Title: How do consumers perceive food safety risks? – Results from a multi-country survey

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1 **Abstract**

2 An online survey was distributed to consumers in nine countries in order to investigate their perceptions
3 related to causers of food safety risks, types of food associated with food-borne illnesses and the role of
4 actors in the food supply chain. A total of 2,723 respondents have participated in the survey. Results
5 indicated that food hygiene has been recognized as the most important issue associated with food safety
6 risks. Consumers considered meat and meat products as well as egg and egg-based products, as types of
7 food that pose the highest risks to consumer's health. Food processors and food inspection services play
8 the most significant role in food supply chains. Results further revealed that country of origin has the
9 highest influence on consumer perception, opposed to gender with the least influence. Overall, results
10 obtained in this study confirmed the role of food hygiene as the predominant factor in ensuring food
11 safety in the mind of consumers and that animal-originated food has been perceived as the type of food
12 holding higher health risk opposed to food of plant origin. At the same time, these results challenge the
13 trust in food processors and food inspection services.

14 **Key words**: food safety; food supply chain; risk perception; different types of food; food consumers.

15

1.   Introduction

17 Global food markets have faced many food safety incidents in the past, including both microbial and
18 chemical contaminants as vectors causing outbreaks. In year 2020, more than 3,000 foodborne
19 outbreaks, and more than 30,000 cases of illnesses have been reported in 27 countries of the European
20 Union (EU). However, a decrease of 47% in the number of foodborne outbreaks and a decrease of 61.3%
21 in the number of human cases compared to the previous year was mainly attributed to the Covid-19 and
22 the withdrawal of the United Kingdom from the EU (EFSA, 2021). For years, *Campylobacter* has been
23 identified as the most commonly reported agent of zoonotic disease within the EU, followed by
24 *Salmonella*. The number of outbreaks associated with *Listeria monocytogenes* infection has continuously
25 increased over the last 4 years in the EU. Beside microbiological cause, other food safety incidents
26 occurred in the EU, including dioxins in animal feed, mercury poisoning in fish, nitrofuran, Bovine
27 Spongiform Encephalopathy, or ethylene oxide in sesame seeds (Fung, Wang, & Menon, 2018; Kowalska
28 & Manning, 2022; McEvoy, 2016). In China, during a 15-year surveillance period, a total of 19,517
29 outbreaks were recorded with fungi, meat, vegetable, grain and aquatic products emphasized as types of
30 food products causing them (Li, et al., 2020). A similar 12-year surveillance program in India revealed
31 grains and beans, followed by fruits, vegetables and sweets as food commodities serving as vehicles for
32 recorded outbreaks (Bisht, et al., 2021). Hence, food safety has become an issue of intense public
33 concern, as various crises have been both frequent and repetitive.

34 The food safety risks are mainly associated with unexpected presence of various contaminants
35 throughout the food supply chain (Machado Nardi, Teixeira, Ladeira, & de Oliveira Santini, 2020). The
36 perception of food safety threats provides information related to risks associated with foods that
37 consumers perceive as critical for their health (Redmond & Griffith, 2004; Webster, Jardine, Cash, &
38 McMullen, 2010), and it is an important determinant in undertaking risk-reducing behavior. At the same
39 time, it affects consumer acceptance of novel food products, food choices and purchasing patronage
40 (Loureiro & Umberger, 2007; Tonsor, Schroeder, & Pennings, 2009). Recently, different studies have
41 investigated food safety risks associated with the Covid-19 pandemic (Thomas & Feng, 2021) and the role
42 of customers in risk communication (Zhu, Wen, Chu, & Sun, 2022). Consumer's perception on food safety
43 risks is recognized as one of the pillars that is in direct relation with the efforts towards raising awareness
44 of different types of health-related food safety hazards (Redmond & Griffith, 2004).

45 It is of note that consumers' risk perception have been investigated within one country (Erdem, Rigby, &
46 Wossink, 2012; Van Asselt, Poortvliet, Ekkel, Kemp, & Stassen, 2018) or within several EU countries
47 (Jacxsens, et al., 2015; Krystallis, et al., 2007; Van Wezemael, Verbeke, Kügler, de Barcellos, & Grunert,
48 2010), but no study has been performed including consumers from both EU and non-EU countries.
49 Having in mind the above-mentioned, the aim of this study was to shed light on the perception of

50 consumers from five EU and four non-EU countries related to three dimensions of food safety issues: i)
51 causers of food safety risks; ii) types of food associated with food-borne incidents; and iii) the role of
52 different actors in the food supply chain.

