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Factors affecting consumer choice of novel non-thermally processed fruit and vegetables products: Evidence from a 4-country study in Europe

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ABSTRACT

A wide variety of novel non-thermal processing technologies (NTPTs) are under development to meet the increasing consumer demand for high-quality fruit and vegetable (F&V) products. Understanding consumers' needs and possible barriers to acceptance of these technologies is however essential to assess the commercial feasibility of mildly processed F&Vs. Situated within this context, and extending previous work on the topic, in this paper we present results from a large-scale choice-based conjoint analysis consumer survey to investigate consumers' choice behavior towards NTPT-processed F&V products in four European countries – Denmark, Italy, Serbia, and Spain, using three model products – orange juice, iceberg salad, and cherry tomatoes respectively processed via three NTPT – mild processing, novel washing, and active packaging, compared to three conventional processing techniques – pasteurization, conventional washing, and conventional packaging, respectively. Images of the three product categories were developed to systematically vary in three key attributes: stated benefits (health and nutrition, natural taste, shelf-life), information on processing (conventional, NTPT), and price point (reference, premium price). The results showed that, out of the three attributes considered, "stated benefit" was the most important driver of consumer choice – in all countries and across product categories. Benefits relevant to health and nutrition, and to natural taste were more positively received, compared to extension of shelf-life. Information on processing and price levels had a similar influence on consumer choice of iceberg salad and cherry tomatoes, whilst for orange juice processing had a larger effect than price, suggesting that information on processing may be more impactful for F&V-derived products than for fresh produce. Individual differences among consumers according to country, age, gender, and dietary status, appeared small and transient. The most consequential individual characteristic was consumers' level of food technology neophobia (FTN), with results showing that high FTN consumers (17% of the sample) were less likely to choose F&V treated with NTPT, compared to consumers with medium or low FTN. Overall, this research suggests that products treated with NTPT may have a broad appeal across European consumers, and that targeted communication explicitly and efficiently focusing on health and taste benefits has the greatest chance to meet consumer preferences.

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Acronyms

CA	Conjoint analysis
CBC	Choice-based conjoint
FTN	Food Technology Neophobia
F&V	Fruit and Vegetables
HPP	High Pressure Processing
HMNL	Hierarchical Multinomial Logit Regression
NTPT	Non-thermal processing technologies
PEF	Pulsed Electric Field

1. Introduction

Fruit and vegetables (F&V) are key elements of a healthy and balanced diet providing humans with essential nutrients and bioactive compounds (Slavin & Lloyd, 2012). Increased consumer interest in health and sensory aspects of foods (*e.g.*, freshness, naturalness, and nutritional value) and sustainable diets has contributed to a growing demand for less processed F&Vs (Pollard, Kirk, & Cade, 2002), which is a major driver for the development of a wide variety of novel non-thermal processing technologies (NTPT) in recent years (Bruhn, 2007; Knorr, Ade-Omowaye, & Heinz, 2002; Morales-de la Peña, Welti-Chanes, & Martín-Belloso, 2019; Pollard et al., 2002; Rollin, Kennedy, & Wills, 2011). Such technologies use mild temperatures and limited amounts of physical and chemical processing aids. They can therefore be used to better preserve the original quality of F&V, such as maintaining the nutritional value, fresh appearance and flavor of F&V for longer time with no (or very limited) addition of preservatives (Honorio et al., 2019; Ragaert, Verbeke, Devlieghere, & Debevere, 2004).

NTPTs include a wide range of methods based on different physical and chemical principles; therefore, it is customary to divide them into a few major categories based on their effects and application in the post-harvest handling of F&V – sanitization, preservation, stabilization, extraction, etc. (Barba et al., 2018; Bevilacqua et al., 2018; Zhang, Wang, Zeng, Han, & Brennan, 2019; Khouryieh, 2021). Notable examples for sanitization of F&V include washing with electrolyzed water, plasma-activated water, in isolation or in combination with light technologies (Morales-de la Peña et al., 2019). Bioactive coating and active/intelligent packaging would be examples of NTPTs applied for quality preservation and shelf-life extension of some F&V. Pulsed electric field (PEF) and membrane filtration are used in bioactive compound extraction to develop active coatings/film. Finally, for stabilization of F&V-derived products like juices and smoothies, ultrasounds, and high-pressure processing (HPP) are increasingly used (Bevilacqua et al., 2018; Nielsen et al., 2009; Zhang et al., 2019). Each technology has specific microbial inactivation mechanisms (see Barba et al., 2018; Knorr et al., 2011; Morales-de la Peña et al., 2019, for comprehensive reviews of NTPTs, their basic principles, technological maturity, and range of applications), and even though research on NTPTs is still quite limited, the available literature supports the potential of these technologies to assure food safety while preserving better quality attributes, and in many cases being more energy-efficient processes (Santhirasegaram, Razali, & Somasundram, 2016). Moreover, the extension of shelf-life, associated with microbial inactivation and minimization of enzymatic and non-enzymatic changes by NTPT, could potentially be helpful in reducing food waste for both producers and households, thereby contributing to food sustainability (Amani & Gadde, 2015; Aschemann-Witzel, De Hooge, Amani, Bech-Larsen, & Oostindjer, 2015). Consequently, NTPTs have gained increasing interest from the food industry and are emerging as a potential replacement of thermal processes (Morales-de la Peña et al, 2019).

Nevertheless, while it is easy for food producers and scientists to focus on the "objective" advantages of NTPTs, consumers have been known to take a more conservative approach towards novel food technologies and are often hesitant to accept them (Nielsen et al., 2009; Siegrist & Hartmann, 2020; Song et al., 2020). This is often related to a loss of perceived naturalness (i.e., amount of human intervention, which is viewed as inherently negative with regard to food). Moreover, humans are, by nature, relatively suspicious of novel, unfamiliar foods, a phenomenon known as food neophobia (Pliner & Hobden, 1992). This is often related to lack of experience and/or knowledge, as consumers, on average, only have vague notions about how food processing works. Thus, they cannot readily evaluate benefits or risks of specific technologies, and instead rely on simple heuristics, such as familiar brands and/or institutional labels, to reduce the uncertainty (Connor & Siegrist, 2011; Earle & Cvetkovich, 1995; Siegrist & Hartmann, 2020; Song et al., 2020). Accordingly, previous studies also showed that "social trust", *e.g.* confidence in national food and health authorities and certification systems, plays a significant role in influencing consumer perceptions and attitudes towards new food processing methods (Siegrist & Hartmann, 2020).

Despite the fact that the application of food production technologies, especially in the European Union (EU), is a highly regulated issue, the literature documents several instances of consumer perception being influenced by information on the way the products have been processed, with some processing methods (such as irradiation) encountering significant levels of mistrust and dislikes among many consumers (Bredahl, 2001; Deliza, Rosenthal, Hedderley, & Jaeger, 2010; Frewer, Howard, Hedderley, & Shepherd, 1997; Frewer, Howard, & Shepherd, 1995; Grunert, Bredahl, & Scholderer, 2003). Consumer acceptance of novel food technologies appears to be a multidimensional phenomenon, and the literature indicates that the weight of specific attributes will depend on the specific information delivered to consumers. For instance, consumers' perception of benefits and downsides, price, and perceived "naturalness" have been found to affect acceptance of new food technologies like genetic modification and food nanotechnology (Grunert et al., 2003; Matin et al., 2012; Siegrist, 2008). By contrast, very little is known from the literature regarding consumer perception of NTPTs, except that even the more mature NTPTs (such as PEF and HPP) are at present very unfamiliar to consumers (Honorio et al., 2019; Nielsen et al., 2009; Song et al., 2020).

