingredients in their diets, contributing to differences in perceived GM content.

Age as a socio-demographic factor plays a significant role in shaping attitudes towards GMF. The study suggests a negative correlation between age and the perceived necessity of GMF labeling. This suggests that older respondents may express less demand for explicit labeling of GMF products, reflecting potential differences in attitudes across age groups.

Urbanity, represented by city size, appears to be a significant factor influencing individuals' willingness to try GMF. In particular, respondents from larger cities show greater

openness to experimenting with GMF. This urban-rural difference highlights the importance of contextual factors in shaping attitudes towards new food technologies, with urban environments potentially fostering a more receptive environment for GMF adoption.

Life satisfaction, a subjective measure of overall well-being, reveals interesting associations with attitudes toward GMF. Respondents reporting higher life satisfaction express a greater willingness to try GMF. However, this positive trend contrasts with the lower reported proportion of GM foods in their meals. This nuanced relationship suggests that while life satisfaction positively influences openness to trying GMFs, it does not necessarily translate into higher actual consumption of GM ingredients.

Results of the second stage of hierarchical ordinal regression

The second stage of the hierarchical ordinal regression analysis, which included the exclusion of variables related to the perceived health effects of genetically modified foods, revealed significant insights into the dynamics of predictors influencing public demand for GMF labeling. This strategic exclusion allowed for a targeted examination of the unique impact of health-related variables on GMF attitudes.

The results suggest, that the exclusion of the variables representing the health effects of the GMF led to significant changes in the predictive power of the models for the need for GMF labelled. While the original Pseudo R2 ranged from 47% to 53% (for checking the labels) and 11% to 25% (labelling requirement) and the original models were statistically significant on 0,1% level, the exclusion of health variables led to reduction of Pseudo R2 to the level of 1-5% and to the loss of statistical significance (for the need to label model). Thus, the results indicate, that health effects can be considered most powerful predictors of the public requirement to label them.

The effects of exclusion of health variables on the other four regressions was less pronounced as the regressions stayed statistically significant on 0,1% level in all the four cases (checking information on GM content when purchasing and perceived content of GM ingredients in daily own meals). However, the variability explained by the model as measured by Pseudo R2 decreased to the levels from 20% to 3%.

The results underscored the key role of perceived health effects as influential predictors of public adherence to GMF labeling. The substantial reduction in Pseudo R2 and the loss of statistical significance in the models related to the need for labeling after exclusion of health variables highlight the dominant position of health considerations in the formation of consumer attitudes. This finding is consistent with existing literature highlighting health issues as a central factor influencing public perceptions and decisions about GMF.

While the effects of excluding health variables were less pronounced in other regression models, there was a substantial reduction in the variability explained by the model while maintaining statistical significance. This suggests that health considerations play a vital role not only in demand for labeling but also in shaping other aspects of consumer behavior, such as checking GM content information when shopping and perceptions of GM ingredients in everyday foods.

These findings highlight the need for targeted communication and policy strategies that address and mitigate health concerns related to GMF. Understanding the disproportionate impact of health considerations on public attitudes provides valuable insights for policymakers and industry stakeholders seeking to promote greater acceptance of GMF. The delicate interplay between health perceptions and labeling requirements requires comprehensive approaches that prioritize transparent communication and address the multifaceted dimensions of consumer concerns about GMF.

Table 9

Factors predicting attitudes to GMF. Results of ordinal regression analysis without health risks

