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Consumers' valuation for low - carbon emission and low – saturated fat butter

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ABSTRACT

Currently, there is an ongoing debate related to the large environmental impact of livestock greenhouse gas (GHG) emissions and the negative effect of saturated fat contained in the animal foods on human health. In response to these adverse effects, dairy producers have adopted strategies to reduce these effects by modifying the conventional livestock feed composition. This study investigated, for the first time, Finnish consumers' willingness to pay (WTP) and heterogeneous preferences for butter derived from milk produced by cows fed with lipid-rich rapeseed feed, hereafter called rapeseed feed, which can reduce the GHG emissions from cows, and the saturated fat content of dairy products. Using a hypothetical choice experiment (CE) involving butter that varied across four attributes (i.e. type of feed, saturated fat content, Carbon Trust label, and price), our results show that, on average, consumers preferred the low-price butter, produced from cows fed with regular feed, labelled with the claim "Reduced saturated fat", and branded with the "Carbon Trust" label. Interestingly, we found that one-third of consumers were willing to pay a premium price for butter derived from milk produced by cows fed with rapeseed feed. Furthermore, we found that younger, and higher educated consumers tend to prefer butter derived from cows fed with rapeseed feed. These findings provide useful insights into the psychology of consumers' level of acceptance and attitudes that can be used by dairy producers and marketers in communicating to the public the nature of the new feed practices to reduce the negative environmental emissions, and saturated fat content of dairy products.

1. Introduction

Currently, the environmental impact of food production and human health issues are among the most relevant trends that influence consumers' preferences of food products (Alsubhi et al., 2023; Asioli et al., 2020; Clark et al., 2019; Ritchie & Roser, 2022). In this context, the latest data from the Food and Agriculture Organisation (FAO) indicates that aggregate agriculture-related activities, including agriculture-related land use along the supply chain contribute approximately to 19.8% of the global anthropogenic greenhouse gas (GHG) emissions (FAOSTAT, 2020). Specifically, livestock farming accounts for 15% of the global GHG emissions (Gerssen-Gondelach et al., 2017; Tseten et al., 2022). In the European countries, the largest livestock GHG emissions derives from the dairy sector including the enteric fermentation from ruminants (Lesschen et al., 2011). Accordingly, the ruminant livestock production system generates approximately 44% of CH_4 emissions, which is a main component of the total GHG (Shields & Orme-Evans, 2015). This results in negative effects on the environment, which has recently become a major research focus.

Dairy products are one of the most important products in the European food market. Although the EU-27 per capita milk consumption have one of the highest rates in the world, there has been a general decrease over the last years (Statista, 2023b). In 2021, the average milk consumption in EU was about 53 kg per capita (Statista, 2023b). However, other dairy products (e.g. cheese) have increased in their annual consumption over the recent years (Statista, 2023b) while per capita

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butter consumption in Finland declined from 4.5 kg in 2013 to 3 kg in 2021 (Statista, 2023a).

Furthermore, inappropriate consumption of saturated fat in animal-based food products may associate with negative human health effects, such as the risk of cardiovascular diseases and other physiological disorders (Blake & Rudolph, 2021; Hooper et al., 2020; Shingfield et al., 2013), although the negative impact of saturated fat is becoming increasly challenged, particularly for dairy foods (Givens, 2022). Moreover, Vasilopoulou et al. (2020) showed that compared to conventional dairy products, a human diet containing dairy products (milk, hard cheese, and butter) with a proportion of the saturated fatty acids replaced with monounsaturated fatty acids showed potentially beneficial effects on fasting low-density lipoprotein (LDL) cholesterol, and endothelial function although it is not known whether this was due to all three dairy products. Besides, concerns about fat content is one of the factors influencing consumers' consumption and attitudes for dairy products (Bus & Worsley, 2003). For example, Markey et al. (2017) found that consumers have higher purchase intention for butter with a reduced saturated fatty acid content when compared to the butter with a regular saturated fatty acid content.

A solution to reduce the environmental impact of the current livestock system and the saturated fat content of the derived dairy products is to modify the conventional feed composition for cows (Toprak, 2015). Hristov et al. (2013) summarised the enteric CH_4 mitigation practices in terms of food supplement, and management practices for cows. Specifically, adding additives derived from plants (i.e. plant oil, oil seeds, etc.) or changing the management strategies (i.e. reduce herd size) could significantly decrease the non-CO_2 GHG emissions from cows. For example, it was estimated that between 14% – 17% reduction in GHG emissions from cows could be obtained by adding lipid supplements into the cow diet (Mottet et al., 2017). Considering the safety and practical implementation, oil supplement or oilseeds treatment in ruminant diets exploited advantages of CH_4 mitigation (Kliem et al., 2019; Bayat et al., 2018). For instance, the positive effect of oilseeds feeding for livestock on the environment was suggested by Kliem et al. (2019) who observed a reduction of CH_4 emissions from dairy cows fed with linseed-based supplements. Furthermore, oilseeds supplement into dairy cows' diet could partially lower the saturated fat content in the milk (Bayat et al., 2018; Halmemies-Beauchet-Filleau, 2019; Markey et al., 2017). Specifically, oil from domestic rapeseeds (*Brassica napus*) is rich of monounsaturated lipids which can have a great potential to modify the lipid composition of ruminant milk by reducing the proportion of saturated fatty acids, and increasing monounsaturated fatty acids inherent to the lipid supplement (Halmemies-Beauchet-Filleau, 2019). A recent study from Halmemies-Beauchet-Filleau (2019) investigated the effects of lipid-rich rapeseed on cows' diet on milk fat composition, and ruminal methane emissions from dairy cows on grass silage based diets of high digestibility. They found that by adding lipid-rich rapeseed to a dairy cow diet decreased the proportion of saturated fatty acids in the milk fat, substantially reduced ruminal CH_4, and hydrogen emissions.

