



Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Consumer valuation of carbon labeled protein-enriched burgers in European older adults

Ieben Broeckhoven, Wim Verbeke, Juan Tur-Cardona, Stijn Speelman, Yung Hung*

Department of Agricultural Economics, Ghent University, Coupure Links 653, Ghent, Belgium

ARTICLE INFO

Keywords:

Choice experiment
Consumer preference
Elderly
Protein
Sustainability label
Willingness to pay

ABSTRACT

Considering population aging and the adverse health consequences older adults face due to protein malnutrition, older adults' protein intake is receiving increasing attention. Meanwhile, growing concern around the world's environmental challenges has elucidated the crucial role of dietary choices. This study gives insight into more sustainable ways of increasing older adults' (≥ 65) protein intake in the European Union (EU) to prevent protein malnutrition. A choice experiment ($n = 2159$) was conducted in five EU countries (the Netherlands, the United Kingdom, Poland, Finland, and Spain). Multinomial choice modeling shows that the majority of older adults accept protein-enriched burgers. Overall they prefer red meat and poultry above plant-based burgers. For red meat and poultry burgers, older adults prefer products with carbon labels indicating lower environmental impact. Latent class modeling identified four consumer segments. The largest segment (41%), "Meatlovers", are not likely to change their red meat and poultry consumption. However, carbon labeling entails some opportunity. "Eco-friendly" consumers (28%) are willing to consume protein from more sustainable sources and herewith constitute the primary target group. "Poultry lovers" (12%) are most likely to shift their protein consumption based on health-related motives. Further research is recommended to identify sustainable protein-rich products for older adults who dislike burgers (19%). Subsequent consumer profiling indicates that intentions to consume sustainable protein-enriched burgers are associated with gender, country, importance attached to health, sustainability and familiarity, knowledge on protein and their environmental impact. In contrast, financial situation, importance attached to price, convenience, and sensory appeal are not associated with older adults' preferences.

1. Introduction

The world's population is rapidly growing and aging, with one out of five persons of the EU population already aged 65 years or above (United Nations, 2017). This number is expected to nearly double by 2050 (Eurostat, 2018; Stula, 2012).

Of paramount concern is the significant amount of older adults who face negative and often irreversible health problems from protein malnutrition (Keller, Østbye, & Goy, 2004; Morley, 2012; Volkert et al., 2018). A substantial number of EU older adults have a considerably high probability of having a protein intake below 1.0 g/kg adjusted body weight per day (Hung, Wijnhoven, Visser, & Verbeke, 2019). Adequate consumption of protein is needed to prevent protein malnutrition and enhance healthy aging (Bauer et al., 2013; de Moraes et al., 2013; Hengeveld et al., 2019). At the same time, the world is facing unprecedented environmental challenges, such as climate change, aquatic and terrestrial biodiversity loss (Tilman et al., 2017), land-use change (Foley

et al., 2005) and water scarcity (Gleick & Palaniappan, 2010; Molden, 2013).

Moreover, food production, especially protein production, is well known to have a tremendous environmental impact (Aiking & de Boer, 2018; Vermeulen, Campbell, & Ingram, 2012; Tilman & Clark, 2014; Willett et al., 2019).

This state of affairs gives rise to the challenging question of how to increase protein intake of older adults to prevent protein malnutrition, while simultaneously taking into account the environmental impact of food production and its contribution to the environmental challenges the world is currently facing.

A large number of studies have been devoted to calculating the environmental impact of food production (Tilman & Clark, 2014; Vermeulen et al., 2012; Willett et al., 2019). Recently, there has been a growing interest in comparing the environmental impact of different protein sources. Animal-based proteins are found to have a more significant impact than plant-based proteins (Aiking & de Boer, 2018;

* Corresponding author.

E-mail address: yung.hung@ugent.be (Y. Hung).

<https://doi.org/10.1016/j.foodqual.2020.104114>

Received 5 June 2020; Received in revised form 1 October 2020; Accepted 1 November 2020

Available online 5 November 2020

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McMichael, Powles, Butler, & Uauy, 2007; Tilman & Clark, 2014). Animal-based proteins, when compared to plant-based protein sources, are known to be associated with higher emissions of greenhouse gases (Clune, Crossin, & Verghese, 2017; Hoolohan, Berners-Lee, McKinstry-West, & Hewitt, 2013; Masset et al., 2014), higher ecological footprint (Davis et al., 2016), and a more significant impact on biodiversity (Willett et al., 2019).

Considering the importance of protein productions' contribution to current environmental challenges, scholarly studies in search of alternative more sustainable protein sources have multiplied. These studies found that alternative protein sources have less environmental impact than animal-based protein sources, but are comparable in terms of protein content (Kumar et al., 2017; Parodi et al., 2018). Despite their benefits, alternative protein sources remain a niche market (World Economic Forum, 2019). Research on older consumers in the EU found that of the alternative protein sources, plant-based proteins received higher acceptance than insect, single-cell, and in-vitro meat-based proteins (Grasso, Hung, Olthof, Verbeke, & Brouwer, 2019). Consumers in the EU generally perceive a match between a healthy, a sustainable and a plant-based diet when making food consumption decisions (Van Loo, Hoefkens, & Verbeke, 2017).

Most large scale studies on consumer preferences for protein sources with differing environmental impacts have focused mainly on young adults or the general population. The potential of increasing older adults' protein intake in a more sustainable manner remains largely unexplored.

Therefore, the objective of this study was to quantify the older adults' acceptance of and willingness to pay for protein-enriched burgers using discrete choice experiments and choice modeling.

More concretely, this study elicits older adults' relative preference for different protein sources, including animal-based protein sources, such as red meat and poultry, as well as alternative plant-based protein sources. In order to understand the role of environmental impact in older adults' food choices, this study investigated their preferences and willingness to pay for different protein source dependent carbon labels.

As consumer preferences are expected to be heterogeneous, latent class choice modeling was applied to investigate whether consumer segments with significantly varying preferences exist. Consumer segments were profiled based on socio-demographics, dietary habits, intention to change protein sources, food-related attitudes, knowledge, and perception of protein and food in the diet. Profiling consumer segments will enable the development of more nuanced and targeted policy recommendations and product development.

2. Theoretical background

2.1. Choice experiments and willingness to pay

Several consumer preference elicitation methods exist, such as conjoint analysis, choice experiments, and experimental auctions. These elicitation methods can be sub-divided into stated preference methods, such as conjoint analysis and choice experiments, and revealed preference methods such as experimental auctions. Experimental auctions have a non-hypothetical incentive-compatible nature (Lusk & Shogren, 2007), which has the advantage of minimizing hypothetical bias in contrast to stated preference methods (Murphy, Allen, Stevens, & Weatherhead, 2005). However, non-hypothetical studies often cannot be used when performing market research on new products or concepts as they have not yet been developed (Wedel & Kamakura, 2012).

In this study discrete choice experiments were chosen for the following reasons: (1) multiple attributes can be valued simultaneously, (2) choice experiments are consistent with consumer behavioral theory, such as random utility theory (McFadden & Zarembka, 1974) and

Lancaster's theory of consumer demand (Lancaster, 1966), (3) compared to contingent valuation (CV) methods, in CE's consumers have to choose between alternative products, which resembles real-life choices and therefore may induce less hypothetical bias than CV.

