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From perception to preference: Insights on front-of-package nutrition labelling effectiveness from a choice experiment under time-pressure

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ABSTRACT

Front-of-package nutrition labelling (FOPNL) aims to help consumers make healthier food choices quickly, but adoptions in real life are challenging. The European Commission failed to reach a consensus on a harmonized European FOPNL, which was expected in 2022. Opposition to Nutri-Score (NS) led to the proposal of NutrInform Battery (NI), while the Multiple Traffic Lights (MTL) is being considered as possible compromise. This study examined how NS, NI, and MTL influence food choices under time pressure, compared to the standard nutrition facts table (NFT), and explored familiarity, understanding, and preferences in two European countries. An online choice experiment (between-group design) was conducted in a country with implemented NS (DE-Germany) and without implemented FOPNL (SI-Slovenia). The study included a sample of 1641 adult consumers representative for each country. Each was randomly assigned to NS, NI, MTL, or NFT group. In 10 timed (20s) product choices (cereals or yogurts), participants chose between options varying in nutritional composition, presence of EU organic label and price. Understanding was tested through ranking tasks, and further questions accessed preferences and familiarity. Results show that that under time pressure nutritional composition was the most important attribute guiding food choice, followed by price and the EU organic logo. This pattern was consistent across both countries and products. FOPNLs improved food choices compared to NFT, with country-specific differences: NS was most effective in Germany and MTL in Slovenia, which reflected level of familiarity and understanding of labels in each country. Good understanding of FOPNL was reflected in better food choices, while poor understanding (approx. 30 % of participants) resulted in worse food choices compared to NFT, which highlights the critical need for consumer education. Subjective preferences towards FOPNLs did not completely reflect their understanding and food choice. We conclude that FOPNLs can support healthier choices but may depend on consumer recognition and comprehension. Results stress the need for harmonized labelling backed by education and awareness to maximize positive impact of FOPNLs.

1. Introduction

Unhealthy dietary patterns are a major contributor to the global burden of non-communicable diseases (NCDs), including obesity, type 2 diabetes and cardiovascular diseases (World Health Organization, 2024). These adverse health outcomes are often linked to over-consumption of energy-dense, nutrient-poor foods with high levels of sugar, salt and saturated fats (Belc et al., 2019). One public health strategy to address this issue is empowering consumers to make healthier food choices by providing relevant nutritional information through food labelling (Gokani, 2024). However, food labelling is only effective if consumers notice it, accept it, and know how to interpret it. Otherwise, its impact is limited (Shangguan et al., 2019).

Front-of-package nutrition labelling (FOPNL) was presented as a strategy to simplify nutritional information of food packages and present it in a simplified format. By placing key nutritional indicators on the front of food packaging, FOPNL aims to guide consumers towards healthier choices at a glance. FOPNL systems vary in design, information load, and interpretability, and evidence suggests that these differences affect the level of how effectively FOPNL guides consumers towards

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healthier food choices (Feunekes et al., 2008). FOPNLs come in different formats. FOPNLs include both non-interpretative formats, such as Reference Intakes (RI) and NutrInform Battery (NI), which present numerical information per portion, and interpretative formats like Nutri-Score (NS) or the Multiple Traffic Light (MTL) system, which use colour or grading to summarise overall nutritional quality (Storcksdieck Genannt Bonsmann et al., 2020). While FOPNL as a concept was shown to be an effective public health tool (Jones et al., 2019), the effectiveness of specific scheme depends heavily on a number of contextual and design-related factors.

In recognition of FOPNL's potential public health benefits, the European Commission (EC) committed to propose the adoption of a harmonized, mandatory FOPNL across all member states (European Commission, 2020). Among the candidate systems, NS, a five-colour grading scheme, has been endorsed by several EU countries. While some studies indicate that interpretative schemes like NS can support healthier choices especially because of its straightforward interpretative design (Julia et al., 2025), others question their applicability across diverse diets and cultural contexts (Delhomme, 2021). One of such argument is that NS is calculated per 100 g (or mL), without consideration of portion sizes, which are important in the assessment of overall diet. As an answer, Italy proposed their own system NI, a non-interpretive, nutrient specific format in the form of battery icons, showing the percentage of reference intakes per portion (Donini et al., 2023). Meanwhile, the MTL developed in the UK is also a nutrient specific system, but uses colour coding (green, amber, red) (Department of Health and Social Care, Department of Health (Northern Ireland), The Scottish Government, & Welsh Government, 2020), offering a semi directive format, and is therefore often seen as middle ground between NS and NI. Despite the EC's initial support for FOPNL harmonization, its realization has been postponed, because views on different FOPNL systems are too polarized among Member States and there is insufficient and inconsistent evidence regarding the relative effectiveness of various FOPNLs, especially their impact on consumer behavior (European Parliament, 2025). This has delayed regulatory progress and maintained this area of food labelling unharmonized with various national and commercial schemes in place.

While studies on different FOPNL designs suggested advantages of interpretative schemes, results are not always fully conclusive. While some studies suggest that colour coded grading labels such as NS helps consumers' ability to identify healthier options (Pettigrew et al., 2023), other research points to comparable or stronger effects of labels like warning labels (Hock et al., 2021) or MTL systems (An et al., 2021). The variability in observed outcomes can be attributed to several external factors. FOPNL schemes do not exist in isolation, but are embedded in wider sociocultural, policy and food environments (Godden et al., 2023). National differences in labelling familiarity, consumer literacy, and nutritional education influence how effectively a given scheme is understood and used in real life (Taillie et al., 2020). Furthermore, individual preferences, purchasing habits, and cognitive biases often shape consumer responses to labelling. Studies suggest that taste and price remain the key drivers of food choices (Dana et al., 2021), while factors like sustainability have been gaining importance in the last couple of years (Brown et al., 2020). Time pressure is also an important factor in food purchasing and reflects modern fast-paced life (Schulte-Mecklenbeck et al., 2013). All these factors shape how effectively FOPNLs support consumers in making healthier food choices. However, many studies done on FOPNLs are conducted in controlled settings without competing stimuli or time pressure and are not taking into account national differences, which limits their real-life applicability. While consumer's exposure and recognition of FOPNL formats, together with cultural differences, vary widely across countries (Hock et al., 2021), such factors are critical to include as they are complicating conclusive insight into FOPNLs debate and consequently the development of a harmonized EU-wide FOPNL system.

The aim of our study was to assess relative effectiveness of FOPNLs guide consumers towards healthier choices compared to standard nutrition facts tables (NFTs). We tested the effects of the three FOPNL formats (NS, NI, and MTL) that are most relevant for EU policy, incorporating time pressure and two competing attributes (price and the EU organic label) to more closely approximate real-world conditions that are often not captured in controlled experiments. To account for country-differences, the study was conducted in two EU member states with different FOPNL environments: Germany - with government-supported voluntary use of NS (European Commision, 2020), and Slovenia, where no FOPNL format has been formally implemented. To give these exposure level differences (high in Germany and low in Slovenia) more context, we also examined several other factors, such as familiarity with the label, understanding and subjective preferences towards the investigated labelling schemes.

2. Conceptual development

2.1. Consumer processing of nutritional information

Food labelling serves as a tool to support informed food choices (Grunert & Wills, 2007). However, for food labelling to be effective, people have to have the opportunity to process the information (related to attention and exposure), understand it, believe it and find it relevant in a food purchasing situation (Grunert et al., 2014; MacInnis et al., 1991). Under these conditions it can affect purchase intention and actual food choice. The format of the information effects all steps of this cognitive process. According to persuasive communication theory, the format, source and clarity of a message determine whether and how it will influence behavior (Aagerup et al., 2019; Davies & Wright, 1994). Back-of-pack information, such as nutrition facts table (NFT), are a standard way of providing nutritional information, but their effectiveness on food choices has been found to be limited, since people rarely pay attention to them and they are also poorly understood (Shangguan et al., 2019). To address this issue, the FOPNL format was introduced, to facilitate attention and enable quicker and easier comprehension. Processing of FOPNLs can be explained by dual-processing theory and the use of System 1 (intuitive and fast) and System 2 (analytical and slow) cognitive processing. Processing of food labels can be categorized into four styles (ignorance, glance, skim, and elaboration), each influenced differently by various labelling formats. While ignorance is believed to be unaffected by any label, glance (System 1 dominant) responds best to health logos and colour-coding (NS), skim style (partial System 2) to MTL, and elaboration style (deep System 2) to NFT and RI (Sanjari et al., 2017).

Processing style activation depends on contextual and personal factors, especially time pressure, ego depletion, nutritional knowledge and health motivation. High time pressure or cognitive depletion suppresses deep System 2 and favors heuristic processing, while strong health motivation or adequate nutrition knowledge fosters deeper engagement. Conversely, low motivation or lower knowledge often reduces the likelihood of system 2 processing, leading consumers to rely on shortcuts or ignore labels altogether. Importantly, these situational factors help explain the inconsistency in the effectiveness of different label formats. One format may succeed in one context yet fail in another, depending on whether the consumer is guided by intuition or deliberation. This highlights the need for label designs that balance simplicity and detail, catering to both quick heuristic judgments and more deliberate comparisons. Moreover, consistent exposure to familiar formats can shift consumer reliance from System 2 to System 1 of processing, highlighting the role of exposure in shaping label use.

Although different styles of cognitive processing can influence food choice, research shows that in modern world situational factors most often drive decisions to be made within seconds, with little consideration, relying more on System 1 and heuristics (Milosavljevic et al., 2023; Storcksdieck Genannt Bonsmann et al., 2020).

2.2. Effectiveness of different FOPNL designs

Studies that measure how effectively FOPNLs communicate their message through format, with the aim of guiding consumers towards healthier choices (hereafter effectiveness), generally cover four important aspects: attention, understanding and effect on consumers intentions and food choices. Studies on FOPNLs mainly suggest that interpretative labels are more effective in most of the mentioned aspects (Storcksdieck Genannt Bonsmann et al., 2020). The more directive, colour-coded FOPNLs were shown to grab attention quicker and have a quicker response rate (Bix et al., 2015), which could indicate greater potential of such schemes under time pressure. Such label design also show better results in guiding consumers towards healthier food choices due to their simplicity and ease of understanding, which is aligned with the use of heuristic decision-making (Sanjari et al., 2017). However, an ongoing debate persists about the optimal interpretive format. Studies measuring objective understanding in most cases show that NS label design is best understood, normally followed by MTL, Health Star rating, Warning Label and RI, forming a hierarchy of directiveness of FOPNL designs (Egnell, Talati, Hercberg, Pettigrew and Julia, 2018; Vandevijvere et al., 2020). However, results are not always consistent and can vary across food categories and countries. These inconsistencies become more common when it comes to subjective preferences and food choices. MTL label design has high subjective preference in many countries, however there were notable differences between countries, which could reflect the familiarity and implementation of schemes in the local environment. Similarly, a study on food choices across 12 countries found differences in FOPNLs effectiveness that may be influenced by varying levels of public awareness (Talati et al., 2019a, 2019b). When looking at actual food choices, studies show that most FOPNLs formats mostly outperform the compulsory NFT, while differences between interpretative FOPNL formats can be limited, without a clear winner (An et al., 2021; Kelly et al., 2024).

