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Drivers of genetically modified food acceptance in members of generations Z and Y: Insights from a theory of planned behavior framework

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A B S T R A C T

Genetically modified food (GMF), which emerged in the mid-1990s, have enabled the development of more affordable, sustainable products with enhanced characteristics compared to their conventional counterparts. However, their consumption in European Union countries such as Spain remains limited. This paper develops a model based on the theory of planned behavior to explain the behavioral intention (BI) to use GMF, considering perceived value (PV), perceived usefulness (PU), perceived risk (PR), food neophobia (NPH), social influence (SI), gender, and age. Subsequently, it is tested in a sample of zoomers (members of Generation Z) and millennials (members of the Generation Y). Structural equation modeling reveals that PV, PU, SI, and belonging to Generation Z (GENZ) have a significantly positive influence on BI, while PR has a negative impact. Additionally, quantile regressions confirm that PU and SI are the most influential variables, as they maintain a consistent positive impact in the analyzed quantiles. The influence of PV, PR, and GENZ also remained consistent in sign in all quantile regressions. However, while PV and PR showed significant coefficients in most percentiles, GENZ was significant only at the extremes of the BI range. In a nutshell, PU and SI are the strongest positive predictors of behavioral intention, while PR acts as a consistent deterrent. Members of generation Z show higher predisposition toward GMF acceptance, particularly at the extremes of BI. The results of the analysis have various practical implications for the successful implementation of GMF, which are discussed in this study.

1. Introduction

Genetically modified food (GMF) come from genetically modified organisms (GMOs), whose genetic material is altered beyond natural processes (WHO, 2014). GMOs in food production provide benefits like improved defense against insects and plant illnesses and harsh climates, thereby increasing agricultural productivity. They also improve the dietetic content of aliments by boosting fundamental components such as proteins and vitamins. Additionally, GMF extends the shelf life (Muringai et al., 2020). These advantages make GMF a promising solution to modern challenges including food shortages and climate change and contribute to a more efficient and resilient food system (Hingston & Noseworthy, 2018; Covino & Boccia, 2016).

Despite the benefits associated with GMF, their acceptance remains controversial among both governmental bodies and the general public, particularly within the European Union (EU), where opposition is notably strong (Borrello et al., 2021). The regulatory stance of EU on GMOs reflects a series of contradictions: while it restricts domestic cultivation for political or cultural reasons, it simultaneously imports large volumes of GMOs-derived products, such as transgenic soy used in animal feed. These policies often lack scientific grounding and appear to be shaped more by public sentiment than empirical evidence (Goodman,

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2024). Moreover, inconsistent labeling practices prevent consumers from fully understanding the prevalence of GMOs in the food system. Ironically, regulations intended to protect local environments displace environmental impacts to exporting countries. If this emotionally driven approach persists, the EU risks not only forgoing the potential of new technologies like gene editing but also contributing to global food insecurity, especially in regions that depend on genetically improved crops to ensure sustainable production (Defez, 2016).

The production of GMOs is not without uncertainty or potential drawbacks. Despite literature do not report relevant harmful influence due to its consumption (Vega Rodríguez et al., 2022), many people feel potential risks, because of unintended outcomes from genetic processes like possible generation of new toxins, or increased allergenicity of some foods (Popek & Halagarda, 2017). From an environmental perspective, problems seem more justified, with potential influence on biodiversity and the risk of genetic contamination (Gatew & Mengistu, 2019). Ideological and economic issues also arise, such as the possible concentration of the seed market in the hands of large corporations (Sutkovic et al., 2020) and the opposition of certain religious groups who consider genetic engineering an interference in the natural order (Montesinos-López et al., 2016). These perceptions may hinder the development of biotechnology in food production and reduce investment in research and innovation in this field (Beghin & Gustafson,2021).

Advancements in genetic processes at the end of 20th century and the beginning of the 21st century have enabled the development of more precise tools such as genetic editing techniques, including CRISPR technology (Kolkur et al., 2024). These techniques, improve the efficiency and results of traditional transgenic methods (Ray et al., 2023). As a result, public perception of GMF has evolved over the past 30 years. Although opposition to food biotechnology was very high in the European Union at the beginning of the 21st century, it has gradually declined over time (Bratlie et al., 2019). Nevertheless, a considerable level of resistance remains (Goodman, 2024).

The present study examines the factors influencing the behavioral intention (BI) of Spanish consumers from Generation Z (zoomers) and Generation Y (millennials) to try GMF in 2023. Although the acceptance of GMF has been widely studied—including some research conducted in Spain (see Costa-Font & Gil, 2009)—most recent studies are concentrated in America and Asia (Del-Aguila-Arcentales et al., 2025), particularly in the current context marked by the emergence of gene editing technologies (Goodman, 2024). In contrast, research within the European Union remains limited (Beghin & Gustafson, 2021), typically focused on countries like Italy and Germany (Del-Aguila-Arcentales et al., 2025), while studies specifically addressing the Spanish context are virtually nonexistent.

The study of perceptions about GMF needs a conceptual basis to systematize the study. This research adopts the psychological approach by Theory of Planned Behavior (TPB). TPB identifies three basic categories of variables to justify a person's predisposition perform a specific action. Following Ajzen (1991) they are attitude, perceived behavioral control, and subjective norm (Ajzen, 1991). This focus has been often employed in assessments on the acceptance of innovative foods (Ang & Anapi, 2024; Mosikyan et al., 2024; Saha et al., 2022). Fig. 1 shows the proposed model. This psychometric focus enables the capture and analysis of complex latent constructs such as attitudes, social norms, perceived risks, and food neophobia—factors that are fundamental to understanding the acceptance of GMF. This type of model, widely validated in research on behaviour in a great deal of settings, offers high explanatory power and can be easily replicated across different cultural contexts using standardized scales (Ajzen, 2011; Sirieix et al., 2013).

Attitude refers to an individual's evaluation of performing a particular behavior (Ajzen, 1991). In the context of biotechnological foods, this evaluation is shaped by perceptions related to health, price, sustainability, and ethical concerns (Dorce et al., 2021). In this study, these evaluative dimensions are operationalized through three constructs: perceived value, perceived benefits, and perceived risk. The first construct captures the advantages of GMF in terms of price-quality ratio (Alalwan et al., 2023), while the second measures the functional and environmental benefits of GMF (Prati et al., 2012). Perceived risk reflects the apprehensions or negative expectations associated with such products (Costa-Font et al., 2008; Jin et al., 2022).

The second component of the model is perceived behavioral control, which refers to individuals' beliefs about their capacity to engage in a given behavior, considering internal dispositions and external constraints (Ajzen, 1991). Here, food neophobia is included as a specific inhibitory factor: a predisposition to reject unfamiliar food products, including GMF, regardless of their actual properties or safety (Rabadán & Bernabéu, 2021). This aversion is often not directed at the food itself but at the biotechnological process behind its production, even when the end product resembles conventional food items (Faccio & Guiotto Nai Fovino, 2019).

The third pillar of the model is social influence—also termed subjective norm—which reflects individuals' perception of social expectations regarding whether they should or should not perform a certain behavior (Ajzen, 1991). In the case of GMF, this construct captures the role of family, peers, media, and broader societal discourse in shaping attitudes and intentions, regardless of whether such influence aligns with scientific consensus (Kubisz et al., 2021).