2.2. Choice models and WTP

2.2.1. Consumer utility

Choice experiments are based on the assumption that the utility of individual i of choosing alternative j in choice situation t can be represented by Eq. (1):

$$U_{ijt} = \beta_i x_{ijt} + \varepsilon_{ijt} \quad (1)$$

as based on random utility theory (McFadden & Zarembka, 1974), where $i = 1, \dots, N$ is the number of respondents; $j = 1, \dots, J$ is the number of alternatives within choice situation t ; x_{ijt} is the M -dimensional column vector of observed variables; β_i is the M -dimensional row vector of individual parameters, and ε_{ijt} is the error term.

As part of the utility derived from a choice T_i by individual i is unobservable by the researcher, the overall consumers' utility consists of an observed deterministic component $\beta_i x_{ijt}$, and a random stochastic component represented by ε_{ijt} .

According to the concept of utility-maximizing behavior, each individual will choose the alternative that gives them the highest utility. Moreover, consumers are assumed to derive utility from the products' attributes, not from the overall product as such.

2.3. Multinomial logit model

Multinomial logit (MNL) choice models consider three or more choice options. Furthermore, the classic MNL model assumes homogeneous preferences within a population, meaning that there is no correlation in unobserved factors.

Under the assumption that the random errors are independently and identically distributed (IID) across J alternatives and N individuals and following a Type I extreme value (EV1) distribution, the probability that an individual i chooses alternative j from a choice situation T_i is given by the MNL model as following Eq. (2) (Hensher, Rose, & Greene, 2005):

$$Prob_i\{\text{Alt } j \text{ chosen}\} = \frac{e^{\beta_i x_{ijt}}}{\sum_{j=1}^J e^{\beta_i x_{ijt}}}, \quad j = 1, \dots, J. \quad (2)$$

The random parameters are assumed to be Independent and Identically Distributed (IID), whereby independent means that no covariances or correlations between the J unobserved effects exist. Identical random parameters refers to the assumption that the distributions of the unobserved effects are all the same (Hensher et al., 2005).

However, despite its usefulness in providing a clear and fast insight into the general preferences of a sample or population, MNL models have several crucial shortcomings (Greene & Hensher, 2003; McFadden & Train, 2000): the oversimplified assumptions of (i) preference homogeneity across all respondents and thus ignoring unobserved heterogeneity and random taste variability, (ii) independent errors over time and (iii) the independence of irrelevant alternatives (IIA), which implies proportional substitution across alternatives (Ray, 1973).

2.4. Latent class model

In contrast to MNL models, a latent class (LC) approach can accommodate preference heterogeneity. In LC models, it is assumed that the population consists of a finite number of groups of individuals Q . Within each group q , individuals are treated as homogeneous with common parameters β_q , while preferences are assumed to differ between the different groups (Hensher et al., 2005; Wedel & Kamakura, 2012).

Moreover, the classes are differentiated through varying parameter vectors, while the probability density for the variables is the same. As class membership is not known by the analyst prior to modeling; the groups are called latent classes.

The theory underlying LC models states that individual behavior depends on observable attributes on the one hand and latent heterogeneity on the other. In LC models, discrete choices among J alternatives, by individual i observed in T choice situations can be expressed by Eq. (3):

$$Prob_i\{Alt\ j\ chosen|class\ q\} = \frac{e^{\beta_q x_{ij}}}{\sum_{j=1}^J e^{\beta_q x_{ij}}} \quad (3)$$

Based on the assumption that Q latent classes exist in the population, the overall log likelihood is given by Eq. (4):

$$\ln L = \sum_{i=1}^N \ln \left[\sum_{q=1}^Q C_{iq} \left(\prod_i Prob_{ij|q} \right) \right] \quad (4)$$

where C_{iq} is the probability of individual i belonging to class q (Train, 2009).

2.5. Willingness to pay

The willingness to pay for attributes can be calculated as the negative ratio of the partial derivative of the utility function for the attribute under investigation, divided by the derived utility function with respect to the price variable as in Eq. (5) (Gracia, Loureiro, & Nayga, 2009; Morrison, Bennett, Blamey, & Louviere, 2002):

$$WTP_{Attribute} = \frac{-\partial U_{ij|q} / \partial Attribute}{\partial U_{ij|q} / \partial Price} \quad (5)$$

3. Material and methods

3.1. Data collection

Cross-European data collection took place in October 2019 through a cross-sectional online survey involving 500 respondents in each of five EU countries, namely in Poland, Finland, the Netherlands, the United Kingdom, and Spain ($n = 2500$). These countries were selected based on their geographical distribution so that they are representative of the EU. Nonetheless, care should be taken when extrapolating these results to other countries in the EU. Respondents were recruited using probabilistic sampling from a proprietary online panel of a professional marketing research company.

Several screening criteria were applied to recruit respondents. Respondents were 65 years old or above and living independently at home. Furthermore, in order to achieve a nationally representative sample in terms of gender and regional distribution for each of the five EU countries, respondents were screened according to quotas proportional to population distributions.

Online surveys are commonly used for marketing research and the elicitation of consumer preferences due to their relatively low cost and fast completion times (Hensher et al., 2005; Train, 2009). A Choice Experiment (CE) and additional questions related to consumer preferences, behavior, and intentions were used to investigate older adults' relative preferences for protein-enriched burgers. Ethics approval for this consumer study has been granted by the Medical Ethics Committee of Ghent University Hospital (Reference: 2019/0933 – August 2019). All collected data were coded in a non-identifiable format and processed anonymously.

3.2. Questionnaire content

The questionnaire consisted of the following subsections: socio-demographics, dietary habits, intention to change protein sources,

food-related attitudes, knowledge, and perception of protein and food in the diet. By rotating items within a question, order bias was avoided. Respondents could indicate "Prefer not to say/Do not know" to questions related to income, expenditure and health characteristics to reduce response bias.

In terms of socio-demographics, gender, country, age, education level, living area, net monthly household income, perceived financial situation, and food expenditure were included in the questionnaire. In terms of dietary patterns, average meat portion size per day, on a day that respondents ate meat with their warm meal, and number of days per week they ate processed meat were measured. Intentions to change the amount of protein-sources consumed for health-related reasons, such as red meat, processed meat, poultry, and plant-based meat substitutes, were measured by the following options: "Decrease", "Remain the same", "Increase" or "I never consume this food".

Food-related attitudes were assessed using a modified food choice questionnaire (FCQ) based on the scale developed by Stepoe, Pollard, and Wardle (1995) and Januszewska, Pieniak, and Verbeke (2011). Respondents were asked to indicate the importance they attach to the following factors when making food choices: health, convenience, sensory appeal, price, and sustainability factors using a five-point scale ranging from "Not at all important" to "Extremely important". Food fussiness was measured using a five-point Likert-scale with seven items, e.g. "I refuse new foods at first" (Wardle, Guthrie, Sanderson, & Rapoport, 2001).

Knowledge and perception of protein and their relative environmental impact were evaluated through an objective knowledge test, which consisted of thirteen correct or incorrect statements. Respondents had to indicate one of the three options, "True", "False" or "I do not know".