Even though non-interpretative FOPNLs have been shown to be less effective in their design in guiding consumers towards healthier products, most of the research has focused on Guided Daily Amount, now referred as Reference Intakes. Italy's NI, visually similar to RI, emerged as upgraded version of non-interpretative FOPNL and as a counter to NS. Studies suggested some possible advantages of this system over more intuitive schemes like NS, linked with transparency and integrity of the presentation of detailed nutritional composition (Baccelloni et al., 2021; Mazzù et al., 2021). These results were additionally supported by a 20-country study that showed that the NI in most countries outperformed NS in consumer subjective understanding, including comprehensibility, help with shopping, and complexity reduction. The study also found that in most countries, consumers reported a higher overall liking for the NI, suggesting it may be more positively received and better trusted compared to NS across the EU (He et al., 2023). However, like in other subjective preferences studies, the results in this area also varies, with some studies showing reverse results with NS being more preferred in Portugal than NI (Vasseur et al., 2025). Further studies on the objective understanding and effect on food choices for NI format are still lacking.

Based on the theory and reviewed literature, the effectiveness of FOPNL format is clearly influenced by their design, with more directive formats generally performing better, however, inconsistencies across studies highlight the need to consider contextual factors such as cultural familiarity, label exposure, and food category when evaluating their real-world impact.

2.3. Country-specific differences in familiarity with FOPNL formats

One of the major factors accounting for country differences in FOPNL effectiveness is familiarity with different label formats. Familiarity facilitates attention and can facilitate interpretation, if previous exposures have resulted in the storage of information that can be used upon new exposure (Sanjari et al., 2017). This is particularly relevant because countries have very different adoptions rates and support different types of FOPNL. Country level factors are therefore important aspect to include in FOPNL research. While NS is adopted in France, Germany, Spain and some other countries, the NI is implemented in Italy and MTL in the UK (Storcksdieck Genannt Bonsmann et al., 2020); this could result in a more positive effect of these labels on food choices of consumers from those countries. Furthermore, country level support can also affect the trust of consumers. People trust more if something is recommended for use by government rather than manufacturers (Wu et al., 2021). It is also noteworthy that countries can differ in trust in the food supply, social trust, culture, nutritional knowledge and health motivation, which could have an effect on the trust and actual use of the food labels (Macready et al., 2020; Sun et al., 2015). Therefore, country level factors could possibly affect use of FOPNL through familiarity, trust and perceived usefulness.

2.4. Other factors of food choice

When evaluating the effectiveness of different FOPNL formats, it is important to recognize that, in real life, FOPNL schemes do not only compete with one another, but also with a range of other factors influencing consumer food choices. These factors can be divided into personal, situational or other product attributes (Chen & Antonelli, 2020). These external factors are often intertwined. Personal factors include the sociodemographic characteristics and people's nutritional knowledge and health motivation. Based on this, different label format could impact people differently (Godden et al., 2023). Situational factors refer to the context in which decisions are made, such as time pressure, location, shopping intentions, or whether a consumer is having ego depletion. Studies suggest that many food choices in the real world, especially in industrialized countries, are made under time-pressure (Jabs & Devine, 2006), which emphasizes the importance of System 1 and heuristic approach of System 2, which give higher potential to labels that are quickly and easily interpreted. Other product characteristics also substantially affect choices. While nutritional content plays a role, factors like price and taste are often more influential, followed by origin, brand, and sometimes, sustainability (Dana et al., 2021; De Bauw et al., 2022). Price plays a particularly strong role in consumer's food choices, as it reflects both economic accessibility and perceived value. Studies show that even health motivated consumers tend to prioritize affordability, especially in low-income groups (Pettigrew & Pescud, 2013). Price also functions as a quality signal, with both high and low prices shaping perceptions of product healthfulness and trust (Palma et al., 2016). In this context, the use of price in FOPNL research is important, as it represents a realistic competing cue that can either strengthen or overcome the nutritional message of a label. Similarly, organic production carries a diverse meaning for consumers, including environmental and health-related dimensions. Organic labels can create a health halo effect with higher perceived product quality and better nutritional profile, even when such perceptions are not always supported by objective evidence (Bschaden et al., 2022; Durand et al., 2025). Therefore, organic logos act as a powerful heuristic cue that can shape both attention and preferences, sometimes having stronger influence than nutritional information itself. Including organic production as an attribute in food choice acknowledges this broader competitive environment in which FOPNLs operate and allows a more accurate reflection of how consumers weigh different information during food choice. Given that FOPNL schemes are still relatively new to many consumers, they must not only capture attention but also be seen as relevant and credible to effectively compete with these other influential product attributes.

2.5. Conceptual model

Our conceptual model is shown on Fig. 1. Based on previous research and theoretical background discussed above, we propose that the effectiveness of FOPNL depends on label design, with interpretative

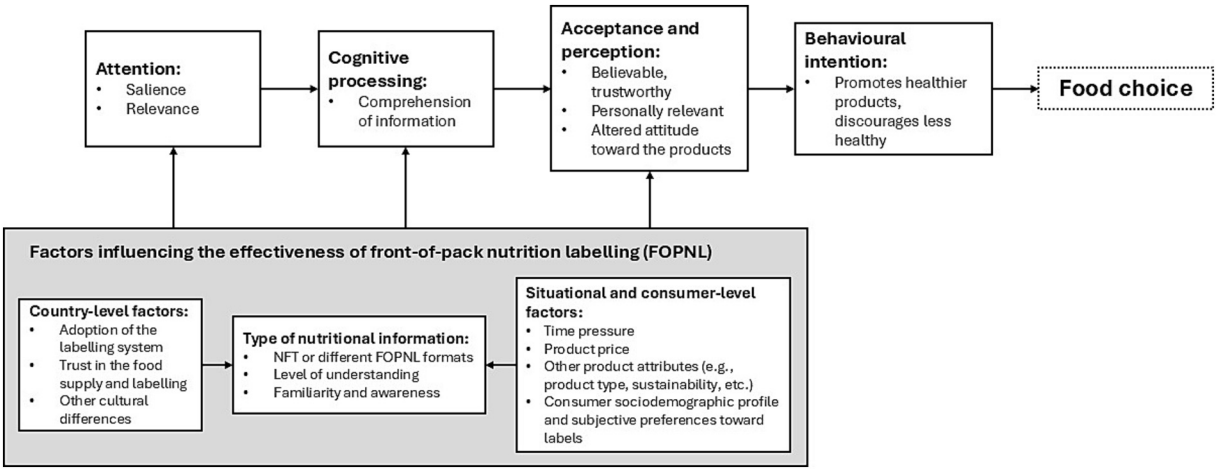

Fig. 1. Conceptual model illustrating the impact of food labelling on consumer food choices and factors influencing the effectiveness of front-of-package nutrition labelling (FOPNL); (NFT, nutrition facts table).

systems showing greater potential compared to non-interpretative ones. However, we also suggest that additional factors beyond label design, such as country differences (including FOPNL adoption rates and support), time-pressure and other factors, significantly influence FOPNL perception, including prior understanding, familiarity, and perceived relevance. These factors may cause variability in FOPNL effectiveness across countries, contributing to the inconclusive findings in existing research.

3. Materials and methods

3.1. Sampling and data collection procedures

Data was collected through an online survey conducted in June 2024. Participants from Slovenia (n = 821) and Germany (n = 820) were recruited through an online consumer panel of a market research agency. The study followed a between-group design, with participants randomly assigned to one of four food labelling conditions that were used in the choice experiment: NFT or one of three FOPNLs: NS, NI and MTL. Although the assignment into groups was done using generation of random numbers, this approach resulted in balanced distribution across gender, age, and education levels for all four groups.

Recruited participants were 18–64 years old, at least occasionally responsible for food purchases, and from households that consume the tested food categories (breakfast cereals and yogurts). Data received from the market research agency included participants that successfully completed the survey, with consideration of exclusion criteria. Individuals with colour blindness were excluded to ensure accurate perception of colour-coded FOPNLs, along with participants who had incomplete surveys or failed attention checks due to speeding.

The study consisted of four sections: (1) sociodemographic data and trust in the food supply, assessed using the validated TrustTracker tool (Macready et al., 2020); (2) a choice experiment with a conjoint design focusing on breakfast cereals and yogurts; (3) an FOPNL understanding assessment with ranking tasks; and (4) questions on familiarity and subjective preferences towards the investigated labelling schemes.

3.2. Discrete choice experiment

Conjoint analysis is a method to assess the relative importance consumers assign to a specific product characteristic in their decision-making process (Green & Srinivasan, 1978). It enables measuring the relative importance of attributes when they coexist, making the analysis more reflective of real-life situations (Natter & Feurstein, 2002). This study adopted choice-based conjoint analysis, which is the preferred method when price attribute is included (Kušar et al., 2023; Miklavec et al., 2015). The conjoint design included three product attributes: nutritional composition (with three levels, presented by one of four food labelling conditions), price (three levels), and the presence or absence of the EU organic logo. These attributes were applied to two food categories: breakfast cereals and flavored yogurts. Attribute levels for each group are shown in Fig. 2. The choice experiment design was developed using the dcreate function in STATA (version 17.0; StataCorp LLC, College Station, TX, USA), which employs a modified Fedorov algorithm to optimize the D-efficiency of the experimental design. An initial full factorial design comprising 18 unique product profiles was generated. To reduce respondent burden while retaining the ability to estimate main effects, an orthogonal fractional factorial design was applied, yielding a final set of 12 product profiles. The final design met the D-efficiency criterion, achieving a value of 0.86, indicating a high level of statistical efficiency (Carlsson & Martinsson, 2003; Cook & Nachtrheim, 1980; Zwerina et al., 2000). Each participant completed 10 choice tasks (five for breakfast cereals and five for flavored yogurts). Participants were choosing between 3 products; each selection was done twice – one for the product they would purchase, and one for the healthiest product. During the choice experiment the products were shown next to the attribute cards as a single example to guide participants. Participants then choose based on the cards next to the product image. Cards were divided into three attribute sections. All labels were uniform in size and optimized for readability on computer and mobile.

3.2.1. Stimuli (nutritional composition, Price, EU organic logo)

Breakfast cereals and flavored yogurts were selected as tested food products for this study, as they are common household staples worldwide. These products also have high variability in nutritional composition, that can be reflected by any of the selected FOPNLs (O'Mahony et al., 2023).

Participants were randomized into groups of approximately 200 people each, based on how the nutritional composition attribute was presented: NFT, NS, NI, or MTL. NFT served as the baseline group because this mandatory information is already available on prepackaged products in the EU. The three FOPNL systems were selected based on their differences in FOPNL format and as a potential candidate for FOPNL harmonization across Europe.