In addition to these three core variables, this study incorporates two sociodemographic factors that have been shown to be relevant in the acceptance of GMF: gender (Elder et al., 2018) and age (Makowska et al., 2024). Specifically, the analysis focuses on the differences between millennials (i.e., members of Y generation) and zoomers (members of Z generation). Focusing on younger generations is especially relevant because they not only represent current emerging consumers but also shape long-term market dynamics. Research has shown that individuals from Generations Y and Z are generally more open to food innovations and more influenced by digital information channels than older cohorts,

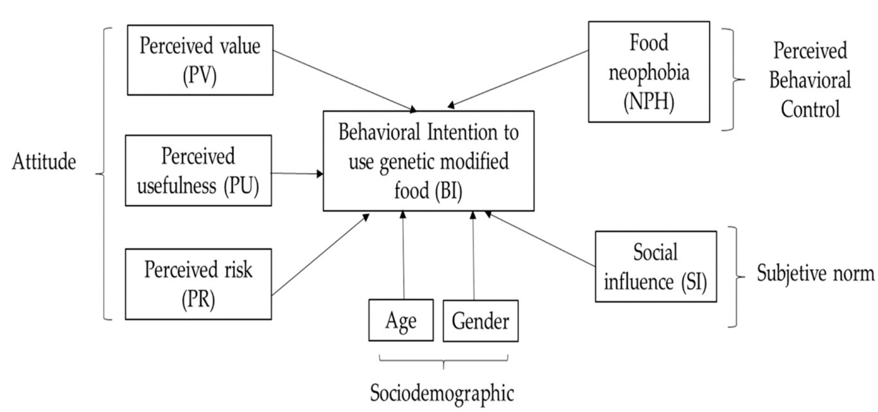

Fig. 1. Theoretical model of genetically modified food acceptance based on theory of planned behavior.

who often express stronger skepticism or preference for traditional food practices (Makowska et al., 2024; Bumbac et al., 2020).

Based on the ground displayed by Fig. 1, this study aimed to achieve two research objectives (ROs):

RO1. To evaluate the explanatory and predictive capacity of a conceptual ground based on TPB in determining the behavioral intention to consume GMF among young European consumers, by integrating attitudinal, normative, and control factors that have been understudied in the Spanish context.

RO2. To examine the heterogeneity in the impact of input factors across the full distribution of behavioral intention levels, using quantile regression, thereby identifying not only central but also marginal drivers of acceptance—an analytical perspective scarcely explored in GMF literature.

To achieve RO1, the study employed structural equation modeling with partial least squares (PLS-SEM), which is a commonly used tool in studies on food acceptance (see for instance, Costa-Font et al., 2008; Jin et al., 2022; Safi-Sis et al., 2022; Alalwan et al., 2023; Gao et al., 2024; Salifu et al., 2024; Andrés-Sánchez et al., 2025). For RO2, quantile regression (QR) was applied to offer a more nuanced and comprehensive understanding of the relationships between explanatory variables and behavioral intention—beyond what is captured by mean-based approaches such as PLS-SEM (Davino et al., 2015; Burmester et al., 2024). While QR has been theoretically suggested as a valuable tool in food acceptance research (Davino et al., 2015), its application remains virtually unexplored in the specific domain of GMF acceptance. This study, therefore, contributes methodologically to the literature by pioneering the use of QR in this context, uncovering latent patterns of influence that would remain undetected under conventional modeling techniques.

2. Conceptual ground

2.1. Factors linked to attitude

The first aspect considered in relation to attitude is the *perceived value* (PV) of GMF, i.e., the evaluation of that type of food in terms of cost-benefit. Although there are differences in the literature regarding its definition, the mainstream approach describes PV as the relationship between perceived benefits and the money or other resources invested in obtaining them (Sánchez-Fernández & Iniesta-Bonillo, 2007).

The perception that a product has been developed using a controversial technology does not necessarily lead to rejection; potential consumers could be inclined to accept it return for a monetary compensation. This phenomenon has also been observed in the context of GMF (Waterfield et al., 2020). This is because food products made using so-called "traditional" methods are generally perceived as more valuable (Etale & Siegrist, 2021). One of the main advantages of biotechnology applied to agriculture is increased efficiency, as GMOs can be engineered to thrive under adverse environmental conditions. This enables farmers to achieve higher yields while using fewer inputs (Alalwan et al., 2023), which in turn can lead to lower food prices (Kramkowska et al., 2013).

A positive perception of the cost-benefit ratio (i.e., a lower price for GMF compared with their traditional counterparts) could encourage consumer acceptance (Montesinos-López et al., 2016; Borrello et al., 2021; Zheng et al., 2023). Therefore,

Hypothesis 1 (H1). : PV has a positive link with BI.

According to Costa-Font et al. (2008), perceived benefits or *perceived usefulness* (PU) constitute a key factor in evaluating the acceptance of new food products. It must be understood in terms of functional utility. GMF provide advantages in farming practices, ecological systems, and human dietary health.

Nutritional quality is a key factor in consumers' food choices (Darian & Tucci, 2011). Hakim et al. (2020) show that perceived quality has a greater influence on the intention to purchase GMF than price. GMF can be developed with specific nutritional enhancements. An example is so-called "golden rice (Goodman, 2024). Moreover, GMF have potential applications in pharmaceutical formulations and can contribute to global strategies for combating malnutrition (Kramkowska et al., 2013).

While health and environmental benefits linked have been shown to influence GMF acceptance (De Marchi et al., 2021; Saha et al., 2022), their potential to improve health tends to carry more weight in terms of perceived advantages compared to ecological aspects (Muringai et al., 2020). The emphasis on health over other more social aspects, such as sustainability, is common in the acceptance of novel foods like meat alternatives (Begho, 2024) and also in GMF of third generation (Boccia & Punzo, 2021).

Literature on the adoption of new food products, particularly regarding GMF, identifies perceived usefulness as a fundamental variable in explaining their acceptance (Chen & Li, 2007; Costa-Font & Gil, 2009; Prati et al., 2012; McComas et al., 2014; Arias-Salazar et al., 2019; Farid et al., 2020; Jin et al., 2022; Gao et al., 2024; Marín-Díaz et al., 2024; Ngo et al., 2024). So,

Hypothesis 2 (H2). : PU has a positive link with BI.

Perceived risk (PR) is often reported as a relevant barrier to adopt GMF (Costa-Font et al., 2008). Although there are no reliable reports supporting that GMF are riskier that non-GMF (Vega Rodríguez et al., 2022), people remain skeptical about genetic technologies because of potential health risks such as allergies or toxicity, as well as environmental concerns (Montesinos-López et al., 2016), which may be attributable to some new foods (Samarasiri et al., 2023).

No long-term studies have evaluated the effects of GMF consumption, leading a significant portion of the population to perceive that the scientific community remains uncertain about its implications (Vega Rodríguez et al., 2022; Bearth et al., 2022). Zhao et al. (2023) suggested that the risks associated with GMF may be overestimated compared to other behaviors with objectively greater documented risks, such as the consumption of food additives. Moreover, Vlontzos and Duquenne (2016) indicate that a higher perception of barriers related to GMF consumption is significantly associated with a greater demand for price discounts to encourage acceptance.

The literature suggests that perceived risk is significantly and negatively related to GMF consumption intention, whereas perceived safety encourages food use (Chen & Li, 2007; Costa-Font & Gil, 2009; McComas et al., 2014; Arias-Salazar et al., 2019; Farid et al., 2020; Hakim et al., 2020; Yang & Hobbs, 2020; Zhaleh et al., 2023; Jin et al., 2022; Alalwan et al., 2023; Cabelkova et al., 2024; Ogwu et al., 2024).

Hypothesis 3 (H3). : PR has a negative link with BI.