3.3. Choice experiment

3.3.1. Product and attribute selection

The first step in the design of a choice experiment is identifying the relevant product and its attributes. A concrete food product, namely protein-enriched burgers, was chosen in order to avoid hypothetical bias arising from leaving the type of product and form of protein sources undefined. The choice of product attributes was informed by the research questions, literature regarding protein-energy malnutrition, and consumer preferences for more sustainable protein sources as well as expert consultations. As protein-energy malnutrition in older adults is a growing concern due to its prevalence and subsequent adverse health consequences (de Morais et al., 2013; Keller et al., 2004; Morley, 2012), the preferred type of protein source was selected as the first attribute. Furthermore, as dietary protein is known to play a major role in terms of the environmental impact of human consumption (Aiking & de Boer, 2018; Tilman & Clark, 2014; Willett et al., 2019), consumers' preferences for the sustainability of protein sources were taken into account by including a carbon label attribute. Lastly, a price attribute was included to allow for the estimation of respondents' WTP for changes in other attributes' levels.

Once the attributes were identified, their levels had to be determined (Table 1). For the type of protein source, red meat, poultry, and plant-based proteins were chosen as the attribute levels. Animal proteins have been shown to account for the most substantial portion (55–73%) of total protein consumed by EU inhabitants, while plant-based proteins

Table 1
Overview of attributes and levels used in the choice experiment.

Protein source	Carbon labels	Price
Red meat	B, C	5%, 10%, 20%
Poultry	A, B, C	5%, 10%, 20%
Plant-based	A, B	5%, 10%, 20%

account for the second-largest portion (24–39%) (Halkjær et al., 2009). The study by Tieland et al. (2015) confirms that the majority of dietary protein consumed by older adults ($\geq 60\%$) originates from animal sources. Within the main group of animal proteins, meat (e.g., red meat, poultry, game, and processed meat) was found to be the most significant contributor to the total amount of proteins consumed, with red meat and poultry accounting for the most substantial portions within this group (Halkjær et al., 2009). Informed by insights described in the introduction of this paper, plant-based proteins were chosen as the most interesting alternative, more sustainable protein source to investigate in the choice experiment.

Carbon labels were used to investigate the importance consumers attach to the environmental impact of their dietary protein choices. In line with Front-of-Pack nutrition labeling practices, colored carbon labels were used instead of numeric CO₂-equivalent emissions to efficiently inform consumers and reduce the cognitive burden (Egnell et al., 2020). Moreover, as the importance attached to environmental impact was assumed to vary with the type of protein source consumers prefer, carbon labels were interacted with protein sources. For the carbon label, three levels were possible: carbon label A, B, or C, with increasing environmental footprint from carbon label A to C.

As actual market prices for protein-enriched burgers vary considerably between countries, the price levels were defined in terms of willingness to pay a price premium of 5%, 10% or 20% for the various types of protein-enriched burgers compared to non-protein-enriched (i.e., conventional) burgers to ensure uniformity and thereby allow for cross-country comparison.

3.3.2. Choice task construction

Using Ngene software, an efficient fractional factorial design with a total of six choice tasks was created for the choice experiment using effects type coding to allow for the estimation of non-linear effects. Each of these six choice tasks contains two choices and an opt-out, with each choice consisting of three attributes (Fig. 1). The three attributes and their levels are (1) protein source (red meat, poultry or plant-based protein), (2) carbon label (A, B or C) and (3) a price premium (5%, 10%, 20%) as shown in Table 1. Restrictions were placed on specific combinations of protein sources and carbon labels to ensure that unrealistic attribute combinations are not present. Unrealistic attribute combinations were determined based on Clune et al. (2017) and Hoolohan et al. (2013). More concretely, the possible carbon levels for red meat burgers were limited to carbon B or C. By contrast, the carbon levels for plant-based protein burgers were restricted to carbon labels A and B. No constraints were applied to the possible carbon labels in the case of poultry-based burgers. As labeled choice experiments are known to reduce respondents' attention to attributes by shifting their focus more to the labels, an unlabeled choice experiment was used as this is more suitable to investigate trade-offs between attributes (de Bekker-Grob et al., 2010).

Based on this efficient fractional factorial design without assuming priors, a pilot survey (n = 18) was conducted to estimate a Multinomial Logit Model (MNL). Subsequently, the parameter estimates and

variances were used as Bayesian priors to improve the experimental design.

Participants were informed on the context of choice experiments, and both attributes and attribute levels were explained beforehand (Appendix A). The order of the choice tasks was randomized to avoid order bias.

Follow-up questions were asked to participants if they chose the opt-out five times or more, to understand why they did so. Of the initial sample (n = 2500), 351 respondents chose the opt-out five times or more and indicated that their reason for doing so was due to (i) not wanting to read all the information, (ii) not seeing any difference between the two alternatives, or (iii) the choice task being too difficult for them to decide.

Therefore, their responses were considered to be invalid, which led to the subsequent removal of their data and resulted in the valid sample (n = 2159) for choice analysis.

3.4. Consumer segment profiling

The consumer segments obtained through latent class modeling based on the choice experiment have been profiled using the variables included in the online consumer survey. In order to get a better understanding of the characteristics of the consumer segments, several analyses were performed to test whether significant differences exist between the consumer segments. Categorical variables were analyzed using a chi-square association test, while non-categorical variables were analyzed using an independent-samples Kruskal-Wallis test using SPSS v26.

Chi-square association tests were considered to be non-reliable if more than 20% of the cells had an expected cell-count of less than five, which is a requirement for a valid comparison across consumer segments (Campbell, 2007).

In the first stage, consumer segments were compared to test whether overall significant differences exist across the segments at a significance level of $\alpha = 0.05$. If overall significant differences were found, pairwise comparisons were performed to identify which consumer segments differ based on the adjusted significance. Adjusted significance based on Bonferroni correction was used to compensate for the increased likelihood of incorrectly rejecting the null hypothesis (Type I error) resulting from testing multiple hypotheses during pairwise comparisons (Jaccard, Becker, & Wood, 1984; Mittelhammer, Judge, & Miller, 2000).

Effect sizes were calculated to support the interpretation of the p-value, which can take on small values due to the large sample size used in this study. Effect size provides insight into the proportion of variance in a consumer segment that is explained by the variable under consideration and thereby indicates the strength of how significantly consumer segments differ in terms of the variable under consideration (Levine & Hullett, 2002). For chi-square tests, Cramer's phi ϕ_c was used, which can be considered to be small if the value ranges from 0.1 to 0.3, medium from 0.3, and large from 0.5 (Olivier & Bell, 2013). For the independent-samples Kruskal-Wallis tests, partial eta-squared η_p^2 was used, which can be considered to be small within the range of 0.01–0.06, medium from 0.06 and large from 0.13 onwards (Harlow, 2014).



Source of protein	Red meat burger	Plant-based burger	Neither of the protein-enriched burgers
Extra price to pay	20%	20%	
Carbon footprint			
I would choose...	<input type="radio"/>	<input type="radio"/>	

Fig. 1. Example of a choice task consisting of two choice sets and an opt-out.

