ACRYLAMIDE AWARNESS AND RELATED DOMESTIC FOOD PRACTICES AMONG THE RESIDENTS OF THE REPUBLIC OF IRELAND

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ABSTRACT

A lack of knowledge in relation to the risks of high levels of exposure to acrylamide contamination in home-made meals among consumers has led to questionable food preferences and preparation practices.

A questionnaire (N=555, over 18, Irish inhabitants, March to June 2019) was used to determine the specific domestic food practices and food preferences in relation to potatoes, bread and coffee, as well as ascertaining individual levels of acrylamide knowledge among Ireland's inhabitants .

Of those questioned, 39% had heard about a harmful component formed during heat treatment of carbohydrate-rich food, while only 14.8% recognised the term 'acrylamide'. Awareness relating to the carcinogenic effects of acrylamide was 94.5% among those who had heard about this as a harmful compound, whilst 85.4% of this group were aware of the role of high cooking temperatures as the main contributor in acrylamide generation.

In relation to the major foodstuff contributors in acrylamide formation, it was shown that potatoes were involved in 75% of respondents; bread, biscuits and crackers in 52%, cereals in 48% and coffee in 38%.

On the subject of home-food practices, it was shown that potato-storage behaviours, pealing, washing practices, cut-sizes and common cooking methods for the preparation of potato chips do not significantly increase acrylamide exposure. In contrast, there were concerns in relation to the process of soaking fresh potatoes before cooking, the parboiling process, the method for estimating the cooking end-point and adhering to the cooking instructions on food packages.

Desire for a medium-golden to brown appearance on the surface of roasted potatoes, chips and toasted bread was the underlying reason for this concern.

The consumption rate among the main foodstuff contributors in acrylamide generation was also recorded. Consensus for the use of acrylamide information labelling in food packages reached 73.8%, while 80% were in favour of adding precautionary information about potential formation of acrylamide if cooking instructions are not adhered to. The present study highlighted the need for increased efforts at different levels to teach and improve knowledge about good cooking practices, as well as changing food habits, to minimise exposure to acrylamide from home-prepared meals.

DECLARATION

I hereby certify that this material, which I now submit in part fulfilment of the requirement for the award of MSc in Food Safety Management, is entirely my own work and has not been taken from the work of others save and to the extent such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the guidelines for dissertation production in the M.Sc. Food Safety Management and has not been submitted in whole or in part for an award in any other Institute or University.

The work reported on in this thesis conforms to the principles and requirements of the Institute's guidelines for ethics in research.

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Signed _____

Candidate

Date _____

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ABBREVIATIONS

AA Acrylamide

ATSDR : The Agency for Toxic Substances and Disease Registry

BEUC: The European Consumer Organisation

CONTAM : The Panel on Contaminants in the Food Chain

DG SANTA: The Directorate-General for Health and Food Safety

ECF : European Coffee Federation

EFSA : European Food Safety Authority

EPA : Environmental Protection Agency

EU : European Union

EUPPA : European Potato Processors' Association

FAO : Food and Agriculture Organization

FDA: The Food and Drug Administration

FOBs: Food Operative Business

FSAI : Food Safety Authority of Ireland

HEATOX: Heat-Generated Food Toxicants, Identification, Characterization, and Risk Minimization Project.

IARC : International Agency for Research on Cancer

IUNA: Irish Universities Nutrition Alliance

JECFA : Joint FAO/WHO Expert Committee on Food Additives

MB : Medium bound

SCF: Scientific Committee on Food

WHO : World Health Organization

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LITERATURE REVIEW

Chapter 1 . LITERATURE REVIEW

1.1. Introduction

Concern has grown ever since it was discovered that acrylamide is being formed in food during thermal treatment and preparation of starchy foods. The EU has led the worldwide effort geared towards protecting consumer health as well as improving food safety awareness. A considerable amount has already been achieved in a relatively short space of time. For example, on April 11, 2018, Regulation (EU) 2017/2158 came into act, which has been applied to control and manage the acrylamide (AA) level in most food products. The overall aim of this regulation is to minimise the health risks caused by AA, which is associated with food production in all manufacturing stages (European Commission, 2017). Governmental authorities have been given the responsibility of monitoring the compliance of different manufacturers, restaurants and food chains with the legal benchmark levels of AA in foodstuffs by establishing the suitable mitigation measures and food safety management system to reduce AA in their food products There is now evidence that suggests the AA levels in food products are, for the most part, compliant with the benchmarks (Mesias et al., 2019). This illustrates that new regulations are being followed, but also that the respective national authorities have been competently monitoring food suppliers and using the power of law to positive effect.

However, it is an ongoing task. To maintain adequate consumer protection, the domestic nation has a major role to play if continued success is to be maintained. Ultimately, regulations will only be successful if they are rigidly enforced. Since the role of domestic food practices rests with each individual nation, food preferences and consumption habits have a major impact on the total dietary level of exposure to AA (Mesias et al., 2018). This occurs through food choices, food preparation, individual preferences, and cooking and overall domestic food perceptions. Therefore, the scientific opinion of the European Food Safety Authority (EFSA) is that AA

investigation among the population and related home-food practices is crucial. The EFSA believes this can provide the key in achieving a safe-level exposure to AA (EFSA, 2015).

At present, to the best of the author's knowledge, there has not been an attempt to explore acrylamide awareness and domestic food practices among the population of Ireland. There are reports which have covered the estimated daily exposure to AA in Ireland. However, there are no studies available that cover specific home practices and food preferences in regard to AA in Ireland.

In terms of the purposes served by the references to the literature, this section covers the following four main outlines. Firstly, the background part, which looks at historical aspects, the chemical profile of AA, the associated health risks and the EU's efforts to manage the risk of exposure to AA. The second part deals with the main foodstuffs that contribute to high AA level exposure, in particular potatoes, bread and coffee. The third part reviews the impact of different home-food practices on AA levels. The fourth part presents the previous studies in regard to the home practices and preferences, as well as examining the outcome of global AA awareness studies. The section will then close out with a look at previous research gap, as well as current research questions and the study's objectives.

