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Influence of automated animal health monitoring and animal welfare label on consumer preferences and willingness-to-pay for filet mignon

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Precision Livestock Farming (PLF) has the potential to address some of the societal concerns regarding intensive livestock production, such as those with regard to animal health and welfare. However, information on the attitudes of consumers towards PLF is scarce. An online survey with a Discrete Choice Experiment was conducted in Flanders, Belgium to determine whether *type of animal health monitoring* (visual assessment without PLF, PLF at group level, PLF at individual animal level), *animal welfare label* (4 levels) and *price* influence the preference for filet mignon of consumers. In total, 454 respondents participated in the survey, of which 250 purchased filet mignon themselves. The characteristics *gender*, *frequency of buying filet mignon*, *attitude towards organic* and *attitude towards welfare labels* affected the utility (or "preferences") of the meat. The utility was highest for female respondents, for respondents who bought filet mignon less than once a month, for those who consciously bought organic meat and those with a positive attitude towards labels guaranteeing animal welfare and health. The utility of filet mignon was not affected by the *type of animal health monitoring*, whereas *animal welfare label* and *price* had a significant effect. Respondents were willing to pay more for filet mignon carrying a welfare label, ranging from 15.2 €/kg (Label 1) up to 18.1 €/kg (Label 3) compared to a reference price of 12 €/kg (No label). For the use of PLF for automated health monitoring, it should be further researched if consumers are neutral towards the use of PLF, or whether the technology might be relatively unknown.

KEYWORDS

discrete choice experiment, precision livestock farming, animal welfare, price, pork meat, survey

1 Introduction

Precision Livestock Farming (PLF) has the potential to address some of the societal concerns regarding intensive livestock production systems, including pig production. Through automatic, real-time monitoring and data processing of animal and farm environment characteristics, optimized farm management could be achieved, resulting in improved animal health and welfare, increased productivity and reduced environmental impact. However, the extent to which PLF technologies could mitigate or even reinforce societal concerns related to pig production is still unclear (Giersberg and Meijboom, 2021). For example, citizens were found to appreciate automation (such as automatic feeding and climate control) and modernity (in terms of efficient production, technological innovations, hygienic and clean farming practices and entrepreneurial principles) of current pig production systems (Boogaard et al., 2011). In contrast only about half of the 3000 participants in a three-continent consumer survey wanted their food to come from a technologically advanced (instead of a traditional) farm, while 85% of them believed that technology in agriculture is part of the future of farming (Feed4Thought, 2019). Krampe et al. (2021) states that consumers have previously often been neglected in research concerning the adoption of PLF technologies in the value chains. They promote more attention towards the complex societal aspects surrounding PLF (Krampe et al., 2021). Information on the attitudes toward PLF of stakeholders other than farmers is thus still limited (Giersberg and Meijboom, 2021), while understanding the factors that determine consumer perceptions of a product's value or cost is crucial to product innovation, choice of marketing strategy and maintaining competitive advantage (Ngapo et al., 2004). Consumer perceptions towards various other meat attributes, such as sensory characteristics (odour, texture, appearance) and animal welfare labels, have been studied more extensively (Grunert et al., 2004; Aaslyng et al., 2007). Animal welfare labels, such as the 'Beter Leven Keurmerk' used in the meat industry in the Netherlands (Beter Leven, 2018a, 2018b, 2018c), can be a strong marketing tool that helps the consumers make informed purchasing decisions. Comparison with such labels can help to situate the potential of PLF as marketing tool.

The goal of this study was to determine the influence of PLF on the consumer preferences and to quantify these preferences for PLF by measuring their willingness to pay (WTP) for a piece of pork with certain PLF attributes. Filet mignon was chosen as case because it is situated in the average price range and it is well-known in Flanders, Belgium. More specifically, this study aims (1) to investigate if the type of *animal health monitoring* (i.e. visual assessment without PLF, PLF at group level, PLF at individual animal level), the *animal welfare label*, and the *price* of the meat influence the preference for filet mignon of consumers in Flanders, Belgium, (2) to determine how sociodemographic characteristics influence this preference, and (3) to analyze the consumer's WTP for the type of animal health monitoring and the animal welfare label.

2 Materials and methods

2.1 Experimental approach and data collection

Consumer data were collected using an online survey using LimeSurvey (LimeSurvey GmbH, Hamburg, Germany). The link to the survey was distributed in Flanders, Belgium by Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) through a press release and social media platforms. From there, it was spread further through social media networks and other Flemish Government agencies. Everybody could participate as there were no specific requirements for consumers. Data collection took place from June to September 2018.

2.1.1 General, sociodemographic questions

The questionnaire comprised of general questions about the participants, as well as specific questions concerning their preferences at the start of the survey. An overview of these questions is shown in Table 1. Most questions had predefined answers to choose from, whereas for some an open answer was allowed. These questions were translated into sociodemographic characteristics.

For respondents that indicated they did not purchase filet mignon themselves, the survey ended after the general questions. These respondents were not shown the Discrete Choice Experiment (DCE), as their choices were not deemed representative for consumer behaviour on filet mignons.