Since the adoption of new feeding strategies and practices could be expensive and challenging to dairy producers, research should be conducted to investigate consumers' acceptance of dairy products derived from cows fed lipid-rich rapeseed as a potential feeding strategy to be applied. Therefore, there is a need to get information from consumers to evaluate their preferences and willingness to pay (WTP) towards this new feeding strategy and to ensure a successful introduction of these derived new products on the market. To the best of authors' knowledge, there is no previous study that has investigated consumers' acceptance for dairy products derived from cows feed with lipid-rich rapeseed.

To fill this void, using a hypothetical choice experiment (CE), we investigated Finnish consumers' WTP for a new type of butter, which was derived from milk produced by cows fed with a diet containing lipid-rich rapeseed, hereafter called rapeseed feed, that vary across four attributes (i.e. type of feed, saturated fat content, Carbon Trust label, and price). Moreover, we investigated the effect of consumer characteristics (i.e. socio-demographics, habits, and attitudes) on preference heterogeneity which can provide useful information for producers and marketers on improving product development and better target communication strategies of these new products. Butter was chosen because it is one of the most important dairy products, and it is a popular staple dairy product in Finland (Statista Research Department, 2020).

2. Materials & methods

2.1. Experimental design

In the CE, four attributes were used to describe the different types of butter, including"feed", "saturated fat content", "Carbon Trust label", and"price" (Table 1). Although having more attribute levels in the design could have provided more insights and variation in consumer preferences, in choice experiment studies it is a common practice do not including too many attributes because of the larger cognitive burden becomes for the respondents to evaluate more attribute levels and products (Caputo & Scarpa, 2022; Lizin et al., 2022) which can reduce data quality, and have implications for WTP estimations. First, we included the attribute "feed" because the main aim of the study was to investigate consumers' WTP for butter derived from milk produced by cows fed with different types of feed. Thus, two levels of "feed" were specified:'regular feed', such as cows fed mainly with forage and cereals or'rapeseed feed', such as cows fed mainly with forage and cereals supplemented with lipid-rich rapeseed. Second, the attribute "saturated fat content" was included in the study because this could affect consumers' preferences for dairy products as previous research reported (Belc et al., 2019; Lordan et al., 2018; Vargas-Bello-Pérez et al., 2020) as well as because this information is linked with the attribute"feed" (i.e. the use of rapeseed feed in cows' diet may reduce the saturated fat content on the derived dairy products, see Halmemies-Beauchet-Filleau, 2019) which could be important for dairy producers to better communicate the human health benefit of the rapeseed feed. Two levels of "saturated fat content" were included:'reduced saturated fat' or'regular saturated fat'. Third, we included the attribute "Carbon Trust label" - referring to the environmental impact of food production, transportation, and the food product in terms of GHG emissions. We included this information because the environmental impact of food production is currently one of the top concerns affecting consumer food choices as previous research reported (see for example, Asioli et al., 2020; Edenbrandt & Lagerkvist, 2022; Testa et al., 2021) as well as because this information is linked with the attribute"feed" (i.e. the use of rapeseed

Table 1
Attributes and levels.

ATTRIBUTES	LEVELS
Feed	0 - Regular feed 1 - Rapeseed feed
Saturated fat content	0 - Reduced saturated fat 1 - Regular saturated fat
Carbon Trust label	0 - No label 1 - With Carbon Trust label
Price	2.95 Euro/500 g 3.95 Euro/500 g 4.95 Euro/500 g 5.95 Euro/500 g

feed in cows' diet may reduce the carbon emission, see Halmemies-Beauchet-Filleau, 2019) which could be important for dairy producers to better communicate the environmental benefit of the rapeseed feed Thus, the two levels of this attribute were: use of the 'Carbon Trust label' or no label used at all. Finally, four price levels were specified to approximately cover the range of market prices of a typical 500 g pack of butter in Finland (i.e. 2.95 Euro/500 g; 3.95 Euro/500 g; 4.95 Euro/500 g; 5.95 Euro/500 g). The prices for butter were based on prices recorded in different Finnish stores including grocery stores, farmers' markets, specialty stores, organic stores, and supercentres.

