Can environmentally themed music increase consumers' willingness to pay for low-carbon food? A discrete choice experiment method

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Transitioning to low-carbon food consumption is indispensable for adapting to and mitigating climate change. Nevertheless, altering dietary habits presents a host of formidable challenges. To explore the role of environmentally themed music in promoting low-carbon food consumption, we conducted a discrete choice experiment, incorporating Michael Jackson's renowned "Earth Song" in the background information. The results revealed the following key insights: Firstly, consumers show concerns about food safety, nutrients, and unnaturalness of the cell-cultured beef, demonstrating the existence of food neophobia or distrust of novelties in cell-cultured beef. Secondly, while the inclusion of environmentally themed music did not completely eliminate consumers' food neophobia, it undeniably played a pivotal role in significantly improving their willingness to pay (WTP) for cell-cultured meat. This effect was achieved by effectively conveying environmental information, stimulating guilt and responsibility, and igniting consumers' enthusiasm for environmental protection. Thirdly, the introduction of "Earth Song" caused a crowding-out effect on eco-friendly packaging and carbon labeling, and reshaped trust in distribution channels. These impacts are all related to the high price of low-carbon food. All these conclusions underscore the substantial role that environmentally themed music can play in promoting low-carbon foods and valuable insights for policymakers and low-carbon food producers.

KEYWORDS

environmentally themed music, low-carbon food consumption, cell-cultured beef, willingness to pay, discrete choice experiment

1 Introduction

The agriculture and food system exert a profound influence on global climate change, emerging as one of the foremost contributors to greenhouse gas emissions worldwide (Clapp et al., 2018; Clark et al., 2020; Webb et al., 2020). The Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land revealed that from 2007 to 2016, land use activity including agriculture, forestry and other activities accounted for approximately 13% of CO_2, 44% of CH_4, and 81% of N_2O. These emissions constitute 23% of the total net emissions of anthropogenic greenhouse gases (GHG).

When considering upstream and downstream activities such as food processing, packaging, transportation, retail, and consumption, the entire agri-food system contributes as much as one-third of the global total GHG (Crippa et al., 2021). The sharp increase in greenhouse gas emissions originating from the agriculture and food system is primarily attributed to the ongoing global population growth and shifts in dietary structure. Particularly noteworthy is the sustained increase in demand for animal protein, which has played a pivotal role in driving these emissions upward (Godde et al., 2021; Cheng et al., 2022).

Transitioning to low-carbon food consumption will be indispensable for adapting to and mitigating climate change (Hedenus et al., 2014; Springmann et al., 2016; Chen et al., 2019; Puigdueta et al., 2021). Nonetheless, convincing individuals to alter their dietary habits and adopt more environmentally friendly and low-carbon food consumption faces formidable obstacles (Vermeir and Verbeke, 2006; Hughner et al., 2007; Mohorčich and Reese, 2019; Post et al., 2020; Wang et al., 2021). This challenge arises because food consumption extends far beyond its basic role as a means of sustenance; it is deeply intertwined with people's lifestyles (Tian and Yu, 2015; Flaherty et al., 2018) and their socio-cultural environment (Seyfang, 2006; Carrus et al., 2018; Welch and Southerton, 2019). Previous research has explored the determinants of being a low-carbon food consumer (such as gender, age, education, etc.) and strategies for achieving low-carbon food consumption, such as information interventions and nudging (Thaler and Sunstein, 2009), social norms and social activities (Kim, 2017), incentives and regulatory policy (Bonnet et al., 2018; Dogbe and Gil, 2018; Katare et al., 2020). Regrettably, due to the behavior change dynamics, we have neither found who are low-carbon food consumers nor the single best strategy that will effectively promote low-carbon food consumption (Hughner et al., 2007; Reisch et al., 2013).

Emotions are important triggers for food intake (Lyman, 1982; Canetti et al., 2002; Bublitz et al., 2010; Evers et al., 2013, 2018; Köster and Mojet, 2015; De Wijk et al., 2019), however, the emotions intervention instruments for promoting low-carbon food consumption have not received the attention they deserve. Music not only evokes emotions, but influences the processing of visual information and interacts with it, potentially facilitating the shift toward low-carbon food consumption. This paper takes one of the most well-known environmental themed songs globally, "Earth Song," as an example and employs choice experiment to assess the role of environmentally themed music in promoting low-carbon food consumption. In comparison to existing research, this paper primarily innovates in two aspects: First, the study introduces the iconic environmental-themed music "Earth Song" as background information into the choice experiment. By comparing the differences in willingness to pay (WTP) for cell-cultured beef, eco-friendly packaging, carbon labels, and distribution channels between these two groups, the paper aims to explore to what extent environmental-themed music can influence consumers' low-carbon food choices. Second, the paper goes beyond traditional economic analysis by incorporating music analysis methods and explains the direct impact of "Earth Song" on food neophobia and its indirect impact on other attributes of low-carbon food. Therefore, this study provides a holistic understanding of the role of environmentally-themed music in promoting low-carbon food consumption.

2 Literature review

2.1 Green consumption and low-carbon food consumption

The concept of green consumption was first introduced in "The Green Consumer Guide" (Elkington and Hailes, 1988). It refers to consumers' purchase of products that minimize resource waste, environmental pollution, and adverse impacts on human health and national development. Green consumption requires individuals to maintain an organic balance between human and environmental needs while satisfying their requirements. Over time, the notion of green consumption has evolved and become more comprehensive. Carson (2008) extended it from the purchase to the use and disposal. It now involves fostering clean and low-carbon transformations throughout the complete life cycle of products. This shift signifies the increasing awareness of the requirement for all-inclusive and sustainable consumption methods, especially with regard to worldwide environmental predicaments and the efforts to mitigate climate change.

With reference to green consumption, we can define low-carbon food consumption as "meeting basic nutrition and health needs while minimizing the use of natural resources, toxic materials, waste, and pollutants throughout the lifecycle." Low-carbon food consumption includes reducing the consumption of carbon-intensive foods (Hoek et al., 2011; Hoolohan et al., 2013), as well as choosing alternative foods produced through more environmentally friendly methods, such as plant-based food (Aschemann-Witzel et al., 2021), insect-based food (Caparros Megido et al., 2016; Smetana et al., 2016; Michel and Begho, 2023), or production methods like organic and cell-cultured (Mohorčich and Reese, 2019; Fish et al., 2020). It also involves reducing the use of food plastic packaging and choosing locally produced, seasonal, or foods with short supply chains (MacGregor and Vorley, 2006; De Boer et al., 2016; Shen et al., 2020; Puigdueta et al., 2021).

