

## Research Paper

# From Stable to Table: Determination of German Consumer Perceptions of the Role of Multiple Aspects of Poultry Production on Meat Quality and Safety

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## ABSTRACT

Contamination with potentially pathogenic microorganisms may occur at all stages of the food chain. We conducted a representative cross-sectional survey of 1,008 consumers aged 16 years and older in Germany via an online panel. The aim was to assess the perception of consumers regarding the influence of aspects of meat production on the safety and quality of meat. More than 70% of the participants indicated that poultry fattening farms had a high or very high influence on meat safety, followed by cooks or meat preparers (66.3%). Meat consumption was significantly associated with a high perception of the influence of cooks or meat preparers ( $P = 0.025$ ). The oldest participants were almost three times as likely to vote high influence and six times as likely to select very high influence (instead of no or limited) as the youngest participants (high influence: odds ratio [OR] = 2.89,  $P = 0.016$ ; very high influence: OR = 6.06,  $P < 0.001$ ). Of all participants, 78.1% believed organic farming had a positive influence on the safety of meat compared with conventional farming. Participants older than 60 years voted significantly more frequently than youngest participants (16 to 19 years) that organic farming had no influence ( $P = 0.006$ , OR = 5.71) or a positive influence ( $P = 0.007$ , OR 3.93) on meat safety. In addition, it could be shown that most consumers believed that irradiation of meat had a negative influence on the safety of meat. In conclusion, consumers were aware that many aspects were important for food safety and quality. The influence of organic farming compared with conventional farming, as well as the influence of irradiation, was often incorrectly assessed by consumers. Consumers seemed to need more information on sensitive issues, such as the different types of farming or the effects of irradiation, to better assess the impact of these aspects on the safety and quality of meat.

## HIGHLIGHTS

- Consumers' awareness on their role in meat safety needs to be increased.
- Consumers believe organic meat is safer than conventionally produced meat.
- Most consumers assess meat irradiation negatively.

Key words: Consumer awareness; Food chain; Food safety; Germany; Online survey; Public health

Food contaminated with zoonotic agents is an important source of infection in humans (5). The World Health Organization (59) estimates that based on 31 foodborne-included hazards, 600 million foodborne infections occurred worldwide in 2010 and 420,000 people died from them. Some 315,000 foodborne infections are confirmed annually in the European Union (EU), although the actual number is likely to be higher (17). In 2017, 27 member states in the EU reported 5,079 food and water-related outbreaks (18). An outbreak is defined as two or more people developing the same foodborne illness after eating or drinking the same food (20). In Germany, 416 foodborne outbreaks were

reported in 2018. At least 2,476 illnesses, 324 hospitalizations, and 11 deaths were related to the outbreaks (42). Current data from the EU show that in 2017, 60% of foodborne outbreaks supported by strong evidence were associated with food of animal origin. Meat and meat products (including meat from poultry, pork, bovine, sheep, and other unspecified red meats and their products) were the food group most frequently involved (18). *Campylobacteriosis* was the most frequently reported zoonosis throughout the EU in 2017, followed by salmonellosis (18). This trend is particularly evident in Germany. Among the reported outbreaks in which a food vehicle was reported, the food category "meat or meat products" was selected most frequently (45%) (47). Among the notifiable bacterial infectious agents that can be transmitted to humans via

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meat, *Campylobacter enteritis* and salmonellosis were the most frequently reported in Germany in 2018, with 76,872 and 13,529 reported cases, respectively (47).

Contamination with zoonotic agents can occur at all stages of the food chain, from primary production to consumption (5, 59). The food chain has become more complex, with more steps and stakeholders involved in recent years, and demographic, cultural, economic, and environmental developments have increased food-related health risks (58). Tackling foodborne disease is a shared responsibility of all stakeholders along the food chain, from stable to table (primary production to consumption) (59).