1.2. Background

1.2.1. Historical Aspect

In 2000, an experiment was carried out on rats by feeding them fried animal feed. The results showed an increase in haemoglobin (Hb) adduct levels of AA by 10 times in comparison to controlled rats (Tareke et al., 2000). This result encouraged the same research group to experiment with cooking foodstuffs. By 2002, they discovered that high level of AA formed in starch-rich foods between 50-4000 µg/kg, when food was exposed to high heat treatment,

compared with 5-50 µg/kg in protein-rich foods (Tareke et al., 2002). Following these findings, the Swedish National Food Administration and Stockholm University announced in April 2002 that AA can be formed in many carbohydrate-rich foods during baking and frying under high temperature. As a consequence, worldwide concern to AA in foods rose, particularly because acrylamide had previously been classified as (Group 2A) probably carcinogenic to humans by the International Agency for Research on Cancer (IARC, 1994). Further studies conducted all over the world made similar findings about AA formation, mainly in carbohydrate-rich food prepared under high temperature and low moisture. Furthermore, findings confirmed that the formation pathway of AA in foods occurs during the Maillard process. This is the reaction of free asparagine and reducing sugars under high temperature and low moisture (Nursten, 2005; Stadler et al., 2002; Mottram, Wedzicha and Dodson, 2002). Meanwhile, the Joint FAO/WHO Consultation on Health Implications of Acrylamide in Food rose concerns about other possible significant risk factors from some cooked foodstuffs, in addition to neurotoxic effects (WHO, 2002). Thus, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) conducted a massive data collection and data analysis on the occurrence of AA from several countries, mainly in Europe and North America. The outcomes from data analysis revealed that the main food groups contributing to high levels of AA are potato-based products, cereal-based products and coffee (JECFA, 2006).

1.2.2. Acrylamide Chemical Structure, Formation and Properties

Acrylamide (C_3H_5NO) () is a white or colourless, odourless crystalline solid organic compound with low molecular weight and high water solubility (ATSDR, 2012).

Table 1-1 summarises the chemical and physical characteristics of AA.

Acrylamide has been used mainly in industry since 1954 under registry (No CAS 79-0601) in the production of polyacrylamides, which are used as flocculants in the treatment of wastewater and clarifying drinking water. It has also been used in paper and pulp processing, cosmetic products such as body lotion and shampoo, and polyacrylamide gel electrophoresis. Additionally, acrylamide enters in the formulation of grouting agents (IARC, 1994).

Figure 1-1 Chemical structure of acrylamide (AA)

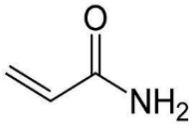


Table 1-1 Physical and Chemical Properties of Acrylamide

Property	**Information**	**References**
Molecular weight	71.08	(ATSDR, 2012)
Melting point	84.5℃	(ATSDR, 2012)
Boiling point	192.6 ℃ 87 ℃ (2 mm) 103 ℃ (5 mm) 125 ℃ (25 mm)	(ATSDR, 2012)
Vapour pressure at 25 ℃ at 40 ℃ at 50 ℃	 0.9 Pa (7x10-3 mm Hg) 4.4 Pa (3.3x10-2 mm Hg) 9.3 Pa (7.0x10-2 mm Hg)	(ATSDR, 2012)
Henry's law constant: at 25 ℃	1.7x10-9 atm-m3/mol (estimated)	(ATSDR, 2012)
Solubility: Water at 20℃ 30℃	Soluble in water, alcohol, acetone Insoluble in benzene and heptanes 3.711x105 mg/L 4.048x105 mg/L	(ATSDR,2012)
Partition coefficients: Log Kow Log Koc	 −0.67 (octanol/water) 1 (organic carbon/water)	 (ATSDR,2012) (US-EPA, 2010).
Stability	Stable at room temperature but may polymerize violently on melting	(US-EPA,2010)

Pathways of Acrylamide Formation

Early research into the mechanism of AA generation in food suggested that the main pathway for AA formation is the Maillard reaction between free amino acids, particularly asparagine and reducing sugars (glucose, fructose and others) in carbohydrate-rich foods (Halford et al., 2012), when exposed to temperatures higher than 120°C and under low humidity (Halford et al., 2011; Mottram, 2007; Nursten, 2005; Mottram, Wedzicha and Dodson, 2002; Stadler et al., 2002). However, under certain conditions AA may form at a temperature less than 100°C, such as during the processing of prunes and pears (Becalski et al., 2011).

There are several other suggested pathways (as shown in Figure 0**1-2**) within the Maillard reaction, while alternative pathways and precursors have also been stated as contributing to the formation of AA in food. These include acrylic acid, as a precursor formed via acrolein and ammonia by oxidative degradation of lipids (Gertz and Klostermann, 2002; Yasuhara et al., 2003; Vattem and Shetty, 2003). Additionally, the formation of pyrolytic acrylamide from wheat gluten, with protein-bound alanine (Claus et al., 2006), or peptides with proteins as precursors (Casado et al., 2013).

Maillard reaction is a non-enzymatic browning reaction that occurs during the cooking of food. This reaction is responsible for generating the aroma, flavour and colour of the cooked food (Nursten, 2005). The mechanism for AA formation in food through the Maillard reaction (Figure 0**1-2**) involves a reaction between a carbonyl compound (C=O) and asparagine under high temperature, resulting in N-glycosyl asparagine formation, which in turn undergoes hydrolysis, producing a Schiff base (Blank et al., 2005; Stadler et al., 2002). Following on from that, an unstable intermediate compound forms from decarboxylation of the Schiff base. Either this compound can hydrolyse to 3- aminopropionamide, which on elimination of ammonia yields acrylamide, or the alternative pathway involves elimination of an imine from

decarboxylated Schiff base which leads to acrylamide formation (Zyzak et al., 2003). The role of 3-aminopropionamide (3-APA) in acrylamide formation has been described by Granvogl and Schieberle (2006) and Granvogl et al. (2004).

