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# Consumers' attitudes, perceptions and willingness to try hazelnut skins-fed beef

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ABSTRACT

Consumers are raising concerns over the ethical and social acceptability of feeding regimes used in animal-based food productions. However, the use of agro-industrial by-products, such as hazelnut skins as a strategy to reduce the environmental impact of livestock production may be negatively perceived from the consumer's perspective. Here, we investigated the factors predicting consumers' intentions to try meat obtained from cattle fed hazelnut skins. Nine hundred Italian regular meat consumers were recruited *via* an online provider of market research panels. Three different framings were presented to consumers as meat products fed with food industry by-products *vs* possessing either feed quality or an environmental benefit. Consumers generally responded positively to the product when they were informed that it helps promote sustainable production, reduces food waste, or improves feed quality, with no significant difference between framings. Consumers who reported not to be very concerned about feeding methods and to have a low green self-identity tended to be more skeptical towards the use of alternative feeds. The level of neophobia significantly influenced the respondents' risk perceptions. Our findings suggest that product characteristics and risk and benefit perceptions will significantly influence the acceptance of hazelnut skins as feed ingredient. The factor "environmental benefits" was a key predictor of "willingness to try", while concerns about the potential health effects were identified as a major barrier to accepting novel feed alternatives. This research confirms the great need to educate consumers in order to empower meat choices that are environmentally friendly at the production system level.

## 1. Introduction

Meat and meat products are important sources of high-quality protein and essential vitamins and minerals, such as iron and zinc, in the human diet (Ahmad, Imran, and Hussain, 2018). In general, consumers expect meat to be wholesome, fresh, lean, tender, juicy, and flavorsome (Fraqueza, Borges, and Patarata, 2018; Pophiwa, Webb, and Frylinck, 2020). However, existing research indicates that consumers' perceptions of meat and meat products are based on dynamic psychosocial constructs, such as the perception of quality, potential biological and chemical hazards and health risks, ethical issues related to animal welfare and slaughter, and psychosocial beliefs (EFSA, 2020, 2021; European Commission, 2021a; Klink-lehmann, Langen, Simons, and Hartmann, 2022; Lin-Schilstra and Fischer, 2022; Malone and Lusk, 2017; Ogoshi, Yasunaga, Obana, Ogawa, and Imamura, 2010; Wales, Harvey, and Warde, 2006). Identifying how consumers perceive meat and meat products and which factors influence purchasing and consumption behaviors is essential for producers and processors to adapt to new demands and, offer sustainable value propositions able to meet consumers' needs.

Animal welfare and environmental impact have become significant drivers of how consumers perceive meat consumption (de Araújo, Araújo, Patarata, and Fraqueza, 2022; Mota-Gutierrez et al., 2024). A recent systematic review highlighted that the three most important quality attributes of cattle production as perceived by consumers from different regions and countries were place of origin, animal welfare, and the feed supply system (Henchion, McCarthy, and Resconi, 2017). Interest in pasture-based or grass-fed beef production systems and the use of alternative feeds such as insects or micro-algae, has grown since they are perceived as low-input systems with reduced feed costs and improved animal health and welfare (Menozzi et al., 2021; Popoff, MacLeod, and Leschen, 2017; Sogari et al., 2022; Spartano and Grasso,

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2021; Weinrich and Busch, 2021). Greek consumers were also shown to express positive attitudes towards agricultural products from animals fed locally produced feed; however, only the young and higher educated consumers expressed interest in information about the origin of locally produced animal feed (Kleisiari et al., 2022).

The diet of an animal is able to influence the composition and sensory characteristics of meat, as shown for organic or grass-fed beef (Monahan, Schmidt, & Moloney, 2018). According to García-Torres, López-Gajardo, and Mesías (2016), consumers preferred the sensory attributes of organic beef fattened in feedlots using organic feedstuff, but when the farming system was taken into consideration then organic beef from animals fed on grass became the preferred choice. The perceived positive characteristics of organic meat together with the negative impact of production systems on the environment and increasing consumer knowledge about the latter has led to an increase in the demand for sustainable meat production and more sustainable food consumption. However, consumers may be reluctant to consume or buy food products they perceive to be waste products due to concerns about food safety or even feel disgust towards the type of ingredients involved. Regardless of the substantial and rigorous regulations and continuous inspection of meat parameters, consumers continue to express concerns about the potential presence of chemical contaminants in meat and meat products (de Araújo et al., 2022). In general, consumers are hesitant over the use of chemical compounds in food formulations, such as additives, antibiotics, and drug residues (Bearth, Cousin, and Siegrist, 2014, 2016). In the context of meat production, consumers prefer meat products treated with natural antioxidants over chemical products despite all food additives used in the industry having to pass the *Codex Alimentarius* (de Andrade et al., 2017). Besides quality attributes, the many personal characteristics of consumers (*e.g.* food neophobia, concern about food and food waste, neuroticism, moral conscientiousness, self-esteem, openness to new experiences, extraversion, temperament, personal values, and reasoning) all play a role in governing food choices (Bazzani, Caputo, Nayga, and Canavari, 2017; Carrillo, Prado-Gascó, Fiszman, and Varela, 2012; Chen, 2007; Grebitus and Dumortier, 2016; Merlino et al., 2023).

Alternative feeds may offer a feasible means of improving the sustainability of livestock production (Diaz Vicuna et al., 2024). Moreover, the growing problem posed by agro-industrial waste production and feed-food competition can be tackled by minimizing food surplus, food waste, and using sustainability marketing to raise consumer awareness about emerging feed resources (Grasso and Asioli, 2020; Papargyropoulou, Lozano, and Steinberger, 2014; Williams, Wikström, Otterbring, Löfgren, and Gustafsson, 2012). Many food by-products of both animal and plant origin are being considered as possible feed alternatives. Food by-products are generated from the processing of raw materials into foods. Their use as feed can help reduce food waste and contribute towards improving the sustainability of food production systems (Galanakis, 2012).

Hazelnut skin (HS) is one of the three by-products obtained during post-harvesting processing of hazelnuts (the others are the shell and hazelnut meal), and it makes up approximately 2.5 % of the total kernel weight (Ceylan, Adrar, Bolling, and Capanoglu, 2022). According to FAO statistics, Italy produced 98,670 tons of hazelnuts in 2022 (FAOSTAT. Food and Agriculture Organization of the United Nations, 2024), and thus approximately 2500 tons of HS. Previous studies have addressed the question of re-valorizing agro-industry by-products to reduce the environmental impact of livestock production, improve product quality and animal health, and reduce feed costs and feed-food competition (Kasapidou, Sossidou, and Mitlianga, 2015; Natalello et al., 2019; Salami et al., 2019). Several studies have identified HS as a promising source of dietary fiber, phenolic compounds with antioxidant properties, and protein for both the food and feed industries (Bertolino et al., 2015; Del Rio, Calani, Dall'Asta, and Brighenti, 2011). Recently, the benefits obtained from using HS to replace traditional feed ingredients and improve the nutritional value of the feed and its effects on animal performance have been investigated in ewes (360 g/kg dry matter) (Campione et al., 2020), lambs (150 g/kg dry matter) (della Malva et al., 2023; Priolo et al., 2021), and dairy cows (1 kg dry matter) (Renna et al., 2020).

Given the need to encourage consumers to make more sustainable meat choices, more research is needed to understand the attitudes of prospective consumers towards meat derived from animals fed agro-industrial by-products, and the factors that motivate or inhibit consumers to try this type of meat. The present study makes a unique contribution to the literature by investigating consumer perspectives on the commercialization of meat obtained from HS-fed cattle. This study focused on Italian regular meat consumers, considering the long and well-rooted culture of hazelnut production in the nation, being the second largest producer in the world (9.15 %) after Turkey (FAOSTAT. Food and Agriculture Organization of the United Nations, 2024). The global market for raw hazelnuts was calculated at US 512.25 million for 2024, with a predicted market growth rate of 8.10 % for 2024–2029, and Europe is the fastest growing and largest market in the world (Mordor Intelligence, 2024). However, to the best of the authors' knowledge there are no details in the literature about the exact market size and consumption rates of skinned (blanched) hazelnuts. Nevertheless, blanched hazelnuts are generally more expensive due to the additional processing costs. The present study investigated whether consumers were concerned about how animals were fed and their attitudes, perceptions, and willingness to try (WTT) beef fed with HS. In addition, we evaluated the effect of information about the benefits derived from introducing HS into the diet of beef cattle on consumers' acceptance of this product. Products were presented to consumers as having either an effect on feed quality or an environmental benefit. The study sought to understand how consumer associations and perceptions are affected by their level of concern ("personal involvement") about how animals are fed and to examine the results in terms of the consumers' personal characteristics. The findings will help policy makers and producers address consumers concerns about alternative feeds and thus foster more sustainable meat choices.

## 2. Methods

### 2.1. Study design

A between-subjects design was applied to investigate how the way information is framed (in terms of sustainable production, feed quality, or food waste reduction) influences consumer responses about using HS as part of a feed formula for beef cattle. All framings contained the same basic definition of hazelnut by-products, but they differed in the final part, which mentioned one of the benefits associated from using HS. In the first group, participants/consumers were introduced to hazelnut by-products in reference to feed quality "*Hazelnut skins are a by-product of hazelnut processing in the confectionery industry, and they can be used as feed ingredient for livestock (such as beef cattle) as they do not present any significant risk to the health of the animals or the consumers. On the contrary, hazelnut skins can help improve the nutritional quality of the animal's diet*". In the second group, participants/consumers were given information that referred to food waste reduction "*Hazelnut skins are a by-product of hazelnut processing in the confectionery industry, and they can be used as feed ingredient for livestock (such as beef cattle) as they do not present any significant risk to the health of the animals or the consumers". On the contrary, their use can help reduce food waste*". In the third group, participants/consumers were only given the definition of hazelnut by-product without any reference to quality or food waste *"Hazelnut skins are a by-product of hazelnut processing in the confectionery industry, and they can be used as feed ingredient for livestock (such as beef cattle) as they do not present any significant risk to the health of the animals or the consumers."* A nutrition/health benefit framing was not included, because not conclusive experiments have demonstrated health benefits in using HS as part of a feed formula for beef cattle. However, according to Asioli

and Grasso (2021) it can be expected to have a similar effect as environmental aspects.

