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Spoločenská akceptovateľnosť NGT: spotrebitelia a poľnohospodári

Social acceptance of NGT: consumers and farmers

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Nové genomické technológie v poľnohospodárstve: spoločenská akceptovateľnosť, ekonomické dopady a rozhodovacie procesy

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Deliverable information

Two scientific papers were submitted to peer-reviewed journals in 2026, thereby fulfilling Deliverable V7, *Social Acceptability of NGTs: Consumers and Farmers*, within the project *New Genomic Technologies in Agriculture: Social Acceptability, Economic Impacts and Decision-Making Processes*, funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia, project No. 09I01-03-V04-00049.

The first paper, entitled **Farmers' Willingness to Produce NGT Crops**, examines the acceptance of crops developed using new genomic techniques among Slovak farmers. The paper is based on a representative survey of 202 agricultural holdings in Slovakia and applies a discrete choice experiment to estimate farmers' preferences for crop attributes, including yield, stress tolerance, selling price and the use of NGTs. The results show that farmers value agronomic and economic benefits, particularly higher yields and improved stress tolerance, but remain cautious towards NGT-derived crops and require a price premium to adopt them.

The second paper, entitled **Consumer Willingness to Pay for NGT-derived Foods**, was submitted to the *British Food Journal* on 16 June 2026 under manuscript ID BFJ-06-2026-1065. The paper focuses on consumer acceptance of food products derived from new genomic techniques and analyses consumers' willingness to pay for NGT-derived foods. Together, the two papers address both key target groups of Deliverable V7: consumers and farmers.

Both papers are attached to this document as supporting evidence of the fulfilment of Deliverable V7.

Consumer Willingness to Pay for NGT-derived Foods

Journal:	*British Food Journal*
Manuscript ID	Draft
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Keywords:	consumer purchasing decisions, Biotechnology, Genetically modified foods

Consumer Willingness to Pay for NGT-derived Foods

Structured Abstract

Purpose
This paper investigates consumer acceptance of products derived from new genomic techniques (NGTs), with a particular focus on estimating consumers' willingness to pay for NGT-derived food products in five representative European countries, including United Kingdom.

Approach
Consumer surveys were conducted in Germany, Denmark, France, Slovakia, and the United Kingdom. These countries were selected to capture a broad geographical distribution and diverse socio-economic, agro-ecological, and agro-economic policy contexts within Europe. The survey was implemented using a Computer-Assisted Web Interviewing approach. A stratified sampling method was applied to ensure that each national sample was representative of the respective country's population in terms of age, gender, region, and education. To elicit consumers' stated preferences, a discrete choice experiment was integrated into the survey.

Findings
A discrete choice experiment showed that consumers prefer products with lower prices, better nutritional scores, and environmentally friendly production methods, but are hesitant to choose products containing NGT-derived ingredients and generally require a price discount to do so. There are differences in willingness to pay for NGT-derived foods between countries and across socio-economic and demographic groups defined by education, age, and gender. Older respondents were significantly less likely to select NGT-derived products. These results underline the importance of fostering consumer awareness and understanding of NGTs as a prerequisite for greater acceptance of NGT-derived foods and for realizing their potential economic, nutritional, and environmental benefits.

Keywords: new genomic techniques (NGTs), consumer acceptance, discrete choice experiment

Key policy highlights
- Transparent, science-based policies and regulations concerning New Genomic Techniques should be established.
- The dissemination of information regarding New Genomic Techniques requires improvement, as consumers often operate with incomplete or imperfect knowledge.
- The provision of information on New Genomic Techniques by trusted public institutions, in collaboration with relevant stakeholders, should be strategically targeted. Such efforts must account for cross-national differences in knowledge as well as variations among distinct segments of the population.
- Public policies should take into consideration the potential environmental and nutritional benefits of New Genomic Techniques and potentially beneficial effect on global food security in comparison to conventional food products.

1 Introduction

In the European Union (EU), strict regulation - often characterized as overregulation - halted the development of genetically modified (GM) crops around the turn of the 21st century and may now slow the market growth of crops developed using New Genomic Techniques (NGTs). There is broad agreement among scientists and regulators that such strict regulation is not grounded in scientifically confirmed risks associated with these technologies. The European Food Safety Authority (EFSA) and other scientific bodies worldwide have consistently stated that the risks from GM and NGT-derived crops are comparable to those of conventionally bred crops (EFSA, 2021; DeFrancesco, 2013; Nicolia et al., 2013; Paarlberg, 2010).

According to the literature, the main reason for the limited success of GM crops and the slow approval of NGT-related regulation in the EU lies in low social acceptance among the public and consumers (Lucht, 2015; Graff and Zilberman, 2007; Scholderer and Frewer, 2003; Beghin and Gustafsson, 2021; Strobbe et al., 2023; Busch et al., 2021; Farid et al., 2020; Caputo et al., 2020; NBAB, 2020). It is therefore important to investigate current consumer attitudes toward food biotechnology and their willingness to pay for NGT-derived foods, taking into account cross-country differences and key consumer characteristics.

There are several potential reasons why consumer acceptance of NGT crops may differ from that of GM crops. First, NGTs are often perceived as less controversial, as they typically do not involve transgenesis, i.e., the transfer of genetic material across non-crossable species (Lusk et al. 2018). Second, the absence of realized risks associated with GM crops may have reduced perceived uncertainty regarding NGTs relative to GM technologies. Third, NGTs are increasingly linked to policy objectives such as food security and climate change mitigation (Georges and Ray 2017, Lemarié and Marette, 2022; Sundström et al., 2024).

At the same time, debate continues about the precise targeting of NGTs and the potential occurrence of off-target effects (Zhao and Wolt, 2017; Zhang et al., 2015), as well as about limitations in specificity, biosafety concerns (Movahedi et al., 2023), and ethical issues associated with these technologies (Zhang et al., 2020; Brokowski and Adli, 2019). Such concerns may shape public discourse and influence consumer preferences.

Imperfect consumer information about modern biotechnology, limited awareness of potential benefits of NGTs, misperceptions of risk, the influence of labeling, and perceptions of "naturalness" may all negatively affect the social acceptance of NGT-derived products (Beghin and Gustafsson, 2021, Farid et al., 2020; Caputo et al., 2020; NBAB, 2020).

Existing studies suggest that acceptance of NGT-derived crops and willingness to pay for NGT foods vary across European countries (Rousselière and Rousselière, 2017, Marette et al. 2021, Pokrivcak et al., 2026), by demographic characteristics such as education and age (Beghin and Gustafsson, 2021), by product type, by the type of information provided to consumers about NGTs and GM (Kilders and Caputo 2021), and by consumer awareness (Farid et al. 2020, Marette et al. 2021; Paudel, Kolady, Just, and Ishaq 2023; Paudel, Kolady, Just, and Van der Sluis 2023).

Many studies conclude that European consumers tend to prefer food from traditional breeding over NGT-derived food, and NGT-derived food over GM food (Beghin and Gustafsson, 2021; Strobbe et al., 2023; Busch et al., 2021; Bearth et al., 2022; Nguyen et al., 2022).

Social acceptance of NGTs among consumers and other stakeholders in the agri-food supply chain is a prerequisite for their successful introduction and market development (Bearth et al., 2024; Qaim, 2020; Beghin and Gustafsson, 2021). Low acceptance constrains research, investment, and innovation, thereby reducing the potential contributions of NGTs to food security and environmental sustainability. Consumer preferences influence market demand, prices, and competitiveness within NGT-related supply chains (Marette et al., 2021; McFadden et al., 2021). Historical experience with GM crops illustrates that inadequate social acceptance can significantly hinder the diffusion of biotechnology in agriculture, as occurred in the EU and globally during the 1990s (Qaim, 2020).

The objective of this paper is to shed more light on consumer acceptance of NGT-derived products. To this end, we conducted consumer surveys in five European countries—Germany, Denmark, France, Slovakia, and the United Kingdom. The surveys included a discrete choice experiment focusing on the consumption of a common food product (yoghurt), enabling estimation of consumers' willingness to pay for food items containing NGT-derived ingredients.

The remainder of the paper is organized as follows. The next section introduces the methodology, describing the consumer survey and the discrete choice experiment used to assess willingness to pay. The results section presents key findings on social acceptance of NGT-derived products across the surveyed countries and compares willingness to pay among consumers. The final section concludes with implications for policy, communication, and future research.

2 Methodology

To assess consumer acceptance of New Genomic Techniques (NGTs), a survey was conducted in Germany (DE), Denmark (DK), France (FR), Slovakia (SK), and the United Kingdom (UK). These countries were selected to represent a broad geographical distribution and diverse socio-economic, agro-ecological, and agro-economic policy contexts within Europe. Prior to the main survey, a pilot test was carried out face-to-face with twelve respondents. The purpose of the pilot test was to refine the questionnaire and verify the clarity and neutrality of the questions, as well as the appropriateness and complexity of the response options in closed-ended items.

The main consumer survey was subsequently implemented using a Computer-Assisted Web Interviewing (CAWI) approach, administered in the respective national languages. Data were collected from a total sample of 5,000 participants (1,000 respondents per country) between January and February 2024. A stratified sampling method was applied to ensure that each national sample was representative of the respective country's population in terms of age, gender, region, and education.

The first section of the questionnaire provided insights into consumer behaviour in each country. Following this introductory part, respondents answered questions forming a discrete choice experiment (DCE) designed to investigate consumer preferences for products with different characteristics, including ingredients derived from New Genomic Techniques (NGTs). Additional questions examined consumers' awareness and perceptions of NGTs.

The term *"New Genomic Techniques"* was explained to participants either through an informational video produced by the European Commission or through an equivalent explanatory text, with each format randomly assigned to half of the respondents. Finally, responses were analysed across gender, age, and education groups to identify potential differences in consumer attitudes and preferences.

2.1 Consumers' choice of a product – Discrete choice experiment

To investigate stated preferences of consumers, a discrete choice experiment (DCE) was used as a part of the consumer survey. The discrete choice experiment is grounded in Lancaster's theory of consumer choice and the random utility theory, making it well-suited for evaluating consumer preferences and estimating willingness to pay for product attributes such as those derived from NGTs. It assumes that consumers do not derive utility from the consumption goods themselves, but from a set of characteristics or attributes the goods possess and the values (or levels) that these characteristics take (Lancaster, 1966). Products have various attributes (price, production process, environmental impacts, perceived quality, product expectations, etc.). DCEs allow for the estimation of how consumers value these attributes and account for trade-offs between them, by asking the respondents to choose their preferred product option from more alternatives. By presenting hypothetical yet realistic product profiles, DCEs mimic actual purchase environments better than pure survey questions. Moreover, the econometric estimation from DCEs allows for deriving willingness to pay (WTP) values for specific attributes, which is the core aim of your study. Direct WTP questions are often biased by strategic responses and contingent valuation lacks the nuanced attribute-level trade-off that DCE captures.

