Meat Science 149 (2019) 1–8

Contents lists available at ScienceDirect

Meat Science

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

Consumers' preferences for freezing of meat to prevent toxoplasmosis– A stated preference approach

Mattijs S. Lambooij[a,*], Jorien Veldwijk[b], Paul van Gils[a], Marie-Josee J. Mangen[a], Eelco Over[a], Anita Suijkerbuijk[a], Johan Polder[a,c], G. Ardine de Wit[a,d], Marieke Opsteegh[a]

[a] National Institute for Public Health and the Environment, RIVM, Bilthoven, The Netherlands
[b] Erasmus School of Health Policy & Management (ESHPM), Erasmus Choice Modelling Center (ECMC), Erasmus University, The Netherlands
[c] Tilburg University, Tranzo, School of Social and Behavioral Sciences, Tilburg, The Netherlands
[d] University Medical Center Utrecht, the Netherlands, Julius Center for Health Sciences and Primary Care, The Netherlands

ARTICLE INFO

Keywords:
Meat
Toxoplasmosis
Food safety
Consumer preferences
Discrete choice experiment

ABSTRACT

Consumption of raw or undercooked meat increases the risk of infection with Toxoplasma gondii. Freezing meat products can eliminate this risk. Freezing of meat may affect consumers' valuation of meat products in two different ways: it may be valued positively because of increased food safety or valued negatively because of (perceived) loss of quality. In a Discrete Choice Experiment on four different meat products we studied the difference in willingness to pay for frozen and non-frozen meat products in the Netherlands. Analyses revealed that most Dutch consumer groups prefer non-frozen meat. Price was important in consumer decisions, whereas the meat being frozen appeared to play a minor role in the decision to purchase meat products.

Even though it may seem obvious that people would prefer safe food to unsafe food, in a context where consumers presume food being safe, many consumers appear unwilling to pay for freezing of meat as additional measure to reduce the risk of food borne infections such as toxoplasmosis.

1. Introduction

Consumers' preferences for meat products take shape in a multi-factor interplay of psychological aspects, marketing related aspects and sensory properties of the meat (Clonan, Wilson, Swift, Leibovici, & Holdsworth, 2015; de Andrade, de Aguiar Sobral, Ares, & Deliza, 2016; Font & Guerrero, 2014). A broad range of factors are known to affect dietary choice in general (Sobal & Bisogni, 2009). These aspects range from life course events, cultural ideas, personal factors, resources, social factors and choice context, and personal characteristics such as health, mood or weight control (de Andrade et al., 2016; Sobal & Bisogni, 2009; Steptoe & Pollard, 1995; Steptoe, Pollard, & Wardle, 1995). Specifically for meat, aspects as own health, sensory appeal or animal wellbeing may play a role in consumer's decisions (de Andrade et al., 2016; Steptoe et al., 1995).

Even though microbiologically safe food (referred hereafter as food safety) is important to the consumers, a gap between consumers' attitude and behaviour was found in safe food handling practices such as cooking or storage (Wilcock, Pun, Khanonax, & Aung, 2004). Still, food safety when buying meat was of concern, people were aware that they had little information about food safety and that they needed to rely on rules of thumb to ensure buying safe meat (Green, Draper, & Dowler, 2003). To deal with this uncertainty, people selected certain stores or shops they trusted to sell safe meat (Green et al., 2003). In another study, consumers of beefsteak were found to value food safety to be the most important aspect in their decision to buy meat, and food safety appeared to be far more important than tenderness and freshness of the product (referred hereafter as food quality) (Loureiro & Umberger, 2007).

Microbial hazards and associated issues are found to be major challenges for the meat industry and will stay important in the future (Sofos, 2008). Toxoplasmosis, the disease caused by *Toxoplasma (T.) gondii*, is a priority zoonotic food-borne pathogen in terms of disease burden. This pathogen causes a large disease burden among food-related pathogens in the world (Batz, Hoffmann, & Morris Jr., 2014; Gkogka, Reij, Havelaar, Zwietering, & Gorris, 2011; WHO, 2015), being responsible for 1900 Disability Adjusted Life Years (DALYs) per year and estimated annual societal costs of €15 million in the Netherlands in 2016 (or €44 million, if undiscounted) (Mangen, Friesema, Haagsma, & Pelt, 2017). About 85% of the estimated DALYs are associated with

* Corresponding author at: National Institute for Public Health and the Environment, Centre of Food, Prevention and Health care (VPZ), PO Box 1372 BA, Bilthoven, The Netherlands.
E-mail address: mattijs.lambooij@rivm.nl (M.S. Lambooij).

https://doi.org/10.1016/j.meatsci.2018.11.001
Received 30 August 2018; Received in revised form 16 October 2018; Accepted 3 November 2018
Available online 05 November 2018

Table 1
Items after expert interviews and literature source (alphabetic order).