2.1.2 Discrete choice experiment

Besides general questions, a DCE was integrated in the survey to determine if *'type of animal health monitoring'*, *'animal welfare label'* and *'price'* (product attributes) influence the consumers' preference for filet mignon. Discrete choice experiments are a popular elicitation format to investigate an individual's preferences (Lusk and Schroeder, 2006), and are often used in agriculture (Čop and Njavro, 2022; Lauterbach et al., 2023). These experiments are classified as 'stated preference' approaches, in which respondents make purely hypothetical choices when presented with a set of alternatives (Meenakshi et al., 2012). The approach allows to draw conclusions from previously unarticulated preferences about real conditions using an attribute-based measure in a hypothetical decision-making context (Fecke et al., 2018). However, the disadvantage is that the results may suffer from bias as there is no actual commitment from the respondent to buy the product or service (Meenakshi et al., 2012). The results should therefore be interpreted with care. In practice, choice sets including different alternatives are presented to the participant, who is invited to choose the most preferable alternative. For each presented alternative, the attributes and their associated levels are pre-defined. Furthermore, these attributes are systematically varied in their levels, leading to different choice sets. In this way, the respective influences on the participant's choices in the DCE can be detected (Louviere et al., 2000; Fecke et al., 2018).

TABLE 1 Description and answer options of sociodemographic characteristics presented to the participants within the survey.

Sociodemographic characteristic	Description	Answer options
Gender	Gender of the respondent	Male, Female
Age	Age category of the respondent	Open Afterwards clustered in < 30 years, 30-55 years, > 55 years
Agriculture	Link of the respondent with agriculture	Yes, No
Environment	Link of the respondent with an environmental organization	Yes, No
Animal welfare	Link of the respondent with an animal welfare organization	Yes, No
Education	Level of education of the respondent	Primary school, Secondary school, Bachelor, Master, Other Afterwards clustered as No higher degree, Bachelor, Master
Family members	Number of family members for whom meat is bought, including the respondent	Open
Number of filets	Number of filet mignons of around 150 g bought in total for all family members	Open
Pieces per person	Number of pieces of filet mignon per person	Calculated from response to 'Family members' and 'Number of filets'
Buying frequency	Frequency of buying filet mignon	Multiple times a month, Once a month, Less than once a month
Price	Price generally paid for filet mignon	Open
Packaging	Preferred type of packaging of the respondent	Pre-packaged, Freshly packaged, No preference
Shopping preference	Main type of shop of the respondent to buy pork meat	Discounter, Butcher, Retailer, Biological or on farm
Organic	Intentional purchase of organic pig meat of the respondent	Yes, No, Yes but not intentionally
GMO	Willingness to buy meat of GMO-fed pigs	Yes, No, No opinion
Label	Preference for the use of labels guaranteeing animal welfare and health	Yes and willing to pay extra, Yes but not willing to pay extra, No

In this survey, respondents were asked to choose one of three alternative filet mignons. Each filet mignon alternative was described by three product attributes, i.e. *'type of animal health monitoring'*, *'animal welfare label'* and *'price'*. To be as realistic as possible and to avoid potential bias, the attribute levels were chosen based on existing welfare labels, the authors' experience with PLF, and a small market survey at discounters, retailers and local butchers. The attributes and their different levels are presented in Table 2. The *'type of animal health monitoring'* consisted of three levels, i.e. Level 1 being monitoring by the pig farmer together with the veterinarian without support of a specific technology, Level 2 being monitoring by the pig farmer and the veterinarian supported by an animal health monitoring technology at group level (for example, sensors that monitor eating and drinking behavior per pen and that generate an alarm at pen level), Level 3 being monitoring by the pig farmer and the veterinarian supported by an animal health monitoring technology at individual animal level (for example, monitoring pig behavior using electronic ear tags and generating an alarm at pig level). The *'animal welfare label'* was subdivided in four labels, ranging from 'No label' to 'Label 3'. The label specifications were based on the minimum requirements of the 'Beter Leven Keurmerk' deployed in the Netherlands (Beter Leven, 2018a, 2018b, 2018c) concerning the minimum time the piglets stay with their mother before weaning, and the pen area and outdoor area per fattening pig. These specifications are presented in Table 3. 'No label' corresponds to the standard legal requirements for animal welfare. The nine price levels ranged from 8 to 24 €/kg and were selected based on the prices found in the local sales locations during a small market survey. The median price found in the market survey of 12 €/kg was considered as the reference.

In a full-factorial design, all possible combinations of the levels of the different attributes would result in an unpractical large number of choice sets (3 x 4 x 9 = 108). To obtain the smallest possible orthogonal design and to keep the number of respondents needed for the analyses low, the number of choice sets was reduced using Ngene 1.2 (Choice-Metrics, Sydney, Australia). In total, 36 choice sets were made. These choice sets were allocated to 3 blocks of each 12 choice sets, and each participant was shown only one of these 3 blocks. This was done to avoid the questionnaire being too extensive and possibly triggering the participants to end the survey prematurely.

Each decision situation presented to the participants (choice set) contained one reference, which is considered as a standard filet

TABLE 2 Filet mignon attributes and their levels used in the discrete choice experiment.

Attribute	Levels
Type of animal health monitoring	Level 1: Pig farmer Level 2: Pig farmer with technology on group level Level 3: Pig farmer with technology on individual animal level
Animal welfare label[1]	No label, Label 1, Label 2, Label 3
Price (€/kg)	8, 10, 12, 14, 16, 18, 20, 22, 24

[1]Animal welfare label based on 'Beter Leven Keurmerk', specifications given in Table 3.