A yoghurt was selected as a concrete product for the DCE in our consumer survey. The selection of a yoghurt was based on two criteria: i) the product should be suitable for the utilisation of NGT-derived plants explored within the project which this research is part of and ii) it should be a widely consumed product well known to the public. The project aimed, among others, to use NGTs in starch potato cultivation to improve virus resistance and tuber starch quality. Potato starch finds it application in frozen foods, semi-finished foods, yoghurts and dairy products, chips and snacks, gluten-free foods and many other products. Out of these products, a yoghurt was considered the most suitable for a consumer choice experiment.

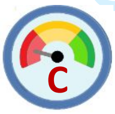
The selection of product attributes was guided by a review of relevant literature on food choice behaviour and sustainability-oriented consumer preferences. The attributes are:

- Price – was included as a necessary component for estimating consumers' willingness to pay. Price is consistently one of the most influential attributes in DCE studies; studies found that price and nutrition information were more influential than social responsibility or ecological impact (Ghvanidze et al., 2017). In our DCE, prices were set at 85%, 95%, 105% and 115% of the average price of a yoghurt in each surveyed country (however, during the data processing phase we have normalized the prices in each country to enable comparison of results of the DCE analysis across countries).
- Nutritional score – reflects growing interest in health-related product information and was confirmed as an important attribute of consumer food choice in prior studies (Ghvanidze et al., 2017; Livingstone et al., 2020; Takacs et al., 2025). Nutritional scores measuring the overall nutritional value of food ranged in our DCE from A (best for health) to C (worst).
- Environmental impact – was chosen to capture consumer values related to sustainability, which have been shown to significantly influence purchasing behaviour. A recent randomized trial experiment found that priming for environmental benefits or the co-benefits for health and the environment had a stronger effects on increasing the importance of "ecofriendly" and "organic" attributes (Liao et al., 2025). In our DCE, environmental impact reflected the impact of food and the food production process on the environment (e.g., use of energy, chemicals). A yoghurt produced by an environmentally friendly process was marked with an "eco" icon; other foods were considered standard.

- Production method of product ingredients, specifically the use or absence of new genomic techniques (NGTs) – represents the central focus of this study. Although it was not explicitly stated in the questionnaire which ingredient of a yoghurt may be from NGT-derived organisms and from consumers' perspective it could be any ingredient (like potato starch, fruit flavour, plant-based milk substitutes[1]), this association is not in conflict with the broader question of whether NGTs were used in the production process.

We generated the discrete choice experiment design using the "dcreate" module in Stata (Hole, 2015), which employs a modified Fedorov algorithm to optimize D-efficiency for estimating model parameters. The resulting design comprised nine choice tasks, each consisting of two distinct yogurt alternatives alongside a "no buy" option (see Figure 1). The order of the choice tasks was randomized among questionnaires. By asking respondents to choose their most preferred option in each choice task, individual consumer preferences were obtained. To assess consumer preferences and to estimate the willingness to pay for each product attribute, a mixed logit model was used. While the design was optimized for main effects, the mixlogit framework allows for the inclusion of interaction terms during analysis. These interactions are between respondent socio-demographic characteristics (e.g., age, education level) and production method. These variables are external to the design and were not part of the attribute set itself; therefore, their inclusion does not compromise the validity or statistical efficiency of the design. Nevertheless, interpretation of these interaction effects shall be conducted with caution and primarily for exploratory purposes.

Figure 1. Example of a choice task from the consumer survey

	Yoghurt A	Yoghurt B	Neither
Price	0.44 EUR (150 g)	0.36 EUR (150 g)	I would not purchase any of these products
Nutritional score			
Environmental impact	standard product		
Production method	no NGT	with NGT	
I would choose	☐	☐	☐

Source: own processing

Data collected in the DCE part of the consumer survey were analysed using a random utility model. In this framework, consumers (denoted as '*n*') choose the alternative (denoted as '*i*') that provides the highest utility ($U_{i\square}$). As described by McFadden (1974), utility of each alternative is determined by an observable component ($V_{i\square}$) and an unobservable component ($\varepsilon_{i\square}$):

$$U_{in} = V_{in} + \varepsilon_{in} = \beta_1 Price_{in} + \beta_2 NutritionScore_{in} + \beta_3 EnviroImpact_{in} + \beta_4 ProductionNGT_{in} + \varepsilon_{in} \quad (1)$$

Individuals will select the alternative '*i*' over other alternatives ('*j*)' if and only if it yields the maximum utility (Louviere et al., 2011).

We used Mixed Logit (MXL) models to evaluate the DCE data. MXL models allow attribute coefficients (β_{kn}) to vary across respondents, accounting for preference heterogeneity and thus

[1] Note: Explanation of NGTs provided to the survey respondents addressed only plant production, so respondents should not associate NGTs with any yoghurt ingredients of animal origin.

improving model realism. Additionally, MXL models adjust the standard errors of utility estimates to account for repeated choices by the same individual (Ryan et al., 2012).
The distribution of the coefficients is described as $f(\beta_{kn}|M)$, where 'M' represents the moments of the distribution. The probability of choosing alternative 'i' by an individual 'n' (P_{in}) is then:

$$P_{in}(M) = \int_{\beta kn} L_{in}(\beta_{kn}) f(\beta_{kn} \mid M) d\beta_{kn} \tag{2}$$

All attribute variables were specified as random variables except for the price and constant variable specified as fixed. As a robustness check, we additionally estimated a mixed logit model with a random price coefficient. The results are reported in the Appendix. The results from the specification with a random price coefficient are consistent with the main model and confirm the robustness of our findings.

3 Results

Table 1 provides information on demographic structure of respondents.

Table 1. Demographic structure of respondents

		DE	DK	FR	SR	UK
Gender	Male	49.5%	50.2%	48.8%	48.3%	49.4%
	Female	50.5%	49.8%	51.2%	51.7%	50.6%
Age	18-34	24.4%	26.3%	27.3%	23.2%	29.1%
	35-49	26.9%	27.9%	26.5%	31.5%	27.3%
	50-64	24.0%	24.4%	24.7%	25.8%	22.9%
	65 +	24.7%	21.4%	21.5%	19.5%	20.7%
Education	None [1]	0.0%	0.0%	0.0%	0.3%	0.0%
	Primary school	17.2%	25.6%	24.1%	10.7%	29.5%
	Secondary school	55.1%	45.2%	46.3%	63.9%	36.7%
	University	27.7%	29.2%	29.6%	25.1%	33.8%

Note [1]: Respondents with no formal education added to the group with primary education. This applies to three respondents from Slovakia.
Source: own processing

Table 1. Demographic structure of respondents – cont.

Country	Region
DE Germany	Baden-Württemberg 12.6%, Bayern 15.1%, Berlin 4.6%, Brandenburg 3.2%, Hessen - Thüringen 10.2%, Mecklenburg-Vorpommern 2.3%, Niedersachsen-Bremen 9.9%, Nordrhein-Westfalen 21.6%, Rheinland-Pfalz - Saarland 5.7%, Sachsen - Sachsen-Anhalt 9.1%, Schleswig-Holstein - Hamburg 5.7%.
DK Denmark	region Hovedstaden 30.2%, region Midtjylland 22.7%, region Nordjylland 10.5%, region Sjælland 14.8%, region Syddanmark 21.8%.
FR France	Île De France 19.0%, Bassin Parisien 16.9%, Nord - Pas-De-Calais 6.3%, Est 8.6%, Ouest 13.8%, Sud-Ouest 10.8%, Centre-Est 12.2%, Méditerranée 12.4%.
SR Slovakia	region Bratislava 13.1%, region Trnava 10.3%, region Nitra 12.7%, region Trencin 10.9%, region Zilina 12.9%, region Banska Bystrica 11.8%, region Presov 14.4%, region Kosice 13.9%.
UK United Kingdom	South 35.2%, Midlands & East 25.0%, Wales 4.9%, North 23.5%, Scotland 8.2%, Northern Ireland 3.2%.

Source: own processing

Across all five European countries, consumers show strong interest in food quality and price as the main determinants of their purchasing decisions, though the relative importance of each varies slightly. Results for all countries are summarised in Table 2.

Table 2. Food purchasing behaviour

	DE	DK	FR	SR	UK
Most important determinant when buying food					
Design or appearance	4.4%	4.9%	5.6%	3.8%	5.5%
Environmental impact	6.3%	6.4%	7.1%	4.7%	5.2%
Ethical issues of food production	9.4%	9.5%	7.8%	3.6%	7.0%
Geographical origin	7.1%	3.6%	6.6%	5.4%	4.8%
Nutritional value and energy content	9.7%	13.7%	9.5%	8.4%	13.3%
Price	26.3%	34.8%	33.7%	33.2%	32.1%
Quality	36.8%	27.1%	29.7%	40.9%	32.1%

Source: own processing

The survey examined consumers' awareness of NGTs. Overall, approximately half of the respondents had heard of NGTs (50.5%), while the remaining half had not. The highest proportion of consumers familiar with NGTs was found in Germany and the United Kingdom, and the lowest in Slovakia. Male respondents reported awareness of NGTs more often than female respondents (with a statistically significant dependence between gender and awareness of NGTs in Denmark, France, Slovakia, the United Kingdom). Younger respondents (with the exception of those in Slovakia) tended to be more aware of NGTs (although a statistically significant relationship between age and awareness was confirmed only for the United Kingdom). Respondents with a university education were more likely to be aware of NGTs than those with lower education attainment (significant dependence between education and awareness of NGTs found in Germany, France, the United Kingdom). Detailed results are presented in
Table 3.

These findings confirm that awareness of NGTs varies both across countries and among different population groups. At the country level, awareness of NGTs or genome editing (depending on the study) is typically reported at around 50% (Lakomy et al., 2018; Molodziejko et al., 2024). Among the countries included in our study, we expected the highest share of respondents aware of NGTs to be in the United Kingdom, given the country's progress in legislation and implementation of NGTs in the agri-food sector and its previous public discussions on the topic. In 2023, the United Kingdom adopted the Genetic Technology (Precision Breeding) Act (UK Parliament, 2023), whereas in the EU the legislative framework for NGTs remains under development. However, active public and policy debate, strong research institutions, and extensive media coverage of the EU's legislative process – combined with consumer interest in scientific information about food – may explain why awareness was even higher in Germany (Lakomy et al., 2018 similarly reported high awareness of genome editing in Sweden, 74%, attributing this to the country's strong biotechnology background). At the population-group level, men generally report higher awareness of NGTs than women, and awareness tends to increase with education level, while patterns across age groups are less consistent (Lakomy et al., 2018).