According to several studies, most consumers in Germany assume that food is 100% safe (6, 45). Almost 70% of consumers in Germany have never heard of *Campylobacter* (30). Only 7% of consumers in Germany are concerned about *Campylobacter* in meat (7). In contrast, only 2.8% of the respondents were unaware of *Salmonella* (30), and 26% of consumers were concerned about the presence of *Salmonella* in food (7). Consumer expectations of agriculture are high. Having access to top-quality and safe food is the most important requirement from the perspective of consumers in Germany (10). Consumers express great confidence in farmers, whereas the retail sector is regarded as less trustworthy (10, 29). In addition to agriculture and retail, consumers are part of the food chain, e.g., by maintaining the cold chain when transporting food or at home when preparing meals. Consumers' knowledge about specific protective measures, such as avoiding cross-contamination by using different cutting boards or personal hygiene in their household, varies substantially among countries (4, 24, 25, 35, 38, 44). However, a study from Germany shows that consumers are largely unaware of the steps along the food processing value chain that affect the safety and quality of the products (45).

The aim of the study was to assess the influence that consumers attribute to the various aspects of meat production regarding the safety and quality of poultry meat. The participants in the study were asked about their perceptions using examples from the poultry meat production chain. The aim was to determine which aspects of meat production—based on consumer perceptions—were responsible for compliance with selected examples, such as poultry fattening farms, animal transport, slaughtering, retail, or who cooked the meat. Based on the results, we examined whether consumer assessment was consistent with scientific findings. This is relevant for targeted consumer awareness campaigns related to food safety.

## MATERIALS AND METHODS

**Data collection and questionnaire development.** To conduct this study, a questionnaire was designed comprising an aggregate of 43 questions divided into five sections. The questions covered the following thematic blocks: sociodemographic factors, socioeconomic factors, and consumer knowledge of selected pathogens, such as *Campylobacter*, *Salmonella*, and *Toxoplasma*. Consumers were also asked about the degree of the influence of selected aspects of meat production (poultry fattening farm, animal transport, slaughtering, retail, and cook or preparer) on the safety and quality of poultry meat and the positive or negative

influence of specific aspects of the meat production chain (organic farming in comparison to conventional agriculture, maintaining the cold chain, proper meat handling and preparation in the kitchen, meat irradiation with ionizing radiation, and packaging under a modified atmosphere). For a common understanding of these terms among the respondents, each of them was explained in detail. Safety was defined as the transmission or spread of pathogens such as *Campylobacter* and/or *Salmonella*, whereas quality was defined as taste and mouthfeel (juiciness and tenderness). Questions concerning meat consumption were not focused on poultry meat, because we assumed that meat consumers would also consume poultry meat and we were interested in the general knowledge of transmission of pathogens via (poultry) meat. The questionnaire was written in the German language; an English translation is available in the supplements.

The items addressed in the questionnaire were selected from literature. Questionnaire validation took place in several steps. First, a draft was discussed with experts from the departments of veterinary epidemiology and food hygiene, and the questionnaire methodology was validated by the market research company Pangea labs. This was followed by a functionality check by the panel provider. In a final step, the questionnaire was answered by five consumers of different genders and ages and validated for comprehensibility and unclear formulations.

For the implementation of the survey, we enlisted the services of a commercial German panel provider, GapFish. Participants were preregistered and could be selected by demographic characteristics, such as age, gender, and occupation. The participants were recruited through various channels, such as TV, radio, or social media campaigns, as well as through search engine marketing or affiliate partnerships. The participants were invited by GapFish through an individual e-mail link, which could only be used once to exclude multiple submissions. To ensure that all participants included in the sample read the questions properly, so-called speeders with unrealistic short answer times were identified and excluded immediately by the system. After completion of the survey, participants received a small payment, which was either transferred via a bank to the participants or could be donated directly to a good cause. The panel provider, based on its experience, had recommended a survey of at least 1,000 consumers in Germany to ensure a demographically representative sample and a low margin of error on relevant parameter estimates. The target population consisted of individuals aged 16 years and older. Only individuals fluent in German could participate, which in some cases excluded first-generation immigrants. To ensure representativeness regarding age and geographical location, the study population was proportionally stratified according to the German federal states, gender, and five age groups. Sampling was continued until all strata were complete. When a stratum was complete, further participation was refused. In aggregate, 1,008 consumers participated. Data collection started on 11 August 2017, and was completed on 20 August 2017.

**Statistical analysis.** The evaluation of the data was carried out with IBM SPSS Statistics Version 26. Responses from 1,008 consumers who had answered all questions completely were included in the statistical analysis. Exceptions from completeness were made for questions on the level of education, primary residence, number of children in the household, and household income after tax. For these questions, there was an option to indicate either that the question could not be answered or that the respondent did not wish to answer. If a participant selected one of these answer options, this answer was not considered in the

univariate and multinomial analyses, thus reducing the item-specific sample size.