### 2.2. Questionnaire

The full questionnaire used in this study is presented in the Appendix and can be referred to for further details. A total of 950 surveys were completed (a 94.74 % response rate). We excluded 5.55 % ($n = 50$) of the sample due to missing data or for not fulfilling the quality checks (straight-lining). The final analysis included data from 900 meat consumers. The average length of time taken to complete the survey was approximately 8 min. Overall, participants stated their attitudes, product characteristics, and perceptions about the benefits and risks of meat from beef cattle fed HS as part of the feed formula assessed using a 7-point Likert scale (Supplementary Appendix). The questionnaire included the following measures:

- **Definition:** to ensure the valid use of the term "food industry by-products", participants were asked to complete the following phase "*Food by-products are materials of value produced as a residual of, or incidental to food production processes. They are used in animal feed to…"* with one of the following options: (i) improve feed quality, (ii) reduce food waste, or (iii) none of the above (European Commission, 2021b). This measurement ensured that all the participants were able to recall the specific framing received.
- **Food-neophobia:** the food-neophobia score (FNS), composed by five neophilic and five neophobia items, was measured using a 7-point scale (ranging from 1 = strongly disagree to 7 = strongly agree) (Laureati, Proserpio, Jucker, and Savoldelli, 2016; Pliner and Hobden, 1992). After reverse coding the responses for the neophobia statements, a total FNS ranging from 10 to 70 was calculated by summing the ratings for each item; the higher the FNS, the higher the level of food neophobia.
- **Beef consumption frequency:** this scale measures the weekly frequency of beef consumption using a 3-point scale (ranging from 1 = 1–5 times *per* week to 3 = more than 10 times *per* week).
- **Consumer green self-identity and personal involvement (concern) about how beef cattle are fed**: the green self-identity scale was composed of two items ("I think of myself as an environmentally-conscious consumer" and "I consider myself as someone who is very concerned about environmental issues") and the personal involvement scale was composed of three items ("What animals are fed is important to me", "I am concerned about what animals are fed" and "What animals are fed is very important to me") to assess how much the topic of animal feed was important to them or presented a concern. Each item was measured using a 7-point scale (ranging from 1 = strongly disagree to 7 = strongly agree) (Altintzoglou, Honkanen, and Whitaker, 2021).
- **Consumer attitudes**: in line with existing research (Escobedo del Bosque, Spiller, and Risius, 2021), this scale was composed of three items to evaluate consumers' acceptance of meat obtained from beef cattle fed HS as part of the feed formula. Each item was rated using a 7-point scale (ranging from 1 = strongly disagree to 7 = strongly agree) (Arvola et al., 2008).
- **Product characteristics**: this scale, composed of nine items, measured consumers' opinions about the properties of meat obtained from beef cattle fed HS as part of the feed formula. Each item was rated using a 7-point scale (1 = not important at all to 7 = extremely important) (Lin-Hi, Reimer, Schäfer, and Böttcher, 2022; Llauger, Claret, Bou, López-Mas, and Guerrero, 2021; Lusk, 2018).
- **Benefit perceptions:** this scale, composed of 13 items, was designed to measure consumers' perceptions about the benefits derived from eating meat obtained from beef cattle fed HS as part of the feed formula. Each item was rated using a 7-point scale (ranging from 1 = strongly disagree to 7 = strongly agree) (Altintzoglou et al., 2021; Mancini et al., 2019).
- **Risk perceptions:** this scale, composed of four items, was adapted to measure consumers' perceptions of the risk of consuming meat obtained from beef cattle fed HS as part of the feed formula. Each item was rated using a 7-point scale (ranging from 1 = strongly disagree to 7 = strongly agree) (Bearth et al., 2014).
- **Willingness to consume** meat obtained from beef cattle fed HS as part of the feed formula was formulated as a closed question (yes/no) to investigate consumer readiness to consume products involving food industry by-products as feed (Mancini et al., 2019).
- **Sociodemographic characteristics** (gender, age, education level, occupation, marital status, number of people living in the household, number of children in the household, place of residence, and monthly family income): the order of the items within each question was randomized for each participant.

### 2.3. Data collection and management

Data collection was performed in September 2023 by the company Teleperformance using the Computer Assisted Web Interviewing (CAWI) approach to ensure a balanced sample representative of the Italian market. The inclusion criteria were regular consumption of beef products, the provision of the individual's consent for data usage, and a minimum age of 18 years. The questionnaire was initially drawn up in English and pre-tested by experts in consumer science. Following their approval, the questionnaire was translated into Italian by bi-lingual native speakers. The Italian version of the survey was also pre-tested on five individuals not involved in the project to identify any potential problems related to the phrasing of the questions, omissions, or any other difficulties experienced by respondents, as shown previously to be important in translated surveys (Mitchell, Ploubidis, Datta, and Wellings, 2012; Rodrigues, Sousa, Fetscherin, and Borges, 2024). As a result of these pre-tests, minor modifications were made related to the phrasing of the questions and response options. The online survey was anonymous, and the respondents electronically signed an informed consent form before participating in the survey and after having read a disclosure sheet that described the project and the aims of the survey. Respondents did not receive monetary compensation for their participation. This study followed the ethical standards defined by the Declaration of Helsinki and was approved by the University Bioethics Committee of the University of Turin (Ref – GD/169873/2023).

### 2.4. Statistical analysis

Statistical analysis was performed using R software considering an alpha level of 5 %. A comparison of mean scores was used to assess associations between the data on attitudes (interval variables, seven-point scale) and perceptions (interval variables, seven-point scale) as the dependent variables. Statistical analyses were carried out using generalized linear mixed-effect models (GLMM). Mixed models were chosen because of their ability to capture both fixed food neophobias (low, medium, high), the information given (food waste reduction, feed quality, and sustainable production), consumers' willingness to try (willing, unwilling), concern about what animals are fed (personal involvement: low or high) and green self-identity (low and high) and random effects (number of subjects, $n = 900$). The frequency distribution of the food neophobia scores (FNS) was calculated and the subjects were divided into the three following groups: "low neophobia" (subjects in the lowest quartile, FNS $\leq 23$, $n = 310$), "medium neophobia" (subjects in the second and third quartile, FNS $\geq 24$ and $\leq 41$, $n = 307$) and "high neophobia" (subjects in the highest quartile, FNS $\geq 42$, $n = 283$) (Laureati et al., 2016). GLMM analysis was used to examine the main effects and interactions between the information given, with the addition of low *vs* high personal involvement (concern) about feeding methods groups and low *vs* high green self-identity groups. These groups were defined using the median = 5 of the personal involvement and green self-identity constructs, confirmed by a Cronbach's alpha of 0.967,

resulting in a 45 % / 55 % distribution, and a similarly balanced distribution in the experimental conditions. The *P*-values were adjusted using Bonferroni's method, and when the mixed model revealed significant differences ($P < 0.05$), the least significant difference test was applied. Mixed models were built and evaluated according to Crawley using R (Crawley, 2012). Cronbach's alpha was used to assess the internal consistency of the construct scales, where a value greater than 0.70 is usually recommended.

## 3. Results

### 3.1. Sample description

The resulting sample consisted of 900 participants, representative of the Italian population, distributed across the experimental groups in a balanced manner. Table 1 reports the social and demographic characteristics of the sample.

### 3.2. How the information given influences attitudes and perceptions about meat obtained from cattle fed hazelnut skins according to the level of personal involvement (concern) about feeding methods

The results of the GLMM showed that providing respondents with definitions of sustainable production, food waste, and feed quality did not significantly influence the attitudes and perceptions of regular meat consumers. Overall, the perception of benefits of eating meat from cattle fed HS as part of the feed formula according to the level (high *vs* low) of personal involvement (*i.e.* concern) about feeding methods was rather high, whereas risk perception was rather low (Table 2). Regular meat consumers with a high personal involvement regarding what animals are fed showed significantly more positive attitudes, and perceived the quality (juiciness), health (healthiness, nutritional composition and safety), and animal welfare attributes of meat from HS fed cattle to be better than consumers characterized by low personal involvement about cattle feeding methods ($P \leq 0.05$, Table 2). The degree of personal involvement in livestock feeding methods influenced all the benefit perceptions tested in this study; however, we found no impact on any of the perceptions of risk ($P \leq 0.05$, Table 2).

### 3.3. Influence of the level of green self-identity according to level of personal involvement (concern) about feeding methods in attitudes and perceptions about meat from hazelnut skin fed cattle

Table 3 presents the results for the composite attitudes and perceptions towards meat obtained from cattle fed hazelnut skins as part of the feed formula according to the level of green self-identity and personal involvement (concern) regarding livestock feeding methods. Attitudes and perceptions about the quality (taste, juiciness), and health (healthiness and safety) attributes had a significant main effect on the perception of all the possible benefits derived from eating meat obtained from cattle fed HS as part of the feed formula in participants reporting high personal involvement (concern) about feeding methods. They had no significant impact on the perception of risks ($P \leq 0.05$, Table 3). In contrast, the mean difference between those with low *vs* high green self-identity and low personal involvement (concern) about livestock feeding methods was significantly less. Participants with a low personal involvement and high green self-identity expressed significantly more positive attitudes and perceptions about quality attributes (taste and appearance) and perceived greater benefits (food waste reduction, overall good impressions, more pleasant, nutritious and healthy meat) of meat obtained from animals fed HS as part of the feed formula than those with low personal involvement and low green self-identity ($P \leq 0.05$, Table 3).