Nutritional composition was selected as a main attribute of investigation, with the aim of testing how different FOPNL designs could influence its importance and encourage healthier food choices. Levels were determined based on market observations for both food categories, using the latest data from the representative Slovenian branded food composition database CLAS (Pravst et al., 2022). Differences between

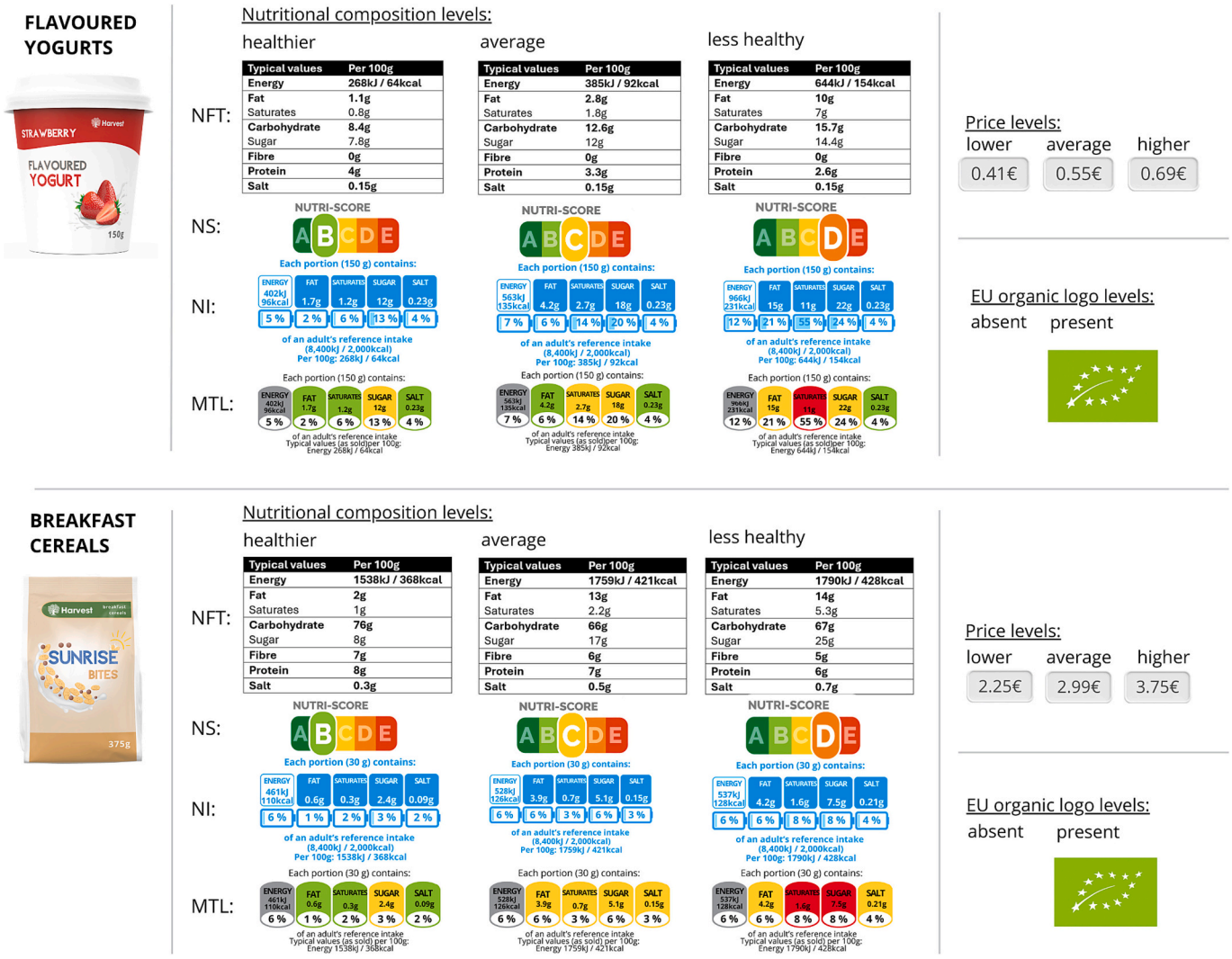

Fig. 2. Attribute levels of flavored yogurts and breakfast cereals in a choice-based conjoint experiment with between-group design using four nutritional labeling conditions (NFT: nutrition facts table, NS: Nutri-Score, NI: NutrInform Battery, MTL: Multiple Traffic Lights). [English translation].

levels were designed to be consistently reflected across all labelling conditions, ensuring no conflicting information while maintaining real-world relevance.

Price was selected as a second attribute of interest since many studies show it is one of the most influential factors in food choice, ranked just behind taste, which cannot be tested in an online study environment. Used prices of the products also reflected market observations based on CLAS database. First, we determined the most common food packaging for both categories, which was 150 g for flavored yogurts and 375 g for Breakfast cereals. The average price for each of those products was then determined, with the two additional price levels set at ±25 % of the average.

The organic production attribute was included in the conjoint design as part of the broader sustainability dimension, with evidence showing that such labels can influence not only food choices but also perceptions of healthiness (Bschaden et al., 2022). The EU Organic logo, introduced in 2010, is a well-established and regulated label in the EU (European Commission, 2010). It sets clear production standards and thus offers a high level of credibility and trust, particularly compared to less familiar and less institutionalized FOPNL systems. Importantly, when it comes to labelling, the EU organic logo is the most recognized label among European quality labels, making it a highly relevant reference point in studies of food labelling schemes (European Commission, 2024). This credibility is also reflected in market practices: in Slovenia, the EU organic logo is the most widely used logo on pre-packaged foods (Hafner et al., 2025). Including this attribute in the choice experiment therefore provides a realistic representation of consumer environments, as it captures a label with both strong market presence and consumer recognition. In the choice experiment we presented two levels for EU Organic logo (either present or absent).

3.2.2. *Time-pressure*

With fast paced modern lifestyle people might take less time to choose food products, which means they do not process information fully and ground their decision on a set of attributes or on single attribute important to them (Godinho et al., 2016). To bring our conjoint experiment closer to a real-life situation, we added time pressure to each of the experimental food choices. Time pressure was presented with a graphically highlighted 20s countdown per choice, which gradually changed colour from green (a lot of time) to red (lack of time). After the time went down, a warning message “Time is up, choose quickly!” was presented. To prevent dropouts, time pressure was not enforced, meaning their choice was still used after the timer ended; such an approach was also used previously (Panzone et al., 2020). The countdown time was selected based on the literature review and pre testing (van Herpen et al., 2011).

3.3. Objective knowledge, familiarity and subjective preferences

After the choice experiment, the study questionnaire included a section on objective knowledge of FOPNLs and NFT. Study participants completed two ranking tasks (one on flavored yogurts and one on breakfast cereals – the same products as in choice experiment, but only showing the nutritional composition) where they had to rank three products from "healthiest" to "least healthy". A similar approach was used before (Egnell et al., 2020; Hodgkins et al., 2015). This section included the ranking of products based on the labelling condition they were exposed to in the choice experiment (either NFT, NS, NI or MTL). Correct ranking tasks for both products (flavored yogurt and breakfast cereal) were considered as good understanding. In this section, participants were not exposed to time pressure, but we were measuring ranking time in the background. After ranking, participants were asked about their familiarity with FOPNL conditions (NS, NI, MTL) and the EU organic logo. A series of Likert scale questions about their subjective preferences towards those labels were also used. Likert scale questions were adopted from previous study on the FOPNL perception done in several European countries (Talati, Egnell, Hercberg, Julia and Pettigrew, 2019a).

3.4. Data analysis

For data analysis we used STATA (version 17.0; StataCorp LLC, College Station, TX, USA), R-environment and Microsoft Excel. Choice experiment data were analyzed with ChoiceModelR package in R (Chapman & McDonnell Feit, 2019; Sermas, 2024). The ChoiceModelR function implements a hierarchical Bayesian multinomial logit model using Markov Chain Monte Carlo sampling to estimate individual-level part-worth utilities (PWU). This method captures variation in preferences across individuals, allowing for accurate estimation of choice behavior. For each participant we determined Relative importances (RI) of each attribute and attribute levels PWU; four such calculations were carried out (reflecting 2 different tested products and 2 different choices (product they would choose and product they think is healthiest)). Results were presented as mean PWU and RI per each food labelling condition group (NFT, NS, NI, MTL) two different choices (actual choice and perceived healthiness), two different testing products, and per each country (DE, SI).

The other parts of the study were analyzed by descriptive statistics. Differences of means for Likert Scale questions were analyzed with Friedman test with post-hoc Wilcoxon nonparametric test.

4. Results

In the study we recruited 2504 participants who agreed to participate, of whom 863 were excluded for not meeting inclusion criteria or not completing the survey. Detailed data on inclusion-exclusion and further allocations are shown on Fig. 3.

The final sample consisted of 1641 participants, evenly distributed between Slovenia ($n = 821$) and Germany ($n = 820$) (Table 1). Gender distribution was balanced, with female and male participants each representing 50 % of the sample. Minor differences were observed between Slovenian and German participants concerning education level, self-assessed economic status, and nutritional knowledge. Specifically, German participants were more commonly highly educated, had higher self-assessed economic status, and better nutritional knowledge, compared to their Slovenian counterparts. Moreover, a notably larger proportion of German participants lived in urban areas (70 %) compared to participants from Slovenia (58 %). According to the TrustTracker measure, German participants trust food chain actors more (4.3 (±1.1)) (especially manufacturers, retailers, and authorities) than Slovenians (4.0 (±1.1). In both countries, farmers were the most trusted, with Slovenian participants showing even greater trust (5.1 (±1.4)) in them than Germans (4.9 (±1.4)). Ranking factors influencing food choices revealed consistent results across both countries, with taste identified as the most subjectively significant factor, followed by price, nutritional composition, origin, organic production, and, least importantly, brand. Similar participant distributions were maintained across all four groups in the between-group design, ensuring comparability for subsequent conjoint analysis.

4.1. Familiarity with FOPNLs and consumer preferences

Results in Table 2 show participants' familiarity with and subjective preferences for the tested labels. There was high and comparable recognition of the EU Organic logo in Germany (84 %) and Slovenia (83 %). The most recognized label in Germany was FOPNL NS, with a recognition rate of 95 %, whereas in Slovenia, fewer than half of the participants (45 %) recognized it. In Slovenia, the most familiar FOPNL was MTL (53 %), which was also similarly recognized in Germany (56

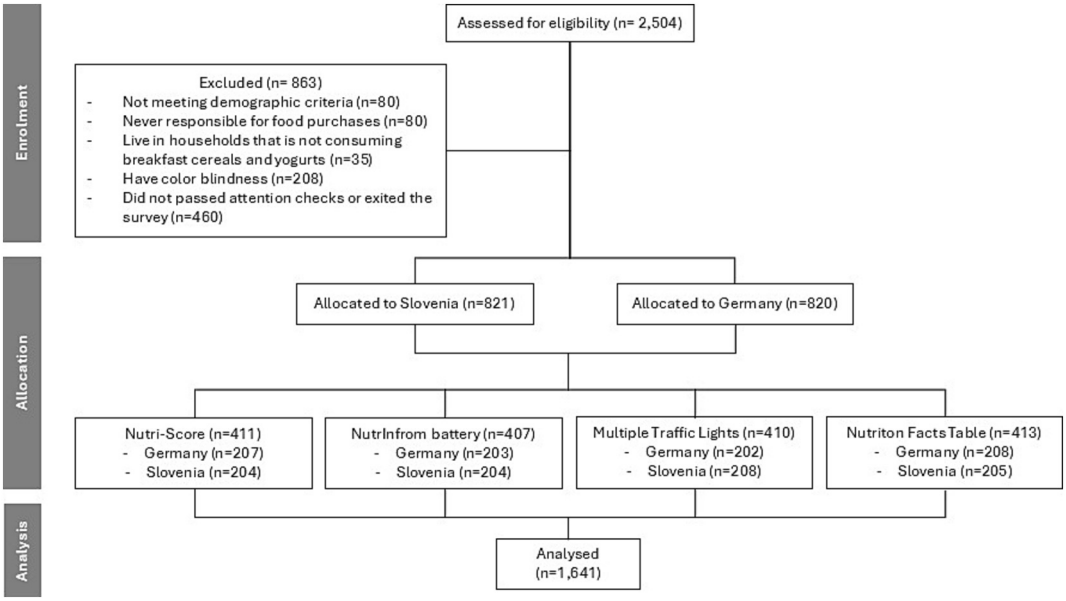

Fig. 3. Flow chart of an online survey conducted in Slovenia and Germany.

Table 1
Demographic and lifestyle characteristics of the study sample.