2.2 Factors influencing low-carbon food consumption

Food consumption extends well beyond its fundamental role as a means of sustenance, it occupies a central position within people's lifestyles (Sonestedt et al., 2005; Flaherty et al., 2018) and is deeply intertwined with their socio-cultural environment (Carrus et al., 2018; Cairns, 2019). The complexity of decisions related to food makes them susceptible to a wide range of social, cognitive, emotional, and environmental influences (Bublitz et al., 2010).

Considerable research has been dedicated to pinpointing low-carbon food consumers and delving into the strategies that can facilitate the shift toward low-carbon food consumption. However, scholars have yet to reach unanimous conclusions regarding the identity of low-carbon food consumers or the most effective strategies for promoting such consumption. The factors influencing low-carbon food consumption that currently occupy the attention of researchers can be categorized into three main groups: demographic factors, external factors, and internal factors.

2.2.1 Demographic factors

Demographic factors encompass variables such as gender, age, education, income, among others. Numerous studies and surveys have underscored the significant impact of demographic factors on low-carbon food consumption. For instance, research has shown that compared to men, women are more likely to be consumers of organic food (Lea and Worsley, 2001; Ureña et al., 2007). This trend is further corroborated by the 2017 Alibaba Green Consumption Report, which reported that 64% of primary participants in green consumption activities are females. However, men are more receptive to cell-cultured meat (Wilks et al., 2019; Liu et al., 2023). Regarding age, previous research showed that alternative meats are generally more preferred by younger consumers (Bryant and Barnett, 2018); however, Grasso et al. (2019) found that 58% of 1,825 older adults aged 65 years or above in five EU countries can accept plant-based protein. In terms of education, some research found well-educated group had higher acceptance of alternative meats (Zhang et al., 2020; Liu et al., 2023), while other research found education did significantly affect consumers' intent with respect to cultured meat (Bryant and Sanctorum, 2021). These contrasts underscore the need for a nuanced understanding of the interplay between demographic factors and individuals' choices in low-carbon food consumption. Actually, it is the reason some studies found that the relationship between demographic factors and low-carbon food consumption was difficult to identify (Hughner et al., 2007; Wang et al., 2021).

2.2.2 External factors

External factors cover an extensive range of environmental factors, such as social, cultural, economic, and institutional factors. Food evaluation and consumption often involve various senses, therefore environmental factors have received the most attention regarding their impact on food perception and consumption (Hetherington et al., 2006; Crisinel et al., 2012; Spence, 2012; Spence et al., 2014).

In terms of social environment, Jensen and Lieberoth (2019) found that the lack of social norms related to entomophagy hinders people's consumption of insects. Compared to Europeans, Americans exhibit greater openness toward cultured meat while the Chinese and Indians are the most receptive (Bryant and Barnett, 2018). Such geographical differences may be related to the different cultures. When it comes to economic factors, price is the most discussed. High price is often considered to be an obstacle in shaping consumer acceptance of organic food and cultured meat (Hughner et al., 2007; Marian et al., 2014; Michel and Begho, 2023). Nonetheless, it's important to note that influence of price on consumer choices may decrease as organic food becomes more of a lifestyle choice, as argued by Aschemann et al. (2007). As to the institutional environmental, low-carbon food consumption carries evident positive environmental externalities. This underscores the critical role of effective external interventions and institution design in facilitating the transition toward sustainable practices. Dogbe and Gil (2018) found that implementing a revenue-neutral tax on CO_2 will efficiently reduce food-related CO_2 emissions, but border trade may pose challenges to this policy. Furthermore, economic incentives may reduce the impact of internal factors such as moral

motivation (Nyborg et al., 2006). Moreover, Post et al. (2020) and Michel and Begho (2023) proved that information intervention or nudge will improve consumers' acceptance of cultured meat and insect food. Research on carbon labeling also supports the importance of information (Xu and Lin, 2021). Nevertheless, it's worth noting that information interventions do not consistently yield desired outcomes. Lensvelt and Steenbekkers (2014), Barsics et al. (2017), and Berger and Wyss (2021) all find that the provision of information is either ineffectual or even counter-productive.

2.2.3 Internal factors

Internal factors refer to attitudes, familiarity, perceived values, motivations, pro-environmental knowledge, and more.

In terms of attitudes, food neophobia or distrust of novelties received a lot of attention when discussing the adoption of entomophagy and cultured meat (Faccio and Guiotto Nai Fovino, 2019; Dupont and Fiebelkorn, 2020; Boereboom et al., 2022). Food neophobia is defined as a person's reluctance to unfamiliar foods (Pliner and Salvy, 2006; Dovey et al., 2008). Previous studies have documented a negative correlation between food neophobia and the acceptance of insects and cultured meat (Wilks and Phillips, 2017; Hartmann and Siegrist, 2018; Lammers et al., 2019). Similarly, the familiarity of consumers with the nutritional value and naturalness of traditional meat can be a significant barrier to their receptivity to low-carbon food (Siegrist and Hartmann, 2020; Pakseresht et al., 2022). Perceived values and motivations are essential drivers of consumer choices. For instance, consumers typically associate the value as environment-friendliness, health, food safety and animal welfare with organic food, therefore green consumers are willing to pay a higher price for organic food (Hughner et al., 2007; Hansen et al., 2018; Ghali-Zinoubi and Toukabri, 2019). Conversely, concerns about health and food safety can deter some consumers from embracing insects and cell-cultured meat (Wilks and Phillips, 2017; Hadi and Brightwell, 2021). This sharp contrast underscores the critical role of knowledge regarding the relationship between insects, cultured meat and climate change, as well as non-technical knowledge about cultured meat (Siegrist et al., 2018). Moreover, the inclination for impression management significantly affects green consumption behavior. By opting for eco-friendly options, consumers project a positive self-image, creating a pro-social persona. This behavior is motivated by impression management, resulting in the frequent selection of green products (Peloza et al., 2012).

2.3 Music and food consumption

As an important environmental factor, previous research has officially confirmed the effects of music, including rhythm, pitch, timbre, volume, and complexity on food perception and consumption. Roballey et al. (1985) and Milliman (1986) found that fast-paced sounds can encourage consumers to eat faster. Additionally, Peng-Li et al. (2020) found that tailored music can guide consumers' visual attention to specific food. Motoki et al. (2022) discovered that listening to Jazz and Classical music increased people's preferences for healthy foods (e.g., vegetable

sandwiches) as compared with Rock/Metal music. Biswas et al. (2019) investigated the consequences of ambient music and background noise volume on food choices and found low volume music/noise leads to increased sales of healthy foods.