4. Results

4.1. Descriptives for the overall sample

The sample characteristics are described in Table 4. Respondents are distributed roughly equal among the five countries included in this study, with slightly more respondents from the UK (21.0%) and fewer respondents from Poland (18.1%). About half of respondents are male (52.3%), with 58.2% and 52.0% of respondents being male in the sample of Poland and the Netherlands, respectively. Thus, the sample might be slightly unbalanced in terms of gender. In terms of age, 53.5% are between 65 and 69 years of age, while the remaining 46.5% are 70 years or above. The highest educational level achieved is tertiary or higher for 37.6% of respondents, while 62.4% have completed the secondary level or below. Compared to EU data on educational attainment level, our study has a higher percentage of older adults with tertiary education in Poland and Spain (Eurostat, 2020). Most of the respondents live in an urban environment (46.1%), followed by suburban living areas (31.6%), and only 22.3% in a rural setting. In terms of perceived financial situation, 20.0% reported having some or severe financial difficulties, while most people stated that they get by all right (38.2%) or manage quite to very well (41.8%). These findings are also reflected in the monthly net household income, with most people (64.3%) earning more than €2000 net per month per household. Only 13.6% of respondents reported earning less than €1000, while 22.1% reported earning between €1000–2000. In line with this, the majority of respondents (59.2%) spend more than €90 per person per week on food.

The average portion size of meat consumed during warm meals (on a day that they ate meat) is roughly one-third of a plate, while respondents reported consuming processed meat on average 1–2 days per week.

Overall, 80.8% of respondents intend to keep their consumption of red meat the same in order to reach optimal health. Similarly, most people intend to keep their consumption of processed meat (76.7%) and poultry (88.5%) unchanged. Only relatively few people intend to decrease their consumption of red meat (19.2%) and processed meat (23.3%). By contrast, roughly a quarter of the respondents reported that they never consume meat substitutes, and only 10.9% intend to increase their consumption of meat substitutes.

When asked how important health, convenience, sustainability, price, familiarity and sensory appeal are when choosing food to eat, most people reported those factors as being somewhat to moderately important. Lastly, the average score obtained on the objective test to examine respondents' knowledge on the relative ecological impact of different food items is 66%, while the average grade obtained on the objective protein knowledge test was 51%.

Table 2
MNL model estimates, standard errors and significance (n = 2159).

Coefficients	β	σ	p-value
<i>Protein-source</i>			
Red meat	0.39**	0.06	<0.001
Poultry	0.48**	0.05	<0.001
Plant-based	-0.14**	0.05	0.004
<i>Protein-source × carbon label</i>			
Red meat × carbon B	0.11*	0.59	0.050
Poultry × carbon A	0.30**	0.07	<0.001
Poultry × carbon B	0.27**	0.07	<0.001
Plant-based × carbon A	-0.18**	0.06	0.004
<i>Price</i>			
Price	-0.01*	0.00	0.022

Note: * and ** indicate significance at the 5% and 1% levels, respectively. β and σ represent the parameter estimates and standard deviations, respectively. Model fit: LL = -13593, AIC = 27201, pseudo-R² = 0.0387.

4.2. Multinomial logit model

A multinomial logit (MNL) model was first estimated to get a general overview of consumer preferences. The null hypothesis that all parameter estimates are zero is rejected based on the likelihood ratio test ($p < 0.01$) (Table 2). All parameter estimates in the MNL model are statistically significant.

Overall, respondents derive utility from protein-enriched burgers if the protein source is red meat or poultry. On the contrary, older adults would prefer no burger at all over a plant-based protein-enriched burger as the parameter estimate in the MNL model is negative for this attribute.

When the parameter estimates for the protein source-specific carbon labels are positive, the consumer utility for the carbon-friendly option is higher than that for the carbon-unfriendly option. More concretely, respondents derive significant utility from carbon B labeled red meat burgers (carbon-friendly option) compared to one with a carbon C label (carbon-unfriendly option). Similarly, in the case of poultry burgers, the carbon-friendly options (carbon A and B labels) are preferred over the less carbon-friendly option (carbon C). However, for plant-based protein burgers, the coefficient for carbon A label is negative, suggesting that consumers prefer the carbon B label above a carbon A label for plant-based burgers. It should be noted that the design of illustrations may have an effect on respondents' choices. Lastly, as expected, the price coefficient estimate is negative, which indicates that utility will decrease as the price of a protein-enriched burger increases.

4.3. Latent class model

As consumer preferences are expected to be heterogeneous, a latent class model was developed to investigate whether relevant consumer segments and thus heterogeneity among consumers' preferences exist. Subsequently, models with up to six latent classes were run.

On the one hand, as the number of latent classes increased from 1 to 6, the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) decreased, while McFadden's pseudo-R² increased. However, both the decrease in AIC and BIC started leveling off from three latent classes onward, indicating that the additional information captured by adding more classes was limited. On the other hand, for consumer segmentation and profiling to make sense, the class sizes must also be taken into account (Keane & Wasi, 2013), which were too small (<5%) for models with five or more latent classes.

Therefore, based on the AIC, BIC, and relative segment size (Fig. 2), the LC model with four latent classes was chosen. The AIC decreased from 27,201 to 20,088 when going from a one to a four class model, while the BIC decreased from 27,261 to 20,177, respectively.

The relative size of the four identified latent classes, parameter estimates, and their standard deviations are shown in Table 3 for each of the four latent classes.

The largest class, called "Meat lovers", consists of 40.9% of the sample. In terms of their preferences for a protein source, the coefficients for red meat and poultry are positive and significant at 1%, indicating their preference for red meat and poultry burgers over the no-buy option, while they do not derive any utility from a plant-based protein source in burgers. Concerning carbon levels, "Meat lovers" prefer the carbon-friendly option (carbon B preferred over C) in the case of red meat, while the opposite is true if the protein source is plant-based (carbon B preferred over A). For poultry-based burgers, "Meat lovers" prefer carbon level C above B, but do not differentiate between carbon A and C. Lastly, they have a strong negative preference for paying a price premium for protein-enriched burgers.

The second latent class, called "Poultry lovers", accounts for 11.6% of the sampled older adults. They are characterized by a positive preference for poultry as the protein source, while they disfavor red meat and plant-based protein burgers. In terms of carbon level preferences, "Poultry lovers" are carbon-indifferent.

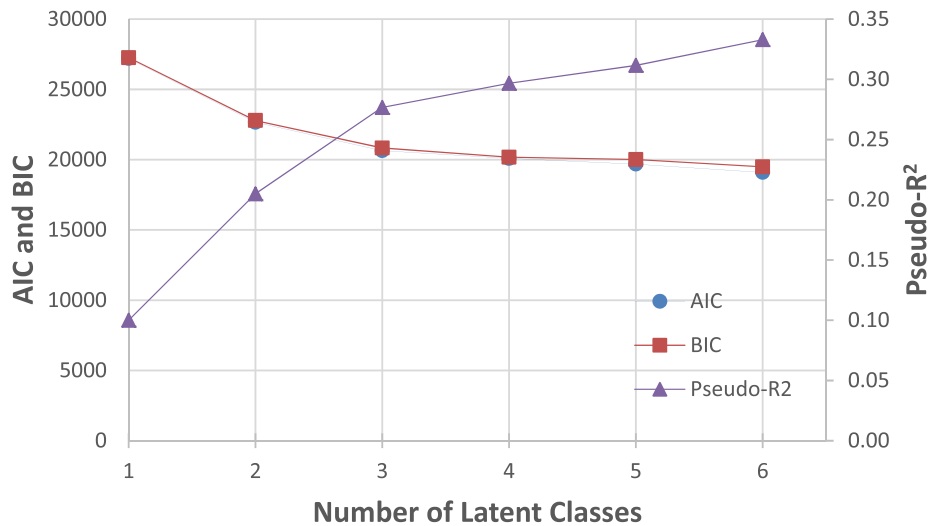


Fig. 2. Latent class models with information criteria (n = 2159).