	Total sample $n = 1641$	Germany $n = 820$	Slovenia $n = 821$
Sex, n (%)			
Male	817 (50 %)	401 (49 %)	416 (51 %)
Female	818 (50 %)	413 (50 %)	405 (49 %)
Other	6 (< 1 %)	6 (1 %)	0 (0 %)
Age, n (%)			
18–24 y	183 (11 %)	96 (12 %)	87 (11 %)
25–34 y	316 (19 %)	166 (20 %)	150 (18 %)
35–44 y	365 (22 %)	168 (21 %)	197 (24 %)
44–54 y	377 (23 %)	182 (22 %)	195 (24 %)
55–64 y	400 (24 %)	208 (25 %)	192 (23 %)
Education, n (%)			
Lower secondary	35 (2 %)	17 (2 %)	18 (2 %)
Upper secondary	372 (23 %)	291 (36 %)	81 (10 %)
Post-secondary non-tertiary	376 (23 %)	53 (7 %)	323 (39 %)
Short-cycle tertiary	265 (16 %)	162 (20 %)	103 (13 %)
Bachelor's or equivalent	144 (9 %)	38 (5 %)	106 (13 %)
Master's or equivalent	305 (19 %)	137 (17 %)	168 (21 %)
Doctoral or equivalent	144 (9 %)	122 (15 %)	22 (3 %)
Self-perceived economic status, n (%)			
Very below average	98 (6 %)	54 (7 %)	44 (5 %)
Slightly below average	281 (17 %)	127 (16 %)	154 (19 %)
Average	864 (53 %)	410 (50 %)	454 (55 %)
Slightly above average	364 (22 %)	203 (25 %)	161 (20 %)
Very above average	34 (2 %)	26 (3 %)	8 (1 %)
Living area, n (%)			
Urban	1045 (64 %)	573 (70 %)	472 (58 %)
Rural	596 (36 %)	247 (30 %)	349 (43 %)
Self-perceived nutritional knowledge, n (%)			
No knowledge	38 (2 %)	22 (3 %)	16 (2 %)
A little	238 (15 %)	115 (14 %)	123 (15 %)
Somewhat	1100 (67 %)	534 (65 %)	566 (69 %)
A lot	265 (16 %)	149 (18 %)	116 (14 %)
Trust in food chain actors, mean (±sd) *	4.2 (±1.1)	4.3 (±1.1)	4.0 (±1.1)
Farmers	5.0 (±1.4)	4.9 (±1.4)	5.1 (±1.4)
Manufacturers	3.8 (±1.5)	4.0 (±1.5)	3.6 (±1.5)
Retailers	4.0 (±1.4)	4.3 (±1.4)	3.8 (±1.5)
Authorities	3.9 (±1.6)	4.1 (±1.6)	3.6 (±1.6)
Factors affecting food choices, mean (±sd) *			
Taste	4.5 (±1.4)	4.8 (±1.3)	4.2 (±1.5)
Price	4.1 (±1.6)	4.0 (±1.6)	4.2 (±1.6)
Nutritional composition	3.8 (±1.5)	3.6 (±1.5)	4.0 (±1.5)
Origin	3.4 (±1.6)	3.3 (±1.5)	3.5 (±1.6)
Organic production	3.1 (±1.6)	3.0 (±1.6)	3.1 (±1.6)
Brand	2.1 (±1.4)	2.3 (±1.6)	2.0 (±1.3)

Notes:* 7-point Likert scale data.

%). The least recognized label in both countries was NI, with fewer than one-third of participants identifying it (31 % in Germany and 27 % in Slovenia).

Consumer subjective preferences for labelling schemes were examined through questions assessing likability, trust, perceived understanding, usefulness and support for compulsory use (Table 2). The MTL appeared as the preferred label in both Germany and Slovenia. In Germany, MTL had significantly higher mean likability (4.9 compared to 4.7 for second rated NS), trust (4.8 vs. 4.5 NS) and usefulness (4.9 vs. 4.6 NS; all $p < 0.05$). MTL and NS were rated equally in understanding and support for compulsory use, both with mean score of 5.2 and 5.0,. In Slovenia, MTL also received the highest scores across all aspects, with 5.0 for likability, 4.8 for trust, 5.2 for understanding and 5.1 for usefulness. NS and NI were comparable in most aspects, with trust rated at 4.3 and 4.4, and understanding at 4.7 and 4.6, respectively. However, in terms of likability, NS clearly outperformed NI (4.7 compared to NI 4.4; $p < 0.05$). Cross-country comparisons for FOPNLs revealed that NS was overall more favored in Germany, whereas MTL was more favored in Slovenia. Interestingly, a higher level of interpretability (colours and grading system), typically associated with easier comprehension, did not consistently translate into higher perceived understanding. Furthermore, the relationship between label familiarity and subjective preferences was explored. Results indicated a notable difference in subjective preferences between participants familiar and unfamiliar with each label. Participants familiar with a given label reported higher levels of likability, trust, perceived understanding, usefulness and support for compulsory use, compared to those who were unfamiliar with the label. In Germany, the most preferred FOPNL among the familiar group was NI, followed closely by MTL, while in Slovenia, MTL remained the top choice. In the non-familiar group, MTL was the preferred option in both countries. While familiarity positively affected all labels, the most notable differences were observed for the EU organic logo (both countries) and NI in Germany, and for NS in Slovenia.

4.2. *Objective knowledge*

Results of the ranking test assessing participants' objective understanding of the nutritional information provided by either NFT or FOPNLs are shown in Table 3. In Germany, the highest rate of correct responses was observed for the NS, with 87 % of participants accurately ranking both tasks. This was followed by MTL (76 %), NI (67 %), and the NFT (66 %). In Slovenia, overall performance was lower across all labels. MTL was the most accurately understood label (70 %), followed by NS (66 %), NI (65 %), and NFT (53 %). To further explore the role of label

Table 2
Number and percentage of participants who recognized each label and mean (± sd) scores for various label perception metrics.

	I have seen this label before	I like this label	I trust this label	This label is easy to understand	This label would help me with my purchasing decisions	It should be compulsory for this label to be shown on packaged food products
GERMANY (*N* = 820)						
Nutri-Score		4.7 (± 1.8) [a]	4.5 (± 1.8) [a]	5.2 (± 1.7) [a]	4.6 (± 1.9) [a]	5.0 (± 1.8) [a]
familiar	775 (95 %)	4.7 (± 1.8)	4.5 (± 1.6)	5.2 (± 1.9)	4.6 (± 1.8)	5.0 (± 1.8)
non-familiar	45 (5 %)	3.8 (± 1.8)	4.0 (± 1.7)	4.2 (± 1.8)	3.9 (± 2.0)	4.2 (± 2.0)
NutrInform battery		4.3 (± 1.8) [b]	4.4 (± 1.7) [a]	4.7 (± 1.8) [b]	4.4 (± 1.9) [b]	4.6 (± 1.8) [b]
familiar	254 (31 %)	5.3 (± 1.9)	5.2 (± 1.6)	5.6 (± 1.9)	5.2 (± 1.8)	5.3 (± 1.9)
non-familiar	566 (69 %)	3.8 (± 1.7)	4.1 (± 1.7)	4.3 (± 1.8)	4.1 (± 1.8)	4.2 (± 1.8)
Multiple traffic lights		4.9 (± 1.7) [c]	4.8 (± 1.6) [b]	5.2 (± 1.6) [a]	4.9 (± 1.8) [c]	5.0 (± 1.7) [a]
familiar	461 (56 %)	5.2 (± 1.8)	5.2 (± 1.6)	5.5 (± 1.8)	5.2 (± 1.8)	5.3 (± 1.7)
non-familiar	359 (44 %)	4.4 (± 1.8)	4.4 (± 1.7)	4.8 (± 1.8)	4.5 (± 1.9)	4.6 (± 1.8)
EU Organic logo		4.5 (± 1.7) [d]	4.5 (± 1.7) [a]	4.3 (± 1.9) [c]	4.2 (± 1.8) [d]	/
familiar	691 (84 %)	4.7 (± 1.8)	4.7 (± 1.7)	4.5 (± 1.9)	4.4 (± 1.8)	/
non-familiar	129 (16 %)	3.3 (± 1.7)	3.3 (± 1.6)	3.0 (± 1.8)	3.2 (± 1.7)	/
SLOVENIA (N = 821)						
Nutri-Score		4.7 (± 1.8) [a]	4.3 (± 1.7) [a]	4.7 (± 2.0) [a]	4.5 (± 1.9) [a]	4.9 (± 1.8) [a]
familiar	372 (45 %)	5.3 (± 1.7)	4.9 (± 1.7)	5.4 (± 1.8)	5.0 (± 1.8)	5.3 (± 1.8)
non-familiar	449 (55 %)	4.2 (± 1.8)	3.8 (± 1.6)	4.1 (± 1.9)	4.1 (± 1.8)	4.5 (± 1.8)
NutrInform battery		4.4 (± 1.9) [b]	4.4 (± 1.7) [a]	4.6 (± 1.9) [a]	4.6 (± 1.9) [a]	4.8 (± 1.9) [a]
familiar	178 (22 %)	5.0 (± 1.8)	5.1 (± 1.7)	5.2 (± 1.8)	5.0 (± 1.8)	5.4 (± 1.7)
non-familiar	643 (78 %)	4.2 (± 1.5)	4.2 (± 1.5)	4.5 (± 1.4)	4.4 (± 1.6)	4.6 (± 1.6)
Multiple traffic lights		5.0 (± 1.7) [c]	4.8 (± 1.7) [b]	5.2 (± 1.8) [b]	5.1 (± 1.7) [b]	5.4 (± 1.7) [b]
familiar	437 (53 %)	5.3 (± 1.7)	5.1 (± 1.6)	5.6 (± 1.6)	5.3 (± 1.7)	5.6 (± 1.6)
non-familiar	384 (47 %)	4.8 (± 1.4)	4.4 (± 1.4)	4.9 (± 1.5)	4.8 (± 1.6)	5.1 (± 1.6)
EU Organic logo		5.0 (± 1.7) [c]	4.7 (± 1.7) [b]	4.8 (± 1.9) [a]	4.6 (± 1.8) [a]	/
familiar	683 (83 %)	5.2 (± 1.6)	4.9 (± 1.7)	5.0 (± 1.8)	4.7 (± 1.7)	/
non-familiar	138 (17 %)	3.9 (± 1.6)	3.6 (± 1.7)	3.6 (± 1.8)	3.7 (± 1.8)	/

Notes: Values not sharing the same superscript letter (for each column within country) are significantly different ($p < 0.05$) (post-hoc comparisons). Scores: 7-point Likert scale data.

Table 3
Participants' understanding and median time (s) for correct healthiness ranking across labelling formats in Germany and Slovenia.

	GERMANY			SLOVENIA		
	Understanding		Median time to correct ranking	Understanding		Median time to correct ranking
	Good	Poor		Good	Poor	
Nutritional table n(%)	**138 (66 %)**	**70 (34 %)**	**24 s**	**109 (53 %)**	**96 (47 %)**	**23 s**
Nutri-Score n(%)	**180 (87 %)**	**27 (13 %)**	**12 s**	**135 (66 %)**	**69 (34 %)**	**13 s**
familiar	173 (88 %)	23 (12 %)		69 (74 %)	24 (26 %)	
non-familiar	7 (64 %)	4 (36 %)		66 (59 %)	45 (41 %)	
NutrInform battery n(%)	**136 (67 %)**	**67 (33 %)**	**19 s**	**133 (65 %)**	**71 (35 %)**	**22 s**
familiar	58 (61 %)	37 (39 %)		39 (66 %)	20 (34 %)	
non-familiar	78 (72 %)	30 (28 %)		94 (65 %)	51 (35 %)	
Multiple traffic lights n(%)	**154 (76 %)**	**48 (24 %)**	**16 s**	**145 (70 %)**	**63 (30 %)**	**18 s**
familiar	101 (78 %)	29 (22 %)		84 (71 %)	34 (29 %)	
non-familiar	53 (74 %)	19 (26 %)		61 (68 %)	29 (32 %)	

Notes: Understanding was classified as good if the participant correctly completed both ranking tests (on flavored yogurts and breakfast cereals).

familiarity in objective understanding, participants were split based on their prior question about the familiarity to the assigned FOPNL. Familiarity was found to be connected to understanding. While differences between familiar and unfamiliar participants were modest for NI and MTL, a larger gap was observed for NS. As part of the ranking tasks, the time required to correctly complete the tasks was also recorded in the background. On average, German participants completed the tasks more quickly than their Slovenian counterparts. Across both countries, the shortest median time was recorded for NS (12 s, 13 s), followed by MTL (16 s, 18 s), NI (19 s, 22 s), and NFT (23 s, 24 s), reflecting the interpretability hierarchy of the labels.

