ORIGINAL SCIETNTIFIC PAPER

ATTITUDES ANALYSIS TOWARDS GENETICALLY MODIFIED FOOD

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ABSTRACT

Hunger, food safety, and unsustainable agriculture are currently among the main global issues. Agricultural technology is focused on making agriculture and the food industry sustainable and profitable. Healthy diets, food waste, and food origin are issues that concern European citizens, with Croatians having general mistrust towards genetically modified food. The research problem was to determine Croatian citizens' attitudinal dimensions and differences towards genetically modified food considering the level and method of obtaining information. Quantitative, descriptive research was conducted using an online survey. The questionnaire was forwarded to respondents via digital channels (snowball sampling method). The results have shown the existence of three factors that group attitudes towards genetically modified food using exploratory factor analysis: (1) impact on health & general acceptance, (2) impact on the environment, and (3) impact on the economy. Overall agreement considering the positive effect of genetically modified foods on all three factors is moderate to low, with the "health & general acceptance" factor scoring the lowest. There was no statistically significant difference for any factor considering whether respondents were informed about genetically modified food, source of information (scientific vs. non-scientific), and time of informing; although there are tendencies for more positive attitudes towards genetically modified food among informed respondents, especially when they gathered information via scientific sources.

***Keywords**: genetically modified food, GMO, informing, attitudes, ecology, economy, health*

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INTRODUCTION

Hunger, food safety, and unsustainable agriculture are currently among the main global issues. Today, every 9th person in the world is malnourished (795 million). By 2050, the world's population will reach 9.1 billion, 34% higher than today. Annual cereal production will need to rise to about 3 billion tonnes from 2.1 billion today, and annual meat production will need to increase by over 200 million tonnes to reach 470 million tonnes [17]. Agritech (agricultural technology) is focused on making agriculture and the food industry sustainable and profitable, and it is also one of the fastest-growing industries in the world. Between 1996 and 2014, crop biotechnology was responsible for the additional global production of 158.4 million metric tons of soybeans and 321.8 million tons of corn. The technology has also contributed an extra 24.7 million tons of cotton lint and 9.2 million tons of canola [3].

An increasingly worrisome challenge is climate change, affecting developing countries disproportionately. A third challenge that has emerged with the rise in energy prices is the rapid increase in the use of agricultural feedstock for biofuels, causing additional scarcity in food and feed markets [17]. This will lead to the usage of mostly renewable and still non-renewable sources from earth, sea, and oceans by transforming waste into valuable resources and sustainable food/biological products, and bioenergy. Bioeconomy is key in transforming society from fossil fuel dependency through changes in the way we use resources in all aspects of everyday life. The wellbeing of future European citizens is dependent on this transformation. In accordance with the UN Sustainable Development Goals, the European Commission proposes a decrease in food waste as part of the "farm to table" strategy [8].

The Special Eurobarometer Food Safety in the European Union report from 2019 reveals the general mistrust of Croatians towards genetically modified food, with it being the shared second top concern when it comes to food safety after food poisoning from bacteria. It also showed that TV is the most prominent media channel for obtaining information and that scientists are the most trusted sources of information [15].

The research problem in this paper is to determine Croatian citizens' attitudinal differences towards genetically modified food considering their level of information about it. The problem can be further operationalized through four goals: 1. Determine fundamental factors in attitudes towards genetically modified food; 2. Analyse attitudinal differences between persons who informed themselves about genetically modified food vs. those who never did; 3. Analyse attitudinal differences considering sources of information (scientific vs. non-scientific); and 4. Analyse attitudinal differences considering information recency.

The following hypotheses are set for each research problem: H1: attitudes towards genetically modified food have three fundamental factors: (1) health, (2) economy, and (3) environment; H2: persons who informed themselves about genetically modified food have a more positive attitude towards it than persons who are not informed at all; H3: persons who used scientific sources to gather information have more positive attitudes towards genetically modified food than persons who used only non-scientific sources; and H4: persons who were recently informed about genetically modified food have more positive attitudes towards it.

The paper is structured in the following way: firstly, we present an overview of existing research considering attitudes and information about genetically modified food, followed by methodology details and research results, ending with discussion and conclusions.

LITERATURE OVERVIEW

At the end of the 20th century, the world became more familiar with genetic engineering, and in 1983, tobacco resistant to antibiotics was developed, which was used only for experimental purposes [14]. Food with non-naturally occurring (DNA) modifications is called "genetically modified food", and the process is usually called "genetic engineering". In most cases, this is done by introducing genes from another organism. Today, most genetically modified food comes from plants, but in the future, we can expect genetically modified microorganisms and animals. Nowadays, genetic modification is mostly done to improve crop yield by introducing genes that are resistant to plant diseases or more tolerant to herbicides. The World Health Organization and the Food and Agriculture Organization collaborate on the Codex Alimentarius Commission in the development of guidelines, standards, codes of practice, and different recommendations concerning food and genetically modified organisms [32].