**Table 1**
Socio-demographic and personal characteristics of the sample ($n = 900$).

| | N | % |
|---|---|---|
| *Gender* | | |
| Women | 453 | 50.44 |
| Men | 446 | 49.56 |
| *Generation* | | |
| Baby boomers (60–69 years old) | 209 | 23.22 |
| Generation X (44–59 years old) | 241 | 26.78 |
| Millennials (28–43 years old) | 374 | 41.56 |
| Gen Z (18–27 years old) | 76 | 8.44 |
| *Education* | | |
| PhD | 72 | 8.00 |
| Master's degree | 193 | 21.44 |
| Bachelor's degree | 112 | 12.44 |
| Secondary school | 490 | 54.44 |
| Primary school | 33 | 3.698 |
| *Monthly Income (€)* | | |
| Less than 1000 | 73 | 8.11 |
| Between 1001 and 2000 | 291 | 32.33 |
| Between 2001 and 4000 | 323 | 35.89 |
| Between 4001 and 6000 | 70 | 7.78 |
| More than 6000 | 20 | 2.22 |
| Preferred not to respond | 122 | 13.67 |
| *Employment status* | | |
| Other | 36 | 4.00 |
| Unemployed | 99 | 11.00 |
| Public-sector worker | 122 | 13.56 |
| Self-employed | 94 | 10.44 |
| Private-sector worker | 376 | 41.78 |
| Retired | 74 | 8.22 |
| Student | 53 | 5.89 |
| Not seeking work | 46 | 5.11 |
| *Willingness to try* | | |
| Willing | 796 | 88.44 |
| Unwilling | 104 | 11.56 |
| *Level of food neophobia* | | |
| High | 283 | 31.44 |
| Medium | 307 | 34.11 |
| Low | 310 | 34.45 |
| *Green self-identity* | | |
| High | 737 | 81.89 |
| Low | 163 | 18.11 |
| *Personal involvement (regarding how animals are fed)* | | |
| High | 608 | 67.56 |
| Low | 292 | 32.44 |

The **Willingness to try** (WTT) groups were assigned based on the responses to the closed question (yes = willing or no = unwilling to try meat from animals fed HS as part of the feed formula).
Respondents were assigned to the **level of neophobia** groups based on the sum of the scores for the items in the food neophobia scale: "low neophobia" (subjects in the lowest quartile, FNS $\leq$ 23), "medium neophobia" (subjects in the second and third quartile, FNS $\geq$ 24 and $\leq$ 41), and "high neophobia" (subjects in the highest quartile, FNS $\geq$ 42).
Respondents were assigned to the green self-identity and personal involvement (concern about what animals are fed) groups based on the average of the scores of the items in each scale. Scores equal to or less than the median value of 5 were considered to indicate a low level of green self-identity or personal involvement; values greater than 5 were considered to indicate high green self-identity/ personal involvement.

**Table 2**
Mean differences in attitudes and perceptions about meat obtained from hazelnut skin-fed cattle between Italian meat consumers with high *vs* low levels of personal involvement (concern) about what animals are fed ($n = 900$).

| | High personal involvement | | | Low personal involvement | | | | |
|---|---|---|---|---|---|---|---|---|
| | mean | SE | | mean | SE | | *F*-value | *P*-value |
| Meat consumption frequency | 1.09 | 0.02 | | 1.11 | 0.02 | | 1.58 | 0.2093 |
| **Attitude** | 4.99 | 0.07 | a | 4.38 | 0.08 | b | 38.90 | **<.0001** |
| **Product characteristics** | | | | | | | | |
| taste | 4.48 | 0.07 | a | 4.19 | 0.07 | b | 10.01 | 0.0016 |
| appearance | 4.24 | 0.07 | | 4.12 | 0.07 | | 1.69 | 0.1935 |
| nutritional composition | 4.64 | 0.07 | a | 4.16 | 0.08 | b | 26.03 | **<.0001** |
| texture (juiciness) | 4.55 | 0.07 | a | 4.13 | 0.07 | b | 20.12 | **<.0001** |
| healthiness | 4.77 | 0.08 | a | 4.36 | 0.08 | b | 16.16 | **1.00E$^{-04}$** |
| safety | 4.78 | 0.08 | a | 4.35 | 0.09 | b | 16.44 | **0.0001** |
| high price | 4.08 | 0.07 | | 4.02 | 0.07 | | 0.44 | 0.5097 |
| high level of animal welfare | 4.60 | 0.07 | a | 4.10 | 0.08 | b | 24.79 | **<.0001** |
| smell | 3.82 | 0.09 | | 3.85 | 0.10 | | 0.06 | 0.8123 |
| **Benefit perceptions** | | | | | | | | |
| I believe meat from hazelnut skin-fed cattle would **have a positive effect on my health** | 4.77 | 0.07 | a | 4.38 | 0.07 | b | 17.41 | **<.0001** |
| I believe meat from hazelnut skin-fed cattle would **have a positive effect on the environment** | 5.12 | 0.07 | a | 4.75 | 0.07 | b | 17.17 | **<.0001** |
| I believe meat from hazelnut skin-fed cattle would **help reduce the environmental impact of beef to some extent** | 4.92 | 0.07 | a | 4.52 | 0.08 | b | 17.56 | **<.0001** |
| I believe meat from hazelnut skin-fed cattle would **help increase animal welfare to some extent** | 4.90 | 0.07 | a | 4.55 | 0.07 | b | 14.72 | **1.00E$^{-04}$** |
| I believe meat from hazelnut skin-fed cattle would **help reduce food waste** | 5.08 | 0.07 | a | 4.71 | 0.07 | b | 15.62 | **0.0001** |
| I believe meat from hazelnut skin-fed cattle would **have a familiar taste, similar to products that I already know** | 4.70 | 0.07 | a | 4.33 | 0.07 | b | 16.34 | **1.00E$^{-04}$** |
| I believe meat from hazelnut skin-fed cattle would **be pleasant** | 4.88 | 0.07 | a | 4.54 | 0.07 | b | 13.74 | **2.00E$^{-04}$** |
| I believe meat from hazelnut skin-fed cattle would **look good, smell good, and have adequate texture** | 4.74 | 0.06 | a | 4.38 | 0.07 | b | 16.82 | **<.0001** |
| I believe meat from hazelnut skin-fed cattle would **not contain toxins, drug residues, antibiotics, etc.** | 4.96 | 0.07 | a | 4.61 | 0.08 | b | 12.02 | **6.00E$^{-04}$** |
| I believe meat from hazelnut skin-fed cattle would **be more natural than beef** products from animals fed traditional feed | 4.92 | 0.07 | a | 4.46 | 0.08 | b | 24.27 | **<.0001** |
| I believe meat from hazelnut skin-fed cattle would **be more nutritious (more vitamins, fiber, etc) than beef products from animals fed traditional feed** | 4.78 | 0.07 | a | 4.43 | 0.07 | b | 15.07 | **1.00E$^{-04}$** |
| I believe meat from hazelnut skin-fed cattle would **be healthier than beef products from animals fed traditional feed** | 4.80 | 0.07 | a | 4.43 | 0.08 | b | 15.03 | **0.0001** |
| I believe meat from hazelnut skin-fed cattle would **be cheaper than beef products from animals fed traditional feed** | 4.57 | 0.07 | a | 4.37 | 0.08 | b | 4.52 | **0.0337** |
| **Risk perceptions** | | | | | | | | |
| I think that meat products from beef cattle fed hazelnut skins as part of the feed formula are harmful to my health | 3.66 | 0.09 | | 3.76 | 0.10 | | 0.58 | 0.4459 |
| I think that meat products from beef cattle fed hazelnut skins as part of the feed formula are unhealthy | 3.97 | 0.10 | | 3.90 | 0.11 | | 0.32 | 0.5716 |
| I am worried about the possible effects that eating meat products from beef cattle fed hazelnut skins as part of the feed formula could have on my body | 3.89 | 0.10 | | 3.75 | 0.11 | | 1.05 | 0.3062 |
| I believe that meat products from beef cattle fed hazelnut skins as part of the feed formula are a risk for human health | 3.71 | 0.10 | | 3.75 | 0.11 | | 0.09 | 0.7642 |

**Meat consumption frequency scales:** 1 = 1–5 times *per* week; 2 = 6–10 times *per* week; 3 = more than 10 times *per* week. **Product characteristics scale:** 7 = Extremely important; 6 = Very important; 5 = Considerably important; 4 = Moderately important; 3 = Slightly important; 2 = Low importance; 1 = Not important at all. **Attitudes and perceptions scales:** 1 = Strongly disagree; 2 = Disagree moderately; 3 = Disagree slightly; 4 = Neutral; 5 = Agree slightly; 6 = Agree moderately; 7 = Strongly agree.
Abbreviation. **SE:** standard error. Different letters indicate statistical differences related to personal involvement (concern about feeding methods), using the least significant difference test ($P < 0.05$). *P*-values were adjusted using Bonferroni's method. Significantly higher mean values are highlighted in green.

### *3.4. How the level of neophobia influences attitudes and perceptions about meat obtained from cattle fed hazelnut skins*

Overall, the results for the composite perceptions of meat from hazelnut skin fed cattle as part of the feed formula by level of neophobia were rather low, while risk perception was rather high (Table 4). Mean differences between the degree of level of neophobia for risk perceptions of meat from cattle fed HS as part of the feed formula were notable. Participants with a high level of neophobia perceived significantly more risks, while participants with a low degree of neophobia indicated greater acceptance ($P \leq 0.05$, Table 4).