2.2. Food neophobia

Food Neophobia (NPH) is the aversion or reluctance to consume new or unfamiliar foods (Pliner & Hobden, 1992). Although advances in biotechnology since the 1980s and 1990s have allowed the development of aliments with multiple benefits, their acceptance faces a significant barrier in the form of resistance to change associated with food neophobia (Rabadán & Bernabéu, 2021).

In the context of technologies such as GMOs or cultivated meat, the perception of innovation does not arise from the aliments —which are visually and sensorially equal from its conventional counterpart—but how they have been produced (Faccio & Guiotto Nai Fovino, 2019). Genetically modified food is often perceived a priori by consumers as unnatural, harmful, or unhealthy, particularly when they involve animal-based products, which tend to generate stronger rejection than plant-based ones. Moreover, the presence of a label indicating GMO content has a significant negative impact, reinforcing consumer aversion even when the GMF is objectively identical to its non-modified equivalent (Lefebvre et al., 2019).

Various studies have shown that consumers tend to prefer products labeled as natural or minimally processed (Rozin et al., 2012; Lefebvre et al., 2019; Goodman, 2024). Food neophobia has been identified as a key determinant of the acceptance of new products, including GMF (Ortega et al., 2022; Kiran et al., 2023; Marín-Díaz et al., 2024).

Hypothesis 4 (H4). : NPH has a positive link with BI.

2.3. Social influence

Social influence (SI), also referred to as the subjective norm (Venkatesh et al., 2003), describes the perception that external pressure encourages an individual to consider a specific behavior as socially acceptable or desirable. If individuals perceive that their close environment, such as family or friends, approves or uses a specific aliment, they tend to develop a positive perception of the product in order to conform to the norms and preferences of their social group (Wolstenholme et al., 2021). This effect is especially significant among young people, who tend to be more influenced by reference figures, such as friends, parents, or older siblings (Brosig & Bavorova, 2019).

The importance of SI becomes more pronounced for products such as GMF, as consumers often possess limited knowledge about the technologies involved in their development and the available scientific evidence regarding their risks and benefits (Siegrist, 2008). Moreover, social norms related to food choices play a critical role in shaping consumption decisions, as they provide important cues concerning the health risks, dietary benefits, and suitability of specific products within a dietary context (Günden et al., 2024). Accordingly, it has been shown that greater trust in biotechnology and scientific institutions increases consumers' willingness to use oil derived from GMOs (Zhaleh et al., 2023).

Advances in public perception of biotechnology have been shaped not only by its success in areas such as pharmaceutical production (Wozniak-Gientka et al., 2022), but also by the public's growing ability to differentiate between traditional genetic modification techniques, such as transgenesis, and more recent innovations like gene editing—distinctions that tend to foster greater acceptance of GMF (Tadich & Escobar-Aguirre, 2022). In this context, evidence-based interventions by expert organizations have proven effective in correcting misinformation about GMF on social media; however, passive strategies that rely solely on social cues—such as the number of "likes"—are insufficient to produce meaningful changes in perception (Bode et al., 2021). Similarly, interventions involving the provision of positive information about GMF and adjustments to product labeling have been shown to increase consumers' willingness to pay for GMF (Hashemzadeh et al., 2022).

However, ethical, economic, and environmental concerns persist, negatively influencing the social perception of GMF and hindering their widespread acceptance (Hingston & Noseworthy, 2018). Some criticisms focus on the fear that these products overly benefit large agricultural corporations, leading to monopolies on seeds and increasing costs for small-scale farmers (Kolkur et al., 2024). Environmental concerns include potential transference of genes to native fauna and flora and the emergence of pest and weed resistance (Kramkowska et al., 2013). However, in the European Union, specific regulations have been implemented to prevent genetic contamination of non-genetically modified crops (Bratlie et al., 2019).

In the context of GMF, several studies have highlighted the impact of subjective norms on consumers' willingness to accept them (Prati et al., 2012; Borrello, Cembalo, Vecchio, 2021; Safi-Sis et al., 2022; Alalwan et al., 2023; Andrés-Sánchez et al., 2025). So,

Hypothesis 5 (H5). : SI is positively related to BI to try GMF.

2.4. Social and demographic factors

Studies on adoption of food products, often incorporates social and demographic factors, with gender and age being particularly significant. The inclusion of gender is based on physiological variations in dietary requirements between men and women and societal disparities (Rodrigues et al., 2020). Men tend to show greater willingness to adopt new food trends, which is also observed in the case of GMF (Elder et al., 2018; Ramadan et al., 2024).

Age has a significant influence on food preferences (Boccia & Punzo, 2021). Generation X and Baby Boomers prioritize quality, while zoomers and millennials—our research focus—are more price conscious (Makowska et al., 2024). Despite increased globalization of food consumption, zoomers seek convenience while favoring healthy, local, and organic products due to moral, ethical, and economic concerns (Bumbac et al., 2020). Millennials consider both quality and price, with freshness and taste shaping their choices (Barska et al., 2023). Studies on new food technologies suggest an inverse link of age with GMF acceptance because younger generations may be more open to these innovations than older generations (Ramadan et al., 2024). Thus,

Hypothesis 6 (H6). : Males tend to be more favorable toward using GMF than females.

Hypothesis 7 (H7). : Members of Generation Z are more favorable to using GMF than Generation Y.

3. Materials and methods

3.1. Sampling and sample

The paper analyzes data from an online survey conducted in March and April 2023 in Spain. The survey targeted individuals from Generation Z and Generation Y, ranging in age from 18 to 44 years. Accordingly, participants aged 18–25 were classified as Generation Z, while those aged 26–44 were considered part of Generation Y. Survey analysis is arguably one of the most fruitful methods used in the literature to study the acceptance GMF (Del-Aguila-Arcentales et al., 2025).

The survey was distributed to individuals active on food review platforms using a non-probabilistic convenience sampling method. Additionally, participants were encouraged to share the survey with others interested in the topic, incorporating a snowball sampling approach. While findings from convenience samples are typically limited in their generalizability (Andrade, 2021), a notable strength of this approach lies in the fact that respondents were individuals with a genuine interest in food and cooking. This likely enhanced their motivation to participate and increased the likelihood of thoughtful and considered responses.

Furthermore, the sampling strategy enabled the inclusion of individuals with above-average awareness of or interest in food-related issues, and probably they included GMF. Recruiting participants through specialized food forums and platforms increases the probability that respondents possess relevant familiarity—whether through personal interest, prior exposure, or active engagement in food-related discussions. As such, although the sample is not representative of the general population, it reflects the perceptions of informed and engaged consumers—precisely the audience most likely to influence public discourse and adoption dynamics surrounding GMF.

Ethical clearance for this study was obtained and officially recorded by the affiliated institution of the corresponding author under protocol number CEIPSA-2025-PRD-0005. Prior to participating in the survey, all respondents gave their informed consent.

In total, 470 questionnaires were obtained. Only those in which all items related to BI, PV, PU, PR, NPH, SI, gender and age were fully answered were considered valid, resulting in 422 valid responses. The sample size was statistically sufficient to ensure adequate power for evaluating the fit of a regression model, as illustrated in Fig. 1, which includes seven predictor variables. According to calculations performed using G*Power 3.1 software (Faul et al., 2009), this sample size provides 80 % statistical power at a 5 % significance level to detect even very small effect sizes (0.02) for both individual regression coefficients and the model as a whole.