53

2. Materials and Methods

2.1 Survey and questionnaire

56 Data used in this study were collected from nine countries in the period from July 2021 to December
57 2021 using Google forms® online platform. The survey has been performed using a questionnaire
58 developed in English language and translated to local languages using the method of back translation to
59 ensure accuracy. The respondents were mainly recruited from existing networks of professional and
60 family contacts and by further dissemination of the questionnaire throughout their networks. A total of
61 2,738 respondents have participated in the survey and 2,723 fully answered questionnaires were further
62 processed. Demographic characteristics of the sample are depicted in Table 1.

63 A questionnaire consisting of two sections has been developed to analyze how consumers perceive food
64 safety risks. The first section comprised of main demographic characteristics of participants including
65 country, gender, age and education. The second section explored three dimensions of food safety risks:
66 (i) the most / least important issues associated with food safety; (ii) types of food that pose the highest /
67 lowest risk to consumers' health, and (iii) the most / least important food supply chain actor responsible
68 for food safety. Each of the three dimensions had seven pre-defined attributes developed from research
69 of Machado Nardi, et al. (2020) and Djekic, et al. (2021).

2.2 Data processing

71 As each of the three dimensions of food safety risks had two anchors, best-worst scores method was
72 employed by counting the number of times each attribute was chosen as most / least or highest / lowest
73 by the respondents. Based on the results, the "S" score for each of the three dimensions has been
74 determined. Equation for calculating the "S" score was performed in line with works of Merlino, Borra,
75 Girgenti, Dal Vecchio, and Massaglia (2018) and Djekic, et al. (2021) and is presented below.

$$S = \frac{F_B - F_W}{n} \qquad \text{/1/}$$

76 F_B - frequency of being chosen as most/highest; F_W - frequency of being chosen as least/lowest; n –
77 number of respondents.

78 In parallel, χ^2 test for association was employed to discover potential relationships in-between the three
79 dimensions and the demographic characteristics of the sample (country, gender, age and education). The
80 level of statistical significance was set at 0.05. Data were processed using Microsoft excel and IBM SPSS
81 Statistics.

82

3. Results and discussion

3.1 Demography of the sample

85 The demographic portfolio of respondents that participated in an online survey shows that 2,723
86 questionnaires were collected from nine countries (Table 1). Female consumers (67.2%) prevailed
87 opposed to male consumers (31.2%). Age distribution shows that 51.1% of respondents were below 40
88 years of age and 48.9% were older. Regarding education, over 50% of the interviewees hold a
89 college/university degree.

3.2 Three dimensions of food safety risks

91 Best-worst method enables identification of influential food safety risk attributes considered by the
92 consumers. "S" score shows the relative power of an attribute within the sample, where "0" indicates no

93   power and scores striving to "+1.0/-1.0" show increasing/decreasing power (Wittenberg, Bharel, Bridges,
94   Ward, & Weinreb, 2016). This method allows better judgment of participating consumers, as they only
95   evaluate extremes, not preferences of attributes with defined levels (Marley & Louviere, 2005).

96   Table 2 depicts subjective priority of the three food safety dimensions among all participating
97   consumers. Within the first dimension, it is obvious that "food hygiene" (0.544) is recognized as a most
98   important food safety issue, opposed to "food additives" being the least important issue (-0.332) (Table
99   2). The fact that consumers participating in this study perceived hygiene and cleanliness as the most
100   important food safety feature is in line with other previously published studies (Bukachi, et al., 2021).
101   Consumers recognized food hygiene as a very important factor in food production settings (Nguyen, et
102   al., 2018), as well as in restaurants and canteens (Kim, Almanza, Ma, Park, & Kline, 2021; Liu & Lee, 2018)
103   which is in line with the fact that food hygiene is a mandatory prerequisite program outlined in both food
104   legislation and food safety standards (BRC, 2018; CAC, 2020; ISO, 2018). Food hygiene is equally
105   important in households in preventing potential food-borne issues (Singh, Walia, & Farber, 2019).