### *3.5. Factors influencing the acceptance and avoidance of meat obtained from cattle fed hazelnut skins among consumers willing and unwilling to try new foods/beef from cattle fed hazelnut skins*

Independent of whether respondents reported to be willing or unwilling to try meat from cattle fed HS, respondents considered the healthy product characteristic as the most relevant ($P \leq 0.05$, Table 5). Consumers who expressed their willingness to try meat from cattle fed hazelnut skins were also those who perceived the product to be safe for consumption ($P \leq 0.05$ unwilling to try; $P < 0.0001$ willing to try, Table 5). Regardless of whether respondents reported being willing to try the product or not, the results of the GLMM show that the respondents considered environmental benefits (helping to reduce food waste) as the most relevant benefit ($P = 0.0150$ unwilling to try; $<0.0001$ willing to try, Table 5). By contrast, the perception that meat from cattle fed hazelnut skins as part of the feed formula was unhealthy was the item exerting the greatest influence over acceptance compared with all other perceived risks, independent of whether they were willing to try the product or not ($P = 0.0361$ unwilling to try, $P < 0.0001$ willing to try, Table 5).

## 4. Discussion

Trends in meat production systems are changing in a response to greater market demand for higher product quality, better animal welfare, and greater sustainability. However, consumers may be skeptical towards claims about farming practices (antibiotic- and hormone-free), living conditions (free range, pasture-raised), and animal diets (grass-fed, grain-fed, vegetarian fed, sustainability certifications) due to mistrust of the labeling systems (Vittersø and Tangeland, 2015). Existing literature indicates that a large share of consumers who have renounced meat from their diets do so due to environmental reasons. On the other hand, some consumers are open to trying alternative protein sources or only eat beef products derived from pasture-fed systems (Austgulen, Skuland, Schjøll, and Alfnes, 2018; Risius and Hamm, 2018). Consumer awareness, knowledge, trust, subjective and socio-demographic characteristics are key drivers shaping consumers' perceptions about food safety risks and consumption intentions (Machado Nardi, Teixeira, Ladeira, and de Oliveira Santini, 2020; Borrello et al., 2017).

The results of the present study showed that while the personal involvement construct (concern about what animals are fed) impacted all the benefit perceptions, perceptions of risk did not appear to hinder the respondent's WTT meat from cattle fed HS. One possible explanation might be the high level of familiarity with hazelnuts in the Italian population, leading to hazelnut waste products as being viewed as presenting low risks. Indeed, familiarity with food products serves as a basis for building trust and purchase intention (Wang, Perez-Cueto, Scarpa, and Scrimgeour, 2024). Furthermore, our results suggest that providing information about the animal feed system and the associated benefits could diminish consumer concerns about "novel foods" and ultimately positively influence consumer choices. However, neophobia—the "mistrust" of foods that have never been tried—stands to jeopardize the acceptability of novel foods, and by consequence the success of innovations in food production and sustainability (Faccio and Lucrezia, 2019). Our results indicate that the level of neophobia influences risk perceptions and the propensity to try meat from animals fed with agro-industrial by-products, in line with the findings from previous studies regarding consumers' attitudes towards insect-based food and cultured meat (Barrena and Sánchez, 2013; Faccio and Lucrezia, 2019). These findings highlight the role of inherent reluctance to novelty in shaping consumer attitudes, particularly regarding food choices. In addition, our results suggest that the target customers for meat from HS-fed cattle would be those with a high green self-identity, who are highly concerned about what animals eat (high personal involvement), and clearly willing to try novel foods. These results should encourage the meat industry to target environmentally conscientious meat consumers by means of segmentation analysis to enhance their marketing strategies through sustainability claims. Indeed, use of the "life cycle assessment" as a tool for measuring the environmental impact of these types of products is already actively encouraged in Europe (Directive 2009/125/EC) to substantiate any sustainability claims or certifications.

Growing consumer concern for health and environmental issues has resulted in consumers paying greater attention to their meat purchasing and consumption choices according to the dietary regimes of animals. This has fueled an increase in novel food research, especially as markets seeking to understand the motivations behind consumers' novel food purchases. Our results suggest that environmental conscientiousness, when combined with limited concern (personal involvement) about feeding methods, amplifies positive perceptions towards HS-fed beef. These results also support the significant role of environmental sustainability-related issues in driving consumers to adopt novel foods (Merlino et al., 2024). The "zero-waste society" target set by the European Union and the environmental burden arising from both food processing and livestock are fueling research into new and more sustainable ingredients that can be used effectively in livestock nutrition for the production of safe and high-quality products. Nevertheless, HS continues to be under-exploited as a feed ingredient for farm animal and relevant source of functional compounds. The commercial use of HS as part of feed formulations or as a functional feed ingredient constitutes to be a challenge, as well as an opportunity, for field scientists who must ensure that the product complies with feed legislations, can be produced year-round to meet global feed demand, and leads to the placement of novel animal feed on the market.

Inserting by-products back into the food chain as food grade ingredients is a sustainable approach to reducing waste and maximizing resources, but more work is needed since significant scientific progress in this area is relatively recent. Numerous studies have recognized the

**Table 3**
Mean differences in the attitudes and perceptions about meat obtained from cattle fed hazelnut skin between Italian meat consumers with high *vs* low green self-identity, stratified according to the level of personal involvement (concern) about feeding methods ($n = 900$).

| | High personal involvement (about feeding methods) | | | | | | | | Low personal involvement (about feeding methods) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High green self-identity | | | Low green self-identity | | | | | High green sef-identity | | | Low green self-identity | | | | |
| | mean | SE | | mean | SE | | *F*-value | *P*-value | mean | SE | | mean | SE | | *F*-value | *P*-value |
| **Attitudes** | 4.82 | 0.09 | | 4.10 | 0.20 | | 13.36 | 0.0017 | 4.09 | 0.21 | | 3.68 | 0.15 | | 2.91 | 0.1000 |
| **Product characteristics** | | | | | | | | | | | | | | | | |
| taste | 4.62 | 0.09 | a | 4.15 | 0.21 | b | 5.517 | **0.0192** | 4.10 | 0.18 | a | 3.48 | 0.13 | b | 8.866 | **0.0036** |
| appearance | 4.29 | 0.10 | a | 3.80 | 0.21 | b | 5.699 | **0.0173** | 4.02 | 0.18 | a | 3.48 | 0.13 | b | 6.997 | **0.0095** |
| nutritional composition | 4.64 | 0.10 | | 4.26 | 0.21 | | 3.399 | 0.0657 | 3.75 | 0.17 | | 3.81 | 0.12 | | 0.122 | 0.7274 |
| texture (juiciness) | 4.50 | 0.09 | a | 3.96 | 0.21 | b | 7.476 | **0.0064** | 3.77 | 0.20 | | 3.67 | 0.14 | | 0.177 | 0.6752 |
| healthiness | 4.79 | 0.10 | a | 4.35 | 0.23 | b | 4.082 | **0.0438** | 4.35 | 0.19 | | 4.01 | 0.14 | | 2.471 | 0.1191 |
| safety | 4.71 | 0.10 | a | 4.14 | 0.23 | b | 6.912 | **0.0088** | 4.04 | 0.23 | | 4.02 | 0.17 | | 0.005 | 0.9429 |
| high price | 3.99 | 0.09 | | 3.83 | 0.20 | | 0.756 | 0.3849 | 3.95 | 0.20 | | 3.73 | 0.15 | | 0.932 | 0.3367 |
| high level of animal welfare | 4.58 | 0.10 | | 4.24 | 0.22 | | 2.468 | 0.1167 | 3.94 | 0.19 | | 3.62 | 0.14 | | 2.321 | 0.1308 |
| smell | 3.85 | 0.12 | | 3.74 | 0.27 | | 0.185 | 0.6672 | 3.90 | 0.21 | | 3.64 | 0.15 | | 1.239 | 0.2683 |
| **Benefit perceptions** | | | | | | | | | | | | | | | | |
| I believe meat from cattle fed hazelnut skins as part of the feed formula would… | | | | | | | | | | | | | | | | |
| have positive effects on my health | 4.77 | 0.09 | a | 4.00 | 0.20 | b | 15.987 | **0.0001** | 3.95 | 0.24 | | 3.76 | 0.17 | | 0.514 | 0.4753 |
| have positive effect on the environment | 5.22 | 0.08 | a | 4.51 | 0.18 | b | 16.408 | **0.0001** | 4.42 | 0.20 | | 4.05 | 0.15 | | 2.676 | 0.1050 |
| help reduce the environmental impact to some extent | 5.02 | 0.08 | a | 4.26 | 0.19 | b | 17.775 | **<.0001** | 3.87 | 0.26 | | 3.74 | 0.19 | | 0.191 | 0.6632 |
| help increase animal welfare to some extent | 4.88 | 0.09 | a | 4.25 | 0.20 | b | 10.587 | **0.0012** | 4.31 | 0.21 | | 3.96 | 0.15 | | 2.076 | 0.1528 |
| help reduce food waste | 5.24 | 0.08 | a | 4.70 | 0.19 | b | 9.060 | **0.0027** | 4.44 | 0.22 | a | 3.82 | 0.16 | b | 6.305 | **0.0136** |
| have a familiar taste, similar to products that I already know | 4.71 | 0.09 | a | 4.06 | 0.19 | b | 11.848 | **0.0006** | 3.93 | 0.23 | | 3.44 | 0.17 | | 3.666 | 0.0584 |
| be pleasant | 4.89 | 0.09 | a | 4.34 | 0.19 | b | 8.623 | **0.0034** | 4.39 | 0.20 | a | 3.89 | 0.15 | b | 4.611 | **0.0342** |
| look good, smell good, and have adequate texture | 4.77 | 0.09 | a | 4.32 | 0.19 | b | 6.222 | **0.0129** | 4.30 | 0.23 | a | 3.76 | 0.17 | b | 4.411 | **0.0382** |
| not contain toxins, drug residues, antibiotics, etc | 4.89 | 0.10 | a | 4.00 | 0.21 | b | 19.290 | **<.0001** | 4.32 | 0.22 | | 3.95 | 0.16 | | 2.144 | 0.1463 |
| be more natural than beef products from animals fed traditional feed | 4.91 | 0.09 | a | 4.06 | 0.19 | b | 21.020 | **<.0001** | 3.89 | 0.24 | | 3.90 | 0.17 | | 0.001 | 0.9706 |
| be more nutritious (more vitamins, fiber, etc.) than beef products from animals fed traditional feed | 4.76 | 0.09 | a | 4.30 | 0.19 | b | 6.167 | **0.0133** | 4.26 | 0.20 | a | 3.74 | 0.15 | b | 5.096 | **0.0262** |
| be healthier than beef products from animals fed traditional feed | 4.79 | 0.09 | a | 4.24 | 0.20 | b | 8.200 | **0.0043** | 4.21 | 0.23 | a | 3.46 | 0.17 | b | 8.222 | **0.0050** |
| be cheaper than beef products from animals fed traditional feed | 4.71 | 0.09 | a | 4.15 | 0.21 | b | 7.861 | **0.0052** | 3.99 | 0.24 | | 3.69 | 0.17 | | 1.237 | 0.2688 |