Table 3

Latent Class model estimates and standard errors (n = 2159).

Relative size (%)	Meat lovers 41%		Poultry lovers 12%		Eco-friendly 28%		NoBurgers 19%	
	β	σ	β	σ	β	σ	β	σ
<i>Protein-source</i>								
Red meat	4.29**	0.33	-0.64**	0.32	0.63**	0.17	-2.96**	0.33
Poultry	3.29**	0.21	1.60**	0.22	1.19**	0.13	-16.90	58,440
Plant-based	0.01	0.18	-1.05**	0.29	2.55**	0.15	-3.13**	0.26
<i>Protein-source × carbon label</i>								
Red meat × carbon B	1.13**	0.24	0.27	0.34	0.35	0.23	0.40	0.41
Poultry × carbon A	0.61	0.32	0.28	0.32	1.11**	0.25	13.32	58,440
Poultry × carbon B	-1.11**	0.24	0.57	0.32	0.76**	0.23	13.33	58,440
Plant-based × carbon A	-0.75*	0.32	-0.59	0.46	-0.31	0.23	0.14	0.35
<i>Price</i>								
Price	-0.11**	0.02	-0.05**	0.02	-0.02	0.01	-0.03	0.03

Note: * and ** indicate significance at the 5% and 1% levels, respectively. β and σ represent the parameter estimates and standard deviations, respectively. Model fit: LL = -10009, AIC = 20088, BIC = 20177, pseudo-R² = 0.2967

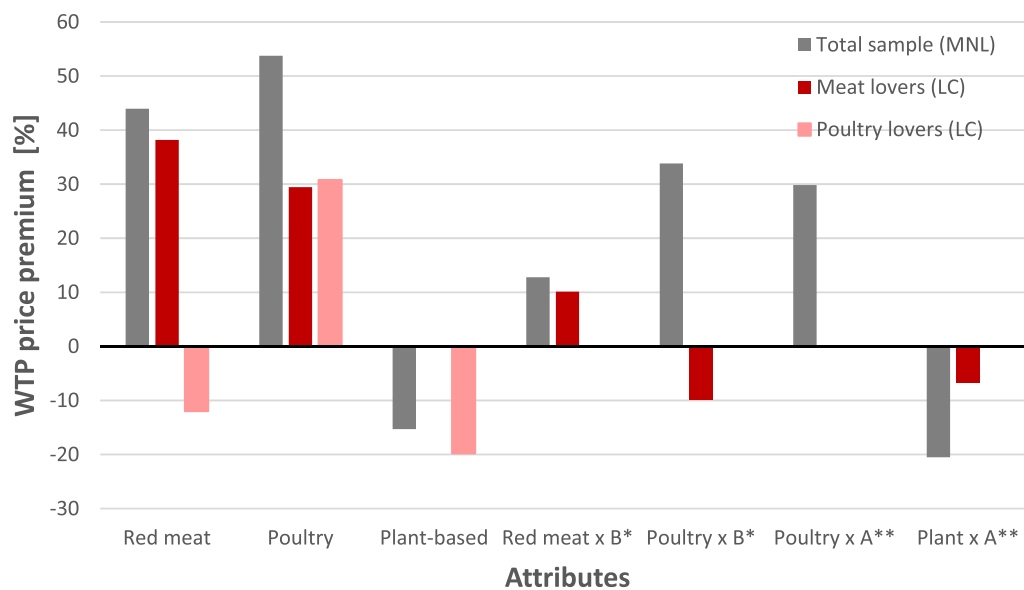


Fig. 3. Willingness to pay for attributes based on MNL and LC models (n = 2159). Note: A** refers to carbon label A, while B* refers to carbon label B. WTP-values are not shown when the attribute is not significant based on the underlying MNL or LC model. As restrictions were placed on the combinations of Red meat × A and Plant × C, their WTP-values were not calculated. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The third latent class, called “Eco-friendly”, consists of 28.4% of the sampled older adults and is characterized by a positive preference for all three protein sources. They prefer poultry with a carbon A or B level over C, while in the case of red meat or plant-based protein, there was no difference in preference for carbon levels. In addition, price does not affect their utility.

Lastly, the fourth latent class, called “NoBurgers” and representing 19.1% of the sample, is characterized by a strong negative preference for all three protein sources. Furthermore, no significant preferences for certain carbon levels were identified. They are also indifferent to paying a price premium for protein-enriched burgers.

4.4. Willingness to pay for protein sources and carbon labels

4.4.1. Overall WTP

Based on the MNL model, WTP estimates have been calculated (Fig. 3). In terms of protein source, on average, consumers are willing to pay more than a 20% premium¹ for red meat and poultry-based protein-enriched burgers compared to non-protein enriched burgers. By contrast, on average, older adults have a negative willingness to pay for protein-enriched burgers if the burgers are plant-based.

Besides consumers’ willingness to pay for protein-enriched burgers with varying types of protein sources, WTP for carbon labels is calculated for each type of protein source. In the case of poultry burgers, consumers are willing to pay more than a 20% premium for the carbon-friendly option (carbon A or B label are valued more than carbon C). However, on average, consumers have a negative willingness to pay for the carbon-friendly option (carbon A is valued less than carbon B) when the protein-enriched burgers are plant-based.

4.4.2. WTP across consumer segments

While the MNL model allows for the calculation of the overall WTP, which assumes homogeneous consumer preferences, the LC model allows for WTP estimates that take into account heterogeneity in consumer preferences across the latent classes. Once more, WTP estimates were not calculated for non-significant parameters.

In terms of protein sources, “Meat lovers” are willing to pay a price premium of more than 20% for red meat burgers, while “Poultry lovers” have a negative WTP for red meat burgers. Moreover, “Meat lovers” have a greater WTP for red meat burgers than “Poultry lovers”. By contrast, “Poultry lovers” have a greater WTP for poultry than “Meat lovers”. Both segments are willing to pay a price premium of more than 20% for poultry burgers. While “Poultry lovers” have a positive WTP for poultry burgers, they have a negative WTP for red meat and plant-based burgers.

WTP for protein source-specific carbon labels is only meaningful for the “Meat lovers” consumer segment. Moreover, they are willing to pay 10.14% more for a carbon B label than a carbon C label in the case of red meat burgers. However, when the protein source of burgers is poultry, they have a negative WTP for a carbon B label compared to a carbon C label. Similarly, if a burger’s protein is plant-based, “Meat lovers” have a negative WTP for a carbon A label compared to a carbon B label.