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TABLE 3 Minimum requirements per animal welfare label.

Level	Time with mother before weaning (days)	Pen area per fattening pig (m^2)	Outdoor area per fattening pig (m^2)
No label	21 - 28	0.8	0.0
Label 1	23 - 28	1.0	0.0
Label 2	35	1.1	0.7
Label 3	42	1.3	1.0

mignon found in most shops. This reference had the same attribute levels throughout the survey, i.e. animal health monitoring by the pig farmer, no animal welfare label, and a reference price of 12 €/kg. An example of a choice set is given in Table 4. The different levels were explained before the choice sets were given, and respondents could check the description of the levels of the attributes at any time during the DCE.

2.2 Data analysis

2.2.1 Theoretical background for analysis of discrete choice experiments

The random utility theory (RUT) proposed by Thurstone (1927) forms the theoretical foundation of the DCE. This theory was later extended by McFadden and others (e.g. McFadden, 1986; McFadden and Train, 2000). The theory proposes the use of 'utility' and assumes an individual attaches a certain utility to each option that can be chosen (Louviere et al., 2010; Van De Gucht et al., 2017). According to this theory, individuals will always try to maximize their benefit (McFadden, 1974), and hence choose the product with the highest utility (or benefit). Through the use of DCE, the individuals' utility for each tested product attribute, as well as the influence of each product attribute on the probability of choosing a product can thus be revealed (Profeta et al., 2021). These utilities can be summarized by systematic (explainable) components and random (unexplainable) components. Systematic components comprise attributes explaining differences in choice alternatives and sociodemographic characteristics, which are other variables that explain differences between individuals. Random components consist of all unidentified factors that influence the choices (Louviere et al., 2010; Van De Gucht et al., 2017). The utility of a specific option (U_{ij}) is given by.

$$U_{ij} = V_{ij} + \epsilon_{ij}$$

where U_{ij} is the utility of individual j for alternative i, V_{ij} is the systematic component of individual j for alternative i, and ϵ_{ij} is the random component of individual j for alternative i. When incorporating the attributes of the alternatives (X) and the sociodemographic characteristics of the respondents (S), the systematic component, V_j, can be written as.

$$V_j = \beta_{0j} + \beta_{1j}X_{1j} + \beta_{2j}X_{2j} + \cdots + \beta_{kj}X_{kj} + \beta_{1j}S_{1j} + \beta_{2j}S_{2j} + \cdots + \beta_{nj}S_{nj}$$

where β_0 is the constant which stands for the intrinsic utility of an alternative irrespective of the attribute and levels, β_{kj} is the weight of the k^{th} attribute for individual j, X_{kj} is the k^{th} attribute for individual j, β_{nj} is the weight of the n^{th} sociodemographic characteristic for individual j, and S_{nj} is the measurement of the n^{th} sociodemographic characteristic for individual j. In this study, the constant β_0 has no true meaning as all alternatives are pieces of filet mignon, and it is therefore deleted from the models.

TABLE 4 Example of a choice set used in the discrete choice experiment.

Attribute	Alternative 1	Alternative 2	Alternative 3 (Reference)
Type of animal health monitoring	Pig farmer	Technology on group level	Pig farmer
Animal welfare label	Label 1	Label 3	No Label
Price (€/kg)	24	12	12

2.2.2 Modeling the response data

The participants' choices were analyzed with Nlogit 6 (Econometric Software Inc., Plainview, NY) using a multinomial logit model, as described by Van De Gucht et al. (2017). First, a base model that describes the utility of each filet mignon alternative was defined using the 3 attributes from the discrete choice experiment. *Type of animal health monitoring* and *animal welfare label* were categorical attributes, hence a coefficient was estimated for each level.

$$U_{mignon1} = \beta_{11}Health_{level2} + \beta_{12}Health_{level3} + \beta_{21}Welfare_{label1} + \beta_{22}Welfare_{label2} + \beta_{23}Welfare_{label3} + \beta_3 Price$$

$$U_{mignon2} = \beta_{11}Health_{level2} + \beta_{12}Health_{level3} + \beta_{21}Welfare_{label1} + \beta_{22}Welfare_{label2} + \beta_{23}Welfare_{label3} + \beta_3 Price$$

$$U_{mignon3} = U_{reference\ mignon} = 0$$

Where β is the attribute constant, Health is the type of animal health monitoring, Welfare is the animal welfare label, and Price is the price of the filet mignon.

In a second step, the sociodemographic characteristics of the respondents were tested in an univariable way by adding them separately to the base model. Binary categories were tested using effect coding. Regression coefficients (β) were calculated, indicating if a variable had a positive or negative contribution to the model outcome, being the utility. Variables were selected for multivariable analysis at significance level $P< 0.15$. Third, a multivariable model was built with the sociodemographic characteristics that were selected from the univariable model using a backwards stepwise procedure at $P< 0.05$. Finally, Wald post-hoc tests were performed.