**Attitudes and perceptions scales:** 1 = Strongly disagree; 2 = Disagree moderately; 3 = Disagree slightly; 4 = Neutral; 5 = Agree slightly; 6 = Agree moderately; 7 = Strongly agree. **Product characteristics scale:** 7 = Extremely important; 6 = Very important; 5 = Considerably important; 4 = Moderately important; 3 = Slightly important; 2 = Low importance; 1 = Not important at all.
Abbreviation. **SE:** standard error. Different letters indicate statistical differences related to green self-identity according to high or low personal involvement (concern about feeding methods), using the least significant difference test ($P < 0.05$). *P*-values were adjusted using Bonferroni's method. Significantly higher mean values are highlighted in green.

value of hazelnut by-products as a promising source of bioactive compounds to enhance the nutritional value of foodstuffs such as egg pasta, chicken burgers, dairy products, bakery products, and natural colorants (Bertolino et al., 2015; Ceylan et al., 2022; Longato et al., 2019; Zeppa et al., 2015). While much attention has been directed towards creating value from upcycled ingredients, the reason for the lack of meat products from animals fed plant by-products on the market is due to the complexity of the necessary, underlying communications, bringing about a mix of regulatory and marketing challenges. Therefore, a political strategy to address both sustainable production and consumption needs to be tackled from a "triangular" perspective between businesses, governments, and consumers (Tukker, Sto, and Vezzoli, 2008). In this regard, companies in the agri-food supply chain and technology providers are gradually becoming open to participate in the circular economy of food systems, in the spirit of the new economic paradigm that sees all players in the supply chain actively involved in the responsible use of resources (Ciccullo, Cagliano, Bartezzaghi, and Perego, 2021). While some producers are offering sustainable choices to the market, their endeavors have not always translated into an increase in sufficient sales (Gabzdylova, Raffensperger, and Castka, 2009).

To generate interest in the use of HS as part of the feed formulation for food-producing animals, the hazelnut producer, the feed manufacturer, and livestock producers should all benefit from a reasonable profit, permitting them to survive in a competitive market. Despite new regulations pertaining to the authorization, marketing, and use of feed materials and compound feeds government subsidies and new legislation that help farmers diversify their operations, thus making them more resilient to changes, might help the feed industry cover some of the production costs and consequently enforce environmental sustainability by promoting the use of agricultural by-products. The main limitations of the commercial application of food by-products in animal nutrition are related to production logistics and economic viability of the farms

**Table 4**
Mean differences in the respondents' perceptions about meat obtained from cattle fed hazelnut skins among Italian meat consumers with high, medium, and low neophobia ($n = 900$).

| | High neophobia | | | Neutral | | | Low neophobia | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | mean | SE | | mean | SE | | mean | SE | | *F*-value | *P*-value |
| **Product characteristics** | | | | | | | | | | | |
| appearance | 3.82 | 0.41 | | 3.74 | 0.40 | | 3.73 | 0.41 | | 1.569 | 0.2087 |
| nutritional composition | 3.92 | 0.42 | | 3.92 | 0.41 | | 4.04 | 0.42 | | 1.536 | 0.2158 |
| high price | 3.94 | 0.39 | | 3.89 | 0.39 | | 3.79 | 0.39 | | 1.293 | 0.2750 |
| high level of Animal Welfare | 4.85 | 0.43 | | 4.84 | 0.43 | | 5.02 | 0.43 | | 2.973 | 0.0517 |
| smell | 4.12 | 0.52 | a | 3.88 | 0.51 | ab | 3.67 | 0.52 | b | 6.051 | **0.0025** |
| **Risk perceptions** | | | | | | | | | | | |
| I think that meat products from beef cattle fed hazelnut skins as part of the feed formula are harmful to my health | 4.49 | 0.52 | a | 4.02 | 0.52 | b | 3.61 | 0.52 | c | 23.410 | **<.0001** |
| I think that meat products from beef cattle fed hazelnut skin as part of the feed formula are unhealthy | 4.84 | 0.54 | a | 4.26 | 0.54 | b | 3.74 | 0.54 | c | 34.136 | **<.0001** |
| I am worried about the possible effects that eating meat products from beef cattle fed hazelnut skins as part of the feed formula could have on my body | 4.80 | 0.54 | a | 4.29 | 0.53 | b | 3.63 | 0.54 | c | 39.680 | **<.0001** |
| I believe that meat products from beef cattle fed hazelnut skin as part of the feed formula are a risk for human health | 4.69 | 0.53 | a | 4.28 | 0.52 | b | 3.76 | 0.53 | c | 26.562 | **<.0001** |

**Perceptions scale:** 1 = Strongly disagree; 2 = Disagree moderately; 3 = Disagree slightly; 4 = Neutral; 5 = Agree slightly; 6 = Agree moderately; 7 = Strongly agree. **Product characteristics scale:** 7 = Extremely important; 6 = Very important; 5 = Considerably important; 4 = Moderately important; 3 = Slightly important; 2 = Low importance; 1 = Not important at all.
Abbreviation. **SE:** standard error. Different letters indicate statistical differences related to level of neophobia using the least significant difference test ($P < 0.05$). *P*-values were adjusted using Bonferroni's method. Significantly higher mean values are highlighted in green.

and the feed and food processing industries (Kasapidou et al., 2015). Moreover, the cost of collecting, processing and utilizing HS may not be of particular economic interest compared with other by-products, and the volumes produced may not be sufficient to justify large-scale operations. Additionally, there is a lack of safety assessments for the use of food by-products in human and animal nutrition, and thus inadequate regulations for ensuring the safety and quality of these by-products.

The incorporation of by-products into animal diets requires detailed knowledge of the product's nutritional factors in terms of antioxidant, immunomodulatory and antibacterial effects that may affect animal performance and growth. Feeding lambs HS improved the nutritional properties of the meat by increasing the concentration of desirable fatty acids and led to an increase in the myofibril fragmentation index, lightness, redness and chroma color parameters (della Malva et al., 2023; Menci et al., 2023; Priolo et al., 2021). In dairy cows, milk production levels and the fat and protein content of milk did not vary between those receiving a traditional feed formulation *vs* feeds including/supplemented with HS, whereas lactating ewes fed a pelleted concentrate containing HS produced milk characterized by a greater presence of desirable fatty acids (Campione et al., 2020; Renna et al., 2020). Feeding HS to pigs did not diminish consumers' evaluations of salami; to the contrary, informing consumers about the feeding methods actually enhanced their perceptions of the products, especially in terms of taste quality (Bolletta et al., 2024). The promising results of the inclusion of sustainable and low-cost feed ingredients in animal nutrition underscore their potential to enhance feed efficiency, reduce costs, minimize environmental impact, and ensure quality, ultimately contributing to more sustainable and economically viable livestock production systems.

As one of the first quantitative studies to investigate consumers' perceptions about alternative feeds, this study makes an important contribution to a topic that concerns both risk communicators and consumers. Our results showed that providing information about the positive effects of an alternative feed did not alter the willingness of Italian regular meat consumers to try products from animals fed in this way. By contrast, providing information on the benefits of using insect products in poultry feed positively influenced the willingness of Italian consumers to pay for poultry meat fed insect meal or live insects (Sogari et al., 2022). However, the willingness of German consumers to buy meat from animals fed insects as an alternative protein source depended on the consumers' attitudes and social norms (Weinrich and Busch, 2021), as also found in this study in which food neophobia, green self-identity, and personal involvement over how animals are fed predicted better acceptance and positive perceptions. English consumers were found to exhibit favorable attitudes towards the use of alternative feeds (namely, insect meal for fish feeds) (Popoff et al., 2017), as also found in the present study. According to Menozzi et al. (2020), consumers across different European countries (France, Germany, Italy, Spain, and UK) showed a preference towards sustainability labels, nutrition, and health claims for fish products, but consumer preferences and willingness to pay varied according to country and fish species. This observation partially aligns with the present study, which indicated Italian consumers to prefer sustainability benefits (HS in animal feed helps to reduce food waste). These results should be considered in relation to labeling strategies.

