

„Dunărea de Jos” University of Galați
Doctoral School of Mechanical and Industrial Engineering



DOCTORAL THESIS

Summary

The implications of kitchens' design and hygiene practices on consumers' food safety

PhD student,

Eng. Octavian Augustin MIHALACHE

Scientific coordinator,

Prof. dr. eng. Anca Ioana NICOLAU

Paper elaborated in the frame of the project

**Safer food through changed consumer behavior: Effective tools and products,
communication strategies, education and a food safety policy reducing health burden
from foodborne illnesses - SafeConsume (Horizon 2020; Grant agreement nr. 727580)**

Series I 4: Industrial Engineering nr. 78

GALAȚI 2021

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Keywords: foodborne illness, hygiene practices, food safety, structural equation modelling, hand washing, kitchen design, kitchen work triangle, food safety triangle, cross-contamination, refrigeration practices

Justification of the research and its scientific objectives

Food safety is currently addressed on the basis of the concept "from farm to fork", which involves contributing to the assurance of safety for all the participants involved in the food chain, including consumers. Therefore, the prevention of foodborne illnesses requires the cooperation of all the representatives of the links of the food chain, while a certain link cannot be blamed or considered solely responsible for a food safety problem. Effective food safety strategies aimed at reducing the risk of contamination of food with pathogens require a dual approach that integrates education and legislation, which is why at an international level, the implementation of legislation in all sectors of the food industry and consumer education have become priorities.

The European Food Safety Authority (EFSA) also believes that food safety is the responsibility of all participants in the food chain and, although it cannot directly control what is happening at the domestic level, it is working to educate consumers and their involvement in reducing food risk. This is supported by the fact that in 2019, EFSA reported 5,175 foodborne outbreaks that affected 53,383 people, inadequate consumer hygiene practices in the household being the most commonly reported source (41.3%).

Since one of the conditions for the success of the educational process is knowledge of needs, it is important to know the consumer's behaviour, practices and the level of knowledge he/she has. In this context, this doctoral thesis aims to contribute to the knowledge of the Romanian consumer and to integrate his profile into the European context.

Thus, the main aim of the thesis was to identify the factors influencing consumers' behaviour in hygiene practices during food preparation and to make recommendations regarding consumers' food safety through the following objectives:

- Structural equation modelling of consumers' food safety knowledge, food shopping attitude, and hygiene practices during food preparation,
- Determination of the effectiveness of hand hygiene practices applied during food preparation in the home environment,
- Analysis of the influence of kitchen design on consumers' hygiene practices,
- Assessment of consumers' knowledge and practices of food refrigeration.

PhD thesis summary

This present PhD thesis contains five chapters and final conclusions regarding the results of the research. The thesis includes 21 figures and 24 tables.

The first part of chapter I, entitled “Foodborne illnesses originating in the domestic environment. Vulnerable categories of consumers” presents statistics on the number of food poisonings that occurred over a five-year period between 2014 and 2019 in Europe and Romania, as well as the main pathogens responsible for foodborne illnesses according to reports issued by the European Food Safety Authority (EFSA). It is pointed out that the household is one of the most common sources of foodborne outbreaks, mainly caused by inadequate hygiene practices. Furthermore, there are presented recommendations made by authorised organisations on good hygiene practices during food preparation to reduce the risk of cross-contamination and foodborne disease.

The second part of the chapter presents the categories of consumers vulnerable to foodborne illnesses. The groups of consumers, the inadequate food safety practices carried out by them, the complications arising from infection with foodborne pathogens and the severity of symptoms, which is much higher due to the deficient immune system, are discussed.

The second chapter, entitled “The correlation between consumers' food safety knowledge, food shopping attitude, and hygiene practices during food preparation: structural modelling” addresses the relationship of food safety knowledge, the attitude of consumers when buying food with prioritisation of food safety, quality and integrity and hygiene practices carried out during the preparation of food at home. The knowledge-attitude-practice (KAP) questionnaire is used for data collection from consumers and is analysed using SEM (structural equation modeling). The results highlighted by the SEM analysis, which refers to the fact that those with adequate knowledge can minimise the risks of food consumption from the food acquisition stage and continue to do so during food cooking, have been confirmed by the observations made during visits made at home to Romanian consumers. The KAP model designed in this study can also be used in other food safety studies carried out, for example, on consumers in the Member States of the European Union.

The third chapter, entitled “The efficacy of hand hygiene practices during food preparation in the home environment”, presents the self-reported hygiene practices of consumers from ten European countries and an experiment comparing the effectiveness of several hand cleaning

procedures. This comparison involves using the bioluminescence test to quantify the remaining dirt on the participants' hands. The results of this chapter allow the ranking of hand cleaning methods based on their efficacy. The graphics on the basis of which the ranking was made can be used as visual means that can be used to train consumers so that they understand the importance of hand washing.

The fourth chapter, which is named “The analysis of the correlation between kitchen design – hygiene practices – food safety” describes the influence of the location of the kitchen equipment on the self-reported and observed hygiene practices of European consumers. Real sketches of consumer kitchens in five European countries are presented and the correlation between kitchen equipment arrangements and cross-contamination practices is analysed. A new arrangement in kitchens that prioritizes food safety is suggested. The results of this study can be used as a reference point for future studies carried out by sociologists, food safety risk assessors, hygiene experts and kitchen designers and as the norm for the placement of equipment and furniture in the kitchen, so that food safety and ergonomics combine harmoniously.

The fifth chapter, entitled “Refrigeration practices applied by consumers in the domestic environment” analyses the knowledge and self-reported refrigeration practices of Romanian consumers on the basis of a questionnaire. Following the results of the questionnaire, an experiment is carried out to track the accuracy of the participants' sense of touch regarding the assessment of the correct temperature of four food products and the refrigerator wall. The experiment demonstrates that the temperature in the refrigerator cannot be properly assessed on the basis of tactile sense and that those who do so may think that they keep food at an appropriate refrigeration temperature when, in reality, food may be at temperatures that endanger consumers' food safety.

The final conclusions provide an overview of the results of the research carried out in this thesis. The author's original contributions and how the results can be harnessed for the development of consumer' food safety knowledge, as well as the perspectives for further research. Finally, the dissemination of the results obtained during the doctoral studies is presented.

The experimental activities of the thesis were carried out in the Microbiology Laboratory which is part of the **Laboratory of Physico-Chemical Analysis and Microbiology for Food**

The implications of kitchens' design and hygiene practices on consumers' food safety

(**LAFCMA**), from the Faculty of Food Science and Engineering, “Dunărea de Jos” University of Galați.

The experimental research was carried out with financial support from the **SafeConsume** project – Safer food through changed consumer behavior: Effective tools and products, communication strategies, education and a food safety policy reducing health burden from foodborne illnesses (Horizon 2020; Grant agreement No. 727580, <http://safeconsume.eu/>).

Chapter I

Foodborne illnesses originating from the household environment. Vulnerable consumer groups

Foodborne illnesses originating from the household environment

Foodborne illness is defined as any infectious or toxic disease contracted by ingestion of food contaminated with various bacteria and their toxins. Food poisonings are caused by several factors, including violations of certain hygiene rules applicable to food preparation (Adams & Moss, 2003).

The transfer of microorganisms occurs directly or indirectly from food and/or water, which in most cases act as vehicles for food infections. Contamination with pathogens that can cause food poisoning can occur at any stage of the production – delivery – consumption chain, or in the form of cross-contamination in restaurants or domestic kitchens (Singh & Mondal, 2019).

Food safety data provided by the World Health Organisation (WHO, 2020) mention the following:

- 600 million people - nearly 1 in 10 people in the world - get sick after eating contaminated food and 420,000 die each year.
- 40% of the burden of foodborne diseases is borne by children under the age of 5, with 125,000 deaths each year.
- Foodborne illnesses hinder socio-economic development by affecting health systems and situations of national economies, tourism and trade.
- Improving hygiene practices in the food and agriculture sector helps to reduce the occurrence and spread of antimicrobial resistance along the food chain and in the environment.

The most recent report released in 2021 by the European Food Safety Authority (EFSA) shows the 2019 foodborne outbreaks (EFSA & ECDC, 2021). To make a comparison of outbreaks and cases of food poisoning in Europe and Romania over five years, we used the data from this report and from the report issued by EFSA in 2014 (EFSA & ECDC, 2015). Thus, we can say that although in the last five years the number of outbreaks of food poisoning reported by the

EU Member States has decreased from 5,251 outbreaks to 5,175, the number of people affected by foodborne illnesses increased from 45,165 cases (EFSA & ECDC, 2015) to 53,383 (EFSA & ECDC, 2021) (Figure 1.1a) with inadequate consumer hygiene practices in the household environment being the most commonly reported cause.

The number of foodborne diseases in Romania has decreased in the last 5 years, from 27 outbreaks with 349 cases in 2014 to 7 food outbreaks and 247 reported cases in 2019 (Figure 1.1b) (EFSA & ECDC, 2015; EFSA & ECDC, 2021). However, the cases of food poisoning continue to be considered under-reported (WHO Regional Office for Europe, 2017). Inadequate food safety practices in the household environment have been responsible for numerous food outbreaks (such as cooking products at inadequate temperatures, storing products that should be refrigerated at room temperature) (Langiano et al., 2012; Wu et al., 2018).

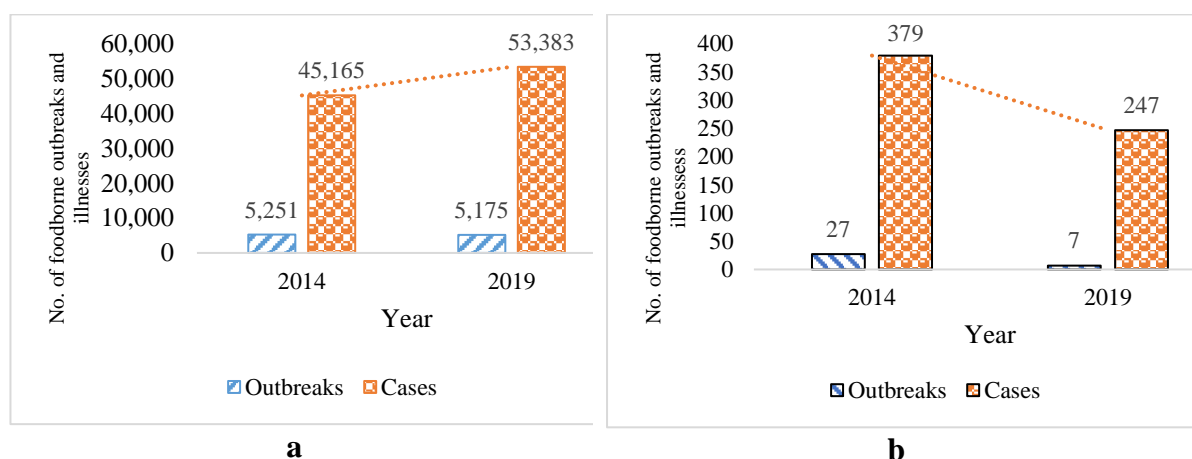


Figure 1.1. The number of foodborne outbreaks and illnesses that occurred in Europe (a) and Romania (b) in 2014 and 2019

Figure 1.2a shows that in 2014 the household sector was the source of 220 cases of food poisoning outbreaks (37.3% of total outbreaks), with outbreaks increasing to 296 in 2019 (41.3% of total outbreaks). By contrast, the number of outbreaks in Romania that originated from the household setting decreased from 13 (48.14% of the total outbreaks in 2014) to 2 (28.57% of the total outbreaks in 2019) (Figure 1.2b).

Chapter I

Foodborne illnesses originating from the household environment. Vulnerable consumer groups

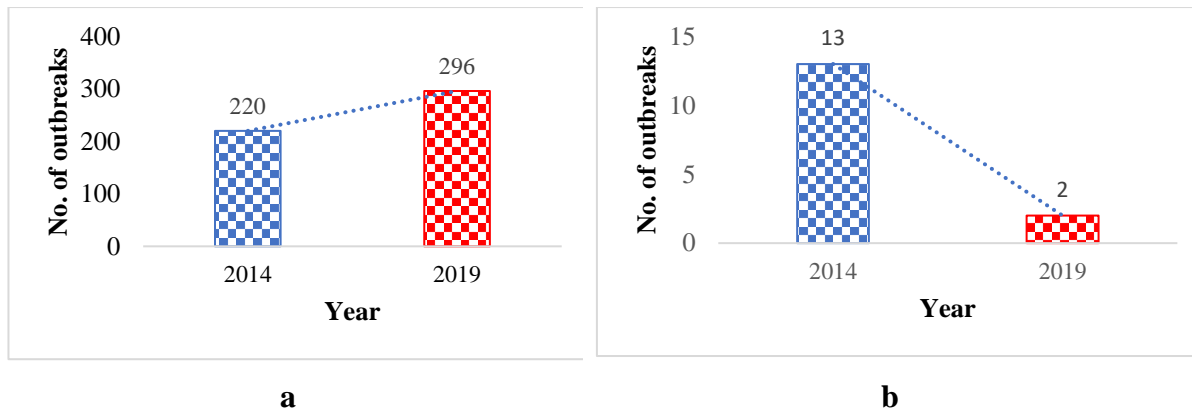


Figure 1.2. The number of foodborne outbreaks from Europe (a) and Romania (b) that originated from the domestic environment in 2014 – 2019

Figure 1.3 shows the main pathogens responsible for foodborne outbreaks in Europe over the last 5 years. Although the number of cases of foodborne illnesses caused by *Campylobacter* and *Salmonella* decreased, the number of cases caused by *E. coli*, *Yersinia* and *L. monocytogenes* increased (Figure 1.3). The lack of data reporting on food poisoning cases in Slovakia for 2019 could have contributed substantially to the EFSA report, as the country reported 522 outbreaks, 2,454 cases and 531 hospitalisations on average per year (EFSA & ECDC, 2021).

