Consumers want safer meat – but not at all costs

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Abstract— **Consumers, the public authorities, and the food industry are all concerned with the safety of meat. The increasing demand for safer food from the consumers and the public authorities puts pressure on producers to identify efficient methods to reduce risks. Earlier studies have shown that consumers state a willingness to pay for safer meat – but we know very little about how different methods to reduce risks affect the consumers' preferences for safer meat. In the present study, a choice experiment for a representative sample of the Danish population was conducted to elicit whether consumers' willingness to pay for reducing the risks of Salmonella infections was affected by the specific risk reduction methods (risk reductions using the current policy, at farm level, or decontamination at slaughterhouse using water/steam or lactic acid). More specifically, the consumers were asked to choose between different packages of minced pork that differed with respect to Salmonella risks, risk reduction method, and price. The sample consisted of 844 Danish consumers, who answered a questionnaire over the internet. Our results indicate that consumers demand safer meat, but not at all costs – there is a limit to what they will pay and they care about how the risk reduction is obtained. They prefer risk reductions to take place at farm level followed by decontaminations using water/steam and (least preferred) lactic acid.**

Keywords— **Food safety, consumer valuation, choice experiments**

I. INTRODUCTION

Animal products are associated with a wide variety of safety characteristics as well as other quality characteristics. The safety characteristics of meat include zoonotic bacteria (such as Salmonella and Campylobacter), pesticide residues, whether GMO's or hormones are used in production, medicine residues. The severity of zoonotic diseases in humans can vary from mild symptoms to life threatening conditions [1]. Campylobacteriosis and Salmonellosis are the most frequently reported zoonotic diseases in humans in the EU with more than 330,000 confirmed cases in 2006. As only parts of all cases are registered, the true number is generally believed to be up to 20 times larger [2]. These are large numbers and the costs to society are substantial.

In the pursuit of further reductions, there is a growing research in technological possibilities of reducing zoonotic risks in different parts of the supply chain (effect measures) as well as the economic costs of producing safer meat. In addition, there is a growing awareness amongst policy makers of the importance of understanding consumer demand for food safety as consumer willingness to pay for safer food is a necessary condition for market based improvement of food safety. But food safety characteristics are not directly visible and labelling of safety characteristics is not carried out systematically. From a consumer point of view, the lack of visibility is a problem as it makes it difficult to choose safety characteristics. Social sciences can help us to improve our understanding of consumers' perceptions, attitudes, and behaviour towards food safety and such knowledge provides just as important inputs to food safety policy as knowledge concerning effectiveness and cost effectiveness of risk reduction strategies.

The aim of the present study is to analyze how consumer valuation of reductions in zoonotic risks depends on the technological methods used to obtain these risk reductions. More specifically, an economic valuation method denoted choice experiment (CE) is used to estimate consumer willingness-to-pay (WTP) for a reduction in Salmonella risks in Danish pork. In addition, it is analyzed whether consumer WTP is affected by information concerning how the risk reductions have been achieved (current policy, reductions in risk at farm level, reductions in risk at slaughter houses using water/steam or lactic acid).

This is a highly relevant case. The Danish pork industry presently faces great challenges in reducing Salmonella risks as the Danish Salmonella control programmes are presently under revision. In particular, increased use of decontamination of fresh

meat is considered as potential policy measure to obtain further reductions in Salmonella risks. Decontamination has so far only been applied to treat high risk meat (animals from herds with Salmonella at level 3) and to treat carcasses with multi-resistant DT104 Salmonella bacteria. Hence, introducing decontamination methods as part of the general Salmonella control is a new path for Danish Salmonella control.

A brief review of the existing literature on valuation of food safety and risk reduction methods is presented in Section 2. Section 3 contains a description of the survey, while the results are presented in section 4. Discussion of results and concluding remarks follow in Section 5.

II. VALUATION OF FOOD SAFETY AND TECHNOLOGY

The literature on consumers' stated preferences for safety characteristics can be categorised as follows: There are quit a few studies on consumers' stated preferences for food safety, there are some studies on microbial risks in meats (such as Salmonella), and there are only very few studies that specifically mention the risk reduction method. The present review is concerned with the latter.