Advantages of genetically modified food include increased quality of plants, which improves their production, and lower use of pesticides due to the inclusion of insect-resistant genes. Genetically modified crops can increase yield and produce higher amounts of food in shorter periods, which is important in terms of the growing world population and limited arable land. Genetic engineering has also enabled fruit and vegetable production in laboratories during off-seasons. In the future, it will be possible to use GMO technology in the production of vaccines and other medicines [2]. On the other hand, due to genetic modification of food, insects and vermin could become immune to different pesticides, or even some viruses could become more virulent due to contact with new genes. Finally, it is possible that genetically modified organisms negatively impact biodiversity or jeopardize human health [18].

Better productivity and higher efficiency gained due to genetic modification technology have had a significant and positive impact on farms' incomes. Between 1996 and 2020, the economic benefits have been significant for farms using genetically modified technology, with their income having increased by $261.3 billion US dollars, i.e., in the mentioned period, the average farm income gain for all genetically modified crops increased by about $112/hectare. In 2020, farm income gains were $18.8 billion (average of $103/ha). Cumulative farm income gains have been divided between 52% for farms in developing countries and 48% for farms in developed countries [5].

Food Safety in the European Union, Special Eurobarometer – Wave EB91.3 study on 27,655 respondents from the European Union reveals that 43% of Croatians are personally interested in the topic of food safety, similar to the European Union 28 average (41%). A total of 69% of Croatians state that food safety is most important to them (the most frequently mentioned item). When obtaining information, television is the most prominent channel (77%), followed by word of mouth (52%) and newspapers and magazines (34%), while scientists are the most trusted sources regarding food risks (75% of Croatians would agree) [15]. Data for the whole European Union shows that "genetically modified ingredients in food or drinks", which was the fourth issue respondents were most worried about in the 2010 survey, has been identified as a concern by 27% of respondents. General mistrust of Croatians towards genetically modified food is also evident. A total of 12% of respondents mentioned genetically modified ingredients in food or drinks when thinking of a top concern regarding food safety, making it the (shared) second top reason mentioned after food poisoning from bacteria. Second place is shared with concerns about antibiotic, hormone, or steroid residues in meat and diseases found in animals [15].

There has been much research connecting socio-economic and demographic variables, including knowledge, utility perception, and attitudes towards genetically modified food [11]. Considering consumer behaviour theory, higher knowledge leads to higher acceptance. Additionally, a consumer who is well informed is usually concerned with a lack of knowledge [24]. Consumers state that they are not aware which products are genetically modified because of a lack of information on product packaging labels [23]. Accordingly, it is the consumer's right to demand labelling of genetically modified products, independent safety testing, environmental impact assessment, and liability for any damage connected with genetically modified food [22].

In a study by Barrena and Sanchez [4], they found that risk perception of food products, health effects of food, age, and income are the main factors affecting consumers' decisions. Information about genetically modified food obtained from different sources, for example, the media, the Internet, and other sources, is potentially worrying for most respondents [33]. In Chinese research by Kim et al. [19], the results show that 58.8% of respondents believe that genetically modified food is dangerous for human health, while only 5.8% of respondents have a positive attitude towards it. Research by Cui and Shoemaker [10] showed that with a lower understanding of genetically modified technology, respondents were more hesitant in accepting genetically modified food. The results also highlight the impact and importance of the study on the public perception of science in China [10].

Genetically modified organisms are the subject of debate in European countries, especially because their risk-benefit ratio is considered particularly unfavourable and because the public often distrusts their promoters and the regulatory process [6]. Most English consumers believe that genetically modified food is unsafe. With the decline in demand for genetically modified food in many UK supermarkets, such products have been phased out. European consumers are demanding labelling and independent safety testing for all genetically modified food [27]. The Special Eurobarometer Food Safety in the European Union report from 2019 showed that 59% of Croatians changed their consumption behaviour permanently or temporarily after reading or hearing information about food risk [15]. Research by Luntulwandile and Karodia [26] emphasises that information about genetically modified food and a higher level of education influence attitudes.

A study by Erjavec et al. [16] investigated the attitudes and knowledge of Slovenian citizens towards genetically modified organism technology. Correlation analysis showed that respondents with more objective knowledge had more flexible and positive attitudes towards the health impact of genetically modified organisms, while respondents with lower knowledge had more rigid and negative attitudes.

Komoto et al. [20] conducted an international comparative study, and the results show that consumers in France and Japan have greater resistance to genetically modified food than those in the US and the UK. Japanese consumers have shown greater fear of the dangers of genetically modified food than consumers in any other country. Respondents who answered that they were willing to buy genetically modified food demanded a discount of 20%, while in Japan a discount of 30% was demanded, thus showing their negative perception towards the consumption of such food. Consumers in every country are asking for assurance through scientific data, which would prove that genetically modified food is safe. Until then, consumers in each country are more likely to seek additional information to form their perceptions and attitudes about genetically modified foods [20].