	GMF labelled		Check information on GMF		GMF content	
	Estimate	Sig.	Estimate	Sig.	Estimate	Sig.
Threshold=1	-0.258	0.852	-1	0.537	0.441	0.789
Threshold=2	0.783	0.57	1.423	0.376	2.76	0.095
Threshold=3	3.097*	0.025	3.817*	0.018	4.435**	0.008
Threshold=4	4.448	0.001			6.289***	<.001
Information about GMF						
Heard of GMF	0.162	0.147	-0.425**	0.002	-0.138	0.327
Interested in GMF	0.158	0.184	1.185***	<.001	-0.151	0.275
Enough Info about GMF	0.08	0.31	0.466***	<.001	-0.126	0.173
Environmental concerns						
Effect on environment important	0.018	0.872	0.399**	0.004	0.139	0.321
Reduce Waste (component 1)	-0.079	0.399	0.186	0.116	-0.199	0.097
Save Resources (component 2)	-0.042	0.625	-0.16	0.13	0.179	0.11
Recycling (component 3)	0.019	0.82	-0.189	0.061	0.079	0.465
Importance when purchasing						
Origin	0.171*	0.029	0.009	0.918	0.273**	0.004
Packaging	0.114	0.118	-0.008	0.923	0.225*	0.015
Price	0.037	0.601	-0.135	0.097	0.202*	0.018
Ingredients	0.112	0.179	-0.157	0.111	0.274**	0.006
Package size	0.049	0.505	-0.064	0.441	0.057	0.519
Food habits						
Number of meals per day	-0.12	0.145	-0.147	0.142	0.017	0.867
Importance of self catering	-0.032	0.784	0.12	0.431	0.319*	0.031
Frequency of food purchasing	-0.03	0.751	-0.04	0.737	-0.252*	0.028
Socio-demographics						
Gender (men)	0.185	0.259	0.089	0.662	-0.38	0.066
Age	-0.004	0.438	-0.005	0.463	0.001	0.931
Education	-0.017	0.854	-0.004	0.97	-0.123	0.279
Town size	-0.039	0.469	0.019	0.771	-0.059	0.367
Household standard of living	0.058	0.628	0.061	0.679	-0.006	0.966
State of own Health	-0.049	0.678	0.171	0.239	-0.245	0.091
Non believer in God	-0.15	0.225	0.034	0.874	-0.025	0.912
Life satisfaction	0.222	0.217	-0.26	0.081	0.304*	0.046
Model Fitting Information						
Sig.		0.42		<.001		<.001
N	624		626		415	
Pseudo R-Square						
Cox and Snell	0.037		0.192		0.121	
Nagelkerke	0.04		0.212		0.132	
McFadden	0.014		0.091		0.051	

Note: Link function: Logit. ***-significant on 0,1% level. ** - significant on 1% level, * - significant on 5% level. . Components 1, 2, 3 reflects the three components of PCA presented in Table 7.

Discussion

The observed associations between GMF information, interest, and behavior, presented in the sections above, are consistent with the broader literature on public perception and decision-making in the context of genetically modified organisms (Moon and Balasubramanian, 2004; Moerbeek and Casimir, 2005; and Vilella-Vila et al., 2005). These findings underscore the importance of targeted information campaigns to improve public understanding and shape attitudes toward GMF. While the data suggest positive correlations, they also prompt consideration of the design and delivery of outreach initiatives. Addressing knowledge gaps and promoting interest could contribute to more informed consumer choice and subsequently influence wider societal acceptance of genetically modified products. As GM technologies continue to evolve, strategies that effectively communicate information and satisfy the public interest will play a key role in navigating the complex landscape of GMF adoption.

The observed associations highlight the complex relationship between environmental awareness, sustainable behavior and attitudes towards GMF. Individuals with increased environmental awareness seem to be more careful about checking the content of their food, especially when it comes to GM ingredients. This highlights the interconnectedness of environmental and food concerns, suggesting that consumers who actively contribute to environmental protection can extend their conscientiousness to the decisions they make in the area of food consumption. As environmental sustainability becomes an increasingly integral aspect of consumer decision-making, recognizing and addressing these connections can underpin strategies to promote transparency and understanding in the GMF context.

The associations between health risk beliefs and attitudes toward GMF presented in this paper point to a complex interplay between perceived risks and consumer behavior. In general our results are consistent with the literature (Bernstein et al., 2003; Dona and Arvanitoyannis, 2009; Gizaw, 2019; Krimsky, 2019; Ozkok, 2015). The association between concern about DNA alteration and increased information-seeking behavior suggests that individuals with specific health-related concerns may be more active in controlling GM ingredients. The importance of the health risks for the subjective need of GMO labeling isa highlighted by the fact that the second stage of hierarchical ordinal regression analysis was not statistically significant if the health concerns are excluded. the association between health risk beliefs and support for GMF labeling underscores the importance of addressing perceived health risks in public discourse and educational initiatives. As concerns about potential health effects continue to influence public opinion, efforts to provide accurate and accessible information about the health effects of GMFs are essential to support informed decision-making and shape more differentiated attitudes.