4.3. Choice experiment

Through the conjoint experiment we investigated the importance of nutritional composition, price and EU organic logo on choices of flavored yogurts and breakfast cereals and their perceived healthiness. Mean part-worth utilities (PWU) for attribute levels and relative importance (RI) of attributes across labelling groups and countries are shown in Fig. 4.

Nutritional composition consistently showed the highest RI for product choice across all labelling groups (46–67 %). Healthier compositions were associated with positive PWU, while less healthy ones had negative PWU. However, the range of PWU varied between countries and labelling formats. In Germany, participants exposed to NS demonstrated the widest PWU range for nutritional composition, particularly for yogurts, indicating stronger differentiation between levels. This was followed by MTL, though the differences between MTL, NI, and NFT were limited. In contrast, Slovenian participants showed generally narrower PWU ranges across all labelling conditions, suggesting lower sensitivity to nutritional composition levels. Among Slovenian groups, MTL showed the widest PWU range, while NS had the narrowest. In both countries, the difference in PWUs between the middle and low nutritional composition levels was slightly greater than between the middle and high levels, indicating that consumers are somewhat more influenced by discouraging less healthy options than by promoting healthier ones.

Price was the second most important attribute in product choices, with RI ranging from 23 % to 46 %. The lowest price levels consistently had positive PWUs, while the highest had negative PWUs. In Germany, even the middle price level was slightly negatively perceived, whereas in Slovenia, it had a near-zero PWU. German participants also showed higher average RI for price than Slovenians. Price appeared slightly more dominant for breakfast cereals than yogurts, possibly due to larger absolute differences between price levels. The EU organic logo had the lowest RI (8–14 %) across all groups, with no meaningful variation between labelling conditions.

Patterns in perceived healthiness mirrored those of product choice, but with approximately double the PWU range. Nutritional composition had an even higher RI (65–79 %), mainly due to a reduction in the importance of price, while the RI of the organic logo remained stable. NS continued to show the widest PWU range in Germany, and MTL in Slovenia, for both food categories.

To gain additional insights, we also analyzed product choice data based on participants' familiarity and understanding of the labelling conditions.

Understanding was shown as a pronounced predictor of product choices (see Fig. 5). Participants with better understanding of the labelling scheme showed higher RI of nutritional composition and wider PWU ranges, indicating greater sensitivity to composition differences. NS remained the most effective in Germany, and MTL in Slovenia. More notable were the results among participants with poor understanding. In this group, NFT often had a more positive influence on food choices than the FOPNL formats. The effect of FOPNLs was minimal, with MTL performing best. In some cases, such as yogurts (both countries) and breakfast cereals (Germany), NS even showed reversed PWU patterns: lower nutritional composition levels received positive PWUs, and higher composition negative, suggesting possible reversed misinterpretation in those not familiar with such label. Given that around one third of participants demonstrated poor understanding of the labelling conditions, these findings highlight a topic that should be further investigated. We also compared PWU by education level and found slight differences, with more educated participants being somewhat more influenced by the composition attribute. However, when comparing label groups, the overall trend remained consistent, with NS being most effective in Germany and MTL in Slovenia, regardless of education level.

5. Discussion

The present study explored the effectiveness of different FOPNL formats in affecting health perceptions and stimulating healthier food choices among consumers. It focused on decision-making in scenarios resembling real-world situations by incorporating a time-pressured environment, competing product attributes such as price and the EU organic logo, and was tested across two countries with differing levels of the implementation of FOPNL. The study findings indicate that nutritional composition was an important product attribute for food choice and that FOPNLs, particularly interpretative formats like NS and MTL, are generally easier and quicker to understand and more effective at guiding consumer choices compared to the traditional NFT. However, the impact of FOPNL may differ across countries and is likely influenced by consumers' familiarity and awareness of the label and consequently their understanding.

In the discrete choice experiment nutritional composition was the most important attribute, followed by price and the EU organic logo. This pattern was consistent across both tested products and countries. Studies often expose that in real life price is usually the dominant driver of food choice, right behind the taste (Dana et al., 2021), which was also

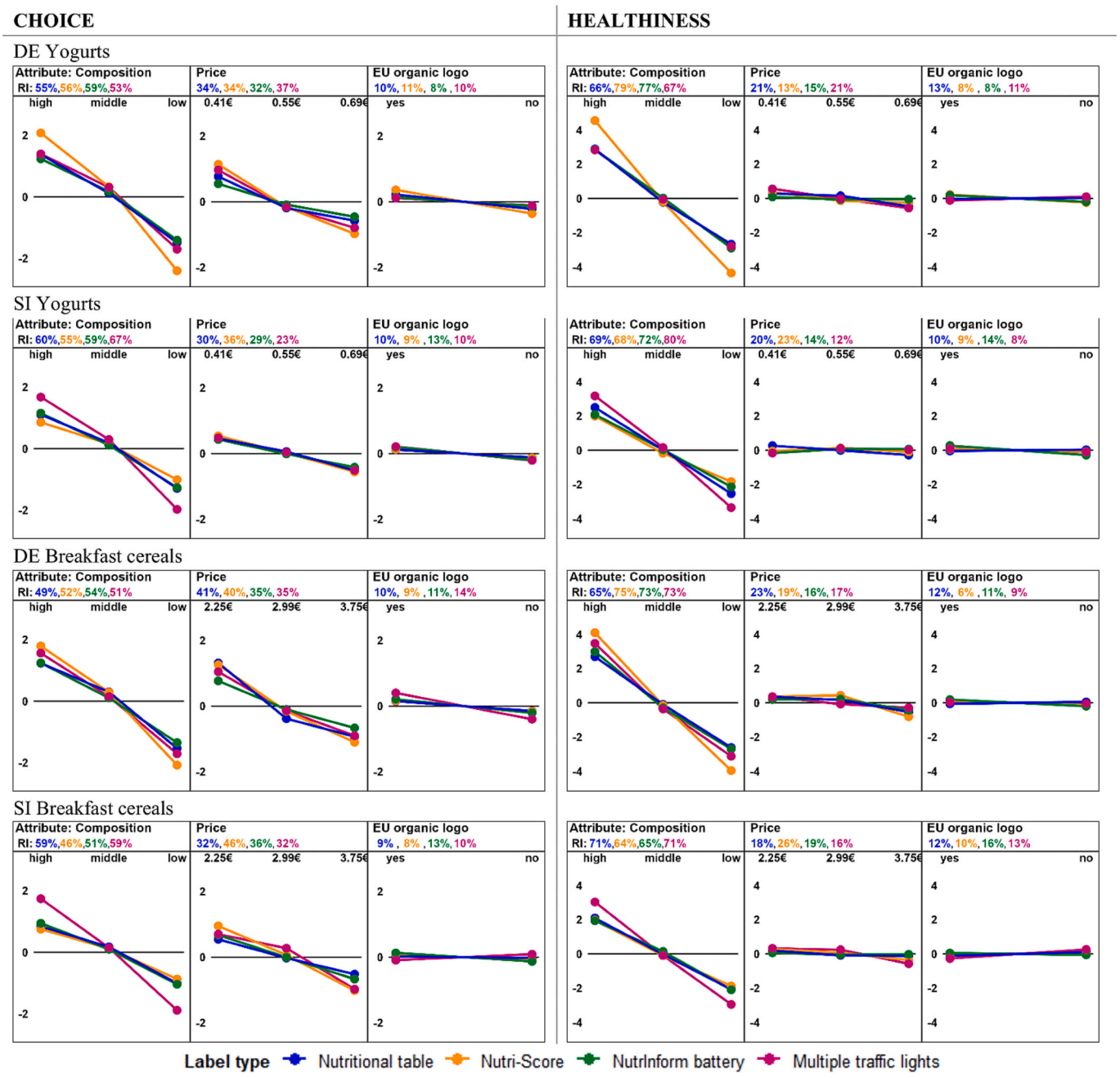

Fig. 4. Mean part-worth utilities and relative importance (RI) of nutritional composition, price, and EU organic logo on product choice and perceived healthiness of yogurts and breakfast cereals by labelling format and country.
Notes: DE: Germany; SI: Slovenia; Choice refers to the question: "Which product would you purchase?" and Healthiness refers to the question: "Which product is the healthiest?"

seen in our sample in participant subjective ranking of the attributes. Price has an effect either through preference for cheaper products or as a perceived quality cue (Grunert, 2002). The difference in our results can be explained by the conjoint design. All attributes were presented with equal weight, which meant that nutritional composition could not be overlooked as it often is in a supermarket (Grunert, Fernández-Celemín, Wills, Storcksdieck Genannt Bonsmann and Nureeva, 2010; Rønnow, 2020). Price variability was also controlled and did not include extremes that can strongly influence real-world behavior (Verlegh, Schifferstein and Wittink, 2002). In addition, participants did not make actual purchases, which may have reduced price sensitivity and shifted attention towards nutrition. Still, the direction was clear because lower prices encouraged choice while higher prices discouraged it. The EU organic logo had only a minor effect, modestly increasing preference. This finding is consistent with previous studies that show only a small segment of consumers values organic production highly while most consumers give priority to other attributes (Schäufele-Elbers & Janssen, 2023). Even though sustainability aspect grows, this might not exceed importance of price and composition for the majority of consumers. Further segmentation analysis would provide deeper insights, but this was beyond the scope of our study. Our main objective was to compare FOPNLs and the experiment showed cross-country differences in the effectiveness of FOPNLs for both food choices and for identifying the healthiest option. In Germany, NS was the most recognized and best understood FOPNL, with the most notable effect on participants' food choices. Several external factors likely contributed to this: Germany