In order to realize the benefits of NTPTs, as well as to ensure the commercial feasibility of minimally processed F&V, it is important that consumers be informed and educated about the possible benefits of processing by these novel food technologies. Relatedly, it is important to remark that consumers do not ordinarily evaluate individual attributes but, rather, evaluate products as a whole; therefore, it is also crucial to understand the possible trade-offs between information on processing, price, benefits, and other claims.

Situated within this context, the present study aims to better understand consumers' perception of NTPTs processed F&V products among European consumers. This extends our previous qualitative research on the same topic which focused on consumers' perception of non-thermally processed F&V products across six EU countries (Song et al., 2020). The main findings of that study were that healthier and more nutritious, extended shelf-life, and better hygiene and safety, were important benefits European consumers expected NTPTs to be associated with, whilst impacts on product quality, and the possibility of resulting in a higher price, were the most salient concerns. Participants from Spain, Denmark, and the Netherlands appeared more interested in consuming NTP F&V, compared to Italy, Serbia, and Germany. The study also confirmed that consumers have difficulties in assessing relevant benefits and risks related to F&V processed by NTPTs due to lack of knowledge, and therefore expected that packaging could explicitly relay this information in an efficient way. The main limitation of this previous research was that it was solely based on qualitative data (focus group interviews), which limits the generalizability of the findings and also makes it not suited to assess the relative importance of different attributes for consumer perception of NTPTs. Additionally, its exploratory

nature left open the issues of individual and socio-demographic differences with respect to acceptance of NTPTs, which can be expected to exist across different countries.

To address these shortcomings, the present paper presents evidence from a large-scale quantitative survey conducted in four European countries (Denmark, Italy, Spain, and Serbia) designed to validate and extend the findings of Song et al., 2020. In the survey, choice-based conjoint (CBC) tasks were designed to explore consumers' preferences for the combinations of attributes that make up the F&V products. Conjoint analysis (CA) is a technique used to investigate how consumers value and trade-off different product attributes (see Almli & Næs, 2018 for a review) through the development of *ad hoc* product concepts by means of statistically optimized experimental designs (Deliza, MacFie, & Hedderley, 2003). CA has been extensively applied to study how consumers' food preferences and choices are influenced by different product attributes, including information on growing conditions and post-harvest processing of F&V and other food products categories (Britton & Tonsor, 2019; Cardello, Schutz, & Lesher, 2007; Deliza et al., 2010; Hoke, Campbell, Brand, & Hau, 2017; Shan et al., 2017; van der Pol & Ryan, 1996).

The primary aim of the study was to investigate how the three key attributes identified in the preceding qualitative study (Song et al., 2020), i.e. stated benefits, processing, and price, affect consumer choice towards NTPTs processed F&V. Additionally, the study aimed to uncover potential cross-cultural and individual differences among European consumers that might affect their choices of NTPT-processed F&V. Heterogeneity in consumer responses may be expected between countries, given the differences in dietary habits and food cultures among European countries, as well as within countries with the literature suggesting that, for example, sociodemographic factors such as age and education level affect (negatively the former, positively the latter) consumer acceptance of novel food technologies (Deliza et al., 2010; Siegrist, Gutscher, & Earle, 2005; Sillani & Nassivera, 2015; Song et al., 2020). The importance of sociodemographic factors in and of themselves is, however, debated and generally considered to be a matter of correlation rather than causation (Siegrist & Árvai, 2020). Therefore, other individual characteristics are increasingly emerging as relevant to explaining variation in food technologies acceptance. Amongst them is food technology neophobia (FTN), a personality trait pertaining to avoidance of technological innovations related to food (Cox & Evans, 2008). FTN has been found to only weakly correlate with general food neophobia, i.e., the tendency to reject unfamiliar food (Evans, Kermarrec, Sable, & Cox, 2010), making it more appropriate in the present context. Additionally, FTN has been recently suggested to be related to food knowledge, and specifically that consumers with more food knowledge seem to have lower FTN (Cavaliere & Ventura, 2018). In this paper, both FTN and consumer knowledge of processing were used as independent variables for groupwise comparisons, in addition to sociodemographic characteristics and country of origin, to evaluate which individual characteristics mostly affect consumer acceptance of NTPT-processed F&V products.

2. Materials and methods

2.1. Survey design

The survey was structured in three main parts and created via Surveygizmo (Alchemer, Boulder, USA). The first part was a choice-based conjoint analysis task (DeSarbo, Ramaswamy, & Cohen, 1995). Prior to beginning this part, participants were required to read a short introduction which relayed the meaning of NTPT in general and the specific NTPTs involved in the task, in order to provide a frame of reference for the subsequent task. Specifically, the instructions explained consumers that they would be evaluating both fresh produce and processed fruit products processed with novel "mild" technologies to preserve and ensure safety as achieved by (depending on the product) either the use of processes alternative to high temperature, novel washing technologies, or active packaging. Care was taken to word the introduction in a consumer-friendly language and as neutrally as possible (i.e., without unduly stressing benefit or problems) to avoid influencing their later responses. The exact instructions provided to the participants were as follows:

> *In the first part of the survey, you will be showed different sets of images for three product categories – orange juice, iceberg salad and cherry tomatoes – varying in different characteristics.*
> *Some products are minimally processed with novel "mild" technologies, meaning that they have been processed with technologies alternative to high temperature to preserve the natural nutritional value of the product and ensure safety. Some products are washed by novel washing technology or packed in active packaging to the same purpose.*
> *For each set of images, you will be asked to indicate the one you would be most likely to purchase. This is repeated four times for each product category, so please pay attention to the task, even if it may seem repetitive.*
> *The remainder of the survey contains some questions about your opinions and habits regarding fruit and vegetables.*
> *We suggest you do not spend too much time on each question. Remember there are no "right" or "wrong" answers. It should take no more than 10 to 15 minutes to complete the survey.*

After the introduction session, participants were presented with multiple concepts for three base F&V products – orange juice, iceberg salad and cherry tomatoes – systematically varying in three attributes – stated benefits (3 levels related to health and nutrition, natural taste, or shelf-life), processing information (2 levels: conventional or NTPT), and price point (2 levels: a reference price or a premium price). The reason for focusing on three different product categories was to cover different NTPTs (high pressure processing, novel washing and active packaging) and thereby have a more robust assessment for the effect of NTPT on consumer choice of F&V products. The three specific product categories were chosen upon discussion between the authors as they were expected to be familiar and widely used by consumers in all participating countries. Table 1 provides a detailed breakdown of the design, including the specific levels for each attribute. A full factorial design was applied leading to 12 individual concepts for each base product. For the NTPT levels, it was chosen to convey the level in non-technical terms as it is unrealistic that the specific processing method would be prominently featured in front-of-pack communication. Therefore, the three NTPT levels corresponding to 1) HPP for orange juice, 2) washing with plasma-

Table 1
Experimental design used to create product options for the conjoint task of the survey (NTPT = Non-thermal processing technologies; Country abbreviations: DK = Denmark; ES = Spain; IT = Italy; SE = Serbia).