Hearing about NGTs does not necessarily mean that consumers consider themselves knowledgeable about them or that they actually understand the concept. The questionnaire therefore included an explanation of the term, with the aim of enabling respondents to understand the questions and provide informed answers.

Table 3. Awareness of NGTs

	DE	DK	FR	SR	UK
Heard of NGTs (all)	59.9%	49.6%	47.1%	45.7%	50.1%
- Males	60.6%	54.2%	51.4%	49.5%	54.5%
- Females	59.2%	45.0%	43.0%	42.2%	45.8%
P-value: chi2 for gender – awareness of NGTs	0.652	0.004	0.007	0.020	0.007
- Age 18-34	63.5%	55.5%	47.6%	41.8%	62.2%
- Age 35-49	59.9%	45.2%	47.2%	42.5%	55.3%
- Age 50-64	58.3%	50.4%	47.8%	45.7%	42.8%
- Age 65+	57.9%	47.2%	45.6%	55.4%	34.3%
P-value: chi2 for age – awareness of NGTs	0.574	0.092	0.965	0.018	0.000
- Primary education	54.1%	43.4%	44.8%	38.2%	54.6%
- Secondary education	58.8%	51.3%	44.1%	45.7%	37.1%
- University education	65.7%	52.4%	53.7%	49.0%	60.4%
P-value: chi2 for educ. – awareness of NGTs	0.037	0.066	0.024	0.164	0.000

Note: P-values for each country compared to alpha = 0.05.
Source: own processing

3.1 Discrete choice experiment and willingness to pay for NGT-derived food product

For a selected product, a yoghurt, hypothetical alternatives were presented to consumers and they had to choose among them. In the survey there was a set of choice tasks and alternatives of a yoghurt in each choice task differed in attributes price, nutritional score, environmental impact and production method of ingredients. By choosing an alternative consumers stated their preferences for the product based on its attributes. Using mixed logit models, we revealed that all mean coefficient values for the attributes (including the opt-out) were statistically significant at the 1% level in each of the surveyed countries (except for the "eco" label in Slovakia). This allowed us to reject the null hypothesis that the selected attributes were unimportant to respondents.

In addition to significance, signs of the attributes play an important role in the DCE estimation by MXL. A positive sign means that the attribute has a positive impact on the preference of the consumer for a given product (yoghurt); a negative sign means the opposite. For instance, in Germany the negative coefficient for nutritional score B means that having a worse nutritional score (score B), rather than nutritional score A, decreases the utility of consumers from consumption of a yoghurt by 0.937. Similarly, the coefficient for nutritional score C shows that if the score is C, the utility decreases by 2.219. All the coefficients have the expected signs. Ceteris paribus, respondents in general prefer a yoghurt with a lower price, better nutritional score, friendlier environmental impact and produced conventionally without the use of NGTs (Table 4).

Table 4. Mixed logit model – estimation results

	DE	DK	FR	SR	UK
Mean	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.

price	-3.306***	-6.501***	-3.325***	-3.436***	-3.387***
asc	5.578***	8.144***	5.615***	5.734***	5.512***
nutri_b	-0.937***	-0.837***	-0.811***	-0.722***	-0.826***
nutri_c	-2.219***	-1.803***	-2.124***	-1.765***	-1.992***
eco_y	0.437***	0.388***	0.397***	0.088	0.456***
ngt_y	-0.399***	-0.399***	-0.454***	-0.617***	-0.222***
SD					
nutri_b	1.098***	1.165***	-0.860***	0.814***	0.857***
nutri_c	2.112***	2.034***	1.943***	1.704***	2.059***
eco_y	1.409***	1.433***	1.138***	1.423***	1.387***
ngt_y	0.827***	1.000***	0.893***	1.385***	0.657***
Number of obs	**27000**	**27000**	**27000**	**27000**	**27000**
Log likelihood	-7352.893	-7803.994	-7345.600	-7538.127	-7372.900
LR chi^2	1373.81	1590.56	1108.64	1449.81	1393.72
Prob > chi^2	0.000	0.000	0.000	0.000	0.000

Note1: nutri_b and nutri_c = nutritional score B and nutritional score C (relative to nutritional score A), eco_y = ecologically friendly production process (relative to standard production process), ngt_y = production process employing NGTs (relative to conventional production process without NGTs), asc = constant term
Note2: *** significant at 1% level, ** significant at 5% level, * significant at 10% level
Source: own processing

We estimated the willingness to pay of consumers for NGT-derived products based on the main effects of mixed logit results (Table 5). Inclusion of a price variable in the model allowed to estimate the monetary value of different attributes of yoghurt. In other words, how much consumers are willing to pay to have a yoghurt with improved characteristics (like a better nutritional score). Our results show that consumers require a price discount to buy a yoghurt with a worse nutritional score or produced by NGTs. Out of the five studied countries, the largest price discount for an NGT yoghurt is required by Slovak consumers (a discount of 18% for an NGT yoghurt relative to a no-NGT yoghurt) while the lowest price discount is required by consumers in Denmark and the United Kingdom (a discount of 6.1% and 6.6%, respectively). On the other hand, consumers are willing to pay a higher price for yoghurts that are friendly to the environment in their production methods and use of ingredients. The only exception is Slovakia, where the coefficient for the “eco” icon is not significant.

The opt-out coefficients in all models are relatively large in magnitude and statistically significant indicating a strong average preference for not selecting any of the offered yogurt alternatives. This suggests a strong baseline reluctance to purchase under current attribute combinations. In utility terms, respondents preferred opting out unless the alternative offered considerable benefits (e.g., lower price, better nutritional score…).

Table 5. Willingness to pay

	DE	**DK**	**FR**	**SR**	**UK**
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
nutri_b	-0.283***	-0.129***	-0.244***	-0.210***	-0.244***
nutri_c	-0.671***	-0.277***	-0.639***	-0.514***	-0.588***
eco_y	0.132***	0.060***	0.119***	0.026	0.135***
ngt_y	-0.121***	-0.061***	-0.137***	-0.180***	-0.066***

Note1: nutri_b and nutri_c = nutritional score B and nutritional score C (relative to nutritional score A), eco_y = ecologically friendly production process (relative to standard production process), ngt_y = production process employing NGTs (relative to conventional production process without NGTs)

Note2: *** significant at 1% level, ** significant at 5% level, * significant at 10% level
Source: own processing

We also explored the interaction between the "NGT" attribute (use of NGTs in the production of ingredients) and selected sociodemographic variables, including gender, age and education of respondents (Table 6). The results indicate that women in Denmark and the United Kingdom have significantly lower preference for an NGT-derived yoghurt than men. The interaction between gender and the NGT attribute is not significant in Germany, France and Slovakia, meaning that there are no statistically significant differences between the preferences of men and women for NGT foods. Older individuals exhibit a lower preference for yogurts produced by NGTs compared to the reference group of people aged 18 to 34. The older are the respondents the less they prefer to buy NGT-derived yoghurts. Education does not affect the preference for NGT-derived yoghurts, except for secondary education in the United Kingdom having a statistically significant impact on consumer preferences. Consumers with secondary education in the United Kingdom prefer NGT-derived yoghurts less than respondents with primary education.

Table 6. Mixed logit model with interaction terms

	DE	**DK**	**FR**	**SR**	**UK**
Mean	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
gender*ngt_y	-0.001	-0.294***	-0.089	-0.005	-0.182**
age_35_49*ngt_y	-0.187*	-0.175	-0.298***	-0.311**	0.085
age_50_64*ngt_y	-0.261**	-0.310**	-0.291**	-0.445***	-0.192*
age_65_over*ngt_y	-0.401***	-0.518***	-0.459***	-0.536***	-0.218**
edu_secondary*ngt_y	-0.069	0.001	-0.077	0.081	-0.223**
edu_university*ngt_y	-0.101	0.022	-0.037	-0.085	-0.064
price	-3.306***	-6.494***	-3.324***	-3.437***	-3.391***
asc	5.579***	8.139***	5.614***	5.735***	5.523***
nutri_b	-0.938***	-0.838***	-0.810***	-0.722***	-0.827***
nutri_c	-2.219***	-1.800***	-2.122***	-1.765***	-1.991***
eco_y	0.435***	0.386***	0.397***	0.089	0.456***
ngt_y	-0.122	-0.023	-0.113	-0.327*	0.035
SD					
nutri_b	1.098***	1.160***	-0.861***	0.812***	0.855***
nutri_c	2.112***	2.032***	1.944***	1.701***	2.057***
eco_y	1.409***	1.431***	1.139***	1.422***	1.386***
ngt_y	0.814***	0.974***	0.877***	1.372***	0.631***
Number of obs	**27000**	**27000**	**27000**	**27000**	**27000**
Log likelihood	-7345.949	-7790.258	-7337.380	-7530.905	-7356.968
LR chi^2	1369.64	1570.42	1104.40	1437.84	1381.48
Prob > chi^2	0.000	0.000	0.000	0.000	0.000

Note1: nutri_b and nutri_c = nutritional score B and nutritional score C (relative to nutritional score A), eco_y = ecologically friendly production process (relative to standard production process), ngt_y = production process employing NGTs (relative to conventional production process without NGTs). Reference group for gender: man; for age: 18-34 years; for education: primary education.
Note2: *** significant at 1% level, ** significant at 5% level, * significant at 10% level
Source: own processing

The willingness to pay estimates in Table 7 show that women are willing to pay less for an NGT product than men, this result is statistically significant in Denmark and the United Kingdom. In all countries, it was confirmed that the older the consumers, the less they are willing to pay for an NGT product. On the contrary, education had no significant effect on the willingness to pay in any of the countries, except for secondary education in the United Kingdom.