The main symptoms that occur as a result of infection with these pathogens are: diarrhea (often bloody), fever, stomach cramps, nausea and vomiting. The symptoms caused by food poisonings can be more severe, posing a health threat especially for vulnerable people.

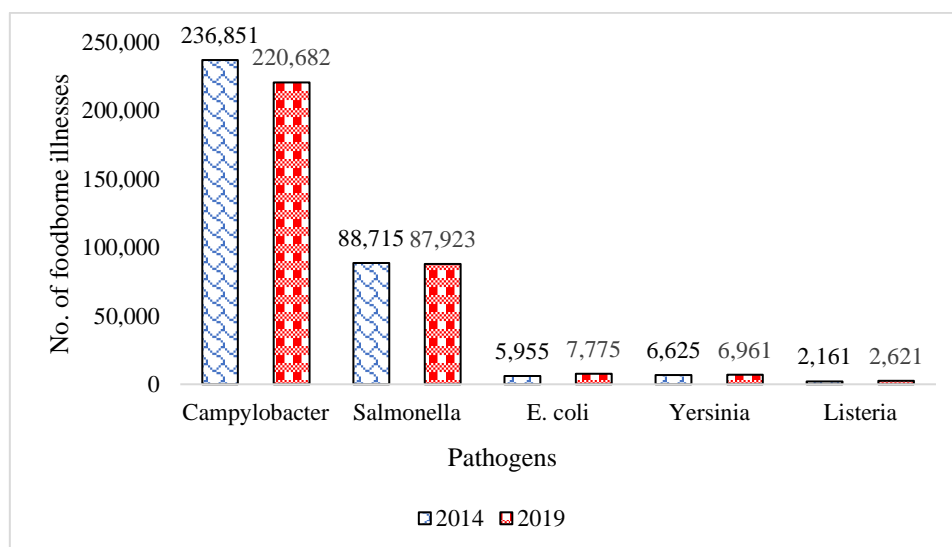


Figure 1.3. The main foodborne pathogens and the number of cases of foodborne illnesses from 2014 and 2019 in Europe

Vulnerable consumer groups

The vulnerable categories of consumers are represented by **the elderly** (people >65 years old), **children** (children <5 years old), pregnant **women** and **people with weak immune systems**, all of which have problems related to the functioning of the immune system.

The immune system is the body's natural reaction or its response to the aggression of invading pathogens and is of two kinds: innate immune system, which represents nonspecific immunity, and acquired immune system, which represents specific immunity.

For healthy people, a properly functioning immune system fights bacteria and other pathogens that cause infections while for the elderly, the immune system becomes slow in recognizing and eliminating harmful bacteria and other pathogens that cause infections, such as food poisoning (FDA, 2020). For children, the immune system is not yet fully developed while, for pregnant women, the immune system undergoes modulations, which lead to decreased specific immunity. For the people with cancer, AIDS, diabetes or those who do certain medical treatments (with cytostatics or cortisone), the immune system becomes deficient, i.e., it no longer works as effectively as it should.

Elderly consumers (<65 years old), children (<5 years old) and pregnant women are among the most vulnerable people to foodborne diseases (FDA, 2020). More inadequate food safety practices (e.g., thawing or storing food at room temperature) were observed in families with susceptible members to food poisoning (such as children, the elderly and pregnant women) compared to families who did not have vulnerable members in their household (Langiano et al., 2012). There was also an increased incidence of foodborne diseases in households of families with elderly members (>60 years old) (Gkana & Nychas, 2018). At the same time, there were reported more cases of hospitalization for elderly consumers due to foodborne illnesses caused by pathogens such as *Campylobacter* (Medeiros et al., 2006; Troeger et al., 2018) and increased rates of death from *Salmonella* infections (Chen, Glass, Liu, Hope, & Kirk, 2016).

Pregnancy alters the mother's immune system, making pregnant women more susceptible to foodborne diseases. Pathogenic bacteria can cross the placenta and infect the fetus, whose immune system is underdeveloped and is not able to fight infections. Food poisoning during pregnancy is serious and can lead to miscarriage, premature birth or death of the fetus (FDA, 2020).

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Foodborne illnesses originating from the household environment. Vulnerable consumer groups

Children <5 years old have a high risk of food poisoning and associated health problems because their immune system is still developing and cannot fight infections as it does for people >5 years old ([FDA, 2020](#)).

Consumers with poor immune systems can be infected with pathogens even in small doses. Following infection with pathogens for elderly people, children, pregnant women and people with compromised immune systems symptoms vary considerably from flu-like diseases to acute diarrhea with dehydration, meningoencephalitis and meningitis ([Singh & Mondal, 2019](#)). Educational campaigns on appropriate food safety practices and information on high-risk foods for vulnerable groups of consumers are essential to reduce cases of food poisoning.

Chapter II
The correlation between consumers' food safety knowledge, food shopping attitude, and food hygiene practices during food preparation: structural modelling

Chapter II

The correlation between consumers' food safety knowledge, food shopping attitude, and food hygiene practices during food preparation: structural modelling

This chapter presents the concept of KAP (knowledge-attitude-practices) in the context of the food safety of Romanian consumers. The KAP model (Figure 2.1) argues that if consumers receive the necessary information that would improve their knowledge, then food hygiene practices could be improved (Zanin et al., 2017) and, if a positive attitude is adopted with a focus on food safety, food quality or food integrity, this would lead to increased awareness of food safety when buying and preparing food at home. Although it has been suggested that this model is based solely on the assumption that the level of knowledge is the main precursor to behavioural change and does not take into account cultural, social and environmental influences (Redmond & Griffith, 2003; Rennie, 1995), recent studies have demonstrated the importance of the model in prioritising planning and training actions (Basser et al., 2017; da Cunha et al., 2019; Lim et al., 2016; Zanin et al., 2017).

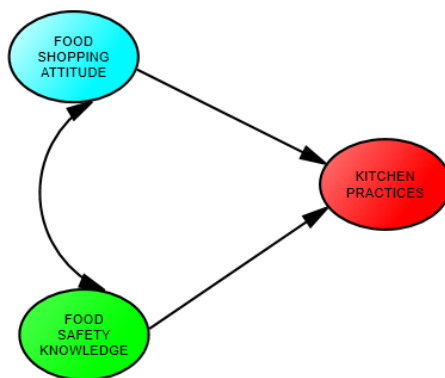


Figure 2.1. KAP model

The hypotheses tested for the KAP model are as follows:

Hypothesis 1.

(H1): Consumers' food safety knowledge is correlated with their food shopping attitude with prioritisation of food safety, quality and integrity.

Hypothesis 2.

(H2): A consumer attitude during food shopping favourable to food safety directly influences the self-reported hygiene practices of consumers in the kitchen.

Hypothesis 3.

(H3): Consumers' food safety knowledge directly influences their self-reported hygiene practices.

The aim of our study was to assess the relationship between consumers' knowledge and attitude in terms of food safety and their effect on kitchen hygiene practices, as well as to determine how well hygiene practices are predicted by the food safety knowledge and attitude of consumers during food shopping. The evaluation of these relationships is based on structural equation modelling (SEM), a methodological approach that combines measurement models and structural models that have previously been used in other studies (Baser et al., 2017; Lim et al., 2016). To date, no attempt has been reported in the application of SEM to examine the relationship between consumers' food safety knowledge and their food shopping attitude with regard to food safety practices. As far as we know, there are currently no studies available to highlight the self-reported practices on food safety of Romanian consumers.

Thus, the objectives of this study are:

- To assess the relationship between consumers' food safety knowledge of, attitude during food shopping (with prioritization of food safety, quality and integrity) and their influence on self-reported hygiene practices among Romanian consumers;
- To highlight the behaviour of Romanian consumers and food safety practices during shopping.

Results and discussions

The method of modeling through structural equations can be considered as a tool for creating the evidence of the study, being a structured process of exploring the relationships specified within a theoretical model. Figure 2.2 shows the KAP structural model with factorial loads, standardized structural coefficients and the total variance of the self-reported kitchen practices explained by its predictors.

The model (Fig. 2.2) presents a significant positive correlation between food safety knowledge and a food shopping attitude favourable towards food safety ($r = 0.36$; $p < 0.001$) among Romanian consumers, thus supporting **hypothesis H1**. This indicates that when consumers'

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food safety knowledge improves, their food shopping attitudes with prioritisation of food safety become appropriate and vice versa, which means that consumers' level of knowledge can improve on the basis of food safety advice provided by food suppliers (e.g., safety certification labels).

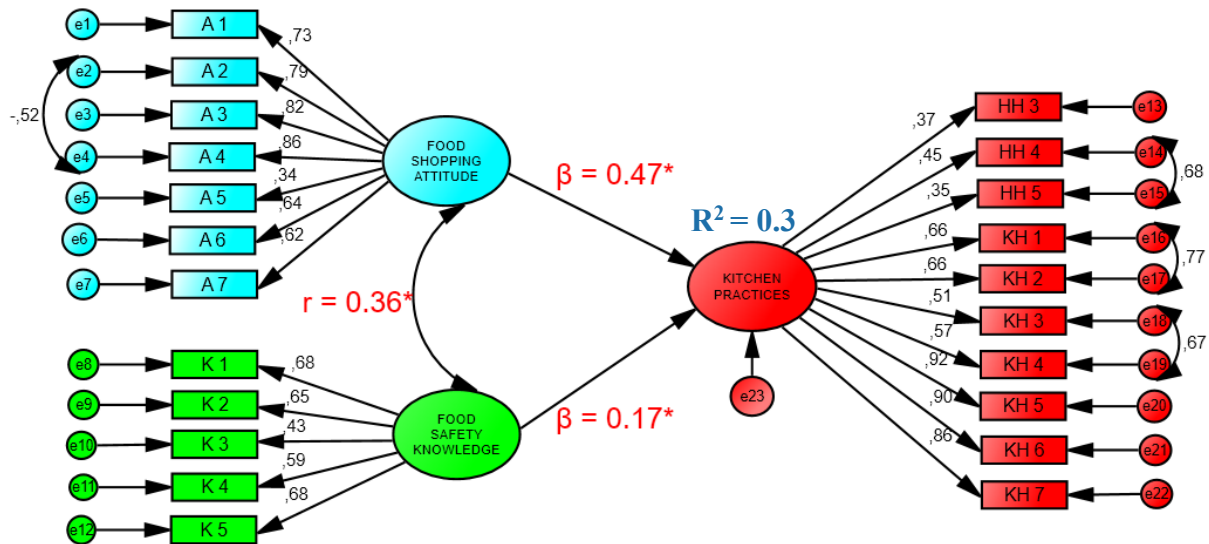


Figure 2.2. Structural model with the relationships between food safety knowledge, food shopping attitude, and kitchen practices; $*(p < 0, 001)$

Mullan, Wong, & Kothe, (2013) found that among adolescents in the UK and Australia, knowledge and attitude in terms of food safety were positively correlated. In their observational study, attitude was assessed on the basis of issues such as hygienic preparation of meals, and knowledge was measured taking into account the time and temperature for cooking and food storage, prevention of cross-contamination, etc. In a US study on students' food safety attitude, Booth et al., (2013) noted that when consumers' food safety knowledge declined there was an increase in negative attitudes to food safety with regard to simple food safety practices.

Hypothesis H2, which suggests that consumers' attitude during food shopping (with prioritisation of food safety, quality, etc.) has a significant positive effect on consumers' food safety practices in the kitchen is accepted ($\beta = 0.47$; $p < 0.001$). This hypothesis indicates that, through a pro-food safety attitude, consumer practices related to food safety will also improve. Consumers' attitude has been positively correlated with the food safety practices of consumers from countries such as Iran, Jordan, Malaysia, Pakistan, Ghana, Cameroon and Nigeria (Odeyemi et al., 2019). Among Australian students there have been observed positive correlations between food safety attitude and practices, such as hand washing and cleaning

kitchen surfaces, keeping food at the right temperature and avoiding unsafe food consumption (Mullan, Allom, Sainsbury, & Monds, 2015).

Hypothesis H3, which indicates that food safety knowledge has a significant positive effect on consumers' kitchen hygiene practices, is also accepted ($\beta = 0.19$; $p < 0.001$). This suggests that when consumers' food safety knowledge improves, their food safety practices also improve. There have been either reports of no relationship or significant negative effects between consumers' knowledge and behaviour (Baser et al., 2017; Lim et al., 2016). Unusan (2007) study on the knowledge and behaviour of Turkish consumers in food safety at home indicated that, although respondents demonstrated a high level of knowledge, there was no interest in food safety practices, as they believed that improper handling of food did not pose a direct threat to their health.