106   Results from several studies have indicated that European consumers showed higher concerns regarding
107   chemical risks (e.g. residues of antibiotics, hormones or pesticides) than the microbiological ones
108   (Meagher, 2019), most probably due to the great potential for severe consequences, long-term effects
109   and lack of personal control to prevent chemical risks. The consumers that participated in these studies
110   have been given multiple choice to rate several food safety risks. However, when consumers that
111   participated in our study were asked to decide on the single most important food safety risk, without
112   ranking them, they gave the priority to "food hygiene". For this result, no statistical difference between
113   countries has been determined ($p > 0.05$). At the same time, the χ^2 test for association confirmed that
114   there is statistically significant difference between countries for the least important food safety risk
115   (Table 3, $p < 0.005$), with consumers from Bosnia and Herzegovina, Croatia, Serbia, Spain, Turkey and
116   India selecting "food additives", while "GMO" risk was the least important food safety risk for Polish and
117   Slovenian consumers.

118   Despite the fact that several huge outbreaks occurred recently in the EU with non-animal food products
119   (e.g. contamination of sprouted seeds with *Escherichia coli* O104:H4, contamination of frozen corn with
120   *Listeria monocytogenes*, contamination of berries with Norovirus), (Sarno, Pezzutto, Rossi, Liebana, &
121   Rizzi, 2021), our results showed that still the first association with high risk product is animal-originated
122   food. Our participants have recognized "meat and meat products" as foods that pose the highest food
123   safety risk (0.314), followed by "eggs and egg-based products" (0.299) (Table 2). This is mostly attributed
124   to the perishable nature of animal food products, but also to numerous food safety issues related with
125   meat products (e.g. Bovine Spongiform Encephalopathy (BSE), contamination with dioxin, and antibiotic
126   residues) and individual perceptions of animal food products safety and health risks (Verbeke, Frewer,
127   Scholderer, & De Brabander, 2007).

128   Looking into the data obtained from specific countries, our results showed that consumers from Croatia,
129   Poland, Portugal and Spain have selected "eggs and egg-based products" as the riskiest food group
130   (Table 3, $p < 0.005$). This is also expected, as infections caused by *Salmonella* have been considered as
131   the largest burden of disease among all enteric diseases and salmonellosis outbreaks have often been
132   associated with the consumption of eggs (Cardoso, et al., 2021). Therefore, animal related food concerns
133   have raised public consciousness and second thoughts about the risks related to their consumption. For
134   most participants in this study, "cereals and cereal products" prevail as products with the lowest risks (-
135   0.353), but also "fresh produce" (-0.235) and "nuts" (-0.153) (Table 2). As indicated previously,
136   consumers in this study have not primarily focused their attention on chemical risks, and this is in line
137   with their opinion that these stable products mostly associated with chemical hazards (residues of
138   pesticides and toxins) have been rated as low risk products. This concurs with the meta-analysis on food
139   safety risk perceptions pointing to food of animal origin as the main causer of health risk opposed to
140   food of plant origin (Machado Nardi, et al., 2020).

141   It is interesting that "food inspections" and "food processors" are recognized as the most important food
142   supply chain actors, with "S" scores of 0.238 and 0.203, respectively (Table 2). Despite the fact that the
143   current EU legislations (Regulation, 2002) emphasizes on food operators being mostly responsible for

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144 food safety, consumers from Bosnia and Herzegovina, Croatia, Serbia and India still share the opinion
145 that "food inspections" are of outmost importance. At the same time, consumers from Portugal, Spain
146 and Turkey share the opinion that responsibility is distributed among "food processors", while
147 consumers from Poland and Slovenia believe that "primary producers" are the most responsible (Table 3,
148 $p < 0.005$). Similarly, the study performed in China with the aim to investigate the responsibility among
149 pork supply chain, also confirmed that consumers are seeing food producers as the most responsible for
150 food safety (Wu, Qiu, Lu, Zhang, & Wen, 2017). At the same time, evidence from several studies has
151 confirmed that trust is an important factor in perceiving food safety risks, both trust in governmental
152 institutions and food supply chain actors (Erdem, et al., 2012; Machado Nardi, et al., 2020; Vainio,
153 Kaskela, Finell, Ollila, & Lundén, 2020). Consumers believe that they are the least important food actor in
154 the chain, when it comes to food safety risks (-0.446, Table 2). For this conclusion there was no statistical
155 difference between countries, or other demographic groups (Table 3, $p > 0.05$). This is an interesting
156 finding as it is known that personal responsibility for food safety is in direct correlation with unsafe food
157 preparation behavior (Lin & Roberts, 2020; Zhang, Zhu, & Bai, 2022). These results highlight the potential
158 problems associated with food safety risks from a consumer's perspective (Machado Nardi, et al., 2020).
159 Also, this reveals the role of cultural background and individual characteristics on perception of food
160 safety risks, building upon conclusions raised by Machado Nardi, et al. (2020).