Table 7. Willingness to pay with interaction terms

	DE	DK	FR	SR	UK
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
gender*ngt_y	0.000	-0.045***	-0.027	-0.002	-0.054**
age_35_49*ngt_y	-0.057*	-0.027	-0.090***	-0.090**	0.025
age_50_64*ngt_y	-0.079**	-0.048**	-0.088**	-0.130***	-0.057*
age_65_over*ngt_y	-0.121***	-0.080***	-0.138***	-0.156***	-0.064**
edu_secondary*ngt_y	-0.021	0.000	-0.023	0.024	-0.066**
edu_university*ngt_y	-0.030	0.003	-0.011	-0.025	-0.019
nutri_b	-0.284***	-0.129***	-0.244***	-0.210***	-0.244***
nutri_c	-0.671***	-0.277***	-0.638***	-0.514***	-0.587***
eco_y	0.132***	0.059***	0.119***	0.026	0.135***
ngt_y	-0.037	-0.004	-0.034	-0.095*	0.010

Note1: nutri_b and nutri_c = nutritional score B and nutritional score C (relative to nutritional score A), eco_y = ecologically friendly production process (relative to standard production process), ngt_y = production process employing NGTs (relative to conventional production process without NGTs). Reference group for gender: man; for age: 18-34 years; for education: primary education.
Note2: *** significant at 1% level, ** significant at 5% level, * significant at 10% level
Source: own processing

4 Conclusion

From the consumer survey results it follows that consumers are not sufficiently aware of NGTs. Approximately half of the population never heard the term NGT with differences across the surveyed countries, age groups, gender and the level of education achieved by consumers. Furthermore, consumers are significantly less aware of the NGTs than of GMOs.

Men, younger individuals, and more educated consumers tend to be more aware of NGTs than women, older individuals, or those with lower levels of education but the relationship between the various segments of population and the awarness of NGTs are nuanced and not linear.

The results of the discrete choice experiment show that consumers require a price discount to buy a product (yoghurt) produced by NGTs relative to identical conventional (non-NGT) product. Similarly consumers require price discount for products with lower nutritional score relative to identical product with higher nutritional score. On the other hand, consumers are willing to pay a higher price for products that are friendly to the environment in production methods and in the use of ingredients. Discounts and premia differ among the countries as expected.

The results of discrete choice experiment indicate that women in Denmark and the United Kingdom have significantly lower preference for an NGT-derived yoghurt than men. That is women in these countries are willing to pay significantly less for NGT product than men.

However, in Germany, France and Slovakia there are no statistically significant differences between willingness to pay for NGT foods of men and women.

Older individuals are willing to pay less for food produced using NGTs than the reference group of people between 18 and 34 years of age. The older are the respondents, the less they prefer to buy NGT-derived foods.

Education does not affect significantly the willingness to pay for NGT-derived food – yoghurt, except for some minor exceptions, like secondary education in the United Kingdom.

In conclusion, NGTs have a significant potential to improve competitiveness and sustainability of the EU agriculture but there is a need to overcome low awarness of NGTs and insufficient social acceptability by consumers and the public, which is reflected in lower willingness to pay for NGT based foods than for similar conventional foods.

Data availability
The data used for the study is confidential and the authors do not have the permission to share the data collected in the survey.

Disclosure of interest
The authors report there are no competing interests to declare.

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Appendix 1

Mixed logit model – estimation results (random price)

	DE	**DK**	**FR**	**SR**	**UK**
Mean	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
asc	7.388***	10.179***	7.451***	7.509***	7.880***
price	-3.482***	-6.584***	-3.396***	-3.344***	-3.617***
nutri_b	-0.903***	-0.685***	-0.748***	-0.613***	-0.772***
nutri_c	-2.069***	-1.406***	-1.902***	-1.491***	-1.773***
eco_y	0.456***	0.436***	0.402***	0.142***	0.470***
ngt_y	-0.348***	-0.230***	-0.392***	-0.495***	-0.169***
SD					
price	3.021***	4.133***	3.121***	3.300***	3.561***
nutri_b	0.860***	0.431***	0.464***	0.081	-0.484***
nutri_c	1.910***	1.424***	1.646***	1.292***	1.737***
eco_y	1.167***	-0.764***	0.850***	0.992***	1.046***
ngt_y	0.538***	0.328***	0.577***	1.033***	0.149
Number of obs	**27000**	**27000**	**27000**	**27000**	**27000**
Log likelihood	2581.050	3558.280	2354.440	2848.750	2891.120
LR chi^2	-6749.273	-6820.136	-6722.699	-6838.657	-6624.200
Prob > chi^2	0.000	0.000	0.000	0.000	0.000

Note1: nutri_b and nutri_c = nutritional score B and nutritional score C (relative to nutritional score A), eco_y = ecologically friendly production process (relative to standard production process), ngt_y = production process employing NGTs (relative to conventional production process without NGTs), asc = constant term
Note2: *** significant at 1% level, ** significant at 5% level, * significant at 10% level
Source: own processing

Mixed logit model with interaction terms (random price)

	DE	**DK**	**FR**	**SR**	**UK**
Mean	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
gender*ngt_y	0.032	-0.176***	-0.099	0.005	-0.166***
age_35_49*ngt_y	-0.151	-0.041	-0.259***	-0.186	0.045
age_50_64*ngt_y	-0.168	-0.092	-0.239**	-0.242*	-0.009
age_65_over*ngt_y	-0.169	-0.146	-0.336***	-0.383***	-0.029
edu_secondary*ngt_y	-0.060	-0.045	-0.130	0.057	-0.130*
edu_university*ngt_y	-0.102	-0.076	-0.122	-0.199	-0.033
asc	7.385***	10.196***	7.463	7.514***	7.874***
price	-3.479***	-6.667***	-3.380	-3.346***	-3.611***
nutri_b	-0.903***	-0.688***	-0.746	-0.614***	-0.772***
nutri_c	-2.072***	-1.411***	-1.908	-1.492***	-1.773***
eco_y	0.456***	0.429***	0.405	0.142***	0.469***
ngt_y	-0.182	-0.040	-0.043	-0.288*	-0.034
SD					

price	3.018***	4.173***	3.130***	3.302***	3.542***
nutri_b	0.861***	0.445***	-0.460***	0.074	-0.485***
nutri_c	1.910***	1.436***	1.641***	1.291***	1.738***
eco_y	1.167***	0.776***	0.857***	0.992***	1.047***
ngt_y	0.530***	0.311***	0.561***	1.023***	0.114
Number of obs	**27000**	**27000**	**27000**	**27000**	**27000**
Log likelihood	2568.610	3525.72	2350.120	2836.740	2860.700
LR chi^2	-6746.461	-6812.612	-6714.517	-6831.456	-6617.354
Prob > chi^2	0.000	0.000	0.000	0.000	0.000

Note1: nutri_b and nutri_c = nutritional score B and nutritional score C (relative to nutritional score A), eco_y = ecologically friendly production process (relative to standard production process), ngt_y = production process employing NGTs (relative to conventional production process without NGTs). Reference group for gender: man; for age: 18-34 years; for education: primary education.
Note2: *** significant at 1% level, ** significant at 5% level, * significant at 10% level
Source: own processing

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Farmers willingness to produce NGT crops

RESEARCH ARTICLE

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Abstract

This paper explores the acceptance of New Genomic Techniques in agriculture, with a focus on Slovak farmers. As the European Commission proposed a revised legal framework to distinguish New Genomic Techniques from genetically modified organisms, understanding stakeholder views is crucial for informed policymaking. Our research integrates a representative survey of farmers and a discrete choice experiment used to estimate a willingness to adopt crop varieties derived by New Genomic Techniques in Slovakia. The results show that farmers value agronomic traits like yield and stress tolerance but are cautious about crops derived by New Genomic Techniques, often requiring a price premium.

Keywords: discrete choice experiment, New Genomic Techniques, willingness to sell
JEL codes: Q01, Q16, Q18

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1. Introduction

New Genomic Techniques (NGTs) can be an important tool to enhance food security in the European Union (EU) and globally while improving the impact of agriculture and food supply chains on climate, biodiversity, and natural resources. By increasing food production without requiring expansion of agricultural land and other inputs, NGTs can contribute to a more sustainable, efficient, and secure food supply chain capable of meeting future nutritional demands while minimizing environmental pressures (EC, 2021; FAO, 2022).

In the EU, NGTs are defined as techniques capable to change the genetic material of an organism and that have emerged or have been developed since 2001 (EC, 2021). New Genomic Techniques differ from old genetic modification methods resulting in Genetically Modified Organisms (GMO). While GMO typically involve the insertion of foreign DNA from unrelated species, NGTs allow targeted and precise changes within an organism's own genome (Eckerstorfer *et al.*, 2019) without transferring genes between species that cannot multiply in nature. NGTs enable the development of plant varieties that could also arise through natural mutations or conventional breeding but with greater speed and accuracy.

NGTs have sparked not only scientific and economic interest but also debate on the suitability of the existing EU regulatory framework, social acceptance of NGTs by consumers and the public and willingness of farmers and whole food supply chains to invest into production of NGT crops (EC, 2021).

This paper contributes to the debate on NGTs by examining farmers' perceptions and willingness to cultivate crops developed through NGTs, focusing on Slovakia. Farmers' willingness to invest into production of NGT crops is crucial for development and growth of NGT production in the EU and globally, thus enabling the EU to obtain benefits from development and implementation of NGT technology. The study uses a survey-based discrete choice experiment (DCE) to obtain farmers' preferences for attributes of crop varieties developed using new genomic techniques. DCE based on survey data is well suited for this study because it allows for controlled variation of individual crop traits and allows for estimation of the trade-offs that farmers make between them. Such information on attribute-level preferences cannot be obtained from observational market data, even if NGT crops are already commercially available, because their real-world adoption is affected by multiple confounding factors.

Gaining a deeper understanding of how farmers perceive NGTs, the factors that shape their attitudes, and the specific conditions under which they would consider adopting crops edited by NGTs is crucial for effective agricultural policy. Therefore, we focused on farmers' acceptance of NGTs and their willingness to produce wheat that was modified with NGTs.

Research on farmers' attitudes towards NGT or even GMO has not been on a rapid pace compared with that on consumers (Agnoli *et al.*, 2025; Chatzopoulou and Chatzopoulos, 2024). There are only a few recent papers investigating farmers' attitudes towards NGT crops in Europe and there are no papers on farmers' attitudes towards NGT crops in the Central and East European Countries. Furthermore, to our knowledge, there are no papers quantifying farmers' willingness to adopt NGT crops. This is a significant gap in the literature given recent rapid development of biotechnology in general and specifically NGTs. Farmers' willingness to adopt NGTs might be crucial for the growth of the NGT-based agricultural production and competitiveness of agricultural sectors as well as for the implementation of NGT methods at both EU and national levels.

The paper is organized as follows. The next section provides a brief literature review on NGT crop traits, NGT legislative framework in the EU, and adoption of NGTs and GMOs. The subsequent section describes our methodology and data. The final section summarizes and concludes.