Feature	Levels		
	ORANGE JUICE	**ICEBERG SALAD**	**CHERRY TOMATOES**
Processing			
NTPT	"Mild Processing"	"Novel washing"	"Active Packaging"
Conventional	"Pasteurization"	"Conventional washing"	"Conventional packaging"
Benefit			
Health	"Healthier & more nutritious"	"Healthier & more nutritious"	"Healthier & more nutritious"
Taste	"Flavourful & natural taste"	"Flavourful & natural taste"	"Flavourful & natural taste"
Shelf-life	"Longer shelf-life"	"Longer shelf-life"	"Longer shelf-life"
Price			
Reference	DK = 16 DKK, IT = 1.0 EUR, ES = 1.46 EUR, SE = 2.1 EUR	DK = 12 DKK, IT = 1.9 EUR, ES = 1.5 EUR, SE = 1.6 EUR	DK = 18 DKK, IT = 1.99 EUR, ES = 1.99 EUR, SE = 2.4 EUR
Premium	DK = 20 DKK, IT = 1.3 EUR, ES = 1.89 EUR, SE = 2.7 EUR	DK = 16 DKK, IT = 2.5 EUR, ES = 1.95 EUR, SE = 2.1 EUR	DK = 23 DKK, IT = 2.6 EUR, ES = 2.59 EUR, SE = 3.1 EUR

activated water or light technologies for iceberg salad, and 3) active/intelligent packaging for tomatoes, were rendered, respectively, as "mild processing", "novel washing" and "active packaging", after discussion within the authors and from inspiration by existing products in the market. Likewise, reference price levels were decided upon investigation of actual market prices for these F&V products in the participating countries; the premium prices were developed by adding 30% to each reference price. This relative increase was deemed large enough for it to be appreciable by consumers, and was chosen after consultation with the agricultural economics literature where studies for fruit and vegetables indicate that very few consumers are willing to pay premiums beyond the 30% mark (*e.g.*, Krystallis & Chryssohoidis, 2005; Krystallis, Fotopoulos, & Zotos, 2006).

Finally, statements concerning stated benefits were developed on the basis of the three benefits most frequently mentioned associated with NTPTs based on the results of Song et al., 2020 – i.e., their potential to bring about healthier products, with better taste, and with longer shelf-life.

All participants evaluated a total of 12*3 = 36 product concepts in 12 CBC tasks (4 tasks per base product), using a fully randomized design. Compared to other CA formats (*e.g.*, rating based), CBC was chosen as it is regarded as more realistic and 'lifelike', since it requires research participants to make a series of trade-offs by indicating their specific preference within a controlled set of potential products, with the analysis of these trade-offs revealing the implicit valuation of individual attribute levels making up the product (DeSarbo et al., 1995). Fig. 1 shows an example of the conjoint survey. In each task, participants had to evaluate triads of products and indicate which of the options they were more likely to purchase. A "none" option was available to participants if they would not purchase any of the products presented. The presentation order for the base products was as follows: orange juice, iceberg salad, and cherry tomatoes. Within each base product, the presentation order for 12 concepts presented within the four tasks was fully randomized.

After concluding the CBC tasks, the second part of the survey included a series of questions to measure consumers' knowledge of food processing methods, which were later used for groupwise comparisons, as well as storage and consumption of fruit and vegetables (data not shown in this paper). Table 2 provides the statements related to food processing knowledge index. Statements were developed by the authors to specifically relate to the food processing technologies relevant to the project. Participants had to indicate whether the statements were true or false to them (a "don't know" response option was provided as well).

The third and final part contained a few questions on the participants' background (sex, age, educational background, income, dietary status) and the FTN scale (Cox & Evans, 2008).

The survey template was first developed in English and then translated by native speakers in the national languages of the four participating countries (Danish, Italian, Serbian, and Spanish) before conducting the study. The translated versions of each survey can be obtained from the corresponding authors upon reasonable request.

2.2. Participants

All data were collected in the period between June 24th and August 7th, 2020. Participants were recruited via social media channels and internal consumer databases available to the project partners. The inclusion criteria were: (a) be responsible for grocery shopping; (b) not be affiliated with the SHEALTHY project; (c) not working professionally with food and nutrition; (d) be of legal age and able to provide consent.

Participants' informed consent to participate in the study was collected at the beginning of the survey, where consumers were likewise informed that their participation was anonymous, voluntary, and that they could stop or withdraw from the study at any time. The study received approval from the Research Ethics Committee of the University of Southern Denmark (case nr. 20/39562).

In total, 854 participants aged between 19 and 88 in four European countries completed (in full) the survey online (581 additional participants were excluded due to providing incomplete responses, resulting in a completion rate of 59%). Table 3 shows a detailed breakdown of the participants' demographic information on the aggregate and country-by-country basis.

2.3. Data analysis

The CBC data were rendered in a long format with each row representing an alternative in the choice set. The design variables were rendered as binary data ("1″ and "0" denoting presence or absence of that attribute, respectively) as well as the choice response ("1" if the product was chosen out of the choice set and "0" otherwise). Estimations of the relative importance of attributes of all CBC levels (see Table 1) were performed using a hierarchical Bayes multinomial logit model (HMNL) using the ChoiceModelR package (Sermas & Colias, 2012) in R (v. 3.4, R Core Team (2018), 2018).

ChoiceModelR uses a Markov Chain Monte Carlo (MCMC) algorithm to estimate a hierarchical multinomial logit model with a normal heterogeneity distribution. Canonically, the model takes the following form: denoting with *Xtj* the vector of attributes of alternative *j* in the choice task *t*, the probability of choosing alternative *j* during choice task *t* is given by:

$$P(y_t = j) = \frac{\exp(\beta_i X_{tj})}{\sum_{allj'} \exp(\beta_i X_{tj'})}$$

where β_i is the coefficient for each individual consumer, *i*. These coefficients represent "part-worth" utility values, which indicate how much difference each attribute and each level could make in the total utility of a product for the given participant.

In our analysis, 4000 posterior draws were generated by the MCMC of which 2000 were used to estimate the model parameters, using a hybrid Gibbs Sampler with a random walk metropolis step for the HMNL coefficients for each participant. At the aggregate level, the relative importance of each attribute was computed as the average of the participant-level part-worth utilities (i.e., the HMNL regression coefficients) (Chapman & Feit, 2015).

One-way ANOVA in SPSS Statistics 24 (IBM, USA) was used to 1) compare part-worth utilities showing the contribution of the levels to consumer choice both overall and by country; and 2) compare part-worth utilities for different consumer groups defined by age, gender, dietary status, income, education, FTN level, and processing knowledge level. The FTN score (ranging from 13 to 91) was used to group consumers according to a triadic split: Low = 13–39, Medium = 40–65, High = 66–91. For the knowledge index, 1 point was assigned for each correct response to the three questions (Table 2), thus this score ranged from 0 to 3. Consumers who gave 0 or 1 correct responses were classified as having a "Low" level of food processing knowledge and consumers who answered $\geq$ 2 answers correctly were classified as having a "high" knowledge level.

3. Results

3.1. Relative importance and utility values

Fig. 2 shows the relative importance of price, processing, and benefit for consumer choice of the three product categories – orange juice, iceberg salad, and cherry tomatoes estimated, both at the aggregate and on a country-by-country basis, estimated by HMNL regression.