2.2.3 Model interpretation

As stated above, the coefficients indicate if the contribution of a specific characteristic contributes in a positive or negative way to the utility. However, the value of the estimated model coefficients and thus the magnitude of the impact on the outcome, depends on the range of attribute levels used in the DCE, and should therefore be interpreted with care. Coefficient estimates should not be compared between attributes or sociodemographic characteristics included in the model, but between utilities assigned to alternatives with specific attribute levels (Hensher et al., 2005; Van De Gucht et al., 2017). However, the utility derived from the choice model as described above only allows comparison with the reference, of which the utility was set to zero. Coefficients higher than zero indicate that the specific level contributes positively to the utility of the alternative, and is thus preferred by the respondents compared to the reference. When a continuous attribute or characteristics (e.g. price) is increased by 1 unit, the utility assigned to the alternative increases with the attribute's coefficient estimate in case of a positive estimate, and vice versa, provided that all other attribute levels are kept constant.

2.2.4 Willingness-to-pay

Discrete Choice Experiments are an appropriate tool for calculating a measure of WTP (Hensher et al., 2005). The WTP is the maximum a customer is willing to pay for a proposed product with its specific characteristics. It indicates how much more a product can cost if a an attribute changes to another level. For the different attribute levels, the WTP was calculated by dividing the previously estimated attribute coefficient by the price coefficient of the univariable model. As the calculation of the WTP is a ratio of two estimated coefficients depending on the range of attribute levels used in the experiment, the WTP is also an estimation depending on these attribute levels. Therefore, the selection of the price levels should be done with care in order to become a realistic measure for WTP. The levels must accurately capture the range of preferences for most of the respondents. It is important to ensure the price levels are not too high or too low for attributes under evaluation, in this case health monitoring and welfare label. Typically, ranges around the mean costs are included. Price levels in this study were selected based on market prices. A market study was conducted, including different market channels from discount supermarkets to short chain farm butchers. Nine levels from 8 to 24 €/kg were chosen around the median price of 12 €/kg (see Table 2).

3 Results

3.1 Survey results

In total, 454 respondents participated in the survey, of which 250 completed the choice experiment. The other 204 respondents indicated they do not buy filet mignon due to various reasons and were thus not shown the DCE. Reasons for not purchasing filet mignon were a dislike for filet mignon/pork meat or preference for other pork meat (57%), other family members doing the purchases (21%), being vegetarian (9%), having own/other sources of meat (3%), being vegan (1%), and religious reasons (1%). Only 1 respondent (0.5%) indicated not to buy filet mignon because the price is too high.

For the further analysis, only the respondents that completed the full choice experiment are taken into account (Table 5). Most respondents were female (62%). The age distribution was 19% of the respondents being 30 years or younger, 62% between 30 and 55 years, and 19% being older than 55. Considering the highest level of education, 55% had at least a master degree, 31% had a bachelor degree, and 14% had a lower degree. Approximately half of the respondents had either a professional or personal link with agriculture (53%). In addition, 6% and 3% had a link with an environmental or animal welfare association, respectively. Fifty-two percent of the respondents buys filet mignon less than once a month, 28% once a month, and 20% more than once a month. With regard to packaging, 42% had no preference for either pre- or freshly packaged, 42% specifically preferred freshly packaged, while 16% preferred pre-packaged meat. The majority of respondents preferred to buy meat at the retailer (56%) or the local butcher (34%), while discounters (6%), bio-shops (2%), and at the farm (2%) were less popular shopping locations with the respondents. Most respondents buy non-organic pork meat (62%), 17% consciously buys pork with an organic label, and another 21% sometimes buys pork with an organic label, but not intentionally. Twelve percent of the respondents would not buy meat of pigs fed by GMO-crops, while 64% would and 24% had no opinion on this matter. When asked for the need for labels to guarantee the pig health and welfare, 30% of the respondents indicated it is not necessary for them. Of the respondents that acknowledge the need for such a label, 17% was not willing to pay extra for the meat.

In total, 85% of the respondents indicated not to know how much they generally pay for filet mignon. For the other 15%, the majority (68%) declared to pay around 7 to 12 €/kg, while prices ranged from 3 to 30 €/kg.

3.2 Discrete choice experiment

Table 5 shows the results of the base model, the univariable model and the final model. The table can be read as an outcome of a regression model. The β coefficients in the univariable and final models are parameter estimates for the variables (characteristics), similar to the regression coefficients in for example a linear regression model. They indicate the possible significant contribution (positive of negative) of each (level of) characteristic to the model outcome, being the utility.

In the final model, attributes *'animal welfare label'* and *'price'* were highly significant, while *'type of animal health monitoring'* was not significant. Using technology at either group or individual animal level to monitor animal health thus did not affect the utility of the filet mignon compared to that of the reference meat for which health monitoring was performed by the pig farmer and the veterinarian. Compared to the reference filet mignon with no animal welfare label, increasing the label level would result in a

TABLE 5 Analysis results of the base model, univariable models with socio-demographic characteristics and the final multivariable model.