The limitations of the present study should be mentioned, which might influence the generalizability of the findings across the Italian population. In particular, younger people were under-represented in the sample. Future research should consider alternative recruitment and data collection methods to represent the younger segment of the population more accurately. Hence, the sample might not be representative of the Italian resident population, but of predominant meat consumers in Italy. The methodology used in this study may also have some limitations, such as the lack of a control group that did not receive any information about the use of HS as part of the feed formula, and the potential health benefits for humans or animals were not provided in the framings. To address these limitations, a control group should be included, ensuring a baseline comparison to accurately measure the effects of framing. Additionally, providing information about the health

**Table 5**
Mean differences in respondents' perceptions about meat obtained from cattle fed hazelnut skins among Italian meat consumers willing *vs* unwilling to try the product ($n = 900$).

| | Willing to try | | | Unwilling | | |
|---|---|---|---|---|---|---|
| | mean | SE | | mean | SE | |
| **Product characteristics** | | | | | | |
| appearance | 4.31 | 0.0442 | d | 3.80 | 0.146 | ab |
| healthiness | 4.79 | 0.0442 | a | 4.24 | 0.146 | a |
| high level of animal welfare | 4.67 | 0.0442 | ab | 3.88 | 0.146 | ab |
| high price | 4.18 | 0.0442 | d | 3.74 | 0.146 | b |
| nutritional composition | 4.60 | 0.0442 | bc | 4.02 | 0.146 | ab |
| safety | 4.81 | 0.0442 | a | 4.10 | 0.146 | ab |
| smell | 3.76 | 0.0442 | e | 3.87 | 0.146 | ab |
| taste | 4.54 | 0.0442 | bc | 4.06 | 0.146 | ab |
| texture (juiciness) | 4.48 | 0.0442 | c | 3.95 | 0.146 | ab |
| **Benefit perceptions** | | | | | | |
| **I believe** meat from hazelnut skin fed cattle would | | | | | | |
| be cheaper than beef products from animals fed traditional feed | 4.66 | 0.0422 | f | 4.20 | 0.132 | ab |
| be healthier than beef products from animals fed traditional feed | 4.99 | 0.0422 | cde | 4.11 | 0.132 | ab |
| be more nutritious (more vitamins, fiber, etc) than beef products from animals fed traditional feed | 4.92 | 0.0422 | de | 4.04 | 0.132 | ab |
| be more natural than beef products from animals fed traditional feed | 5.12 | 0.0422 | c | 4.14 | 0.132 | ab |
| be pleasant | 4.93 | 0.0422 | de | 4.34 | 0.132 | ab |
| have a taste familiar to products that I already know | 4.83 | 0.0422 | e | 3.93 | 0.132 | b |
| have positive effect on the environment | 5.37 | 0.0422 | ab | 4.37 | 0.132 | ab |
| have positive effects on my health | 4.90 | 0.0422 | e | 4.05 | 0.132 | ab |
| help increase to some extent animal welfare | 5.08 | 0.0422 | cd | 4.22 | 0.132 | ab |
| help reduce food waste | 5.46 | 0.0422 | a | 4.40 | 0.132 | a |
| help reduce to some extent the environmental impact | 5.29 | 0.0422 | b | 4.21 | 0.132 | ab |
| look good, smell good, and have adequate texture | 4.85 | 0.0422 | e | 4.19 | 0.132 | ab |
| not contain toxins, drug residues, antibiotics, etc | 5.12 | 0.0422 | c | 4.20 | 0.132 | ab |
| **Risk perceptions** | | | | | | |
| I think that meat products from beef cattle fed hazelnut skins as part of the feed formula are harmful to my health | 3.13 | 0.0581 | c | 4.54 | 0.127 | b |
| I am worried about the possible effects that eating meat products from beef cattle fed hazelnut skins as part of the feed formula could have on my body | 3.34 | 0.0581 | b | 4.78 | 0.127 | ab |
| I believe that meat products from beef cattle fed hazelnut skins as part of the feed formula are a risk for human health | 3.14 | 0.0581 | c | 4.78 | 0.127 | ab |
| I think that meat products from beef cattle fed hazelnut skins as part of the feed formula are unhealthy | 3.50 | 0.0581 | a | 4.84 | 0.127 | a |

**Perceptions scales:** 1 = Strongly disagree; 2 = Disagree moderately; 3 = Disagree slightly; 4 = Neutral; 5 = Agree slightly; 6 = Agree moderately; 7 = Strongly agree. **Product characteristics scale:** 7 = Extremely important; 6 = Very important; 5 = Considerably important; 4 = Moderately important; 3 = Slightly important; 2 = Low importance; 1 = Not important at all.
Abbreviation. **SE:** standard error. Different letters indicate statistical differences related to willingness to try using the least significant difference test ($P < 0.05$). *P*-values were adjusted using Bonferroni's method. Significantly higher mean values are highlighted in green.

benefits for consumers across different countries would promote a broader geographic reach, providing a more diverse sample. This approach would enhance the robustness of the findings and strengthen the validity of attributing changes in perceptions solely to the framing, as it would account for potential cultural and regional differences in consumer interpretation and response. A potential theoretical limitation should also be noted. The working model comprised/only considered selected variables which had previously been shown to be important for consumer perceptions of novel food. However, other variables, such as different forms of knowledge, the presence of children in the household and their age, income, meat shoppers and whether consumers are allergic to nuts and might also play a role. These additional variables could be included in future studies following a similar working model.

From the methodological standpoint, the approach used in this study led to useful observations and explanations of the survey data processed through GLMM analysis. The challenge in studies that focus on socially desirable behavior, such as environmental and quality concerns and associated issues such as food waste reduction and meat quality, is to reveal potential barriers to the embodiment of these ideal self-reported attitudes. Statistical models can provide such indications, however, the actual sales in shops and consumers tests remain the strongest indicators of consumer choices. With the increasing relevance of reducing the environmental impact of meat production, future research should endeavor to generate more accurate ways of predicting the behavior of honest consumers in a real market. Sensory and willingness to pay analysis of the meat from cattle fed HS or other food industry by-products could provide a more realistic predictor of consumer acceptance for this type of novel food. Satisfactory results would help to meet consumer requirements and overcoming the survey bias and social-desirability bias present in the present study. However, the results presented here suggest that consumers are more likely to adopt novel foods for hedonic reasons and to promote sustainability.

## 5. Conclusion

This study offers insights into Italian consumers' attitudes, perceptions, and willingness to try meat obtained from cattle fed hazelnut skins as part of the feed formula. The findings show that the level of personal involvement (concern), green self-identity, food neophobia, consumer perceptions about risks and benefits, and product characteristics all play a role in the acceptance of alternative feed ingredients in the livestock sector. The study also revealed a positive response of consumers towards alternative feeds accompanied by information about how their use can benefit the environmental or animal health. These findings constitute an important starting point for further research and for informing consumers about the actual risks associated with agro-industrial by-

products enabling them to make meat choices on a fact-based assessment of the risks and benefits of alternative feed use.

## CRediT authorship contribution statement

**Jatziri Mota-Gutierrez:** Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Valentina Maria Merlino:** Writing – review & editing, Supervision. **Stefano Massaglia:** Writing – review & editing. **Andrea Giorgino:** Writing – review & editing. **Simone Blanc:** Writing – review & editing, Validation, Supervision, Conceptualization. **Claudio Forte:** Writing – review & editing, Resources, Funding acquisition.

## 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

The data that has been used is confidential.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.meatsci.2024.109687.

## References

Ahmad, R. S., Imran, A., & Hussain, M. B. (2018). Nutritional composition of meat. In , *61.10.5772, Vol. 61. Meat Science and Nutrition* (pp. 61–75).

Altintzoglou, T., Honkanen, P., & Whitaker, R. D. (2021). Influence of the involvement in food waste reduction on attitudes towards sustainable products containing seafood by-products. *Journal of Cleaner Production, 285*. https://doi.org/10.1016/j.jclepro.2020.125487

de Andrade, J. C., Nalério, E. S., Giongo, C., de Barcellos, M. D., Ares, G., & Deliza, R. (2017). Consumer perception of dry-cured sheep meat products: Influence of process parameters under different evoked contexts. *Meat Science, 130*, 30–37. https://doi.org/10.1016/j.meatsci.2017.04.003

de Araújo, P. D., Araújo, W. M. C., Patarata, L., & Fraqueza, M. J. (2022). Understanding the main factors that influence consumer quality perception and attitude towards meat and processed meat products. In , *Vol. 193. Meat Science*. Elsevier Ltd.. https://doi.org/10.1016/j.meatsci.2022.108952

Arvola, A., Vassallo, M., Dean, M., Lampila, P., Saba, A., Lähteenmäki, L., & Shepherd, R. (2008). Predicting intentions to purchase organic food: The role of affective and moral attitudes in the Theory of Planned Behaviour. *Appetite, 50*(2–3), 443–454. https://doi.org/10.1016/j.appet.2007.09.010

Asioli, D., & Grasso, S. (2021). Do consumers value food products containing upcycled ingredients? The effect of nutritional and environmental information. *Food Quality and Preference, 91*. https://doi.org/10.1016/j.foodqual.2021.104194

Austgulen, M. H., Skuland, S. E., Schjøll, A., & Alfnes, F. (2018). Consumer readiness to reduce meat consumption for the purpose of environmental sustainability: Insights from Norway. *Sustainability (Switzerland), 10*(9). https://doi.org/10.3390/su10093058

Barrena, R., & Sánchez, M. (2013). Neophobia, personal consumer values and novel food acceptance. *Food Quality and Preference, 27*(1), 72–84. https://doi.org/10.1016/j.foodqual.2012.06.007