The descriptive statistics contain an overview of the participants' demographics, including frequency tables on both questions about the influence of general aspects of meat production on the safety and quality of meat and questions about the influence of specific aspects of the meat production chain on the safety and quality of meat from the perspectives of (i) all consumers together and (ii) individual consumer groups.

Univariable associations between categorical variables were analyzed by cross-tabulation and chi-square statistics. If the number of cells with expected values below 5 was above 25%, Fisher's exact test was used instead of the chi-square test. The level of significance was set to 0.05. When possible, odds ratios (ORs), including 95% confidence intervals, were given. Four target variables were examined. In the first group of chi-square tests, we defined the target variable as the level of influence of the respective aspects of the meat production chain (poultry fattening farm, animal transport, slaughtering, retail, and cook or preparer) on the safety of meat. The parameter values for these target variables were "no or limited influence," "moderate influence," "high influence," and "very high influence." The association of different factors, such as age and gender, with the consumer-perceived level of influence of aspects of meat production on the safety of meat was assessed. In the second group of chi-square tests, we defined the target variable as the level of influence of aspects of meat production on the quality of meat. The parameter values for this target variable were the same as in the first group of chi-square tests.

Subsequently, we investigated whether specific aspects of the meat production chain had a positive or negative influence on the safety or quality of meat from the perspective of consumers. The specific aspects were (i) organic compared with conventional farming, (ii) maintenance of the cold chain, (iii) proper handling and preparation of meat in the kitchen, and (iv) irradiation of meat with ionizing radiation. The parameter values for these target variables of the specific aspects were "negative influence," "no influence," and "positive influence." We investigated the association of demographic factors, such as age and gender, with the consumer-perceived influence of the specific aspects of the meat production chain.

Subsequently, the association of the factors with two of the previously mentioned target variables were examined further in multinomial logistic regression models: (i) the level of influence of the aspects of meat production on the safety of meat and (ii) the influence of the specific aspects of the meat production chain on the safety of meat from the consumer perspective. In each case, the parameters that had  $P < 0.2$  in the previously conducted chi-square test were included as candidates. Variables were selected by manual forward selection: Following addition of a variable, we noted the change in the regression coefficients of the variables already in the model, as well as the change in the model  $R^2$ . Two-way interactions between explanatory variables were tested for inclusion in the multinomial model and removed if they proved to be statistically insignificant or led to instability of the model.

## RESULTS AND DISCUSSION

The survey was conducted by a commercial online survey company and was designed as a stratified sample from an existing target panels. The advantage was that the data collection could be completed rapidly and with limited effort. The planned number of respondents was attained quickly because of the efficient dissemination of the access

link to the online questionnaire by e-mail to the participants that were already preregistered with the panel provider. Due to their existing voluntary registration to participate in consumer surveys, as well as the relevance of the topic, the acceptance rate was high. Data transfer to the first author was automated; this eliminated transcription errors. However, not all potential sources of selection and information bias could be controlled for. Not all consumer groups have the same level of online access, and only those consumers who had consciously registered for a panel could participate in the study. In addition, no queries were possible in cases of ambiguities or difficulties in understanding specific questions. The presence of third parties or the use of information material while completing the questionnaire could not be excluded. This would have biased the survey results toward higher knowledge. Multiple submissions were excluded by the one-time delivered and one-time usable link.

**Participant demographics.** Comparison of the study population of 1,008 individuals with the demographic characteristics of the German national population in 2017 (50–53) indicated no major deviations, and we therefore feel confident regarding the external validity of our study results (Table 1).

**Consumer perceptions of the influence of the aspects of meat production on the safety and quality of poultry meat.** Food safety was defined in our study as the transmission and spread of pathogens such as *Campylobacter* and/or *Salmonella*. To avoid misunderstandings, this was explained to consumers before they answered the questions. German consumers generally expect that food is safe and does not pose health risks (45). In addition to the presence of pathogens, consumers in Germany are concerned about antibiotic resistance, as well as the presence of pesticides, glyphosate, and microplastics in food (8, 19).