In the study by Rzymski and Krolczyk [28], the attitudes of citizens of the Republic of Poland about the possibilities, limitations, risks, and advantages of using genetically modified organisms were examined. The results show that 79.9% of respondents think that genetically modified food is not discussed enough in the media, and 53.1% of respondents do not have enough knowledge about genetically modified organisms. The surveyed group believes that genetically modified food is unsafe for people (61.1%) and the environment (64.7%). Most respondents admitted that they are afraid of genetically modified food (82.2%) and perceive it as less healthy than traditionally produced food (67.7%). It is important to emphasize that 50% of respondents support the medical use of genetically modified organisms, but also that over 1/3 of respondents do not support the use of genetically modified food for any purpose [28].

In China, research was conducted on 160 companies in the food, seed, animal feed, and chemical industries. It was found that 55% of managers oppose the consumption of genetically modified food, 20% support genetically modified food, and 25% were neutral. Only 13% of managers in chemical companies support the commercialization of genetically modified crops, while as many as 87% were against it. Regarding attitudes towards genetically modified food, managers in the food and seed industries had more positive attitudes than those in the chemical and animal feed industries [13].

Chagwena et al. [7] conducted research in Zimbabwe about attitudes towards genetically modified food technology among respondents who were informed exclusively via mainstream media or who were self-informed. A total of 54% of respondents consumed genetically modified food, and 38% of them did not know if it was genetically modified. They stated that genetic modification does not improve flavour (60%) or nutritive value (52%). The study showed that negative attitudes are related to lower intention regarding the consumption and production of genetically modified food. Health risks, environmental pollution, and manipulation by large corporations for profit gains are the main reasons for rejection. Although the results show familiarity with genetically modified food technology, general respondent knowledge is low, which can be improved through educational activities and stronger campaigns [7].

Research in Turkey about attitudes towards genetically modified food, knowledge level, behaviour, and acceptance considering age, gender, and marital status showed statistically significant differences. Furthermore, the results show a generally unfavourable attitude towards genetically modified food; 42.1% believe that genetically modified food is not good for health, 39.6% are convinced that consuming genetically modified food will have adverse health effects, and 43.5% are worried about warnings regarding harmful health effects of genetically modified food. Still, 50.7% of men and 49.3% of women buy genetically modified food. The results showed that married respondents have greater knowledge about genetically modified food than single respondents, and men have more positive attitudes than women [29].

The study by Abedi and Alemzadeh [1] in Iran analysed the perception and attitudes of the public towards the risks and benefits of genetically modified food. Most respondents were not familiar with biotechnological methods (70%), and most of them (70%) were not aware of any risks and benefits. Respondents with higher education had more knowledge about biotechnology and genetically modified organisms in general compared to respondents with lower education. The results also showed that 60% of respondents do not have any knowledge about genetically modified food specifically and its purpose [1].

Das and Sumit [12] conducted a cross-sectional survey with a closed-ended questionnaire in the four largest districts of Bangladesh, where the respondents were over 18 years of age and had completed at least a secondary level of education. It was observed that out of a total of 614 respondents, 24.8% had no

knowledge of GM food. Of the remaining 462 respondents, 41.8% had some knowledge, and 30.7% had a positive attitude. The level of knowledge and attitude varied significantly depending on the respondents' gender, occupation, monthly income, educational status, etc. Logistic regression analysis showed that respondents with higher monthly incomes and higher education were more likely to have better knowledge and a more positive attitude [12].

The Pew Research Center [25] conducted a survey on the attitudes of the American public about genetically modified foods as part of its ongoing survey of public attitudes about scientific and technological developments. The majority of respondents believe that genetically modified food is likely to lead to health problems for the population (53%) or create problems for the environment (58%). At the same time, 44% of respondents also stated that such food is likely to help increase the global food supply, and 56% stated that genetically modified food will result in more affordable food [25].

Kunyanga et al. [21] collected data on the threats and effects of the GMO ban and the status of the Biosafety Act and the Cartagena Protocol on Biosafety implementation in Kenya. A cross-sectional survey was conducted with 216 purposively sampled participants and additional in-depth interviews with 16 key informants in a qualitative survey. The results were triangulated using data from the literature review. A total of 57% of respondents indicated that genetically modified organisms and genetically modified food are the solution to food security in Africa. Most believe that the introduction of genetically modified technology and the use of genetically modified food are beneficial (52.3%). Fifty-five percent of respondents stated that genetically modified food is safe. The majority of respondents (>90%) stated that there is a low threat of genetically modified technology to the environment, human health, and animal health. Respondents (54.3%) agreed that the Cartagena Protocol is well endorsed.

Shami [30] conducted research to assess people's knowledge of genetically modified food and evaluate its health risks. An online survey was conducted to assess consumer knowledge about genetically modified foods. The survey showed that 74.3% of respondents know what genetically modified food is. A total of 43.7% believe that the risk of genetically modified food for the environment and human health exists. Most respondents believe that the risk of genetically modified food is greater than its benefit. Some respondents believe that there is an influence of genetically modified food consumption on their genes, although expert knowledge of the exact scientific issues surrounding genetically modified foods is still relatively limited [30].