These findings, related to the role of consumer choices, food habits, and shopping habits, presented in this paper highlight the complex associations between consumer choices, food-related habits and GMF perceptions. Preference for specific food characteristics during the purchasing process and the habit of self-eating are identified as influential factors in shaping the perception of GMF content. Recognizing the impact of these factors can lead to targeted interventions to increase consumer awareness and support informed decision-making about GMF consumption. As individuals increasingly favor certain food attributes and habits, understanding these dynamics becomes critical to developing strategies that align with consumer preferences and contribute to a more transparent and consumer-centric food environment.

Last, but not least, the findings of associations between socio-demographic characteristics and attitudes to GMO labelling, presented in the paper, underscore the

diversity of attitudes toward GMF based on sociodemographic characteristics. Gender, age, urbanicity and life satisfaction all contribute to a complex tapestry of perceptions and preferences regarding GMF. Recognizing these variations is critical to tailoring communication strategies and policy interventions that resonate with different demographics. The study highlights the need for targeted approaches that take into account the subtle interplay between individual characteristics and attitudes towards GMF and promote a more comprehensive understanding of the factors influencing public acceptance and consumption patterns.

Conclusion

This study delved into the complex landscape of public attitudes toward genetically modified foods by examining the factors influencing demand for GMF labeling. It seemed to enrich the ongoing discourse on genetically modified foods by examining the impact of environmental concerns, perceived health risks associated with GMOs, and the availability of information on the public's propensity to challenge GMF labeling and the likelihood that it will scrutinize such labels. The research was conducted on a representative sample of the Czech population, including 884 individuals aged 18 to 90 (M ± SD: 48.17 ± 17.72; 53.40% women, 18.04% with higher education).

The findings shed light on the multifaceted interplay of information, health perceptions, environmental issues, food characteristics, and sociodemographic factors in shaping consumer attitudes. One of the key findings from this investigation is the overriding role of health considerations in influencing the public's insistence on GMF labeling. Perceived health effects were shown to be strong predictors that significantly influenced not only demand for labeling but also influencing behaviors such as checking GM content in purchases and perceptions of GM ingredients in daily foods. This underscores the need for targeted communication strategies that address health-related issues transparently and comprehensively.

Environmental concerns also played a notable role, with individuals favoring the environmental impact of food production showing a greater tendency to check information about GM ingredients when purchasing food and supporting the need for GMF labeling. These findings underscore the interconnectedness of environmental awareness and consumer choices regarding GMF.

Importantly, the study highlighted the importance of food characteristics and habits in shaping attitudes towards GMF. Origin, packaging, price and ingredients were found to be critical factors influencing the perceived content of GM ingredients in foods. Understanding these nuances provides valuable insights for both policymakers and the food industry to tailor communication and marketing strategies to match consumer priorities.

Sociodemographic factors revealed distinct patterns, with gender, age, city size, and life satisfaction contributing to differences in attitudes toward GMF. The complex relationship between these factors highlights the need for tailored approaches that take into account different demographic perspectives.

In the context of a second-stage hierarchical ordinal regression, the exclusion of health-related variables significantly altered the predictive power of the models and highlighted the central role of health considerations in the demand for GMF labeling.

In conclusion, this study underscores the need for nuanced, multidimensional strategies in addressing public concerns and promoting greater adoption of GMF. Transparent communication, targeted education campaigns and policies that align with consumer values

and priorities are essential to navigate the complex landscape of GMF perceptions. As technology advances, continued research and adaptive approaches will be critical to shaping a sustainable and informed future for the integration of GM products into the global food supply.

This research was supported by Czech University of Life Sciences Prague under Grant IGA PEF CZU 2022B005 "Environmental footprint of selected protein sources in the Czech Republic".

References

Arcelo-Villena M.M.C.Q. (2019), Personal constructs and social discourses on genetically modified organisms (GMOs), *Policy Briefs*, 1(5), pp. 1–8.

Azadi H., Ho P. (2010), Genetically modified and organic crops in developing countries: A review of options for food security, *Biotechnology Advances*, 28(1), pp. 160–168, https://doi.org/10.1016/j.biotechadv.2009.11.003

Bernstein J.A., Bernstein I.L., Bucchini L., Goldman L.R., Hamilton R.G., Lehrer S., Rubin C., Sampson H. A. (2003), Clinical and laboratory investigation of allergy to genetically modified foods, *Environmental health perspectives*, 111(8), pp. 1114–1121.