Table 1 presents the respondents' demographic profiles. A total of 185 participants (43.84 %) identified as male, and 231 (54.74 %) as female, which is consistent with previous research suggesting that women are generally more likely to participate in surveys. An example in the context of GMF analysis can be found in Hashemzadeh et al. (2022). Regarding age, 241 respondents (57.11 %) were 29 years old or younger—thus belonging to Generation Z—while 181 (42.89 %) belonged to Generation Y. The mean age was 27.43 years (SD=9.85). Likewise, 309 participants (73.22 %) reported having completed university-level studies. Concerning income, 156 respondents (36.97 %) reported monthly earnings of less than €1000, 99 (23.46 %) earned between €1000 and €1749, 52 (12.32 %) earned more than €1750, and the remaining participants chose not to disclose their income.

3.2. Measurement model

The initial draft of the survey was presented to nine university professors from various fields, including nutrition, biotechnology, and agricultural marketing. Although their feedback did not require substantial changes to the questionnaire, it improved its readability and allowed for an initial check of the reliability of the measurement model.

The survey opened with a brief overview introducing the concept of GMF and summarizing the current state of technology. Following this introduction, participants proceeded to respond to items designed to assess the constructs outlined in the explanatory model presented in Section 2. The BI, PV, and SI scales were adapted from Venkatesh et al. (2012), PU from Jin et al. (2022), and PR from Faqih (2016). The NPH scale was based on Pliner and Hobden (1992). The exact wording of the items is shown in Table A1 (Appendix). Responses were recorded on an eleven-point Likert scale, ranging from 0 (complete disagreement) to 1 (complete agreement).

Gender and age were quantified as dummy variables. In the case of gender, 1 was assigned to men and 0 to others, denoted as MAN. For age, 1 corresponds to respondents belonging to Generation Z (up to 25 years old) and 0 for Generation Y members; thus, this variable was denoted as GENZ.

3.3. Data analysis

Research objectives 1 and 2 were developed by the subsequent use of PLS-SEM and QR. For RO1, PLS-SEM was applied, and QR was subsequently used to implement RO2. While PLS-SEM was performed using SmartPLS 4.0 (Ringle et al., 2024), the implementation of QR was done using gretl software (Cottrell & Lucchetti, 2024).

PLS-SEM is appropriate when it exist concerns regarding the normal distribution of variables, as well as when it is of interest evaluating the predictive capability of the proposed model (Hair et al., 2019). This method has been widely employed in research on consumer behavior, including studies focused on the consumption of GMF (Farid et al., 2020; Jin et al., 2022; Safi-Sis et al., 2022; Marín-Díaz et al., 2024; Alalwan et al., 2023; Gao et al., 2024; Salifu et al., 2024; Andrés-Sánchez et al., 2025).

The model fit follows the procedure established by Hair et al. (2019) and its predictive ability of the model was with the Q^2 statistic from Stone and Geisser, along with the cross-validated predictive ability test (CVPAT) (Sharma et al., 2023).

RO2 was developed by adjusting the model shown in Fig. 1 using QRs at the following probability levels: $\tau = 0.1$, 0.25, 0.4, 0.45, 0.5, 0.55, 0.6, 0.75, and 0.9. The probability levels 0.1, 0.25, 0.5, 0.75, and 0.9 are common in the literature that uses QR, so that $\tau = 0.1$ and 0.25 represent scenarios below the central values. While $\tau = 0.1$ implies an extremely low scenario, $\tau = 0.25$ implies a moderately extreme scenario. Thus, $\tau = 0.5$, which represents a response situated at the center. Finally, $\tau = 0.75$ ($\tau = 0.9$) represents a non-central BI in moderate (extreme) scenarios, implying a value above the central tendency of the response variable (Davino et al., 2022).

However, as done by Agarwal et al. (2022) and Souto-Romero et al. (2025), we added the levels $\tau = 0.4$, 0.45, 0.55, and 0.6. In this way, responses related to infra-BI, central BI, and super BI are captured through three regressions. The influence of input factors on the central responses of BI is reflected in $\tau = 0.45$, 0.5, and 0.55. Responses showing acceptance below the central values were reflected in the regressions at $\tau = 0.1$, 0.25, and 0.4. Regressions associated with response values situated above the central responses were performed at levels $\tau = 0.6$, 0.75, and 0.9.

Following Agarwal et al. (2022) and Souto-Romero et al. (2025), implementing QR with latent variables requires assessing the measurement model, which was performed in the PLS-SEM adjustment step. Subsequently, latent variables were quantified using the factor loadings used to quantify latent variables (Davino et al., 2015).

Combining PLS-SEM with quantile regression (QR) provides a deeper understanding of the factors influencing behavioral intention (BI). QR helps prioritize key elements and determine whether their effects apply across all response levels or only specific segments. For instance, in addressing the first research objective (RO1), PLS-SEM might show that the variable X1 has a greater impact on willingness to try GMF than X2. However, when analyzing the second objective (RO2) with QR, X2 might show a consistent influence across all BI levels, whereas X1 affects only the median quantiles. Relying solely on PLS-SEM could lead to the conclusion that X1 was more influential. However, while X1 had a stronger impact on the expected response value, X2 exerted a more uniform influence throughout the BI distribution. This makes X2 a strategic target for policies promoting GMF adoption, as its effect is broader and more consistent.

Table 1
Sociodemographic profile of the sample.

Factor	Responses	Proportion
Gender		
Male	185	43.84 %
Female	231	54.74 %
Other/prefer not answer	6	1.42 %
Age		
< 25 years	241	57.11 %
≥ 25 years and < 45 years	181	42.89 %
Mean= 27.43, SD= 9.85		
Academic degree		
Primary studies or less	6	1.42 %
Secondary or vocational training courses	106	25.12 %
University studies (graduate, master, PhD.)	309	73.22 %
Monthly income		
< €1000	156	36.97 %
≥ €1000 and ≤ €1749	99	23.46 %
≥ €1750	52	12.32 %
Nonanswered	115	27.25 %

4. Results

4.1. Assessment of the model of measurement

The descriptive statistics for the latent variable items included in Fig. 1 are presented in Table A1 in the Appendix. The BI scores were slightly above five, suggesting a moderate tendency toward acceptance. The danger-related PR items (PR1 and PR3) showed low values, both below three, whereas the uncertainty-related item (PR2) scored notably high, exceeding seven. In contrast, perceptions of social influence in favor of GMF use remained very low, with scores just above one.

Tables A1 and A2 of the appendix show the scales demonstrate internal consistency, with all constructs showing Cronbach's α and composite reliability values ranging between 0.70 and 0.95. Moreover, the scales exhibit satisfactory convergent validity, as indicated by average variance extracted (AVE) values exceeding the 0.50 threshold.

Table A2 of the Appendix provides evidence of the discriminant validity of the scales. The constructs satisfy the Fornell-Larcker criterion, and heterotrait-monotrait ratios remaining under the recommended threshold of 0.85. (Hair et al., 2019).

4.2. Structural model analysis with PLS-SEM

Table 2 shows the results of fitting the relationships shown in Fig. 1. Some results are also displayed in Fig. 2. The overall fit, following Hair et al. (2019), is closer to substantial than medium ($R^2 = 69.1$ %), and there are no issues with collinearity, as the variance inflation factor for all variables is < 3.3. The attitudinal variables significantly influenced BI. Thus, for PV, the path coefficient (β) was 0.088, with a p-value (p) of 0.016; for PU, $\beta = 0.404$ ($p < 0.001$); and for PR, β = -0.134 ($p < 0.001$). On the other hand, NPH has a negative impact that is not significant ($\beta = -0.036$, $p = 0.205$), whereas SI has a positive and significant impact ($\beta = 0.357$, $p < 0.001$). Likewise, being a zoomer significantly predisposed individuals to consume GMF ($\beta = 0.121$, $p = 0.039$), while gender had no impact.