2. Literature review

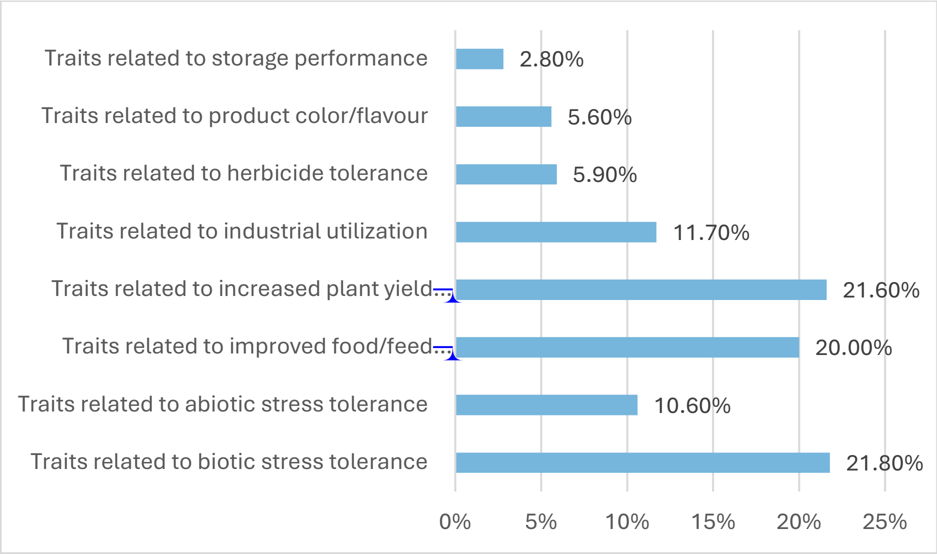
NGTs facilitate the development of crop varieties with increased resilience to abiotic stresses such as drought, heat, and salinity and enhance resistance of crops to pests and diseases, reducing reliance on chemical pesticides and contributing to more sustainable crop protection strategies (Lim *et al.*, 2022; Muha-Ud-Din *et al.* 2024; Ogata *et al.*, 2020; Ricroch and Henard-Damave, 2016). NGT-derived crops can also reduce input requirements (e.g. water, fertilizers or plant protection products), thereby lowering agriculture's environmental footprint (Figure 1).

A study by Sundström *et al.* (2024) evaluated the potential of genome editing methods such as CRISPR/Cas9 to reduce pesticide dependency in European agriculture. Their findings revealed that genome-edited wheat varieties resistant to fungal infections could save farmers up to €70 million in pesticide costs. Furthermore, a genome-edited potato variety with resistance to late blight could reduce pesticide applications by more than 80%, significantly benefiting both farmers and ecosystems (Sundström *et al.*, 2024).

By applying NGTs to edit specific genes in crops like tomatoes, researchers have developed varieties with longer shelf lives, which reduces post-harvest losses and food waste throughout the supply chain. This not only provides higher quality products to consumers but also enhances the overall efficiency of the food supply system (Dal Bello *et al.*, 2024).

NGTs can be instrumental in enhancing the nutritional content of crops. Through precise gene editing, biofortification efforts have led to the development of crops with higher nutrient levels, e.g. higher vitamin A content in rice. This addresses nutritional deficiencies in populations that rely heavily on staple crops (Chen *et al.*, 2019; Zhang *et al.*, 2018). Similarly, genome editing has been used to reduce the presence of harmful substances in food products, such as allergens and toxins, thus improving food safety (Alam and Rustgi, 2025).

In the long-run, NGT crops have a potential to increase productivity and competitiveness of agriculture provided international trade with NGT crops does not face tariff or non-tariff barriers. According to the European Commission's impact assessment, the deregulation of certain NGT crops is essential to ensure the global competitiveness of EU farms (EC, 2023a).



AQ 1

Figure 1. Traits of developed NGT-based crops. Source: EU-SAGE (2025).

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Despite their potential, NGT-derived products are not yet cultivated or commercially available in the EU due to regulatory constraints. EU legislation classifies NGTs as genetically modified organisms (GMOs), which are in the EU strictly regulated, creating barriers for agricultural innovation and investment. In 2023, the European Commission proposed revised legislation that distinguishes some NGTs from GM techniques, aligning EU policy more closely with major trade partners (EC, 2023b). The proposed legislation allows for the use of specific NGTs (e.g., targeted mutagenesis and cisgenesis) but continues to regulate transgenic organisms under existing GMO laws. The reforms aim to establish a science-based framework that facilitates the development and commercialization of NGT crops in the EU and enabling farmers and other food supply chain actors to reap benefits of new technology.

The European Parliament passed the EU's NGT legislation proposed by the Commission in 2024 and the Council approved it later in 2025. Recently a trialogue negotiation between the Commission, the Council and the European Parliament took place to finalize the regulation and accommodate the requirements of the three EU decision-making bodies, which was completed in the end of 2025.

Decision of farmers to adopt innovative technology like NGT is the final step of the technology diffusion process consisting of awareness, interest, evaluation, trial, and adoption (Rogers, 1962). Innovation is defined as a technological factor that changes the production function and regarding which there exists some uncertainty, whether perceived or objective (or both) (Feder and Umali, 1993). In case of NGTs the uncertainty consists of regulatory uncertainty, unstable social acceptability of NGTs by consumers and the public, uncertain prices of inputs and outputs relative to non-NGT production and other economic, social, and environmental factors.

In the past, the Green Revolution brought high yielding varieties of crops that were superior to traditional varieties both technically and economically. These varieties were adopted at exceptional rates. At that time, the adoption rates were influenced by a complex interaction of factors like size of the farm, access to credit, tenure arrangements, risk and uncertainty, human capital, sociological factors, access to inputs, infrastructure and markets (Antle, 1987; Binswanger, 1980; Dillon and Scandizzo, 1978; Feder and O'Mara, 1981; Feder *et al.*, 1985; Ruttan, 1977).

The adoption of NGT or GMO crop varieties is trickier than the adoption of high yielding varieties of crops. GM techniques and NGTs are viewed as controversial by some consumers or stakeholders and their social acceptance cannot be taken for granted. Low social acceptance limits research and investments and lowers the potential benefits of NGT supply chains for contributing to food security and environmental sustainability. Inadequate acceptance of GM products in the 1990s was one of the major factors preventing the introduction and growth of GMOs in the EU and other countries (Qaim, 2020). Social acceptance by consumers and relevant supply chain actors is the prerequisite for a successful introduction and market growth of NGT-derived products (Beghin and Gustafson, 2021).

With respect to GM technology adoption, studies show that economic, social, and environmental factors are the main drivers of farmers' willingness to grow GM crops (Breustedt *et al.*, 2008; Dill *et al.*, 2008; Finger *et al.*, 2011; Marra *et al.*, 2002; Qaim, 2009; Qaim and Traxler, 2005).

Key economic parameters influencing willingness to adopt genetically modified herbicide tolerant crop are the reduction of the costs of pesticide, labour and machinery inputs and time savings in crop management (Brookes and Barfoot, 2018; Bullock and Nitsi, 2001; Carpenter and Gianessi, 1999; Fernandez-Cornejo *et al.*, 2002; Qaim and de Janvry, 2005). Environmental benefits such as substitution of harmful herbicides with less harmful ones was also a reason for adoption of GM crops by farmers (Brookes and Barfoot, 2018; Devos *et al.*, 2008; Nelson and Bullock, 2003; Smyth *et al.*, 2011; Wolfenbarger and Phifer, 2000). Furthermore, personal and farm characteristics played an important role when deciding on adoption of GM crops too (Breustedt *et al.*, 2008; Fernandez-Cornejo *et al.*, 2005; Läpple and Van Rensburg, 2011; Qaim, 2009).

In the past, GMOs have faced resistance from consumers and the public in the European Union, largely due to concerns regarding health and environmental safety, ethical considerations, and the dominance of large multinational corporations in seed markets (Gaskell *et al.*, 2010). This resistance has contributed to a strict regulatory environment and limited adoption of GMO crops in the EU.

By contrast, NGTs appear to be receiving more favourable attention from both the public and policymakers. Their similarity to conventional breeding outcomes and alignment with sustainability goals position them as a potentially more acceptable alternative than GMOs (Pokrivcak *et al.*, 2024, 2026). Furthermore, the European Food Safety Authority states that the risk profile of NGT crops is comparable to that of conventional crops (EFSA, 2021, 2022).

There is a limited number of scientific papers on the farmers' willingness to adopt NGT-based commodities. The existing papers use mainly questionnaire data, information from focus groups discussions or from semi-structured interviews.

Agnoli *et al.* (2025) examined how European wine producers perceive NGTs using qualitative semi-structured interviews conducted in six major wine-producing countries in the EU. Wine producers recognize the potential of NGTs to optimize resource management, enhance climate resilience, and reduce production costs. However, ethical concerns, low consumer acceptance, fear of new technologies, and legislative uncertainties are significant obstacles to be overcome. According to Ferrari (2022) familiarity with CRISPR NGT technology and stronger perceptions of agronomic benefits increase farmers' willingness to adopt gene-edited rice, while uncertainty and perceived risks act as barriers. The study highlights the importance of information and awareness in shaping adoption-related intentions.

Based on a survey of U.S. dairy farmers, Ufer *et al.* (2022) concludes that profitability is a necessary but insufficient condition for adoption, as moral concerns and perceived public acceptance strongly shape farmers' willingness to adopt gene-edited livestock technologies. Kato-Nitta *et al.* (2019) examine how increased scientific knowledge affects acceptance of gene-edited crops relative to conventional GMOs in Japan. The study shows that respondents with agricultural backgrounds, including producers, tend to evaluate gene-edited crops more favourably than transgenic GMOs, particularly when no foreign DNA is involved.

Chatzopoulou and Chatzopoulos (2024) based on primary survey data, demonstrate that farmers' perceptions towards potential risks using GE methods and GMOs differ among types of producers within a country and between the countries. These differences in perceptions are attributed to socio-economic characteristics, sectoral organisation, trust in suppliers, and the social environment within which farmers operate in rural areas. Menary and Fuller (2024) conducted semi-structured interviews with experts from a range of agri-food stakeholder groups in the European Union and United Kingdom to understand current attitudes towards new biotechnology regulation.

Kang *et al.* (2022) survey 111 Chinese seed companies and quantify managers' willingness to adopt and sell gene-edited seeds. They also analyse determinants of support and investment using econometric models: larger firms and firms with more highly educated researchers are supportive, and prior GM investment and collaboration with public institutions increase the probability of R&D investment in gene editing.