Emotion acts as a crucial mediator between musical and food perception and consumption. According to the Mehrabian-Russel model (Mehrabian and Russell, 1974), individuals respond emotionally to background music, as an environmental stimulus, which leads to approach-avoidance behaviors toward the environmental itself. Music is a common method for regulating emotions, with a range of functions such as emotional reward, motivation enhancement, and more (van Goethem and Sloboda, 2011; van den Tol, 2016; Randall and Rickard, 2017; van den Tol and Giner-Sorolla, 2017). Pantoja and Borges (2021) propose that fast music is more effective than slow music in arousing positive taste expectations and purchase intent. van den Tol et al. (2022) found that music can reduce the impact of negative emotions on unhealthy eating.

The potential influence of music on the transition toward low-carbon food consumption has not received the attention it merits. Given that low-carbon food consumption is intrinsically tied to both moral considerations and emotional responses, it's plausible that environmental-themed music could play a considerable role in promoting such consumption. This could be achieved through its ability to regulate emotions and awaken moral motivations, thereby encouraging individuals to make sustainable and environmentally conscious food choices. Recognizing the emotional and moral dimensions of this transition, it becomes evident that environmental-themed music may hold untapped potential in fostering low-carbon food consumption.

3 Research design

3.1 Experiment design

3.1.1 Attributes and levels of the discrete choice experiment

Choice experiments are currently one of the most mainstream methods for preference analysis due to the ability to uncover trade-offs made when choosing among multiple alternatives (Lizin et al., 2022). Lancaster (1966) posited that the price of a commodity is determined by its attributes, namely the hedonic price theory. Building on Lancaster's theory, we can consider the utility derived from a low-carbon food as the sum of the utilities of all its attributes.

In our discrete choice experiment, respondents were asked to imagine that they would like to buy 500 g of beef for their household. Following the previously mentioned definition of low-carbon food, beef was described by four attributes: production method, packaging, carbon labeling, and distribution channels (see Table 1).

3.1.1.1 Beef production

Globally, the livestock sector is a significant contributor to greenhouse gas emissions, generating a warming effect equivalent to 8.1 billion tons of CO_2 annually (Gerber et al., 2013). This accounts for approximately 14.5% of total greenhouse gas emissions. Within the livestock sector, cattle, including both

TABLE 1 Attributes and levels of the discrete choice experiment.

Attributes	Description	Levels
Beef production	Beef production method used	1. Traditional farming
		2. Cell-cultured
Packaging	Beef packaging bag	1. Single-use plastic packaging
		2. Recyclable eco-friendly packaging
Carbon labeling	Carbon labeling on the packaging bag	1. Without carbon labeling
		2. With carbon labeling
Distribution channels	Beef distribution channels	1. Wet markets
		2. Supermarkets
		3. Chain fresh food stores
		4. Online shops
Price	Price per 500 g beef in Chinese yuan	1. 36
		2. 48
		3. 60
		4. 70

beef and milk production are the largest emitters, responsible for approximately 56% of N_2O emissions and 69.1% of CH_4 emissions (FAOSTAT, 2021). Furthermore, cattle farming often involves the conversion of land, previously used for tree and grass growth—organisms that absorb CO_2–into cultivation for feed crops. These statistics highlight the significant environmental consequences related to conventional beef production. Cultured meat, a typical clean meat and a component of the broader field of cellular agriculture, has been considered "the third stage in meat production" (Welin, 2013). One of the most significant advantages of cell-cultured meat is that it bypasses the conventional stages of livestock farming and slaughter. Consequently, compared to traditional beef production, it substantially reduces the extensive consumption of water and land resources associated with raising meat animals artificially. More critically, it leads to a significant reduction in greenhouse gas emissions (Tuomisto and Teixeira De Mattos, 2011; Post et al., 2020). Therefore, two sources of beef, traditional farming and cell-cultured beef are included in our experiment.

3.1.1.2 Packaging

The 2023 Plastic Waste Makers Index (PWMI) indicates that there was an additional 6 million metric tons of plastic waste in 2021 compared to 2019. In 2021, the lifecycle greenhouse gas emissions from single-use plastic in 2021 were equivalent to 450 million metric tons of CO_2. Therefore, it is necessary to accelerate the promotion of environmentally friendly material packaging or recyclable packaging to address the environmental pollution caused by single-use plastics.

3.1.1.3 Carbon labeling

Carbon labeling quantifies the quantity of greenhouse gas emissions generated during a product's manufacturing process and displays it on the product label. This provides customers with carbon-related information and promotes the selection of low-carbon foods. However, carbon labeling, particularly with physical labels, unavoidably leads to an increase in processing and recycling procedures and the utilization of plastic or other materials for labeling during processing. Therefore, this experiment includes two kinds of packing: with carbon labeling and without carbon labeling.

3.1.1.4 Distribution channels

The processing, transportation, and refrigeration stages of meat all require fuel, resulting in substantial greenhouse gas emissions. This indicates that the types of products and the length of the supply chain cause differences in carbon emissions in various distribution channels (Rothwell et al., 2016). In China, wet markets remain the dominant meat distribution channel. Meat sold in wet markets consists mainly of hot-fresh products, which undergo less processing and primarily originate from slaughterhouses close to the market. As a result, the supply chain is shorter and the overall carbon emissions are lower. In contrast, cold-fresh meat is predominantly found in supermarkets and chain fresh food stores. Increased processing, longer supply chains, cold chain logistics for distribution, and freshness preservation equipment, including freezers for storage, resulting in higher carbon emissions levels in supermarkets and chain fresh food stores. Online shops have rapidly emerged as a meat sales channel in China in recent years. Not only do they provide fresh meat, but they also offer frozen meat, with cold chain logistics for distribution and equipment to preserve its freshness, such as freezers. Unfortunately, this results in a higher level of carbon emissions. However, by eliminating the brokering process, the level of carbon emissions may be lower than that of supermarkets and chain fresh food stores.

In addition to these attributes, price plays a pivotal role in influencing consumer choices (Hughner et al., 2007; Marian et al., 2014; Michel and Begho, 2023). Presently, the costs of cell-cultured meat are considerably higher than traditional meat. Garrison et al. (2022) estimated that the wholesale cost of cell-cultured meat could be as low as $63/kg in a large-scale ($60 million) production facility. However, Negulescu et al. (2023) estimated that with 262,000 L airlift reactor (ALR) sized production, the base case cost would be $17/kg. Given these cost dynamics, this study does not use the current price of cell-cultured beef as a reference. Instead, traditional beef is used as a comparison basis. The selected price range for traditional beef is between 36 Chinese yuan per 500 g (an average value based on monitoring data from the Ministry of Agriculture and Rural Affairs, considering 500 county-level marketplaces and collection points nationwide) and 72 Chinese yuan per 500 g (the price of organic beef in the market). This range is divided into four levels: 36, 48, 60, and 72.