Table 3 displays the outcomes of the analysis assessing the model's predictive capability. According to the guidelines established by Hair et al. (2019), the proposed model demonstrates predictive relevance, as indicated by Q^2 values greater than zero. CVPAT demonstrates that the proposed conceptual ground performs better than both benchmarks. However, while superiority over the indicator average is significant, this does not apply to the parsimonious linear model.

4.3. Structural model analysis with QR

Table 4 displays the adjustment for the acceptance of GMF using QR at the levels associated with centrality ($\tau = 0.45, 0.5, 0.55$). The variable with the greatest influence was PU, followed by SI. The path coefficient (γ) for PU increased with τ, ranging from 0.495 to 0.529 ($p < 0.001$). For SI, γ decreases with τ, ranging from 0.277 to 0.311, where $p < 0.001$ in all the three regressions. It is also observed that the influence of PR on BI is consistently significant, with values of γ for $\tau = 0.45$ ($\gamma = -0.147$, $p = 0.004$), $\tau = 0.5$ ($\gamma = -0.100$, $p = 0.007$), and $\tau = 0.55$ ($\gamma = -0.126$, $p = 0.004$).

The sensitivity of BI to changes in PV was positive and increased with τ. However, PV is only significant at $\tau = 0.5$ ($\gamma = 0.104$, $p = 0.002$) and $\tau = 0.55$ ($\gamma = 0.115$, $p = 0.004$). Being female consistently facilitates the acceptance of GMF, although the coefficient is only significant at $\tau = 0.5$ ($\gamma = -0.127$, $p = 0.034$). It can be also observed a consistently negative link with NPH and a positive relationship with GENZ, but neither of these relationships was significant at any level of τ.

Table 5 presents the results of the adjustments at $\tau = 0.1$, 0.25, and 0.4. Again, only PU and SI had a consistently significant impact at all levels. In fact, the influence of SI was greater than that of PU at the two lowest percentiles. For PU, the path coefficient (γ) increased with τ, ranging between 0.330 and 0.515 ($p < 0.001$ in all cases). On the other hand, for SI, γ decreased with τ, ranging from 0.468 to 0.308, where $p < 0.001$.

The negative influence of PR on BI increases in intensity with τ, being significant at $\tau = 0.25$ ($\gamma = -0.108$, $p = 0.013$) and $\tau = 0.4$ ($\gamma = -0.131$, $p = 0.001$). GENZ results in a greater predisposition to consuming GMF at all levels of τ. This over-acceptance decreases with higher τ levels, being significant at the two lower quantiles, $\tau = 0.1$ ($\gamma = 0.227$, $p = 0.012$) and $\tau = 0.25$ ($\gamma = 0.158$, $p = 0.028$). The positive influence of PV on BI occurred at all levels, but it was only significant at $\tau = 0.1$ ($\gamma = 0.110$, $p = 0.028$).

The consistently negative influence of NPH is statistically significant only at $\tau = 0.4$ ($\gamma = -0.069$, $p = 0.040$). Once again, the results show a higher tendency for women to accept GMF, with $\gamma < 0$ in all cases; however, this coefficient is not significant at any level of τ.

Table 6 displays the value of the coefficients fitted for $\tau = 0.6$, 0.75, and 0.9. In these quantiles, the four explanatory variables were consistently significant. Ordered from most to least relevant, we observed PU, SI, PR, and PV. For PU, γ decreased with τ, oscillating between 0.491 and 0.329 ($p < 0.001$ in all cases). For SI, γ ranged between 0.222 and 0.251, and $p < 0.001$ was consistently met. The sensitivity of BI to changes in PR fluctuates between −0.151 and −0.176 and also $p < 0.001$). As for PV, we observe significant influence at $\tau = 0.6$ ($\gamma = 0.122$, $p < 0.001$), $\tau = 0.75$ ($\gamma = 0.096$, $p = 0.004$), and $\tau = 0.9$ ($\gamma = 0.101$, $p < 0.001$).

The negative influence of NPH on BI remained consistent across all adjusted levels, but was not significant in any of them. Similarly, the positive influence of GENZ on BI is consistent, but only significant at $\tau = 0.9$ ($\gamma = 0.110$, $p = 0.020$). Lastly, the relationship between MAN and BI was only significant at $\tau = 0.6$ ($\gamma = -0.135$, $p = 0.013$), suggesting a greater predisposition for females to accept GMF.

5. Discussion

5.1. Broad summary

This paper addressed two research objectives (RO). The first, RO1 examined how perceived value (PV), perceived usefulness (PU), perceived risk (PR), food neophobia (NPH), social influence (SI), gender (MAN), and being a zoomer (GENZ) affect the behavioral intention (BI) to try GMF. The model, based on PLS-SEM and applied to a Spanish sample of Generation Z and Y consumers in 2023, showed a high explanatory power ($R^2 = 70$ %) and strong predictive validity, confirmed by the Stone–Geisser Q^2 coefficient and the cross-validated predictive ability test (Sharma et al., 2023). All explanatory variables except MAN and NPH significantly influenced BI with the expected signs: PV, PU, SI, and GENZ positively, while PR negatively. Although NPH and MAN were not significant in the global model, their theoretical roles remained relevant.

RO2 explored how these variables influenced BI across its entire response distribution through quantile regression (QR). PU and SI stood out as the most consistent predictors, being significant across all quantiles. PR and PV also showed robust effects—negative and positive, respectively—although with slightly lower consistency (significant in eight and seven quantiles). GENZ emerged as a relevant positive predictor at the extremes of the distribution ($\tau = 0.1, 0.25, 0.9$), suggesting a polarization among younger respondents. Interestingly, MAN showed a negative association in eight quantiles, though it was only significant in two. NPH, despite its consistently negative sign, was significant in just one quantile, reinforcing the idea that its influence may vary more

Table 2
PLS-SEM path coefficients for the TPB-based GMF acceptance model.

Path	β	t-ratio	p value	VIF	f^2	Decision on hypothesis
PV -> BI	0.088	2.418	0.016	1.364	0.019	H1(+): Acceptance
PU ->BI	0.404	7.926	< 0.001	2.155	0.245	H2(-): Acceptance
PR-> BI	−0.133	3.521	< 0.001	1.624	0.035	H3(-): Acceptance
NPH -> BI	−0.036	1.268	0.205	1.139	0.004	H4(+): Rejected
SI->BI	0.357	8.638	< 0.001	1.678	0.245	H5(+): Acceptance
MAN-> BI	−0.068	1.202	0.229	1.048	0.004	H6(-): Rejected
GENZ-> BI	0.121	2.062	0.039	1.075	0.011	H7(-): Acceptance

Note: (a) R^2= 69.1 %, (b) β represents the path coefficient, VIF is the variance inflation factor, and f^2 size factor.

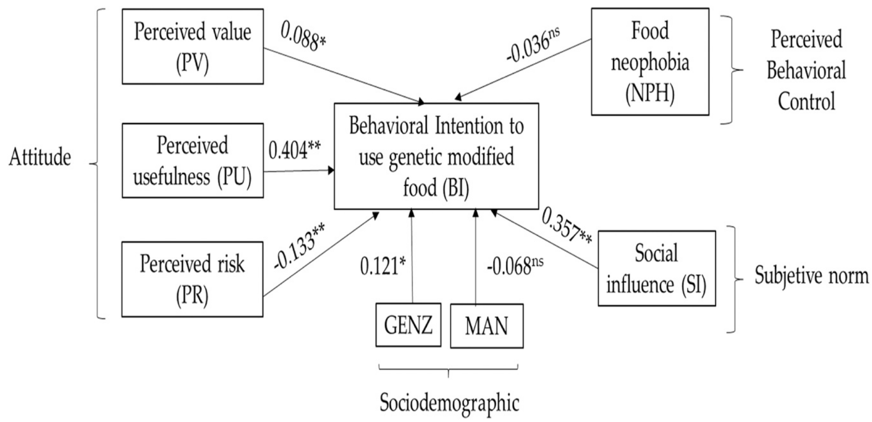

Fig. 2. Results of fitting model in Fig. 1 with PLS-SEM. Note: "ns" indicates non-significance; "*" and "**" denote statistical significance at the 5 % and 1 % levels, respectively.