Bazzani, C., Caputo, V., Nayga, R. M., & Canavari, M. (2017). Revisiting consumers' valuation for local versus organic food using a non-hypothetical choice experiment: Does personality matter? *Food Quality and Preference, 62*, 144–154. https://doi.org/10.1016/j.foodqual.2017.06.019

Bearth, A., Cousin, M. E., & Siegrist, M. (2014). The consumer's perception of artificial food additives: Influences on acceptance, risk and benefit perceptions. *Food Quality and Preference, 38*, 14–23. https://doi.org/10.1016/j.foodqual.2014.05.008

Bearth, A., Cousin, M. E., & Siegrist, M. (2016). "The dose makes the poison": Informing consumers about the scientific risk assessment of food additives. *Risk Analysis, 36*(1), 130–144. https://doi.org/10.1111/risa.12410

Bertolino, M., Belviso, S., Dal Bello, B., Ghirardello, D., Giordano, M., Rolle, L., Gerbi, V., & Zeppa, G. (2015). Influence of the addition of different hazelnut skins on the physicochemical, antioxidant, polyphenol and sensory properties of yogurt. *LWT - Food Science and Technology, 63*(2), 1145–1154. https://doi.org/10.1016/J.LWT.2015.03.113

Bolletta, V., Menci, R., Valenti, B., Morbidini, L., Servili, M., Taticchi, A., Lilli, E., & Pauselli, M. (2024). Feeding pigs with hazelnut skin and addition of a concentrated phenolic extract from olive-milling wastewaters during pork processing: Effects on salami quality traits and acceptance by the consumers. *Meat Science, 213*. https://doi.org/10.1016/j.meatsci.2024.109479

Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., & Cembalo, L. (2017). Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability (Switzerland), 9*(1). https://doi.org/10.3390/su9010141

Campione, A., Natalello, A., Valenti, B., Luciano, G., Rufino-Moya, P. J., Avondo, M., … Pauselli, M. (2020). Effect of feeding hazelnut skin on animal performance, milk quality, and rumen fatty acids in lactating ewes. *Animals, 10*(4). https://doi.org/10.3390/ani10040588

Carrillo, E., Prado-Gascó, V., Fiszman, S., & Varela, P. (2012). How personality traits and intrinsic personal characteristics influence the consumer's choice of reduced-calorie food. *Food Research International, 49*(2), 792–797. https://doi.org/10.1016/j.foodres.2012.09.006

Ceylan, F. D., Adrar, N., Bolling, B. W., & Capanoglu, E. (2022). Valorisation of hazelnut by-products: Current applications and future potential. In *Biotechnology and Genetic Engineering Reviews*. Taylor and Francis Ltd.. https://doi.org/10.1080/02648725.2022.2160920

Chen, M. F. (2007). Consumer attitudes and purchase intentions in relation to organic foods in Taiwan: Moderating effects of food-related personality traits. *Food Quality and Preference, 18*(7), 1008–1021. https://doi.org/10.1016/j.foodqual.2007.04.004

Ciccullo, F., Cagliano, R., Bartezzaghi, G., & Perego, A. (2021). Implementing the circular economy paradigm in the Agri-food supply chain: The role of food waste prevention technologies. *Resources, Conservation and Recycling, 164*. https://doi.org/10.1016/j.resconrec.2020.105114

Crawley, M. (2012). *The R book*. John Wiley and Sons.

Del Rio, D., Calani, L., Dall'Asta, M., & Brighenti, F. (2011). Polyphenolic composition of hazelnut skin. *Journal of Agricultural and Food Chemistry, 59*(18), 9935–9941. https://doi.org/10.1021/jf202449z

della Malva, A., Santillo, A., Priolo, A., Marino, R., Ciliberti, M. G., Sevi, A., & Albenzio, M. (2023). Effect of hazelnut skin by-product supplementation in lambs' diets: Implications on plasma and muscle proteomes and first insights on the underlying mechanisms. *Journal of Proteomics, 271*. https://doi.org/10.1016/j.jprot.2022.104757

Diaz Vicuna, E., Srikanthithasan, K., Odore, R., Massaglia, S., Merlino, V. M., Giorgino, A., … Forte, C. (2024). Influence of age, gender, and willingness to adopt former foodstuffs on the perception of Italian farm animal veterinarians. *Frontiers in Veterinary Science, 11*. https://doi.org/10.3389/fvets.2024.1396807

EFSA. (2020). Annual report of the scientific network on BSE-TSE 2020. *European Food Safety Authority, 17*(10). https://doi.org/10.2903/sp.efsa.2020.EN-1946

EFSA. (2021). *Bovine Spongiform Encephalopathy (BSE)*. European Food Safety Authority. https://www.efsa.europa.eu/en/topics/topic/bovine-spongiform-encephalopathy-bse.

Escobedo del Bosque, C., Spiller, A., & Risius, A. (2021). Who wants chicken? Uncovering consumer preferences for produce of alternative chicken product methods. *Sustainability (Switzerland), 13*(5), 1–22. https://doi.org/10.3390/su13052440

European Commission. (2021a). *Aims of EU Quality Schemes*. European Comission. https://agriculture.ec.europa.eu/farming/geographical-indications-and-quality-schemes/geographical-indications-and-quality-schemes-explained_en.

European Commission. (2021b). *(2021b, January 26). Glossary Item. By-Products*.

Faccio, E., & Lucrezia, G. N. F. (2019). Food neophobia or distrust of novelties? Exploring consumers' attitudes toward GMOs, insects and cultured meat. In , *Vol. 9, Issue 20. Applied Sciences (Switzerland)*. MDPI. https://doi.org/10.3390/app9204440.

FAOSTAT. Food and Agriculture Organization of the United Nations. (2024). *Stats*. Hazelnut Production. https://www.fao.org/faostat/en/#data/QCL.

Fraqueza, M. J., Borges, A., & Patarata, L. (2018). Strategies to reduce the formation of carcinogenic chemicals in dry cured meat products. *Food Control and Biosecurity, 16*, 295–342. https://doi.org/10.1016/B978-0-12-811445-2.00009-X

Gabzdylova, B., Raffensperger, J. F., & Castka, P. (2009). Sustainability in the New Zealand wine industry: Drivers, stakeholders and practices. *Journal of Cleaner Production, 17*(11), 992–998. https://doi.org/10.1016/j.jclepro.2009.02.015

Galanakis, C. M. (2012). Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications. In , *Vol. 26, issue 2. Trends in Food Science and Technology* (pp. 68–87). https://doi.org/10.1016/j.tifs.2012.03.003

García-Torres, S., López-Gajardo, A., & Mesías, F. J. (2016). Intensive vs. free-range organic beef. A preference study through consumer liking and conjoint analysis. *Meat Science, 114*, 114–120. https://doi.org/10.1016/j.meatsci.2015.12.019

Grasso, S., & Asioli, D. (2020). Consumer preferences for upcycled ingredients: A case study with biscuits. *Food Quality and Preference, 84*. https://doi.org/10.1016/j.foodqual.2020.103951

Grebitus, C., & Dumortier, J. (2016). Effects of values and personality on demand for organic produce. *Agribusiness, 32*(2), 189–202. https://doi.org/10.1002/agr.21445

Henchion, M. M., McCarthy, M., & Resconi, V. C. (2017). Beef quality attributes: A systematic review of consumer perspectives. *Meat Science, 128*, 1–7. https://doi.org/10.1016/j.meatsci.2017.01.006

Kasapidou, E., Sossidou, E., & Mitlianga, P. (2015). Fruit and vegetable co-products as functional feed ingredients in farm animal nutrition for improved product quality. In *, 5, Issue 4. Agriculture (Switzerland)* (pp. 1020–1034). MDPI. https://doi.org/10.3390/agriculture5041020.

Kleisiari, C., Kyrgiakos, L.-S., Niavis, S., Tigka, E., Moulogianni, C., Duquenne, M.-N., & Vlontzos, G. (2022). Understanding consumer patterns on meat and dairy products derived from animals fed with locally produced feed. *International Journal of Agricultural Resources, Governance and Ecology, 18*, 199–218.

Klink-lehmann, J., Langen, N., Simons, J., & Hartmann, M. (2022). Jumping on the bandwagon of responsibility—Or not? Consumers' perceived role in the meat sector. *Sustainability (Switzerland), 14*(10). https://doi.org/10.3390/su14106295

Laureati, M., Cattaneo, C., Bergamaschi, V., Proserpio, C., & Pagliarini, E. (2016). School children preferences for fish formulations: The impact of child and parental food neophobia. *Journal of Sensory Studies, 31*(5), 408–415. https://doi.org/10.1111/joss.12224

Laureati, M., Proserpio, C., Jucker, C., & Savoldelli, S. (2016). New sustainable protein sources: Consumers' willingness to adopt insects as feed and food. *Ital. J. Food Sci, 28*, 2016–2653. ISSN: 11201770.