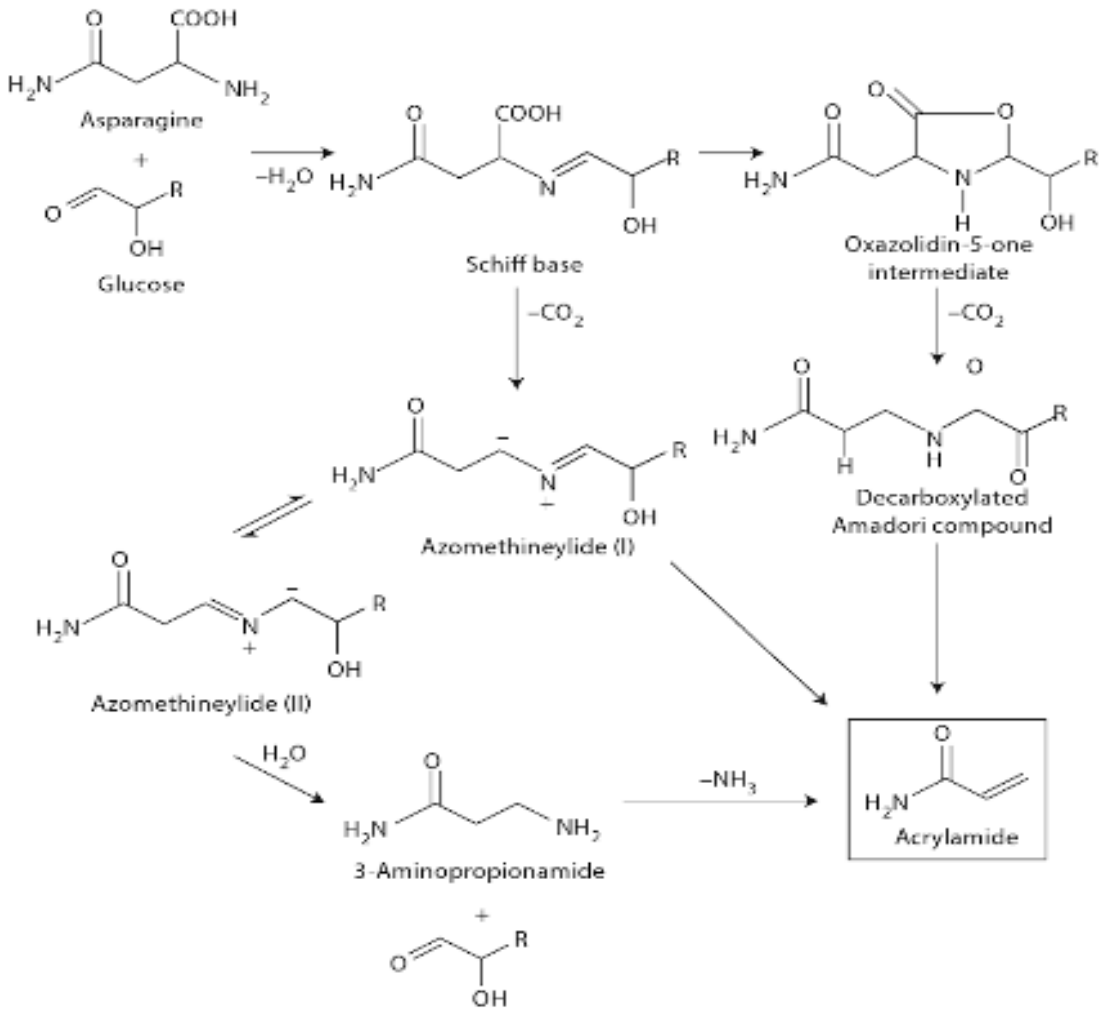


Figure 01-2 The main mechanism for acrylamide formation in food (adapted from (Zhang and Chen, 2015, p.16)

The amount of AA which forms in food depends on a combination of factors. These are the specific precursors ratio, the rate of reaction and the available time to proceed. Therefore, AA

formation is under kinetic control (HEATOX, 2007b; Claeys, De Vleeschouwer and Hendrickx, 2005).

Sources of Exposure to Acrylamide

There is a consensus regarding the major food contributors in the total AA exposure. These foods are potato chips and crisps (fried, roasted, baked), potato products, bread and bakery products, cereals and grain products including coffee (EFSA, 2015; JECFA, 2006; WHO, 2002; Scientific Committee on Food (SCF), 2002; Tareke et al., 2002). For example, potato chips contribute 10% to 60% of AA intake, potato crisps 10% to 22% , bread/toast 13% to 34%, and pastry & biscuits 10% to 15% (JECFA, 2011).

EFSA (2015) reported the average medium bound (MB) AA level in main food commodities among EU markets as follows: dry coffee substitutes 1499µg/kg, solid coffee 522µg/kg, potato fried products 308µg/kg, potato crisps 389µg/kg and soft bread 42µg/kg. These products contributed to the highest levels of AA exposure among food commodities in the EU.

FSAI (2009a) recorded that overall consumption of potatoes and potato products has the largest contribution percentage in total mean µg/kg bodyweight (bw) dietary intake of AA among the population of Ireland. This is followed by bread and biscuit consumption, and then coffee. The report illustrated that among the adult population, potatoes and potato-based products contributed to 48% in AA intake. Bread accounted for 34% and white coffee represented 2% of the total contribution to mean dietary AA intake (Figure 1-3). This was in contrast to the last FSAI report in 2016, which presented the data in the form of the major food groups rather than in terms of the individual foods, like in the 2009 report (Figure 1-4). The data from the 2009 FSAI report specifically detailed the contribution of individual food items, while the 2016 report was more general, stating that cereal groups accounted for 49%, savoury snacks 28% and

vegetables 23%. Overall in the FSAI reports, details relating to the percentage of exposure to AA from homemade food practices were not mentioned.