Choice experiment is a method for eliciting consumers' stated preferences [3]. The basic idea is to let a representative sample of respondents choose between a number of products with pre-specified characteristics (such as food safety, place of origin, cuts, etc.). Thereby it is possible to derive their demand for the individual characteristics of a given type of product. This method is denoted choice experiments [3]. Alternative stated preference methods include the Contingent Valuation Method (CVM) where respondents are asked to place a value on a single well-defined product and experimental auctions where a number of consumers are asked to bid on given products and thereby reveal their willingness to pay for products with specific attributes. The experimental auction approach is defined by [4] as a variant of CVM due to the hypothetical nature of the exercise. In common for all three stated preference methods is their ability to value products or product attributes that are not yet traded in the market.

The most relevant study in the present context is [5] investigated the relative importance of different reduction strategies to reduce the risk of foodborne diseases: Using HACCP[1] to reduce risks at the source, using irradiation, chemical rinses, and status quo. They conducted a CVM survey among dieticians in the US health care system to elicit their WTP for these risk reduction methods. By choosing dieticians as target group, the authors hoped to obtain more well-informed answers. The findings from the survey suggest that the respondents clearly favoured the HACCP system solution from any of the other solutions, with a mean WTP of 5.5 cent per pound. The second-best solution was irradiation with a WTP of 4.4 cent, while the least attractive solution was chemical rinses with a WTP of 1.1 cent per pound.

Other studies of consumer valuation of food risk reduction strategies are mainly dealing with irradiation of meat. Consumers' attitudes towards irradiation of chicken breasts are investigated in [6]. They employed a CVM setting as well as an experimental auction setting. In both settings they found similar price premiums of approximately 10% for food safety obtained through irradiation. Other studies have shown great reluctance among lay people towards using irradiation to increase food safety. Hence, the price premium of 10% might very well be an average of many zeroes (or even negative price premiums) and a few large premiums.

Irradiation of pork products is investigated in [7] using experimental Vickrey auctions. They also tested the effect on WTP of providing the respondents with respectively positive and negative information regarding irradiation of pork products. They found that positive information alone increased consumers' WTP but when positive information was combined with negative information the effect was similar to that of providing only negative information, suggesting that negative information dominates positive information.

Consumer WTP for reducing contamination risk when eating ground beef is analysed using a field experiment in [8]. The approach used is very similar to CVM, dichotomous choice, with the twist of using real products (ground beef), real cash, and actual exchange in a market setting. They found that respondents were willing to pay $0.77 for a pound of irradiated ground

1. [1] Hazard Analysis and Critical Control Point.

beef, and concluded that many individuals were willing to pay for irradiated foods once they were informed about the nature of food irradiation technology and its ability to reduce risk of foodborne illness.

Using an experimental auction setting, [9] estimated consumers' WTP for an irradiated meat sandwich to be $0.71.

III. THE SURVEY

A. Sample selection

The discrete choice experiment was conducted using an internet panel. The sample was obtained from The Nielsen Company's online database. In Denmark, there are approximately 2.4 million private households, of whom 75% are "online". The panel members are all more than 15 years of age, resident in a household with PC and they all have a private internet access. In order to reduce self selection bias and secure a representative sample, the panel members are invited.

B. Product attributes

The risk reduction methods were chosen on beforehand. They include reductions at farm level, reductions at the slaughter houses using water/steam[2] or lactic acid, or current policy. The characteristics and the associated levels that are investigated in the choice experiment are presented in Table 1.

Table 1 Characteristics in the choice experiment

Characteristics	Levels
Salmonella risk	0 1 out of 1000 5 out of 1000 10 out of 1000
Risk reduction method	Current policy farm-level water/steam lactic acid
Price (DKK)	20, 26, 38, 51, 65, 80

2. [2] Water/steam strategy is applied to reduce high risk meat and to remove multi-resistant DT104 Salmonella bacteria in the Danish production today

Prior to the design of the CE, three focus group interviews headed by a sociologist were performed. One of the aims was to find easily understandable formulations of risk reductions and risk reduction methods. The descriptions of risk reductions and risk reduction methods that were presented to the respondents are presented in Table 2.