JMP Pro 16 software was used to formulate the experimental design. The experimental choice set design adheres to the principles of a minimal orthogonal design. Each choice set consisted of a $2 + 1$ structure, i.e., two alternative products (Option A and B) and a no-purchase option (Option C). The 16 experiments are divided into two groups, each comprising 8 choice sets. An illustrative choice set is provided in Table 2.

TABLE 2 Illustrative choice set.

	Option A	Option B	Option C
Beef production	Cell-cultured	Traditional farming	Neither
Packaging	Single-use plastic packaging	Recyclable eco-friendly packaging	
Carbon labeling	Without carbon labeling	With carbon labeling	
Distribution channel	Wet markets	Chain fresh food stores	
Price	72 Chinese yuan	36 Chinese yuan	
Your choice	A	B	C

3.1.2 Background music treatments

The environmentally themed song "Earth Song" was incorporated into the background information to assess the influence of environmentally themed music on consumers' choices of low-carbon food. The choice of the English song "Earth Song" was prompted by three factors. Firstly, the song's popularity. "Earth Song," was written and performed by Michael Jackson, is one of the most widely circulated environmentally themed songs globally. As of the time of the survey, it has been viewed over 390 million times on YouTube with over 200,000 comments. Additionally, it has accumulated over 2 million views on Bilibili, a platform primarily used by young people (only considering the top three most-viewed videos). Secondly, the song provides environmental information. The lyrics of "Earth Song" consistently focus on environmental issues such as the planet's cries, contamination of the oceans, the extinction of animals, and deforestation. Last but not least, emotional expression. The "Earth Song" portrays Michael Jackson's deep sense of sadness, mourning, and anger toward the damage caused to the environment.

All respondents were randomly assigned to control groups or experimental groups. In the experimental group, the background music is played automatically when the survey begins, at a volume of 35 dB. Participants in the experimental group will be asked a set of questions regarding the background music to verify that the volume is on in the survey. These questions include "Did you notice the background music?," "Do you know the name of the background music?," and "Which features of the background music impressed you?" If the respondent did not notice the background music, their questionnaire was considered invalid. However, if they were unable to identify the name of the background music but could accurately discern the lyrics and emotion of the song, their questionnaire was considered valid. No other distinctions were observed in the survey design between the two groups.

3.2 Data collection

3.2.1 Sampling and collection

As the world's largest producer and consumer of food, China's agricultural greenhouse gas emissions account for approximately

12.5% of the world's total (FAOSTAT, 2020). As the income of Chinese residents continues to rise, their dietary patterns have been evolving from carbohydrate-rich diets to diets rich in protein (He et al., 2018). Due to the more intensive emissions associated with animal-based food chains compared to plant-based ones, this dietary shift inevitably increases greenhouse gas emissions from agriculture in China (Tilman and Clark, 2014). In China, from 1987 to 2017, greenhouse gas emissions from food production increased by 51%, while emissions from food consumption increased by 64% (Zhang et al., 2022). This trend not only exacerbates domestic environmental pressures but also contributes to environmental pressures in other countries through food trade (Yu et al., 2013). China has become one of the world's largest meat-importing countries. In 2010, imported feed comprised one-third of China's domestic feed consumption (Bai et al., 2018).

This survey primarily targets urban youth consumers in China. The green consumption reports from e-commerce platforms such as Alibaba and Jingdong also demonstrate that the youth group is the main force of current green consumption in China. Therefore, this paper focuses on the youth group (15–44 years old, as defined by the World Health Organization). Before the final survey, we conducted four focus groups, two groups of food practitioners and two groups of general consumers who are the primary shoppers in their households. Following this, we conducted two rounds of pilot investigations to assess the survey. The final survey was carried out from July to August 2023, during which a total of 600 questionnaires were distributed through Sojump, a prominent data collection service provider in China. The respondents include both first- and second-tier cities such as Beijing and Hangzhou, as well as third- and fourth-tier cities and rural areas such as Weifang. After excluding questionnaires with insufficient response time and missing critical information, a total of 503 valid questionnaires were collected. These comprised 279 questionnaires from the control group and 224 questionnaires from the experimental group.

3.2.2 Analysis of descriptive results

Sample demographic characteristics are shown in Table 3. The descriptive statistics demonstrate that there are no significant differences between the control group and the experimental group regarding gender, disposable income, health knowledge, dietary carbon index, psychological health, and physical health. The only notable distinction was related to education, which exhibited significance at the 5% level, indicating that there is no selective bias.

To elaborate further, the sample consisted of 65.61% females, with an average education level equivalent to an associate's or bachelor's degree. This highlights the substantial representation of young, educated women who are identified as the primary group for green consumption by e-commerce platforms within the sample. This also aligns with prior research in which young and highly educated adults were the main participants. Barsics et al. (2017) surveyed one hundred and thirty-five undergraduate students about their attitudes to edible insects. Boereboom et al. (2022) collected 1,291 responses from four European countries, 84.8% of the respondents were between 24–49 years old. The average disposable income per year of the sample population ranged from 48,000 to 60,000 Chinese yuan. The mean dietary

TABLE 3 Descriptive statistics between the control group and experimental group.

	Group	Mean	SD	T-test
Gender	Control	0.65	0.477	0.694
	Experimental	0.66	0.475	
Education	Control	4.11	0.538	0.05
	Experimental	4.17	0.580	
Disposable income	Control	3.85	2.454	0.829
	Experimental	4.51	2.455	
Dietary carbon index	Control	195.41	49.108	0.699
	Experimental	204.40	49.724	
Health knowledge score	Control	15.61	2.556	0.885
	Experimental	15.11	2.556	
Psychological health	Control	18.62	6.711	0.83
	Experimental	20.44	6.583	
Physical health	Control	20.01	6.947	0.393
	Experimental	18.75	6.970	

carbon index for the sampled population, which was calculated by multiplying the frequency of food intake during the previous week with the carbon footprint parameters of the respective food items, was approximately 200. This index ranged from a minimum value of 49 to a maximum of 344. Notably, the relatively high dietary carbon index was primarily influenced by frequent consumption of beef, lamb, pork, and wheat-based products.