Factor	Literature source
Colour of the meat	(Borgogno, Favotto, Corazzin, Cardello, & Piasentier, 2015; de Andrade et al., 2016; Hamlin, 2016; Ngapo, 2017)
Consistency of the meat	(Borgogno et al., 2015; de Andrade et al., 2016; Hamlin, 2016; Loureiro & Umberger, 2007; Lucherk et al., 2016; Ngapo, 2017)
Country of origin	(de Andrade et al., 2016; Font et al., 2011; Frewer et al., 2011; Loureiro & Umberger, 2007)
Ease of preparation	(Borgogno et al., 2015; Hamlin, 2016)
Expiration date	(Borgogno et al., 2015; Tsiros & Heilman, 2005)
Information on animal welfare during production	(Borgogno et al., 2015; De Marchi, Caputob, & Banterle, 2016; Frewer et al., 2011; Hamlin, 2016; Lazzarini, Zimmermann, Visschers, & Siegrist, 2016; Ortega, Hong, Wang, & Wu, 2016)
Information on level of food safety of the meat	(Borgogno et al., 2015; Loureiro & Umberger, 2007; Ortega et al., 2016; Sofos, 2008)
Level of sustainability of the production of meat (impact on environment)	(Borgogno et al., 2015; De Marchi et al., 2016; Frewer et al., 2011; Hamlin, 2016; Lazzarini et al., 2016)
Information producer (type of farm and life stock system)	(Borgogno et al., 2015; De Marchi et al., 2016; Frewer et al., 2011; Hamlin, 2016; Ortega et al., 2016; Sofos, 2008)
Information quality of meat	(Borgogno et al., 2015; de Andrade et al., 2016; Loureiro & Umberger, 2007)
Information whether meat is organic or not	(Borgogno et al., 2015; De Marchi et al., 2016; Frewer et al., 2011; Hamlin, 2016; Ortega et al., 2016)
Meat cuts (e.g. beefsteak, minced meat)	(de Andrade et al., 2016)
Methods used to control microbiological risks in primary production	(Frewer et al., 2011)
Methods used to control microbiological hazards during processing in meat production chain (e.g. irradiation, freezing, …)	(Kijlstra & Jongert, 2008; Sofos, 2008)
Price	(Borgogno et al., 2015; de Andrade et al., 2016; De Marchi et al., 2016; Font i Furnols et al., 2011; Hamlin, 2016; Loureiro & Umberger, 2007; Mangen & Burrell, 2001; Ortega et al., 2016)
Type of livestock (e.g. cattle, pig, …)	(Borgogno et al., 2015)
Risk of toxoplasmosis	(Sofos, 2008)
Risk of *Salmonella*	(Sofos, 2008)
Tenderness of the meat	(Borgogno et al., 2015; de Andrade et al., 2016; Hamlin, 2016; Loureiro & Umberger, 2007; Lucherk et al., 2016; Ngapo, 2017)

congenital toxoplasmosis (i.e., mothers acquire an infection during pregnancy resulting in abortions and/or disease manifestations in the unborn child) (Mangen et al., 2017). Humans are exposed to *T. gondii* via cat faeces through the environment (e.g. soil, raw vegetables, and water), and via meat consumption of *T. gondii* infected food animals (Elmore et al., 2010).

Possible interventions to reduce the disease burden have been proposed (Opsteegh, Kortbeek, Havelaar, & van der Giessen, 2015). The presence of *T. gondii* in the environment and the presence of natural hosts enables intervention measures in different parts of the transmission chain. For instance, shedding of *T. gondii* oocysts by cats can be reduced through vaccination, interventions in the food chain may reduce exposure of consumers while educating the population may increase awareness of importance of food safety and proper heating of risk products. Within the food production chain, technical possibilities to inactivate various pathogens are for instance high pressure pasteurisation, gamma radiation or freezing of meat products (Bello, Martinez, Ceberio, Rodrigo, & Lopez, 2014; Kudra et al., 2012; Manios & Skandamis, 2015; Rastogi, Raghavarao, Balasubramaniam, Niranjan, & Knorr, 2007). The use of high pressure pasteurisation and gamma radiation are sometimes restricted by legislation.