METHODOLOGY

INSTRUMENTS

To gather results about the level of information and attitudes towards genetically modified food, the authors programmed an online survey via the Google Forms tool. The questionnaire includes an elimination question, which serves to exclude respondents who are not familiar with the genetically modified food concept. All respondents were asked whether they were familiar with the concept and whether they knew what genetically modified food is. Those who were not familiar were not asked any further questions.

The questionnaire is structured into four parts. The screening part, at the beginning, includes basic demographic questions (gender and age) and an elimination question (familiarity with genetically modified food). The second part contains questions about the frequency and source of information regarding genetically modified food. The third module contains questions about attitudes towards genetically modified food. The last part contains additional demographic questions.

The third module contains 19 items, designed by the authors, which examine attitudes towards genetically modified food that can be divided into 3 pillars considering the effect on: (1) health, (2) nature and environment, and (3) economy. The respondents' task was to evaluate their agreement with each item on a scale from 1 to 5, where 1 denotes "completely disagree" and 5 "completely agree". We chose the Likert scale because its construction is relatively simple, and the interpretation of results is straightforward. Items used in this research were derived from literature reviews and have been shown to generally correspond to the above-mentioned pillars across different research papers. Initially, the authors created 24 items, but after the review process to check for clarity, straightforwardness of meaning, and whether the statements were in a clear positive or negative form, only 19 items were included in the final research.

PROCEDURE

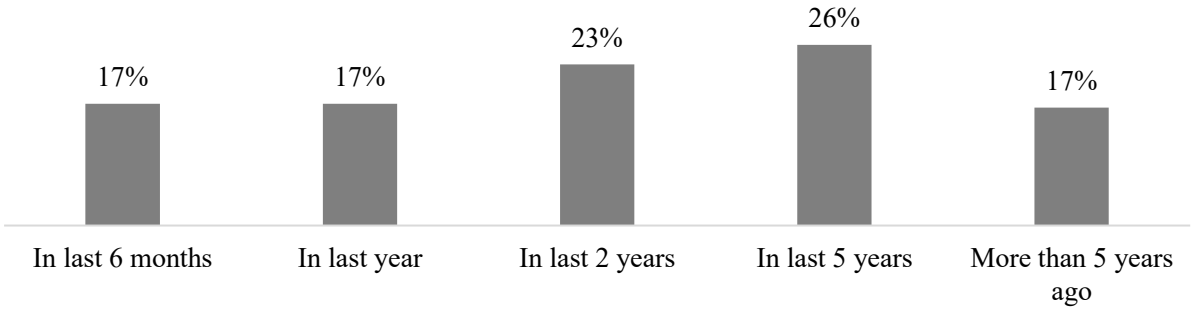
A convenience sampling procedure was used for acquiring respondents, specifically the snowball method. The questionnaire was forwarded to respondents via e-mail and social media. Participants were asked to further forward the questionnaire to their acquaintances and share it on their social platforms. At the beginning of the questionnaire, respondents were informed about the purpose of this research and guaranteed anonymity. Data gathering was conducted during June and July 2021. Multivariate analysis (FA) and analysis of differences between groups (t-test, ANOVA) were used to answer the research problem.

SAMPLE

The target population included all Croatian citizens aged 16 years or older who are at least familiar with the concept of genetically modified food. The questionnaire was completed by 344 respondents; 4 of them were not familiar with the concept, hence they were eliminated from further analysis. Out of 340 respondents who were included in the analysis, 108 (31.8%) were male and 232 (68.2%) were female. A total of 13.4% of respondents were between 16 and 25 years old, 29.1% between 26 and 35, most (38.4%) were in the age group between 36 and 45 years old, 16% between 46 and 55 years, and only 3.2% were older than 55. Higher education qualifications were held by 75.6% of respondents, while the rest had high school education and one respondent was an unskilled worker. Most of the respondents were employed (83.8%).

RESEARCH RESULTS

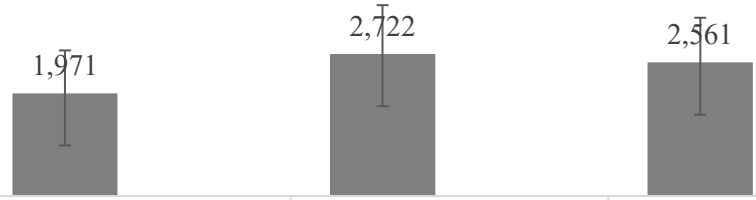
Out of all respondents, 52% informed themselves about genetically modified food in some way. Time of informing shows a negatively skewed distribution, i.e., there are fewer respondents who informed themselves recently (Graph 1).