The health knowledge score of the sampled population (based on five evaluative questions regarding dietary health, with a maximum score of 5 for each question and a minimum of 1, where 1 indicates strong agreement and 5 indicates strong disagreement) had an average score of 15.38 points, suggesting that the sample population's health knowledge needs improvement. The average score for psychological health and physical health were 19.43 and 20.55, respectively. These scores were based on eight evaluative questions related to health, such as thoughts about not being able to handle many things oneself in the past month (with a score of 5 indicating "never" and a score of 1 indicating "always," with a total score of 40). These scores indicate that the sample population's psychological and physical health conditions were not ideal, but this is consistent with the current situation of high competition and high psychological stress among young people in China.

4 Empirical results

4.1 Mixed logit model

In random utility theory, different consumer utility functions assume random components, determining different statistical models. Therefore, the utility of the decision maker n choosing alternative j in choice set t can be described as follows:

$$U_{njt} = V_{njt} + \varepsilon_{njt}$$

where V_{njt} is the deterministic component, ε_{njt} is the random component. Typically, V_{njt} is a normal linear-in-parameter function of observed attributes, including the production method, packaging, carbon labeling, distribution channels and price. V_{njt} can be expressed as follows:

$$V_{njt} = \sum_k X_{knjt}\beta_k$$

where X_{knjt} represents the k th attribute of alternative j in choice set t, and β_k represents the unknown parameters associated with the k th attribute.

We adopt the Mixed Logit Model to capture consumers' preferences. The mixed logit model allows respondents have different preferences. In the Mixed Logit model, the coefficients for each attribute level are not fixed but follow a specific distribution.

$$P_{nit} = \int \frac{\exp(\sum_k X_{knjt}\beta_k)}{\sum_{j=1}^{J} \exp(\sum_k X_{knjt}\beta_k)} f(\beta|\theta)\, d\beta$$

where $f(\beta|\theta)$ is a multivariate joint probability density function of β and β are the parameters associated with the joint distribution.

Marginal willingness to pay (WTP) for attribute k can be calculated following Hanemann (1983):

$$WTP_k = -\frac{\beta_k}{\beta_P}$$

4.2 Regression and WTP calculation

The regression results are presented in Table 4. The log-likelihood value for the control group model is $-1,884.23$ and $-1,438.70$ for the experimental group, with a corresponding p-value of 0, suggesting that the mixed logit model fits the data better than the conditional logit model.

Table 4 shows the primary effect model. As anticipated, both models demonstrate a noteworthy and negative coefficient for price and the opt-out option (Option C), signifying a preference for lower prices and an aversion to forgoing the opportunity to purchase low-carbon food. In terms of the four attributes, the regression results reveal that, except for carbon labeling in the control group and recyclable eco-friendly packaging in the experimental group, all other attributes exert an influence on consumers' choices.

The results of the WTP calculations in the control group (as shown in Figure 1), demonstrate a negative WTP amidst consumers for cell-cultured beef. In comparison to conventionally farmed beef, consumers require an additional compensation of 60.66 Chinese yuan to accept 500 g of cell-cultured beef. This negative WTP indicates the presence of food neophobia or distrust of novelties (Faccio and Guiotto Nai Fovino, 2019; Dupont and Fiebelkorn, 2020; Boereboom et al., 2022). However, with the introduction of "Earth Song," consumers' WTP for cell-cultured beef increased by approximately 40%, although consumers still have negative WTP

TABLE 4 Regression results of consumers' decisions on low-carbon food.

Variable	Control group		Experimental group	
	Coeff (std. dev)	Z-value	Coeff (std. dev)	Z-value
None	−2.648*** (0.308)	−8.59	−3.046*** (0.363)	−8.40
Price	−0.025*** (0.004)	−5.73	−0.015*** (0.005)	−2.91
cell-cultured beef	−1.538*** (0.172)	−8.93	−0.552*** (0.155)	−3.55
Recyclable eco-friendly packaging	0.642*** (0.111)	5.79	0.116 (0.127)	0.91
With carbon labeling	0.142 (0.111)	1.28	−0.246** (0.147)	−1.71
Supermarkets	0.0646 (0.123)	0.52	0.709*** (0.177)	4.01
Chain fresh food stores	0.847*** (0.155)	5.47	0.106 (0.144)	0.73
Online shops	−0.943*** (0.223)	−4.23	− 0.059 (0.165)	−0.36
Model test	LRchi2(6) = 404.46 Log-likelihood = −1,884.23 Prob>chi2 = 0.00		LRchi2(6) =196.11 Log-likelihood = −1,438.70 Prob>chi2 = 0.00	

***Correlation is significant at the 0.01; **Correlation is significant at the 0.05.

for cell-cultured beef. This highlights the role of environmentally themed music in promoting low-carbon food consumption.

In contrast to their attitudes toward cell-cultured beef, consumers in the control group demonstrate a willingness to pay 25.3 Chinese yuan for recyclable eco-friendly packaging and 5.6 Chinese yuan for carbon labeling. However, following the introduction of "Earth Song," consumers' willingness to pay for recyclable eco-friendly packaging and carbon labeling experienced a decline, with the willingness to pay for carbon labels even turning negative. This result indicates a crowding-out effect on consumers' willingness to pay for recyclable eco-friendly packaging and carbon labeling as their acceptance of cell-cultured beef increases. We will delve into this further in the Discussion.

Consumers show significant variations in their preferences for different distribution channels. In the control group, compared to traditional wet markets, they pay more for beef sold in supermarkets and chain fresh food stores, but less in online stores. This conclusion still holds in the experimental group, but consumers exhibited higher acceptance of supermarkets over chain fresh food stores.

5 Discussion

5.1 Food neophobia in cell-cultured beef

In the past, food neophobia was presumed to be a type of defense mechanism, which prevents the consumption of potentially