In this paper, we therefore focus on freezing of high risk meat products to inactivate *T. gondii* tissue cysts in meat for human consumption. However, freezing of meat may affect the valuation by consumers when buying meat. On the one hand, the gain in food safety may be positively valued, but on the other hand freezing may be associated with perceived loss of quality. These two properties affect consumers' willingness to pay (WTP) for meat that was frozen during production in opposite ways and the net result is unknown.

This paper aims to study consumers' preferences towards meat that was frozen to reduce the risk of toxoplasmosis and more specifically to estimate consumers' willingness to pay (WTP) for frozen meat using a discrete choice experiment (DCE).

2. Materials and methods

The DCE methodology is a stated preference method used to elicit individuals' preferences by quantifying the relative importance of the characteristics of, for instance, meat products or services (Hensher, Rose, & Greene, 2005; Louviere, Hensher, & Swait, 2000). Respondents were asked to complete several 'choice tasks' that consist of two or more scenarios. The description of the product is based on its characteristics or 'attributes'. In DCE studies, it is assumed that the preference of respondents for a scenario is determined based on the values of the levels of the included attributes. Based on the choices that individuals make, their preferences are quantified (Veldwijk, 2015). The WTP for levels of attributes can be computed by dividing the model estimate of the attribute/level of interest by the inverse price estimate.

In order to include the factors that are relevant to the target population in making the choice of interest, selection and operationalisation of the attributes and levels need to be thorough. In this study we reviewed the literature, interviewed experts to make a list of possible attributes. Next, a panel was asked to rank these attributes on relevance in a nominal ranking when buying meat products. The results were used to select the attributes and levels to include in the DCE.

This particular DCE was based on purchasing choices of four meat products: dry cured ham, beefsteak, lamb chop and filet americain. In the Netherlands, filet americain is a bread spread consisting of raw minced beef (steak tartare) and about 35–40% of additives such as sauces and spices. Beefsteak and lamb chops are often eaten undercooked, and are consumed in high volumes. Consequently these products entail a relatively high risk of toxoplasmosis based on a quantitative microbiological risk assessment (Opsteegh, Prickaerts, Frankena, & Evers, 2011).

2.1. Selection of attributes

For the current study, we combined results from literature scan and from a nominal ranking procedure to establish the attributes of the scenarios. We used Google Scholar to search recent literature on preferences of consumers when buying meat. The aim was to identify the most important aspects that were known to affect the choices of consumers when buying meat, and not to create a complete list of all factors that affect meat consumers' choices. This scan resulted in a list of

Table 2
Attributes and levels of the DCE.

Attribute	Levels
Frozen	Yes, no
Livestock production system	Indoor, Free range, Organic
Expiration date	Consume within 3 days, consume within 6 days, consume within 10 days (after buying)
Quality of meat	Good, very good, outstanding
Price	15% below average, average, 15% above average

factors (see Table 1). This list was discussed with two experts from the meat industry and a researcher in food safety. No items were added or deleted because of these consultations.

2.2. Nominal ranking and selection of attributes

Subsequently, this list was the basis for the nominal ranking. We took a sample, separate from the DCE sample of 300 respondents (192 replied, response 64%) in this procedure, and we asked respondents to rank the factors in importance (1 most important, 2 s most important etc.). We analysed their responses by mean, median, and factor analysis of the rank scores. The median was used to check for consistency of the ranking, taking account of possible skewed distributions. The results were used to select the attributes and levels for the DCE (Table 2).

The levels of the price attribute were determined on the average price as found on three consumer websites of the product at hand, and the lower and higher level were set as minus and plus 15% of the average price, respectively. The exact values are shown in Table 3.

2.3. DCE

For the DCE 671 household members of the Centre data panel of the University of Tilburg completed the DCE (response 64%). Vegetarians and vegans were excluded from the sample. To avoid systematic variation across products, we wanted the respondents to make choices for all four products. We also wanted to make the questionnaire sufficiently attractive to avoid respondents getting bored or frustrated. To ensure respondents had to answer as little number of choice tasks as possible while still being able to estimate choice models, Ngene 1.0 was instructed to create a D-efficient design of 24 choice sets divided over four blocks (Bliemer & Rose, 2009; Huber & Zwerina, 1996). This design was used to create the scenarios of the four meat products. As a result, respondents were asked to respond to six choice sets per product. In order to avoid respondents losing focus, we split these six choice tasks in two parts, separating them with questions on demographics and consumer behaviour. Eventually we created four different questionnaires, systematically altering the blocks and the four meat products. Consequently, all respondents replied to six choice sets for each product (in sets of three per product). A short description of the attributes preceded the choice sets. It was explained that all products are presented fresh and at refrigerator temperature, but products labelled frozen (i.e. the attribute frozen is 'yes') have been frozen and thawed during processing (see appendix A for explanatory texts for respondents for all attributes and levels). In order to deal with the problem of hard to judge information such as quality of the meat, we present the attribute "quality" in words, as if it were a representation on a label of the product at hand.