As it can be seen in Figure 2.2, in our KAP model, the value R^2 (multiple squared correlations) is 0.3. This suggests that **knowledge and attitude** explained **30%** of the variation in the behaviour of Romanian consumers with regard to food safety. According to behavioral standards, a value of $R^2 > 0.2$ is considered to be a high value, so the knowledge and attitude of our model presented a good level of prediction (Hair, Hult, Ringle, & Sarstedt, 2014). Mullan et al. (2013) reported that the level of knowledge predicted only a small part of the variance in the food safety behaviour of adolescents in the UK and Australia, while Ruby et al., (2019a) noted that the level of knowledge accounted for only 1.2% of the attitude of Malaysian consumers during food manipulation.

The qualitative analysis highlighted that the participants interviewed during shopping believe that the food they buy is safe and infer that safety is associated with the brand and price of food. Table 2.5 shows the structure of the participants in the qualitative study. Participants mentioned their confidence in advice from food safety authorities. However, the complexity of real-life decisions sometimes leads to many different constraints, priorities, motivations and meanings and involves a large number of variables and constructions, often situational, as observed studies show (Wang, Tao, & Chu, 2020).

Table 2.1. The socio-demographic profile of the participants from the qualitative study

Household	BST	FT	V
Age	28-35	31-36	69-84
Residency	U (5)	U (2)	U (2)
		R (3)	R (3)
Level of education	Middle (1)	Low (1)	Low (4)

Chapter II

The correlation between consumers' food safety knowledge, food shopping attitude, and food hygiene practices during food preparation: structural modelling

	High (4)	Low (2)	Low (1)
		Terțiar (2)	
Income	Low (1)	Low (1)	Low (4)
	Medium (3)	Medium (2)	Middle (1)
	High (1)	Ridicat (2)	
Marital status	Single (5)	Married (5)	Married (2)
			Widow (3)

YSM – young single men; YF – young families; EP – elderly people. U – urban; R – rural.

a. An attitude against food waste when buying food could favour proper food safety practices.

From the people interviewed during shopping, two attitudes stand out from the rest. This is the case of a single man living in the urban area (Zoltan) and a young woman living with her family in the countryside (Serena). Zoltan (YSM, 35, U) and Serena (YF, 36, R) always check the expiry date of food to have enough time to eat them, especially when buying large quantities and want to avoid situations such as eating foods with a potential health risk or not contributing to food waste.

b. The level of knowledge influences the food safety practices of elderly people with a low income.

Because of her financial situation, Domnica (EP, 75, U) buys products that expire soon because supermarkets offer these products at a discount. The lady buys fresh meat and, when she gets home, she portions the meat and puts it in the freezer, knowing that this way she can extend the shelf life of the meat.

c. The practice of buying whole fruits and vegetables could favour consumer food safety practices.

Zoltan (YSM, 35, U) knows that unwashed fruits and vegetables can carry pathogens and therefore, when buying melons, does not want to test their degree of ripening by cutting them, this being a common practice in Romanian markets. When he gets home, Zoltan leaves the melon on the floor until there's room for it in the fridge. Also, he washes the melon before placing it in the refrigerator.

d. A cautious attitude combined with proper food safety knowledge encourages consumers to adopt adequate food safety practices.

During fruit shopping at the supermarket, Sorina (YF, 32, R) only buys fruits packaged in casseroles. She tells the research team that she does not like fruits sold in bulk, as they could contain chemicals on the surface or be contaminated with pathogens after being touched by other consumers. Although the fruits will only be eaten after washing, she believes this could provide additional protection for her children.

Conclusions

The SEM analysis indicated a positive correlation between food safety knowledge and food shopping attitude. Knowledge of possible pathogen vehicles provided a positive effect on consumers' self-reported hygiene practices. An even stronger effect has been observed for consumers who consider safety criteria when shopping, as they are more likely to apply good hygiene practices at home. Understanding how Romanian consumers face the dangers of foodborne disease at home will allow for the development of more targeted interventions of educational campaigns.

These campaigns should focus on potential sources of contamination, practices that could prevent cross-contamination and their effects to improve consumers' food safety practices.

Although the study was carried out only for Romanian consumers, this KAP model could be applied to other European consumers, where there are similar food chains, regardless of cultural differences, since food safety is a common umbrella designed to protect all consumers.

Chapter III
The efficacy of hand cleaning procedures applied during meal preparation in the domestic environment

Chapter III

The efficacy of hand cleaning procedures applied during meal preparation in the domestic environment

This chapter presents self-reported hygiene practices for consumers from ten European countries and an experiment that compares the effectiveness of several hand cleaning procedures. Using the bioluminescence test, we quantify the remaining dirt on the hands of the participants and make a ranking of the tested procedures.

Results and discussion

Tabelul 3.1 shows the regressions models in which we analysed the relation between consumers' demographic characteristics and their self-reported hand hygiene practices together with the confidence intervals of OR (odd ratios), p values indicating a signification contribution of the variables to the model.

Tabelul 3.1. The regression analysis of consumers' self-reported hand hygiene practices in relation to their demographic characteristics

Variable	<i>How likely is it that you would clean your hands immediately after touching raw chicken? (N = 7866)</i>			
Age	β	SE	OR (95% CI)	p
16-24	0 ^a		1	
25-34	0.14	0.08	1.15 (0.98; 1.36)	0.08
35-44	0.3	0.08	1.36 (1.16; 1.59)	0.00
45-54	0.55	0.08	1.74 (1.47; 2.05)	0.00
55-64	0.53	0.11	1.71 (1.44; 2.28)	0.00
65-75	0.59	0.11	1.8 (1.43; 2.28)	0.00
> 75	0.46	0.23	1.59 (1; 2.51)	0.04
Gender				
Female	0 ^a			
Male	-0.68	0.04	0.5 (0.46; 0.55)	0.00
Education				
Low	0 ^a		1	
Middle	0.02	0.04	1 (0.92; 1.12)	0.69
High	0.01	0.1	1 (0.8; 1.24)	0.99
Inhabitancy				
City	0 ^a		1	

Town	-0.16	0.06	0.84 (0.74; 0.96)	0.01
	β	SE	OR (95% CI)	p
Country district	-0.15	0.06	0.85 (0.75; 0.97)	0.01
Are you or any other members of the family pregnant?				
No	0 ^a			
Yes	-0.59	0.04	0.55 (0.46; 0.65)	0.00
Members >65 years old				
None	1.16	0.99	3.2 (0.45; 22.37)	0.24
One	-0.31	0.55	0.72 (0.24; 2.1)	0.56
Two	-0.12	0.11	0.88 (0.71; 1.09)	0.25
Three	-0.06	0.08	0.93 (0.79; 1.09)	0.39
More than three	0 ^a		1	
Members <6 years old				
None	-0.4	1.4	0.67 (0.04; 10.9)	0.77
One	-0.66	0.44	0.51 (0.21; 1.22)	0.13
Two	-0.21	0.14	0.8 (0.6; .083)	0.14
Three	-0.33	0.07	0.72 (0.62; 0.83)	0.00
More than three	0 ^a		1	
<i>Proper hand cleaning methods after touching raw chicken (N = 7866)</i>				
Age	β	SE	OR (95% CI)	p
16-24	0 ^a		1	
25-34	0.13	0.09	1.14 (0.95; 1.37)	0.15
35-44	0.1	0.08	1.11 (0.93; 1.32)	0.23
45-54	0.24	0.09	1.27 (1.06; 1.52)	0.00
55-64	0.28	0.09	1.32 (1.1; 1.6)	0.00
65-75	0.44	0.13	1.55 (1.2; 2.01)	0.00
> 75	0.35	0.26	1.42 (0.85; 2.36)	0.17
Gender				
Female	0 ^a			
Male	-0.33	0.05	0.71 (0.64; 0.79)	0.00
Education				
Low	0 ^a		1	
Middle	0.26	0.11	1.3 (1.03; 1.64)	0.02
High	0.38	0.11	1.46 (1.16; 1.84)	0.00
Inhabitancy				
City	0 ^a		1	
Town	-0.16	0.05	0.84 (0.75; 0.94)	0.00
Country district	-0.06	0.06	0.93 (0.81; 1.07)	0.33
Are you or any other members of the family pregnant?				
No	0 ^a			
Yes	-0.42	0.12	0.65 (0.54; 0.79)	0.00
Members >65 years old				
None	0.93	1.2	2.54 (0.21; 30.4)	0.46
One	0.28	0.11	1.32 (1.07; 1.64)	0.01
Two	0.38	0.15	1.46 (1.08; 1.97)	0.01
Three	1.62	0.66	5.09 (1.38; 18.7)	0.01

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More than three	0 ^a		1	
Members <6 years old	β	SE	OR (95% CI)	p
None	-0.16	0.51	0.84 (0.3; 2.34)	0.75
One	-0.19	0.08	0.82 (0.69; 0.96)	0.01
Two	-0.06	0.17	0.93 (0.67; 1.3)	0.7
Three	-0.13	0.53	0.87 (0.3; 2.49)	0.8
More than three	0 ^a		1	
Actions preventing cross-contamination and infection (N = 9966)				
Age	β	SE	OR (95% CI)	p
16-24	0 ^a		1	
25-34	0.24	0.09	1.28 (1.07; 1.52)	0.00
35-44	0.53	0.08	1.7 (1.42; 2.02)	0.00
45-54	0.69	0.09	2 (1.67; 2.41)	0.00
55-64	0.88	0.1	2.4 (1.97; 2.93)	0.00
65-75	0.87	0.14	2.39 (1.81; 3.15)	0.00
> 75	0.54	0.26	1.72 (1.02; 2.9)	0.00
Gender				
Female	0 ^a			
Male	-0.67	0.05	0.51 (0.45; 0.56)	0.00
Education				
Low	0 ^a		1	
Middle	0.22	0.12	1.24 (0.98; 1.57)	0.04
High	0.97	0.42	2.64 (1.13; 6.14)	0.03
Inhabitancy				
City	0 ^a		1	
Town	0.25	0.06	1.29 (1.13; 1.47)	0.00
Country district	0.01	0.05	1 (0.91; 1.13)	0.7
Are you or any other members of the family pregnant?				
No	0 ^a			
Yes	-0.6	0.09	0.54 (0.45; 0.65)	0.00
Members >65 years old				
None	-0.65	0.5	0.52 (0.02; 9.25)	0.65
One	-0.19	0.09	0.82 (0.68; 0.99)	0.03
Two	0.06	0.1	1 (0.68; 1.48)	0.97
Three	-0.98	0.51	0.37 (0.13; 1.02)	0.04
More than three	0 ^a		1	
Members <6 years old				
None				
One	0.37	0.13	1.45 (1.11; 1.89)	0.00
Two	0.68	0.19	1.97 (1.34; 2.89)	0.00
Three	0.12	0.11	1.11 (0.84; 1.54)	0.41
More than three	0 ^a		1	
Proper hand cleaning methods (N = 9966)				
Age	β	ES	OR (95% CI)	p
16-24	0 ^a		1	

Age	β	ES	OR (95% CI)	p
25-34	0.16	0.1	1.17 (0.96; 1.42)	0.11
35-44	0.47	0.1	1.6 (1.32; 1.95)	0.00
45-54	0.61	0.1	1.85 (1.5; 2.28)	0.00
55-64	0.72	0.11	2.06 (1.65; 2.59)	0.00
65-75	0.75	0.16	2.12 (1.53; 2.94)	0.00
> 75	0.35	0.3	1.41 (0.77; 2.59)	0.25
Gender				
Female	0 ^a			
Male	-0.54	0.06	0.58 (0.51; 0.65)	0.00
Education				
Low	0 ^a		1	
Middle	0.39	0.13	1.48 (1.14; 1.92)	0.00
High	0.47	0.13	1.6 (1.23; 2.07)	0.00
Inhabitancy				
City	0 ^a		1	
Town	-0.27	0.05	0.91 (0.77; 1.08)	0.00
Country district	-0.08	0.06	0.76 (0.66; 0.87)	0.3
Are you or any other members of the family pregnant?				
No	0 ^a			
Yes	-0.75	0.09	0.47 (0.39; 0.57)	0.00
Members >65 years old				
None	1.58	1.04	4.87 (0.63; 37.5)	0.12
One	0.28	0.08	1.33 (1.11; 1.58)	0.00
Two	0.11	0.1	1.12 (0.88; 1.43)	0.35
Three	0.74	0.57	2.09 (0.68; 6.41)	0.19
More than three	0 ^a		1	
Members <6 years old				
None	0.08	1.4	1.08 (0.06; 18.3)	0.95
One	-0.22	0.07	0.8 (0.69; 0.93)	0.00
Two	-0.38	0.15	0.68 (0.5; 0.92)	0.01
Three	-0.18	0.49	0.83 (0.31; 2.17)	0.7
More than three	0 ^a		1	

β = regression coefficient; SE = standard error; OR (95% CI) = odd ratio (95% confidence interval); ^areference value; N = number of valid answers

The regression model indicated that respondents aged 35 to 75 years are more likely to wash their hands after touching raw chicken than respondents aged <35 years ($p < 0.05$; OR = 1.36 – 1.8; Table 3.1). These groups were also more likely to report appropriate hand-cleaning methods and key moments when hands should be cleaned than younger consumers (<35 years) ($p < 0.05$; OR = 1.27 - 2.4; Table 3.1). Contrary to our results, a good level of food safety knowledge has previously been recorded among young Malaysian adults (Ruby et al., 2019a), while American consumers aged >60 years were more inclined to follow the recommended

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practices regarding food safety than consumers aged <60 years (Anderson, Verrill, & Sahyoun, 2011).