With regard to livestock farming, it was shown that most participants considered the meat production facets of poultry fattening farm, animal transport, slaughtering, retail, and cook (person) as highly or very highly influential on the safety and quality of meat. With regard to the influence of the poultry fattening farm, consumer assessment was consistent with scientific findings, namely, that different aspects of farming are associated with meat safety. The term "poultry fattening farm" included stables, livestock, work processes, and those employees involved in fattening on the farm—and thus the total primary production. Relevant factors in this domain include the age of the animals (fattening period), poor biosecurity (including lack of stall-specific clothing), control of flock density (thinning), and the presence of flocks of different ages on a farm. A range of studies has demonstrated that these are risk factors for *Campylobacter* infection (entry, transmission, and spread of *Campylobacter*) in broiler chickens on poultry farms, thus affecting the safety of meat (16, 22, 27, 31, 41, 49). In the final multinomial logistic regression model, there was only a significant difference between consumers from eastern and western Germany in the perception of the influence of

TABLE 1. Demographic characteristics of survey participants

	<i>n</i>	Total respondents (%)	German population, 2017 (%) (50–53)
Gender			
Male	508	50.4	49.3
Female	500	49.6	50.7
Age group (yr)			
16–19 (younger than 20)	176	17.5	18.4
20–39	219	21.7	24.6
40–59	451	44.7	29.1
60 and older	162	16.1	27.9
Federal state			
Eastern Germany <sup>a</sup>	215	21.3	19.5
Western Germany	793	78.7	80.5
Size of main residence			
Rural community (<5,000 inhabitants)	158	16.2	13.0
Small town (between 5,000 and less than 20,000)	220	22.6	24.8
Midsized town (between 20,000 and less than 100,000)	264	27.1	27.4
Metropolis (100,000 and more)	332	34.1	34.8
Children in household			
Family (at least 1 child) <sup>b</sup>	337	34.0	19.9
Other households (no child)	654	66.0	80.1
Household income after tax (€)			
<1,500	252	29.8	27.6
1,500–<2,600	236	27.9	31.1
≥2,600	358	42.3	41.3

<sup>a</sup> Brandenburg, Berlin, Mecklenburg–Western Pomerania, Saxony, Saxony-Anhalt, Thuringia.

<sup>b</sup> Family includes all parent–child communities, i.e., married couples, nonmarital same-sex and mixed-sex cohabiting couples, and single fathers and mothers with unmarried children in the household.

poultry fattening farm characteristics on meat safety (Table 2). People from western Germany were more likely than those from eastern Germany to assume that the poultry fattening farm had a high or very high influence on the safety of meat (high influence: OR = 5.49,  $P = 0.008$ ; very high influence: OR = 6.54,  $P = 0.04$ ). In addition, we were able to show that more than two-thirds of consumers believed that organic farming (compared with conventional farming), maintaining the cold chain, and proper handling and preparation in the kitchen had a positive influence on the safety and quality of meat. Concerning farming systems, our results showed that a vast majority (78.9%) of respondents assumed that organic farming had a positive influence on the safety of meat compared with conventional farming. A study from The Netherlands showed that consumers rate the risk of *Campylobacter* contamination of meat from animals kept in indoor systems (conventional, conventional plus, colony cages, or noncage systems) higher than from those in outdoor systems (56). In contrast, a study in Switzerland showed that only 22% of respondents believed that poultry meat from organic farms contains pathogens less frequently than other poultry (3). However, consumer perceptions are not consistent with scientific findings in all aspects: Poultry meat from organic farm animals is more often contaminated with *Campylobacter* than meat from conventional farm animals (54, 57). A study

from Denmark identified a higher risk of illness after exposure to *Campylobacter* from organic broiler meat (48), whereas other studies suggested that there is no significant difference in the incidence of *Campylobacter* on meat or carcasses between samples from organic and from conventional farming (12, 13). Furthermore, two U.S. studies showed that overall, raw organic poultry is not safer than conventionally reared poultry in terms of microbiological risk (28, 43). Concerning the perceived influence of organic farming compared with conventional farming, in the final multinomial logistic regression model, the age groups differed significantly ( $P = 0.034$ ) (Table 3). Participants older than 60 years of age were more likely than the youngest participants to perceive that organically produced meat was equally safe or safer compared with conventionally produced meat (no influence: OR = 5.71,  $P = 0.006$ ; positive influence: OR = 3.93,  $P = 0.007$ ). In contrast to age, our initial hypothesis that there is a difference in perception between genders has not been confirmed, although another study claimed that female participants consider the risk of *Campylobacter* contamination of meat to be higher for indoor housing systems and lower for outdoor housing systems compared with male participants (56). Based on the results of our study, we conclude that German consumers believe that poultry meat from organic farms is safer than poultry meat from conventional farms. Therefore, it is