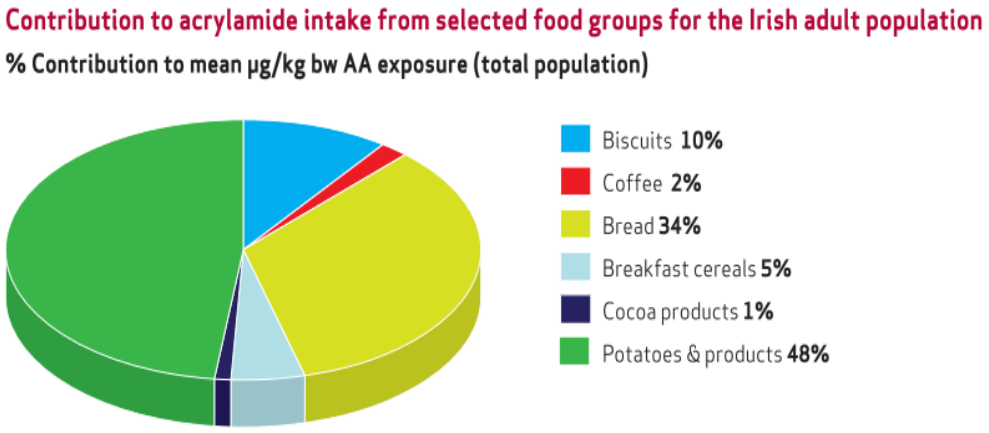


Figure 1-3 The Contribution to acrylamide intake from selected food groups for the Irish adult population (Source, FSAI (2009a, p.3).

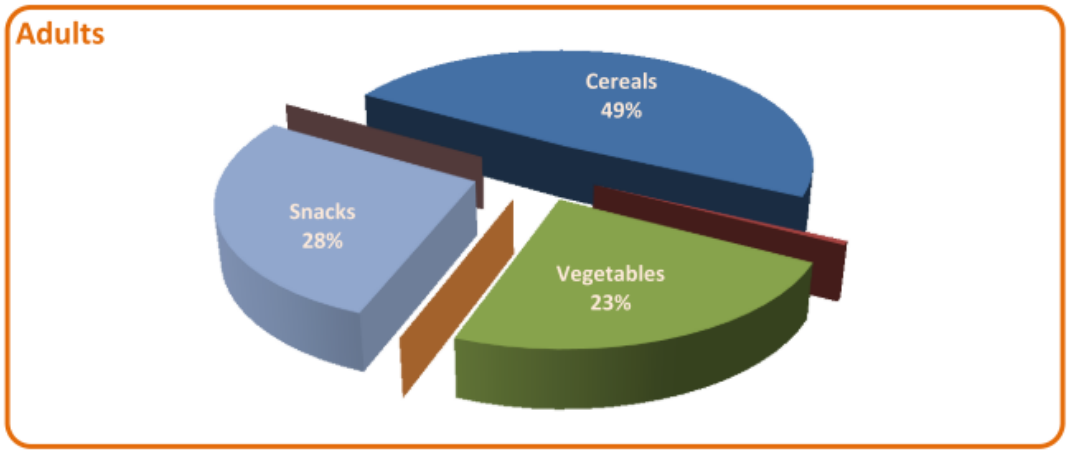


Figure 1-4 Contribution of the major food groups in acrylamide intake for Irish adult (Lower bound (LB) (Source, FSAI, 2016, p71).

Estimates of Acrylamide Exposure

As a result of different exposure levels to AA being recorded in even the same foods, it is clear that these levels depend heavily on how foods are prepared, cooked (methods), cooking conditions (temperature, time, moisture), as well as food preferences and different consumption habits. This was concluded in Brook Lyndhurst's report to the Food Standards Agency (2014) and by the European Union-funded project entitled "Heat-Generated Food Toxicants (HEATOX)" (HEATOX, 2007b). Therefore, estimating the actual dietary acrylamide intake is particularly difficult.

The international mean AA dietary exposures for acrylamide was estimated by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) as 1μg/kg bw per day, and 4 μg/kg bw per day for a high percentile consumer (JECFA, 2006). Comparing this in 2010, the mean range was between 1.1 and 4.8μg/kg bw per day, assuming an individual body weight was 60kg. In spite of this estimated result, the JECFA recommended to keep 1μg/kg bw per day and 4μg/kg bw per day estimates for safety evaluation purposes (JECFA, 2011).

At the level of European nations, the EFSA Panel on Contaminants in the Food Chain (CONTAM) estimated the chronic mean AA exposures for adolescents, adults, elderly and over-age as 0.4 to 1.9μg/kg bw per day and the 95th percentile was 0.6 to 2 μg/kg bw per day. Among EU children, it was 0.5 and 1.9 μg/kg bw per day and the 95th percentile was between 1.4 and 3.4 μg/kg bw per day (EFSA, 2015).

An EFSA report in 2015 referred to developing specific scenarios for calculating the influence of home-food cooking habits and consumers preferences on the total dietary exposure to AA. The estimations revealed that in the scenario of frying potatoes at home, the increases in exposure to AA reached 80%, and 14% in coffee preferences. Preferences for toasted bread showed decreases by 8% when compared to the baseline estimation. However, Mesias et

al.(2018) proved there was underestimation on the dietary exposure to AA among the European population. This is due to the fact that the EFSA report did not contain actual data regarding the acrylamide occurrence in domestic prepared meals in the home. Where the researchers examined the actual home practices was in regard to fried potatoes, and this found that the level of AA in homemade chips was more than double the level which was recorded by EFSA (2015). This, high level of exposure from home-made chips has been pointed out early by researchers in Teagasc, who referred to the level of acrylamide in home-made French fries was estimated in risk assessment model with a mean simulated value of 1073µg/kg (Brunton et al., 2006) and this value was almost three times higher than EFSA home-made potatoes estimation.