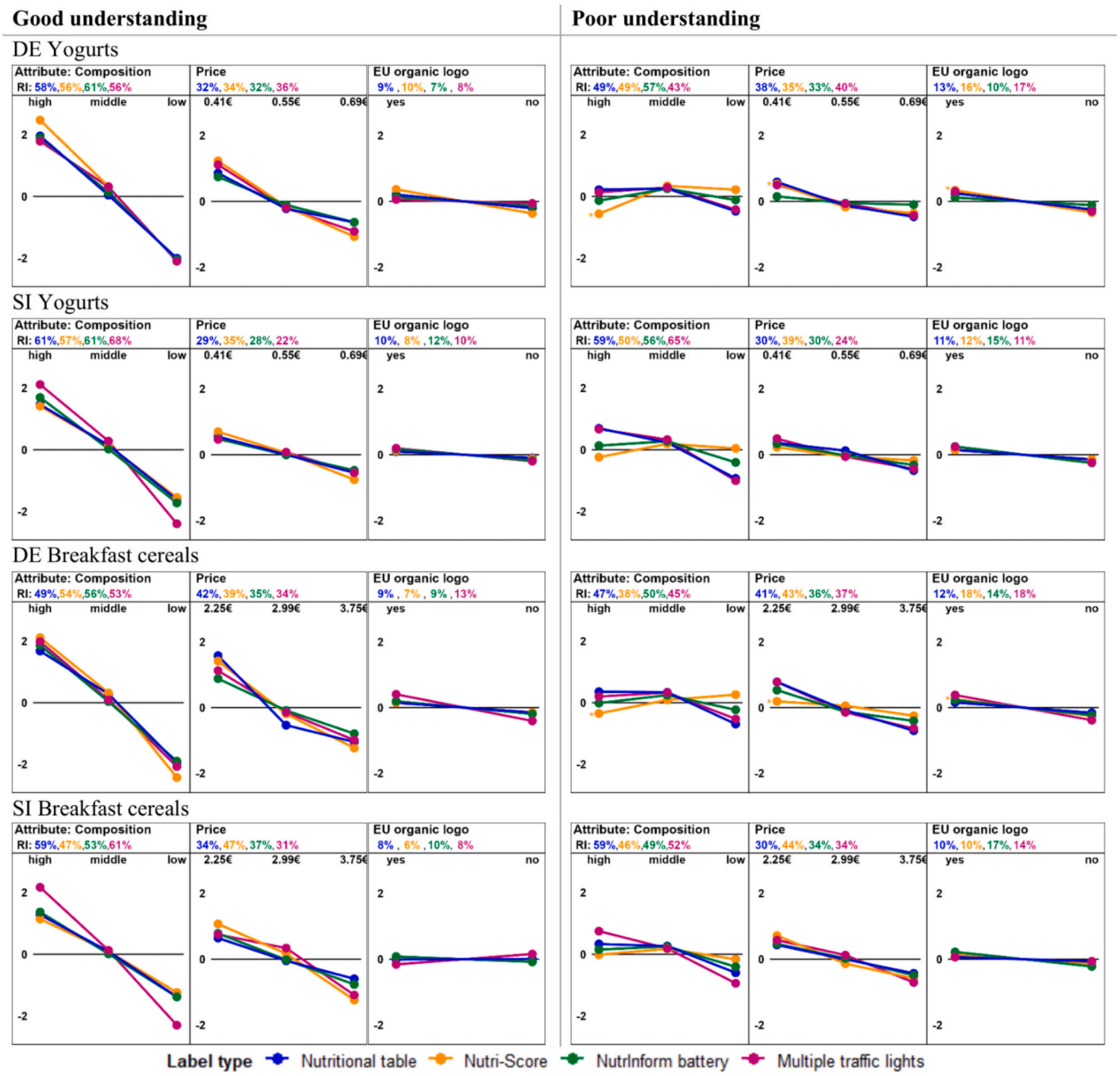

Fig. 5. Mean part-worth utilities and relative importance (RI) of nutritional composition, price, and EU organic logo on product choice of yogurts and breakfast cereals by labelling format and country, further disaggregated based on consumers' label understanding.
Notes: *$n < 30$; DE: Germany; SI: Slovenia; Good understanding was determined as correct ranking tasks for both products (flavored yogurts and breakfast cereals).

officially endorsed the NS in November 2020, prompting adoption by national brands (Deutschland, 2025; Fedde, Büttner-Koc, Plähn and Bosy-Westpha, 2022). Despite the absence of a government-led awareness campaign, consumer and non-governmental organizations in Germany have also actively promoted NS by informing the public and conducting product comparisons that include NS ratings (FoodWatch, 2022; Warentest, 2024). Therefore, according to a 2024 report from the German Federal Ministry of Food and Agriculture, consumer awareness of NS rose from 44 % in 2021 to 88 % in 2024, with 37 % of consumers reporting that the label influences their purchasing decisions (German Federal Ministry of Food and Agriculture, 2024). In contrast, Slovenia has not officially endorsed any FOPNL to date. A recent study on a representative sample of branded foods in Slovenia also found that FOPNLs are rarely used on food packaging and mostly limited to specific food categories, which restricts consumer exposure to these labels (Hafner et al., 2025). This is reflected in our results, which show notably lower recognition of all FOPNLs, compared to Germany. The most effective FOPNL in Slovenia was the MTL, which was also the most recognized and best understood among Slovenian consumers. Although not officially supported, the MTL format has gained visibility in Slovenia through alternative channels. In 2019, the mobile app VešKajJeš (in English "Do You Know What You Eat") was launched in Slovenia as part of a national health promotion programme, supported by the Ministry of Health (Pravst et al., 2022). The app allows users to scan food barcodes and view the nutritional composition of products in MTL format. Over time, the app's user base grew, and the MTL format became a common way to present nutrition information, likely increasing public familiarity and acceptance. The observed differences in label effectiveness between

countries support the theory that exposure through food packaging, public campaigns, or similar initiatives can increase familiarity. Greater familiarity can build trust and encourage label use, as seen in the stronger impact of NS in Germany and MTL in Slovenia (Sanjari et al., 2017). These findings suggest that effectiveness of FOPNL should be interpreted with caution and in light of contextual factors, such as national policies, label visibility, and public education. Results also highlight the large potential of FOPNLs when properly promoted. While FOPNLs show potential, we must highlight that excluding the clear winners within the single country, we can see that other FOPNLs did not notably differ from the effect of NFT on food choice. This goes for MTL and NI in Germany and NS and NI in Slovenia. While we suspect this is connected to the familiarity aspect further research at this topic would be helpful (Verlegh, Schifferstein and Wittink, 2002)

Ranking tasks evaluating understanding of labelling conditions showed similar trends than those seen in food choices. The ranking tasks confirmed that participants generally understood FOPNLs better and quicker than the traditional NFT, even without prior familiarity, showing that the goal of simplified and quick nutritional information is being met (Storcksdieck Genannt Bonsmann, Marandola, Ciriolo, van Bavel and Wollgast, 2020). Understanding improved with familiarity, especially for NS, and was higher among German participants, reflecting once more differences between countries and their exposures. Better understanding was reflected in healthier food choices and more accurate perceptions of product healthfulness. On the other hand, poor understanding led to poor effectiveness of the labels or even led to opposite effects. As 30 % of participants had poor understanding, this highlights the critical need for consumer education. Reduced or even opposite effects may occur due to misinterpretation of the label or perceived irrelevance due to unfamiliarity (Meijer, Detzel, Grunert, Robert and Stancu, 2021), or low trust in the label combined with the belief that healthier products are less tasty (Raghunathan, Naylor and Hoyer, 2006). This reflects results from a previous study, which highlighted that people who chose healthier products (using NS) were also the ones who were more familiar with NS and had better understanding of it (Godden et al., 2023). This shows the critical need for higher exposure and consumer education. Since familiarity can support interpretation, greater exposure may improve understanding of FOPNLs and increase their use (Godden et al., 2023). This is where education on FOPNL, together with harmonized mandatory implementation, becomes important for translating research findings into real-world practice. While voluntary practices can be helpful, they may not always deliver wanted results (Zupanič, Hribar, Fidler Mis and Pravst, 2019). The voluntary implementation of Health Star Rating FOPNL in Australia showed that only around third of the product have the label on their packaging and that more than three-quarters of those are products with higher ratings (3 stars and more) (Front-of-Pack Labelling Secretariat Department of Health, 2024; Jones, Shahid and Neal, 2018). This not only prevents consumers from comparing products but also limits their exposure to and understanding of FOPNL. Additionally, if the label appears on products perceived as less healthy, consumers may disregard it, further reducing trust in the label (Schneider & Ghosh, 2020). As seen before, voluntary FOPNLs might be also used selectively, which suggests their use in marketing rather than as public health tool (Christoforou, Dachner, Mendelson and Tarasuk, 2018), and consumers might interpret it like that decreasing their trust in FOPNL (Pelly, Swanepoel, Rinella and Cooper, 2020). Therefore, background from other studies, together with our findings on cross-country differences, suggests that promotion of the scientific basis and interpretation of FOPNLs, combined with harmonized mandatory implementation, could enhance transparency, understanding, and ultimately the real-life effectiveness of FOPNLs.

However, we should also mention another important angle of FOPNLs - public acceptance, which was in our results reflected through questions on subjective preferences. Participants stated preferences for label formats did not always align with actual effects on food choices or understanding. In both Germany and Slovenia, the MTL label was the most preferred across all aspects, consisted with findings from some previous research (Egnell et al., 2019; Talati, Egnell, Hercberg, Julia and Pettigrew, 2019a; Vargas-Meza, Jáuregui, Contreras-Manzano, Nieto and Barquera, 2019). MTL may appeal to a broader range of consumers by offering both interpretive guidance and detailed information, satisfying those who prefer quick cues and those who want more in-depth data. According to Sanjari et al., this could align with different consumer label-processing styles (Sanjari et al., 2017). These results also align with previous studies showing that consumers tend to prefer more information (Dana et al., 2019), even though many struggle to interpret it due to limited nutrition knowledge, competing attribute or time pressure (Grunert & Wills, 2007; Miller & Cassady, 2015). This explains discrepancy between the results of subjective preferences and actual choices. In contrast, while label such as NS is visually simple and easy to interpret, some consumers might not like and trust it as much. In some studies people expressed transparency concerns, as the score is derived from an algorithm that conceals the underlying data (Cerf, Serry, Marty, Nicklaus and Ducrot, 2024; Mazzù, Romani, Baccelloni and Gambicorti, 2021). This was somehow reflected in our findings, where NS received lower average trust ratings, particularly in Slovenia, where familiarity with this FOPNL is low. Although NS generally have high public support (German Federal Ministry of Food and Agriculture, 2024), this should be continuously monitored, as public trust can strongly influence the label's effectiveness and long-term use (Tonkin, Webb, Coveney, Meyer and Wilson, 2016). FOPNLs with underlying algorithm are particularly vulnerable to this, as they undergo revisions, which can affect public support. Such an example is the Choices symbol, a well-established binary FOPNL in the Netherland. Its changes in the profiling algorithm, were not well understood among consumers and criticized extensively. This led to loss of credibility with consumers and the government resulted in phasing out the logo in the Netherlands (Roodenburg, 2017). While the misalignment between stated preferences and actual behavior is not a novel finding (Grunert & Wills, 2007), it highlights an important yet unresolved issue concerning the practical relevance of these preferences. It remains unclear whether consumers are more likely to attend to, trust, or be influenced by labels they report liking. These aspects remain underexplored in the current literature and warrant further investigation.

Taken together, our findings suggest that particularly interpretative FOPNLs have good potential to improve people's food choices, but due to many contextual factors possibly affecting FOPNL use, FOPNL policy must go beyond the label design. It requires coordinated efforts involving public communication, mandatory adoption for consistency and visibility, and regular evaluation of public trust. Future efforts should also consider how to bridge the gap between stated preferences and actual use, as well as how to better reach consumers with lower nutrition knowledge or label literacy. These insights can inform both national and EU-level strategies for maximizing the public health impact of FOPNLs. Implementation of mandatory FOPNL would warrant strongest exposure of consumers and highest magnitude effects on food choices.

The main strength of this study is that it includes multiple attributes that influence food choices, including time pressure, which makes it more reflective of real-life decision-making environments. It also provides comparison between two countries with different levels of exposure to FOPNLs, using population samples, comparable to the general population in terms of age, gender and region. The study presents an important contribution, as data in the area of cross-country comparison for FOPNL is lacking. By incorporating additional variables such as familiarity, understanding, and subjective preferences, the study offers a comprehensive insight into how FOPNL influences food choices and the factors that shape this effect. Familiarity with labels, although mentioned in the literature, is often not systematically integrated into studies. While interpretative schemes such as NS are often presented as the most effective label design in such environments our study demonstrate that this is not always the case. In Slovenia, for example, NS

performed similarly to the NFT, which indicates that quicker time of processing might not be as important factor if there are no prior exposure and knowledge about it.