Table 2 Description of the two characteristics as presented to the respondents

Characteristics	Levels
Salmonella risks	In 2005, 10 out of 1000 packages of minced pork in Danish stores were infected with Salmonella. The risk of a Salmonella infection can be eliminated by having good kitchen hygiene. Nevertheless, approximately 2500 cases of Salmonellosis were registered in 2005, which could be traced back to pork meat. Usual symptoms of Salmonellosis include fever, headache, nausea, vomiting, and diarrhoea for a duration of 3-6 days (sometimes weeks). In rare cases, Salmonellosis can cause death. *Risk levels* Today 10 out of 1000 packages of minced pork is infected with Salmonella. **Hence, this is also the case for the packages you usually purchase.** Today it is not possible to purchase pork with reduced Salmonella risks but imagine that it is possible. You can choose between products with the following risk of containing Salmonella: 0, 1 out of 1000 or 5 out of 1000.
Risk reduction method	Imagine that packages of minced pork are labelled with information about the method used to reduce the Salmonella risk. There are no health risks associated with any of the methods. The meat will maintain its usual colour and taste after the different treatments. *You are now going to chose between the following risk reduction method:* Risk reduction will take place at the **farm-level.** The amount of Salmonella bacteria in pigs is reduced by changing the feed and hygiene conditions in the pen. Animal welfare is not affected at all. Risk reduction will take place at the **slaughterhouse**. The amount of Salmonella bacteria in pork is reduced by sprinkling the carcasses with **hot water/steam** for a few seconds. Risk reduction will take place at the **slaughterhouse**. The amount of Salmonella bacteria in pork is reduced by sprinkling the carcasses with a low concentration of **lactic acid** for a few seconds

Respondents were faced with two alternative minced pork products plus a third status quo alternative (all packages of 500 g). The latter characterised the respondents' usual purchase, which implicitly involves the present (highest) risk of getting

Salmonella (10 out of 1000) and the current policy on risk reduction[3]. The price for the status quo alternative was identified earlier in the questionnaire, as the price of the usual purchased product by the individual respondent. Hence, the respondents should choose between two hypothetical minced pork products and the minced pork product they usually purchase. This approach, using the respondents ”own” status quo values, have been recommended and used in other studies to mimic the actual purchasing situation as closely as possible, [10] and [11].

C. Design

By systematically combining the 3 types of risk reduction methods, the 3 levels of Salmonella risks, and the 6 different price levels, we obtained a statistical design that enables us to identify how the individual attribute levels affect the choice of minced pork. A D-optimal fractional factorial design was used, resulting in 9 choice sets containing 2 hypothetical alternatives and a statues quo alternative each, [12]. The sample consists of 844 respondents. As each respondent answered 9 choice sets, the data set consists of 7596 observations.

D. Model

The underlying behavioural assumption was that the respondents' utility of a pork product depends on the product attributes (Salmonella risk, risk reduction method, and price). A main effects model was used to analyse the effect of the individual attributes (the independent variables) on the probability of choosing a given product (the dependent variable). The coefficients of the attributes can be interpreted as marginal utilities. We applied a mixed logit error component model with 1000 draws in the simulation process[4].

3. [3] The content of the current Salmonella control of pork production was not detailed to the respondents, it was only mentioned that the current policy did not include any of the above mention reduction methods.

4. [4] The standard method for analysing CE data, multinomial logit could not be used on the present data set as it violated the IIA assumption

IV. RESULTS

The results of the main effect model are presented in Table 3. The attribute level coefficients are all determined relative to a base level which will be described below. We found that the respondents did not distinguish between the highest risk (10 out of 1000) and the second highest risk (5 out of 1000). Consequently, these levels were merged and used as reference level for Salmonella risk. The reference level for risk reduction method was chosen as the water/steam strategy.

Table **3** Main effect model

Attribute	Coef.	Robust std error	Robust t-test	WTP
Salmonella risk				
0	1.9171	0.1029	18.6269	28
1 out of 1000	1.0830	0.0889	12.1832	16
Risk reduction method				
Current Salmonella policy	2.1311	0.1288	16.5489	31
Farm-level risk reduction	0.8151	0.0739	11.0311	12
Lactic acid	-0.7277	0.0895	-8.1293	-11
Price	-0.0678	0.0026	26.5224	
COV 1	-1.8670	0.0869	21.4931	
COV 2	-1.8180	0.0872	20.8609	
LRI	0.3859			
Log L	-5117			