The selected attributes and their levels were then used to generate an orthogonal fractional factorial design using the software Ngene (Sidney, Australia) that resulted in the creation of 24 choice sets, which were then divided into two blocks of 12 choice sets each to prevent respondents' fatigue. Each choice set was composed of two product alternatives (options A and B), and an "opt-out" option (option C) (see an example in Appendix A). The randomisation was conducted within each block of 12 choice sets.

The CE was introduced with the explanation and description of the attributes' levels. Then, before starting the choice tasks, respondents were asked to read a cheap talk (CT) script to mitigate possible hypothetical bias that affects the estimated WTP in stated preference studies (Cummings & Taylor, 1999) (see Appendix B for the CT script).

Upon completion of the choice tasks, the respondents were asked to complete a questionnaire to collect information on their socio-demographics, and attitudinal factors which may affect their WTP for the different types of butter. Thus, we collected socio-demographics characteristics, such as age, gender, income, and education. In addition, we included attitudinal factors, such as consumer degree of neophobia towards new food products adopting the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992) using the 7-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree), the respondents' health attitude adopting health related items from the Health and Taste Attitude Questionnaire (HTAQ) (Roininen et al., 1999) by using the 7-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree), and respondents' pro-environmental attitude adopting the new environmental paradigm (NEP) scale (Dunlap et al., 2000) by using the 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). A pre-test involving 50 consumers was performed during Autumn 2019 to test the survey. The questionnaire is available in appendix C.

3. Data

Data used in this study were collected, using a convenience sample, from an online survey conducted during Autumn 2019 involving 320 participants in Finland using the online platform Qualtrics LLC (Provo, United States). Only consumers who were at least 18 years old, who were responsible at least for half of the total household grocery purchases, and have purchased butter at least once during the last three months were recruited in this study. Our study was approved by an institutional ethical clearance board.

To ensure data quality, we included in the study only participants who declared to thoughtfully provide their best answer, who had 'devoted their full attention to the questions so far', and in their honest opinion they believed that we should use their responses for the study. The latter 'attention check' question has been demonstrated by Meade and Craig (2012) to stimulate respondents to pay extra attention to the subsequent questions. We strategically placed this question before the most important questions of the survey, such as the choice tasks.

Table 2 presents the participants' socio-demographic characteristics. Females and males each accounted for half of the quota sampling, which is similar to the gender composition of the Finnish census population data (Statista, 2022; Statistics Finland, 2022). Regarding age, except for a small proportion (4.38%) of participants aged more than 71 years, 31.56%, 30.94% and 33.13% of them were aged between 18 and 35 years old, 36 – 53 years old, and 54 – 71 years old, respectively. In addition, almost 75% of the participants had a gross annual income less than Euros 60,000, which was relatively lower than the Finnish census population data while nearly 35% of participants have completed college, and university education which is relatively higher than the Finnish census population data (Statista, 2022; Statistics Finland, 2022).

Table 2
Consumers' socio-demographic characteristics.

SOCIO DEMOGRAPHICS	*N* = *320*
Sex at birth	
Male	160 (50.00%)
Female	160 (50.00%)
Age (years)	
18–35	101 (31.56%)
36–53	99 (30.94%)
54–71	106 (33.13%)
>71	14 (4.38%)
Annual income before tax	
Less than Euro 19,999	70 (21.88%)
Euro 20,000 – 39,999	90 (28.13%)
Euro 40,000 – 59,999	82 (25.63%)
Euro 60,000 – 79,999	43 (13.44%)
Euro 80,000 –99,999	18 (5.63 %)
More than Euro 100,000	17 (5.31%)
Education	
Primary school	32 (10.00%)
Vocational school	84 (26.25%)
Secondary school	84 (26.25%)
College	62 (19.38%)
University	50 (15.63%)
Others	8 (2.49%)

Next, we investigated the descriptive statistics of the attitudinal factors investigated in this study (Table 3). Consumers showed an average degree of food neophobia towards new food products, and large health and environmental attitudes. High internal reliability of each attitude was identified by calculating Cronbach's alpha (above 0.80).

4. Econometric analysis

Data analysis was conducted using the so-called discrete choice models (DCMs) (Hensher, Rose, & Greene, 2015; Train, 2009). DCMs are popular econometrics models used to analyse choice data based on modelling "Utility" which is the net benefit a consumer gather from selecting a specific good in a choice situation as a function of the design attributes (Train, 2009; Hensher et al., 2015). The utility of a product *j* for individual *n* in a choice occasion *t* (choice set) is written:

$$U_{njt} = \beta_n' x_{jt} + \varepsilon_{njt} \quad (1)$$

where β_n is a vector of individual-specific parameters accounting for preference heterogeneity, x_{jt} is a vector of design attributes, and ε_{njt} is the unobserved error term, which is assumed to be independent of the vectors β, and x.