In Ireland

The average intake of acrylamide from food had been estimated to be between 0.16 and 0.38 µg/kg bw/day, while the above-average (97.5th percentile) daily intake was estimated to be between 0.51 and 1.03µg/kg bw/day among the adult population in Ireland (FSAI, 2016). In contrast, in 2009, the mean dietary exposure to acrylamide was about 0.6µg/per kg bw/day for the Irish adult population, and the above-average (97.5th percentile) daily intake was approximately 1.75µg/kg bw/day (FSAI, 2009a).

1.2.3. Acrylamide Health Risk Assessment

In 1991, the Scientific Committee on Food (SCF) in the European Commission considered presentation of acrylamide in form of a monomer in food contact materials as a genotoxic carcinogen substance (The Codex Alimentarius Commission, 2004). Later, in 2002 the

Scientific Committee on Food (SCF) confirmed the same conclusion after re-evaluation (SCF, 2002).

Also, by 1994, the International Agency for Research on Cancer (IARC) classified acrylamide as "*probably carcinogenic to humans*" (Group 2A) as acrylamide undergoes biotransformation into the metabolite glycidamide which has genotoxic activity (IARC, 1994). Furthermore, the US Environmental Protection Agency (EPA) classified acrylamide and glycidamide as a "*probable human carcinogen*" category B2 (US-EPA, 2000). AA has been listed by the European Parliament and Council as a carcinogen and mutagen (category 1B). It is also listed as a reproductive toxicant (category 2, fertility) compound in Regulation (EC) No 1272/2008 of the European Parliament and of the Council, of December 16, 2008, on Classification, Labelling and Packaging of Substances and Mixtures.

In 2015, the Scientific Panel on Contaminants in the Food Chain (CONTAM) of the European Food Safety Authority established an opinion on acrylamide in food based on early research and animal studies. The Panel's conclusion was confirmation of the previous evaluations, which considered the presence of AA in food as potentially increasing the risk of development carcinogenic effects among consumers in all age groups. However, based on the estimated levels of dietary exposure, the Panel consider the probability of other harmful effects of AA on foetal development, nervous system and male fertility were not such a heightened concern. The levels of dietary exposure to acrylamide across all age groups in Europe raise a concern regarding its carcinogenic effects (EFSA, 2015). That view was reaffirmed by FSAI (2016).

Recent acrylamide health-risk studies

A recent acrylamide exposure risk-assessment study showed that males are at higher carcinogenic and neurotoxic risk than females. This is because, subsequent to the chronic dietary exposures to AA, the mean mass of food consumed among males was higher than that of females. Moreover, the study stated that the adult group (40 years and above) face the highest risk of developing cancer compared to other population groups (children and teenagers (5-19) and young adults (20-39) (Siaw, et al., 2018).

In 2019, a new discovery of unique mutational signatures imprinted by acrylamide through glycidamide was made. In the discovery, glycidamide mutational signature is found in 35% of tumour genomes corresponding to 19 human tumour types (Zhivagui et al., 2019).

Rivadeneyra-Domínguez et al. (2018) reported that systemic introducing of AA to Wistar rats causes damage to renal and hepatic function, producing dose-dependent alterations of blood chemistry and cytometry parameters.

1.2.4. Regulatory and International Efforts

Since 2002, extensive projects have been established by the Food and Agriculture Organization (FAO), World Health Organization (WHO) and European Commission to explore AA formation mechanisms, levels of exposure, suitable analytical procedures and mitigation strategies in food stuffs. Following on from this, the European Commission, in collaboration with the Confederation of the Food and Drink Industry, established FoodDrinkEurope Acrylamide Toolbox in 2005. This forms platform guidelines for food processing industries in regard to covering the particular requirements to lower AA levels in food processed products. With a total of 15 editions published, the last version of the Acrylamide Toolbox was published

in 2019 (FoodDrinkEurope, 2019). It aims to be a useful guide in the target of correctly implementing Commission Regulation (EU) 2017/2158. This relates to establishing mitigation measures and benchmark levels for reducing the presence of acrylamide in food.

Commission Regulation (EU) 2017/2158 has applied since April 11, 2018, and establishes mitigation measures and benchmark levels for the reduction of the presence of acrylamide in food. It does this by stipulating that food processing manufacturers, restaurants and fast-food chains must apply measures to ensure acrylamide levels in their products remain below 'benchmarks' set in the law (

Table ***1-2***).

Table 1-2 EU benchmark levels for the presence of acrylamide in potato products, bread & coffee referred to EU Regulation 2017/2158.

Food Category	**Benchmark level [µg/kg]**
French fries (ready-to-eat), potato	**500**
Potato crisps from fresh potatoes and from potato dough, potato-based crackers, other potato products from potato dough	**750**
Soft bread (a) Wheat-based bread (b) Soft bread other than wheat-based bread	 50 100
Dry bread Crackers, with the exception of potato-based crackers Crisp bread Ginger bread	 400 350 800
Roast coffee	400
Instant (soluble) coffee	850
Coffee substitutes (a) Coffee substitutes exclusively from cereals (b) Coffee substitutes from a mixture of cereals and chicory (c) Coffee substitutes exclusively from chicory	 500 The relative proportion of these ingredients in the final product. 4000

In addition, European Potato Processors' Association (EUPPA) launched the GoodFries initiative, which aims to help consumers and food services to minimise the AA generation, by

good food preparation practices through recommendations, pictures and a demonstrative video on the best practices to cook fried potatoes (EUPPA, 2019). Moreover, a guide reference about acrylamide management in catering and food service sectors was published by UKHospitality (2018). As well as FDA established guide tool for controlling acrylamide in industry (FDA, 2016)

1.3. The Main Foodstuffs contribute to AA Exposure Intake

WHO (2002) referred to for reliable AA exposure evaluation, the importance of ensuring that the data has been collected from the food items that have lower AA contents, but show high levels of consumption, as well as the main food groups that contribute most to AA exposure.