Table 3
Prices of the meat products (in €).

Product	Low price	Average price	High price
150 g dry cured ham	2.19	2.58	2.99
250 g lamb chops	4.25	5.00	5.75
300 g beefsteak	6.10	7.20	8.30
150 g filet americain	1.85	2.25	2.65

We included an opt-out to resemble the real choice situation as close as possible (Veldwijk, Lambooij, de Bekker-Grob, Smit, & de Wit, 2014), since consumers in shops always can choose not to buy the products at hand for an example of a choice set (please see Appendix A).

The respondents were evenly distributed over the four versions of the questionnaire. Before completing the questionnaire, we asked the respondents to read an introduction on food safety and the reason to freeze meat and its relation to food safety (see Box 1 for translation of this text).

2.4. Analyses

The answers of the respondents to the DCE were analysed with latent class analyses, separate for each meat product. Latent class analysis (LCA) assumes the presence of classes of in the data with preferences.

We conducted four LCA's, one for each meat product. Based on model fit (2 log likelihood) improvement, we determined the optimum in number of classes (respondent groups) per meat product. The size of class-specific attribute parameters indicated the relative importance that a particular group of consumer attaches to the attributes and levels. Due to scaling differences, comparison of utilities (regression coefficients) is not possible between classes; comparison is possible however after computing the WTP through division of the regression parameter of interest by the parameter for price. The WTP is computed based on the parameters in the latent class models (appendix B). Its ranking is based on the relative importance of the mean effect sizes within the classes. The relative importance of the attributes and levels is presented as the relative contribution to the sum of the mean effect sizes. Per attribute, the difference between the highest and lowest attribute level estimate was calculated. The largest difference value received an importance score of one, representing the attribute that was deemed most important by respondents, the other difference values were divided by the largest difference value, resulting in a relative distance of all attributes to the most important attribute.

3. Results

3.1. DCE Sample

Table 4 shows the descriptive statistics of the sample. Compared to the general population,more women than men participated in the sample. In addition the education level was higher than in the general population.

3.2. Results latent class analysis (LCA)

Tables 5 to 8 present the WTPs, and relative importance of the attributes for the attributes per meat product. The 95% confidence interval is given in brackets below the WTP-values (Please see appendix B for full reports of the LCA models).

3.2.1. Ham

For ham, we distinguished three latent classes. The class probabilities, the WTPs per attribute, its 95% confidence interval, the rank score per product per class of the attributes and their importance weight are shown in Table 5.

Respondents had a probability of 0.50 to belong to class 1, 0.21 to belong to class 2 and 0.29 to belong to class 3. These probabilities reveal the probability of people to belong to either of the classes. The WTP for frozen ham does not differ from zero in class 2 (the 95% confidence interval entails 0). Class 1 values the frozen ham 6 cents lower per package than non-frozen ham, and class 3 values frozen ham 14 euro cents higher than non-frozen ham.

Consumers from class 1 are mainly concerned with price (rank 1 and relative importance score of 0.48); class 2 is primarily focused on quality and expiration date, and class 3 first takes account of the

Box 1
Introductory text to choice sets as presented to the respondent.

> After consumption of medium, rare, undercooked or raw meat, you can be infected with the parasite Toxoplasma gondii. This parasite causes the infectious disease toxoplasmosis. You may also get toxoplasmosis via cat poo, for instance when cleaning the litter box. Healthy people usually will rarely notice being infected; they could feel a bit tired or have a mild fever. Sometimes however, for instance in immunocompromised people, a more severe clinical picture evolves. Then, severe eye infections, pneumonia, or meningitis could occur. Unborn children of pregnant women who are infected for the first time by the Toxoplasma gondii parasite may suffer serious consequences. Especially early in pregnancy, toxoplasmosis may lead to miscarriage, or a child with a hydrocephalus, calcification in the brain or eye abnormalities. Later in pregnancy, the chance of infection of the child will increase, but the risk of abnormalities decreases.
>
> An estimated number of one in four of the Dutch population is infected with this parasite. The parasite cannot survive heating or freezing. To avoid eating contaminated meat, meat can be frozen during production. This may lead to some loss in quality but if it is done correctly, the consumer will notice virtually no difference compared to non-frozen meat.

organic production of the ham, and then of the price.