Table 3
Predictive performance of the proposed theoretical ground (Q^2 and CVPAT).

	Measures of PLS-SEM predict			CVPAT (1)			CVPAT (2)		
Construct	Q^2	RMSE	MAE	ALD	t-ratio	p value	ALD	t-ratio	p value
BI	0.676	0.572	0.455	−6.234	12.665	< 0.001	−0.122	1.49	0.137

Note: (a) CVPAT (1) compares the model with the indicator average; CVPAT (2) uses a parsimonious linear model as a benchmark; (b) ALD = Average loss difference between the proposed model and the respective benchmarks.

Table 4
Quantile regression results of behavioral intention near the median (τ = 0.45, 0.5, 0.55).

Percentile	τ= 0.45		τ= 0.5		τ= 0.55		Decision
Variable	γ	p-value	γ	p-value	γ	p-value	
PV	0.077	0.097	0.104	0.002	0.115	0.004	H1: Partially accepted
PU	0.495	< 0.001	0.529	< 0.001	0.527	< 0.001	H2: Accepted
PR	−0.147	0.004	−0.100	0.007	−0.126	0.004	H3: Accepted
NPH	−0.036	0.389	−0.058	0.060	−0.046	0.204	H4: Rejected
SI	0.307	< 0.001	0.311	< 0.001	0.277	< 0.001	H5: Accepted
MAN	−0.099	0.225	−0.127	0.034	−0.103	0.142	H6: Rejected
GENZ	0.073	0.377	0.026	0.673	0.014	0.839	H7: Rejected

Note: Pseudo R^2 values for the regressions are: τ = 0.45 → 46.49 %; τ = 0.5 → 47.09 %; τ = 0.55 → 46.74 %.

Table 5
Quantile regression results of behavioral intention at lower levels (τ = 0.1, 0.25, 0.4).

Percentile	τ= 0.1		τ= 0.25		τ= 0.45		Decision
Variable	γ	p-value	γ	p-value	γ	p-value	
PV	0.110	0.028	0.059	0.140	0.068	0.065	H1: Partially accepted
PU	0.330	< 0.001	0.396	< 0.001	0.515	< 0.001	H2: Accepted
PR	−0.085	0.119	−0.108	0.013	−0.131	0.001	H3: Partially Accepted
NPH	−0.012	0.798	−0.063	0.084	−0.069	0.040	H4: Partially accepted
SI	0.468	< 0.001	0.453	< 0.001	0.308	< 0.001	H5: Accepted
MAN	−0.075	0.396	−0.131	0.063	−0.120	0.066	H6: Rejected
GENZ	0.227	0.012	0.158	0.028	0.083	0.212	H7: Partially accepted

Note: Pseudo R^2 values for the regressions are: τ = 0.1 → 51.92 %; τ = 0.25 → 48.93 %; τ = 0.4 → 47.78 %.

subtly among different response levels.

Regarding attitudinal predictors, the results were strongly aligned with previous research, which frequently reports high levels of significance (Saha et al., 2022). The positive and significant effect of perceived value supports that GMF may gain consumer acceptance when their perceived advantages in price outweigh concerns about naturalness or tradition. This trend has been observed across culturally diverse contexts such as Mexico (Montesinos-López et al., 2016), Italy (Borrello, Cembalo, Vecchio, 2021), Arab countries (Alalwan et al., 2023), and the United States (Zheng et al., 2023).

The robust influence of PU —consistently significant across the entire distribution of behavioral intention (BI)—confirms its central role in GMF acceptance the perception of the potential advantages of GMF, both in terms of nutritional improvements and the sustainability of its production (De Marchi et al., 2021; Saha et al., 2022). This aligns with findings from multiple studies on both transgenic and gene-edited foods across various regions, including Taiwan (Chen & Li, 2007), Southern European countries (Costa-Font & Gil, 2009; Prati et al., 2012; Vlontzos & Duquenne, 2016; Andrés-Sánchez et al., 2025), China (Gao et al., 2024), and Central America (Marín-Díaz et al., 2024).

Table 6
Quantile regression results of behavioral intention at higher levels (τ = 0.6, 0.75, 0.9).

Percentile	τ= 0.6		τ= 0.75		τ= 0.90		Decision
Variable	γ	p-value	γ	p-value	γ	p-value	
PV	0.122	< 0.001	0.096	0.004	0.101	< 0.001	H1: Accepted
PU	0.491	< 0.001	0.417	< 0.001	0.329	< 0.001	H2: Accepted
PR	−0.152	< 0.001	−0.152	< 0.001	−0.176	< 0.001	H3: Accepted
NPH	−0.031	0.264	−0.050	0.103	−0.041	0.089	H4: Rejected
SI	0.251	< 0.001	0.222	< 0.001	0.234	< 0.001	H5: Accepted
MAN	−0.135	0.013	0.031	0.602	−0.035	0.445	H6: Rejected
GENZ	0.042	0.440	0.076	0.202	0.110	0.020	H7: Partially accepted

Note: Pseudo R^2 values for the regressions are: $\tau = 0.6 \rightarrow R^2 = 45.51$ %; $\tau = 0.75 \rightarrow R^2 = 44.54$ %; $\tau = 0.9 \rightarrow R^2 = 27.25$ %.

In contrast, the effect of perceived risk—although significantly negative and statistically robust in eight quantiles—was notably weaker than that of PU. This suggests that anticipated benefits may exert a greater influence than perceived risks. Such a finding aligns with the perspective that perceived risk functions more as a barrier than a determining factor, especially when increased knowledge and positive framing enhance perceived usefulness. This trend has been reported in diverse regions like the United States and Canada (McComas et al., 2014; Yang & Hobbs, 2020), Ghana (Ogwu et al., 2024), Iran (Zhaleh et al., 2023), and Brazil (Hakim et al., 2020).

Food neophobia (NPH) consistently showed a negative sign across all analyses, echoing previous findings (McComas et al., 2014; Boccia et al., 2018; Kiran et al., 2023). However, its lack of statistical significance—both globally and in most quantiles—may reflect the generational profile of the sample. Millennials and zoomers, who are frequently exposed to innovation and digital sources of information, often display lower levels of food neophobia. Moreover, the survey's wording may have emphasized the benefits of GMF over their novelty, thereby reducing the psychological salience of neophobia.

Social influence (SI) emerged as one of the strongest predictors of BI, particularly salient in lower quantiles ($\tau = 0.10, 0.25$), indicating that social cues may be especially decisive for initially hesitant individuals. This is consistent with previous research emphasizing the role of subjective norms in shaping consumer behavior toward GMF across culturally distinct contexts such as Southern European countries (Prati et al., 2012; Borrello et al., 2021; Andrés-Sánchez et al., 2025) and Iran (Safi-Sis et al., 2022).