Graph 1. Time of informing (those who informed themselves about genetically modified food)
Source: Authors

Examining the source of information, 19% used scientific sources, such as scientific articles, internet portals, blogs, and posts on social media, while 32% used non-scientific sources, and 49% consulted both scientific and non-scientific sources. When we combine the data, it is evident that 68% of respondents used scientific sources (among others).

Attitudes towards genetically modified food are shown in three dimensions (which are explained in the following text). Overall agreement considering the positive effect of genetically modified foods on (1) “health & general acceptance”, (2) “ecology”, and (3) “economy” is moderate to low, with “health & general acceptance” having the lowest score. Average scores (mean) and the dispersion measure (standard deviation) for each dimension are visualized in Graph 2. Testing of means shows significant differences among all factors, with “ecology” being scored the highest, followed by “economy”, and with the “health and general acceptance” factor scoring the lowest ($p<0.05$).



	Health & general acceptance	Ecology	Economy
Mean	1,971	2,722	2,561
Std. Deviation	,82147	,93877	,85819

Graph 2. Attitudes towards genetically modified food (shown in three dimensions)
Source: Authors

The following statistical analyses were conducted to test the research hypotheses. Exploratory factor analysis was used to determine underlying factors in attitudes towards genetically modified food. T-tests were calculated to determine differences between those who informed themselves about genetically modified food and those who did not, and to test differences between those who used scientific sources vs. non-scientific (popular) sources when obtaining information. ANOVA was used for determining differences between the time passed since obtaining information about genetically modified food and attitudes towards it.

Exploratory factor analysis was calculated for the first hypothesis – attitudes towards genetically modified food have three fundamental factors: (1) health & general acceptance, (2) ecology, and (3) economy. The KMO and Bartlett test indicate that attitudinal items are adequate for calculating factor analysis – intercorrelations are high, and the correlation matrix is significantly different from the identity matrix, i.e., items are grouped into higher factors (Table 1). Exploratory factor analysis with the criterion eigen = 1 and varimax rotation produced three factors and explained 63.8% of variance (Table 2). Factors were named using semantic analysis of items that saturate each factor, and they concur with the stated 1st hypothesis with some specifics (Table 3). The first factor named "health & general acceptance" is described with items connected to the health of an individual and with items promoting the production and consumption of genetically modified food. The second factor, "ecology", is saturated with items connected to the impact of genetically modified food on nature, the environment, and humanity in general. The third factor, "economy", is explained with items on how genetically modified food impacts the economy and industry.

Scales with average (mean) scores on all items were calculated for all three extracted factors. They were named the same as the extracted factors: "health & general acceptance", "ecology", and "economy". The item "Risk of genetically modified food is smaller than other everyday risks" was not included due to similar saturation with factors 1 (health & general acceptance) and 3 (economy). Five items needed to be rotated so that a higher score would coincide with a positive attitude towards genetically modified food, namely: (1) "genetically modified food is harmful to the environment", (2) "genetically modified food threatens the natural order", (3) "genetically modified food will cause a global natural catastrophe", (4) "genetically modified food presents a specific danger to human health", and (5) "consumption of genetically modified food leads to different diseases". For each factor, Cronbach's alpha measure was calculated, and the results show satisfactory reliability ("health", total 8 items = 0.928; "ecology", total 5 items = 0.857; "economy", total 5 items = 0.800). Average scores in each scale were used in testing other hypotheses. Descriptive analysis indicated a normal distribution of the "ecology" scale (skewness = 0.123) and "economy" scale (skewness = 0.007), while the "health & general acceptance" scale had a positively skewed distribution (skewness = 0.828), indicating a more negative distribution of attitudes towards genetically modified food when considering health impact and promoting genetically modified food production compared to economy or ecology. Considering the sample size and data characteristics, using parametric statistics in testing group differences is justified.

Table 1. Kaiser-Meyer-Olkin and Bartlett's test (1st hypothesis)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.932
Bartlett's Test of Sphericity	Approx. Chi-Square	3823.127
	df	171
	Sig.	0

Source: Authors

Table 2. Factor analysis – Total variance explained (1st hypothesis)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cumul. %	Total	% of Var.	Cumul. %	Total	% of Var.	Cumul. %
1	8.16	42.9	42.92	8.16	42.9	42.9	5.72	30.1	30.1
2	2.69	14.2	57.08	2.69	14.2	57.1	3.33	17.5	47.6
3	1.28	6.76	63.84	1.28	6.76	63.8	3.08	16.2	63.8

Extraction Method: Principal Component Analysis.