There are different types of DCMs, and we used two of the most applied: the Mixed Logit (ML) model to investigate consumer marginal WTP (mWTP) for the design attributes main effects only, the interactions with design attributes, and consumers' characteristics (Train, 2009; Hensher et al., 2015), and the Latent Class Logit (LCL) model to

Table 3
Consumers' attitudes.

ATTITUDES: MEAN (SD), CRONBACH'S ALPHA	(*N* = *320*)
Food neophobia (FNS)	3.54 (0.05) 0.87
Health attitude (HTQA)	4.23 (0.04) 0.80
Environmental attitudes (NEP)	3.46 (0.37) 0.83

investigate consumers' heterogeneity (i.e. identification of consumer segments) (Greene & Hensher, 2003).

We analysed the data in three steps. First, we investigated consumers' mWTP for butter considering the design attributes' main effects only using the ML model in WTP preference space. Thus, based on the eq. (1), the utility ML model for butter *j*, for individual *n*, in choice occasion *t* is written:

$$U_{njt} = ASC + \beta_{1n}FEED_{njt} + \beta_{2n}FAT_{njt} + \beta_{3n}CARBON_{njt} + \beta_{4n}PRICE_{njt} + e_{njt} \quad (2)$$

where ASC is the dummy variable indicating the selection of the OPTOUT option. $FEED_{njt}$ is a dummy variable representing the type of feed given to the cows that produce milk needed to produce butter, taking the value of 0 if the feed is 'Regular feed', and 1 if it is 'Rapeseed feed'. FAT_{njt} is a dummy variable representing information about saturated fat content of the butter, taking the value of 0 if the claim 'Reduced saturated fat' is reported on the pack of butter, and 1 if the claim 'Regular saturated fat' is reported. $CARBON_{njt}$ is a dummy variable representing the 'Carbon Trust label', taking the value of 0 if no label is reported, and 1 if the Carbon Trust label is reported. The price ($PRICE_{njt}$) attribute is represented by four experimentally defined price levels. ε_{njt} is the unobserved error term. The ML model assumes random parameters with normal distributions for all design attributes. These random coefficients are further assumed to be independent. This ML model provides estimates of the mean, and the standard deviation (SD) of the random attribute parameters.

Second, we investigated consumers' mWTP for butter considering the design attributes' main effects, and the interactions effects among them. Thus, based on the eq. (1), the utility ML model for butter *j*, for individual *n*, in choice occasion *t* is written:

$$\begin{aligned} U_{njt} = & \mathbf{ASC} + \beta_{1n}FEED_{njt} + \beta_{2n}FAT_{njt} + \beta_{3n}CARBON_{njt} + \beta_{4n}PRICE_{njt} \\ & + \beta_{5n}(FEED^*FAT)_{njt} + \beta_{6n}(FEED^*CARBON)_{njt} \\ & + \beta_{7n}(FEED^*PRICE)_{njt} + \beta_{8n}(FAT^*CARBON)_{njt} \\ & + \beta_{9n}(FAT^*PRICE)_{njt} + \beta_{10n}(CARBON^*PRICE)_{njt} + e_{njt} \end{aligned} \quad (3)$$

Third, we explored the effect of consumer characteristics on consumers' mWTP for the design attribute FEED. Specifically, we investigated consumers' mWTP for butter considering the design attributes' main effects, and the interactions of FEED with several consumer characteristics (i.e. AGE, GENDER, INCOME, EDUCATION, FNS, HTAQ, and NEP) to investigate consumer mWTP for butter produced using milk derived from cows feed with the rapeseed feed is affected by consumer socio-demographics, and attitudes. Thus, based on the eq. (1), the utility ML model for butter *j*, for individual *n*, in choice occasion *t* is written:

$$\begin{aligned} U_{njt} = & \mathbf{ASC} + \beta_{1n}FEED_{njt} + \beta_{2n}FAT_{njt} + \beta_{3n}CARBON_{njt} + \beta_{4n}PRICE_{njt} \\ & + \beta_{5n}(FEED^*AGE)_{njt} + \beta_{6n}(FEED^*GENDER)_{njt} \\ & + \beta_{7n}(FEED^*INCOME)_{njt} + \beta_{8n}(FEED^*EDUCATION)_{njt} \\ & + \beta_{9n}(FEED^*FNS)_{njt} + \beta_{10n}(FEED^*HTAQ)_{njt} + \beta_{11n}(FEED^*NEP)_{njt} \\ & + e_{njt} \end{aligned} \quad (4)$$