FIGURE 1
WTP comparison between the control and experimental groups.
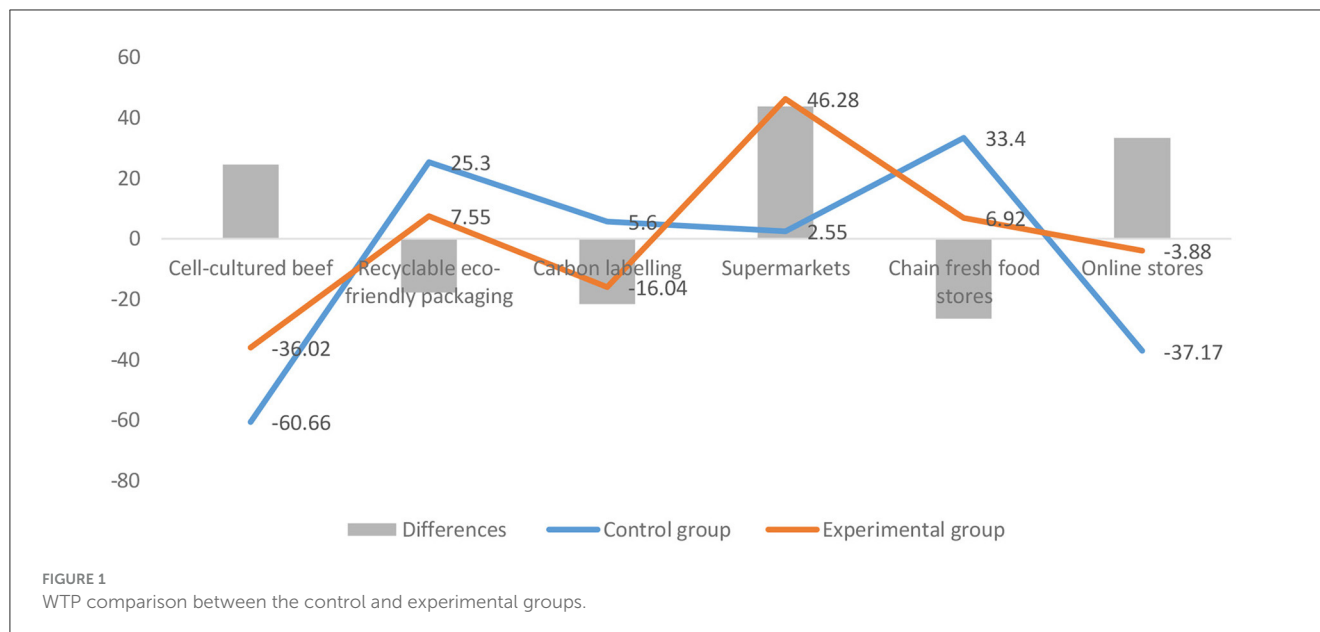
harmful foods. However, at present, food neophobia can be attributed to both inherited and environmental factors. According to previous research (Wilks and Phillips, 2017; Siegrist and Hartmann, 2020; Jezewska-Zychowicz et al., 2021), two kinds of factors may be related to food neophobia.

One key factor is the limited knowledge that consumers possess about cell-cultured meat. In 2020, Singapore became the world's first country to approve the sale of cell-cultured meat. This landmark decision signifies a significant step toward the acceptance and commercialization of this innovative food technology. In December 2021, China's Ministry of Agriculture and Rural Affairs mentioned cell-cultured meat and other artificially synthesized proteins for the first time in the "14th Five-Year Plan for National Agricultural and Rural Scientific and Technological Development." In June 2023, the U.S. Department of Agriculture took a significant step by permitting the sale of cell-cultured chicken from two companies to specific restaurants. Similarly, in July, the Netherlands announced plans to allow tastings of cell-cultured meat, including cell-cultured seafood, in controlled environments within the country. However, consumers lack information regarding the safety of cell-cultured beef, including the safety of raw materials such as seed cells, the hygiene of the cultivation environment, the safety of the production process, and the use of gene-editing technology. Consequently, concerns about the Unnaturalness, safety and healthiness of cell-cultured beef led to a low level of acceptance (Verbeke et al., 2015; Stephens et al., 2018; Chriki and Hocquette, 2020; Van Loo et al., 2020; Treich, 2021).

Another significant factor in China is the heightened sensitivity to food safety issues and distrust in the food industry resulting from past incidents (Ortega et al., 2011). Chinese consumers tend to be exceptionally cautious when it comes to food safety. They tend to be biased against food additives, new food production technologies, and new food ingredients, often referred to as "new food technology." This bias is evident in the popularity of Chinese internet short videos related to "food technology and poor-quality food additives." Starting in August 2022, various creators began

releasing a series of "food additives related technology" videos, including videos on honey synthesized with sugar and flavorings, and starch sausages without meat. As of 29th September 2022, on video platform Douyin, the video tagged "Hextech" had been viewed over 1.52 billion times, "food technology and poor-quality food additives" over 900 million times, and "Sanhua Light Milk" over 570 million times. This kind of extreme sensitivity to new food technology and distrust in the food industry breeds food neophobia in cell-cultured meat in China (Siegrist and Hartmann, 2020).

5.2 Direct impact of "Earth Song" on food neophobia

5.2.1 Providing information on environmental issues

The lyrics of the song consistently tackle environmental issues, including the cries of the Earth, ocean pollution, animal extinction, and deforestation. For example, "Did you ever stop to notice this crying Earth, these weeping shores?" "What about crying whales" "What about forest trails." By providing this information densely, the song compels listeners to pay attention to environmental harm.

Natural sound effects like the sound of wind, rain, or birdsong allow the audience to deeply feel the beauty and vulnerability of the natural world, thus reinforcing the environmental information. In "Earth Song," the orchestration with its exceptional and emotive sonic effects facilitates audience resonance with the environmental information conveyed in the song.

The interaction between the song and the music video also contributes to providing information on environment changes. Although the questionnaire did not include the music video, the function of music-evoked memories (Jakubowski et al., 2023) can still prompt respondents who have seen the music video to recall the challenges people face in dealing with environmental issues, as well as scenes of Jackson calling out to the Earth in a desert setting.

The beauty of nature and the dire consequences of environmental destruction, create a profound visual impact and provoke the audience's concern for environmental issues.

The information conveyed by the song interacts with the environmental benefits of cell-cultured meat in the background information, which gives consumers a higher evaluation of the environmental benefits of cell-cultured meat.

5.2.2 Stimulating guilt and responsibility

The lyrics also point out the human impact on the environment. "What about all the things that you said we were to gain?" "What about all the things that you said was yours and mine?" These lyrics clearly point out that human activities are the cause of the environmental issues mentioned above and criticize destructive behaviors. Furthermore, the lyrics induce a sense of guilt and a sense of morality in the audience.

The song employs rhetorical questions and addresses the audience in the second person, querying whether they have detected these problems, made any efforts to change, and if they are concerned. This method not only conveys the singer's dissatisfaction and disappointment but also evokes a sense of guilt and responsibility in the audience, prompting them to take personal responsibility and contribute to the future of the Earth and humanity.

5.2.3 Triggering resonance in emotion and action

"Earth Song" conveys Michael Jackson's profound concern about the wastage of natural resources and environmental damage firstly. His emotions of sadness and mourning are mainly reflected in his singing (as shown in Figure 2). For instance, in the verse of the song, he uses deep and shallow breath support and his iconic mouth and stomach tremors to form a balanced and weak semi-acoustic voice, emphasizing a sense of helplessness and fear that matches the condemnation of the lyrics, and contrasting this with the borderline balanced mix of the chorus, and the final use of the vocal folds borderline to create a state of manic rupture that can convey different moods and immediate emotional responses to environmental issues. This technique of vocal variation in his voice allows him to convey different moods and the most immediate emotional responses to environmental issues. The lyrics of the chorus are replaced by the meaningless words "AH" and "OO," but the soaring melody and Michael Jackson's heart-breaking vocals are meant to express his imitation of "the earth weeps" and "the shore cries."