TABLE 3. Influence of organic farming in comparison to conventional agriculture on meat safety from the consumer perspective

	Univariable analysis		Multinomial logistic regression <sup>a</sup>								
	$\chi^2$ test		Likelihood quotient tests			No influence			Positive influence		
	P		P	aOR	95% CI	P	aOR	95% CI	P	aOR	95% CI
Age group (yr)	<b>0.011<sup>b</sup></b>	<b>0.034</b>									
16–19			<b>0.006</b>	0.175	0.050–0.612	<b>0.007</b>	0.255	0.094–0.694			
20–39			0.502	0.674	0.213–2.134	0.319	0.596	0.215–1.651			
40–59			0.768	0.854	0.299–2.438	0.621	0.789	0.310–2.013			
>60 (baseline)											
Level of education	<b>0.023</b>	0.151									
No certificate or lower secondary school certificate			0.687	1.217	0.468–3.168	0.367	0.681	0.296–1.568			
At least secondary school certificate (baseline)											
Monthly household income after tax (€)	0.127	0.455									
Low income (<1,500)			0.129	0.476	0.183–1.240	0.158	0.550	0.240–1.260			
Middle income (1,500–3,600)			0.373	0.656	0.260–1.657	0.688	0.845	0.373–1.919			
High income (>3,600) (baseline)											

<sup>a</sup> Reference category is negative influence. aOR, adjusted odds ratio; 95% CI, 95% confidence interval.

<sup>b</sup> Bold font indicates statistically significant P values.

important to educate consumers accordingly. Although organic farming differs from conventional farming in the type of feed used, administration of medicines, size of the herd, area of the barn, etc., the safety of meat does not necessarily depend on these characteristics. One possible explanation is that consumer perceptions of the safety of meat from different types of farming may have been influenced by their perception of organic (extensive) and conventional (mass production) farming, with a view that the organically produced meat is safer because of better farming conditions. When assessing the influence of aspects of meat production on meat quality, a similar trend was seen. For most participants, all aspects of meat production had a high or very high influence on the quality of meat. The influence of the poultry farm was evaluated differently in univariable analysis between age groups ( $P < 0.001$ ), consumers with or without children in the household ( $P < 0.001$ ), and household income after tax ( $P = 0.009$ ). A positive assessment of organic farming on the quality of meat was associated with a higher level of (school) education certificate ( $P = 0.007$ ), as well as with a higher net household income ( $P = 0.015$ ).

For irradiation of meat with ionizing radiation, most consumers in our study suspected a negative influence on safety (58.7%) and quality (60.9%). Our hypothesis that consumers in Germany were more likely to refuse this procedure was thus confirmed. In the analysis of the influence of the irradiation of meat with ionizing radiation from the consumer perspective, the results of the chi-square test could only be partially confirmed in the multinomial logistic regression analysis (Table 4). A significant difference was observed between genders ( $P < 0.001$ ): males were more likely than females to suppose that irradiation had no or a positive influence (OR = 1.61,  $P = 0.017$ ; OR = 2.26,  $P < 0.001$ ) on the safety of meat. Another study also shows that the acceptance of irradiated foods is very low (40), because consumers either are insecure and have doubts about irradiation (21, 26) or regard it as dangerous and believe that it may cause cancer or other diseases (14). Nevertheless, irradiation is an effective method to achieve complete elimination of *Campylobacter* spp. (37, 46). Regarding the influence of irradiation on quality, 60.9% of the participants assumed a negative influence. Univariable analysis showed that there were significant differences within the consumer groups of gender ( $P < 0.001$ ), age ( $P < 0.001$ ), number of children in the household ( $P = 0.029$ ), and occupational status ( $P = 0.018$ ). Men and younger age groups were still more likely to see a positive influence of irradiation, whereas participants without children and nonactors in the food chain were more likely to see a negative influence. Scientifically, it has been reported that irradiation results in sensory changes in the meat (1, 34, 37), although in some studies no significant differences in sensory quality were found (2, 11, 32). Based on paragraph 8 of the Lebensmittel-, Bedarfsgegenstände- und Futtermittelgesetzbuch (German Food and Feed Code (9)), no food except for dried aromatic herbs and spices may be irradiated in Germany. Nevertheless, because irradiation is permitted for other foods in other EU countries (15), it