Specifically, AGE is a categorical variable representing the age of the consumer, taking the value of 1 for consumers that have age between 18 and 35 years, 2 for age between 36 and 53 years, 3 for age between 54 and 71, and 4 for consumer older than 71 years. GENDER is a dummy variable representing the gender of the consumer, taking the value of 0 for females and 1 for males. INCOME is an ordinal variable representing the annual income of the consumer before tax, taking the value of 1 if the income is less than Euro 19,999, 2 for income between Euro 20,000 – 39,999, 3 for income between Euro 40,000 – 59,999, 4 for income between Euro 60,000 – 79,999, 5 for income between Euro 80,000 – 99,999, and 6 for income between more than Euro 100,000. EDUCATION is an ordinal variable representing the education level of the consumer, taking the value of 1 for primary school, 2 for vocational school, 3 for secondary school, 4 for college, and 5 for university degree. FNS is a variable representing the degree of neophobia towards new food products, assessed on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree). HTAQ is a variable representing the respondents' health attitude, assessed on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree). NEP is a variable representing the pro-environmental attitude of the consumers, assessed on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). The rest of the variables are specified as in Eq. (2). The parameters corresponding to the three non-price attributes (i.e. FEED, FAT, and CARBON) were modelled as random parameters assumed to follow a normal distribution, while the opt-out and the interactions parameters (i.e. AGE, GENDER, INCOME, EDUCATION, FNS, HTAQ and NEP) were modelled as fixed parameters.

The ML models were estimated using the module *mixlogit* to obtain the regression coefficients, and the module *wtp* to obtain the corresponding mWTP in monetary terms (i.e. €) (Hole, 2007) run in software STATA 16.1 (StataCorp LP, College Station, US). We run different ML models using different number of draws both with correlated, and not correlated variables. Based on logL, AIC and BIC parameters, the optimal model was five hundred Halton draws with not correlated variables used in the simulations (Hole, 2007; Train, 2009).

Finally, we investigated consumers' heterogeneity by using the LCL model in preference space to identify consumer segments (Greene & Hensher, 2003). The LCL model assumes that the overall population can be divided into two or more segments by assuming constant model parameters within each segment, capturing consumer heterogeneity by assuming a mixed distribution for the segments (Greene & Hensher, 2003). The probability of class membership *s* depends on individual *n* choosing alternative *j* at time *t* which consists of a certain set of observable attributes *x*':

$$Prob_{jnt|s} = \frac{exp(\mathbf{x}'_{ntj}\boldsymbol{\beta}_s)}{\sum_{j=1}^{Jn} exp(\mathbf{x}'_{ntj}\boldsymbol{\beta}_s)} \quad (5)$$

Specifically, *s* indicates the number of latent consumer segments, and β'_s represents the constant parameter vector, corresponding with group *s*. To estimate the LCL model, the commands *lclogit2*, *lclogitml2*, *lclogitwtp* and *lclogitpr2* (Hong, 2020) were run in software STATA 16.0 (StataCorp LP, College Station, US). Besides, considering the stable performace, Expectation – Maximization (EM) algorithm was applied in this study (Bhat, 1997; Train, 2008; Pacifico & Yoo, 2013). To decide the number of consumer groups, improvements in BIC of <2 was treated as negligible evidence, between 2 and 6 was treat as positive evidence, between 6 and 10 was strong evidence and greater than 10 was treated as very strong evidence (Kass & Raftery, 1995). Finally, we selected the LCL model based on the minimum BIC (Hong, 2020), and the segment size.

5. Results

5.1. Estimated parameters for Mixed Logit (ML) model and WTP estimates: Main effects.

The results of the estimation of the parameters of the ML model, and mWTP using equation (2) for the main effects only are exhibited in Tables 4 and 5, respectively.

Table 4 reports the estimates (average regression coefficients) for FEED, FAT, CARBON, PRICE, and OPT-OUT parameters as well as the corresponding standard errors (SEs), standard deviations (SDs), and significances for the attributes (*p-values*). We found that the estimate for the OPT-OUT option was negative and significant (coefficient: −10.04, *p-value*: 0.00), suggesting that consumers tended to prefer one of the two product alternatives in a choice set as opposed to the 'opt-out' option. On average, the results show that consumers tended to prefer low price (coefficient: −1.34, *p-value*: 0.00) butter derived from milk produced from cows fed with regular feed (coefficient: −0.54, *p-value*: 0.00),

Table 4
Estimated parameters for Mixed Logit (ML) model with attributes' main effects.

ATTRIBUTES	AVERAGE			STANDARD DEVIATION		
	Coefficient	SE	*P-value*	Coefficient	SE	*P-value*
Feed	−0.54	0.10	0.00	1.52	0.11	0.00
Fat	−0.43	0.08	0.00	1.07	0.09	0.00
Carbon	0.51	0.07	0.00	0.78	0.09	0.00
Price	−1.34	0.08	0.00	1.03	0.06	0.00
Optout	−10.04	0.35	0.00			
Model parameters						
N. obs	11,520					
Wald chi2	1733.02					
df	9					
logL	−2338.00					
AIC	4694.00					
BIC	4760.16					

SE: standard error.
N. obs: number of observations.
Wald chi2: Wald test.
df: degree of freedom.
logL: log likelihood function.
AIC: Akaike's information criterion.
BIC: Bayesian information criterion.

Table 5
Estimated Willingness to Pay in Preference Space for main effects.