Costa-Font M., Gil J. M., Traill W. B. (2008), Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy, *Food policy*, 33(2), pp. 99–111, https://doi.org/10.1016/j.foodpol.2007.07.002

Delgado-Zegarra J., Alvarez-Risco A., Cárdenas C., Donoso M., Moscoso S., Rojas Román B., Del-Aguila-Arcentales S, Davies N. M, Yáñez J. A. (2022), Labeling of genetically modified (GM) foods in Peru: Current dogma and insights of the regulatory and legal statutes. *International Journal of Food Science*, vol. 2022, Article ID 3489785, 12 pages, https://doi.org/10.1155/2022/3489785

Diamond E., Bernauer T., Mayer F. (2020), Does providing scientific information affect climate change and GMO policy preferences of the mass public? Insights from survey experiments in Germany and the United States, *Environmental Politics*, 29(7), pp. 1199–1218, https://doi.org/10.1080/09644016.2020.1740547

Dona A., Arvanitoyannis I. S. (2009), Health risks of genetically modified foods, *Critical reviews in food science and nutrition*, 49(2), pp. 164–175, https://doi.org/10.1080/10408390701855993

Ekici K., Sancak Y. C. (2011), A perspective on genetically modified food crops, *African Journal of Agricultural Research*, 6(7), pp. 1639–1642, https://doi.org/10.5897/AJAR10.284

EuropaBio (2019), Pricing innovation out of the EU, Available at: https://croplifeeurope.eu/wp-content/uploads/2021/05/infographic_pricing_innovation_out_v6_final.pdf

Food Business News (2019), Non-GMO Project growth 'extreme and consistent', Available at: https://www.foodbusinessnews.net/articles/14368-non-gmo-project-growth-extreme.-and-consistent

Garcia-Alonso M., Novillo C., Kostolaniova P., Martinez Parrilla M., Alcalde E., Podevin N. (2022), The EU's GM crop conundrum: Did the EU policy strategy to convert

EFSA GMO guidance into legislation deliver on its promises?, *EMBO reports*, 23(5), pp. 1–5, e54529, https://doi.org/10.15252/embr.202154529

Gibson J., Greig J., Rampold S., Nelson H., Stripling C. (2022), Can you cite that? Describing Tennessee consumers' use of GMO information channels and sources, *Advancements in Agricultural Development,* 3(2), pp. 1–16, https://doi.org/10.37433/aad.v3i2.181

Gizaw Z. (2019), Public health risks related to food safety issues in the food market: a systematic literature review, *Environmental health and preventive medicine*, 24, pp. 1–21, https://doi.org/10.1186/s12199-019-0825-5

Green N. L. (2023), An analysis of some ethical argumentation about genetically modified food, *Argument & Computation*, 1 Jan. pp. 1–20, https://doi.org/10.3233/AAC-220014

Hasell A., Stroud N. J. (2020), The differential effects of knowledge on perceptions of genetically modified food safety, *International Journal of Public Opinion Research*, 32(1), pp. 111–131, https://doi.org/10.1093/ijpor/edz020

Hilbeck A., Meyer H., Wynne B., Millstone E. (2020), GMO regulations and their interpretation: how EFSA's guidance on risk assessments of GMOs is bound to fail, *Environmental Sciences Europe*, 32, pp. 1–15, https://doi.org/10.1186/s12302-020-00325-6

Chen M. F., Li H. L. (2007), The consumer's attitude toward genetically modified foods in Taiwan, *Food Quality and preference*, 18(4), pp. 662–674, https://doi.org/10.1016/j.foodqual.2006.10.002

Jiang S., Fang W. (2019), Misinformation and disinformation in science: examining the social diffusion of rumours about GMOs, *Cultures of Science*, 2(4), pp. 327–340, https://doi.org/10.1177/209660831900200407

Kim Y., Kim S., Arora N. (2022), GMO labeling policy and consumer choice. *Journal of Marketing*, 86(3), pp. 21–39, https://doi.org/10.1177/00222429211064901

Knight A. J. (2009), Perceptions, knowledge and ethical concerns with GM foods and the GM process, *Public Understanding of Science*, 18(2), pp. 177–188, https://doi.org/10.1177/0963662507079375