Note: LRI refers to the Likelihood Ratio Index introduced by [12]. The WTP estimates are presented in DKK, and are the amount the consumers will pay extra for 500g of minced pork with the given characteristics relative to Salmonella risks of 10 out of 1000 and relative to risk reduction at the slaughterhouse using water/steam decontamination

All main effects presented in Table 3 have a statistically significant effect on the choice of the product at the 99.9% level as can be seen from the t-test. All signs of the Salmonella risk coefficients are as expected with positive coefficients compared to the reference levels. The signs for the risk reduction methods are also as expected, with positive coefficients for the current policy and the farm-level strategy, while risk reduction using lactic acid is associated with negative marginal utility (and has a negative impact on the probability of choosing a given product) – all relative to the water/steam strategy. Finally, we found a negative coefficient associated

with the price indicating a negative marginal utility associated with increased price.

The log-likelihood ratio index (LRI) indicates that the model provides an acceptable fit to the data with a value at 0.39. The results also show that the covariances of alternative one and two (COV 1 and COV 2) are different from zero, supporting our choice of a heteroscedastic model.

The estimated coefficients can be translated into WTP estimates by calculating the relative marginal utilities between a given characteristic and price (the marginal rate of substitution or the implicit price of the attribute). The WTP estimates capture marginal considerations and indicate the amount respondents are willing to pay extra for 500g of minced pork with the given quality characteristics keeping all else equal (WTP are presented in the last column of Table 3). The estimated model indicates that respondents' mean WTP for reducing Salmonella risk is DKK 16 for reducing the risk from 10 out of 1000 to 1 out of 1000 and DKK 28 for avoiding risk completely. The ranking of risk reduction strategies is as follows: The current policy is the preferred method for obtaining safer meat followed by risk reduction at farm level, decontamination using water/stream, and finally decontamination using lactic acid. The results show that compared to the strategy water/steam, there is a WTP for the current policy of DKK 31, followed by the risk reduction on the farm-level, with a WTP on DKK 12. This suggests that respondents have positive preferences for products produced under the current Salmonella control policy or where the risk reduction occurs at the farm-level relative to the water/steam strategy. Finally, we found that decontamination with lactic acid compared to water/steam is associated with a negative WTP of DKK -11.

If we change the reference level for risk reduction strategies from water/steam to the current policy, we find that the WTP estimates for all other reduction methods are negative when compared to the current policy (Table 4). Comparing these results with the estimated WTP values for risk reduction, only the combination of the largest risk reduction (no risk of Salmonella) and a risk reduction at the farm-level gives rise to an overall positive WTP (28-19=9).

Table 4 WTP for reduction strategies relative to the current policy

Attribute	WTP
Farm-level	-19
Water/steam	-31
Lactic acid	-42

Note: The WTP estimates are presented in DKK, and are the amount the consumers will pay extra for 500g of minced pork with the given characteristics compared to a product which has not been decontaminated.

These results suggest that the current policy is clearly preferred over any of the other reduction methods. At the same time there appears to be positive preferences for a reduction of the Salmonella risk in general. A possible interpretation of this paradox (preferences for increased risk reduction using the same risk reduction methods as today), could be that the Danish consumers expect meat to come from non-infected animals. Hence, by forcing the respondents to consider Salmonella infected animals/meat, we have reduced their utility of eating meat. We hope that further analyses of the background material from the questionnaire concerning attitudes and habits might shed more light upon this possible interpretation.

These findings are supported by one of the follow-up questions in the questionnaire concerning where they preferred the risk reductions to take place. Their ranking is shown below in Figure 1. Ranking 1- 4 refers to the ranking giving by the respondents.