Abbey *et al.* (2025) represent one of the few studies that explicitly apply a discrete choice experiment to analyse producers' preferences for gene editing relative to genetic modification. The results show that growers generally prefer gene-edited crops over genetically modified ones, but also identify a distinct segment of respondents who consistently reject all bioengineered options. The study demonstrates the usefulness of DCEs for quantifying trade-offs and willingness to pay related to NGT adoption at the producer level.

3. Material and methods

We have conducted a representative survey among farmers in Slovakia. The survey gathered data on farm characteristics, familiarity of farmers with NGTs, attitudes toward NGTs and conventional breeding, and demographic characteristics of respondents. Attitudes toward NGTs and conventional breeding were measured using a three-point scale (negative, neutral, positive). The survey was conducted online from January to March 2025 by an external commercial company that has significant expertise in primary data collection. This company has been conducting annual representative survey among farmers for the Ministry of Agriculture and Rural Development of Slovakia. The sample was 202 respondents. The sample is representative with respect to types of farms, size of farms, gender, age, and education of the primary decision-maker on the farm, and with respect to the geographical location of farms. Pilot survey was conducted in 2024 with 10 representative respondents.

To estimate willingness to produce NGT crops by farmers we used discrete choice experiment.

3.1 Discrete Choice Experiment

We have employed a Discrete Choice Experiment (DCE) to simulate real-world scenarios involving the selection of crop varieties with different traits: including selling price of produced crop, yield, stress tolerance, and NGT labelling. The essence of discrete choice experiment is that each participant makes decisions in which he/she chooses from different alternatives, considering individual characteristics used to compare alternatives (attributes) and attribute levels (Louviere *et al.*, 2000; Ryan *et al.*, 2008). Respondents weigh all attributes and attributes' levels simultaneously in making their judgments.

Product attributes presented to respondents were selected based on a literature review and brainstorming with farmers in the form of a focus group discussion. The attributes considered in the experiment include:

(1) Selling price: Based on the current market data for Slovakia, the price at which the harvested wheat will be sold, with four possible levels: €160, 180, 200 and 220 per tonne. The selling price, as one of the attributes, will allow us to calculate the willingness to grow NGT-derived wheat.

(2) Yield: The expected yield, expressed as a percentage of the average yield for winter wheat in Slovakia (5.30 t/ha). The yield can vary between 85%, 95%, 105% and 115% of this average (4.50, 5.03, 5.57, 6.10 t/ha). Numerous studies show that NGTs allow higher yields to be achieved (Lemmon *et al.*, 2018; Muha-Ud-Din *et al.* 2024; Zsögön *et al.*, 2018) and it is an important attribute of NGT derived crops.

(3) Tolerance to drought, diseases, and pests: This refers to the plant's ability to resist environmental challenges, diseases, and pests. Respondents will choose between wheat varieties with either high or low tolerance to these factors. Tolerance to drought, diseases, and pests has been confirmed to be an important crop trait being enhanced in various species (Lim *et al.*, 2022; Muha-Ud-Din *et al.* 2024; Ogata *et al.*, 2020).

(4) NGT attribute: Indicates whether the crop seed has been modified using New Genomic Techniques or not.

Based on defined attributes and attribute levels, respondents were asked to choose one out of two fictional alternatives in repeated hypothetical choice situations. From these choices, we estimated utility parameters for each attribute and attribute level (Louviere and Woodworth, 1983).

The use of choice experiment is particularly relevant because it allows for the exploration of how farmers weigh the relevant attributes of wheat varieties including whether wheat seeds were NGT or non-NGT based. This approach enables the researcher to understand which attributes farmers prioritize and how much they are willing to trade-off between them. Our experimental design consisted of 9 choice tasks. D-efficient design was calculated to reduce the number of choice tasks required from respondents (using STATA's dcreate module developed by Hole (2015)).

3.2 Mixed Logit Model

Data collected in the DCE part of the survey were analysed using a random utility model. In this framework, farmers (denoted as '*n*') choose the alternative (denoted as '*i*') that provides the highest utility (U_{in}). The utility of each alternative is determined by an observable component (V_{in}) and an unobservable component (ε_{in}) (McFadden, 1974).

$$U_{in} = V_{in} + \varepsilon_{in} = x_{ik}\beta_{kn} + \varepsilon_{in} \tag{1}$$

Here, x_{ik} is a vector of observed attributes of alternative *i*, namely: selling price of wheat, yield, tolerance to drought, diseases and pests, and an indicator for whether the variety is developed using NGTs. The corresponding parameters β_{kn} represent the marginal utilities that farmer *n* assigns to each attribute. Respondents select the alternative over other alternatives if it yields the maximum utility for them. The relationship between the utility function and the observed attributes of the alternatives can be approximated using a linear-in-parameter function (Louviere *et al.*, 2011). Consequently, respondents' utility is associated with the attributes and attribute levels within the choice sets.

Specifically, we have used the Mixed Logit (MXL) model to evaluate the DCE data. MXL models allow attribute coefficients to vary across respondents, accounting for preference heterogeneity and thus improving model realism. Additionally, MXL models adjust the standard errors of utility estimates to account for repeated choices by the same individual (Ryan *et al.*, 2008).

All attribute variables used in the mixed logit models were specified as random variables except for the price and constant variable specified as fixed. First, we have estimated a main effects model, which includes only the core product attributes presented in the choice sets. To explore how preferences vary across different subgroups of participants, we have employed extended models with interaction terms, where selected attributes interact with respondent characteristics, farm characteristics or awareness about NGTs.

3.3 Willingness to produce NGT crops

Once the parameter estimates are estimated, a monetary compensating surplus welfare measure that conforms to demand theory can be derived for each attribute.

To calculate the willingness to produce NGT crops from a mixed logit model we use the ratio of coefficients reflecting the willingness to sell (WTS) NGT production.

$$\text{WTS} = -\frac{\beta\_\text{attribute}}{\beta\_\text{price}} \tag{2}$$

where the coefficients are obtained directly from the mixed logit utility function specified in Equation (1). In this specification, each attribute in the vector x_{ik} (including selling price, yield, tolerance, and the NGT attribute) has an associated parameter in β_{kn}. The term β_price therefore corresponds to the estimated coefficient of the selling price attribute, while β_attribute refers to the estimated coefficient of the specific attribute for which willingness to sell is calculated (e.g. NGT attribute).

This formula assumes that the utility function is linear in parameters and that the price coefficient is positive, as higher selling prices increase farmers' utility. The negative sign in the formula ensures that WTS is interpreted correctly: if an attribute (e.g., NGT labelling) decreases utility, the WTS will be positive, indicating the need for a higher selling price to compensate for that undesired trait.

Using this approach, the discrete choice experiment data can be used to estimate the monetary value farmers assign to different crop attributes and their combinations. This enables the evaluation of policy scenarios or market offers by comparing the utility of specific attribute bundles to the baseline (status quo). Multiple WTS estimates can be calculated based on varying levels of the attributes (Bennett and Blamey, 2001).

Both the main effects model and the interaction models were used to estimate WTS, providing insights not only into average monetary valuations but also into how these valuations differ by respondent or farm characteristics. This method builds on standard willingness to pay (WTP) approaches but is adapted to reflect the perspective of potential sellers, such as farmers, making decisions about adopting innovations like NGTs.

3.4 Sample characteristics

In terms of gender, most respondents were males (72.3%), with females accounting for 27.7%. The respondents included farm executives (34.2%), farm agronomists, zootechnicians, or economists (27.7%), farm owners (19.3%,) and members of farm management teams (18.8%). All respondents are directly involved in strategic decision-making at farms. While no respondents reported having no education or only primary education, 25.7% had completed secondary education, and a substantial 74.3% had obtained university-level education. The largest age group was 50–64 years (40.6%), followed by 35–49 years (33.7%), which together account for nearly three-quarters of the sample. Respondents aged 65 and above represented 13.9%, showing that a significant share of farm professionals remain active beyond typical retirement age. By contrast, only 11.9% of participants were aged 18–34, highlighting the ongoing challenge of generational renewal in the agricultural sector in Slovakia.

The average revenue of farms in the sample for year 2023 was approximately €1 444 311, whereas the median was substantially lower, at €683 947. On average, 46.70% of revenues came from crop production, 25.43% from animal production, and the remaining 6.33% from other types of production. This also reflects the focus of the farms (Figure 2). 76% of sampled farms concentrate on production of cereals and oilseeds. Dairy cattle and beef cattle production were the second and third most common specializations, reported

AQ 2

Table 1. Characteristics of respondents

Gender	
Male	72.3%
Female	27.7%
Level of education	
No education	0%
Primary education	0%
Secondary education	25.7%
University education	74.3%
Position on the farm	
Farm owner	19.3%
Farm executive	34.2%
Member of management	18.8%
Other (agronomist, zootechnician, economist,…)	27.7%
Age category	
18–34	11.9%
35–49	33.7%
50–64	40.6%
65+	13.9%

Source: own processing, 2025

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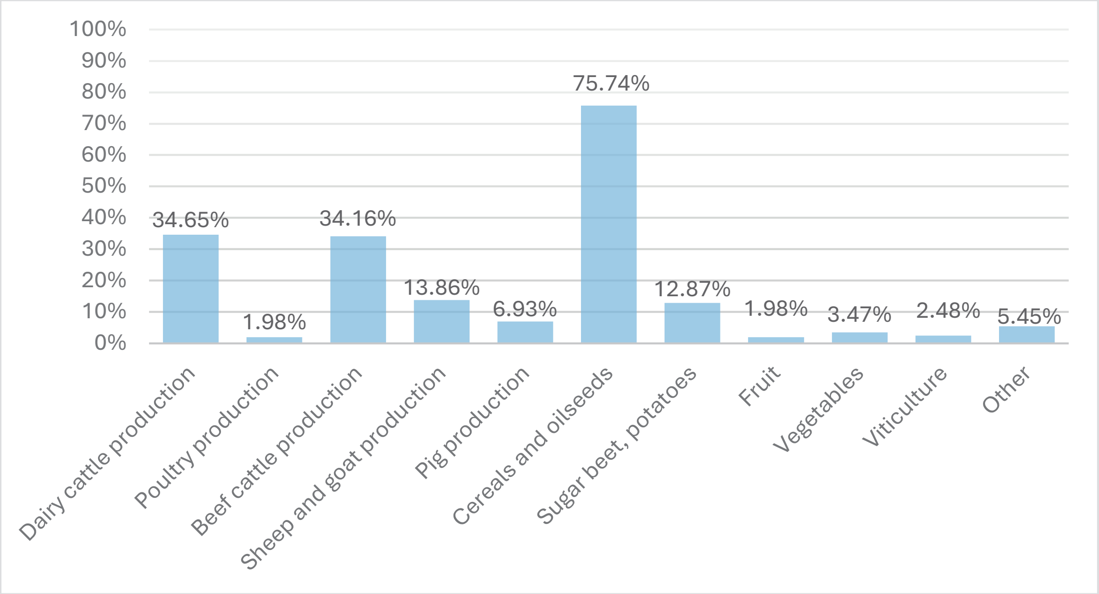

Figure 2. Predominant agricultural activities. Source: own processing, 2025.

by 35% and 34% of farms, respectively. Sheep and goat production accounted for 14%, and pig production for 7% of farms. Sugar beet and potato cultivation was reported as a key activity by 13% of respondents. The lower shares were recorded for vegetable production (3%), fruit production (2%), poultry production (2%), and viticulture (2%). Of all sampled farms 18.8% have organic production and 16.9% farms process their products.