However, some study limitations should be also noted. Although the experimental design closely mimics real-life conditions, it cannot fully recreate them. Our results from choice experiment showed that nutritional composition was the most influential attribute, followed by price. However, other studies indicate that in actual purchasing situations, price often plays a more significant role (Dana et al., 2021). We also need to mention that consumers' choices can be food category specific. While we accounted for that with inclusion of two very different food categories (flavored yogurt and breakfast cereals) and observed quite comparable results for the investigated food properties, different outcomes may occur with other types of products. In our effort to select food products that are representative of the market and free from FOPNL ambiguity, we did not include the extremes of FOPNL scales, such as NS A and E, which would likely have a stronger impact on consumer choices, than products with mid-range grades (Crosetto, Lacroix, Muller and Ruffieux, 2019). Additionally, the study did not include other FOPNL schemes currently used in Europe, such as Keyhole, which could have provided a broader policy-relevant comparison. Furthermore, this paper did not focus on consumer heterogeneity, which could have provided more detailed insights into consumer profiles in each country. Our study did not specifically examine responses among consumers with NCDs or other health-related conditions, whose food choices may be more strongly influenced by FOPNL. Also, although the findings on familiarity, understanding, and subjective preferences were informative, they were mainly descriptive and require further investigation to strengthen the conclusions. Furthermore, our study examined situations where people are under time pressure, reflecting most real-life shopping situations. However, it did not account for variations in time pressure or for scenarios where individuals are not time pressured. According to Sanjari et al., in such cases, non-interpretative schemes may have a greater influence on food choices (Sanjari et al., 2017). Finally, we should highlight that current study analyzed purely the label design, and not the actual system behind it. The effectiveness observed in guiding single product choices should not be equated with effectiveness in shaping balanced healthy diets. While the products were real life examples from the market, we made sure that there is no conflicting information in the representation of nutritional composition between different FOPNL systems. Our approach was product-based, focusing on individual products rather than broader dietary contexts. While this design allowed for clearer isolation of FOPNL effects at the product level, it does not reflect how consumers make decisions across combinations of foods within a meal or over the course of a day. While some studies highlight the importance of conflicting information between systems on less healthy food choices, especially when it comes to NCDs (Castellini et al., 2024), this should be furtherly addressed by future research. Participants were also not pre-informed about the meaning of the FOPNLs, as our aim was to mirror the current environment. In Europe, multiple FOPNLs appear on the market with little to no education campaigns, so consumers usually face them without prior explanation. Further research should examine how food choices based on FOPNLs influence broader dietary patterns, including portion sizing, overconsumption, and meal construction. Combined with a product-based approach, this could provide a more holistic understanding of how FOPNLs function in the real world.

6. Conclusions

Our study showed that under time pressure, nutritional composition had the strongest impact on food choices, followed by price, while the EU organic logo had only a minor effect. Within the nutritional composition attribute, notable differences emerged between FOPNL groups and cross countries. In Germany the group most influenced by the nutritional composition attribute was exposed to NS, whereas in Slovenia it was the group exposed to MTL. In other cases, FOPNLs showed similar effect on food choice to NFT. While this showed direction towards slightly greater potential of interpretative schemes, this was highly dependent on familiarity and understanding of the labels. The key conclusion is that FOPNLs can support healthier food choices under time pressure, especially when consumers are sufficiently exposed to and able to interpret them. Higher exposure can also strengthen consumer trust and perceived relevance of the labels. This impact could be furtherly strengthened through mandatory implementation of harmonized FOPNL, which signals that the system is credible and not driven by industry interests or marketing tactics. Mandatory adoption should be accompanied by educational campaigns and transparent communications, helping consumers notice the FOPNL and understand both the meaning and the knowledge behind it. Only when consumers are informed, confident, and engaged will FOPNLs reach their full potential in guiding healthier food choices. Further studies should also explore how these results translate into real-life situations and broader dietary patterns.

CRediT authorship contribution statement

Edvina Hafner: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Hristo Hristov:** Writing – review & editing, Methodology, Formal analysis. **Klaus G. Grunert:** Writing – review & editing, Methodology, Conceptualization. **Igor Pravst:** Writing – review & editing, Methodology, Data curation, Conceptualization.

Ethical statement

The study was approved by Committee for Ethical Review of Nutrition Research from Biotechnical Faculty, University of Ljubljana, approval KEP-4-13/2024. All responses were anonymized in accordance with the European Union General Data Protection Regulation (GDPR) and institutional ethical guidelines to ensure participant confidentiality.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Aagerup, U., Frank, A.-S., & Hultqvist, E. (2019). The persuasive effects of emotional green packaging claims. *British Food Journal, 121*(12), 3233–3246.

An, R., Shi, Y., Shen, J., Bullard, T., Liu, G., Yang, Q., et al. (2021). Effect of front-of-package nutrition labeling on food purchases: a systematic review. *Public Health, 191*, 59–67.

Baccelloni, A., Giambarresi, A., & Mazzù, M. F. (2021). Effects on consumers' subjective understanding and liking of front-of-pack nutrition labels: A study on Slovenian and Dutch consumers. *Foods, 10*(12).

Belc, N., Smeu, I., Macri, A., Vallauri, D., & Flynn, K. (2019). Reformulating foods to meet current scientific knowledge about salt, sugar and fats. *Trends in Food Science & Technology, 84*, 25–28.

Bix, L., Sundar, R. P., Bello, N. M., Peltier, C., Weatherspoon, L. J., & Becker, M. W. (2015). To see or not to see: Do front of pack nutrition labels affect attention to overall nutrition information? *PLoS One, 10*(10), Article e0139732.

Brown, K. A., Harris, F., Potter, C., & Knai, C. (2020). The future of environmental sustainability labelling on food products. *The Lancet Planetary Health, 4*(4), e137–e138.
Bschaden, A., Schulz, J., & Stroebele-Benschop, N. (2022). The sustainability halo effect: Does the provision of sustainability information of a snack affect sensory and health perception, and willingness to pay? *Future Foods, 5*, Article 100143.
Carlsson, F., & Martinsson, P. (2003). Design techniques for stated preference methods in health economics. *Health Economics, 12*(4), 281–294.
Castellini, G., Bertorelli, S., Carruba, M., Donini, L. M., Martini, D., & Graffigna, G. (2024). The role of Nutri-score and NutrInform battery in guiding the food choices of consumers with specific nutritional needs: A controlled study. *Nutrition, Metabolism, and Cardiovascular Diseases, 34*(12), 2789–2798.
Cerf, M., Serry, A.-J., Marty, L., Nicklaus, S., & Ducrot, P. (2024). Evidence on consumers' perceptions, understanding and uses of the Nutri-score to improve communication about its update: a qualitative study with shopping observations in France. *BMC Public Health, 24*(1), 3037.
Chapman, C., & McDonnell Feit, E. (2019). R For Marketing Research and Analytics: 1 (pp. 363–399). Springer Cham.
Chen, P.-J., & Antonelli, M. (2020). Conceptual models of food choice: Influential factors related to foods, individual differences, and society. *Foods, 9*(12), 1898.
Christoforou, A., Dachner, N., Mendelson, R., & Tarasuk, V. (2018). Front-of-package nutrition references are positively associated with food processing. *Public Health Nutrition, 21*(1), 58–67.
Crosetto, P., Lacroix, A., Muller, L., & Ruffieux, B. (2019). Nutritional and economic impact of five alternative front-of-pack nutritional labels: experimental evidence. *European Review of Agricultural Economics, 47*(2), 785–818.
Dana, L. M., Chapman, K., Dixon, H., Miller, C., Neal, B., Kelly, B., et al. (2021). The relative importance of primary food choice factors among different consumer groups: A latent profile analysis. *Food Quality and Preference, 94*, Article 104199.
Dana, L. M., Chapman, K., Talati, Z., Kelly, B., Dixon, H., Miller, C., et al. (2019). Consumers' views on the importance of specific front-of-pack nutrition information: A latent profile analysis. *Nutrients, 11*(5), 1158.
Davies, M. A. P., & Wright, L. T. (1994). The importance of labelling examined in food marketing. *European Journal of Marketing, 28*(2), 57–67.
De Bauw, M., Franssens, S., & Vranken, L. (2022). Trading off environmental attributes in food consumption choices. *Food Policy, 112*, Article 102338.
Delhomme, V. (2021). Front-of-pack nutrition labelling in the European Union: a behavioural, legal and political analysis. *European Journal of Risk Regulation*, 1–24.
Department of Health and Social Care, Department of Health (Northern Ireland), The Scottish Government, & Welsh Government. (2020). *Building on the success of front-of-pack nutrition labelling in the UK: a public consultation*. GOV.UK.
Deutschland, E. (2025). *The Nutri-score – all important facts and novelties at a glance*. In.
Donini, L. M., Berry, E. M., Folkvord, F., Jansen, L., Leroy, F., Şimşek, Ö., et al. (2023). Front-of-pack labels: "Directive" versus "informative" approaches. *Nutrition, 105*, Article 111861.
Durand, F., Besson, T., Flaudias, V., & Zerhouni, O. (2025). New challenges and perspectives on the organic halo effect on calories estimation: A brief review and Meta-analysis. *Food Quality and Preference, 127*, Article 105460.
Egnell, M., Talati, Z., Galan, P., Andreeva, V. A., Vandevijvere, S., Gombaud, M., et al. (2020). Objective understanding of the Nutri-score front-of-pack label by European consumers and its effect on food choices: an online experimental study. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 146.
Egnell, M., Talati, Z., Gombaud, M., Galan, P., Hercberg, S., Pettigrew, S., et al. (2019). Consumers' responses to front-of-pack nutrition labelling: Results from a sample from the Netherlands. *Nutrients, 11*(8), 1817.
Egnell, M., Talati, Z., Hercberg, S., Pettigrew, S., & Julia, C. (2018). Objective understanding of front-of-package nutrition labels: An international comparative experimental study across 12 countries. *Nutrients, 10*(10), 1542.
European Commission. (2010). *The organic logo*. In.
European Commission. (2020). *First ordinance amending the food information implementing ordinance*. In.
Cook, R. D., & Nachtrheim, C. J. (1980). A comparison of algorithms for constructing exact D-optimal designs. *Technometrics, 22*(3), 315–324.
European Commission. (2020). *Farm to fork strategy*. In.
European Commission. (2024). *The Eurobarometer survey*. In.
European Parliament. (2025). *Proposal for a harmonised mandatory front-of-pack nutrition labelling*. European Parliament.
Fedde, S., Büttner-Koc, S., Plähn, V., & Bosy-Westpha, A. (2022). Implementation of the Nutri-score. First results and a comparison with the NOVA classification. *Ernahrungs, Umschau(5)*, 48–55.
Feunekes, G. I. J., Gortemaker, I. A., Willems, A. A., Lion, R., & van den Kommer, M. (2008). Front-of-pack nutrition labelling: Testing effectiveness of different nutrition labelling formats front-of-pack in four European countries. *Appetite, 50*(1), 57–70.
FoodWatch. (2022). *Nutri-score: Europe's best chance for a consumer-friendly front-of-pack nutritional label*. In.
Front-of-Pack Labelling Secretariat Department of Health. (2024). *Uptake of the health star rating system as at November 2024*. In.
German Federal Ministry of Food and Agriculture. (2024). *Ernährungsreport 2024*. In.
Godden, E., Thornton, L., Avramova, Y., & Dens, N. (2023). High hopes for front-of-pack (FOP) nutrition labels? A conjoint analysis on the trade-offs between a FOP label, nutrition claims, brand and price for different consumer segments. *Appetite, 180*, Article 106356.
Godinho, S., Prada, M., & Garrido, M. V. (2016). Under pressure: An integrative perspective of time pressure impact on consumer decision-making. *Journal of International Consumer Marketing, 28*(4), 251–273.
Gokani, N. (2024). Healthier food choices: From consumer information to consumer empowerment in EU law. *Journal of Consumer Policy, 47*(2), 271–296.
Green, P. E., & Srinivasan, V. (1978). Conjoint analysis in consumer research: Issues and outlook. *Journal of Consumer Research, 5*(2), 103–123.
Grunert, K. G. (2002). Current issues in the understanding of consumer food choice. *Trends in Food Science & Technology, 13*(8), 275–285.
Grunert, K. G., Fernández-Celemín, L., Wills, J. M., Storcksdieck Genannt Bonsmann, S., & Nureeva, L. (2010). Use and understanding of nutrition information on food labels in six European countries. *Journal of Public Health, 18*(3), 261–277.
Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. *Food Policy, 44*, 177–189.
Grunert, K. G., & Wills, J. M. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health, 15*(5), 385–399.
Hafner, E., Hribar, M., & Pravst, I. (2025). Ultra-processed foods in the food supply: Prevalence, nutritional composition and use of voluntary labelling schemes. *Nutrients, 17*(10), 1731.
He, J., Mazzù, M. F., & Baccelloni, A. (2023). A 20-country comparative assessment of the effectiveness of Nutri-score vs. NutrInform battery front-of-pack nutritional labels on consumer subjective understanding and liking. *Nutrients, 15*(13), 2852.
van Herpen, E., Trijp, H. C. M., & v.. (2011). Front-of-pack nutrition labels. Their effect on attention and choices when consumers have varying goals and time constraints. *Appetite, 57*(1), 148–160.
Hock, K., Acton, R. B., Jáuregui, A., Vanderlee, L., White, C. M., & Hammond, D. (2021). Experimental study of front-of-package nutrition labels' efficacy on perceived healthfulness of sugar-sweetened beverages among youth in six countries. *Preventive Medicine Reports, 24*, Article 101577.
Hodgkins, C. E., Raats, M. M., Fife-Schaw, C., Peacock, M., Gröppel-Klein, A., Koenigstorfer, J., et al. (2015). Guiding healthier food choice: systematic comparison of four front-of-pack labelling systems and their effect on judgements of product healthiness. *The British Journal of Nutrition, 113*(10), 1652–1663.
Jabs, J., & Devine, C. M. (2006). Time scarcity and food choices: An overview. *Appetite, 47*(2), 196–204.
Jones, A., Neal, B., Reeve, B., Ni Mhurchu, C., & Thow, A. M. (2019). Front-of-pack nutrition labelling to promote healthier diets: current practice and opportunities to strengthen regulation worldwide. *BMJ Global Health, 4*(6), Article e001882.
Jones, A., Shahid, M., & Neal, B. (2018). Uptake of Australia's health star rating system. *Nutrients, 10*(8), 997.
Julia, C., Gokani, N., Hercberg, S., & Garde, A. (2025). Ten years of Nutri-score front-of-pack nutrition labelling in Europe. *Nature Food, 6*(3), 239–243.
Kelly, B., Ng, S. H., Carrad, A., & Pettigrew, S. (2024). The potential effectiveness of front-of-pack nutrition Labeling for improving population diets. *Annual Review of Nutrition, 44*(1), 405–440.
Kušar, A., Pravst, I., Pivk Kupirovič, U., Grunert, K. G., Kreft, I., & Hristov, H. (2023). Consumers' preferences towards bread characteristics based on food-related lifestyles: Insights from Slovenia. *Foods, 12*(20), 3766.
MacInnis, D. J., Moorman, C., & Jaworski, B. J. (1991). Enhancing and measuring consumers' motivation, opportunity, and ability to process brand information from ads. *Journal of Marketing, 55*(4), 32–53.
Macready, A. L., Hieke, S., Klimczuk-Kochańska, M., Szumiał, S., Vranken, L., & Grunert, K. G. (2020). Consumer trust in the food value chain and its impact on consumer confidence: A model for assessing consumer trust and evidence from a 5-country study in Europe. *Food Policy, 92*, Article 101880.
Mazzù, M. F., Romani, S., Baccelloni, A., & Gambicorti, A. (2021). A cross-country experimental study on consumers' subjective understanding and liking on front-of-pack nutrition labels. *International Journal of Food Sciences and Nutrition, 72*(6), 833–847.
Meijer, G. W., Detzel, P., Grunert, K. G., Robert, M.-C., & Stancu, V. (2021). Towards effective labelling of foods. An international perspective on safety and nutrition. *Trends in Food Science & Technology, 118*, 45–56.
Miklavec, K., Pravst, I., Grunert, K. G., Klopčič, M., & Pohar, J. (2015). The influence of health claims and nutritional composition on consumers' yoghurt preferences. *Food Quality and Preference, 43*, 26–33.
Miller, L. M. S., & Cassady, D. L. (2015). The effects of nutrition knowledge on food label use. A review of the literature. *Appetite, 92*, 207–216.
Milosavljevic, M., Koch, C., & Rangel, A. (2023). Consumers can make decisions in as little as a third of a second. *Judgment and Decision making, 6*(6), 520–530.
Natter, M., & Feurstein, M. (2002). Real world performance of choice-based conjoint models. *European Journal of Operational Research, 137*(2), 448–458.
O'Mahony, S., O'Donovan, C. B., Collins, N., Burke, K., Doyle, G., & Gibney, E. R. (2023). Reformulation of processed yogurt and breakfast cereals over time: A scoping review. *International Journal of Environmental Research and Public Health, 20*(4), 3322.
Palma, D., Ortúzar, J. D. D., Rizzi, L. I., Guevara, C. A., Casaubon, G., & Ma, H. (2016). Modelling choice when price is a cue for quality: a case study with Chinese consumers. *Journal of Choice Modelling, 19*, 24–39.
Panzone, L. A., Sniehotta, F. F., Comber, R., & Lemke, F. (2020). The effect of traffic-light labels and time pressure on estimating kilocalories and carbon footprint of food. *Appetite, 155*, Article 104794.
Pelly, F. E., Swanepoel, L., Rinella, J., & Cooper, S. (2020). Consumers' perceptions of the Australian health star rating labelling scheme. *Nutrients, 12*(3), 704.
Pettigrew, S., Jongenelis, M. I., Jones, A., Hercberg, S., & Julia, C. (2023). An 18-country analysis of the effectiveness of five front-of-pack nutrition labels. *Food Quality and Preference, 104*, Article 104691.