Overall, stated benefit was found to be the most important attribute for all three base products (Table 4). At the aggregate level, variation in stated benefit explained over 50% of consumer choice in all three product categories, far outweighing the other two attributes (Fig. 2). Processing and price levels had a similar influence (≈25%) on consumer

1. You will find below 3 **orange juice** products (500ml) with different features.

Please check the descriptions below each image carefully and choose the one you would be most likely to purchase.
You may choose the "none" option if you wouldn't purchase any of these. *



			None: I wouldn't choose any of these
16 kr.	16 kr.	20 kr.	
Mild processing	Pasteurization	Mild processing	
Longer shelf life	Flavorful & natural taste	Healthier & more nutritious	
○	○	○	○

2. You will find below 3 pre-washed iceberg lettuce products (200g) with different features.

Please check the descriptions below each image carefully and choose the one you would be most likely to purchase.
You may choose the "none" option if you wouldn't choose any of these. *

			None: I wouldn't choose any of these
12 kr.	16 kr.	12 kr.	
Novel washing	Conventional washing	Conventional washing	
Longer shelf life	Healthier & more nutritious	Flavorful & natural taste	
○	○	○	○

3. You will find below 3 **cherry tomato** products (400g) with different features.

Please check the descriptions below each image carefully and choose the one you would be most likely to purchase.
You may choose the "none" option if you wouldn't choose any of these. *



			None: I wouldn't choose any of these
23 kr.	18 kr.	18 kr.	
Conventional packaging	Active packaging	Active packaging	
Longer shelf life	Healthier & more nutritious	Flavorful & natural taste	
○	○	○	○

Fig. 1. Screenshots from the choice-based conjoint survey (English template, translations and labels on the product images in the local language of the participating countries were used for the actual data collection) for each of the three product categories.

Table 2
Items related to food processing knowledge index. Exemplary references for correct responses: first item (Picart-Palmade et al., 2019), second item (Silva & Gibbs, 2004), third item (Norton & Sun, 2008).

Food processing knowledge index	Correct response
Mild processing uses mild temperatures and limited processing aids to achieve food product sanitization, stabilization, and/or preservation.	True
When use pasteurization to kill bacteria in fruit and vegetable products, they need to be heated to at least 70 degrees.	False
High pressure processing (HPP) is one of the mild technologies. It eliminates food pathogens at room temperature without any chemical aids. The process extends the shelf-life and maintains the sensory properties (*e.g.* flavor) and nutritional value of the foods.	True

Table 3
Background of the participants in the four participating countries.

COUNTRY	DENMARK	ITALY	SERBIA	SPAIN	AGGREGATE
Number of respondents	293	252	124	179	848
Age (range)	19–88	20–85	19–82	20–71	19–88
Age (mean ± st. dev.)	48.1 ± 18.2	48.9 ± 15.8	38.4 ± 12.1	40.6 ± 10.3	44.1 ± 14.6
Male	45%	44%	26%	32%	39%
Female	55%	56%	74%	68%	61%
Education (highest level)					
High school or less	40%	51%	6%	15%	33%
Undergraduate degree	43%	29%	63%	30%	39%
Postgraduate degree	17%	20%	31%	55%	28%
Income					
<13,000 €	13%	22%	54%	12%	21%
13,001–40,000 €	39%	61%	30%	61%	49%
40,001–67,000 €	34%	14%	11%	21%	22%
>67,000 €	14%	3%	5%	6%	8%
Dietary status					
Omnivore	92%	83%	82%	91%	88%
Vegetarian or Vegan	3%	14%	7%	5%	7%
Other	5%	4%	10%	4%	5%
Food Technology Neophobia					
Low	2%	19%	27%	32%	17%
Medium	82%	61%	67%	57%	68%
High	16%	19%	6%	11%	15%
Food processing knowledge					
Low	65%	57%	64%	61%	62%
High	35%	43%	36%	39%	38%

choice of iceberg salad and cherry tomatoes but, importantly, not for orange juice, where the effect of processing (33%) was larger than that of price (33% vs 14%).

Danish consumers appeared more price-oriented than consumers in the other three countries, whereas Italian, Serbian, and Spanish consumers were comparatively more affected by information on processing for orange juice, and by benefit information for iceberg and tomato. Again, the main difference related to orange juice, where price and information had a similar influence on the choices of Danish consumers, whereas consumers in the other three countries clearly gave more importance to processing than to price for this product category (Fig. 2). However, the main finding from the aggregate analysis, i.e., that stated benefit was the most important attribute for consumer choice of all three base products, was robustly confirmed across all countries (Fig. 2).

Table 4 shows the part-worth utility values quantifying the contribution of each level to consumer choice, again, both at an aggregate and on a country-by-country basis. Overall, non-thermal processing was associated with an increase in likelihood of choice for all three product categories, with the largest effect being for orange juice (difference in part-worth utility values 1.9, vs 0.8 and 0.6 for iceberg and tomatoes, respectively). Moreover, NTPT was significantly preferred to conventional processing in all countries with two exceptions – in Serbia, for tomatoes, and in Spain, for iceberg salad – where no significant differences between the two processing levels were found.

Regarding the effect of stated benefits, "healthier and more nutritious" and "flavourful and natural taste" were more positively received than the third benefit ("longer shelf-life"). Table 4 shows that in general, consumers were 2 to 3 times more likely to choose products when these benefit claims were present compared to the "longer shelf-life" one. The health benefit ("Healthier and more nutritious") was consistently the most impactful of the two as it significantly increased consumers' interest in all countries and for all products; by contrast, whereas effect sizes for "flavourful and natural taste" were smaller, albeit still significantly larger than the shelf-life claims (Table 4).

As expected, consumers preferred the reference price (i.e., the less expensive one) for all three products. At the aggregate level, the effect size was similar for all three products (differences in part-worth utility values between reference and premium price was 0.9, 1.5 and 1.2). However, this effect appear smaller for orange juice in all countries but Denmark, and in fact in two countries (Italy and Serbia) the presence of a higher price did not affect consumer choice, consistent with the previously observed result that price was less important for orange juice than for the other two base products (Fig. 2).

The results appeared, again, very stable across countries, at least when considering the direction of the effects. Some minor differences in effect sizes were observed. In Denmark, Serbia, and Spain, NTPT processing had significant positive impact on consumer choices for orange juice than it did for iceberg and tomato, whereas in Italy the effect size was similar for all three products. Regarding the stated benefits, the health and nutritional claim had a stronger effect on Serbian consumer than in the other three countries. Serbian and Spanish consumers appeared less price-sensitive than in other countries: although the trend towards a preference for the cheaper products was observed, for two out of three products was the effect of price was not significant in those country (Table 4).

Finally, Table 4 also reports the percentages of consumers who did not make a choice, i.e., who selected the "none" response option in the conjoint task. Overall, 18% percent of all choice tasks resulted in a no choice outcome, ranging from 22% for Orange juice to 14% for cherry tomatoes (Table 4), thus indicating some minor differences depending on the base products. Differences between countries were also uncovered as countries varied with respect to the % of no choice responses with Serbia having the least on average (13%), followed by Spain (17%), Denmark (19%), and finally Italy (24%).

3.2. Individual differences

The second aim of the study was to assess individual differences between European consumers that might affect their behavior with respect to F&V processed with NTPT. Country-wise differences between EU countries were presented in the preceding section and, as we have seen, were generally limited.

Table 5 shows the results of the CBC task after grouping consumers in terms of relevant demographic (age, gender, education and income), psychographic (FTN level), and behavioral variables (dietary status and food processing knowledge).