3.2.2. Lamb chops

Table 6 presents the results for people who buy lamb chops. The consumers in classes 1 and 3 are willing to pay 23 Euro cents and 17 Euro cents less for frozen lamb chops respectively than for non-frozen lamb chops. The consumers in class 2 are indifferent and are willing to pay a similar amount for frozen and non-frozen meat on average. Classes 1 and 3 are willing to pay 60 cents and 21 cents more respectively for chops from organically raised lambs compared to lambs raised indoors. In addition, people in class 1 are willing to pay 36 cents for superb quality lamb chops in comparison with good quality. In classes 1 and 2, price is the dominant factor, but in class 1 people also weigh the livestock production system to some extent. People of class 3 weigh expiration date most strongly when buying lamb chops, followed by either or not freezing of lamb chops, quality, price and finally livestock production system.

3.2.3. Beefsteak

Table 7 shows that buyers of beefsteak in class 1 are willing to pay 35 Euro cents more for non-frozen beefsteaks, in class 2, the WTP of frozen beefsteak does not differ from non-frozen beefsteak. People in class 1 are willing to pay 66 cents more for organically produced beefsteak over beefsteak from cattle housed indoors, and 70 cents for superb quality beefsteak compared to good quality.

Both classes weigh the price of the beefsteak most.

3.2.4. Filet americain

Four classes of consumers could be identified for filet americain. Classes 1 and 3 weigh whether the filet americain is frozen or not, and are willing to pay less for frozen meat (Table 8). Where class 1 subsequently weighs the quality, class 3 weighs the price as second most important attribute. Classes 2 and 4 weigh quality of the meat and organically produced meat respectively as most important factor. Class 2 subsequently weighs the price of the filet americain and class 4 secondly weighs whether the filet americain was frozen during production. As a minority, this class values frozen meat higher than non-frozen meat.

4. Discussion

This DCE study evaluated preferences for five important attributes of four commonly consumed meat products, with a special interest in consumer preferences for (not) freezing of these products. The results were included in a social cost benefit-analysis on the net gain of freezing of meat during the production process to inactivate the *T. gondii* parasite to improve food safety (Suijkerbuijk et al., 2017).

Considering the main question of this paper: to study consumers' preferences towards meat that was frozen to reduce the risk of toxoplasmosis and more specifically to estimate consumers' willingness to pay (WTP) for frozen meat, we found that freezing of meat to improve the food safety is valued negatively by the majority of consumers or at best not found to be an important factor in their purchasing choice. We found that price is a very important deciding factor for consumers when they purchase meat, which is in line with previous research (Mangen & Burrell, 2001; Schifferstein, Candel, & van Trijp, 1998; W. Verbeke & Vianen, 1998), especially for the more expensive products.

The majority of the consumers of meat products appear to take little

Table 4
Descriptive statistics sample (N = 671).

	Sample	General population
Gender	45% male, 55% female	50% male, 50% female
Age	Mean = 52.0 years, (sd = 18.49)	
Education[a]	Primary; 6.8%	16.8%
	Lower secondary; 28.0%	18.9%
	Upper secondary: 13.4%	10.9%
	Post secondary, non-tertiary; 22.3%	27.5%
	Tertiary-bachelor; 25.8%	13.6%
	Tertiary-master or higher; 10.5%	8.0%
Days per week meat for dinner	4.3 days (sd = 1.85)	
Days per week meat on sandwich for lunch	3.3 (sd = 2.33)	
Who is responsible for grocery shopping	Respondent, alone or with family member = 85.5%, Not the respondent = 14.5%	
Location to buy meat	Supermarket = 78%	
	Butchers' = 20%	
	Farmers shop = 2%	
Do you know people who had had toxoplasmosis?	Yes = 1.5%	
Do you know people who got ill after eating meat?	Yes = 11%	

[a] ISCED 2011 classification (Eurostat, 2018).

Table 5
Class probabilities, willingness to pay (WTP) rank, and relative importance weight of attributes of three classes of consumers of dry cured ham.