Krimsky S. (2019). GMOs decoded: A skeptic's view of genetically modified foods. *MIT Press*

Kumar N., Yadav S. (2021), Review on Genetically Modified Organism Foods, *Journal of Pharmaceutical Research International*, 33(60B), pp. 2815–2823, https://doi.org/10.9734/JPRI/2021/v33i60B34946

Vilella-Vila M., Costa-Font J., Mossialos E. (2005), Consumer involvement and acceptance of biotechnology in the European Union: a specific focus on Spain and the UK, *International Journal of Consumer Studies*, 29(2), pp. 108–118, https://doi.org/10.1111/j.1470-6431.2004.00425.x

Moerbeek H., Casimir G. (2005), Gender differences in consumers' acceptance of genetically modified foods, *International Journal of Consumer Studies*, 29(4), pp. 308–318, https://doi.org/10.1111/j.1470-6431.2005.00441.x

Moon W., Balasubramanian S. K. (2004), Public attitudes toward agrobiotechnology: The mediating role of risk perceptions on the impact of trust, awareness, and outrage, *Applied Economic Perspectives and Policy*, 26(2), pp. 186–208, https://doi.org/10.1111/j.1467-9353.2004.00170.x

Nawaz M. A., Mesnage R., Tsatsakis A. M., Golokhvast K. S., Yang S. H., Antoniou M. N., Chung G. (2019), Addressing concerns over the fate of DNA derived from genetically modified food in the human body: A Review, *Food and Chemical Toxicology*, 124, pp. 423–430, https://doi.org/10.1016/j.fct.2018.12.030

Ozkok G. A. (2015), Genetically modified foods and the probable risks on human health, *International Journal of Nutritional Food Science* 4(3), pp. 356–363, https://doi.org/10.11648/j.ijnfs.20150403.23

Qaim M. (2020), Role of new plant breeding technologies for food security and sustainable agricultural development, *Applied Economic Perspectives and Policy*, 42(2), pp. 129–150, https://doi.org/10.1002/aepp.13044

Rihn A., Khachatryan H., Wei X. (2021), Perceived subjective versus objective knowledge: Consumer valuation of genetically modified certification on food producing plants, *Plos one*, 16(8), e0255406, https://doi.org/10.1371/journal.pone.0255406

Shtulman A., Share I., Silber-Marker R., Landrum A. R. (2020), OMG GMO! Parent-child conversations about genetically modified foods, *Cognitive Development*, 55, 100895, https://doi.org/10.1016/j.cogdev.2020.100895

Sikora, D., Rzymski P. (2021), Public acceptance of GM foods: a global perspective (1999–2019), *Policy Issues in Genetically Modified Crops*, pp. 293–315, https://doi.org/10.1016/B978-0-12-820780-2.00013-3

Smyth S. J., McHughen A., Entine J., Kershen D., Ramage C., Parrott W. (2021), Removing politics from innovations that improve food security. *Transgenic research*, 30, pp. 601–612, https://doi.org/10.1007/s11248-021-00261-y

Sociologicky ústav (2022), (Akademie věd ČR), Centrum pro výzkum veřejného mínění Potraviny 2021 [dataset]. Ver. 1.0. Praha: *Český sociálněvědní datový archiv,* Cited 6.6.2023, https://doi.org/10.14473/CSDA00294

Streiffer R., Hedemann T. (2005), The political import of intrinsic objections to genetically engineered food, *Journal of Agricultural and Environmental Ethics,* 18, pp. 191-210, https://doi.org/10.1007/s10806-005-0633-3

Tsatsakis A. M., Nawaz M. A., Tutelyan V. A., Golokhvast K. S., Kalantzi O. I., Chung D. H., Kang S. J., Coleman M. D., Tyshko N , Yang S. H., Chung G. (2017), Impact on environment, ecosystem, diversity and health from culturing and using GMOs as feed and food, *Food and Chemical Toxicology*, 107, pp. 108–121, https://doi.org/10.1016/j.fct.2017.06.033

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), pp. 116–123, https://doi.org/10.1016/j.fshw.2016.04.002

Zheng Q., Wang H. H. (2021), Do consumers view the genetically modified food labeling systems differently? "Contains GMO" versus "Non-GMO" labels, *The Chinese Economy*, 54(6), pp. 376–388, https://doi.org/10.1080/10971475.2021.1890356