In general, differences in choice behavior across consumer segments appeared small (Table 5). Although several of the differences are statistically significant, the difference is always a matter of degree whereas

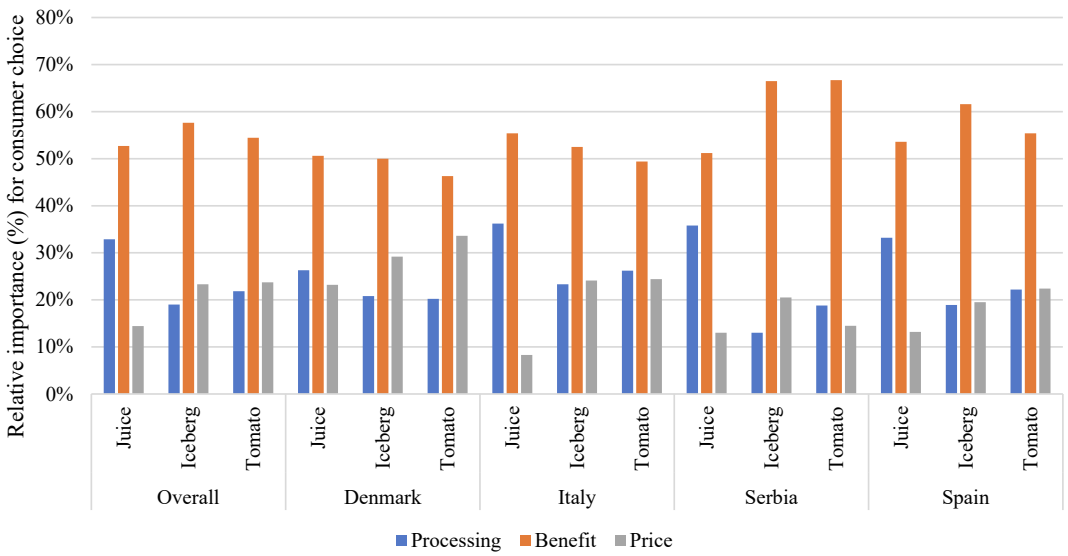

Fig. 2. Relative importance of price, processing, and benefit for consumer intention to purchase juice, iceberg salad, and cherry tomato products – overall and on a country-by-country basis.

Table 4
Percentages and mean part-worth utilities (coefficients from hierarchical Bayes multinomial logit regression) showing the contribution of the levels to consumer choice both aggregated and by country. The last column reports percentages of consumers who selected none of the options in the choice set. Note that percentages may not add to 100 due to rounding. NTPT = non-thermal processing technologies.

		Processing			Benefit				Price			No choice responses
		NTPT	Conventional	*p*	Health	Taste	Shelf-life	*p*	Reference	Premium	*p*	
Overall (*N* = 848)	Juice	49% (2.9)	30% (1.0)	***	36% (2.2)	29% (1.5)	12% (−0.9)	***	45% (2.1)	34% (1.2)	***	22%
	Iceberg	46% (2.3)	35% (1.5)	***	37% (1.8)	26% (1.3)	19% (−0.6)	***	49% (2.5)	32% (1.0)	***	18%
	Tomato	45% (1.9)	36% (1.3)	***	38% (2.1)	30% (1.2)	16% (−0.2)	***	52% (3.3)	29% (2.0)	***	14%
Denmark (*N* = 293)	Juice	48% (2.9)	31% (1.4)	***	37% (2.9)	32% (1.5)	10% (−0.6)	***	50% (3.3)	30% (1.8)	***	21%
	Iceberg	45% (0.2)	34% (−0.3)	***	37% (0.4)	25% (0.4)	17% (−0.8)	***	53% (1.3)	25% (−0.3)	***	21%
	Tomato	48% (0.9)	38% (0.4)	***	35% (1.0)	34% (0.4)	16% (−0.2)	***	60% (−0.4)	26% (−1.8)	***	14%
Italy (*N* = 252)	Juice	45% (2.1)	28% (0.2)	***	36% (1.4)	25% (0.7)	11% (−1.9)	***	38% (0.7)	34% (0.4)	n. s.	27%
	Iceberg	45% (3.1)	27% (1.5)	***	34% (1.8)	22% (0.9)	17% (−1.0)	***	44% (2.1)	28% (0.3)	***	27%
	Tomato	51% (1.2)	32% (−0.2)	***	39% (2.3)	27% (1.1)	18% (−0.7)	***	53% (1.9)	30% (0.4)	***	17%
Serbia (*N* = 124)	Juice	55% (2.2)	29% (0.1)	***	43% (1.9)	25% (0.7)	15% (−1.1)	***	45% (2.6)	38% (2.2)	n. s.	16%
	Iceberg	47% (2.7)	41% (2.2)	*	45% (2.8)	29% (1.6)	13% (−0.7)	***	47% (1.9)	40% (1.3)	***	12%
	Tomato	47% (2.4)	41% (2.4)	n. s.	44% (2.9)	30% (1.7)	14% (−0.5)	***	51% (6.6)	37% (5.6)	n. s.	12%
Spain (*N* = 179)	Juice	50% (4.4)	26% (2.1)	***	33% (2.7)	32% (3.1)	11% (−0.1)	***	43% (1.6)	33% (0.4)	*	24%
	Iceberg	49% (3.0)	38% (2.5)	n. s.	37% (2.3)	28% (2.2)	22% (0.0)	***	53% (4.5)	34% (2.5)	n. s.	13%
	Tomato	48% (3.2)	39% (2.6)	*	37% (2.0)	33% (1.7)	17% (0.6)	***	55% (5.1)	32% (3.8)	n. s.	13%

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

the direction of the effect (i.e., the preferred level of the conjoint design) is always the same across all group comparisons and consistent with the findings presented in the previous section.

The largest difference was found with regard to consumers' FTN levels. In line with expectations, consumers with high FTN (17% of the sample, cf. Table 3) were less likely to choose F&V treated with NTPT compared to consumers with low and medium FTN (Table 5). Regarding demographics, the main difference pertained to age groups, where younger consumers (19–34) were slightly more positive towards NTPT processed F&V than older consumers (51 +). Importantly, age and FTN score were found to be positively correlated ($r_{(846)} = 0.52$, $p < 0.0001$). No significant differences between gender groups were found, although it may be interesting to report that women were found to have a slightly lower FTN scores than men (FTN $_{(F)} = 51.4$, FTN $_{(M)} = 54.1$, $t_{(749)} = -2.95$, $p = 0.003$). Differences between income groups were also very limited and for the most part not statistically significant.

Table 5
Breakdown of consumer choices (%) by age, gender, dietary status and level of Food Technology Neophobia. The last column reports percentages of consumers who selected none of the options in the choice set. Note that percentages may not add to 100 due to rounding. FTN = Food Technology Neophobia, NTPT = non-thermal processing technologies.