4. Results

To determine the level of awareness about NGTs, we first asked respondents if they had ever heard of NGTs and GMOs. 3.47% of respondents stated they had never heard of GMOs and 37.13% had never heard of NGTs. 66.34% of respondents heard of GMOs but know little about them, while 55.45% respondents heard of NGTs but know little about them. There is ex ante a considerable knowledge gap, particularly concerning NGTs (Figure 3). Awareness of NGTs among farmers was significantly lower than for GMOs, which is consistent with the literature that both farmers' and consumers' awareness of NGTs is low and both consumers' and producers' awareness of NGTs is lower than of GMO (Chatzopoulou and Chatzopoulos, 2024; Kang *et al.*, 2022; Kato-Nitta *et al.* 2019, among others).

Since some respondents had never heard of NGTs and others had heard of them but knew little about them, we provided the respondents with an unbiased science-based explanatory text that provided basic information about NGTs. After reading a short explanatory text on NGTs respondents were asked whether they understood what NGTs offer relative to conventional plant breeding techniques. 38.61% of respondents indicated that they had understood, 51.98% of respondents partially understood, and 9.41% of participants indicated that they did not understand the improvement related to NGTs s at all.

Figure 4 illustrates the distribution of respondents' attitudes toward conventional breeding and NGTs. A very small proportion of respondents has a negative attitude toward conventional breeding and 9.41% toward NGTs. Among those with a neutral attitude, a larger share, 59.41%, shows neutral opinion toward NGTs and 29.70% toward conventional breeding. By contrast, the positive attitude group strongly favours conventional breeding (69.31%), while 31.19% express a positive opinion about NGTs. This is overwhelmingly supported by the existing empirical literature. Provision of unbiased and scientific information to farmers is crucial for the development and growth of NGT-based crop production (Abbey *et al.* 2025).

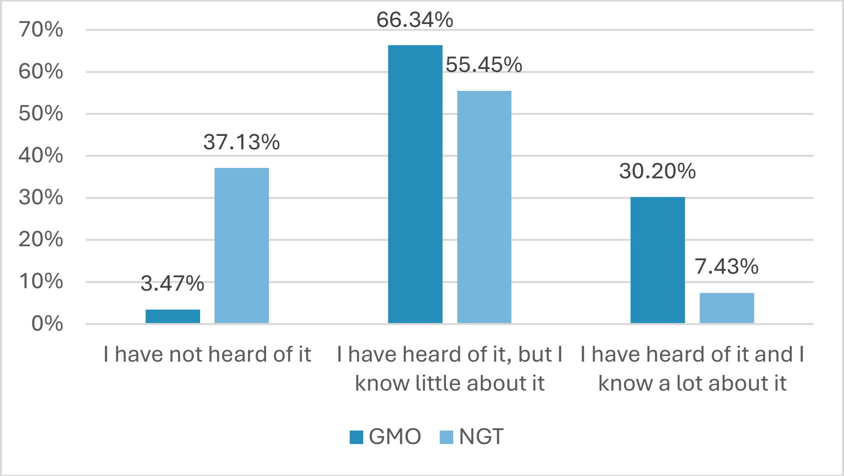

Figure 3. Awareness of GMO and NGT. Source: own processing, 2025.

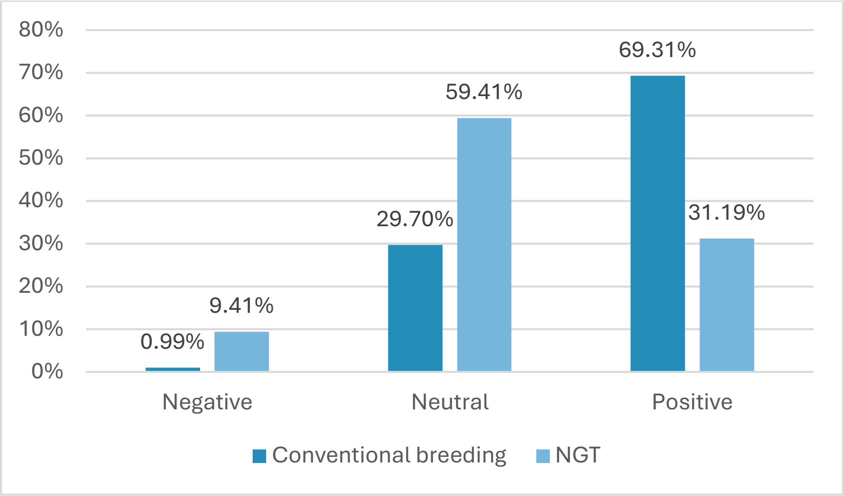

Figure 4. Attitude toward conventional breeding and NGT. Source: own processing, 2025.

A mixed logit model was used to analyse data from the discrete choice experiment. The estimated model account for preference heterogeneity among respondents by allowing coefficients to vary across individuals. This flexibility makes it suitable for modelling complex decision-making processes, such as farmers' choices regarding the adoption and supply of crops developed using NGTs. The model estimates the relative importance of different product attributes and quantifies the willingness to supply under various conditions. The results provide insights into how different factors influence farmers' preferences and help identify segments with distinct attitudes toward NGTs.

Table 2 presents the results of the baseline mixed logit model without interaction terms. The model includes main attributes such as selling price of the crop, yield levels, stress tolerance, and whether the variety was labelled as derived from new genomic techniques. The analysis is based on 3636 observations, representing all the choices made by respondents across the full set of experimental tasks. The model estimates both mean coefficients reflecting average preferences and standard deviations capturing heterogeneity in preferences across individuals.

Table 2. MXL: main effects model

Attribute	Coefficient	SE	*z*-value	*p*-value	95% CI
Price	0.013	0.002	6.890	0.000	[0.009, 0.017]
Yield: 5.03 t/ha	0.518	0.114	4.560	0.000	[0.295, 0.741]
Yield: 5.57 t/ha	1.143	0.123	9.300	0.000	[0.902, 1.384]
Yield: 6.10 t/ha	1.903	0.173	11.010	0.000	[1.564, 2.242]
Stress tolerance	1.038	0.117	8.840	0.000	[0.808, 1.268]
NGT	–0.870	0.138	–6.300	0.000	[–1.141, –0.600]
Constant	0.122	0.076	1.610	0.107	[–0.026, 0.271]
SD					
Yield: 5.03 t/ha	–0.005	0.154	–0.030	0.976	[–0.307, 0.298]
Yield: 5.57 t/ha	–0.002	0.205	–0.010	0.992	[–0.405, 0.401]
Yield: 6.10 t/ha	1.065	0.205	5.200	0.000	[0.663, 1.466]
Stress tolerance	1.112	0.128	8.680	0.000	[0.861, 1.364]
NGT	1.428	0.153	9.360	0.000	[1.129, 1.728]
Number of observations	3636				
LR $\chi^2(5)$	166.34				
Log likelihood	–933.118				
Prob>χ^2	0.000				

Reference group for yield: 4.50 t/ha; stress tolerance, high stress tolerance relative to low; NGT, production process employing NGTs (relative to conventional production process without NGTs). Source: own processing, 2025.

All attributes are statistically significant at the 1% level, except for the constant term. The coefficient for the selling price of the grown commodity is positive (β=0.013, $p<0.001$) indicating that farmers prefer varieties associated with higher selling prices, as they increase revenue potential. This result aligns with economic rationality and confirms that the price farmers receive for their output is a strong driver of decision-making on adoption of new technology. Yield was modelled using three dummy variables relative to a reference level of 4.50 t/ha. All higher yield levels are highly significant and positively valued. The coefficients increase with yield reflecting a clear and strong preference for varieties with higher yields, which is consistent with farmers' economic incentives. The attribute of stress tolerance has a positive and significant coefficient (β=1.038, $p<0.001$), confirming that farmers value stress tolerant varieties that can better cope with environmental challenges. The coefficient for the NGT attribute is negative and statistically significant (β=–0.870, $p<0.001$) indicating that, on average, farmers are less likely to choose varieties labelled as developed with new genomic techniques relative to conventionally bred varieties, suggesting a degree of scepticism or risk aversion toward NGTs. The robustness of yield and stress tolerance as preferred attributes also mirrors the outcomes of numerous multi-country DCE models on GMOs (e.g., Lusk *et al.*, 2005). The standard deviation of the NGT attribute is high and significant suggesting substantial heterogeneity in how much different farmers value these attributes (e.g. preferences for NGT crops may vary considerably among individuals, while some strongly oppose them, others may be more neutral or even favourable).

We also expanded the basic model with sociodemographic characteristics, awareness, and opinions of conventional breeding and NGTs.

The first extended model (Table A1 in the Appendix) incorporated interaction terms between the NGT label and respondents' awareness of GMOs and NGTs, along with gender, education, and age. Despite including multiple interaction terms, none of the awareness-related interactions reached statistical significance. Respondents aware of GMOs or NGTs did not show significantly different responses to varieties derived by NGTs compared to those with no awareness. This suggests that awareness of biotechnologies alone may not substantially influence acceptance or rejection of NGT labelled crops. Similarly, interactions with gender, education, and age were not statistically significant, confirming that these sociodemographic factors do not meaningfully affect preferences for NGT labelled crops as was the case in other studies. Several factors may explain this result in the Slovak context. First, Slovak agriculture is characterized by a relatively homogeneous managerial structure. Farm management is predominantly male, and managers of large commercial farms typically have tertiary education. The structure of the Slovak farming sector is also reflected in the structure of survey sample, which gave us relatively small variation in respondents by gender, education and age characteristics. Second, most Slovak farms operate as large professional enterprises rather than family farms. Decision-making in these organizations is typically collective and institutionalized, involving management teams or stakeholder groups rather than relying solely on the preferences of an individual manager. Consequently, farm-level decisions do not necessarily reflect the personal traits of the decision-maker (such as gender, age, or education), but rather the shared organizational objectives, or economic priorities. Third, NGTs remain an emerging and relatively abstract issue in Slovakia. According to recent evidence, 93.7% of the general population have never heard of NGTs or have only very limited knowledge about them (Pokrivcak *et al.*, 2026). At this early stage, attitudes toward NGTs are likely to be influenced by broader public discourse and institutional trust rather than personal characteristics such as gender, education, or age.