Source: Authors

Table 3. Factor analysis – Rotated component matrix (1st hypothesis)

	Component		
	1	**2**	**3**
Genetically modified food is safe for my health	0.819		
Genetically modified food is as safe for my health as natural food	0.817		
Genetically modified food is safe for the health of my family	0.79		
It is necessary to encourage the import of genetically modified food	0.774		
Genetically modified food is safe for future generations	0.772		0.308
Production of genetically modified food needs to be stimulated	0.748		
Production of genetically modified food needs to be allowed in Croatia	0.74		
There is no risk in the consumption of genetically modified food	0.656		
The risk of genetically modified food is smaller than other everyday risks	0.547		0.527
Genetically modified food is harmful to the environment		-0.82	
Genetically modified food threatens the natural order		-0.8	
Genetically modified food will cause a global natural catastrophe		-0.78	
Genetically modified food presents a specific danger to human health		-0.75	
Consumption of genetically modified food leads to different diseases	0.301	-0.75	
Genetically modified food is good for the economy	0.319		0.749
Genetically modified food would solve the food shortage problem in developed countries	0.403		0.744
Consumption of genetically modified food will reduce world hunger	0.377		0.738
Genetically modified food brings economic prosperity to all	0.362		0.593
Genetically modified food will completely replace natural food			0.558

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Source: Authors

The second hypothesis – people who informed themselves about genetically modified food have a more positive attitude towards it than persons who did not inform themselves at all – was tested with an independent samples t-test for all three factors. There were no statistically significant differences between people who informed themselves and those who did not in attitudes towards genetically modified food across all three scales (Tables 4 and 5).

Table 4. Descriptive statistics for informing status and attitudes towards genetically modified food (2nd hypothesis)

		N	Mean	Std. Deviation	Std. Error Mean
Health & general acceptance	Informed	179	1.979	.82613	.06175
	Not informed	161	1.962	.81873	.06453
Ecology	Informed	179	2.714	.92916	.06945
	Not informed	161	2.730	.95217	.07504
Economy	Informed	179	2.612	.86509	.06466
	Not informed	161	2.503	.84944	.06695

Source: Authors

Table 5. Independent samples t-test for differences between informed and not informed respondents in attitudes towards genetically modified food (2nd hypothesis)

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Health & general acceptance	Equal variances assumed	0.183	0.669	0.191	338	0.848
	Equal variances not assumed			0.191	334.83	0.848
Ecology	Equal variances assumed	0.311	0.577	-0.161	338	0.872
	Equal variances not assumed			-0.161	332.32	0.872
Economy	Equal variances assumed	0.044	0.833	1.172	338	0.242
	Equal variances not assumed			1.173	335.4	0.242

Source: Authors

The third hypothesis – persons who used scientific sources for obtaining information have more positive attitudes towards genetically modified food than persons who used only non-scientific sources – was also tested with an independent samples t-test for all three factors. There were no statistically significant differences in attitudes considering health & general acceptance, ecology, and economy between respondents who informed themselves via scientific sources and those who used only other sources (Tables 6 and 7).

Table 6. Descriptive statistics for source of information and attitudes towards genetically modified food (3rd hypothesis)

		N	Mean	Std. Deviation	Std. Error Mean
Health & general acceptance	Scientific	121	2.031	.81622	.07420
	Non-scientific	58	1.871	.84324	.11072
Ecology	Scientific	121	2.764	.86987	.07908
	Non-scientific	58	2.610	104.255	.13689
Economy	Scientific	121	2.662	.88921	.08084
	Non-scientific	58	2.516	.80978	.10633

Source: Authors

Table 7. Independent samples t-test for differences between respondents informed via scientific and non-scientific sources in attitudes towards genetically modified food (3rd hypothesis)

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Health & general acceptance	Equal variances assumed	0.03	0.862	1.217	177	0.225
	Equal variances not assumed			1.203	109.23	0.232
Ecology	Equal variances assumed	3.014	0.084	1.033	177	0.303
	Equal variances not assumed			0.97	96.295	0.335
Economy	Equal variances assumed	0.736	0.392	1.129	177	0.260
	Equal variances not assumed			1.167	122.49	0.245

Source: Authors

For the fourth hypothesis – persons who were recently informed about genetically modified food have more positive attitudes towards it – analysis of variance (ANOVA) was used because the answer to the question regarding the time of obtaining information had 5 possible answers ("in the last 6 months"; "in the last year"; "in the last 2 years"; "in the last 5 years"; "more than 5 years ago"). There were no statistically significant differences across all three genetically modified food attitude scales (Tables 8 and 9).

Table 8. Descriptive statistics for time of obtaining information and attitudes towards genetically modified food (4th hypothesis)

		Health & general acceptance	Ecology	Economy
In last 6 months	Mean	1.935	2.632	2.452
	N	31	31	31
	Std. Deviation	.84093	112.321	.93946
In last year	Mean	1.956	2.671	2.806
	N	31	31	31
	Std. Deviation	.84320	.83034	.89664
In last 2 years	Mean	2.046	2.805	2.556
	N	41	41	41
	Std. Deviation	.81382	.82884	.85617
In last 5 years	Mean	1.976	2.730	2.748
	N	46	46	46
	Std. Deviation	.77890	.89663	.77796
More than 5 years ago	Mean	1.963	2.693	2.447
	N	30	30	30
	Std. Deviation	.92624	103.155	.87680