Gender was a strong negative predictor in the regression model indicating that men were less inclined to wash their hands after handling raw chicken, or to know, in general, when and how hands should be cleaned ($p < 0.01$; OR = 0.5 – 0.71; Table 3.1). Our findings are consistent with other studies in which women had better knowledge of food safety (Burke et al., 2016; Ruby et al., 2019a) and were more inclined to follow proper food handling practices than men (Katiyo et al., 2019).

The regression analysis indicated a higher probability that respondents with a medium/high level of education would practice appropriate hand washing methods after touching raw chicken and indicate when hands should be washed than respondents with a low level of education ($p < 0.05$; OR = 1.24 – 2.64; Table 3.1). Parra, Kim, Shapiro, Gravani, & Bradley, (2014) suggested that respondents with a high level of education are more concerned about food safety than those with a low level of education.

Those who lived in towns were positive predictors only for when hands should be washed ($p < 0.05$; OR = 1.29; Table 3.1), suggesting that they knew when hand washing should take place, but were less inclined to wash their hands after touching raw chicken or to apply the appropriate hand cleaning procedures, as opposed to consumers living in cities. Regarding inhabitancy, the results vary as indicated by Tomaszewska et al., (2018) where Thai consumers who lived in villages and towns had better food hygiene knowledge than those who lived in cities, the contrary being observed for Polish consumers.

Families living with elderly members (>65 years) were less inclined to report when hand hygiene should be applied ($p < 0.05$; OR = 0.37 – 0.82; Table 3.1) but were better informed about appropriate hand washing methods, as they were up to five times more inclined to apply adequate hand hygiene practices after handling raw chicken than families without any elderly members ($p < 0.05$; OR = 1.32 – 5.09; Table 3.1). Other studies suggested that elderly respondents (>60 years old) do not perform proper hygiene practices in kitchen (Evans & Redmond, 2019) and that their hands are one of the most contaminated surfaces in the kitchen (Jevšnik et al., 2013), which can increase the risk of cross-contamination.

Families with children (<6 years) reported the key moments for hand washing ($p < 0.05$; OR = 1.45 – 1.97; Table 3.1) but at the same time were less inclined to wash their hands after handling the raw chicken ($p < 0.5$; OR = 0.72; Table 3.1) or know how to wash them in general ($p < 0.05$; OR = 0.68 – 0.8; Table 3.5) than families without young children. During the SafeConsume visits, while preparing food, parents were seen being more concerned about their children safety than following the appropriate hygiene practices during cooking (Skuland et al., 2020).

Families with pregnant women were negative predictors throughout the regression analysis, implying that respondents from this group are less likely to wash their hands after touching raw chicken and indicate a low awareness of when and how hands should be washed ($p < 0.05$; OR = 0.47 - 0.65; Table 3.1). Contrary to these results, during observational studies on hand hygiene practices during the preparation of meals carried out under the SafeConsume project, pregnant women were aware of the appropriate hand cleaning procedures mainly due to the high concerns for the safety of their fetus (Skulland et al., 2020).

Quantification of dirt after application of borsch and borsch and sunflower oil to the hands of consumers is shown in Figure 3.1 and was measured after the simulation of hand contamination and did not involve any cleaning procedure.

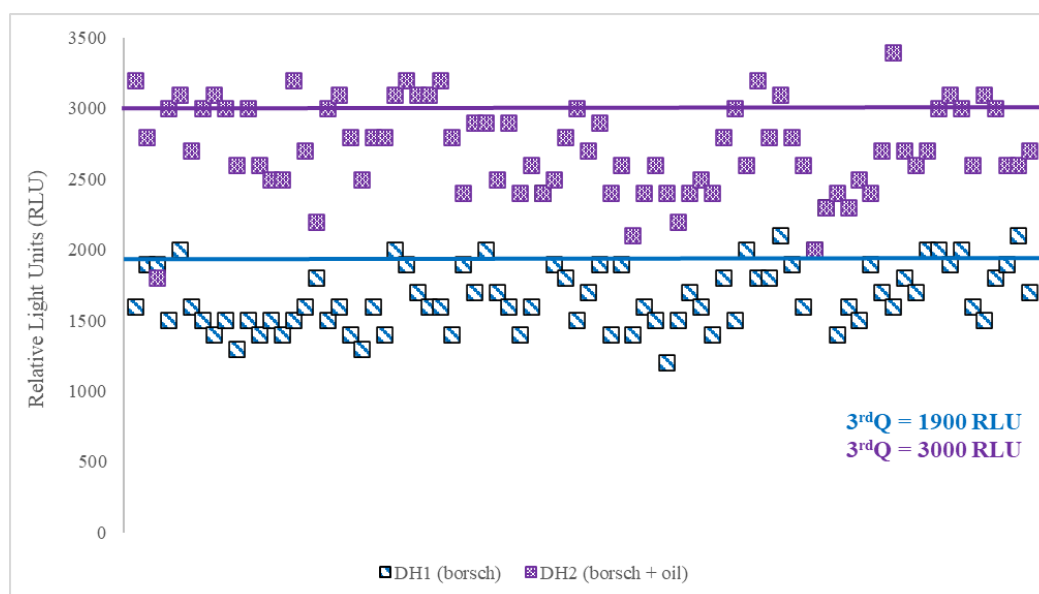


Figure 3.1. Quantification of hand dirtiness based on the 3rdQ values; DH1 (light blue) – first scenario of contamination (borsch); DH2 (purple) - second scenario of contamination (borsch + oil)

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After analysing the dirt on the hands for both cases of contamination, higher values were obtained for hands contaminated with borsch and sunflower oil ($3^{\text{rd}}\text{Q} = 3000 \text{ RLU}$) compared to hands contaminated only with borsch ($3^{\text{rd}}\text{Q} = 1900 \text{ RLU}$).

The 3^{rd}Q values obtained for the two cases of dirtiness were considered the maximum amount of dirt to be released during the experiment and taken as reference points for comparing the different hand cleaning procedures.

Figure 3.2 shows the 3^{rd}Q value for the remnant dirt on the hands of participants after applying each HCP to DH1, while Table 3.2 shows the effectiveness of HCPs and significant differences, if any were present.

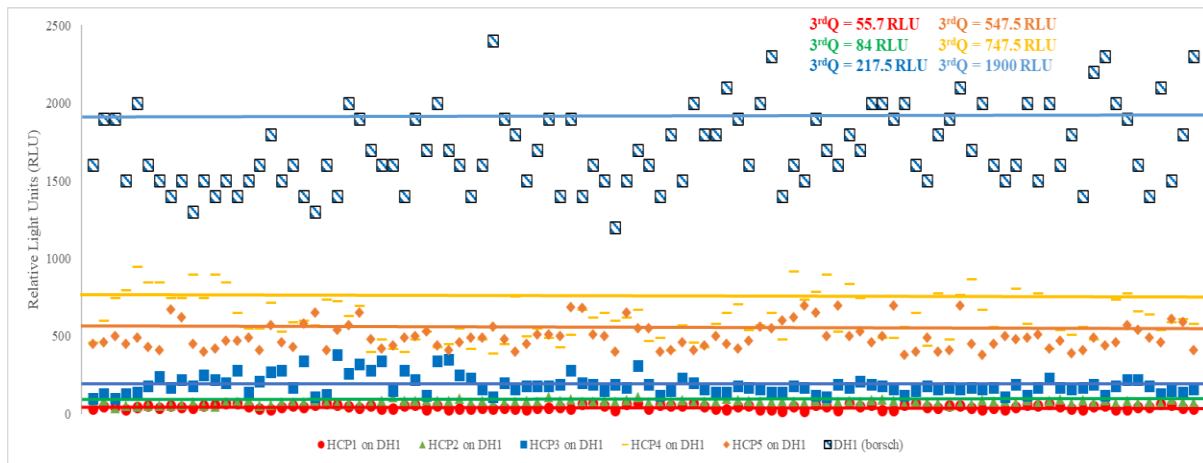


Figure 3.2. Quantification of remnant dirtiness for all HCPs on DH1; HCP1 (red) - Washing hands for 20 s with running warm water ($40 \pm 2 \text{ }^\circ\text{C}$) and soap, then wiping hands with paper towel; HCP2 (green) - Washing hands for 20 s with running cold water and soap, then wiping hands with paper towel; HCP3 (dark blue) - Rinsing hands for 5 s with running cold water, then wiping them with paper towel; HCP4 (yellow) - Wiping hands for 20 s with wet wipes; HCP5 (orange) - Wiping hands for 20 s with antibacterial wet wipes

Tabelul 3.2. The efficacy of the hand cleaning procedures applied to DH1 and DH2

RLU on hands	Mean value, RLU	Efficacy, %	Grouping letter*
DH1 contamination	1708		
Warm water + soap	45.1	97.3	A
Cold water + soap	77.2	95.4	B
Rinse	188	88.9	C
Wipe with wet tissue	618	63.8	D
Wipe with antibacterial tissue	498.6	70.8	E

DH2 contamination	2725		
Warm water + soap	100.1	96.3	F
Rinse	258.5	90.5	G

DH1 – first scenario of contamination (borsch); DH2 – second scenario of contamination (borsch + oil); *Means that do not share the same letter are significantly different at $p < 0.01$.

As indicated by 3rdQ value (HCP1 = 55.7 RLU) washing hands with warm water and soap was the most effective method of cleaning hands. This is also supported by the fact that it was 97.3% effective, significantly better than the rest of the HCPs ($p < 0.01$; Table 3.2).

Washing hands with cold soap and water (HCP2) was second (3rdQ = 84 RLU) with 95.4% efficacy. However, there were significant differences between HCP1 and HCP2 ($p < 0.01$; Table 3.2).

Rinse with cold water for 5 s (HCP3) was the third best method (3rdQ = 217.5 RLU) and had an efficacy of 88.9%. This procedure was significantly less effective than HCP1 and HCP2, but was found to be more suitable for cleaning hands than wiping hands with wet/antibacterial wipes ($p < 0.01$; Table 3.2). Efficacy can be attributed to the flow of water in the release of bacteria and organic dirt from the hands.

The highest RLU values were observed after participants wiped their hands with wet wipes (3rdQ = 747.5 RLU) and antibacterial (3rdQ = 547.5 RLU). However, antibacterial wipes were 70.8% effective and were found to be a more suitable solution than wet wipes that removed 63.8% of dirt ($p < 0.01$; Table 3. 2).

Figure 3.3 shows the dirt left on the participants' hands after application of HCP1 and HCP3 on DH2.

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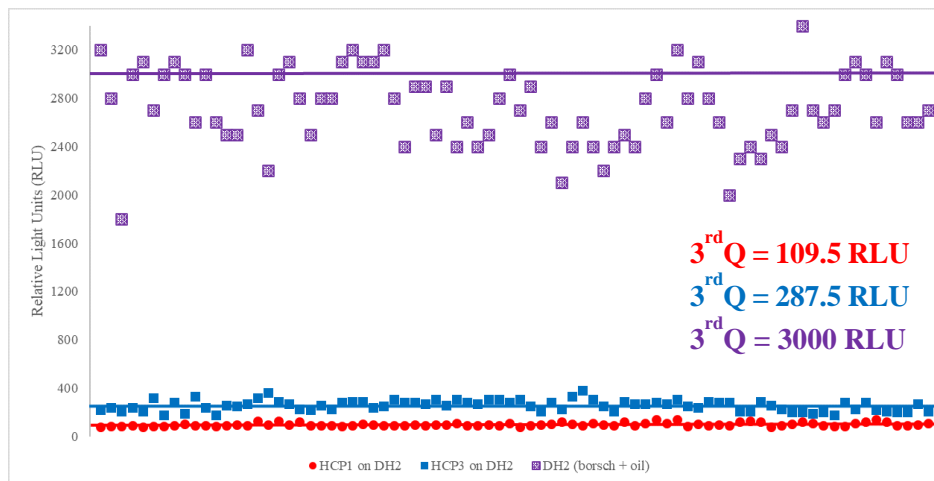


Figure 3.3 Quantification of remnant dirtiness after applying HCP1 and HCP3 on DH2; HCP1 (red) - Washing hands for 20 s with running warm water (40 ± 2 °C) and soap, then wiping hands with paper towel; HCP3 (dark blue) - Rinsing hands for 5 s with running cold water, then wiping them with paper towel

Similar to the previous type of contamination, for greasy hands, after participants washed their hands with warm water and soap, the remaining dirt was lower ($3^{\text{rd}}\text{Q} = 109.5$ RLU) than after rinsing hands with cold water ($3^{\text{rd}}\text{Q} = 287.5$ RLU). Although the effectiveness of washing with warm water (HCP1 = 96.3%) is significantly higher than that of rinsing with cold water (HCP3 = 90.5%) ($p < 0,01$; Table 3.2), both cleaning procedures have an efficacy of over 90%.

Conclusions

The fact that families with members vulnerable to foodborne illnesses have not reported adequate hand hygiene practices is alarming because vulnerable consumers such as pregnant women, older women and children are more susceptible to food borne diseases than healthy adults.