1.3.1. Potatoes

There are several factors that affect acrylamide levels in potato products, such as the concentration of precursors (reducing sugars and free asparagine) in raw potatoes, which in turn is dependent on potato varieties and storage condition. Cooking conditions (temperature/time) and the moisture content (Elmore et al., 2005) are also factors that impact upon acrylamide levels in potato products..

1.3.1.1. Precursors of AA in Potatoes

There is a natural variation in the level of free reducing sugars in different potato varieties, from season to season and from year to year (Sun, Rosen and Thompson, 2018; Viklund et al., 2008; HEATOX, 2007a; Silva and Simon, 2005). This is also the case within the same varieties under different growing conditions (season, temperature, type and amount of fertilisers and soil) (De Wilde et al., 2006,a,b). Reducing sugar concentration in potato tubers and, consequently, AA level are significantly dependent on potato varieties (Sun, Rosen & Thompson, 2018; Shojaee-Aliabadi et al., 2013; Vivanti, Finotti and Friedman, 2006; Amrein et al., 2003).

The presence of reducing sugars in potato tubers appears to be the main determinant for acrylamide formation rather than asparagine (Sun, Rosen and Thompson, 2018; Kalita and Jayanty, 2017; Wicklund et al., 2006; Brunton et al., 2006; De Wilde et al., 2005; Williams, 2005; Chuda et al., 2003; Amrein et al., 2003). Fructose and glucose, in particular, play the greater impact in AA formation, while sucrose and asparagine concentrations in tubers did not show any correlation to acrylamide levels (Sun, Rosen and Thompson, 2018; Mestdagh et al., 2008; Wicklund et al., 2006; Silva and Simon, 2005; Amrein et al., 2004). This supported what Shojaee-Aliabadi et al. (2013) studied on one potato variety (Savalan) that contains high level of asparagine and low level of sugars. However, the findings indicated a low level of AA in the fried potatoes. Muttucumaru et al. (2017) assumed free asparagine could impact upon AA formation level, particularly when it was presented in relatively low concentration compared with the concentration of reducing sugars. Halford et al. (2012a), meanwhile, monitored a significant correlation between AA formation and asparagine and free amino acid in French fried potato varieties. Matsuura-Endo et al. (2006) summarised the contribution degree of both

reducing sugars and asparagine in AA formation according to the fructose/asparagine molar ratio, which means if the ratio was less than two, the sugars will correlate well with the AA formation. On the other hand, when the ratio was more than two (at low temperature) asparagine will be the limiting factor for AA formation.

Conversely, Skog et al. (2008) reported an absence of any correlation between precursor content in typical home-cooking potatoes and acrylamide content. They assumed there was a reason to hinder the availability of the precursor to generate AA at the surface of potato cuts. That is in line with the findings of Sansano et al. (2015), who talks about the lack of correlation between AA contents in fried potatoes and the amount of reduced sugars in the raw potatoes. Researchers explained this by the presence of complex mechanism responses on AA inhibition, such as the interference of additives in the Maillard reaction and the kinetics and conditions of frying beside the role of the precursors (Sansano et al., 2015).

1.4.1.2. Storage Practices Affecting Acrylamide Precursors or Acrylamide in Potatoes

The storage conditions of raw potatoes can significantly influence acrylamide formation in cooked potatoes through directly affecting the level of reducing sugars (Matsuura-Endo et al., 2006; Chuda et al., 2003). The storage temperature and storage period represent the pivot factors.

1.3.1.2. Storage Conditions

Temperature

Early research discovered that keeping potato tubers at a cold condition of 4°C or lower leads to sweetening of potatoes. This is where the level of reducing sugars (glucose and fructose) increases due to breakdown of potato starch to reducing sugars (Sowokinos, 1990). Low temperature enhance inactivation of phosphofructokinase, which results in the accumulation of hexose phosphates, and that increases sucrose generation (Hammond, Burrell and Kruger, 1990).

It has been explained in literature that AA formation levels were higher when the potatoes had been stored at 4°C or lower, rather than 8°C or over prior to cooking (Viklund et al., 2008; Matsuura-Endo et al., 2006; De Wilde et al., 2005; Silva and Simon, 2005; Amrein et al., 2004b). Chuda et al. (2003) recorded that, at 2°C storage temperature, AA level in potato chips rose tenfold than if potatoes were stored at 20°C for two weeks. Therefore, potatoes should be stored at temperatures above 8 ºC (Palermo et al., 2016).

Storage Time

Several studies investigated the impact of storage time and temperature in the level of AA in end-products and they tend to concur, there is a positive correlation between storage time of potato tubers and AA formation in final products, and explained that as subsequent to the rising in reducing sugars (fructose and glucose) content of tubers during storage period (Silva and Simon, 2005; Matthäus, Haase and Vosmann, 2004). Storing various cultivars of potatoes at 8°C for two to six months has shown a total increase in reducing sugar contents of potatoes, which reached a 2.74-fold increase after six months in comparison to two months in some

cultivars, such as Lady Rosella (Elmore et al., 2015). In contrast, HEATOX (2007a) recorded that the sugar level in Lady Olympia potato varieties showed a reduction after six months of storage at 8°C.

1.3.1.3. Potato Consumption Rate in Ireland

According to the Teagasc (2018) official website, potato consumption in Ireland reached an average of 125kg per Irish household per year. Furthermore, a recent Bord Bia report stated that more than 97% of Ireland's population are purchasing potatoes and they consumed potatoes on average over three times per week (Neary, 2019). ShelfLife (2015) reported that 29% of people in Ireland eat potatoes daily, while 60% consume potatoes two to three times weekly.

Mintel (2019b) carried out a survey to discover the types of potatoes commonly consumed among participants from Ireland, where the survey showed fresh potatoes bags are the popular where represented 83% of respondents, while frozen processed potatoes formed 26% and loose potatoes choices25%.

Also, a recent research investigated the level of using processes potatoes in the foodservice sector in Leinster, where the results revealed that, the tendency to purchase and eat fresh potatoes in Ireland is showing growth in comparison to processed potatoes (Gray, 2018).