Source: Authors

Table 9. ANOVA differences between respondents' time of obtaining information and genetically modified food attitudes (4th hypothesis)

		Sum of Squares	df	Mean Square	F	Sig.
Health & general acceptance	Between Groups	.267	4	.067	.096	.984
	Within Groups	121.217	174	.697		
	Total	121.484	178			
Ecology	Between Groups	.628	4	.157	.179	.949
	Within Groups	153.047	174	.880		
	Total	153.675	178			
Economy	Between Groups	3.766	4	.942	1.266	.285
	Within Groups	129.447	174	.744		
	Total	133.213	178			

Source: Authors

DISCUSSION

The sampling process (convenience, snowball sampling method) using the applied data collection method (respondents via e-mail and social media) created an unbalanced sample structure, especially considering education level, limiting the generalization of results. Hence, the following conclusions are limited to more educated, digitally active Croatian citizens from major cities.

Previous research in the field indicates that attitudes towards genetically modified food are mostly negative and that the majority of respondents believe it is not good for their health. The Special Eurobarometer Food Safety in the European Union report from 2019 showed general mistrust of Croatians towards genetically modified food, with it being the second top concern when it comes to food safety [15]. In the study by Kim et al. [19], 58.8% of respondents from the Republic of Korea stated that genetically modified food is dangerous for human health, while only 5.8% have a positive attitude towards it. Respondents in this research have even more negative attitudes – 71.8% believe that genetically modified food is not good for their health [19].

According to Želježić [34], possible harmful effects on the environment due to the production of genetically modified food are increased soil toxicity and disturbed ecosystem balance. A total of 41.5% of respondents in this study believe that genetically modified food is dangerous for the environment, while only 21.5% believe it is not.

With faster and larger food production with the help of genetically modified technology, it is possible to tackle world hunger, especially in developing countries. However, although they are affected by different challenges and food shortages, developing countries, including Zimbabwe, Zambia, Mozambique, and Malawi, have declined help in the form of genetically modified food from the United States and the World Food Program [7].

Similarly, this study showed that Croatians are sceptical towards genetically modified food considering its effect on health, ecology, and economy, with the most negative attitudes towards genetically modified food's effect on health.

Most studies recognize three dimensions in attitudes towards genetically modified food: (1) considering the influence on health, (2) on nature and the environment, and (3) on the economy. Exploratory factor analysis in this research revealed three factors in line with the predicted hypothesis, but with some specifics. The first factor, "health & general acceptance", is connected to the influence of genetically modified food on health, but also with general acceptance and promotion of genetically modified food production. The second factor, "ecology", is connected to the influence of genetically modified food on nature and the environment, but also on human health in general. The third factor, "economy", is described with attitudes towards the influence of genetically modified food on the economy and industry (Table 10). Three derived factors correspond to results in other countries and different studies, with the exception of the "health & general acceptance" factor. The derivation of a new dimension ("health & general acceptance") indicates that the perception of the effect of using and consuming genetically modified food on health is highly connected with the acceptance of policies facilitating the usage of this genetically modified technology.

Table 10. Hypotheses status

H1	Attitudes towards genetically modified food have three fundamental factors: (1) health, (2) economy, and (3) environment	**partly confirmed**
H2	Persons who informed themselves about genetically modified food have a more positive attitude towards it than persons who did not inform themselves at all	**rejected**
H3	Persons who used scientific sources for obtaining information have more positive attitudes towards genetically modified food than persons who used only non-scientific sources	**rejected**
H4	Persons who were recently informed about genetically modified food have more positive attitudes towards it	**rejected**

Source: Authors

Past research confirms that gaining information about genetically modified food and the level of education can influence attitudes [11], [24], [7]. The education level in this study is specific (most respondents have finished college) and homogeneous; hence, it is difficult to find differences between them, especially when investigating constructs such as attitudes. Although the results are not statistically significant at the $p<0.05$ criterion, differences in attitudes towards genetically modified food on the economy scale, between those who informed themselves and those who never did, show a somewhat lower p-value ($p=0.242$). We can assume that with a larger, nationally representative sample, i.e., one that would include more respondents with lower education levels, the hypothesis would be confirmed – there would be a more positive attitude towards the impact of genetically modified food on the economy among respondents who informed themselves. Similarly, a somewhat lower p-value is also evident on the economy scale when analysing differences in the time of obtaining information ($p=0.285$). However, the distribution of results does not clearly show a more positive attitude with more recent information.

Information about genetically modified food can be obtained via different sources (TV, radio, print media, the Internet, etc.); however, most respondents believe that genetically modified food is potentially worrisome [33]. Consumers state that they are not aware which items are genetically modified due to a lack of information on labels [23]. Public attitudes toward GM food are formed through a reasoning mechanism that starts from trust in science and public authorities, ultimately determining consumers' final purchasing decisions [9]. Familiarity with the concept of genetically modified organisms is low. Namely, most respondents (82.5%) believe that they do not have enough information and would like more, 3.5% are not interested and do not have an opinion, and only 10.5% stated that they have enough information and knowledge about genetically modified food [31]. Even though the research did not show statistically significant differences in attitudes considering the source of information, there are some clear indications that using scientific sources is connected to more positive attitudes towards the impact of genetically modified food on health & general acceptance, ecology, and economy, i.e., for all dimensions (p-values around 0.3 or lower).