From the hand hygiene experiment we can conclude that washing hands with warm water and soap for 20 s is the most effective method when hands are either dirty or greasy, as it often happens during the cooking of poultry meat or meat in general. Water temperature was a significant parameter in the removal of dirt, since washing hands with cold water and soap was less effective than washing with warm water and soap, but, nevertheless, it was the second most effective hand cleaning procedure. Rinsing under running water for 5 s, a routine during meal preparation, significantly reduces the risk of contamination, as it removes 90% of the dirt from the hands. However, it may not be sufficient after touching a product contaminated with a pathogen with a low infectious dose (e.g., *Campylobacter* and Norovirus). Antibacterial

wipes have been significantly more effective than wet wipes, indicating that they are a better choice when soap and water are not available.

Visualising the dirt removed from their hands after applying different cleaning procedures can help consumers better understand the importance of hygiene in both kitchens and other situations and determine the adoption of the appropriate procedure in correlation with the type of dirt.

Chapter IV

The analysis of the correlation kitchen design – hygiene practices – food safety

This chapter examines the influence of the location of kitchen equipment on the hygiene practices of European consumers on the basis of a questionnaire and visits conducted to consumers' households. The novelty of the study is that it underlines the importance of implementing the concept of food safety in the kitchen by highlighting the significant correlations between kitchen equipment and consumers' food hygiene practices.

Results and discussions

Consumers' self-reported hygienic practices and the placement of the sink

Table 4.1 displays the results from the regression analysis of the self-reported hygiene practices during food preparation in relation to the placement of the sink.

Table 4.1. Regression analysis of the self-reported hygiene practices during food preparation in relation to the placement of the sink

Model 1		<i>How likely is it that you would clean your hands immediately after touching raw chicken?*</i>			
	β (SE)	BCa (CI 95%)	OR (CI 95%)	p	
Sink placement					
Inside	0 ^a		1		
Outside	-0.64 (0.03)	-0.32; -0.89	0.52 (0.44; 0.61)	0.00*	
Model 2		<i>After cutting chicken, how likely is it that you will re-use the same cutting board for vegetables, salads or fruit?*</i>			
Sink placement					
Inside	0 ^a		1		
Outside	0.37 (0.08)	0.19; 0.54	1.5 (1.23; 1.71)	0.00*	
Model 3		<i>After cutting chicken, how likely is it that you will re-use the same knife (without washing it) for vegetables, salads or fruit?*</i>			
Sink placement					
Inside	0 ^a		1		
Outside	0.56 (0.08)	0.25; 0.86	1.8 (1.48; 2.07)	0.00*	

β = regression coefficient; SE = standard error; BCa (95% CI) = Bias-corrected accelerated (95% confidence interval) using the bootstrapping technique (1000 iterations); OR (95% C.I.) = odds ratio (95% confidence interval); a = reference value; *N = 7866 valid answers; **p < 0.01.

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The sink placement was a negative predictor, as consumers who had the sink placed outside the kitchen were less inclined to wash their hands after touching raw chicken than consumers who had the sink in the kitchen (Table 4.1).

The location of the sink also indicated that respondents who had the sink outside the kitchen are 1.5 to 1.8 times more inclined than respondents who had kitchens equipped with sinks to reuse, without washing them, for the preparation of vegetables, fruits or salads, the same cutting boards and/or knives used to cut raw chicken (Table 4.1).

In general, the regression analysis of the questionnaire showed that the placement of the sink outside the kitchen was strongly associated with a lower frequency of practices that can reduce cross-contamination.

Observed food hygiene practices and main cross-contamination events that took place in the kitchens during the SafeConsume visits

In Figure 4.1, the main potential cross-contamination events and the occasion they occurred are presented. The events were counted as actions which involved participants handling food and then manipulating other kitchen items or foods without washing hands in between the actions. The most frequent actions after touching raw foods (raw chicken, raw vegetables, lettuce) included opening drawers or the fridge, manipulating food containers, checking/answering the phone and inefficient hand cleaning such as wiping with a dish cloth instead of applying the recommended washing procedure with water and soap. The other potential cross-contamination events consisted of consecutive handling of different types of food without applying a hand cleaning procedure such as: handling washed vegetables that will be eaten raw after touching unwashed lettuce and/or raw chicken, handling washed lettuce after touching raw unwashed vegetables and/or raw chicken, proving that consumers were not aware on the key moments when it is important to apply hygienic practices. There were also cases when the consumers touched their face or interacted with their children right after handling raw foods and without washing their hands.

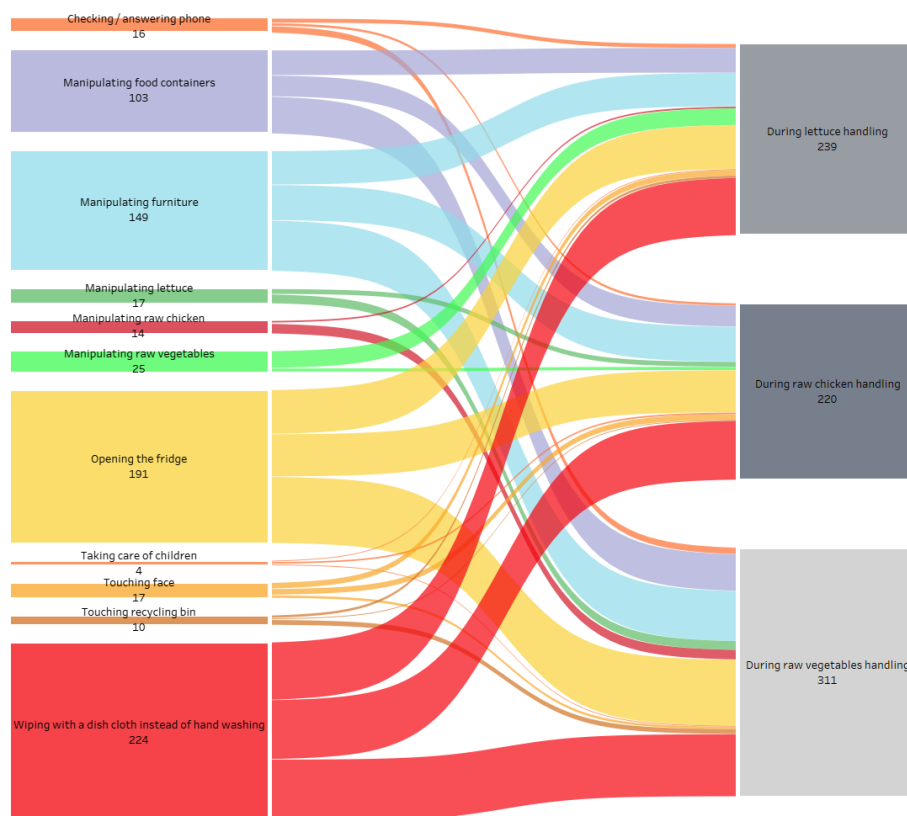


Figure 4.1. Sankey diagram illustrating the main potential cross-contamination events and the occasion they occurred

Table 2 displays the number of cross-contamination events that occurred in each country (alphabetically ordered) and the occasion they occurred. The highest average number (21) of potential cross-contamination events was recorded during handling of vegetables (tomatoes, cucumbers, onions etc.), and the lowest during the preparation of lettuce salad (15) and raw chicken (15) (Table 2). A comparison between countries revealed that Romania and Hungary registered the highest average number of potential cross-contamination events.

Table 4.2. Average number of potential cross-contamination events per country and per kitchen and the occasion they occurred

Average number of CC events that occurred during handling of...				
Country	raw chicken	raw vegetables	lettuce	Total
France	3	3	3	9
Hungary	6	3	3	12
Norway	1	6	2	9
Portugal	2	3	4	9
Romania	3	6	3	12

Legend

Average number of CC events		
≤ 5	5-10	> 10

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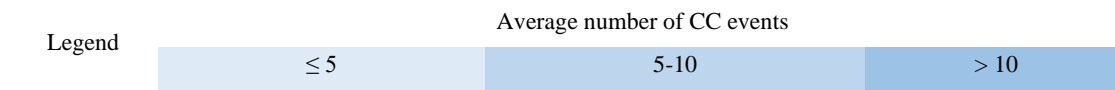
The analysis of the correlation kitchen design – hygiene practices – food safety

Correlations between food hygiene practices during food preparation and kitchen designs

We observed a similar average number of cross-contamination actions in kitchens where the work triangle complied with the recommended perimeter of 4 – 7.9 m and in kitchens where the perimeter was >7.9 m (Table 4.3). Out of the 51 households in which the arrangement of the equipment followed the recommendations of the work triangle in the kitchen, eight had the key equipment arranged in line (special case of the work triangle, in which the tips of the triangle are arranged in line). Examples of kitchens where the work triangle had the recommended value for its perimeter are shown in Figure 4.2a and 4.2b and examples of kitchens where the recommended value for the work triangle is exceeded as a result of placing one of the equipment outside the kitchen are shown in Figure 4.2c and 4.2d.

Table 4.3. Average number of potential cross-contamination events and the occasion they occurred in kitchens where the arrangement of the key equipment had the recommended perimeter of the work triangle (4-7.9 m) and kitchens where the arrangement of the equipment had a perimeter >7.9 m

Average number of CC events that occurred during handling of...					
Kitchen work triangle perimeter, m	N	Average number of CC events			Total
		raw chicken	raw vegetables	lettuce	
4-7.9	51	3	4	3	10
>7.9	13	4	5	2	11



N = number of kitchens

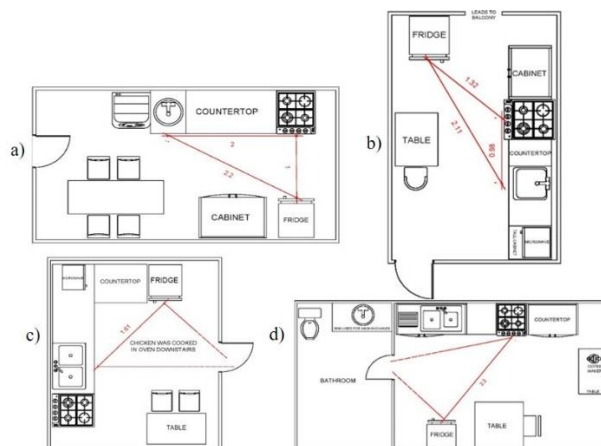


Figure 4.2. – a) and b) Kitchen layouts (RO_Amalia_YF and PT_Augusto_EP), where the work triangle has the recommended perimeter (4 – 7.9 m); c) and d) Kitchen layouts (NO_Fredrik_YSM and FR_Vincent_YSM) where one of the equipment was outside the kitchen, hence the recommended perimeter was exceeded

The food safety triangle – key element in kitchen designs regarding risk reduction of foodborne illnesses

In the food safety triangle, one apex was considered either the countertop or the table depending on the place where the consumers prepared the meal. Most of the consumers used the surface of a cabinet (countertop) while in other cases the kitchen table alone was the place where consumers prepared food. In comparison with the work triangle, for the food safety triangle we have considered the preparation area (countertop or table) instead of the cold storage area (refrigerator), as this is the place where most of the meal preparation is done and requires more hand cleaning actions to avoid cross-contamination events.

Table 4.4 presents the average number of potential contamination events and when they occurred in kitchens where the arrangement of the key equipment had a perimeter ≤ 4 m and kitchens where the arrangement of the equipment had a perimeter >4 m.

The average perimeter of the food safety triangle from the visited households was 4 m, and we chose to compare the number of cross-contamination actions between kitchens where the perimeter was ≤ 4 m (37 households) and >4 m (27 households). Two more cross-contamination actions per household were noticed in kitchens with the perimeter >4 m than in kitchens with the perimeter ≤ 4 m (Table 5). In our calculations, we considered the distance sink-working place-stove even for kitchens where the key equipment was placed in line (26 kitchens). Other comparisons that were tested involved perimeters from ≤ 2 to >8 m but no significant differences were found regarding the number of potential cross-contamination events ($p > 0.05$).

Table 4.4. Average number of potential contamination actions and the occasion they occurred in kitchens where the arrangement of the key equipment had a perimeter ≤ 4 and kitchens where the arrangement of the equipment had a perimeter >4 m.

Average number of CC events that occurred during handling of...					
Food safety triangle perimeter, m	N	raw chicken	raw vegetables	lettuce	Total
≤ 4	37	2	4	3	9
>4	27	4	4	3	11

Average number of CC events		
Legend	≤ 5	> 10

N = number of kitchens

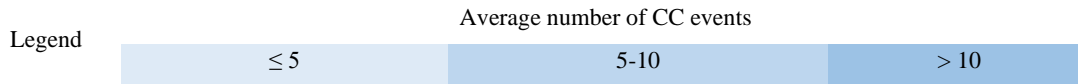
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The analysis of the correlation kitchen design – hygiene practices – food safety

In Table 4.5 is displayed the average number of potential cross-contamination events, the occasion they occurred, and the sink – countertop distance. In 34 kitchens, the sink – countertop distance was ≤ 1 m and the average number of potential contamination actions was 8, while in the other 30 kitchens the sink – countertop distance was >1 m and the average number of potential contamination actions was 12.