		N	Processing		Benefit			Price		No choice responses
			NTPT	Conventional	Health	Taste	Shelf-life	Ref	Premium	
Age	19–34	273	54% (2.7)	34% (1.3)	40% (2.1)	31% (1.4)	17% (−0.4)	54% (2.8)	34% (1.5)	12%
	35–50	273	47% (2.4)	32% (1.2)	38% (2.1)	27% (1.4)	14% (−0.6)	48% (2.5)	31% (1.3)	21%
	51+	302	43% (1.6)	33% (0.6)	33% (1.5)	28% (1.0)	15% (−0.8)	48% (1.6)	28% (0.3)	24%
		p[1]	***	***	***	***	*	***	***	
Gender	Female	514	49% (2.2)	33% (1.0)	38% (1.9)	28% (1.3)	15% (−0.7)	50% (2.3)	32% (1.0)	18%
	Male	334	46% (2.2)	34% (1.0)	35% (1.8)	29% (1.3)	16% (−0.5)	50% (2.2)	30% (0.9)	20%
		p	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	
Dietary[2] status	Omnivores	769	48% (2.3)	34% (1.1)	37% (1.9)	29% (1.3)	16% (−0.5)	51% (2.4)	31% (1.1)	18%
	Vegetarian or Vegan	49	44% (1.9)	28% (0.6)	43% (2.0)	20% (0.8)	9% (−1.3)	42% (1.7)	30% (0.6)	28%
		p	n.s.	*	n.s.	***	***	n.s.	n.s.	
Income	< 13,000 €	179	49% (2.3)	33% (1.1)	37% (2.1)	29% (1.2)	16% (−0.9)	50% (2.6)	32% (1.4)	18%
	13,001–40,000 €	415	48% (2.3)	33% (1.1)	37% (1.8)	29% (1.4)	15% (−0.6)	49% (2.3)	31% (1.0)	20%
	40,001–67,000 €	186	45% (2.0)	34% (1.0)	36% (1.7)	28% (1.3)	15% (−0.5)	50% (2.1)	29% (0.8)	21%
	> 67,000 €	68	51% (2.0)	33% (0.8)	40% (1.8)	27% (1.0)	17% (−0.5)	53% (2.1)	31% (0.7)	16%
		p	n.s.	n.s.	*	n.s.	n.s.	n.s.	*	
Education	High school or less	281	45% (1.8)	36% (0.7)	39% (1.7)	27% (1.1)	14% (−0.1)	51% (1.7)	30% (0.4)	19%
	Undergraduate	331	48% (2.2)	33% (1.0)	37% (1.9)	28% (1.2)	16% (−0.6)	50% (2.4)	31% (1.1)	19%
	Postgraduate	237	50% (2.7)	30% (1.5)	35% (2.1)	30% (1.5)	16% (−0.4)	49% (2.9)	32% (1.5)	19%
		p	***	***	*	***	*	***	***	
FTN level	Low	136	56% (3.5)	32% (1.7)	42% (2.4)	27% (1.6)	19% (−0.1)	52% (3.6)	35% (2.3)	13%
	Medium	579	49% (2.2)	34% (1.1)	37% (1.9)	30% (1.3)	16% (−0.6)	51% (2.3)	32% (1.0)	17%
	High	133	33% (1.1)	30% (0.3)	32% (1.4)	23% (0.8)	9% (−1.3)	41% (1.1)	23% (−0.3)	36%
		p	***	***	***	***	***	***	***	
Food pr. knowledge	Low	526	49% (2.0)	31% (0.9)	36% (1.8)	28% (1.2)	14% (−0.8)	46% (2.1)	33% (0.8)	21%
	High	322	53% (2.6)	32% (1.3)	39% (2.1)	28% (1.4)	17% (−0.3)	51% (2.7)	33% (1.3)	16%
		p	***	*	***	*	***	***	***	

[1] *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$, n.s. $p > 0.05$.

[2] There were 30 consumers who could not be classified into the two dietary groups. These included participants who had restricted diet (*e.g.* pescetarians) or medical reasons (*e.g.*, celiacs), and/or participants who checked the "Other" options but did not provide an explanation.

These results regarding age and FTN level are also underscored by looking at differences in "no choice" responses, which were minor in all cases but for these two characteristics: specifically, young consumers (19–34) expressed that they would not choose any of the products at about half the rate compared to consumers in the older age groups, and high FTN consumers had more than double the "no choice" responses than low and medium FTN consumers (Table 5).

By contrast, the effect of education level was small but significant for all three experimental factors. The most notable difference was that higher educated consumers had a stronger preference for NTPT over conventional processing. Importantly, FTN was significantly associated with education level ($F_{(2,845)} = 26.5$, $p < 0.001$) with more highly educated consumers showing lower FTN scores on average (Mean FTN scores: High School or less = 55.9, Undergraduate = 52.9, Postgraduate = 47.7, all pairwise comparisons were significant at $p \leq 0.01$). The same trend was observed when comparing groups based on their performance on the food processing knowledge questions, with more knowledgeable consumers showing a slightly stronger preferences for NTPT over conventional processing.

Furthermore, a few differences in choice behavior were observed between groups defined in terms of dietary status. Specifically, omnivores gave more importance to the taste claim compared to vegetarians and vegans. By contrast, vegetarians and vegans had a stronger preference for the health and nutrition claim over the other two benefit claims, although part worth utilities for this level were similar for both groups.

4. Discussion

4.1. Factors affecting consumer choice of NTPT-processed fruit and vegetables products

The main finding of the study was that stated benefits emerged as the most important attribute out of the three, exerting a much larger influence on consumer choice than both price level and information on processing. Importantly, this finding could be replicated in all four EU countries involved in the study, and for all three base products considered (orange juice, iceberg salad and cherry tomatoes). Statements pertaining to health and nutrition were most impactful in increasing the likelihood of consumer choice, followed by taste related benefits, whereas extension of the product shelf-life was less important to consumers.

Taken collectively, these findings indicate that consumer choice of F&V is mostly related to self-relevant aspects, i.e. having a healthy and nutritious diet. This is well in line with evidence regarding food choice drivers reported in the literature on technology acceptance, and the increasing pre-eminence of health and well-being in consumers' minds (*e.g.*, Cardello et al., 2007; Honorio et al., 2019; Lusk, Roosen, & Bieberstein, 2014; Siegrist, 2008; Song, Pérez-Cueto, Laugesen, van der Zanden, & Giacalone, 2019; Westhoek et al., 2014). Moreover, our findings mirror those of a recent Eurobarometer study, involving over 30.000 consumers, showing that health aspects still prevail over other considerations in driving consumer food choice of European consumers (Grunert, 2020). The sizeable margin by which health benefits dominated over other attributes is likely also due to the specific products considered in this study: F&Vs are widely regarded as healthy, and their consumption regularly promoted in public health campaigns, which could be expected to increase the salience of health relative to other aspects, such as taste. For example, the literature on functional foods generally suggests that their acceptance is closely related to consumer belief in their overall health benefit (Siegrist, Shi, Giusto, & Hartmann, 2015; Urala & Lähteenmäki, 2007; Verbeke, 2005), whereas for more hedonic food products taste, pleasure, and convenience aspects are usually found to be the main choice drivers (*e.g.*, Lusk & Briggeman, 2009).

The claim of a more flavorful product with a more natural taste was the second-best choice driver, indicating that, in addition to health,

consumers' desires for natural products with high sensory quality is also very important for F&V. Insights from large studies, such as the Kampffmeyer Food Innovation Study (2012) (2012), involving over 4,000 consumers in eight EU countries, repeatedly showed food naturalness as a decisive buying incentive for European consumers, with the vast majority of respondents perceiving a close connection between "natural" and "healthy" (Roman, Sánchez-Siles, & Siegrist, 2017), which explains the effects of health and naturalness benefits on consumer choice revealed in our study. This connection also emerged with regards to consumers' perception of NTPT (Song et al., 2020), and is promising with respect to introducing products treated with these technologies since their main potential is that of delivering better nutritional and sensory profiles of F&V, compared to their thermal counterpart.