	Class 1 (0.50[a])		Class 2 (0.21[a])		Class 3 (0.29[a])	
	WTP (95%CI)	Rank (RI[b])	WTP	Rank (RI[b])	WTP (95% CI)	Rank (RI[b])
Frozen[1]	−0.06 (−0.12; −0.01)	5 (0.07)	−0.96 (−0.20; 0.28)	3 (0.22)	0.14 (0.04; 0.25)	3 (0.13)
Production: Free range[2]	0.11 (0.03; 0.19)	3 (0.15)	0.39 (−0.26; 1.03)	4 (0.11)	0.14 (0.01; 0.27)	1 (0.40)
Production: Organic[2]	0.13 (0.04; 0.21)		0.46 (−0.30; 1.23)		0.30 (0.13; 0.46)	
Expiration date 6 days[3]	−0.02 (−0.10; 0.06)	2 (0.16)	0.03 (−0.43; 0.48)	2 (0.29)	0.09 (−0.04; 0.22)	5 (0.04)
Expiration date 10 days[4]	0.11 (0.03; 0.20)		1.26 (−0.35; 2.86)		−0.04 (−0.20; 0.11)	
Quality very good[4]	0.09 (0.01; 0.18)	4 (0.14)	0.02 (−0.46; 0.50)	1 (0.30)	0.10 (−0.04; 0.23)	4 (0.06)
Quality outstanding[4]	0.12 (0.03; 0.21)		1.31 (−0.32; 2.94)		−0.07 (−0.21; 0.08)	
Price		1 (0.48)		5 (0.09)		2 (0.36)

[a] Class probability of LCA.
[b] Share of 1.00.
[1] Reference category is Non-frozen.
[2] Reference category is Production indoor.
[3] Reference category is Expiration date 3 days.
[4] Reference category is Good quality.

account of food safety, given the relative importance of freezing or the expiration date for many consumers in the current study.

Of the two possible directions (freezing is positively valued because of improved food safety, or negatively valued because of perceived associations with quality loss), consumers most prominently appear to associate freezing of meat with a loss of quality, resulting in a reduction in WTP. We aimed to disentangle the two aspects by explaining in the introductory text to the DCE how freezing meat can reduce the risk of developing symptoms of toxoplasmosis without quality loss. Consequently, the quality of the meat product was included as a separate attribute that varied independently of freezing. Nonetheless, most people valued frozen meat less than unfrozen meat, despite the fact that it is safer. A number of reasons may account for this finding. In the introductory text top the experiment, it was mentioned that only a small minority of people that are infected will develop serious symptoms. In our sample, only 1.5% of the respondents knew somebody who had had toxoplasmosis. Consequently, the respondents may conclude that as they feel healthy and do not belong to the risk group of pregnant women (average age of sample was 52 years) the risk for them is negligible and that additional preventive measures are not needed. A second possible explanation could be that the consumers trust the regulatory measures in the Netherlands to the extent that they assume that they do not need to take additional measures to increase food safety. Dutch consumers appear to have low level of concern about food safety, and about production methods in particular (de Jonge, van Trijp, Goddard, & Frewer, 2008). This may result in a high level of trust of consumers in institutions such as the food production sector and government (de Jonge, van Trijp, van der Lans, Renes, & Frewer, 2008). Large-scale food contaminations are rare and when they take place, government and industry take swift action to remove the contaminated food from the human food chain. Consequently, further improving these high levels of food safety may suffer from diminishing marginal utility, similar to all goods. Trust of the citizens in their institutions to protect them from harm may be “too high” for them to feel the need to take additional action to protect themselves from risks that are inherent to some actions. Additionally, the memory of most consumers is poor: for example, after the initial “panic” among consumers following the BSE crisis in 1996, about a month after the BSE incidents in the Netherlands the meat sales where at pre-BSE-levels (Mangen & Burrell, 2001). In the UK, the initial sales after the BSE dropped, but recovered again as well. However some structural reduction in meat sales appear to have taken place in the UK and the Netherlands (Burton & Young, 1996, 1997; Mangen et al., 2017), but this is probably merely related to general tendencies to reduce meat consumption in some Western countries. In countries with less well-established food safety regulations, adding additional food safety measures may be valued differently. This study is subject to some limitations. In order to present choices that respondents could understand, we presented four meat products suspected to be important for meat borne *T. gondii* infections in humans, but also covering different animal species and types of products. This leaves the question to which extent these results can be generalized to other meat products, in case other products will be identified as important sources of *T. gondii* infection. For example, viable *T. gondii* in ham has been detected from Serrano ham (Gomez-

Table 6
Class probabilities, willingness to pay (WTP) rank, and relative importance weight of attributes of three classes of consumers of lamb chops.