Item	Characteristics	Level	n	Univariable model			Final model		
				β	SE	P-value	β	SE	P-value
Base Model	Health monitoring					NSU			NSM
		Without technology							
		Technology group level							
		Technology individual animal level							
	Label animal welfare					< 0.001			< 0.001
		Label 0		Ref[a]			Ref[a]		
		Label 1		0.588[b]	0.075		0.852[b]	0.092	
		Label 2		1.077[c]	0.079		1.362[c]	0.094	
		Label 3		1.123[c]	0.076		1.379[c]	0.089	
	Price of pig meat (€)			-0.184	0.007	< 0.001	-0.191	0.007	< 0.001
Extended model	Gender					< 0.001			< 0.001
		Male	95	-0.238[a]	0.043		-0.214[a]	0.045	
		Female	155	0.238[b]	0.043		0.214[b]	0.045	
	Age					< 0.001			NSM
		< 30 years	47	Ref[a]					
		30-55 years	155	-0.259[b]	0.081				
		> 55 years	48	-0.837[c]	0.111				
	Education					< 0.001			NSM
		No higher degree	34	Ref[a]					
		Bachelor	78	-0.445[b]	0.096				
		Master or higher	138	0.051[a]	0.086				
	Link agriculture					NSU			NSM
		No	117						
		Yes	133						
	Link environment					< 0.001			NSM
		No	236	-0.280[a]	0.070				
		Yes	14	0.280[b]	0.070				
	Link animal welfare					< 0.001			NSM
		No	243	-0.248[a]	0.076				
		Yes	7	0.248[b]	0.076				
	Family members			-0.070	0.021	0.001			NSM
	Number of filets			-0.088	0.018	< 0.001			NSM
	Pieces per person					< 0.001			NSM
		0 - 0.75	24	Ref[a]					
		0.76 - 1.25	154	-0.269[b]	0.086				
		> 1.25	72	-0.507[c]	0.101				
	Frequency of buying					< 0.001			< 0.001

(Continued)

TABLE 5 Continued

Item	Characteristics	Level	n	Univariable model			Final model		
				β	SE	P-value	β	SE	P-value
		Multiple times a month	50	Ref[a]			Ref[a]		
		Once per month	69	-0.063[b]	0.098		0.482[b]	0.111	
		Less than once per month	131	0.274[c]	0.084		0.690[c]	0.094	
	Packaging					< 0.001			NSM
		Pre-packaged	39	Ref[a]					
		Freshly packaged	106	-0.332[b]	0.088				
		No preference	105	0.100[ab]	0.91				
	Shopping preference					< 0.001			NSM
		Discount	15	Ref[a]					
		Local butcher	85	-0.595[b]	0.099				
		Retail	141	-0.147[ab]	0.091				
		Bio or on farm	8	0.290[ab]	0.244				
	Organic					< 0.001			< 0.001
		No, and Yes but not intentionally	207	-0.605[a]	0.059		-0.400[a]	0.070	
		Yes	43	0.605[b]	0.059		0.400[b]	0.070	
	GMO					< 0.001			NSM
		Yes	160	Ref[a]					
		No	29	0.585[b]	0.145				
		No opinion	61	-0.114[a]	0.094				
	Label					< 0.001			< 0.001
		Yes and willing to pay	145	Ref[a]			Ref[a]		
		Yes but not willing to pay	29	-1.433[b]	0.089		-1.363[b]	0.099	
		No	76	-0.933[c]	0.129		-0.952[c]	0.138	

For categorical variables, significant differences (P< 0.05) within the categories are indicated with different superscripts.
NSU = not significant in the univariable model; NSM = not significant in the multivariable model.

utility increase of 0.852, 1.362 and 1.379 for filet mignons with Label 1, Label 2 and Label 3, respectively. Decreasing the price of the meat with 1 € would increase the utility by 0.191.

Regarding the sociodemographic characteristics, *gender*, *frequency of buying filet mignon*, and the *attitude towards organic* and *labels* were retained in the final model (P< 0.001). The utility assigned to a specific filet mignon was 0.428 higher with female respondents than with male respondents. The utility was highest for respondents who bought filet mignon less than once a month (β = 0.690). Utility for those who bought filet mignon once a month was lower (β = 0.482), however still significant compared to consumers who bought the piece of meat multiple times a month. Respondents who consciously bought organic meat increased the utility by 0.8 compared to those who do not intentionally buy organic meat. For respondents that don't see the need for animal welfare and health labels the utility decreased by 0.952 compared to respondents who have a positive attitude towards labels and are willing to pay for it. For those that showed a positive attitude towards these labels but were not willing to pay for it, the utility decreased by 1.363.

3.3 Willingness-to-pay

Besides calculating the utility of a filet mignon with specific characteristics of health monitoring, animal welfare label and a specific price, the results of a DCE are most often represented as measures for the WTP. WTP measures are calculated on the same results of the DCE, so in this study the results of the 250 respondents. Figure 1 shows the respondents' WTP on top of the reference price of 12 €/kg for the different animal welfare labels. The price that the respondents are willing to pay for filet mignon with a welfare label ranges from 15.2 €/kg (Label 1) up to 18.1 €/kg (Label 3), which corresponds to an increase of about 27 to 51%.