While, Teagasc researchers group simulated risk assessment module among Irish population in regard to the impact of home-made chips in the level of exposure to acrylamide, the results for a simulated mean value per a portion of chips were 0.94µg/kg bw for males and 0.69µg/kg females (Brunton et al., 2006). This result represented only a portion of fried potatoes, meanwhile, WHO estimated the daily intake limit set at 1µg/kg bw/day. Thus, the contribution of home French fried on daily exposure to acrylamide among Irish communities was considered higher than WHO limits.

1.3.2. Bread

Bread is considered a source of acrylamide intake by people all over the world, despite the low level of AA recorded in bread. The reason it is considered a source of acrylamide intake is related to a high consumption rate of bread (EFSA, 2011). Mesías and Morales (2015) reported that acrylamide from bakery products could be a major contributor to the daily acrylamide intake of between 20% and 60%. In a recent study which monitored AA levels among 56 Iranian traditional flat breads (whole-wheat flour) and 30 industrial breads, it was concluded that the average daily intake of acrylamide in Iran, based on consumption of traditional bread, was estimated at 145 ng/kg bw/day (Eslamizad et al., 2019).

In Ireland, the average annual per capita bread consumption stands at 67.9kg in 2019 (Statista, 2019). Thus, the contribution to acrylamide intake from bread consumption among the Irish adult population has been recorded at 34% (FSAI, 2009a).

EFSA (2015) reported that the acrylamide MB (average medium bound) levels in the 'soft bread' category was at 42µg/kg, while in the 'crisp bread' category it was 171 µg/kg. Additionally, AA levels in wheat bread were lower than in rye bread.

1.3.2.1. Factors Influencing Acrylamide Formation in Bread

Acrylamide level in bread depends on specific factors, such as the initial concentrations of asparagine, rather than concentration of reducing sugars (Surdyk et al., 2004). This differs according to the type of flour (Wang et al., 2017), the pH of the dough, the water activity and the baking condition in regard to the time and temperature of the heating process (Mustafa, 2008; Gökmen et al., 2007). Surdyk et al. (2004) presented a significant interaction correlation between baking temperature, baking time in wheat bread and AA content.

1.3.2.1.1. Precursors

Asparagine is the main contributor in the formation of AA in baked products, rather than the role of reducing sugars, as confirmed by (Mustafa, 2008; Claus et al., 2006; Mustafa et al., 2005). There is a positive correlation between the level of free asparagine in cereal products and the amount of acrylamide in bread (Capuano et al., 2009; Fredriksson et al., 2004). That means the main key in AA level is the concentration of free asparagine in flour. By contrast, Esfahani et al. (2017) referred to how there wasn't a significant relationship detected between the acrylamide precursors, either the reducing sugars or free amino acid contents in dough samples, and the level of AA in bread end-products.

Shen, Chen and Li (2019), meanwhile, confirmed that both asparagine and reduced sugars, particularly fructose, have highly impacted upon the level of AA in white pan bread.

1.3.2.1.2. The pH of the Dough

The effect of low pH in sourdough has a role in AA reduction in bread (Nachi et al., 2018; Esfahani et al., 2017; Wang et al., 2017; Bartkiene et al., 2013; Fredriksson et al., 2004).

1.3.2.1.3. Baking Conditions

Jouquand et al. (2018) tested the effect of temperature/time in melanoidins compounds formation and the relation with AA level in French baguettes. The result pointed out that under baking parameters (225°C for 22 minutes) a high crust colour with a crispy base and an intense flavour could be achieved without increasing the generation of acrylamide, where the level remained below 18 μg/kg. The authors suggested a slow dough fermentation could contribute to limit the formation of acrylamide in French baguettes.

Moreover, there was a correlation between the water content in bread and AA level (Esfahani et al., 2017). That explains why the dry breads have higher levels of AA compared with soft bread from the same type of flour.

1.3.2.1.4. Types of Bread

The amount of free asparagine in flour varied significantly, which is influenced by plant varieties and cultivars (Stockmann et al., 2018; Rapp et al., 2018; Wang et al., 2017; Claus et al., 2006). Stockmann et al. (2018) illustrated that cultivars differed in free asparagine by up to 67% in wheat, 55% in spelt, and 33% in rye, as well as noting a relation between asparagine in specific species of grain and the growing time per year. Consequently, the contents of asparagine in flour will reflect on the total AA in end-products. This means the total daily exposure to AA from bread consumption will differ between consumers according to the type of bread they consume, even if it is the same amount of bread at the same degree of toasting. The contents of asparagine among different types of flour have been measured in many studies

and then compared to the AA level in end-products. Table 1-3 summarises the average measured asparagine concentration in different flour types.

Table 1-3 Asparagine level measures among different flour types

Flour Types	Level of Asparagine/ flour (mg/100gm)	Reference	Note
Wheat flour	1.74-19.05	(Claus et al., 2006)	
	14-17	(Fredriksson et al., 2004)	sifted flour
	25.5-36.5	(Wang et al., 2017)	
	14.325-39.275	(Rapp et al., 2018)	
	14.5	(Shen, Chen & Li, 2019)	
	10	(Stockmann et al., 2018)	
	0.64-4.46 (mmol/kg)	(Curtis et al., 2010)	
	14	(Granby et al., 2008)	sifted flour
Rye flour	41.37-44.1	(Claus et al., 2006)	
	53-68	(Fredriksson et al, 2004)	sifted flour
	43	(Stockmann et al., 2018)	
	3.63-15.14 (mmol/kg)	(Curtis et al., 2010)	
	110	(Fredriksson et al., 2004)	whale grain
	76	(Granby et al., 2008)	whale grain
Spelt flour	6.46-12.17	(Claus et al., 2006)	
	8	(Stockmann et al., 2018)	
Whole grain flour	48-51	(Fredriksson et al., 2004)	
Wheat bran	261-318	(Fredriksson et al, 2004)	

Crawford et al. (2019) evaluated the AA in experimental and commercial flatbreads with different flour types. The researchers found that commercial flatbread as naan (whole wheat)

contained about (32.8µg/kg), in contrast with crackers, which show significantly high levels of AA ranging from 455 to 504µg/kg. Furthermore, this study recorded that the gluten-free Matzo-style bread hit 1880-2070 µg/kg AA.