Table 4.5. Average number of potential contamination actions and the occasion they occurred in kitchens where the arrangement of the key equipment had a perimeter ≤ 4 and kitchens where the arrangement of the equipment had a perimeter >4 m

Average number of CC events that occurred during handling of...					
Food safety triangle perimeter, m	N	raw chicken	raw vegetables	lettuce	Total
≤ 4	37	2	4	3	9
> 4	27	4	4	3	11



N = number of kitchens

Examples of kitchens from the visited consumers where the food safety triangle had a perimeter ≤ 4 m and the sink – countertop distance was ≤ 1 m are shown in Figure 4.3a and 4.3b, while in 4.3c and 4.3d there are examples of a food safety triangle arrangement with the perimeter >4 m and sink – countertop distance >1 m.

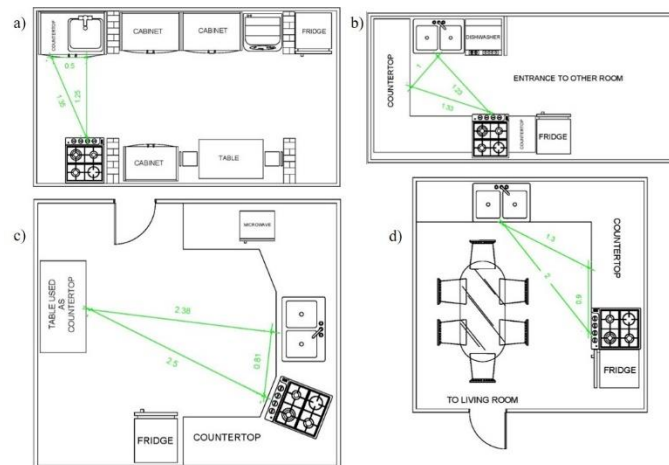


Figure 4.3. a) and b) Kitchen equipment arrangement where the food safety triangle has a perimeter ≤ 4 m and a sink – countertop distance ≤ 1 m (RO_Ionel_YSM and NO_Inger_EP); c) and d) Kitchen equipment arrangement where the food safety triangle has a perimeter >4 m and a sink – countertop distance >1 m (HU_BA_YF and FR_Elodie_YF)

Conclusions

Significant correlations were found between the location of the sink (inside or outside the kitchen) and the observed hygienic practices of consumers, results which was supported by the questionnaire, as consumers who had sinks outside the kitchen performed fewer cleaning actions than those who had the sink inside the kitchen.

The regression models for consumers' observed food hygiene practices indicated that cross-contamination events are more likely to occur when the sink – countertop distance is >1 m and the perimeter of the safety triangle is >4 m. Hence, we consider that the food safety triangle, which is the triangle formed by the apexes of sink – countertop – stove that we suggest in this paper as replacement of the kitchen work triangle, with the perimeter ≤ 4 m and its side represented by the sink – countertop distance ≤ 1 m may be an acceptable compromise between safety and efficiency in kitchens.

As our study was observational, examined kitchens that highly differed in the way they were designed and equipped and took into consideration just the number of potential cross-contamination events and not the severity of the associated risks, it opens the floor for studies to confirm our theory.

Chapter V

Refrigeration practices applied by consumers at home

The studies in this chapter were aimed at demonstrating the need to educate consumers about domestic refrigeration practices through the following objectives:

- Assessment of consumer refrigeration knowledge and practices by means of an online questionnaire focusing on the surfaces of refrigerators used as an indicator of food safety,
- Assessment of consumer sensations and perceptions on the ability of the sense of touch to provide valid information about the actual refrigeration temperature and their ability to discriminate against the temperature of different packaged foods kept in the refrigerator and the walls of refrigerators. The sensations and perceptions of low temperatures were assessed by the sense of touch using different foods and surfaces as thermal indicators for temperatures. Two parameters were determined: the discrimination threshold (DT), defined as the smallest temperature difference that a person could detect between two thermal stimuli, and the point of subjective equality (PSE) which is defined as the equivalent perception of the cold intensity of two different thermal stimuli,
- Estimating the likelihood of consumers correctly perceiving the temperature of several food and the refrigerator wall.

Results and discussions

Table 5.1 shows consumers' self-reported knowledge and refrigeration practices.

Table 5.1. Consumers' self knowledge and refrigeration practices (N = 320)

Question	Frequency, (%)
<i>1. I check the fridge temperature...</i>	
Using the refrigerator display	39.5
Using tactile sensations	17.5
I do not check	43.4
<i>2. How often do you check the refrigerators' temperature?</i>	

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Weekly			28.1
Monthly			19.1
I do not know			52.8
3. Do you think that food temperature from your fridge indicates the real temperature of your refrigerator?			
No			41.9
Yes			38.4
I do not know			19.7
4. The surface that best indicates the real temperature of my fridge is (%):			
	I agree	I disagree	I do not know
Fridge door	15.3	63.7	20.9
Fridge wall	42.2	42.5	15.3
Upper shelf	35.9	43.1	20.9
Middle shelf	50.3	28.7	20.9
Bottom shelf	33.1	45.9	20.9
Aluminum can	29.4	42.2	28.4
Bottle glass	34.7	41.3	24.1
PET	14.7	57.5	27.8
5. How do you adjust the refrigerators' temperature?			
			Yes
Using a thermometer or the refrigerators' display			85.9
I do not adjust the refrigerators' temperature			14.1
6. The reasons for which I adjust the refrigerators' temperature (%):			
	I agree	I disagree	I do not know
Season change	51.2	34.1	14.7
The fridge has been cleaned	56.9	28.7	14.4
The food in my fridge are not as cold as they should be	70.9	14.4	14.7
The fridge is full	56.6	25	18.4

N = number of valid answers

The responses from the survey show that 43.4% of respondents never checked the temperature of the refrigerator, while more than half of those who check the temperature of the refrigerator

at home said they did not know when they did the last check. In a survey conducted in the UK, 42% of respondents mentioned that they never check the temperature of the refrigerator and about half (48%) check the refrigerator temperature at least once a week (Prior et al., 2013). In a survey conducted on French consumers, only 37% of respondents monitored refrigerator temperatures (Legendijk et al., 2008). The Food and Agriculture Organization (FAO) recommends regular temperature checking at least once a week (Joshi et al., 2010). On the other hand, even if consumers use a thermometer to check the temperature of the refrigerator, they often do not know where to place it in the refrigerator (Anon, 2015).

Figure 5.1 shows the experimental temperatures perceived and predicted model curves based on cumulative Gaussian distribution of food items and surfaces maintained at 4°C and 8°C.

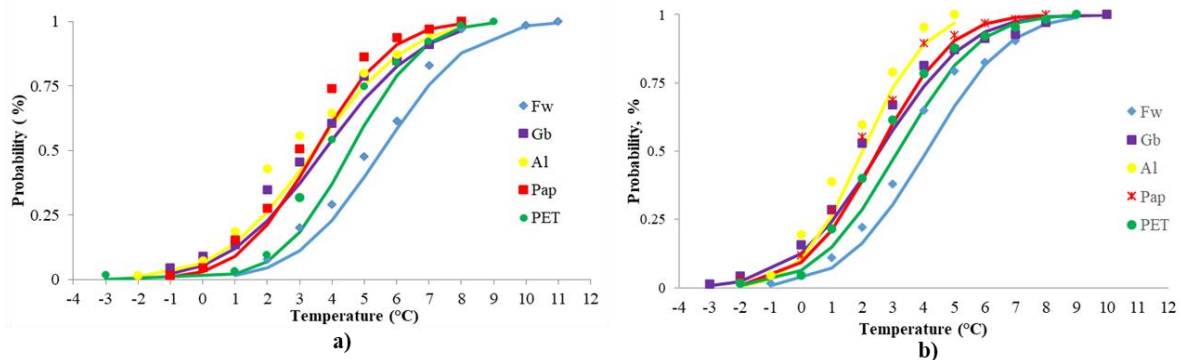


Figure 5.1. Experimental temperatures perceived and predicted model curves based on cumulative Gaussian distribution of food items and surfaces maintained at: a) 4°C and b) 8°C

PSE at 50% response level indicates that consumers perceive the aluminum cans with 2 °C lower than the real temperature (4°C), while the temperature perceived after touching paper and glass bottle was equal, and with 1°C lower than the actual temperature. The PSE perceived for PET was 3.5°C and 4.5°C for the fridge wall. It can be noticed that at 50% response level, PSE varied in the range 2 – 4.5°C for all materials (Figure 5.1a).

The DT values at 25% response level, give the temperature range out of which consumers could reliably discriminate between materials. The difference between PSE and DT was 1°C for aluminum can, 1.2°C for glass bottle, 1.8 for paper, 1.5°C for PET and 1.2°C for the fridge wall. The probability of perceiving the real temperature of the food and fridge wall at 4°C is relatively low in the range of 16.17 – 18.89% (Figure 5.2a).

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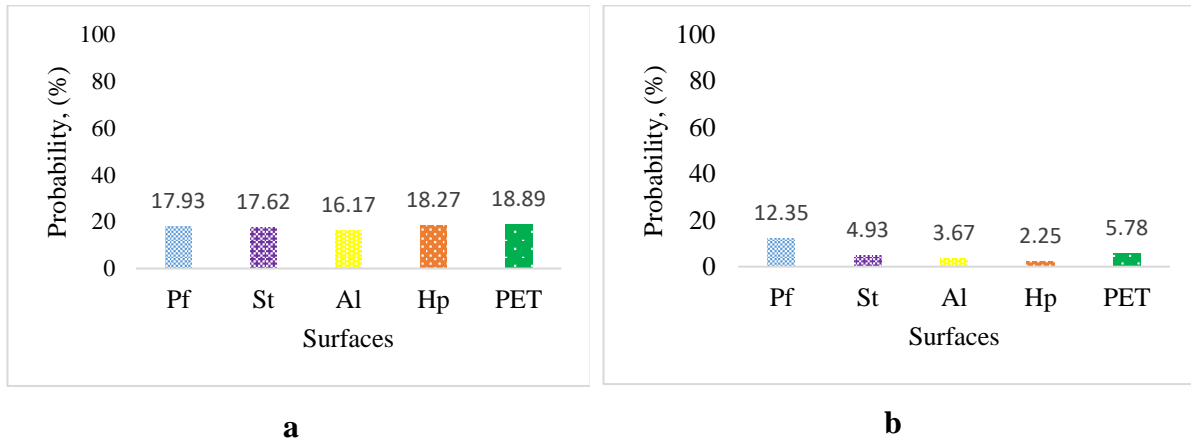


Figura 5.2. The probability of correctly estimating the temperature of the tested surfaces at: a) 4°C and b) 8°C based on the Gauss distribution

When the same experiment was performed at 8 °C, three packaging materials of different foods registered very close PSE values: 3.5°C for aluminum cans, 3.5°C for paper and, 3.9°C for glass bottle. In the case of PET, the temperature at 50% response level was 4.9°C and for the refrigerator wall, 5.8°C, with significantly different perceived temperature values compared to all the other reported values of temperature ($p < 0.05$).

At 8°C all the PSE values were lower than the actual temperature, so consumers could easily be misled by their senses to trust their food is safe. Here consumers could be at risk if based on their tactile sense consider the food products safe while the actual temperature is above the recommended temperature for refrigeration.

The probability of consumers estimating the correct temperature by tactile perception of the fridge wall or of food products stored at 8°C is very low starting from 2.25% for the fridge wall up to 12.35% for the parchment paper (Figure 5.2b).

Conclusions

Consumers that assess the temperature of refrigerated food by tactile cold perception could be misled and at risk of food poisoning. Thus, consumers should not rely on their tactile sense to measure the temperature of different foods/surfaces at refrigeration temperature, especially when the products are kept at 8°C, a temperature that favours the development of certain pathogens.

This study provides a strong argument against the assessment of refrigeration temperature by the sense of touch demonstrating that it is very difficult to differentiate the temperature of food

and surfaces and that the perceived temperature for the same intensity of the cold sensation is different for foods and surfaces. Such a study supports the need to launch educational campaigns on good refrigeration practices, especially for countries where such actions have never been organised.

Final conclusions, original contributions, and future research perspectives

Final conclusions

This thesis is an approach to food safety both from the perspective of consumers, who have been questioned about their knowledge of food hazards and hygiene rules applicable to shopping, and when storing and cooking food, and have been observed how they apply them, as well as from that of hygiene specialists and food safety management, who have studied the responses and routines of consumers and with specific means have examined them so as to be able to provide the authorities with explanations on the high number of food poisonings that have originate from the home environment and the motivation to educate consumers.

The KAP (knowledge-attitude-practices) questionnaire, which was carried out with the aim of analysing the relationship between the knowledge, attitude and practices of Romanian consumers related to food safety, was analysed using SEM (structural equation modelling), and the results indicated the following:

- Romanian consumers with a high level of food safety knowledge have shown a higher interest in food safety, food quality and integrity;
- The SEM analysis indicated that respondents with a high level of knowledge of food safety also have an appropriate attitude to food safety during food shopping;
- The level of knowledge has a significant positive effect on self-reported hygiene practices in the kitchen;
- The attitude of consumers with regard to food safety during shopping has had a stronger effect than that reported by the level of knowledge, indicating that they are more inclined to apply hygiene practices during food preparation,
- Knowledge together with the attitude of consumers on prioritizing food safety explains 30% of consumer practices, a percentage considered high because human behaviour is very complex and difficult to explain.