161 **4.   Conclusion**

162 The results identified food safety risk perception for consumers living in different countries and different
163 regions of the world. Consumers, regardless of the country in which they live, believe that food hygiene
164 is the most important issue associated with food safety and a prerequisite for the prevention of
165 foodborne illnesses. Nevertheless, some differences have been induced in consumers' perception
166 regarding the most important actors in the food chains, which is most probably related to the cultural
167 background and their previous experience with their national food safety legislation and inspection. In
168 parallel, consumers are aware of potential food safety risks associated with animal origin food products,
169 namely meat and eggs, highlighting their role in food-borne incidents. Results obtained in this study
170 might serve as a good foundation and a starting point for public health authorities to increase
171 compliance with responsible behaviors related to risk mitigation and to define successful food policies
172 specific for different regions. A certain limitation of this study may be associated with different
173 demographic characteristics between the countries.

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Table 1. Demographic characteristics per country (N=2,723).

	Overall - n (%)	BA (449)	HR (353)	IN (210)	PL (305)	PT (352)	RS (387)	SL (106)	SP (200)	TR (361)
Gender										
Male	875 (32.1%)	108 (24.1%)	99 (28%)	76 (36.2%)	134 (43.9%)	96 (27.3%)	113 (29.2%)	48 (45.3%)	54 (27%)	147 (40.7%)
Female	1,830 (67.2%)	337 (75.1%)	250 (70.8%)	134 (63.8%)	171 (56.1%)	256 (72.7%)	270 (69.8%)	58 (54.7%)	145 (72.5%)	209 (57.9%)
Other	18 (0.7%)	4 (0.9%)	4 (1.1%)	0 (0%)	0 (0%)	0 (0%)	4 (1%)	0 (0%)	1 (0.5%)	5 (1.4%)
Age										
Less than 20 yrs	168 (6.2%)	1 (0.2%)	1 (0.3%)	6 (2.9%)	49 (16.1%)	7 (2%)	12 (3.1%)	7 (6.6%)	9 (4.5%)	76 (21.1%)
21 – 40 yrs	1,222 (44.9%)	165 (36.7%)	154 (43.6%)	180 (85.7%)	84 (27.5%)	113 (32.1%)	196 (50.6%)	47 (44.3%)	110 (55%)	173 (47.9%)
41 – 60 yrs	849 (31.2%)	181 (40.3%)	96 (27.2%)	20 (9.5%)	65 (21.3%)	198 (56.3%)	104 (26.9%)	27 (25.5%)	70 (35%)	88 (24.4%)
Over 60 yrs of age	484 (17.8%)	102 (22.7%)	102 (28.9%)	4 (1.9%)	107 (35.1%)	34 (9.7%)	75 (19.4%)	25 (23.6%)	11 (5.5%)	24 (6.6%)
Education										
Elementary school	59 (2.2%)	0 (0%)	14 (4%)	0 (0%)	6 (2%)	1 (0.3%)	20 (5.2%)	2 (1.9%)	2 (1%)	14 (3.9%)
High school	560 (20.6%)	81 (18%)	94 (26.6%)	0 (0%)	167 (54.8%)	36 (10.2%)	100 (25.8%)	33 (31.1%)	5 (2.5%)	44 (12.2%)
College / University	1,499 (55.0%)	285 (63.5%)	215 (60.9%)	154 (73.3%)	116 (38%)	11 (3.1%)	253 (65.4%)	53 (50%)	145 (72.5%)	267 (74%)
Master / PhD degree	605 (22.2%)	83 (18.5%)	30 (8.5%)	56 (26.7%)	16 (5.2%)	304 (86.4%)	14 (3.6%)	18 (17%)	48 (24%)	36 (10%)

Legend: n represents the number of respondents; (%) represents their share in the sample
Country codes: Bosnia and Herzegovina - BA; Croatia – HR; India – IN; Poland – PL; Portugal – PT; Serbia - RS; Slovenia – SI; Spain – SP; Turkey – TR.