	Class 1 (0.27[a])		Class 2 (0.17[a])		Class 3 (0.54[a])	
	WTP (95% CI)	Rank (RI[b])	WTP (95% CI)	Rank (RI[b])	WTP (95% CI)	Rank (RI[b])
Frozen[1]	−0.23 (−0.39; −0.06)	5 (0.09)	1.04 (−0.96; 3.04)	3 (0.11)	−0.17 (−0.32; −0.03)	2 (0.23)
Production: Free range[2]	0.17 (−0.08; 0.42)	2 (0.25)	−0.10 (−1.47; 1.27)	2 (0.30)	0.26 (0.06; 0.46)	5 (0.02)
Production: Organic[2]	0.60 (0.30; 0.90)		−1.27 (−3.82; 1.28)		0.21 (0.00; 0.42)	
Expiration date 6 days[3]	−0.20 (−0.45; 0.05)	4 (0.15)	−0.80 (−2.72; 1.11)	4 (0.06)	0.08 (−0.12; 0.28)	1 (0.36)
Expiration date 10 days[4]	0.17 (−0.08; 0.41)		−1.60 (−4.71; 1.50)		−0.18 (−0.38; 0.03)	
Quality very good[4]	−0.10 (−0.35; 0.15)	3 (0.19)	0.79 (−1.23; 2.82)	5 (0.06)	0.08 (−0.06; 0.22)	3 (0.22)
Quality outstanding[4]	0.36 (0.10; 0.62)		−0.99 (−3.26; 1.29)		0.09 (−0.10; 0.29)	
Price		1 (0.31)		1 (0.47)		4 (0.17)

[a] Class probability of LCA.
[b] Share of 1.00.
[1] Reference category is Non-frozen.
[2] Reference category is Production indoor.
[3] Reference category is Expiration date 3 days.
[4] Reference category is Good quality.

Table 7
Class probabilities, willingness to pay (WTP) rank, and relative importance weight of attributes of three classes of consumers of beefsteak.

	Class 1 (0.76[a])		Class 2 (0.24[a])	
	WTP (95% CI)	Rank (RI[a])	WTP (95% CI)	Rank (RI[b])
Frozen[1]	−0.35 (−0.60; −0.11)	5 (0.11)	−0.30 (−0.72; 0.12)	4 (0.11)
Production: Free range[2]	0.09 (−0.28; 0.47)	2/3 (0.21)	0.41 (−0.19; 1.01)	2 (0.21)
Production: Organic[2]	0.66 (0.28; 1.04)		0.53 (−0.04; 1.10)	
Expiration date 6 days[3]	−0.31 (−0.68; 0.05)	4 (0.14)	−0.29 (−0.85; 0.27)	3 (0.18)
Expiration date 10 days[4]	0.13 (−0.21; 0.48)		0.16 (−0.35; 0.68)	
Quality very good[4]	−0.01 (−0.35; 0.34)	2/3 (0.21)	0.03 (−0.49; 0.56)	5 (0.09)
Quality outstanding[4]	0.70 (0.31; 1.08)		0.23 (−0.30; 0.76)	
Price		1 (0.34)		1 (0.42)

[a] Class probability of LCA.
[b] Share of 1.00.
[1] Reference category is Non-frozen.
[2] Reference category is Production indoor.
[3] Reference category is Expiration date 3 days.
[4] Reference category is Good quality.

Samblas, Vilchez, Racero, Fuentes, & Osuna, 2015) and other dry-cured ham (Herrero et al., 2017), but not from Parma ham (Genchi et al., 2017). Moreover, the effects of additives other than salt and processing methods such as mincing and fermenting have not been studied thoroughly and are therefore not included in the current risk assessment for meat borne toxoplasmosis (Opsteegh et al., 2011). Extension of the risk assessment model and changes in consumption behaviour can alter the relative contribution of the different meat products.

Another limitation is that we only focused on freezing as a food safety measure. Other measures that may be taken are high-pressure pasteurisation or gamma radiation and it remains unknown whether these measures would have resulted in a positive WTP for safer food. However, similarly to freezing, these measures are also valued negatively by consumer. It is known that the change in colour after high pressure treatment negatively affects consumers' WTP. Also radiation has been found to be valued negatively (Hayes, Fox, & Shogren, 2002; Nayga, Poghosyan, & Nichols, 2004). This may be caused by consumers believing that technologies radiation or high pressure treatment, that have the aim to improve food safety, are beyond control of the consumers, unnatural or artificial (Verbeke, Frewer, Scholderer, & De Brabander, 2007).