ATTRIBUTE	MWTP (€/500 g)	95% C.I.
Feed	−0.40	−0.56 ~ -0.25
Fat	−0.32	−0.44 ~ -0.20
Carbon	0.38	0.27 ~ 0.49

MWTP: marginal willingness to pay.
C.I.: confidence interval.

labelled with the claim "Reduced saturated fat" (coefficient: −0.43, *p-value*: 0.00), and branded with the Carbon Trust label (coefficient: +0.51, *p-value*: 0.00). Interestingly, all the attributes (i.e. FEED, FAT, CARBON, and PRICE) have significant SDs (*p-values*: 0.00), particularly for FEED indicating the existence of consumer heterogeneity.

Next, based on the estimated parameters of the ML model presented above, we calculated the consumers' mWTP for the attributes FEED, FAT, and CARBON (Table 5). Consumers were willing to pay a lower price for butter derived by milk produced from cows fed with rapeseed feed (mWTP: −0.40 €/500 g; CI: −0.56 ~ -0.25), but they were willing to pay a premium price for butter labelled with the claim "Reduced saturated fat" (mWTP: −0.32 €/500 g; CI: −0.44 ~ -0.20) and branded with the Carbon Trust label (mWTP: +0.38 €/500 g; CI: 0.27 ~ 0.49).

6. Estimated parameters for Mixed Logit (ML): Main effects and interactions effects with design attributes.

The results of the estimation of the parameters of the ML model, and mWTP using equation (3) for the main effects, and interaction effects

Table 6
Estimated parameters for Mixed Logit (ML) model with attributes' main effects and interactions among design attributes.

ATTRIBUTES	AVERAGE			STANDARD DEVIATION		
	Coefficient	SE	*P-value*	Coefficient	SE	*P-value*
Feed	−0.65	0.44	0.14	1.49	0.11	0.00
Fat	1.16	0.44	0.01	1.19	0.10	0.00
Carbon	−0.79	0.44	0.07	0.36	0.17	0.04
Price	−1.33	0.10	0.00	1.07	0.06	0.00
Feed * Fat	−1.11	0.35	0.00	0.01	0.31	0.97
Feed * Carbon	1.25	0.38	0.00	1.14	0.22	0.00
Feed * Price	−0.02	0.08	0.78	0.03	0.05	0.62
Fat * Carbon	0.28	0.35	0.42	0.37	0.26	0.16
Fat * Price	−0.27	0.08	0.00	0.01	0.05	0.86
Carbon * Price	0.12	0.08	0.15	0.07	0.05	0.14
Optout	−10.25	0.48	0.00			
Model parameters						
N. obs	11,520					
Wald chi2	1762.16					
df	21					
logL	−2315.50					
AIC	4673.01					
BIC	4827.39					

SE: standard error.
N. obs: number of observations.
Wald chi2: Wald test.
df: degree of freedom.
logL: log likelihood function.
AIC: Akaike's information criterion.
BIC: Bayesian information criterion.

with the design attributes are exhibited in Table 6 which reports the same parameters presented in Table 4. We found some interesting results. Consumers who preferred butter derived from milk produced by cows fed with rapeseed feed tended to prefer more butter labelled with the claim "Reduced saturated fat" (Feed*Fat: coefficient: −1.11, *p-value*: 0.00), and branded with the "Carbon Trust label" (Feed*Carbon: coefficient: +1.25, *p-value*: 0.00). Moreover, consumers who prefer butter labelled with the claim "Regular saturated fat" also prefer low price butter (Fat*Price: coefficient: −0.27, *p-value*: 0.00).

7. Estimated parameters for Mixed Logit (ML) model: Main effects and interactions with consumers' characteristics.

The results of the estimation of the parameters of the ML model using equation (4) for the main effects, and interaction effects with the consumers' characteristics are exhibited in Table 7 which reports the same parameters presented in Table 4. We found two interesting outcomes. Younger (Feed * Age: coefficient: −0.40, *p-value*: 0.00) and more educated (Feed * Education: coefficient: +0.32, *p-value*: 0.00) consumers tend to prefer more butter derived from milk produced by cows fed with rapeseed feed.

8. Estimation results from latent class Logit (LCL) model.

In view of the significant SDs of the design attributes main effects within the ML model – as shown in section 4.1 - we investigated the possibility that there are distinct segments of consumers. Thus, to investigate consumer heterogeneity, we estimated the LCL model. Based on the BIC values, and the size of the segments we chose the four-segments solution.