4.5. Consumer segment profiling

Consumer segments were profiled based on socio-demographics, dietary habits, food-related attitudes, and knowledge and perception of protein (Table 4).

¹ WTP-values that lie beyond the price range of 0–20% price premium considered in the price attribute of the choice experiment are reported as willingness to pay “more than 20%”. This conservative interpretation takes into account the possible error obtained from extrapolation outside of the pre-defined price space.

4.5.1. Socio-demographics

Both gender and country of origin vary between the four consumer segments (p-values < 0.001), while age, education level, living area, monthly net household income, perceived financial situation, and food expenditure do not differ significantly between consumer segments.

The “Meat lovers” segment consists of more males and fewer females than the “Poultry lovers” and “Eco-friendly” segments. The “NoBurgers” segment also consists of more males than the “Eco-friendly” segment. The gender and country distributions are different between segments but only have a small effect size. Moreover, the “Meat lovers” and “NoBurgers” groups consist of more Finns than the “Poultry lovers” segment. The “Poultry lovers” and “NoBurgers” segments consist of more Polish older adults than the “Meat lovers”. “Poultry lovers” and “Eco-friendly” consumers tend to be higher educated than “Meat lovers” and “NoBurgers”; however, no significant pairwise differences were found.

4.5.2. Dietary habits

“Meat lovers” were found to consume larger portions of meat when they ate meat with their warm meal compared to “Eco-friendly” consumers and “NoBurgers”.

“Eco-friendly” consumers were found to consume smaller meat portions on days that they ate meat with their warm meal than “Poultry lovers” and “Meat lovers”. In a similar trend, “Eco-friendly” consumers consumed processed meat fewer times per week than “Meat lovers” and “NoBurgers”. Both meat portion size and consumption frequency of processed meat per week have a significant effect with a small effect size.

4.5.3. Intention to change consumption of protein sources

Besides actual consumption related differences, there are also differences between the consumer segments in terms of reported intentions of changing their diet to achieve optimal health.

“Eco-friendly” consumers reported more often that they intend to decrease the amount of red meat they consume compared to “Meat lovers”. However, overall only 19.2% of respondents indicated an intention to decrease the amount of red meat consumed. In line with this, “Meat lovers” reported more often that they do not intend to change their consumption of red meat when compared to “Eco-friendly” consumers.

No significant differences were found between the four consumer segments in terms of intentions to change the amount of processed meat or poultry consumed. Overall, 76.6% of respondents indicated that they do not intend to change their consumption of processed meat. Similarly, 88.2% of all respondents reported that they do not intend to change the amount of poultry they consume.

“Eco-friendly” consumers reported more often that they intend to increase the amount of meat substitutes consumed compared to “Poultry lovers” and “Meat lovers”. Also, “NoBurgers” consumers reported more often that they intend to increase the consumption of meat substitutes compared to “Meat lovers”. “Eco-friendly” and “NoBurgers” consumers indicated less often than “Meat lovers” that they never consume meat substitutes. In addition, “Eco-friendly” consumers are more likely to consume meat substitutes than “Poultry lovers”.

4.5.4. Food-related attitudes

The “Eco-friendly” segment attaches higher importance to food being healthy than “Meat lovers” and the “NoBurgers” consumers. Also, “Poultry lovers” are characterized by attaching more importance to healthy food than “Meat lovers”. In terms of the sustainability of food, the “Eco-friendly” segment attaches higher importance to sustainability than “Meat lovers” and “Poultry lovers”. “NoBurgers” also attach greater importance to the sustainability aspect of food than “Meat lovers”. The familiarity of food items is shown to be of greater importance to “Meat lovers” than the “Eco-friendly” segment.

While attitudes relating to the importance of the health aspect of

Table 4
Variables for profiling consumer segments based on Latent Class modeling (n = 2159).

Variable	Levels	Total sample (%)	Meat lovers 41%	Poultry lovers 12%	Eco-friendly 28%	NoBurgers 19%	p-value (ϕ_c)
<i>Socio-demographics</i>							
Gender	Male	52.3	57.7 ^a	47.2 ^{b,c}	44.5 ^c	54.9 ^{a,b}	<0.001 (0.116)
	Female	47.7	42.3 ^c	52.8 ^{a,b}	55.5 ^a	45.1 ^{a,b}	
Country	UK	21.0	23.4	21.3	19.6	17.6	<0.001 (0.128)
	NED	20.3	19.9	19.1	22.0	19.5	
	SPA	20.2	19.3	22.6	21.4	18.8	
	POL	18.1	14.4 ^b	24.3 ^a	18.8 ^{a,b}	21.7 ^a	
	FIN	20.4	23.0 ^a	12.8 ^b	18.3 ^{a,b}	22.4 ^a	
Age	65–69	53.5	54.9	51.5	52.9	52.3	0.695 (0.026)
	≥ 70	46.5	45.1	48.5	47.1	47.7	
Education	< Tertiary	62.4	65.2	58.7	58.7	63.9	0.042 (0.062)
	≥ Tertiary	37.6	34.8	41.3	41.3	36.1	
Living area	Urban	46.1	44.9	41.7	47.0	49.9	0.198 (0.063)
	Suburban	31.6	33.0	38.7	28.2	29.4	
	Rural	22.3	22.1	19.6	24.8	20.7	
Perceived financial situation (n = 2125)	Mange quite or very well	41.8	40.5	45.9	41.3	42.9	0.101 (0.003)
	Get by alright	38.2	38.9	35.1	37.8	39.2	
	Some or severe difficulties	20.0	20.5	19.0	20.8	17.9	
HH income (n = 2118)	< €1000	13.6	13.4	15.2	14.3	12.0	0.142 (0.003)
	€1000–€2000	22.1	22.2	24.2	21.7	21.6	
	> €2000	64.3	64.4	60.6	64.0	66.3	
Food expenditure (n = 1937)	< €90	40.8	44.3	44.3	39.6	39.4	0.629 (0.030)
	≥ €90	59.2	55.7	55.7	60.4	60.6	
<i>Dietary habits</i>							
Meat portion size [#]	μ ($\pm\sigma$)	0.306 (± 0.165)	0.325 ^a (± 0.164)	0.323 ^{a,b} (± 0.170)	0.285 ^b (± 0.172)	0.287 ^b (± 0.149)	p-value (η_p^2) <0.001 (0.017)
Weekly processed meat consumption frequency	μ ($\pm\sigma$)	1.35 (± 1.12)	1.46 ^a (± 1.20)	1.31 ^{a,b} (± 1.16)	1.16 ^b (± 1.20)	1.40 ^a (± 1.29)	<0.001 (0.015)
<i>Intention to change protein-source*</i>							
Red meat (n = 2087)	Remain same	80.8	84.5 ^a	80.3 ^{a,b}	76.3 ^b	79.4 ^{a,b}	p-value (ϕ_c) 0.001 (0.087)
	Decrease	19.2	15.5 ^b	19.5 ^{a,b}	23.7 ^a	20.6 ^{a,b}	
Processed meat (n = 2099)	Remain same	76.7	76.1	75.5	76.5	78.2	0.840 (0.020)
	Decrease	23.6	23.6	24.5	23.5	21.8	
Poultry (n = 2083)	Increase	11.5	12.4	11.2	10.5	12.7	0.606 (0.046)
	Remain same	88.5	87.6	88.8	89.5	87.3	
Meat substitute (n = 2126)	Increase	10.9	6.8 ^c	7.3 ^{b,c}	17.2 ^a	12.3 ^{a,b}	<0.001 (0.171)
	Remain same	64.4	63.6 ^a	63.2 ^a	64.3 ^a	66.9 ^a	
	Don't consume	24.7	29.6 ^a	29.5 ^{a,b}	18.5 ^c	20.8 ^{b,c}	
<i>Food-related attitudes</i>							
Health	μ ($\pm\sigma$)	3.92 (± 0.998)	3.80 ^{b,c} (± 1.04)	4.04 ^{a,b} (± 0.940)	4.09 ^a (± 0.935)	3.86 ^{b,c} (± 1.00)	p-value (η_p^2) <0.001 (0.017)
Convenience	μ ($\pm\sigma$)	3.20 (± 1.13)	3.16 (± 1.16)	3.20 (± 1.13)	3.26 (± 1.14)	3.21 (± 1.06)	0.520 (0.001)
Sensory appeal	μ ($\pm\sigma$)	3.95 (± 0.949)	3.98 (± 0.937)	3.89 (± 0.944)	3.94 (± 0.957)	3.94 (± 0.968)	0.547 (0.001)
Sustainability	μ ($\pm\sigma$)	3.15 (± 1.15)	2.98 ^c (± 1.14)	3.07 ^{b,c} (± 1.11)	3.40 ^a (± 1.11)	3.21 ^{a,b} (± 1.17)	<0.001 (0.023)
Price	μ ($\pm\sigma$)	3.56 (± 1.06)	3.51 (± 1.08)	3.64 (± 1.01)	3.59 (± 1.06)	3.59 (± 1.03)	<0.001 (0.023)
Familiarity	μ ($\pm\sigma$)	3.10 (± 1.13)	3.17 ^a (± 1.15)	3.17 ^{a,b} (± 1.07)	2.97 ^b (± 1.15)	3.10 ^{a,b} (± 1.11)	0.006 (0.006)
Food fussiness	μ ($\pm\sigma$)	2.61 (± 0.44)	2.61 (± 0.45)	2.60 (± 0.44)	2.60 (± 0.42)	2.65 (± 0.44)	0.355 (0.002)
<i>Knowledge and perception of protein-sources</i>							
Eco-knowledge (%)	μ ($\pm\sigma$)	66.0 (± 34.0)	62.0 ^c (± 35.3)	70.7 ^{a,b} (± 31.5)	71.7 ^a (± 31.4)	63.0 ^{b,c} (± 36.0)	p-value (η_p^2) <0.001 (0.015)
Protein knowledge (%)	μ ($\pm\sigma$)	50.8 (± 32.1)	48.4 ^{b,c} (± 33.1)	53.4 ^{a,b} (± 30.5)	54.5 ^a (± 31.0)	49.2 ^{a,b} (± 32.1)	0.003 (0.007)