Lin-Hi, N., Reimer, M., Schäfer, K., & Böttcher, J. (2022). Consumer acceptance of cultured meat: An empirical analysis of the role of organizational factors. *Journal of Business Economics.*. https://doi.org/10.1007/s11573-022-01127-3

Lin-Schilstra, L., & Fischer, A. R. H. (2022). Paradoxical consumers in four European countries: Meat-eating justification and willingness to pay for meat from animals treated by alternatives to surgical castration. *Meat Science, 188*. https://doi.org/10.1016/j.meatsci.2022.108777

Llauger, M., Claret, A., Bou, R., López-Mas, L., & Guerrero, L. (2021). Consumer attitudes toward consumption of meat products containing offal and offal extracts. *Foods, 10*(7). https://doi.org/10.3390/foods10071454

Longato, E., Meineri, G., Peiretti, P. G., Gai, F., Viuda-Martos, M., Pérez-Álvarez, J.Á., … Fernández-López, J. (2019). Effects of hazelnut skin addition on the cooking, antioxidant and sensory properties of chicken burgers. *Journal of Food Science and Technology, 56*(7), 3329–3336. https://doi.org/10.1007/s13197-019-03813-7

Lusk, J. L. (2018). Consumer preferences for and beliefs about slow growth chicken. *Poultry Science, 97*(12), 4159–4166. https://doi.org/10.3382/ps/pey301

Machado Nardi, V. A., Teixeira, R., Ladeira, W. J., & de Oliveira Santini, F. (2020). A meta-analytic review of food safety risk perception. *Food Control, 112*. https://doi.org/10.1016/j.foodcont.2020.107089

Malone, T., & Lusk, J. L. (2017). Taste trumps health and safety: Incorporating consumer perceptions into a discrete choice experiment for meat. *Journal of Agricultural and Applied Economics, 49*(1), 139–157. https://doi.org/10.1017/aae.2016.33

Mancini, S., Sogari, G., Menozzi, D., Nuvoloni, R., Torracca, B., Moruzzo, R., & Paci, G. (2019). Factors predicting the intention of eating an insect-based product. *Foods, 8*(7). https://doi.org/10.3390/foods8070270

Menci, R., Biondi, L., Natalello, A., Lanza, M., Priolo, A., Valenti, B., Bertino, A., Scerra, M., & Luciano, G. (2023). Feeding hazelnut skin to lambs delays lipid oxidation in meat. *Meat Science, 202*. https://doi.org/10.1016/j.meatsci.2023.109218

Menozzi, D., Nguyen, T. T., Sogari, G., Taskov, D., Lucas, S., Castro-Rial, J. L. S., & Mora, C. (2020). Consumers' preferences and willingness to pay for fish products with health and environmental labels: Evidence from five european countries. *Nutrients, 12*(9), 1–22. https://doi.org/10.3390/nu12092650

Menozzi, D., Sogari, G., Mora, C., Gariglio, M., Gasco, L., & Schiavone, A. (2021). Insects as feed for farmed poultry: Are italian consumers ready to embrace this innovation? *Insects, 12*(5). https://doi.org/10.3390/insects12050435

Merlino, V. M., Mosca, O., Blanc, S., Sparacino, A., Massaglia, S., Borra, D., … Fornara, F. (2023). The role of socio-demographic variables and buying habits in determining milk purchasers' preferences and choices. *Frontiers in Nutrition, 10*. https://doi.org/10.3389/fnut.2023.1072208

Merlino, V. M., Mosca, O., Fornara, F., Roma, R., Bonerba, E., Schiavone, A., … Tarantola, M. (2024). Which factors affect the Italian consumer's intention to insect-eating? An application of an integrated attitude-intention-eating model. *Food Quality and Preference, 113*, Article 105040. https://doi.org/10.1016/j.foodqual.2023.105040

Mitchell, K. R., Ploubidis, G. B., Datta, J., & Wellings, K. (2012). The Natsal-SF: A validated measure of sexual function for use in community surveys. *European Journal of Epidemiology, 27*(6), 409–418. https://doi.org/10.1007/s10654-012-9697-3

Monahan, F. J., Schmidt, O., & Moloney, A. P. (2018). Meat provenance: Authentication of geographical origin and dietary background of meat. In *Meat.* In *, Vol. 144. Science* (pp. 2–14). Elsevier Ltd.. https://doi.org/10.1016/j.meatsci.2018.05.008

Mordor Intelligence. (2024). Hazelnut Market Size and Share Analysis - Growth Trends and Forecasts (2024–2029). https://www.mordorintelligence.com/industry-reports/global-hazelnut-market.

Mota-Gutierrez, J., Sparacino, A., Merlino, V. M., Blanc, S., Brun, F., Massimelli, F., … Massaglia, S. (2024). Socio-demographic and cross-country differences in attention to sustainable certifications and changes in food consumption. *npj Science of Food, 8*(1). https://doi.org/10.1038/s41538-024-00274-x

Natalello, A., Luciano, G., Morbidini, L., Valenti, B., Pauselli, M., Frutos, P., … Priolo, A. (2019). Effect of feeding pomegranate byproduct on fatty acid composition of ruminal digesta, liver, and muscle in lambs. *Journal of Agricultural and Food Chemistry, 67*(16), 4472–4482. https://doi.org/10.1021/acs.jafc.9b00307

Ogoshi, K., Yasunaga, H., Obana, N., Ogawa, T., & Imamura, T. (2010). Consumer reactions to risk information on bovine spongiform encephalopathy in Japan. *Environmental Health and Preventive Medicine, 15*(5), 311–318. https://doi.org/10.1007/s12199-010-0144-3

Papargyropoulou, E., Lozano, R., Steinberger, K., Wright, J., Ujang, N., & Bin, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production, 76*, 106–115. https://doi.org/10.1016/j.jclepro.2014.04.020

Pliner, P., & Hobden, K. (1992). Development of a scale to measure the trait of food neophobia in humans. *Appetite, 19*(2), 105–120.

Pophiwa, P., Webb, E. C., & Frylinck, L. (2020). A review of factors affecting goat meat quality and mitigating strategies. In *, Vol. 183. Small Ruminant Research*. Elsevier B.V. https://doi.org/10.1016/j.smallrumres.2019.106035.

Popoff, M., MacLeod, M., & Leschen, W. (2017). Attitudes towards the use of insect-derived materials in Scottish salmon feeds. *Journal of Insects as Food and Feed, 3*(2), 131–138. https://doi.org/10.3920/JIFF2016.0032

Priolo, A., Valenti, B., Natalello, A., Bella, M., Luciano, G., & Pauselli, M. (2021). Fatty acid metabolism in lambs fed hazelnut skin as a partial replacer of maize. *Animal Feed Science and Technology, 272*. https://doi.org/10.1016/j.anifeedsci.2020.114794

Renna, M., Lussiana, C., Malfatto, V., Gerbelle, M., Turille, G., Medana, C., Ghirardello, D., Mimosi, A., & Cornale, P. (2020). Evaluating the suitability of hazelnut skin as a feed ingredient in the diet of dairy cows. *Animals, 10*(9), 1–23. https://doi.org/10.3390/ani10091653

Risius, A., & Hamm, U. (2018). Exploring influences of different communication approaches on consumer target groups for ethically produced beef. *Journal of Agricultural and Environmental Ethics, 31*(3), 325–340. https://doi.org/10.1007/s10806-018-9727-6

Rodrigues, P., Sousa, A., Fetscherin, M., & Borges, A. P. (2024). Exploring masstige brands' antecedents and outcomes. *International Journal of Consumer Studies, 48*(1). https://doi.org/10.1111/ijcs.12869

Salami, S. A., Luciano, G., O'Grady, M. N., Biondi, L., Newbold, C. J., Kerry, J. P., & Priolo, A. (2019). Sustainability of feeding plant by-products: A review of the implications for ruminant meat production. In *, Vol. 251. Animal Feed Science and Technology* (pp. 37–55). Elsevier B.V. https://doi.org/10.1016/j.anifeedsci.2019.02.006.

Sogari, G., Menozzi, D., Mora, C., Gariglio, M., Gasco, L., & Schiavone, A. (2022). How information affects consumers' purchase intention and willingness to pay for poultry farmed with insect-based meal and live insects. *Journal of Insects as Food and Feed, 8*(2), 197–206. https://doi.org/10.3920/JIFF2021.0034

Spartano, S., & Grasso, S. (2021). UK consumers' willingness to try and pay for eggs from insect-fed hens. *Future Foods, 3*. https://doi.org/10.1016/j.fufo.2021.100026

Tukker, A., Sto, E., & Vezzoli, C. (2008). "The governance and practice of change of sustainable consumption and production." Introduction to the ideas and recommendations presented in the articles in this special issue of the journal of cleaner production. *Journal of Cleaner Production, 16*(11), 1143–1145. https://doi.org/10.1016/j.jclepro.2007.08.011

Vittersø, G., & Tangeland, T. (2015). The role of consumers in transitions towards sustainable food consumption. The case of organic food in Norway. *Journal of Cleaner Production, 92*, 91–99. https://doi.org/10.1016/j.jclepro.2014.12.055

Wales, C., Harvey, M., & Warde, A. (2006). Recuperating from BSE: The shifting UK institutional basis for trust in food. *Appetite, 47*(2), 187–195. https://doi.org/10.1016/j.appet.2006.05.007

Wang, O., Perez-Cueto, F. J. A., Scarpa, R., & Scrimgeour, F. (2024). The influence of innovation-adoption characteristics on consumers' trust and purchase intentions of innovative alternative proteins: A comparison between plant-based food, cultured food, and insect-based food. *Food Quality and Preference, 113*. https://doi.org/10.1016/j.foodqual.2023.105072

Weinrich, R., & Busch, G. (2021). Consumer knowledge about protein sources and consumers' openness to feeding micro-algae and insects to pigs and poultry. *Future Foods, 4*. https://doi.org/10.1016/j.fufo.2021.100100

Williams, H., Wikström, F., Otterbring, T., Löfgren, M., & Gustafsson, A. (2012). Reasons for household food waste with special attention to packaging. *Journal of Cleaner Production, 24*, 141–148. https://doi.org/10.1016/j.jclepro.2011.11.044

Zeppa, G., Belviso, S., Bertolino, M., Cavallero, M. C., Dal Bello, B., Ghirardello, D., … Gerbi, V. (2015). The effect of hazelnut roasted skin from different cultivars on the quality attributes, polyphenol content and texture of fresh egg pasta. *Journal of the Science of Food and Agriculture, 95*(8), 1678–1688. https://doi.org/10.1002/jsfa.6871