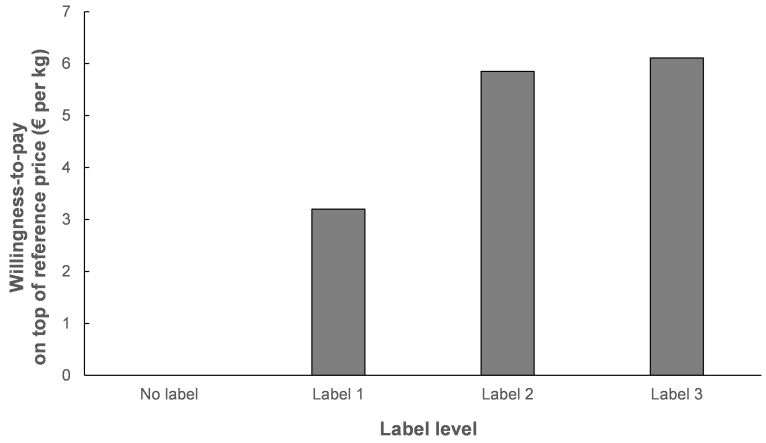

FIGURE 1
Willingness-to-pay on top of the reference price of 12 €/kg (in €/kg) for the different animal welfare labels.

The type of animal health monitoring was not significant in the univariable model and health monitoring supported by technology did hence not result in an additional WTP.

As the sociodemographic characteristic gender was significant, the model was run separately for male and female responders in order to calculate a gender specific measure of WTP. The price female responders are willing to pay varies from 16.0 to 19.5 €/kg for animal welfare label 1 to label 3, respectively, compared to 12 €/kg in absence of a label. The WTP of male respondents range from 13.9 €/kg (Level 1) to 15.8 €/kg (Level 3), compared to 12 €/kg for the reference filet mignon. For the other significant sociodemographic characteristics in the multivariate model, no separate models were run as the number of respondents per separate model would be too low.

4 Discussion

4.1 Survey results

The total number of respondents that completed the survey and choice experiment was 250. A large group of survey participants (n = 454) were however not presented with the choice experiment as they indicated not to buy filet mignon (n = 204). Various reasons were reported for this buying behaviour, including as major reason a dislike for this type of meat or pork in general (57%). This suggests that filet mignon is not a particular popular type of meat, although pork is still the most consumed meat in Belgium (51,5% in 2021) according to STATBEL (2022). In this respect, future studies might want to consider a different choice of pork meat when surveying consumer preferences and WTP for pig health monitoring and welfare labels. No overall survey response rate could be calculated as it was unknown how many persons had received the survey though the different communication channels.

The results show that women were slightly overrepresented compared to men (62% vs. 38%). This may be due to women being generally more involved in food shopping and meal preparation (Schösler et al., 2015; Van Droogenbroeck and Van Hove, 2020) and thus might be more inclined to complete this survey, although men consume meat in larger amounts (Lin et al., 2011) and more frequently (Michel et al., 2021). The age category 'between 30 and 55 years old' was also better represented than the younger and older category. The majority of the respondents were higher educated (55% master, 31% bachelor degree) and had a link with agriculture (53%), which can be explained by the communication channels used to distribute the survey, i.e. partially through the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) and its employees. These characteristics might have slightly biased the results of the choice experiment. However, except for *gender*, those characteristics were not found to significantly affect the utility and thus the WTP for filet mignon (see later). In addition, the percentage of respondents indicating to at least occasionally, and either consciously or non-intentionally, buy pork with an organic label (38%) was higher than expected based on the percentage of organic meat purchasers in Flanders, Belgium of around 14% (Timmermans and Van Bellegem, 2020). This also suggests a possible bias in the consumers' preferences.

4.2 Discrete choice experiment

4.2.1 Importance of the meat attributes

The first goal of this study was to investigate whether the *type of animal health monitoring*, the *animal welfare label* and the *price* of filet mignon are important to consumers. *Animal welfare label* and *price* significantly affected the utility. They are therefore important attributes to the respondents that influence their choice of filet mignon. This finding is supported by the survey results in which 70% of the respondents acknowledged the need for an animal welfare and health label and 83% of this group indicating to be willing to pay extra for such a label. The utility increased with increasing animal welfare label level, although not significantly between Label 2 and 3. With regard to the label requirements, there is only little difference between 'No label' and 'Label 1'. More specifically, within 'Label 1' the time the piglet can stay with the mother before weaning is between 23 and 28 days, which

corresponds to potentially two additional days with the mother compared to the 21 to 28 days specified in the minimum 'No label' requirements. Within 'Label 1', the pen area per fattening pig should also be slightly larger than that of 'No label', i.e. 1.0 m^2 vs. 0.8 m^2. These small differences in requirements suggest that simply having an animal welfare label is sufficient to increase the utility of the meat. The results furthermore suggest that an outdoor area increases the utility, as this is what mainly distinguishes 'Label 2' and 'Label 3' from 'Label 1'. Besides the outdoor area also the other two welfare requirements slightly differ between 'Label 1' and the higher level labels. However, the seven additional days of the piglet with the mother, the 0.2 m^2 extra pen area and the 0.3 m^2 extra outdoor area per pig, did not significantly increase the utility of 'Label 3' compared to 'Label 2'. These findings support the idea that consumers may see the outdoor area as the most important added value for animal wellbeing. However, the set-up of this survey with multiple requirement differences between the levels of the animal welfare label (i.e. time with mother before weaning, pen area and outdoor area per fattening pig) does not allow to draw conclusions regarding the relationship between the specific requirements of each level and the consumers' preferences. More studies are needed to determine the importance of the animal welfare label, as well as its specific requirements, with regard to consumers' preferences.