The superscripts ^{a–c} indicate significant differences across the four consumer segments at the 0.05 level. Cramer's phi (ϕ_c) or partial eta-squared (η_p^2) indicate the magnitude of the effect size. [#] Portion size was measured based on plate size “1/5 plate”, “1/4 plate”, “1/2 plate”, “2/3 plate”, or “3/4 plate”. * If respondents did not intend to change their protein-intake for health-related reasons, their response was coded as “Remain the same”. Response levels (“Increase”, “Remain the same”, “Decrease” and “Don't consume this”) were removed if the expected cell-count was too low for a valid comparison.

food, food sustainability, and familiarity differ across consumer segments, the importance attached to the convenience and price of food as well as sensory aspects of food are not different between consumer segments. The segments did not differ in terms of food fussiness.

4.5.5. Knowledge and perception of protein

In terms of objective knowledge of the environmental impact of food products, “Eco-friendly” consumers are found to have a higher objective knowledge score than “Meat lovers” and “NoBurgers”. Furthermore, “Meat lovers” are less knowledgeable regarding the environmental impact of food than “Poultry lovers”. Consumer segments were also compared in terms of objective protein knowledge, with “Eco-friendly” consumers being more knowledgeable regarding protein than “Meat lovers”. The effect of the objective environmental impact knowledge score is significant, in contrast to the effect of the objective protein score.

5. Discussion

5.1. Overall consumer preferences based on the MNL model

The findings based on the MNL model show that older adults generally derive utility from protein-enriched burgers, thereby making this a potentially acceptable product to increase older adults’ protein intake, as part of a dietary strategy to prevent protein malnutrition. Nevertheless, the protein source matters substantially for this older population group.

Generally, results of the choice experiment show that European older adults would prefer no burger above a protein-enriched burger that is plant-based, while red meat and poultry-based protein-enriched burgers are preferred above no burger. These findings are in line with the finding that a vast majority of more than three-quarters of older adults in our sample do not intend to change their consumption of red meat, processed meat, and poultry. Furthermore, about one-quarter of respondents report never consuming plant-based meat substitutes, while only 10.9% indicate to intend increasing the amount of plant-based meat substitutes they consume. This could eventually be explained by a lack of familiarity (Siegrist, Hartmann, & Keller, 2013), which differed “Meat lovers” from “Eco-friendly” in our study. In line with the study of den Uijl, Jager, de Graaf, Waddell, & Kremer, 2014, the older adults in our study were not particularly fussy about food. While food fussiness and food neophobia share a common etiology (Smith et al., 2017), an earlier study found that food neophobia was moderate in older adults (Soucier, Doma, Farrell, Leith-Bailey, & Duncan, 2019). Food neophobia has been shown to act as a barrier to the acceptance of meat substitutes (Hoek, Luning et al., 2011). Therefore, plant-based meat substitutes should have a certain resemblance to meat in order to replace meat (Hoek, van Boekel, Voordouw, & Luning, 2011), our findings confirm the importance of familiarity.

Older adults prefer carbon labels which represent the lowest amount of environmental impact in terms of carbon emission in the case of red meat or poultry-based burgers. However, in the case of plant-based burgers, the opposite was found. This might be explained by older adults being aware that in general animal-derived protein sources have a higher carbon footprint than plant-based proteins (Clune et al., 2017; Hoolohan et al., 2013; Masset et al., 2014). The reasoning being that these consumers might think that when simply choosing plant-based burgers, they are already making an effort to reduce the environmental impact of their dietary choices. Subsequently, they might not feel the need to do even more to reduce their environmental impact by additionally also buying a plant-based protein-enriched burger with the most environmentally friendly carbon labeling. An alternative hypothesis might be skepticism or disbelief towards far-stretching environmental claims on plant-based products among older consumers. A similar but opposite reasoning might explain their preference for red meat or poultry-based burgers that have the best carbon labels. When preferring red meat or poultry-based burgers above plant-based burgers,

older consumers might be aware that they are choosing the less environmentally friendly option. Therefore, they might prefer red meat or poultry-based burgers that have a more environmentally friendly carbon label to compensate for choosing a less environmentally friendly protein source.