Regarding sociodemographic variables, gender (i.e., MAN) showed no significant effect in the PLS-SEM model, though QR revealed a weak but consistently negative influence, with significance in two quantiles. This suggests that gender may play a nuanced role, possibly moderated by cultural and generational factors. Contrary to common assumptions that women are more food-averse, our findings tentatively point toward a higher female predisposition to consume GMF. This aligns with studies reporting null or reversed gender effects (Badghan & Namdar, 2022; Hao et al., 2024; Gao et al., 2024), potentially indicating a shift in food risk perceptions among younger women.

Finally, the positive and occasionally significant effect of GENZ compared to millennials reflects a well-documented trend: younger consumers are generally more open to food innovations and biotechnology (Ramadan et al., 2024). This supports the inclusion of generational cohorts as relevant moderators in predictive models of GMF acceptance.

While this study is based on the Spanish context—characterized by strong skepticism and regulatory constraints—its findings resonate with evidence from non-EU and developing countries. For instance, Saha et al. (2022) observed that in India, trust in institutions and political beliefs play a decisive role in genetic modified crop acceptance. Similarly, in Pakistan and China, food neophobia and ecological concerns have emerged as key barriers (Kiran et al., 2023). Meanwhile, U.S. consumers show greater exposure to GMF, yet their acceptance remains contingent on trust, labeling, and transparency (Zheng et al., 2023). These parallels and contrasts emphasize the need for culturally sensitive, theoretically grounded frameworks that can be adapted to diverse global contexts.

5.2. Implications for theory and implementation

The findings demonstrate that a model grounded in TPB offers a solid conceptual framework for thoroughly understanding the factors influencing individuals' willingness to consume GMF. The proposed model accounts 70 % of the variance of behavioral intention, indicating a satisfactory level of predictive power.

The mixture of PLS-SEM and quantile regression allows for the evaluation of the predictive capacity of the presented model, a prognosis about which factors considered are most consistent in prediction across the entire response variable, while also providing a more complete view of the relationship between variables (Souto-Romero et al., 2025). The conditional quantiles of a distribution offer additional information not provided by standard regression approaches, which can be important for understanding, for example, how a consumer characteristic might influence discrepancies in preference (Davino et al., 2015) and to obtain a measure of their sensitivity not just at the average BI when explanatory variables change, but throughout the whole range of the outcome (Burmester et al., 2024). As far as we are aware, no prior studies have undertaken a comparable analysis within the domain of GMF acceptance

The findings of this research have applications in practice for manufacturers and policymakers to develop the adoption of GMF by consumers in the geographic setting of the study, a region country of the European Union. The suggestions derived from this study should focus on enhancing two key aspects: perceived usefulness and social impact. Two secondary factors were identified: perceived risk and perceived value.

Regarding the customization of GMF, the ability to incorporate specific attributes into these products allows for offering options that are tailored to individual needs and directing marketing toward specific market niches (Boccia & Punzo, 2021). The relevance of PU suggests that GMF could be considered as a strategic product to capture particular types of consumers, such as those concerned with sustainable environmental practices or those seeking specific nutritional benefits (Vlontzos & Duquenne, 2016; De Marchi et al., 2021). Since these advantages, unlike price, are not immediately obvious, it is crucial to communicate them through the use of labels that highlights their benefits, like "grown without pesticides" or "enriched with 25 % more vitamin C." This approach may reframe the discourse from "potential risk" to "tangible benefit" (Hingston & Noseworthy, 2018).

The relevance of social influence suggests that, in order to promote the acceptance of GMF, it is relevant to implement strategies to enhance their public image. One effective approach involves the development of accessible informational platforms that transparently and scientifically communicate the production processes, benefits, and rigorous safety assessments associated with these foods. Such initiatives may be endorsed by reputable prominent individuals in the gastronomic field, with oversight provided by impartial entities such as academic institutions and scientific research organizations. In this context, when expert organizations communicate the scientific consensus regarding the safety of GM foods, public misperceptions tend to decline. This, in turn, helps reduce misinformation and enhances consumers' willingness to accept GM foods, consistent with the Gateway Belief Model (Bode et al., 2021). Additionally, subtle informational nudges should not be overlooked, as they have also been shown to increase consumers' willingness to purchase GM foods (Hashemzadeh et al., 2022).

The European Union's labeling regulation for GMF has been described as rigorous, discriminatory, and unbalanced (Bratlie et al., 2019). In the EU, production and labeling are governed by the manufacturing process (Wozniak-Gientka et al., 2022), which contrasts with regions such as the United States, where labeling regulations are based on product composition (Goodman, 2024). This divergence has contributed to higher acceptance and consumption of GMF in the U.S. and to conflicting situations in the EU. A traditionally grown crop that does not require pesticides may be labeled as "organic"—which is highly appreciated—whereas a genetically modified crop designed to eliminate the need for pesticides must be labeled as "genetically modified," with no possibility of bearing the "organic" label (Goodman, 2024). Such inconsistencies foster unjustified risk perception, which, although secondary, play a substantial influence on the formation of costumers' perceptions. In conclusion, GMF labeling regulations should adhere to the principles of legal clarity, equal treatment, proportionality, and alignment with current scientific knowledge (Zetterberg & Edvardsson Björnberg,2017). It has also been shown that applying subtle nudges through labeling strategies can increase consumers' willingness to pay for GMF (Hashemzadeh et al., 2022). In fact, incorporating in labelling positive attributes such as environmental or health-related benefits—alongside enhanced scientific information has been found to further increase consumers' willingness to pay for these products (Zhan et al., 2021).

Regarding price-based competition, the European Union has experienced significant food price inflation in 2022 and 2023 (European Central Bank, 2024). In this context, the availability of more affordable products could increase their appeal, thereby raising consumers' perceived value.

5.3. Limitations of the paper

This report has several limitations. The survey was composed solely of citizens from one country, and it has been widely recognized that cultural legacy and historical background contexts play a significant role in understanding the intention to consume GMF (Yang & Hobbs, 2020). These cultural differences have been evidenced in various studies, both in intercultural analyses between continents (Bongoni, 2016; Lucht, 2015; Wozniak-Gientka et al., 2022; Kiran et al., 2023) and European countries (Boccia & Punzo, 2021; Wozniak-Gientka et al., 2022). Therefore, the conclusions of this study should be interpreted with caution when applied to territories with different cultural contexts. For example, in the United States, there is a more positive perception and higher consumption of GMF than in European Union countries (Lucht, 2015). Furthermore, there are significant differences in perceptions among European countries themselves (Bearth et al., 2022; Wozniak-Gientka et al., 2022).

Additionally, the analysis focuses on millennials and members of Generation Z (zoomers). Therefore, one should be cautious when attempting to extrapolate the results of this study to previous generations, such as Generation X or the Baby Boomers, as their food-related decisions may be influenced by different factors (Makowska et al., 2024).

The long-term applicability of this study's findings may be constrained due to persistent regulatory challenges and inconsistencies surrounding GMF (Goodman, 2024), as well as the continual advancement of biotechnological methods (Defez, 2016; Vodnar et al., 2021). Research indicates that customer acceptance of GMFs tends to increase when individuals are educated about newer genetic modification techniques—such as gene editing—and are clearly informed about how these differ from conventional approaches like transgenesis. This effect is contingent on the provision of transparent and accessible explanations (Nguyen et al., 2022; Tadich & Escobar-Aguirre, 2022). Therefore, the perception and acceptance of GMF require longitudinal studies and continuous analysis to track the evolution of biotechnology techniques applied in the food sector.