CONCLUSION

Strong growth in biotechnology and genetic engineering leads to progress in agriculture, science, and medicine. Genetic engineering, i.e., genetically modified organisms and food, are becoming more present in the everyday diet of the human population, food production, and medicine, improving human lives, but simultaneously creating dangers and risks of malpractices and abuses of this technology. Attitudes towards genetically modified food are contrasting. It is believed that when there is full acceptance of genetically modified food, it will completely replace conventional food, and with possible risks and dangers connected to biotechnology, caution is necessary.

The study has shown that Croatian citizens do not differ significantly in attitudes and perceptions from citizens of other countries. The literature review has shown similar tendencies in not accepting the technology of genetically modified food and organisms in general for consumption and production. The results have shown rejection and fear due to health risks of consuming genetically modified food, concern for the environment due to producing genetically modified food, and lack of belief that producing genetically modified food would help the economy or alleviate world hunger. The main reason found in

other research and indicated in this one is the lack of personal knowledge about genetically modified food technology and insufficient information available in the public space. Positive attitudes toward genetically modified technology have been shown to be greatly connected to the perception of genetically modified food and its impact on health.

The research problem consisted of four research goals and hypotheses. Multivariate analysis (FA) and group differences testing (t-test, ANOVA) were used to answer research goals/test hypotheses. The results have shown the existence of three underlying factors/dimensions that affect attitudes towards genetically modified food: (1) "health & general acceptance", described as attitudes towards the effect of genetically modified food on the health of individuals and general tendency to accept or not accept genetically modified food; (2) "ecology", attitudes towards the effect of genetically modified food on nature, the environment, and human health in general; and (3) "economy", attitudes towards the impact of genetically modified food on the economy and industry. Of special importance is the derivation of a new dimension ("health & general acceptance"), which indicates that the perception of the effect of using and consuming genetically modified food on health is highly connected with the acceptance of policies facilitating the usage of this genetically modified technology. This suggests that any government or European Union level programs must address this issue first and foremost, and that improving perceptions of genetically modified food regarding the general health of individuals and their close ones (family, friends, etc.) should be connected to higher overall acceptance of genetically modified technology.

The results did not show differences in attitudes towards genetically modified food underlying factors for all research goals. Attitudes towards genetically modified food do not differ between respondents who informed themselves or did not about the topic, those who used scientific vs. non-scientific sources of information, nor considering the recency of obtaining information. Although there were no statistically significant results, the research did show indications that respondents who informed themselves about genetically modified food using scientific sources could have more positive attitudes towards its impact on the economy. Additionally, using scientific sources could also lead to more positive attitudes towards all attitudinal dimensions considering genetically modified food. It is important to emphasize that by using exclusively scientific sources, governments, organizations, and institutions are limiting message reach to only part of the population, which, we could argue, is already informed about the effects of genetically modified technologies. Our analysis showed that even in a sample which is biased towards higher education, 32% do not use scientific sources and an additional 49% use both scientific and non-scientific sources when obtaining information about genetically modified food. Hence, other media channels and formats play an important role in facilitating positive attitudes and general acceptance of genetically modified food and related technologies.

Sample limitations, the overrepresentation of respondents with a higher education level and its size, are probable reasons for rejecting hypotheses dealing with differences in attitudes between groups who were differently informed (at all, and considering time and source). Additional research, which would control the mentioned factors, with a larger and more representative sample and quota control, could possibly prove the mentioned indications as statistically significant.

Nonetheless, the contribution of this study is evident in proving the existence of three underlying factors in attitudes towards genetically modified food (health & general acceptance, ecology, and economy), especially the identification of a new underlying factor which connects general positive attitudes towards using and consuming genetically modified food with policies and their perceptions regarding individuals' health. This research also recognizes tendencies for greater acceptance of the technology behind genetically modified food with higher knowledge and by obtaining information about it, especially via scientific sources. The research showed that attitudes towards genetically modified food among Croatian citizens do not differ significantly from attitudes of citizens in other countries, especially in the European Union, which indicates the possibility for a global or European Union synergistic strategy in managing attitudes towards genetically modified food by alleviating current fears and increasing knowledge about its benefits. This strategy must primarily take into account how individuals today perceive the usage of genetically modified food regarding their health and address it by providing scientific results in a more understandable and "common man-friendly" manner using different media formats, i.e., using mainstream media channels with simplified messages about how genetically modified food and related technology are not dangerous for individuals' health and how they can improve economic status and help the environment. By encouraging acceptance of genetically modified food, we will make a step towards a more sustainable future.

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