5.2. Consumer preferences per segment based on the LC model

The largest consumer segment, “Meat lovers”, prefer red meat and poultry above plant-based burgers, a tendency found for food products in general (Grasso et al., 2019; Halkjær et al., 2009). “Meat lovers” also reported more often that they do not intend to change their consumption of red meat. Both findings can be explained by the high level of importance they attach to familiarity when making food choices. Furthermore, this is supported by the finding that “Meat lovers” are more likely to have never consumed plant-based meat substitutes. Their disliking of plant-based burgers might also be explained by plant-based burgers often being more expensive or perceived to be of a less good value for money (Schösler, Boer, & Boersema, 2012; Vanhonacker, Van Loo, Gellynck, & Verbeke, 2013), as “Meat lovers” have the strongest negative price preference. In terms of carbon labeling, the same reasoning as for the overall population could apply here, namely that preferring carbon A labeling on red meat burgers is a way for them to compensate for choosing the less environmentally friendly protein source, namely red meat burgers.

The importance “Poultry lovers” attach to healthy food might explain why they prefer poultry over red meat burgers (World Health Organization, 2003). Therefore, communicating the possible health benefits of balancing animal and plant-based protein intake might be a potential strategy to stimulate sustainable protein consumption in this segment as this has been shown to increase WTP for alternative protein sources, such as in the case of insect-based proteins (Lombardi, Vecchio, Borrello, Caracciolo, & Cembalo, 2019). The importance attached to sustainability when making food choices could be an additional reason for preferring poultry over red meat burgers. Nonetheless, “Poultry lovers” attach less importance to sustainability than the “Eco-friendly” segment, which might explain their preference for poultry over plant-based burgers.

“Eco-friendly” consumers attach more importance to the health aspect of food than “Meat lovers” and “NoBurgers”, and more importance to sustainable food than “Meat lovers” and “Poultry lovers”. This might explain the high utility they derive from plant-based burgers as well as their indifference to price. The finding that they obtain a higher score on the environmental impact knowledge test than “Meat lovers” and “NoBurgers” suggests that they perceive plant-based burgers as having a lower environmental impact than red meat burgers, regardless of which carbon label is applied to it. This might explain why “Eco-friendly” consumers do not have a significant preference for specific carbon labels in the case of red meat and plant-based burgers.

The “NoBurgers” consumer segment is characterized by consumers who derive a strong negative utility from all protein sources. Results obtained from analyzing the reason why people chose the opt-out, showed that the primary reason is just not liking burgers in general, irrespective of the type of protein source. Nonetheless, “NoBurgers” consumers attach more importance to the sustainability aspect of food and report more often that they intend to increase their consumption of plant-based meat substitutes than “Meat lovers”. Despite this, they scored lower on the environmental impact knowledge test. Therefore, raising awareness and knowledge with respect to which foods have a lower environmental impact could provide an opportunity to improve the sustainability of this segment’s food consumption.

5.3. Limitations

As most consumer research, this study relied on self-reported measures of preferences, attitudes, perceptions and diet-related behaviors.

Although self-reported opinions provide valuable insights, they may suffer from social desirability and hypothetical bias, and hence, may deviate from actual behavior (Fisher, 1993). Nonetheless, compared to contingent valuation methods, hypothetical bias is reduced in choice experiments by providing choice situations that resemble real-life choice situations, including a possibility to opt-out. The results of this study could only be considered valid if completed by older adults without cognitive impairment (Doty & Kamath, 2014). Therefore, when designing the choice experiment, special attention was given to minimizing cognitive burden by limiting the number of choice tasks, attributes, and attribute levels. As the protein-source attribute levels have been grouped into protein categories (red meat, poultry and plant-based), care should be taken when applying these results to more specific protein sources, e.g. beef or pork-based burgers. Last but not least, this study only included older adults who live independently at home. Whereas this delimitation is justified since this population group makes independent food purchasing and consumption decisions, it implies that findings from this study cannot be generalized to the broader group of older consumers who live in nursing or other older people's care homes.

6. Conclusion

This study provides insight into older adults' relative preferences, intentions, and willingness to pay for protein-enriched burgers. Such insight is relevant when aiming at the prevention of protein malnutrition while safeguarding the healthiness and sustainability of this population groups' diets. Preferences for different protein sources and carbon labels, as well as willingness to pay for these attributes, were modeled using choice experiments. To the best of our knowledge, this research is the first to focus on older adults' preferences and willingness to pay for protein-enriched food products, which explicitly compares their preferences for more sustainable plant-based protein sources with traditional animal-based proteins.

Choice analysis showed that protein-enriched burgers are accepted by most older adults, with most older consumers preferring traditional red meat or poultry as protein sources. Four consumer segments were identified using latent class analysis. Consumer segments were profiled based on socio-demographics, dietary habits, intention to change protein sources to reach optimal health, food-related attitudes, knowledge, and perception of protein and food in the diet.

Consumer profiling indicates that older adults' intentions to consume alternative, more sustainable protein-enriched products are associated with gender, country, importance attached to health, sustainability and familiarity, knowledge of protein and the environmental impact of different protein sources. By contrast, financial constraints, food fussiness, importance attached to price, convenience, and sensory appeal were not associated with older adults' intention to consume and willingness to pay for alternative, more sustainable, and protein-enriched products.

Of the four consumer segments identified through latent class analysis, the largest segment, "Meat lovers", are not likely to reduce meat consumption to achieve a more sustainable diet. However, communicating the possible health benefits of balancing meat and plant-based protein intake might be a potential strategy to stimulate sustainable protein consumption in the "Poultry lovers" segment. Plant-based meat alternatives are acceptable to the "Eco-friendly" older adult segment, which could be part of a dietary strategy to increase protein intake while accounting for environmental impact.

Using carbon labeling to indicate the relative environmental impact of protein sources could be a promising strategy to promote more sustainable protein consumption, as those consumer segments who prefer red meat and poultry burgers derive more utility from the carbon label representing the lowest carbon footprint.

Funding

This research is part of the EU-funded project PROMISS ("Prevention Of Malnutrition In Senior Subjects in the EU") within the framework of Horizon 2020 research and innovation program, contract No. 678732.

Acknowledgements

Financial support from the European Commission is gratefully acknowledged. We thank all respondents of the questionnaire for providing us with the data to make this work possible.

Declaration of Competing Interest

The authors declare no conflict of interest.

Appendix A. – Info for respondents in the choice experiment

In this section, you will be asked to choose between two alternative burgers.

Both burgers are rich in protein, and therefore cost more than the usual burgers.

The two burgers can differ in specific characteristics:

Source of protein: Red meat (e.g., beef, pork); Poultry (e.g., chicken or turkey); or Plant-based (e.g., beans, nuts).

Extra price to pay: Additional cost of the burger in percentage, compared to the usual burger price.

Carbon footprint: The impact of burger production on the environment. A burger with carbon footprint 'A' is better for the environment than 'B' according to the greenhouse gas emissions; and a burger with carbon footprint 'B' is better for the environment than 'C'.

All other characteristics of the burgers are the same. Please indicate your preferred option.

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