The psychometric approach employed in this study also entails certain limitations, including the risk of social desirability bias, reliance on self-reported data, and the well-known gap between stated intentions and actual behavior. In contrast, experimental economics methods—widely used in the field (see, e.g., Zhan et al., 2021; Hashemzadeh et al., 2022; Zhaleh et al., 2023)—enable the observation of real or incentivized decisions, such as willingness to pay, under controlled conditions. This affords them high internal validity and a stronger capacity to identify causal relationships (Lusk & Briggeman, 2009). Nevertheless, these strengths come with trade-offs: such methods often suffer from limited external validity, involve higher logistical costs, and are less suitable for capturing complex cognitive and affective constructs associated with GMF acceptance (Grunert, 2015).

6. Conclusions

This paper analyzed the responses from a survey in Spain composed of members of Generations Z and Y regarding their acceptance of GMF. To do this, a theoretical ground based in TPB was applied in which the impact of input factors was evaluated both on expectation of behavioral intention (using PLS-SEM) and across the entire range of responses (using QR).

The model demonstrated good fit and solid predictive capacity, which supported the robustness of the analyses performed. In the PLS-SEM fit, the PV, PU, PR, and GEN variables were found to be significant. Additionally, it was observed that perceived benefits and subjective norms were the variables with the greatest impact, as they showed the largest effect size and their positive influence was consistent throughout the possible values of the response. The signs of the influence of PV, PR, and GENZ also remained consistent across all quantile regressions performed. However, while PV and PR showed significant coefficients in most of the adjustments, GENZ was significant only at the extremes of the range.

Although the impact of NPH was negative, as expected, its influence was not significant in either the PLS-SEM fit or eight of the nine quantile regressions. On the other hand, gender does not seem to be a significant factor, although in cases where some relevance was observed, the results suggest a greater tendency among women to accept GMF.

Following this analysis, several action strategies were proposed to encourage GMF consumption. These strategies are related to market segmentation, promotional actions, and labeling practices, with the goal of enhancing perceived usefulness, social influence, and perceived value, and reducing the perceived risk associated with GMF.

Beyond confirming established relationships identified in prior literature on GMF acceptance, this study offers three main contributions. First, it addresses a notable geographic gap by focusing on Spain—a European country where empirical studies on GMF adoption remain scarce, despite a socio-political context characterized by strong consumer skepticism and regulatory ambiguity. Second, the study targets Generations Y and Z, two cohorts increasingly central to market dynamics but understudied in GMF literature, providing valuable insights into the preferences and attitudes of emerging consumer groups.

Third, this research introduces a novel analytical approach by PLS-SEM with quantile regression. While TPB has been widely applied in food acceptance research, the use of QR to explore the heterogeneity of explanatory factors across the full distribution of behavioral intention is virtually absent in the field. This methodological innovation enables the identification of drivers that operate consistently at different levels of consumer predisposition—something conventional models fail to capture. In doing so, the study contributes both theoretically and practically to the development of more nuanced, targeted strategies for promoting GMF acceptance.

CRediT authorship contribution statement

Mario Arias-Oliva: Validation, Resources, Project administration, Methodology, Investigation, Conceptualization. **Jorge de Andrés-Sánchez:** Writing – original draft, Visualization, Software, Formal analysis. **Mar Souto-Romero:** Writing – review & editing, Validation, Supervision, Methodology. **Puelles-Gallo Maria:** Resources, Project administration, Investigation, Data curation, Conceptualization.

Informed consent

All participants provided their informed consent.

Institutional Review Board Statement

(1) All participants were given detailed written in-for-mation about the study and procedure; (2) no data directly or indirectly related to the health of the subjects were collected, and thus, the Declaration of Helsinki was not generally mentioned when the subjects were informed; (3) anonymity of the collected data was ensured at all times; (4) the ethical approval of this research was registered by the corresponding author's institution (CEIPSA-2025-PRD-0005).

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests, Mario Arias-Oliva reports article publishing charges, statistical analysis, and writing assistance were provided by Cátedra Smart Cities Universitat Rovira i Virgili. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1
Descriptive statistics of the items for latent constructs

Item	mean	Standard deviation	Factor loading
Behavioral intention (BI)			
BI1: I plan to include GMF in my diet.	5.00	5.02	0.95
BI2: I expect that I will consume GMF in the future.	6.45	4.80	0.93
Perceived value (PV)			
PV1: I believe GMF offers at a fair price.	5.00	5.08	0.80
PV2: GMF provides good quality for the cost.	4.00	4.96	0.94
PV3: The price of GMF is reasonable considering what they deliver.	2.89	4.60	0.92
Perceived usefulness (PU):			
PU1: I find the production and consumption of GMF to be beneficial.	6.00	4.92	0.93
PU2: Using and producing GMF helps to achieve important goals more efficiently.	6.00	4.93	0.91
PU3: There are numerous advantages associated with the use and development of GMF.	5.00	5.04	0.93
Perceived risk (PR)			
PR1: Eating GMF poses potential dangers.	2.79	4.51	0.91
PR2: There is considerable uncertainty linked to the consumption of GMF.	7.46	4.37	0.72
PR3: Compared to other food options, genetically modified products seem more hazardous.	3.96	4.92	0.92
Phobia to novel foods (NPH)			
NPH1: I typically avoid trying foods that are new to me.	0.45	2.08	0.72
NPH2: I am skeptical of foods created using genetic modification techniques.	0.33	1.80	0.84
NPH3: If I'm unfamiliar with a food's origin or production method, I prefer not to try it.	3.24	4.70	0.66
NPH4: I tend to dislike foods that come from foreign cultures or countries.	0.09	0.93	0.71
NPH5: Foods developed through genetic technologies make me feel uneasy.	0.53	2.24	0.81
NPH6: I'm highly selective about the new foods I'm willing to eat	2.46	4.32	0.69
Social influence (SI)			
SI1: People I value believe I should eat GMF.	1.25	3.32	0.94
SI2: Individuals who affect my decisions think I ought to consume GMF.	1.11	3.16	0.95
SI3: Those whose views matter to me would support my choice to eat GMF.	1.05	3.08	0.94

Table A2
Evaluation of the measurement model: reliability and validity Indicators

	(a)			(b)							
	CA	CR	AVE	BI	PV	PU	PR	NPH	SI	MAN	GENZ
BI	0.86	0.87	0.88	**0.94**	0.46	0.75	−0.55	−0.23	0.71	0.07	0.25
PV	0.87	0.90	0.79	*0.53*	**0.89**	0.51	−0.27	−0.07	0.34	0.08	0.19
PU	0.91	0.91	0.85	*0.85*	*0.56*	**0.92**	−0.53	−0.17	0.61	0.09	0.20
PR	0.81	0.87	0.73	*0.64*	*0.29*	*0.59*	**0.85**	0.34	−0.45	−0.17	−0.18
NPH	0.84	0.97	0.55	*0.23*	*0.08*	*0.17*	*0.38*	**0.74**	−0.19	0.00	−0.03

(*continued on next page*)

Table A2 (*continued*)

	(a)			(b)							
SI	0.94	0.94	0.89	*0.78*	*0.37*	*0.66*	*0.51*	*0.19*	**0.94**	0.12	0.18
MAN	—	—	1	*0.08*	*0.09*	*0.09*	*0.20*	*0.06*	*0.13*	**1**	−0.06
GENZ	—	—	1	*0.27*	*0.20*	*0.21*	*0.20*	*0.04*	*0.18*	*0.06*	**1**

Note: (a) Measures of internal consistency and reliability: CA = Cronbach's α; CR = composite reliability; AVE = average variance extracted. (b) Squared rooted AVE appears on the main diagonal; heterotrait–monotrait ratios (HTMT) are below the diagonal; Pearson correlations are above the diagonal.

Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors on request.

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