These results will allow educational campaigns to be carried out with a focus on sources of contamination and appropriate hygiene practices in the kitchen to prevent cross-contamination and to reduce the risk of foodborne illnesses that take place at home.

The implications of kitchens' design and hygiene practices on consumers' food safety

By mapping hand hygiene practices in 10 European countries through a questionnaire and experimentally determining the effectiveness of five hand cleaning procedures, we have revealed that:

- Vulnerable groups of consumers (families with: elderly members. young children or pregnant women) reported low awareness of key moments when hands should be sanitized and the recommended method of hand washing;
- Washing hands with warm water and soap for 20 s is the most appropriate hand cleaning method during cooking, when hands are either dirty or greasy;
- Rinsing only with water for 5 s reduced 90% of the dirt of the hands, but is not recommended especially after touching a product contaminated with pathogens with a low infectious dose (such as noroviruses and bacteria of the *Campylobacter* genus);
- Antibacterial wipes are recommended only when water and soap are not available.

The dissemination of these results will contribute to consumers adopting procedures for hand hygiene, during the preparation of meals at home, related to the type of dirt on the hand, the food touched and the food and utensils they are about to touch. This will give consumers a deeper understanding of the key moments and methods of hand cleaning.

Through a questionnaire answered by consumers from 10 European countries and by analysing the kitchen design of 64 consumers from five European countries, it was noted that:

- Both self-reported and observed hygiene practices of consumers were correlated with the sink placement, indicating that those who had sinks in the kitchen were more inclined to apply hygiene practices than those with improvised kitchens, without sinks, or those with sinks that had functioning problems;
- The work triangle, recommended by designers when designing kitchens does not favour consumer hygiene practices regardless of whether or not the recommended dimensions are respected;
- Fewer cross-contamination events took place for the consumers where the sink – countertop distance was ≤ 1 m and the perimeter of the safety triangle (sink – countertop – stove) was ≤ 4 m.

These data can be used as a starting point for future research on food safety arrangements, instead of models focused on ergonomics.

Interventions regarding food safety education campaigns could take an integrated approach, promoting key moments for cleaning hands, utensils and kitchen surfaces and the importance of kitchen equipment arrangements.

Inadequate practices that increase the risk of foodborne illnesses include time/temperature abuse, respectively consumer refrigeration practices. Consumers often rely on the tactile sense to check the temperature of products in the refrigerator, a practice not recommended, as consumers can be easily misled by the perception of the temperature of different food products. In order to better understand consumers' knowledge and refrigeration practices, as well as the accuracy of the tactile perception of Romanian consumers, we conducted a questionnaire and an experiment that indicated:

- The respondents from the survey rely on the tactile sense and temperature of different foods and surfaces in the refrigerator to assess the refrigeration temperature;
- When touching cold food and surfaces, consumers perceive their temperature as being lower than the real temperature;
- The probability that participants correctly assessed the temperature of products and surfaces stored at 4°C and 8°C ranged from 2.25 to 18.89%.

This study demonstrated the lack of accuracy of the tactile sense in the assessment of refrigeration temperature. If it is not based on the indication of thermometers or thermocouples, consumers do not realise when the temperature in the refrigerator exceeds the recommended threshold (4°C) and let the equipment operate at temperatures at which the development of pathogens is favoured, thereby exposing themselves to the risk of foodborne illnesses.

Original contributions

The results of this doctoral thesis contribute to the extension of knowledge of the addressed field, respectively the influence of food hygiene practices and kitchen design on the food safety of consumers, through the following aspects:

- Initiating studies whose findings can contribute to raising awareness of the risk of foodborne illnesses that consumers expose themselves to, especially for vulnerable groups, by presenting statistics on the number of foodborne outbreaks that have

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occurred over the past five years in Europe and Romania, in particular those originating in the home environment and caused by inadequate hygiene practices;

- Developing a KAP (knowledge-attitude-practices) questionnaire and building the first SEM (structural equation modelling) model on Romanian consumers' food safety knowledge, food shopping attitude, and hygiene practices during food preparation;
- Highlighting self-reported hand hygiene practices for consumers in ten European countries in relation to their demographic profile by developing a regression model;
- Contributing to the analysis of the effectiveness of hand cleaning methods by conducting an experiment which quantifies the dirt removed from the participants' hands by the bioluminescence test;
- Highlighting the correlation between the sink placement (inside/outside the kitchen) with inadequate hygiene practices during food preparation by means of regression analyses;
- Suggesting a new arrangement in the kitchen, called the food safety triangle (imaginary line formed between the sink – countertop – stove), intended to replace the work triangle (imaginary line formed between the sink – stove – refrigerator), so consumers' food safety is prioritised over the work efficiency in kitchens;
- Use the point of subjective equality (PSE) and the determination threshold (DT) to indicate the risk that consumers expose themselves to when they rely on their tactile sense to check the refrigeration temperature of food.

Future research perspectives

Given the high number of foodborne illnesses associated with the home environment, the research may continue with:

- highlighting other domestic practices that put consumers at risk of foodborne illness and barriers preventing them from working in such a way that hygiene rules are respected;
- investigating the attitude and behaviour of consumers towards interventions conducted by authorities to reduce the number of foodborne diseases;
- microbiological studies related to the hygiene of consumers during shopping, food storage and cooking and the hygiene of their kitchens.

Dissemination of the results obtained during the PhD studies

Articles published in ISI journals

Mihalache, A. O., Dumitraşcu, L., Nicolau, A. I., Borda, D. (2021). Food safety knowledge, food shopping attitude and safety kitchen practices among Romanian consumers: A structural modelling approach. *Food Control*, 120. <https://doi.org/10.1016/j.foodcont.2020.107545>.

Impact factor: 5.548

Borda, D., **Mihalache, A. O.**, Dumitraşcu, L., Gafiţianu, D., Nicolau, A. I. (2021). Romanian consumers' food safety knowledge, awareness on certified labelled food and trust in information sources. *Food Control*, 120. <https://doi.org/10.1016/j.foodcont.2020.107544>.

Impact factor: 5.548

Didier, P., Nguyen-The, C., Martens, L., Foden, M., Dumitrascu, L., **Mihalache, A. O.**, Nicolau, A. I., Skuland, S. E., Truninger, M., Junqueira, L., & Maitre, I. (2021). Washing hands and risk of cross-contamination During Chicken preparation among Domestic practitioners in five European countries. *Food Control*, 127. <https://doi.org/10.1016/j.foodcont.2021.108062>.

Impact factor: 5.548

Mihalache, A. O., Møretrø, T., Borda, D., Dumitraşcu, L., Neagu, C., Nguyen-The, C., Maitre, I., Didier, P., Teixeira, P., Junqueira, L. O. L., Truninger, T., Izsó, T., Kasza, G., Skuland, S. E., Langsrud, S., Nicolau, A. I. Kitchen layouts and consumers' food hygiene practices: Ergonomics versus safety, *Food Control*, 131. <https://doi.org/10.1016/j.foodcont.2021.108433>. **Impact factor: 5.548**

Mihalache, A. O., Borda, D., Neagu, C., Teixeira, P., Langsrud, S., Nicolau, A. I. Efficacy of removing bacteria and organic dirt from hands – a study based on ATP measurements for evaluation of hand hygiene when cooking, *International Journal of Environmental Research and Public Health*, 18(16). <https://doi.org/10.3390/ijerph18168828>. **Impact factor: 3.390**

International conferences

Didier, P., Nguyen-The, C., Maitre, I., Truninger, M., Skuland, S. E., Teigen, H. M. F., Nicolau, A. I., **Mihalache, A. O.**, Dumitraşcu, L., Foden, M., Martens, L. Cross-contamination Risk

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Factors in Domestic Chicken-handling Practices among Consumers in Five European Countries in the Transdisciplinary SafeConsume Project. **IAFP'S European Symposium on Food Safety**, 24-26.04.2019, Nantes, Franța.

Bucur, F. I., **Mihalache, A. O.**, Neagu, C., Nicolau, A. I. Faith of salmonellae in mayonnaise during storage under improper refrigeration or refrigeration combined with occasional storage at room temperature. **International Symposium EuroAliment - Inovative Minds for Future Food**, 5-6.09.2019, Galați, România.

Mihalache, A. O., Borda, D., Dumitrașcu, L., Gafițianu, D., Nicolau, A. I. Romanian consumers' perspective on food safety. **6th International Conference on Food Science and Food Safety**. 16.10.2020, Viena, Austria.

Mihalache, A. O., Dumitrașcu, L., Nicolau, A. I., Borda, D. Relationships between food safety knowledge, purchase attitude, and kitchen practices: Evidence from Romanian consumers. **The 34th EFFoST International Conference - Bridging high-tech, food tech and health: Consumer-oriented innovations**, 10-12.11.2020, Tel Aviv, Israel.

National conferences with international participation

Mihalache, A. O., Dumitrașcu, L., Nicolau, A. I. Assessing Consumers Hygiene Practices During Food Preparation in Homes from Galati County. **The 7th Edition of the Scientific Conference of Doctoral Schools - Perspectives and Challenges in Doctoral Research**, 13-14.06.2019, Galați, România.

Iordăchescu, G., Ploscuțanu, G., Mihalcea, L., Dima, I., **Mihalache, A. O.**, Baston, O., Bârnă O., Pricop, M. E., Boudjek, a G. V. Exploiter les déchets des tomates pour obtenir des produits et á haute valeur nutritionnelle. **Réseau Régional Francophone Sur la Santé, La Nutrition et La Sécurité Alimentaire Santé Instruction Nutrition**, 6.12.2020, Iași, România.

Mihalache, A. O., Dumitrașcu, L., Nicolau, A. I., Borda, D. Linkages between food safety knowledge, purchase attitude, and kitchen practices among Romanian consumers. **The 8th Edition of the Scientific Conference of the Doctoral Schools - Perspectives and Challenges in Doctoral Research**, 18-19.06.2020, Galați, România.

Mihalcea, L, Iordăchescu, G., Ploscuțanu, G., Dima, I., Coman, G., Bârnă, O., Baston, O., Pricop, M. E., **Mihalache, A. O.**, Boudjeka G. V. Use of tomato (*Solanum Lycopersicum*)

waste to obtain healthy products with high nutritional value. **The 19th International Conference Life Sciences For Sustainable Development**, 24-25.09.2020, Cluj-Napoca, România.

Iordăchescu, G., Inglezakis, V., Stanciu, S., Ploscuțanu, G., **Mihalache, A. O.** Past, present and future for traditional products from southeastern Romania. **The 4th Multidisciplinary Conference on Sustainable Development**, 20-21.05.2021, Timișoara, România.

Mihalache, A. O., Nicolau, A. I., Dumitrașcu, L., Borda, D. Challenging consumers' tactile sense in relation food refrigeration practices. **The 9th Edition of the Scientific Conference of the Doctoral Schools - Perspectives and Challenges in Doctoral Research**, 10-11.06.2021, Galați, România.

Prizes

2nd Prize for presenting: Mihalache A. O., Dumitrașcu L., Nicolau A I., Borda D. Linkages between food safety knowledge, purchase attitude, and kitchen practices among Romanian consumers at: **The 8th Edition of the Scientific Conference of the Doctoral Schools - Perspectives and Challenges in Doctoral Research**, 18-19.06.2020, Galați, România.

Prize G. M. Costin awarded by PhD Carmen Moraru with the support Association of Specialists in the Romanian Dairy Industry for: Mihalache A. O., Dumitrașcu L., Nicolau A I., Borda D. Linkages between food safety knowledge, purchase attitude, and kitchen practices among Romanian consumers at: **The 8th Edition of the Scientific Conference of the Doctoral Schools - Perspectives and Challenges in Doctoral Research**, 18-19.06.2020, Galați, România.

Mention for presenting: Mihalache A. O., Nicolau A. I., Dumitrașcu L., Borda D. Challenging consumers' tactile sense in relation food refrigeration practices at: **The 9th Edition of the Scientific Conference of the Doctoral Schools - Perspectives and Challenges in Doctoral Research**, 10-11.06.2021, Galați, România.

Prize Professor Constantin Moraru awarded by PhD Carmen Moraru with the support Association of Specialists in the Romanian Dairy Industry for the research results presented at: Mihalache A. O., Nicolau A. I., Dumitrașcu L., Borda D. Challenging consumers' tactile sense in relation food refrigeration practices. **The 9th Edition of the Scientific Conference of**

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the Doctoral Schools - Perspectives and Challenges in Doctoral Research, 10-11.06.2021, Galați, România.

International research projects

01.02.2019 – Present – SafeConsume - Safer food through changed consumer behavior: Effective tools and products, communication strategies, education and a food safety policy reducing health burden from foodborne illnesses (Horizon 2020; Acordul de grant nr. 727580, <http://safeconsume.eu/>).

01.08.2020 – Present – LOC- FOOD BSB1101 - Local Development and Cross Border Cooperation in the area of Agricultural Products and Traditional Food.

National and international workshops

„PhageUgal Summer School” organised by the Faculty of Food Science and Engineering, “Dunărea de Jos”, University of Galați partnered with APC Microbiome Ireland, 16-17.06.2019, Galați, România.