Information on processing and price levels were less important than stated benefits, and their influence on consumer choice was similar for iceberg salad and cherry tomatoes, whereas for orange juice processing had a larger effect on choice than price. This finding suggests that the relative importance of processing technology varies across different F&V products, and specifically that information on processing may be more impactful for F&V-derived products than for fresh produce. This makes intuitively good sense and, accordingly, our earlier results (Song et al., 2020) indicate that consumers mostly think about growing conditions of fresh fruit and vegetables (*e.g.*, whether they are organic or locally produced). By contrast, they know very little about the post-harvest handling of F&Vs, meaning that steps like washing, cutting, peeling coating, packaging in a modified atmosphere, etc. may not be seen as "processing" by consumers, at least compared to a product like juice where there is a more obvious human intervention (Giannakourou & Tsironi, 2021; Li et al., 2020). Moreover, consumers are likely more used to evaluate front-of-pack information reported on *packaged* products, which may or may not be the case for fresh F&V. In our previous study, many consumers reported a preference for buying loose F&Vs (due to concerns about sustainability or because packaging sizes were not optimal), and, even when they do buy packaged F&Vs most do not ordinarily check information reported in the package (Song et al., 2020). Therefore, different communication strategies for F&V derived products compared to fresh produce are recommended. For fresh produces, such as iceberg salad and tomatoes, messages focus on products' healthiness and naturalness may have more positive effects on consumer choice. Moreover, products' fresh appearance improved by NTPT could be used by consumers as an importance clue of products' healthiness, naturalness, and nutritional value (Gunden & Thomas, 2012). For F&V-derived products, such as juice and smoothies, consumers could possibly pay more attention to the information on processing and associate it with potential effects on products' healthiness, naturalness (Honorio et al., 2019), and shelf-life, which could be even further associated with food waste reduction and sustainability ((Aschemann-Witzel, De Hooge, Amani, Bech-Larsen, & Oostindjer, 2015; Aschemann-Witzel, Giménez, & Ares, 2019).

With respect to the impact of information on processing on consumer choice, the present findings appear very positive for commercialization of F&V products treated with novel NTPTs: for all products (orange juice) treatment by NTPT (indicated as "mild processing", "novel washing", and "active packaging" in the CBC task) increased the likelihood of choice compared to its thermal counterparts. The effects were stronger for orange juice than for iceberg salad and cherry tomatoes but at least at the aggregate level the same finding was observed for all product categories. At the individual country level some effects for iceberg and cherry tomatoes were not significant, but in general there was no indication that treatment with NTPT in F&V products, when communicated in consumer-friendly terms, should pose a barrier to consumer acceptance; on the contrary, our findings indicate they should even increase consumer willingness to buy F&V. It should be emphasized that the information on processing in the CBC task study used generic process names that could be used to represent a class of NTPTs methods (*e.g.*, "novel washing") instead of very specific definitions (*e.g.*, "washing with plasma-activated water"), which was deemed more realistic with respect to front of pack communication. Obviously, alternative labels for the same processes could evoke different responses in consumers. For example, in a study with US consumers, Cardello and collaborators reported that consumers' responses to the concept of "cold preservation" (a generic term used to refer to nonthermal methods in the past) were very positive, whereas responses to individual technologies were more diverse. Still, both the two NTPTs probed in that study (high pressure and pulsed electric field) were also neutral or positively received, whereas the largest negative effect on consumer perception was associated with processing such as irradiation and genetic modification (Cardello et al., 2007), technologies which are well-known to engender consumer mistrust also due to their presence in the media (*e.g.*, Bearth & Siegrist, 2019; Bredahl, 2001; Deliza et al., 2010; Grunert et al., 2003; Siegrist & Hartmann, 2020). Consumers' lack of awareness about NTPTs (Song et al., 2020) work in their favor in this case, as without there being a public discourse around these food technologies it becomes less likely that consumers start to have negative perceptions of them.

Finally, price was the least important out of the three attributes considered in the study, which is possibly because food and beverages are generally inexpensive products, so a 30% increase in unit price would not substantially affect their bottom line. Still, consumers almost always preferred the cheaper version of each product, as one would expect. Interestingly, the possibility that NTPT treatment could result in higher prices was one of the most often mentioned concerns in our previous study (Song et al., 2020). The effect was significant for consumer choice of iceberg salad and cherry tomatoes, whereas in two out of the four countries it was not significant for orange juice (together with the findings regarding processing, this suggest that attributes affecting consumer choice of fresh vs processed F&V products may be slightly different). Generally, these results indicate that, if treatment with NTPT will command a higher price for F&V (especially fresh produce), consumers may be less likely to buy them. Still, it should be emphasized that price had a smaller impact on choice than the other two attributes, in particular when compared to stated benefits.

These findings have clear implications for effective communication of the benefits of NTPTs and successful marketing of F&V treated with these novel technologies. In particular, it can be concluded, based on this study, that a value proposition built around healthiness and better retention of nutrients will be the most likely to encounter the favor of consumers. Other key indications are that treatment with NTPT is not likely to pose a significant barrier to consumer acceptance, but that a price increase likely will, especially for fresh produce. Of course, acceptance of NTPT-treated F&V will maximize if these products could supply bundles of the major consumer benefits – a healthy product, with good taste, and at a reasonable price.

4.2. Individual and cross-cultural differences among European consumers

The second aim of the study was to explore differences among European consumers with respect to their cultural, demographic, psychographic, and behavioral background.

Before discussing the specific results, it should be emphasized that, taken collectively, the results did not reveal any major differences among consumer groups with respect to the influence of the different attributes included in the study. The most consequential groupwise difference pertained to consumers' degree of FTN, where the results showed that consumers with high FTN were less likely to choose F&V treated with NTPT. The finding that FTN could influence perception of novel NTPT-processed F&V products fits expectations, given that FTN is supposedly a universal trait that influences acceptance of innovations related to food. Accordingly, caution towards or outright rejection of novel food technologies among consumers with high FTN is often reported in the literature (Cavaliere & Ventura, 2018; Cox & Evans, 2008; Evans et al., 2010). The results showed that high FTN consumers (17% of

the sample) were less likely to choose F&V treated with NTPT, compared to consumers with medium or low FTN, but it should be emphasized that the latter two groups actually showed a *preference* for NTPT over conventional processing.

Other notable findings were that younger consumers were slightly more positive in trying NTPT-processed F&Vs than older consumers. This is consistent with previous studies indicating that younger generations are relatively less neophobic with regard to novel food technologies (Ares & Gámbaro, 2007; Matin et al., 2012), and also confirm our previous findings on NTPTs specifically (Song et al., 2020). It is likely that age differences are also underscored by differences in FTN, since in this study we found FTN to be inversely correlated to age and education (i.e., older consumers tended to be less educated and be more concerned about food technologies). Generally, the less a consumer know about a technology the more they are prone to rely on simple heuristics (*e.g.*, "the less processing the better") and to exhibit fear towards novel technologies (Cattaneo, Lavelli, Proserpio, Laureati, & Pagliarini, 2019; Siegrist & Hartmann, 2020). Further supporting this interpretation, preference for NTPT over conventional processing in this study was also found to be stronger in consumers with higher education level and who were more knowledgeable about food processing.

Lastly, individual differences were observed with respect to dietary status: omnivores were more sensitive to price compared to vegetarian/vegans, whereas the latter placed more consideration on health and nutrition claims, which was according to expectations as previous research indicating that the health motive in food choice to be more important in vegetarians than in omnivores (*e.g.*, Mullee et al., 2017). Once again, these groupwise differences were small and a matter of effect size, not direction.