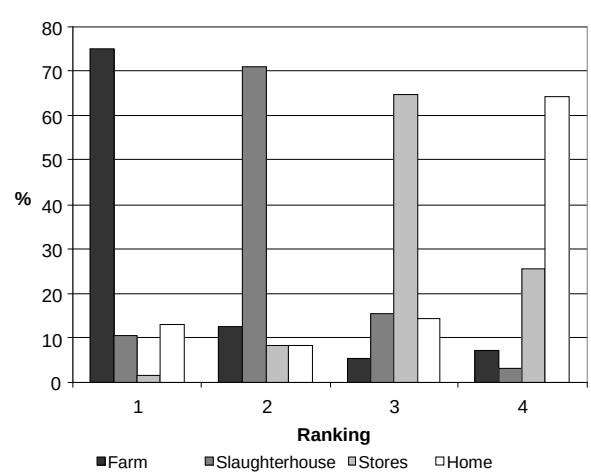

Fig. 1 Respondents' ranking of their preferred Salmonella risk reduction in the food chain

The respondents were asked to rank the following four strategies for risk reduction: Farm-level, slaughterhouse, in the stores, or at home in the kitchen. Figure 1 shows (when looking at the distribution of risk reduction methods that are ranked 1st), that respondents clearly prefer that Salmonella risk reductions take place at the farm-level as 75% ranked this strategy as their most preferred option. Only 13% thought that Salmonella risks should primarily be carried out home, 10% preferred risk reductions to be the responsibility of slaughterhouses. Hardly any respondents placed the primary responsibility of Salmonella risk reductions on the stores. In addition, Figure 1 reveals that 70% rank Salmonella risk reductions the slaughter house as 2nd, 65% rank Salmonella risk reductions in the stores as 3rd, and Salmonella risk reductions at home in the kitchen as the least (the 4th) preferred option.

These rankings correspond with WTP estimates. The figure suggests that the respondents prefer a risk reduction close to the primary production-levels, and the further from this level the reduction takes place, the less it is preferred. These results actually correspond with the principle of "from farm to fork", which states that food safety begins on the farm, and not at the slaughterhouse, the grocery store, or in the kitchen, [14].

Our interpretation of positive (but not infinitely large) WTP for reducing Salmonella risks, and their strong rankings of risk reduction methods is that consumers indeed prefer a safer product, but not at all costs.

V. DISCUSSION AND CONCLUSION

The objective of this paper was to investigate how consumers respond to different technological production strategies used to obtain additional reductions in the zoonotic risks of pork products – in the case of Salmonella. Our overall result is that consumers value reductions in Salmonella risks in pork and that their most preferred risk reduction method is the current policy, followed by risk reductions at farm level, decontamination at slaughterhouses in terms of water/steam and finally, lactic acid.

More specifically, the study aimed at estimating the willingness-to-pay for a Salmonella risk reduction and the technology used to obtain the reduction. The choice experiments suggested that respondents were willing to pay DKK 16 and DKK 28 for reducing the Salmonella risk from 10 out of 1000 to 1 out of 1000 and for avoiding risk completely, all respectively. We found that the respondents were willing to pay DKK 31 for using the current policy compared to the strategy water/steam, and DKK 12 for the reduction strategy on the farm-level. Finally the results showed that decontamination with lactic acid over water/steam resulted in a negative WTP at DKK -11. In comparison with the one study found on WTP of different reduction strategies by [5] our results show the same ranking of the different strategies, with the least preferred strategy being chemical rinses. Opposed to the study by [5], we find that the respondents in our survey general are against the different reduction strategies, and hence have negative WTP for them relative to the current policy. It may be somewhat surprising, that respondents attach a positive WTP for the solution chemical rinses over the current inspection process in the study by [5], but looking behind their result revealed that only 30 % of the respondents had a positive WTP for this solution.

The premiums for all attributes examined in this study are large but the relative premiums are indicative of consumers' relative preferences for these attributes. It should be noted that that the added sum of premiums paid for the individual characteristics is likely to be higher than the actual willingness-to-pay due to increasing marginal utility of income. Secondly the hypothetical nature of the choice experiment may give rise to respondents overstating their actual WTP. Third, self-selection related to participation in the survey, may entail that respondents participating in the survey are more interested in food safety than the average person.

The results from the different reduction strategies suggest that the current policy is clearly preferred over any of the other reduction methods. At the same time there appears to be positive preferences for a reduction of the Salmonella risk in general. Comparing these two results might suggest that consumers prefer a safer product, but not at all costs. When we changed the reference level with respect to the reduction strategies

to the current policy, the results showed that all the WTP estimates of the other reduction methods became negative when compared to the current policy. Furthermore it showed that when comparing these results with the estimated WTP values for risk reduction, only the combination of the largest risk reduction (no risk of Salmonella) and a reduction at the farm-level gave rise to an overall positive WTP.

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