The *type of animal health monitoring* did not have a significant effect on the utility of the filet mignon, suggesting that the respondents pay little attention to type of health monitoring or they are neutral towards the monitoring technology. Since no added value of monitoring technology was observed, consumers might believe that monitoring by the farmer and the veterinarian is sufficient and good animal health is already assured in the current system. Comparable, as no adverse effect of health monitoring technology was found either, there are no indications for consumers having a negative attitude towards health monitoring technology. Focus group discussions in three European countries (i.e., Finland, Spain, the Netherlands) had previously identified some major concerns of consumers regarding the implementation of PLF technologies which may affect their acceptance (Krampe et al., 2021). These concerns included the fear that integration of PLF technologies will introduce more industrialization into livestock farming production, that PLF technologies and data are vulnerable to misuse and cyber-crime, and that PLF information is not communicated adequately to allow informed purchase decisions. In this survey, the respondents were not explicitly asked to indicate their concerns on the implementation of PLF, as to not influence their choices. However, as indicated above, even if these concerns could have been present in these respondents, the utility of the meat in this survey was not influenced.

A more in-depth study on the importance of health monitoring technology (independent of animal welfare) on the utility of pork, and other animal products in general, is needed to better assess the possible added value of this technology, as well as to identify potential means to improve the perception of the technology. Public campaigns for example might improve the general awareness and appreciation of PLF technologies.

Not surprisingly, an increasing *price* of the meat had a negative effect on the utility. Increasing the price of the meat with 1 € decreased the utility by 0.191. Price was found to be the most important information customers look for before they purchase a product (Kumar and Kapoor, 2017). Profeta et al. (2021) also reported a significant, negative effect of increased price on the choice for four meat products (mortadella, salami, chicken nuggets, meat balls) in Germany and Belgium based on a DCE. However, the importance of price generally depends on the consumer profile, with 'indifferent meat consumers' being strongly price oriented, while this is significantly less so for 'cautious meat lovers', as found in a study performed by Verbeke and Vackier (2004) based on data collected in Belgium. Economic motives, such as the lack of spending power or willpower to purchase good quality meat, may have triggered the observed indifferences of the first consumer group. Future studies on PLF technologies should take into account the different consumer profiles to identify and gain insight into the market segments with highest preference for PLF products in order to better position these products through the development of effective communication and marketing strategies.

4.2.2 Importance of the sociodemographic characteristics

The second aim of this study was to determine how sociodemographic characteristics influence the consumers' preference for filet mignon. The preferences were found to be influenced by *gender*, *frequency of buying filet mignon*, and the *attitude towards organic* and *animal welfare* and *health labels*. Female respondents assigned a higher utility to a specific filet mignon than their male counterparts and hence also higher measures of WTP. Various studies have previously demonstrated significant gender differences with regard to food, including food preferences, intake, nutritional knowledge, and shopping behaviour (Beardsworth et al., 2002; Kumar and Kapoor, 2017; Manippa et al., 2017; Lombardo et al., 2020), but to the authors knowledge no studies have been performed on the effect of gender on the utility of food products. In this study, the higher utility assigned by women may be due this gender being generally more involved in food shopping and meal preparation. For example, a study performed in the Netherlands, reported 40% of (native) adult women to be involved in food shopping, compared to 36% of men, whereas the involvement in meal preparation was 51% for women but only 24% in men (Schösler et al., 2015).

The increasing utility for filet mignon with decreasing *frequency of buying* suggests that consumers who buy the product less frequent value it more. These consumers might be more conscious in their buying behaviour and their demands. In recent years, general awareness regarding a healthy and sustainable diet has led to a decrease in total meat consumption per capita in Belgium (Dagevos and Verbeke, 2022). It is becoming more evident that purchasing behaviour of consumers is not only influenced by their personal pleasure but also by more altruistic reasons, such as environmental sustainability and social and economic justice (Gracia et al., 2012). Vanhonacker and Verbeke (2009) found that in Flanders lower chicken meat consumption was associated with higher frequencies of buying pro-welfare chicken products. However, McEachern and Schröder (2002) suggested that lower meat consumption was mainly a compensation for the price

premium of higher welfare products. Nevertheless, it is not surprising that consumer preferences are associated with factors related to sustainability and animal welfare, and these associations may at least partially explain the relationship between utility for pork meat, buying frequency, attitude towards animal welfare and organic labels. Indeed, a positive *attitude towards animal welfare and health labels* had a positive effect on the utility of filet mignon in this survey. In addition, respondents who consciously buy *organic* meat also assigned a higher utility to filet mignon, irrespective of the organic label itself. Using a DCE, Profeta et al. (2021) found that the presence of an organic label exerted a positive effect on the choice for mortadella, chicken nuggets, salami and meat balls in Germany and Belgium. Such a direct effect was however not investigated in this study.