With respect to cross-cultural differences, Danish consumers appeared to be slightly more price-oriented, whereas Italian, Serbian, and Spanish consumers were comparatively more affected by processing and benefit information pertained to different products. These differences may partly depend on the food culture and relevant dietary habits in different countries (Perrea, Grunert, & Krystallis, 2015; Van Kleef et al., 2006), and mirrors similar results reported on these countries (Grunert, Brunsø, Bredahl, & Bech, 2001; Scholderer, Brunsø, Bredahl, & Grunert, 2004). The importance of various basic values, such as healthiness and naturalness, and price may differ across cultures and influence consumers' attitudes and behaviors in different ways (Siegrist & Hartmann, 2020). Moreover, consumers' attitudes towards national food quality and safety status vary from country to country, which may lead to differences in their confidence towards F&V processed by novel technologies (Perrea et al., 2015). For instance, stronger confidence in food quality control systems may lead to more price-driven consumer choice, since consumers may believe that even the quality and safety of lower-priced products are guaranteed as well. This could explain why Danish consumers intended to purchase lower-priced products, since consumers in this country are known to have a high degree of social and specific trust in their national food control authorities (Berg et al., 2005; Song et al., 2020). By contrast, consumers who have more concerns about their national food quality and safety standards may focus more on product processing and benefits/risks in health and nutrition aspects. An additional explanation is that the Danish food retail system has also been traditionally dominated by discount stores, which may also indicate (and foster) more price-orientation in general among Danish consumers. Another minor, but possibly interesting, difference between countries pertained to the percentage of no-choice responses which was slightly higher on average in one country – Italy – compared to the other three. This is possibly linked to the relevance of additional factors not included in this study (see next section for direction for future research). In addition, it may also reflect in differences in preference for fresh vs. packaged F&V (since all three case studies included packaged products) which may exist among between European countries (Baselice, Colantuoni, Lass, Nardone, & Stasi, 2017).

To reiterate, however, the key finding was that effect directions were robust across countries consumer groups, and although some differences in effect size were observed, these differences appeared small and transient. With respect to informing marketing and communication strategies, therefore, the findings of this study indicate that F&V products treated with NTPT should have a broad appeal and could target the population as a whole rather than a specific market segment.

4.3. Limitations and future research

In closing, we highlight some important limitations of this research that could also constitute avenues for future research.

As in all survey-based research, social desirability bias may have influenced some of the results, although the format of conjoint surveys is relatively less affected by this problem than other survey types (Hoiuchi, Markovich & Yamamoto, 2020). For example, price was found in our study as the least important attribute affecting consumer choice of F&V, but in reality, it could be more important than what our findings suggest. In this case, replication and triangulation using non-hypothetical data (*e.g.*, experimental auctions) or revealed preferences (*e.g.*, retail data) are advised to confirm the results.

Secondly, the survey focused on broadly defined product concepts. Additional research would be needed to inform specific front-of-pack designs, and proper design optimization (*e.g.*, in a commercial context) would likely require testing of additional levels within each of the design factors. Additionally, perception of information on processing or benefits claims can be modified by other attributes that consumers routinely use to decrease uncertainty in decision making (*e.g.*, a familiar brand, a certification system, etc.), therefore understanding these interactions should be a useful extension of this research. Furthermore, the importance of taste and flavor as a choice driver suggests the need to include sensory testing in future studies, especially with respect to assessing repurchase likelihood. This can also be done in a conjoint analytic framework, and there are a few studies whereby sensory differences product tasting is integrated as a factor together with extrinsic product aspects such as price and packaging information (De Pelsmaeker, Dewettinck, & Gellynck, 2013; Giacalone, 2018).

Thirdly, with respect to the individual difference aim, this study concluded that European consumers are generally homogeneous in their responses to F&V treated with NTPT. Possibly, better segmentation could have been achieved by including additional variables not considered in this study. Promising candidates include the Health and Taste Attitude Scales (Roininen, Lähteenmäki, & Tuorila, 1999), which measure the importance of health and taste aspects of foods for consumers, and the Food Choice Questionnaire (Steptoe, Pollard, & Wardle, 1995) where some of the factors (*e.g.*, "natural content", "health") are directly related to food processing acceptance and could therefore be expected to explain some of the differences between consumers.

Fourthly, with respect to the generalizability of the findings it should be noted that at the aggregate level, the sample could be considered representative of the European population in terms of age (mean age in the sample was 44.1, the EU median is 43.7), but it had a slight over-representation of women and especially participants higher education (67% of the sample had attained at least an undergraduate degree, against a mean of $\leq$35% in the participating countries, Eurostat, 2021), reflecting the well-known fact that these categories are more likely to be interested in food and health and be more responsible for grocery shopping, and therefore more likely to voluntarily participate in such studies (*e.g.*, Molina-Montes et al., 2021). Since education level was found to affect consumer responses in this study, it is likely that the aggregated results slightly overestimate the utility of NTPT in the general European population, although crucially, no evidence of rejection was uncovered even in consumers with the lowest level of educational attainment.

Lastly, while the results were very consistent across countries, only four countries were included in this research, so the degree to which the findings can be replicated cross-culturally outside of the EU, and

especially in countries with a non-western background, should be assessed in future research.

5. Conclusions

This study used a choice-based conjoint analysis consumer survey to investigate how three key attributes: stated benefits (health and nutrition, natural taste, shelf-life), processing information (conventional, NTPT), and price point (reference, premium price) affect consumer choice of NTPT-processed F&V product concepts. Results from four European countries (Denmark, Italy, Serbia, Spain) and three base products (orange juice, iceberg salad and cherry tomatoes) consistently indicated that stated benefit was the most important attribute influencing consumer choice. Specifically, benefits related to health and nutrition, and to natural taste were more positively received, compared to extension of shelf-life. Information on processing and price levels had a similar influence on consumer choice of iceberg salad and cherry tomatoes, whilst for orange juice processing had a larger effect than price, suggesting that information on processing may be more impactful for F&V-derived products than for fresh produce. Differences across consumer segments, defined in terms of country, demographics and psychographic variables, were overall small and transient. The most consequential difference pertained to consumers' level of food technology neophobia, with results showing that consumers with high FTN (17% of the sample) were less likely to choose F&V treated with NTPT compared to consumers with medium and low FTN. Taken collectively, the results of this research suggest that products treated with NTPT may have a broad appeal across European consumers, and that targeted communication explicitly and efficiently focusing on health and taste benefits has the greatest chance to meet the interest of consumers.

CRediT authorship contribution statement

Xiao Song: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft. **Lone Bredahl:** Investigation, Methodology, Writing – review & editing. **Maria Diaz Navarro:** Investigation, Funding acquisition. **Paola Pendenza:** Investigation, Funding acquisition. **Isidora Stojacic:** Investigation, Funding acquisition. **Simona Mincione:** Investigation, Funding acquisition. **Giustina Pellegrini:** Investigation, Funding acquisition. **Oliver K. Schlüter:** Investigation, Funding acquisition. **Elena Torrieri:** Methodology, Writing – review & editing, Funding acquisition. **Rossella Di Monaco:** Methodology, Writing – review & editing, Funding acquisition. **Davide Giacalone:** Conceptualization, Investigation, Methodology, Software, Project administration, Funding acquisition, Supervision, Writing – original draft, 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.

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