Table 2. Subjective priority of three food safety dimensions presented as frequency counts and standardized average score ("S) considering the entire sample.

Issues associated with food safety risks			
Attributes	**Most important**	**Least important**	**"S" average score**
Food hygiene	1,531	132	0.514
Food-borne bacteria	500	274	0.083
Toxins	161	74	0.032
Pesticides residues	190	227	-0.014
Residues of hormones / antibiotics	75	263	-0.069
Genetic Modified Organisms	141	724	-0.214
Food additives	125	1,029	-0.332
Types of food that pose risks to consumer's health			
Attributes	**Highest risk**	**Lowest risk**	**"S" average score**
Meat and meat products	1,008	154	0.314
Eggs and egg-based products	776	153	0.229
Milk and dairy products	509	159	0.129
Fish and fish products	270	78	0.071
Nuts	26	442	-0.153
Fresh produce (fruits / vegetables)	80	721	-0.235
Cereals and cereal products	54	1,016	-0.353
Food supply chain actors responsible for food safety			
Attributes	**Most important**	**Least important**	**"S" average score**
Food processors	710	63	0.238
Food inspections	772	218	0.203
Primary producers	572	321	0.092
Governmental institutions	359	331	0.010
Distributers / retailers	202	264	-0.023
Other	6	210	-0.075
Food consumers	102	1,316	-0.446

Table 3. Most/least frequently mentioned attributes associated with all three food safety dimensions.

		Most important food safety issue	Least important food safety issue	Food type that poses highest health risk	Food type that poses lowest health risk	Most important in the food supply chain	Least important in the food supply chain
Country	BA		Food additives	Meat and meat products	Nuts	Food inspections	
	HR		Food additives	Eggs and egg-based products	Cereals and cereal products	Food inspections	
	IN		Food additives	Meat and meat products	Nuts	Food inspections	
	PL		GMO	Eggs and egg-based products	Nuts	Primary producers	
	PT	Food hygiene	Food borne bacteria	Eggs and egg-based products	Cereals and cereal products	Food processors	Food consumers
	RS		Food additives	Meat and meat products	Cereals and cereal products	Food inspections	
	SL		GMO	Meat and meat products	Cereals and cereal products	Primary producers	
	SP		Food additives	Eggs and egg-based products	Cereals and cereal products	Food processors	
	TR		Food additives	Meat and meat products	Cereals and cereal products	Food processors	
		$p > 0.05$	$\chi^2=896.955**$	$\chi^2= 1806.627**$	$\chi^2= 1532.126**$	$\chi^2= 875.520**$	$p > 0.05$
Gender	Male	Food hygiene	Food additives	Meat and meat products	Cereals and cereal products	Food processors	Food consumers
	Female					Food inspections	
	Other					Food inspections	
		$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$\chi^2= 21.913*$	$p > 0.05$
Age	Less than 20 yrs	Food hygiene	Food additives	Meat and meat products	Cereals and cereal products	Food inspections	Food consumers
	21 – 40 yrs			Meat and meat products		Food inspections	
	41 – 60 yrs			Eggs and egg-based products		Food processors	
	Over 60 yrs of age			Eggs and egg-based products		Food inspections	
		$p > 0.05$	$p > 0.05$	$\chi^2= 124.978**$	$p > 0.05$	$\chi^2= 99.412**$	$p > 0.05$
Education	Elementary school	Food hygiene	Food additives	Eggs and egg-based products	Cereals and cereal products	Food inspections	Food consumers
	High school			Meat and meat products		Food inspections	
	College / University			Meat and meat products		Food inspections	
	Master / PhD degree			Eggs and egg-based products		Food processors	
		$p > 0.05$	$p > 0.05$	$\chi^2= 47.825**$	$p > 0.05$	$\chi^2= 135.554**$	$p > 0.05$

* $p < 0.05$; ** $p < 0.005$

Country codes: Bosnia and Herzegovina - BA; Croatia – HR; India – IN; Poland – PL; Portugal – PT; Serbia - RS; Slovenia – SI; Spain – SP; Turkey – TR. Genetic Modified Organisms – GMO.