The main effect of the NGT attribute itself became statistically insignificant (β=–0.931, p=0.231), likely due to the inclusion of many interaction terms which may dilute the statistical power. However, other attribute coefficients remained stable and highly significant, including the preference for higher price (β=0.013, p<0.001), the highest yield (6.10 t/ha: β=1.901, p<0.001), and stress tolerance (β=1.039, p<0.001), consistent with prior model. Importantly, the standard deviation for the NGT attribute (SD=1.383, p<0.001) remained significant, indicating persistent heterogeneity in farmers' views. This suggests that while awareness alone does not fully explain differences in acceptance, there is still considerable variation across individuals, likely influenced by unobserved beliefs, values, or experiences.

In the second extended model, we focused on verifying the influence of attitudes towards breeding techniques on the acceptance of NGTs. This model introduced interaction terms between the NGT label and respondents' attitudes toward conventional breeding and new genomic techniques. The aim was to test whether individual opinions about breeding methods influence farmers' acceptance of crop varieties derived by NGTs. The results show strong and statistically significant effects for these attitudinal variables. Respondents with a positive opinion of conventional breeding showed a significantly lower preference for NGT labelled varieties. Both interaction terms were statistically significant and negative: neutral opinion on conventional breeding (β=–1.704, p=0.024) and positive opinion on conventional breeding (β=–2.570, p<0.001), suggesting that positive view on conventional breeding is associated with stronger rejection of NGTs. By contrast, a neutral attitude toward NGTs was associated with a coefficient of 1.984 (p<0.001), and positive opinion on NGT with 3.351 (p<0.001). These findings indicate that favourable opinions about NGTs significantly enhance acceptance. The main effect of the NGT attribute becomes statistically insignificant (β=–1.158, p=0.119) indicating that the acceptance of NGTs is highly dependent on underlying attitudes. As in previous models, the yield and stress tolerance attributes remain highly significant, and their standard deviations suggest continued heterogeneity in preferences.

Table 3 presents the Willingness to Sell (WTS) estimates derived from the main effects mixed logit model, reflecting the monetary value that farmers are willing to give up or require when selecting crop varieties with specific attributes. Since the price variable in the model represents the selling price received by the farmer, negative coefficients indicate that farmers are willing to accept a lower selling price (i.e., reduced income per tonne) in exchange for a more favourable attribute. Conversely, positive coefficients imply that farmers would require a higher selling price to adopt a less preferred trait. Farmers were willing to accept €39.16 per tonne less for varieties with a yield of 5.03 t/ha compared to the reference level (4.50 t/ha), and this discount increases progressively with higher yield levels. This suggests that higher yield is strongly valued and that farmers are willing to trade off a lower unit price for a higher total output per hectare. Similarly, they were

Table 3. Willingness to sell: main effects model

Attribute	Coefficient	SE	*z*–value	*p*–value	95% CI
Yield: 5.03 t/ha	–39.162	10.450	–3.750	0.000	[–59.644, –18.680]
Yield: 5.57 t/ha	–86.338	16.316	–5.290	0.000	[–118.317, –54.359]
Yield: 6.10 t/ha	–143.762	25.267	–5.690	0.000	[–193.284, –94.240]
Stress tolerance	–78.423	13.034	–6.020	0.000	[–103.969, –52.876]
NGT	65.741	12.857	5.110	0.000	[40.541, 90.941]

Reference group for yield: 4.50 t/ha; stress tolerance, high stress tolerance relative to low; NGT, production process employing NGTs (relative to conventional production process without NGTs). Source: own processing, 2025.

willing to accept a €78.42 per tonne lower price for varieties with enhanced stress tolerance, indicating the importance of resilience in production. By contrast, the only positive WTS value was observed for the NGT attribute, with a coefficient of €65.74 per tonne, meaning that farmers would need to receive a higher price per tonne to choose an NGT variety over a conventional one. This reflects a general scepticism associated with new genomic techniques, with farmers requiring financial compensation to offset their concerns.

At the time of conducting farmers' survey (March 2025), the market price of wheat in Slovakia was approximately €207 per tonne. Our results indicate that farmers would, on average, require a price premium of about 31.76% to switch from conventional to NGT wheat, ceteris paribus. This premium likely reflects various risks and costs which are associated with NGT crops in the EU and globally. First. there is more uncertain demand for NGT wheat relative to the demand for conventional wheat, because of lower and uncertain social acceptance of NGTs. Second, NGT wheat is expected to involve higher production and administrative costs, such as costs of enhanced inspections, administration costs or tracing requirements for NGTs relative to conventional wheat. This required price premium seems like a significant constraint on the adoption of NGT wheat, but we must also consider the effects of NGTs on improved yields, better grain quality, and lower negative effects of biotic and abiotic stress factors on wheat production. Furthermore, the required premium is strongly time dependent. Expected increase of social acceptance and the reduction of regulatory uncertainty is likely to lead to lowering of required price premiums for NGT crops in the future.

Although not directly comparable, a meta-analysis of 286 WTA estimates for sustainable agricultural practices (Boufous *et al.*, 2023) found that farmers often require significant compensation for adopting unknown or sustainability-enhancing technologies in the form of either higher selling prices or lower production costs.

5. Conclusions

The findings of this paper attempt to contribute to the growing body of literature on the acceptance of New Genomic Techniques in agriculture. The questionnaire survey was conducted among 202 farms across Slovakia.

The Discrete Choice Experiment results indicate that Slovak farmers strongly favour attributes linked to economic and agronomic performance, such as higher selling price, higher yields and improved stress tolerance of crops. Our conclusion is analogous to research conducted in other European countries, USA, China, Japan and elsewhere (Agnoli *et al.* 2025; Ferrari, 2022; Kang *et al.*, 2022; Ufer *et al.*, 2022). These traits were consistently and positively valued across all model specifications, reflecting the practical priorities of producers operating in increasingly uncertain climatic and market conditions. By contrast, the attribute signalling whether a crop variety was developed using NGTs had a consistently negative effect on choice probability.

Farmers showed a strong willingness to accept lower selling prices for varieties offering agronomic advantages such as higher yield and improved stress tolerance. These results underscore the central importance of productivity and climate resilience in varietal selection. By contrast, the NGT attribute was generally associated with a requirement for a higher selling price, suggesting that, on average, farmers perceive NGT derived crops as less desirable and would need additional financial compensation to adopt them.

We acknowledge some limitations in the interpretation of paper results, which stem from the nature of the studied issue and the methodology we used. First, given the sample size of the questionnaire survey, the inclusion of multiple interaction terms in the extended model influenced the results of the statistical tests and the NGT attribute became insignificant in the extended model. Second, a significant portion of respondents (37.13%) had never heard of NGTs before the survey. We provided them with an explanatory text, but a single, short educational intervention during the survey may not fully capture how well-informed long-term attitudes would differ from immediate reactions.

To conclude, NGTs present both an opportunity and a challenge for European agriculture. Their successful adoption depends not only on technological efficacy but also on inclusive governance, regulatory foresight and stakeholder acceptance. There is a clear need for long-term research on consumer and farmer acceptance of NGT-derived products, particularly in the context of changing EU legislation. Future studies should investigate how attitudes evolve over time with increased exposure to NGTs, shifts in public discourse, and the rollout of pilot programs. From a policy perspective, it is crucial that EU and national regulatory bodies adopt a transparent and science-driven framework that reflects the diversity of genomic interventions and their associated risk profiles. To address prevailing scepticism and information gaps, tailored communication strategies must be developed that differentiate NGTs from traditional GMOs, emphasize their potential benefits for sustainability and climate resilience, and clarify regulatory measures. These campaigns should engage farmers, consumers, educators, and civil society through transparent, participatory formats.

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Appendix

Table A1. Extended MXL models with "awareness" and "attitudes" interaction terms

Attribute	Model with "awareness" terms		Model with "attitude" terms	
	Coefficient	*p*–value	Coefficient	*p*–value
Gender×NGT	–0.334	0.257	0.217	0.420
Education×NGT	0.263	0.382	0.268	0.320
Age 35–49×NGT	–0.111	0.799	0.001	0.997
Age 50–64×NGT	0.208	0.625	0.247	0.503
Age 65+×NGT	–0.267	0.605	0.068	0.881
GMO_aware_low×NGT	–0.089	0.905	–	–
GMO_aware_high×NGT	0.124	0.876	–	–
NGT_aware_low×NGT	–0.121	0.675	–	–
NGT_aware_high×NGT	0.548	0.346	–	–
Conv_neutral×NGT	–	–	–1.704	0.024
Conv_positive×NGT	–	–	–2.570	0.000
NGT_neutral×NGT	–	–	1.984	0.000
NGT_positive×NGT	–	–	3.351	0.000
Price	0.013	0.000	0.014	0.000
Yield: 5.03 t/ha	0.515	0.000	0.522	0.000
Yield: 5.57 t/ha	1.142	0.000	1.135	0.000
Yield: 6.10 t/ha	1.901	0.000	1.909	0.000
Stress tolerance	1.039	0.000	1.041	0.000
NGT	–0.931	0.231	–1.158	0.119
Constant	0.122	0.109	0.126	0.098
SD				
Yield: 5.03 t/ha	–0.005	0.975	–0.002	0.991
Yield: 5.57 t/ha	–0.002	0.993	–0.008	0.966
Yield: 6.10 t/ha	1.070	0.000	1.058	0.000
Stress tolerance	1.106	0.000	1.130	0.000
NGT	1.383	0.000	1.105	0.000
Number of observations	3,636		3,636	
LR $\chi^2(5)$	156.97		121.65	
Log likelihood	–929.273		–899.280	
Prob>χ^2	0.000		0.000	

Reference group for yield: 4.50 t/ha; stress tolerance, high stress tolerance relative to low; NGT, production process employing NGTs (relative to conventional production process without NGTs). Reference group for gender: man; for age: 18–34 years; for education: secondary education. GMO/NGT_aware_low and GMO/NGT_aware_high refer to low and high awareness of GMOs/NGTs relative to no awareness of GMOs/NGTs. Conv/NGT_neutral and Conv/NGT_positive represent neutral and positive attitudes of conventional breeding/NGTs relative to negative attitudes. Source: own processing, 2025.