The song expresses its anxiety and concern about environmental degradation also through various musical techniques, which are mainly reflected in the synthesizer and recording techniques that incorporate the sounds of running water, birdsong, thunderstorms and other natural sounds into the piece in order to awaken people's empathy for caring for the environment. From the clear and bright piano to the heavy metal rock bass and percussion, from the moody lead singer to the impassive chorus, the timbral shifts, acoustic layering, and the fusion of different musical styles create powerful contrasts and shifts in the listening experience, make this song highlight the tension between man and nature and express the creator's anxieties and concerns about the deterioration of the environment through a wide range of musical techniques and elements.

Despite the song contains many negative emotions, it also expresses hope and appeal. Jackson calls on people to take action to protect the earth together and make this world a better place. This emotion of hope and appeal triggers resonance in action. "Tell me what about it, tell me why can't we live together," it expresses the viewpoint that people need to come together and work collectively to improve the condition of the Earth.

Overall, "Earth Song" is a powerful song. Its authentic lyrics and multi-track mixing can effectively inspire respondents' environmental attitudes. Furthermore, "Earth Song" successfully conveys emotions related to environmental issues, allowing listeners not only to hear the information within the song but also to deeply feel the emotions behind that information, evoking consumers' prosociality and sense of morality. As shown by previous studies (Williston, 2011; Faccio and Guiotto Nai Fovino, 2019; Onwezen et al., 2021), attitude, prosociality, and morality are important inner factors to drive green consumption. Therefore, resonance in emotion and action empowers respondents to confront environmental issues and ignite enthusiasm to take action now. Collectively, these factors decrease consumer resistance to cell-cultured beef, which may considerably reduce carbon emissions.

5.3 Indirect impact of "Earth Song" on other attributes

5.3.1 Crowding-out effect on eco-friendly packaging and carbon labeling

In contrast to cell-cultured beef, consumers in the control group exhibited a positive WTP for recyclable eco-friendly packaging and carbon labeling. However, in the experimental group, their WTP decreased, and notably, WTP for carbon labeling even became negative (as shown in Figure 1), demonstrating a crowding-out effect.

Consumers in the control group would like to pay 25.30 Chinese yuan for recyclable eco-friendly packaging. This positive response can mainly be attributed to consumers' familiarity with recyclable eco-friendly packaging. As early as 2008, the General Office of the State Council issued a "Notice on Restricting the Production, Sale, and Use of Plastic Shopping Bags," which banned the production and sale of ultra-thin plastic bags nationwide from June 1st. In 2015, Jilin Province officially prohibited the production and sale of non-degradable plastic shopping bags and plastic tableware in the entire province. This positive response also arises from growing concerns about plastic pollution and microplastic contamination. These issues pose significant risks to human health, impacting hormonal, immune, and nervous systems (Sharma and Chatterjee, 2017; Waring et al., 2018).

Consumers in the control group also exhibit positive WTP for carbon labeling. Carbon labeling serves several purposes: Firstly, it guides consumers toward selecting products with lower carbon emissions by presenting carbon footprint information. This creates an eco-labeling effect, influencing people's cognitive processes and behavioral choices, ultimately leading to a reduction
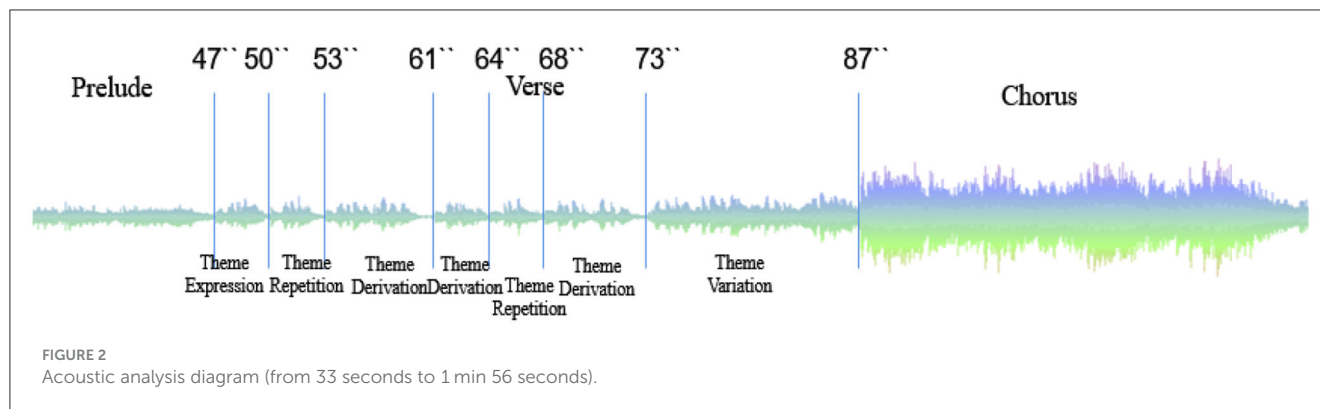
in greenhouse gas emissions and mitigation of climate change (Cohen and Vandenbergh, 2012; Sörqvist et al., 2016). Secondly, carbon labeling serves as evidence of a company's responsibility and its commitment to green transformation, which helps enhance consumer trust (Mueller Loose and Remaud, 2013).

The crowding-out effect is primarily due to consumers' budget constraints, as the uptick in consumers' WTP for cell-cultured beef somewhat restricts their budget allocation for packaging and carbon labeling. Persistently elevated product prices have consistently posed a significant hurdle to the promotion of low-carbon goods (Griskevicius et al., 2010; Marian et al., 2014; Michel and Begho, 2023). The Alibaba Research Institute's "2016 China Green Consumer Report" shows that the average premium for green basket products is as high as 33%, with premiums exceeding 50% for products Therefore, consumers need to weigh the carbon-reducing contributions of different attributes against their costs when making decisions. As consumer acceptance of cell-cultured beef increases, consumers will inevitably have to reduce their willingness to pay for other attributes to ensure that the total price paid is acceptable.

Different level of crowding-out effect in recyclable eco-friendly packaging and carbon labeling is mainly because eco-friendly packaging itself can reduce carbon emissions and contributes to the construction of consumer identities. Its eco-conscious appearance reflects consumers' self-perceived morality and portrays them as possessing more gentle and friendly character traits and qualities (Sachdeva et al., 2009; Mazar and Zhong, 2010; Haws et al., 2012). In contrast, carbon labels only serve as a guide and cannot directly reduce carbon emissions, carbon labeling is unlikely to drive much change in food systems (Gadema and Oglethorpe, 2011). Furthermore, in certain instances, the additional costs associated with printing and materials for carbon labels may even lead to an increase in carbon emissions.