1st edition of the workshop „Technology Commercialization” organized by the Technical University of Cluj-Napoca and financed by Junior Achievement România, 15-16.06.2020.

Other activities associated with the PhD studies

Participation at “Competiția Națională Conștientizarea și Dezvoltarea Spiritului Antreprenorial – Portul Antreprenorial” coordinated by Prof. Anca Nicolau, Galați, organised by “Dunărea de Jos”, University of Galați, 30.11 – 1.11 2018.

Member of the organising committee for „Competiția Națională pentru Conștientizarea și Dezvoltarea Spiritului Antreprenorial coordinated by Prof. Anca Nicolau, conducted at Galați during 30.10 – 1.11.2018.

Participation at „Târgul de Postere de Idei și Planuri de Afaceri” conducted at Galați, within the SAADC 2018 event (Studenti și Absolvenți Antreprenori în Dialog cu Companiile), organised by “Dunărea de Jos”, University of Galați, 10.12.2018.

Participation at „Sesiunea Națională de Comunicări Științifice Studentești Sursele de energie în dezvoltarea și administrarea afacerilor durabile”, organised by „Petrol și Gaze” University of Ploiești, 21-23.11, 2018.

Participation at the competition “Simulatorul de Bussiness – Educație Managerială prin Educație Digitală în Mediul Academic”, organised by „Petrol și Gaze” University of Ploiești, 22-23.11, 2018.

Prizes

Mention at „Competiția Națională pentru Conștientizarea și Dezvoltarea Spiritului Antreprenorial – Portul Antreprenorial”, Galați, 30.10 – 1.11.2018.

Mention at „Târgul de Postere de Idei și Planuri de Afaceri” conducted at Galați, within the SAADC 2018 event (Studenti și Absolvenți Antreprenori în Dialog cu Companiile), organised by “Dunărea de Jos”, University of Galați, 10.12.2018.

Special Prize Generali at „Sesiunea Națională de Comunicări Științifice Studentești Sursele de energie în dezvoltarea și administrarea afacerilor durabile”, organised by „Petrol și Gaze” University of Ploiești, 21-23.11, 2018.

3rd prize at the competition “Simulatorul de Bussiness – Educație Managerială prin Educație Digitală în Mediul Academic”, organised by „Petrol și Gaze” University of Ploiești, 22-23.11, 2018.

Selective bibliography

1. Adams, M. R., & Moss, M. O. (2003). *Significance of food borne diseases* (2nd ed.), *Food Microbiology*, 2. RSC Publishing, Cambridge.
2. Anderson, A. L., Verrill, L. A., & Sahyoun, N. R. (2011). Food safety perceptions and practices of older adults. *Public health reports*, 126(2), 220–227. <https://doi.org/10.1177/003335491112600213>.
3. Anon (2015). A study of domestic fridges on the island of Ireland. Valabil la: <http://www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Research Reports/Domestic-Fridges.pdf>. Accesat 16.10.2019.
4. Baser, F., Ture, H., Abubakirova, A., Sanlier, N., & Cil, B. (2017). Structural modeling of the relationship among food safety knowledge, attitude and behavior of hotel staff in Turkey. *Food Control*, 73, 438–444. <https://doi.org/10.1016/j.foodcont.2016.08.032>.
5. Booth, R., Hernandez, M., Baker, E. L., Grajales, T., & Pribis, P. (2013). Food safety attitudes in college students: A structural equation modeling analysis of a conceptual model. *Nutrients*, 5(2), 328–339. <https://doi.org/10.3390/nu5020328>.
6. Burke, T., Young, I., & Papadopoulos, A. (2016). Assessing food safety knowledge and preferred information sources among 19-29 year olds. *Food Control*, 69, 83–89. <https://doi.org/10.1016/j.foodcont.2016.04.019>
7. Chen, Y., Glass, K., Liu, B., Hope, K., & Kirk, M. (2016). Salmonella Infection in Middle-Aged and Older Adults: Incidence and Risk Factors from the 45 and Up Study. *Foodborne Pathogens and Disease*, 13(12), 689–694. doi:10.1089/fpd.2016.2170.
8. da Cunha, D. T., de Rosso, V. V., Pereira, M. B., & Stedefeldt, E. (2019). The differences between observed and self-reported food safety practices: A study with food handlers using structural equation modeling. *Food Research International*, 125(May), 108637. <https://doi.org/10.1016/j.foodres.2019.108637>.
9. EFSA & ECDC (European Food Safety Authority & European Centre for Disease Control and Prevention). (2015). The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2014. *EFSA Journal*, 13(12). doi:10.2903/j.efsa.2015.4329.
10. EFSA & ECDC (European Food Safety Authority & European Centre for Disease Control and Prevention). (2021). The European Union One Health 2019 Zoonoses Report. *EFSA Journal*, 19(2). <https://doi.org/10.2903/j.efsa.2021.6406>.
11. Evans, E. W., & Redmond, E. C. (2019). Domestic Kitchen Microbiological

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- Contamination and Self-Reported Food Hygiene Practices of Older Adult Consumers. *Journal of Food Protection*, 82(8), 1326–1335. doi:10.4315/0362-028x.jfp-18-533.
12. FDA (Food and Drug Administration). (2020). People at Risk of Foodborne Illness. Valabil la: <https://www.fda.gov/food/consumers/people-risk-foodborne-illness#pregnant-women>. Accesat 18.05.2021.
 13. Gkana, E. N., & Nychas, G.-J. E. (2017). Consumer food safety perceptions and self-reported practices in Greece. *International Journal of Consumer Studies*, 42(1), 27–34. <https://doi.org/10.1111/ijcs.12391>.
 14. Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). A primer on partial least squares structural equation modeling (PLS-SEM). Washington DC, United States of America: SAGE Publications, Inc.
 15. Jevšnik, M., Ovca, A., Bauer, M., Fink, R., Oder, M., & Sevšek, F. (2013). Food safety knowledge and practices among elderly in Slovenia. *Food Control*, 31(2), 284–290. doi:10.1016/j.foodcont.2012.10.003.
 16. Joshi, R., Banwet, D. K., & Shankar, R. (2010). Consumer link in cold chain: Indian scenario. *Food Control*, 21(8), 1137–1142. <https://doi.org/10.1016/j.foodcont.2010.01.008>.
 17. Katiyo, W., de Kock, H. L., Coorey, R., & Buys, E. M. (2019). Assessment of safety risks associated with handling chicken as based on practices and knowledge of a group of South African consumers. *Food Control*, 101(January), 104–111. <https://doi.org/10.1016/j.foodcont.2019.02.027>.
 18. Lagendijk, E., Asséré, A., Derens, E., & Carpentier, B. (2008). Domestic refrigeration practices with emphasis on hygiene: Analysis of a survey and consumer recommendations. *Journal of Food Protection*, 71(9), 1898–1904. doi: [10.4315/0362-028x-71.9.1898](https://doi.org/10.4315/0362-028x-71.9.1898).
 19. Langiano, E., Ferrara, M., Lanni, L., Viscardi, V., Abbatecola, A. M., & De Vito, E. (2012). Food safety at home: Knowledge and practices of consumers. *Journal of Public Health (Germany)*, 20(1), 47–57. <https://doi.org/10.1007/s10389-011-0437-z>.
 20. Lim, T. P., Chye, F. Y., Sulaiman, M. R., Suki, N. M., & Lee, J. S. (2016). A structural modeling on food safety knowledge, attitude, and behaviour among Bum Bum Island community of Semporna, Sabah. *Food Control*, 60, 241–246. <https://doi.org/10.1016/j.foodcont.2015.07.042>.

21. Medeiros, L. C., Chen, G., Horn, J., Van Fralic, J., Hillers, V. V., & Kendall, P. (2006). Essential food safety behaviours for older adults. *Food Protection Trends*, 26(8), 586–592.
22. Mullan, B. A., Wong, C., & Kothe, E. J. (2013). Predicting adolescents' safe food handling using an extended theory of planned behavior. *Food Control*, 31(2), 454-460 <https://doi.org/10.1016/j.foodcont.2012.10.027>.
23. Mullan, B., Allom, V., Sainsbury, K., & Monds, L. A. (2015). Examining the predictive utility of an extended theory of planned behaviour model in the context of specific individual safe food-handling. *Appetite*, 90, 91–98. <https://doi.org/10.1016/j.appet.2015.02.033>.
24. Odeyemi, O. A., Sani, N. A., Obadina, A. O., Saba, C. K. S., Bamidele, F. A., Abughoush, M., Asghar, A., Dongmo, F. F. D., Macer, D., & Aberoumand, A. (2019). Food safety knowledge, attitudes and practices among consumers in developing countries: An international survey. *Food Research International*, 116(June 2018), 1386–1390. <https://doi.org/10.1016/j.foodres.2018.10.030>.
25. Parra, P. A., Kim, H. K., Shapiro, M. A., Gravani, R. B., & Bradley, S. D. (2014). Home food safety knowledge, risk perception, and practices among Mexican-Americans. *Food Control*. <https://doi.org/10.1016/j.foodcont.2013.08.016>.
26. Prior, G., Taylor, L., Smeaton, D., & Draper, A. (2013). Exploring food attitudes and behaviours in the UK: Findings from the Food and you survey 2012. Unit repor(march). Valabil la: http://www.foodbase.org.uk//admintools/reportdocuments/805-1-1460_Wave_2_Main_Report.pdf. Accesat 15.07.2020.
27. Redmond, E. C., & Griffith, C. J. (2003). Consumer food handling in the home: A review of food safety studies. *Journal of Food Protection*, 66(1), 130–161. <https://doi.org/10.4315/0362-028X-66.1.130>.
28. Rennie, D. M. (1995). Health education models and food hygiene education. *The Journal of the Royal Society for the Promotion of Health*, 115(2), 75-79.
29. Ruby, G. E., Ungku Zainal Abidin, U. F., Lihan, S., Jambari, N. N., & Radu, S. (2019a). Predicting intention on safe food handling among adult consumers: A cross sectional study in Sibu district, Malaysia. *Food Control*, 106. <https://doi.org/10.1016/j.foodcont.2019.06.022>.
30. Ruby, G. E., Ungku Zainal Abidin, U. F., Lihan, S., Jambari, N. N., & Radu, S. (2019b). A cross sectional study on food safety knowledge among adult consumers. *Food Control*, 99(November 2018), 98–105. <https://doi.org/10.1016/j.foodcont.2018.12.045>.

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31. Singh, R. L., & Mondal, S. (2019). *Food Safety and Human Health* (1st ed.). <https://doi.org/10.1016/C2017-0-04079-X>.
32. Skuland, S. E. (Ed), Borda, D., Didier, P., Dumitraşcu, L., Ferreira, V., Foden, M., Langsrud, S., Maître, I., Martens, L. Møretrø, T., Nguyen-The, C., Nicolau, A. I. Nunes, C., Rosenberg, T. G., Teigen, H. M., Teixeira, P., & Truninger, M. (2020). European food safety: Mapping critical food practices and cultural differences in France, Norway, Portugal, Romania and the UK. SIFO REPORT 6-2020. ISBN: 82-7063-506-5. Oslo: Consumption research Norway, Oslo Metropolitan University.
33. Tomaszewska, M., Trafialek, J., Suebpongsang, P., & Kolanowski, W. (2018). Food hygiene knowledge and practice of consumers in Poland and in Thailand - A survey. *Food Control*, 85, 76–84. <https://doi.org/10.1016/j.foodcont.2017.09.022>.
34. Troeger, C., Blacker, B. F., Khalil, I. A., Rao, P. C., Cao, S., Zimsen, S. R., ... Abebe, Z. (2018). Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet Infectious Diseases*. doi:10.1016/s1473-3099(18)30362-1.
35. Unusan, N. (2007). Consumer food safety knowledge and practices in the home in Turkey. *Food Control*, 18(1), 45–51. doi: 10.1016/j.foodcont.2005.08.006.
36. Wang, J., Tao, J., & Chu, M. (2020). Behind the label: Chinese consumers' trust in food certification and the effect of perceived quality on purchase intention. *Food Control*, 108. <https://doi.org/10.1016/j.foodcont.2019.106825>.
37. WHO (World Health Organisation). (2020). Food Safety. Key facts. Valabil la: <https://www.who.int/news-room/fact-sheets/detail/food-safety>. Accesat 24.09.2020.
38. WHO Regional Office for Europe. (2017) The burden of foodborne diseases in the WHO European Region, WHO Publications, p.2. http://www.euro.who.int/_data/assets/pdf_file/0005/402989/50607WHOFoodSafety-publicationV4_Web.pdf?ua=1. Accesat 18 septembrie 2020.
39. Wu, Y.-N., Liu, X.-M., Chen, Q., Liu, H., Dai, Y., Zhou, Y.-J., Wen, J., Tang, Z.-Z., & Chen, Y. (2018). Surveillance for foodborne disease outbreaks in China, 2003 to 2008. *Food Control*. <https://doi.org/10.1016/j.foodcont.2017.08.010>.
40. Zanin, L. M., da Cunha, D. T., de Rosso, V. V., Capriles, V. D., & Stedefeldt, E. (2017). Knowledge, attitudes and practices of food handlers in food safety: An integrative review. *Food Research International*, 100 (April), 53–62. <https://doi.org/10.1016/j.foodres.2017.07.042>.