Pettigrew, S., & Pescud, M. (2013). The salience of food Labeling among low-income families with overweight children. *Journal of Nutrition Education and Behavior, 45*(4), 332–339.
Pravst, I., Hribar, M., Žmitek, K., Blažica, B., Koroušić Seljak, B., & Kušar, A. (2022). Branded foods databases as a tool to support nutrition research and monitoring of the food supply: Insights from the Slovenian composition and Labeling information system. *Frontiers in Nutrition, 8*(1077).
Raghunathan, R., Naylor, R. W., & Hoyer, W. D. (2006). The unhealthy = tasty intuition and its effects on taste inferences, enjoyment, and choice of food products. *Journal of Marketing, 70*(4), 170–184.
Rønnow, H. N. (2020). The effect of front-of-pack nutritional labels and Back-of-pack tables on dietary quality. *Nutrients, 12*(6), 1704.
Roodenburg, A. J. C. (2017). Nutrient profiling for front of pack labelling: how to align logical consumer choice with improvement of products? *Proceedings of the Nutrition Society, 76*(3), 247–254.
Sanjari, S. S., Jahn, S., & Boztug, Y. (2017). Dual-process theory and consumer response to front-of-package nutrition label formats. *Nutrition Reviews, 75*(11), 871–882.
Schäufele-Elbers, I., & Janssen, M. (2023). Consumer segmentation based on three dimensions of sustainable food consumption: a simultaneous analysis of meat, organic food, and sweet snack purchases based on household panel data in Germany. *Frontiers in Nutrition, 10*, 1140636.
Schneider, G., & Ghosh, A. P. (2020). Should we trust front-of-package labels? How food and brand categorization influence healthiness perception and preference. *Journal of the Association for Consumer Research, 5*(2), 149–161.
Schulte-Mecklenbeck, M., Sohn, M., de Bellis, E., Martin, N., & Hertwig, R. (2013). A lack of appetite for information and computation. Simple heuristics in food choice. *Appetite, 71*, 242–251.
Sermas, R. (2024). *ChoiceModelR: Choice Modeling in R*. In.
Shangguan, S., Afshin, A., Shulkin, M., Ma, W., Marsden, D., Smith, J., et al. (2019). A Meta-analysis of food Labeling effects on consumer diet Behaviors and industry practices. *American Journal of Preventive Medicine, 56*(2), 300–314.
Storcksdieck Genannt Bonsmann, S., Marandola, G., Ciriolo, E., van Bavel, R., & Wollgast, J. (2020). *Front-of-pack nutrition labelling schemes - A comprehensive review*. EU publications: European Commission.
Sun, P.-C., Huang, H.-L., & Chu, F.-Y. (2015). Factors instead of demographic characteristics related to nutrition label use. *British Food Journal, 117*(12), 3024–3038.
Taillie, L. S., Hall, M. G., Popkin, B. M., Ng, S. W., & Murukutla, N. (2020). Experimental studies of front-of-package nutrient warning labels on sugar-sweetened beverages and ultra-processed foods: A scoping review. *Nutrients, 12*(2), 569.
Talati, Z., Egnell, M., Hercberg, S., Julia, C., & Pettigrew, S. (2019a). Consumers' perceptions of five front-of-package nutrition labels: An experimental study across 12 countries. *Nutrients, 11*(8), 1934.
Talati, Z., Egnell, M., Hercberg, S., Julia, C., & Pettigrew, S. (2019b). *Food choice under five front-of-package nutrition label conditions: An experimental study across 12 countries. (1541-0048)*.
Tonkin, E., Webb, T., Coveney, J., Meyer, S. B., & Wilson, A. M. (2016). Consumer trust in the Australian food system – The everyday erosive impact of food labelling. *Appetite, 103*, 118–127.
Vandevijvere, S., Vermote, M., Egnell, M., Galan, P., Talati, Z., Pettigrew, S., et al. (2020). Consumers' food choices, understanding and perceptions in response to different front-of-pack nutrition labelling systems in Belgium: results from an online experimental study. *Archives of Public Health, 78*(1), 30.
Vargas-Meza, J., Jáuregui, A., Contreras-Manzano, A., Nieto, C., & Barquera, S. (2019). Acceptability and understanding of front-of-pack nutritional labels: an experimental study in Mexican consumers. *BMC Public Health, 19*(1), 1751.
Vasseur, T., Fialon, M., Marques-Vidal, P., Pereira, P., Meirhaeghe, A., Galan, P., et al. (2025). Comparisons of Nutri-score and NutrInform battery on consumer preferences, objective understanding, and food choices among Portuguese consumers. *European Journal of Public Health, 35*(4), 708–713.
Verlegh, P. W. J., Schifferstein, H. N. J., & Wittink, D. R. (2002). Range and number-of-levels effects in derived and stated measures of attribute importance. *Marketing Letters, 13*(1), 41–52.
Warentest, S. (2024). *Produkte im Nutri-Score – die Auf- und die Absteiger*. In.
World Health Organization. (2024). Noncommunicable diseases. In *World Health Organization*.
Wu, W., Zhang, A., van Klinken, R. D., Schrobback, P., & Muller, J. M. (2021). Consumer Trust in Food and the food system: A critical review. *Foods, 10*(10), 2490.
Zupanič, N., Hribar, M., Fidler Mis, N., & Pravst, I. (2019). Free sugar content in pre-packaged products: Does voluntary product reformulation work in practice? *Nutrients, 11*(11), 2577.
Zwerina, K., Huber, J., & Kuhfeld, W. (2000). *A general method for constructing efficient choice designs*.