4.3 Willingness-to-pay

The third goal of this study was to analyze the consumer's WTP for the *type of animal health monitoring* and the *animal welfare label*. Various studies have already indicated the importance of animal welfare in consumer preferences, but often this was not translated into the willingness to pay (considerably) more for the meat (Schnettler et al., 2009; Vanhonacker and Verbeke, 2009). In this study, the willingness to pay more for filet mignon as a premium for an animal welfare label ranged from 3.2 to 6.1 €/kg. It should be noted that the WTP also depends on the pre-set prices of the survey ranging from 8 to 24 €/kg. Considering that in this study the price for the reference filet mignon was 12 €/kg, the WTP was rather high, even more so when taking into account that both the median (10 €/kg) and the average price (11.2 €/kg) reported by the 38 respondents who indicated to know how much they pay for filet mignon were below this reference price. Of these respondents, 68% (i.e., 26 respondents) claimed to pay around 7 to 12 €/kg, which is rather low. The relative high WTP in this study might be the result of the chosen price levels in the experimental set-up although the selection of price levels was done based on real costs per kg filet mignon in different market channels.

Another possible explanation for this high WTP and apparent contradiction with the lower reported price paid in practice is that this study determined a hypothetical WTP as the respondents were forced to make a choice, but had no obligation to buy the product at the end of the survey. Alternatively, an extra option "I don't want to buy this product" could have been provided to the responders throughout the survey. Such an "opt out" option is not beneficial for the model, but might have prevented responders selecting random or unrealistic options. Instead of an real opt out option, a standard filet mignon was added as a reference. This reference had the same attribute levels throughout the survey, i.e. animal health monitoring by the pig farmer, no animal welfare label, and a reference price of 12 €/kg. As a consequence, the respondents might have scored the filet mignon options in the choice experiment based on relative comparison of the attributes rather than in absolute terms. If this is the case, the results of the experiment are still valuable but the WTP needs to be interpreted as trend rather than as concrete price. The relatively large group of respondents who consciously (17%) or sometimes but not intentionally (21%) buy pork with an organic label might also have positively impacted the WTP for the animal welfare label. Organic products are generally more expensive than non-organic products. Consumers who typically buy organic products are generally most interested in issues relating to the environment and animal welfare and are not very price sensitive, as found in a Norwegian study on the purchasing behaviour of eggs (Gerini et al., 2016). Respondents who buy organic meat are therefore likely to also select meat with an animal welfare label and are probably willing and accustomed to pay higher prices, which might have reflected in the choice experiment. In depth interviews or think-aloud surveys asking the respondents why making their choices could be a way to reveal the dominant attribute in further research.

The respondents in this study were not willing to pay more for filet mignon originating from pigs that were reared at a farm that used PLF to monitor animal health. The respondents thus seem neutral towards the type of health monitoring. However, they were willing to pay more for an animal welfare label. It is possible that in the respondents' view, animal health and animal welfare are closely related, and that a welfare label assures good animal health. The actual requirements of the animal welfare label were nevertheless explained in the survey. Krampe et al. (2021) reported that the participants in focus groups (selected as consumers of animal-based products without professional link to the food industry) in Finland, Spain and the Netherlands had 'never heard' about PLF and its associated technologies, such as blockchain. This finding suggests that the concept of PLF is not yet widespread among consumers. To obtain a positive attitude and possibly an increased WTP for animal health monitoring technologies, and PLF technologies in general, consumers should first become more familiar with these innovations and its benefits, and their possible fears should be addressed. In food technology innovation, it is believed that integrating the consumers' perceptions, preferences, and priorities of new technologies during the early stages of development and implementation is an important aspect to increase the societal acceptance of these technologies and to avoid commercial failure (Raley et al., 2016; Siegrist and Hartmann, 2020). Furthermore, as not all product characteristics appeal to all consumers in the same way, the market and WTP might benefit from segmentation with specific positioning of pork raised using PLF for specific customers. In addition, good food labeling is key in providing important information to the consumers and allowing them to make informed decisions (Kumar and Kapoor, 2017). Food labels might thus help increase familiarity with regard to PLF and possibly increase WTP.

5 Conclusion

Information on the attitude of consumers toward PLF technologies is scarce while insight into the consumers preferences is essential to obtain a strong market position. An online survey with an integrated Discrete Choice Experiment was conducted in Flanders, Belgium to determine the consumers' willingness to pay for filet mignon. The utility of filet mignon was not affected by the *type of animal health monitoring*. This suggest that the survey participants were neutral towards the monitoring

technology. The technology might still be rather unknown. Public campaigns and food labelling might improve the general awareness and appreciation. Market segmentation might furthermore help to receive higher prices for PLF raised meat. In contrast, *animal welfare label* and *price* had a significant effect on the utility of the meat and thus influence the respondents choice of filet mignon. Introducing an animal welfare label in Belgium might indirectly result in an economic incentive for farmers to invest in higher welfare requirements.

Data availability statement

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

Ethics statement

Ethical approval was not required for the studies involving humans because the research involved only a completely anonymous and voluntary online survey, without sensitive content. Participants were informed about the goal of the research and the analysis of the results. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JM: Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing. EM: Investigation, Writing – original draft, Writing – review & editing. TVDG: Conceptualization, Methodology, Software, Writing – review & editing. CV: Data curation, Writing – review & editing. IZ: Writing – original draft, Writing – review & editing. SVW: Conceptualization, Formal analysis, Funding acquisition, Methodology, Software, Supervision, Validation, Writing – review & editing.

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Conflict of interest

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

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