TABLE 4. Influence of irradiation of meat with ionizing radiation on meat safety from the consumer perspective

	Univariable analysis		Multinomial logistic regression <sup>d</sup>							
	$\chi^2$ test		Likelihood quotient tests		No influence		Positive influence			
	<i>P</i>	<i>P</i>	<i>P</i>	<i>P</i>	aOR	95% CI	<i>P</i>	aOR	95% CI	
Gender	<0.001 <sup>b</sup>	<0.001								
Male (baseline)										
Female					<b>0.017</b>	0.62	0.419–0.917	<0.001	0.442	0.33–0.593
Level of education	<b>0.041</b>	0.570								
No certificate or lower secondary school certificate					0.052	1.710	0.996–2.935	0.349	0.787	0.477–1.299
At least secondary school certificate (baseline)										
Occupational groups	0.069	0.910								
Employees in the food chain					0.577	0.825	0.42–1.622	0.055	1.520	0.992–2.331
No employees in the food chain (baseline)										

<sup>a</sup> Reference category is negative influence. aOR, adjusted odds ratio; 95% CI, 95% confidence interval.

<sup>b</sup> Bold font indicates statistically significant *P* values.

was of interest to assess how this decontamination procedure was perceived by consumers in Germany. Results imply that consumers are misinformed about irradiation technology and that better education is necessary (23, 26).

Regarding the influence of the cook and kitchen hygiene, it was shown that most consumers in our study (66.3%) believed that the cook or preparer has a high or very high influence on the safety of meat. Nevertheless, only 12% of consumers in Germany are concerned about food hygiene at home (8). We observed significant differences between age groups ( $P < 0.001$ ) and consumers with different frequencies of meat consumption ( $P = 0.025$ ) in how they evaluate the influence of the cook on the safety of meat (Table 5). Compared with the youngest, the oldest participants were three times as likely to assume that the cook has a high influence on the safety of meat (OR = 2.89,  $P = 0.016$ ). In addition, they were six times more likely to believe that the cook has a very high influence on the safety of meat (OR = 6.06,  $P < 0.001$ ). Individuals who did not consume meat or consumed almost no meat were significantly less likely to believe that the cook can highly influence the safety of meat compared with those who consumed meat frequently (OR = 0.333,  $P = 0.021$ ). More than two-thirds of consumers in our study believed that proper handling and preparation of meat in the kitchen has a positive influence on safety. In addition, there were significant differences within consumer groups in this context (Table 6). Participants with higher level of education were twice as likely to be aware that proper handling and preparing meat in the kitchen can lead to an increase in meat safety (OR = 2.01,  $P = 0.043$ ). Respondents from eastern Germany were more likely than those from western Germany to believe that proper handling and preparation in the kitchen had no or a positive influence on the safety of meat (no influence: OR = 2.465,  $P = 0.038$ ; positive influence: OR = 2.170,  $P = 0.025$ ). Other studies have shown that older consumers have a higher awareness of food hygiene and safety compared with younger consumers (33, 36). In the case of compliance with the appropriate kitchen hygiene, the assessment of consumers is also correct that with appropriate measures, safety can be positively influenced. Other research has shown that most consumers practice good kitchen hygiene, such as washing their hands after touching raw meat or changing cutting boards (38). In contrast, many studies show that consumers are often not aware of the risk of cross-contamination because of deficiencies in both food preparation and storage measures (33, 39, 55). These apparently inconsistent results lead us to conclude that although consumers correctly assess how important kitchen hygiene is for food safety, there are obvious gaps in knowledge on adequate kitchen hygiene. Further educational work is therefore necessary to raise consumer awareness. It is necessary for all levels of society to be equally involved in this.