5.3.2 Reshaping trust in distribution channels

Whether in the control group or the experimental group, compared to traditional wet markets, respondents want to pay more for products sold in supermarkets and chain fresh food stores but less for online stores (as shown in Figure 1). Consumers who rely on different channels exhibit significantly different requirements for meat safety, quality, and brand (Ortega et al., 2015). The beef

sold through wet markets has lower processing levels, shorter supply chains, and is more environmentally friendly. However, relatively insufficient quality and safety management has resulted in consumer distrust of products from wet markets. In contrast, supermarkets and chain fresh food stores have more robust management practices, which makes consumers trust them more. Due to the limited cold chain logistics infrastructure in China, a lack of monitoring resources and the information asymmetry resulting from online transactions, the quality of fresh products sold online is more uncertain. In 2020, the national 12,315 platform received a total of 2.03 million complaints and reports related to online shopping, with 781,200 of them related to food (ranking highest among all categories). Among these, there were 65,800 complaints related to fresh food and 25,500 related to live-streaming sales, with issues centered around quality, poor after-sales service, and more. This demonstrates that consumers are not entirely satisfied with online stores, and therefore, their willingness to pay is lower compared to the traditional sales channel of wet markets. Differences in trust in four distribution channels demonstrate the weight of food safety in food consumption (Zhou et al., 2017).

However, in contrast to the control group, consumers in the experimental group exhibited a preference for supermarkets over chain fresh food stores. Considering that consumers in the experimental group have higher acceptance of cell-cultured meat, they tend to find a balance between price and safety (Zhang et al., 2021), and they exhibit higher trust in supermarket, a more popular and widely accepted channel. For the same reason, consumers' attitudes toward online stores change slightly. Consumers may choose to trust stores that they buy frequently, have celebrity live-streaming hosts, or have good reputation, to save costs of low-carbon food (Yin et al., 2010; Danner and Menapace, 2020).

6 Conclusions and implications

6.1 Conclusions

Promoting the transition to low-carbon food consumption represents a crucial strategy in addressing climate change. However, altering dietary habits is a challenging endeavor. This article employs a choice experiment to investigate the impact of

environmentally-themed music on the promotion of low-carbon food, yielding the following key findings:

Firstly, in both the control group and experimental group, consumers exhibit a negative willingness to pay (WTP) for cell-cultured beef, which is a cleaner and more environmentally friendly alternative. This result demonstrates the existence of food neophobia or distrust of novelties in cell-cultured meat. Due to a lack of necessary information and a lack of trust in the food industry, consumers show great concerns about cell-cultured beef, including technologies, food safety, nutrients, and so on.

Secondly, the environmentally themed music "Earth Song" plays a significant role in mitigating consumers' food neophobia to cell-cultured beef and substantially increases their WTP. While it may not entirely eradicate consumers' reservations about cultured beef, "Earth Song" effectively communicates environmental information through its lyrics, vocal techniques, and music videos. Moreover, "Earth Song" conveys Michael Jackson's discontent with environmental issues and hope for change, evoking consumers' prosociality and morality, resulting in a notable increase in their WTP for cell-cultured beef. This underscores the transformative potential of environmentally themed music in steering food consumption choices toward more eco-conscious options.

Thirdly, the inclusion of "Earth Song" also has indirect impacts on other attributes, including the crowding-out effect of eco-friendly packaging and carbon labeling, and reshaping trust in distribution channels. Consumers exhibit positive WTP for eco-friendly packaging and carbon labeling: eco-friendly packaging directly contributes to the reduction of carbon emissions; while carbon labeling furnishes consumers with precise information regarding the carbon emissions associated with food products, thereby stimulating their sense of social responsibility. However, constrained by the high price of low-carbon food, consumers have to reduce their WTP for eco-friendly packaging and carbon labeling when they tend to increase their WTP for cultured meat. As to the distribution channels, consumers would like to pay more for beef sold in supermarkets and chain fresh food stores. However, as acceptance of cultured meat increases, they struggle for the balance between price and food safety, resulting in higher WTP for supermarket and specific online stores.

6.2 Implications

This study underscores the capacity of environmentally themed music to partially alleviate food neophobia and the apprehension toward novel low-carbon food consumption. Environmentally themed music could be used as background music in brand promotion, communicating the brand's low-carbon attributes and environmental values through music. In marketing, music with warm melodies can also be used to evoke consumers' environmental emotions and foster positive emotional bonds with the product. Environmentally themed music can be played in-store, whether in online or offline sales channels.

Nevertheless, the issue of price and unfamiliarity with new food continue to be pivotal considerations. Consequently, finding effective strategies to mitigate these costs remains imperative for facilitating broader adoption. On the one hand, it is essential to officially introduce regulations for cell-cultured meat and education

for consumers, to improve the familiarity with low-carbon and environmentally friendly foods. Regulations should cover the production, distribution, and sale of cell-cultured meat. Additionally, policies such as consumption taxes or carbon taxes should be used to reduce the initial market prices of cell-cultured meat, environmentally friendly packaging and carbon labeling. On the other hand, the promotion of low-carbon food should be effectively integrated with the enhancement of food quality and safety management capabilities. During the initial stages of promoting low-carbon food, a targeted approach should focus on key channels like chain fresh food stores and supermarkets. Simultaneously, the supervision of quality and safety management in these key channels should be strengthened. This includes rigorous inspections of low-carbon food certification labels and carbon labels. Efforts should also be made to advance cold chain logistics infrastructure and traceability systems to meet consumers' multiple demands for "safety," "quality," and "low-carbon" attributes in food.

6.3 Limitations

Firstly, due to the online nature of the questionnaire survey, the researchers were not able to combine the playing of environmentally themed music with real consumer scenarios, such as in shopping malls or chain fresh food stores. This limitation might have weakened the impact of environmentally themed music to some extent, potentially leading to an underestimation of the music's effectiveness.

Secondly, the study sample was limited to young individuals with a high willingness for low-carbon consumption. Moreover, due to space constraints, this paper primarily focused on exploring the impact of music on consumer low-carbon food consumption. It did not empirically test the heterogeneity of music effects or the specific mechanisms through which music influences consumer's low-carbon food preferences.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

ZW: Conceptualization, Data curation, Formal analysis, Supervision, Validation, Writing – original draft. KL: Data

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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