Table 8 shows the estimated parameters from the LCL model, including the regression coefficients for FEED, FAT, CARBON, PRICE and OPTOUT parameters as well as the corresponding standard errors (SEs), and significances for the attributes (*p-values*). Group 1 ('Healthier & Environmentalists': 102 consumers, 31.90% of the sample) is the larger segment of consumers who prefer low price butter (coefficient: −0.25, p < 0.001), derived by milk produced from cows fed with rapeseed feed (coefficient: 0.25, p < 0.01), labelled with the claim "Reduced saturated fat" (coefficient: −0.80, p < 0.001), and branded with the "Carbon Trust label" (coefficient: +0.77, p < 0.001). Group 2 ('Price sensitive': 89 consumers, 27.81% of the sample) includes consumers who are strongly interested in low price butter (coefficient: −2.96, p < 0.001). Group 3 ('Neutral': 72 consumers, 22.5% of the sample) involves consumers who do not show a particular interest in any of the attributes, except for a slight preference for low price butter (coefficient: −1.50, p < 0.001). Group 4 ('Traditionalists': 57 consumers, 17.8% of the sample) is the smaller segment of consumers who prefer low price butter (coefficient: −0.25, p < 0.001), and strongly prefer butter derived by milk produced from cows fed with regular feed (coefficient: −2.25, p < 0.001).

Next, based on the parameters from the LCL model showed in Table 8, we calculated consumers' mWTP for each segment. Table 9 presents consumers' mWTP for FEED, FAT, and CARBON as well as the corresponding standard errors (SEs), and significances for the attributes (*p-values*). Consumers in group 1 ("Healthier & Environmentalist") were willing to pay a premium price for butter derived from milk produced by cows fed with rapeseed feed (mWTP: +0.99 Euros/500 g, p < 0.01), labelled with the claim"Reduced saturated fat" (mWTP: −3.16 Euros/500 g, p < 0.001), and branded with the Carbon Trust label (mWTP: +3.05 Euros/500 g, p < 0.001). Both consumers in groups 2 "Price sensitive", and 3 "Neutral" had no significant mWTPs for any of the non-price attributes investigated. Lastly, "Traditionalist" consumers were strongly willing to pay a lower price for butter derived from milk produced by cows fed with rapeseed feed (mWTP: −8.90 Euros/500 g, p < 0.01).

9. Discussion & conclusions

This study investigated Finnish consumers' WTP and heterogeneity preferences for butter derived from milk produced by cows fed with rapeseed feed which can reduce the GHG emissions from cows, and the saturated fat content of dairy products. Several main outcomes were identified. First, we found that, on average, consumers preferred low price butter derived from milk produced by cows fed with regular feed

Table 7
Estimated parameters for Mixed Logit (ML) model and WTP estimates: Main effects and interactions with consumers' characteristics.

ATTRIBUTES	AVERAGE			STANDARD DEVIATION		
	Coefficient	SE	*P-value*	Coefficient	SE	*P-value*
Feed	−2.98	1.20	0.01	1.44	0.11	0.00
Fat	−0.44	0.08	0.00	1.14	0.10	0.00
Carbon	0.51	0.07	0.00	0.79	0.09	0.00
Price	−1.37	0.07	0.00	1.03	0.06	0.00
Feed *Age	−0.40	0.11	0.00			
Feed * Gender	0.07	0.21	0.73			
Feed * Income	0.01	0.04	0.75			
Feed * Education	0.32	0.08	0.00			
Feed * FNS	0.05	0.12	0.67			
Feed * HTAQ	0.14	0.13	0.27			
Feed * NEP	0.33	0.20	0.09			
Optout	−10.11	0.35	0.00			
Model parameters						
N. obs	11,520					
Wald chi2	1675.77					
df	23					
logL	−2316.71					
AIC	4665.42					
BIC	4783.05					

SE: standard error.
N. obs: number of observations.
Wald chi2: Wald test.
df: degree of freedom.
logL: log likelihood function.
AIC: Akaike's information criterion.
BIC: Bayesian information criterion.

Table 8
Estimation results from Latent Class Logit (LCL) model.

ATTRIBUTE	Group 1 Healthier & Environmentalists (N = 102) Coefficient (SE)	Group 2 Price Sensitive (N = 89) Coefficient (SE)	Group 3 Neutral (N = 72) Coefficient (SE)	Group 4 Traditionalists (N = 57) Coefficient (SE)
Feed	0.25**	0.07	−0.08	−2.25***
	(0.08)	(0.20)	(0.17)	(0.21)
Fat	−0.80***	0.08	−0.24	0.46*
	(0.08)	(0.19)	(0.15)	(0.18)
Carbon	0.77***	0.37	0.05	−0.03
	(0.08)	(0.19)	(0.13)	(0.15)
Price	−0.25***	−2.96***	−1.50***	−0.25**
	(0.04)	(0.21)	(0.13)	(0.08)
Optout	−4.74***	−17.50***	−5.64***	−4.27***
	(0.36)	(1.14)	(0.49)	(0.71)
Model parameters				
BIC	4720.52			

SE: standard error.
BIC: Bayesian information criterion.
Notes: * $p < 0.05$ ** $p < 0.01$ ***$p < 0.001$.

Table 9
Estimated mWTPs for LCL model.