In summary, we found that consumers in Germany attribute an influence on safety and quality to all players in the food chain, consistent with scientific findings. It should be emphasized that conventional agriculture is apparently wrongly perceived by consumers as negatively affecting

TABLE 5. Influence of cook or preparer on meat safety from the consumer perspective

	Univariable analysis			Multinomial logistic regression <sup>a</sup>									
	$\chi^2$ test	Likelihood quotient tests		Moderate influence			High influence			Very high influence			
		<i>P</i>	<i>P</i>	<i>P</i>	aOR	95% CI	<i>P</i>	aOR	95% CI	<i>P</i>	aOR	95% CI	
Age group (yr)	< <b>0.001</b> <sup>b</sup>	< <b>0.001</b>											
16–19			0.224	0.571	0.232–1.408	<b>0.016</b>	0.346	0.146–0.822	< <b>0.001</b>	0.165	0.067–0.407		
20–39			0.997	0.998	0.39–2.557	0.898	0.943	0.386–2.305	0.460	0.712	0.289–1.752		
40–59			0.485	0.751	0.335–1.68	0.205	0.609	0.282–1.311	0.310	0.673	0.313–1.446		
>60 (baseline)													
Meat consumption per wk	<b>0.043</b>	<b>0.025</b>											
No or almost no consumption			0.554	0.756	0.299–1.911	<b>0.021</b>	0.333	0.131–0.847	0.278	0.608	0.248–1.493		
Occasional to regular consumption			0.231	0.656	0.328–1.309	0.136	0.607	0.315–1.17	<b>0.046</b>	0.51	0.263–0.989		
Often or daily consumption (baseline)													
Children in household	0.075	0.566											
At least 1 child			0.163	0.686	0.403–1.166	0.274	0.755	0.456–1.25	0.388	0.798	0.477–1.333		
No child (baseline)													
Occupational groups	0.081	0.125											
Employees in the food chain			0.097	0.545	0.267–1.116	0.203	0.655	0.341–1.257	0.917	0.966	0.505–1.849		
No employees in the food chain (baseline)													

<sup>a</sup> Reference category is no or limited influence. aOR, adjusted odds ratio; 95% CI, 95% confidence interval.

<sup>b</sup> Bold font indicates statistically significant *P* values.

TABLE 6. Influence of proper handling and preparation of meat in the kitchen on meat safety from the consumer perspective

	Univariable analysis		Multinomial logistic regression <sup>a</sup>						
	Likelihood quotient tests		No influence			Positive influence			
	$\chi^2$ test	P	P	aOR	95% CI	P	aOR	95% CI	
Age group (yr)									
16–19	<0.001 <sup>b</sup>		0.216						
20–39				0.843	0.881	0.253–3.073	0.188	0.550	0.226–1.338
40–59				0.299	0.537	0.166–1.735	0.587	0.807	0.373–1.748
>60				0.597	1.301	0.491–3.445	0.626	1.187	0.597–2.360
Level of education									
No certificate or lower secondary school certificate	<0.001		0.048	0.971	1.017	0.401–2.582	0.043	0.498	0.254–0.978
At least secondary school certificate (baseline)									
Children in household									
At least 1 child	0.044		0.116	0.116	1.835	0.861–3.913	0.989	0.996	0.571–1.738
No child (baseline)									
Federal state									
Eastern Germany	0.061		0.044	0.038	2.465	1.051–5.779	0.025	2.170	1.103–4.268
Western Germany (baseline)									
Meat consumption per wk									
No or almost no consumption	0.105		0.024	0.892	0.925	0.301–2.843	0.126	0.560	0.267–1.176
Occasional to regular consumption				0.143	1.887	0.807–4.416	0.107	1.604	0.902–2.851
Often or daily consumption (baseline)									
Monthly household income after tax (€)									
Low income (<1,500)	0.110		0.351	0.139	0.471	0.174–1.275	0.053	0.487	0.235–1.010
Middle income (1,500–3,600)				0.539	0.75	0.299–1.879	0.268	0.672	0.332–1.358
High income (>3,600) (baseline)									

<sup>a</sup> Reference category is negative influence. aOR, adjusted odds ratio; 95% CI, 95% confidence interval.

<sup>b</sup> Bold font indicates statistically significant *P* values.

safety and quality, although this perception is not scientifically demonstrated. One plausible explanation is that the welfare of animals (space per animal, access to the exercise area, and use of antibiotics) is implicitly considered by consumers when assessing the safety and quality of meat. This link should be further investigated in the future to provide better information for consumer education. Lastly, if new processes are used, in addition to known physical methods of germ reduction, consumers should be sufficiently informed about the advantages and disadvantages to reduce uncertainties such as those associated with meat irradiation.

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### SUPPLEMENTAL MATERIAL

Supplemental material associated with this article can be found online at: <https://doi.org/10.4315/JFP-20-491.s1>

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