In order to disentangle the effects of price and quality, we completely randomized the combinations of the levels of the attributes on the scenarios concerning quality, being frozen and price. In the experiment this could lead to cheaper organic meat than meat produced indoors, possibly affecting the respondent's opinion on how realistic the choices were. In the analysis, we interpret the parameter of frozen meat as the effect of freezing of the meat, controlled for the effect of quality of the product and controlling for price. However, in real life choices, the price is often used as a proxy for quality when the quality of the product is hard to judge, and freezing meat is seen as a reduction of quality of meat. We cannot rule out that part of the lower valuation of the freezing of the meat is caused by an assumption about the lower quality of the meat, despite the design of the DCE to disentangle the two effects.

Some practical implications of this study are that if a producer or a country decides to freeze meat during the processing of the product to inactivate *T. gondii*, Dutch consumers are not likely to value this positively. The costs of freezing and thawing meat during production are in the range of 10 to 15 cents per kilo. If all producers would increase the price of their products similarly to compensate for these costs, customers would be forced to accept an increase in price. But if consumers can choose a cheaper product with similar characteristics, most consumers are likely to choose the cheaper product, and will consequently not reward producers who increase the safety of their meat products.

5. Conclusions

Most people prefer their meat products not to be frozen during production, and are willing to pay more for fresh, non-frozen meat. A

Table 8
Class probabilities, willingness to pay (WTP) rank, and relative importance weight of attributes of three classes of consumers of filet americain.

	Class 1 (0.29[a])		Class 2 (0.19[a])		Class 3 (0.28[a])		Class 4 (0.23[a])	
	WTP (95% CI)	Rank (RI[b])	WTP (95% CI)	Rank (RI[b])	WTP (95% CI)	Rank (RI[b])	WTP (95% CI)	Rank (RI[b])
Frozen[1]	−0.56 (−1.00; −0.13)	1 (0.29)	−0.22 (−0.37; −0.08)	4 (0.16)	−0.57 (−0.88; −0.26)	1 (0.47)	0.50 (0.25; 0.75)	2 (0.21)
Production: Free range[2]	0.23 (−0.10; 0.57)	4 (0.13)	0.08 (−0.10; 0.27)	3 (0.17)	0.02 (−0.17; 0.21)	5 (0.04)	−0.31 (−0.55; −0.07)	1 (0.35)
Production: Organic[2]	0.25 (−0.09; 0.59)		0.24 (0.04; 0.44)		0.06 (−0.16; 0.27)		0.50 (0.26; 0.74)	
Expiration date 6 days[3]	0.13 (−0.19; 0.44)	4 (0.13)	−0.01 (−0.19; 0.16)	5 (0.05)	0.01 (−0.18; 0.19)	4 (0.05)	−0.11 (−0.34; 0.11)	3 (0.17)
Expiration date 10 days[4]	0.25 (−0.11; 0.60)		0.06 (−0.12; 0.24)		0.06 (−0.15; 0.27)		0.29 (0.03; 0.56)	
Quality very good[4]	0.06 (0.00; 0.11)	2 (0.25)	−0.05 (−2.33; 2.23)	1 (0.35)	0.04 (−0.13; 0.22)	3 (0.10)	0.18 (−0.03; 0.39)	5 (0.10)
Quality outstanding[4]	0.48 (0.03; 0.93)		0.45 (0.20; 0.69)		0.12 (−0.09; 0.33)		0.24 (−0.03; 0.50)	
Price		3 (0.21)		2 (0.28)		2 (0.33)		4 (0.17)

[a] Class probability of LCA.
[b] Share of 1.00.
[1] Reference category is Non-frozen.
[2] Reference category is production indoor.
[3] Reference category is Expiration date 3 days.
[4] Reference category is good quality.

minority of about one in three consumers of filet americain and ham are willing to pay more for frozen products. In general, we found that price matters more for the more expensive products. Quality of the meat is also found to be important for many consumers.

Only a small proportion of the consumers take factors such as livestock production system into account. The food safety measure of freezing of meat appears to affect the choice of the consumers only to a limited extent, and freezing to reduce the risk of toxoplasmosis is generally valued negatively by most consumers.

Processing plants that would like to differentiate their products by informing consumers that their products are *Toxoplasma*-free would need to first invest substantially in information campaigns before being able to sell their differentiated products as a value-added product. Nevertheless, it is questionable whether consumers would be willing to pay extra for such products.

Declarations of interest

None.

Funding source

This paper was funded by the RIVM (National Institute for Public health and the Environment) Strategic Research Program. The funding source had no influence on decisions in study design, data collection, analysis or interpretation of the data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.meatsci.2018.11.001.

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