ATTRIBUTE	Group 1 Healthier & Environmentalists (N = 102) mWTP (€/500 g) (SE)	Group 2 Price sensitive (N = 89) mWTP (€/500 g) (SE)	Group 3 Neutral (N = 72) mWTP (€/500 g) (SE)	Group 4 Traditionalists (N = 57) mWTP (€/500 g) (SE)
Feed	0.99**	0.02	−0.05	−8.90**
	(0.35)	(0.07)	(0.12)	(2.69)
Fat	−3.16***	0.03	−0.16	1.84
	(0.60)	(0.06)	(0.09)	(0.92)
Carbon	3.05***	0.13	0.03	−0.10
	(0.58)	(0.06)	(0.08)	(0.59)

mWTP: marginal willingness to pay.
SE: standard error.
Notes: * $p < 0.05$ ** $p < 0.01$ ***$p < 0.001$.

that carries the 'Carbon Trust' label, and it is labelled with the claim 'Reduced saturated fat'. These findings were corroborated by Almli et al. (2011) who found that Norwegian consumers had preference for low saturated fat in dairy products, and Canavari & Coderoni (2020) who found that Italian consumers were willing to pay a premium price for milk branded with the carbon footprint label. Second, we found that consumers who preferred butter derived from milk produced by cows fed with rapeseed feed tend to prefer more butter labelled with the claim "Reduced saturated fat" and branded with the "Carbon Trust label". Interestingly, we can notice a positive synergy between the consumer preference for butter labelled with the claim "Reduced saturated fat" and branded with the "Carbon Trust label" which were aspects related health and environmental-friendly, respectively. This finding is corroborated by Verain et al. (2016) in a study with Dutch consumers which includes dairy products. Third, we found that younger, and more educated consumers tend to prefer more butter derived from milk produced by cows fed with rapeseed feed. The latter finding was corroborated by a large number of research who found that younger, and more educated consumers tend to accept more food innovations (for example, Asioli et al., 2019; Mancini & Antonioli, 2019; Slade, 2018). Fourth, we found that one third of consumers were willing to pay a premium price for butter derived by milk produced from cows fed with rapeseed feed. Interestingly, the same segment of consumers had strong preference for butter labelled with the claim "Reduced saturated fat" and branded with the "Carbon Trust label". This finding was corroborated by Almli et al. (2011) who found that a large sample of Norwegian consumers had preference for low saturated fat in dairy products.

These findings have important implications for dairy producers and marketers. First, a potential market for healthier and low carbon emission butter was identified which dairy producers should consider. Second, dairy producers could also benefit from marketing the new type of butter, to a relevant segment of consumers, branded with the "Carbon Trust" label and labelled with the claim 'Reduced saturated fat' given the positive synergies of these attributes with the new product. Third, dairy producers should target the launch of the new product to younger and more educated consumers since these might be the early adopters of the new type of butter before extending to other consumer segments. To increase consumer acceptance of the new type of butter, it is very important to inform consumers about the new feed technique, and its benefits since being a credence attribute it cannot be directly experienced by consumers.

Further research is needed to test the robustness of our findings using larger and random samples, other dairy products, and other ruminant-derived food products like meat, etc. Similar studies should also be conducted in other countries given the expected increase in demand for healthier, and environmentally friendly food products. Future studies should further investigate consumers' WTP by conducting non-hypothetical experiments using experimental auctions (Lusk & Shogren, 2007), multiple price list (MPL) (Asioli et al., 2021) or real choice experiments (RCE) (Alfnes & Rickertsen, 2011) combined with sensory tests (Asioli, et al., 2017) to provide more realistic information about consumer preference for the new type of butter. Furthermore, more research is needed to test the effect of different information treatments (i.e., healthier, and environmental benefits) on consumers' WTP for low carbon emission and low saturated fat butter.

This study has the limitation about the external validity of the results both due to the limited sample size, and the convenience nature of the sample. Thus, the external validity of the results, especially related to the latent class analysis, should be interpreted with caution.

In conclusion, our findings show that consumers' valuation for butter derived from cows fed with rapeseed feed depends on their age, and level of education with about one-third of consumers willing to pay a premium price for the new type of butter. Our results provide insights into consumers' acceptance and attitudes that can be useful for designing effective ways to communicate the potential benefits of alternative feeding strategies for cows to the public to maximize the chances of making these products commercially viable.

CRediT authorship contribution statement

D. Asioli: Conceptualization, Methodology, Software, Supervision, Writing – review & editing. **X. Zhou:** Formal analysis, Software, Validation, Writing – review & editing. **A. Halmemies-Beauchet-Filleau:** Conceptualization, Writing – review & editing. **A. Vanhatalo:** Conceptualization, Writing – review & editing. **D.I. Givens:** Project administration, Funding acquisition, Writing – review & editing. **A. Rondoni:** Writing – review & editing. **A.M. Turpeinen:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

Declaration of Competing Interest

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

Data availability

Data will be made available on request.

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Transparent reporting.

Pre-registration of the study is available in https://aspredicted.org/blind.php?x = mh8i88

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