Gündüz and Cengiz (2015) found that the highest level of AA was recorded among whole-wheat bread when compared to other types of bread (white wheat bread, stone oven wheat bread, wheat bran bread, rye bread). The authors stated that the high level of AA in whole-wheat bread attributed to the significant amount of asparagine contents due to the presence of wheat germ and bran contents in flour. That is similar to Fredriksson et al. (2004), who mentioned the level of asparagine in raw ingredients. Additionally, Mustafa (2008) and Fredriksson et al. (2004) recorded double the amount of asparagine in whole rye flour than in wholegrain wheat. Likewise, Stockmann et al. (2018), Claus et al. (2006) and Elmore et al. (2005) detected free asparagine levels that were two to three times higher in rye flour compared to wheat flour.

The highest content of glucose, fructose and asparagine was found in cultivars of rye compared to other cereals cultivars (Žilić et al., 2017). Therefore, the suspected AA formation in breads from rye flour is considered to be higher than from wheat breads (Stockmann et al., 2018; Capuano et al., 2009; Granby et al., 2008; Claus et al., 2006; and Elmore et al., 2005). Despite evidence that the asparagine in rye flour was nearly three times higher than in wheat flour in a study by Curtis et al. (2010), the AA formation in heated flour at 180°C for 20 minutes in rye flour was much lower than in wheat flour. The authors explained that this was largely due to high concentration of proline in rye flour, which competes with asparagine in reaction with carbonyl compounds (Curtis et al,, 2010).

Lower levels of AA were observed in wheat soft and crisp bread (38 and 126µg/kg, respectively) compared to rye soft and crisp bread (57 and 245 µg/kg, respectively) (EFSA, 2015).

A difference in the level of AA formation had been recorded between white toast and brown toast during toasting under the same conditions. Even though the AA level before toasting was the same in both toast types, brown bread ultimately showed higher AA levels than white bread (Ahn et al., 2002). In line with that, HEATOX (2007a) pointed out that acrylamide generation in the different bread types by toasting were primary related to the concentration before toasting, thus the project's results showed that acrylamide contents in toasted brown bread was much more than in toasted white bread. In the same way, Brook Lyndhurst (2014) reported that in home-made toasted samples, the levels of AA in brown and wholemeal bread were greater than in white toasted bread samples.

1.3.2.2. Toasting Effects

Although untoasted bread contributes to $2\mu g$ dietary AA intake, AA exposure from toasted bread increases significantly (Granby et al., 2008).

Eerola et al. (2007) conducted a test to investigate the impact of different degrees of toasting on AA formation in bread (wheat, oats and rye). The results showed that the difference between slightly toasted bread (40seconds) and strongly toasted bread (180 seconds) nearly doubled the AA level (Eerola et al., 2007), and the level of AA in medium toasting was recorded higher than the untoasted bread by 1.5 to five times (HEATOX, 2007a).

Also, Granby et al. (2008) reported the effect of toasting on increase AA level and comparing between toasted rye and wheat bread slices and untoasted slices. The results showed that rye

bread contained a high level (7-23µg/kg) of AA, while wheat bread contained less than 5µg/kg. Asparagine content of flour is higher in rye than in wheat flour. Therefore, the toasted slices represented 27-205 µg/kg AA in rye slices, compared with 11-161µg/kg AA in toasted wheat slices.

1.3.2.3. Bread Storing Influence in AA level

The effect of storing cooked foods such as breads has been tested with common results, which almost was stability of the AA contents (Tareke et al., 2002). It is more specifically stable at -80 to 6°C according to Mustafa (2008). In contrast, Mustafa (2008) demonstrated a reduction in AA level at 20 to 40 °C after storing rye crisp bread for up to 224 days.

1.3.2.4. Bread Consumption in Ireland

A report examining the pattern of white and wholemeal bread consumption among the Irish population was conducted by the Irish Universities Nutrition Alliance (IUNA) in 2016. It revealed that the mean daily intake of white bread among adult consumers was 51.2g, which equals nearly 1.3 slices per day (one slice's average weight was taken as 38g). It also concluded that 57% of adults were consumers of white bread (61% males, 53% females). Additionally, males over 65 consume the highest amount, about 2.2 slices, compared to the lowest amount, which is 1.5 slices per day among 18 to 35-year-old males. The quantity of white bread consumption among different female age groups was nearly constant at about 1.2 slices per day (IUNA, 2016).

In regard to wholemeal bread-group (wholemeal bread & brown/wholemeal soda-type breads) consumption among the adult nation, IUNA's report recorded that over 72% of Irish adults consumed wholemeal bread daily, with a mean daily intake of 32.8g (approximately 0.9 slices). Wholemeal bread consumption among females formed 74%, while in males it formed 69%. Males consume more portions than females, with a mean of approximately 2.1 slices and 1.6 slices respectively. In 2001, the consumption rate of white bread and rolls among the Irish population was 94%. In the same year, consumption of wholemeal and brown breads and rolls was 73%, with the mean daily intake being 83g per day for males and 61g per day for females (IUNA, 2001).

In regard to the types of bread most purchased in Ireland in April 2019, the packaged sliced bread showed 78%, baguette 53%, flat bread (wrap, pita, naan) 46%, wheaten /brown soda bread 43%, while about 2% of the respondents did not consume bread (Mintel, 2019a).

1.3.3. Coffee

1.3.3.1. The Factors Influence Acrylamide Formation in Coffee

The roasting condition of coffee beans (time and temperature), species of coffee and amount of precursors in raw beans are considered the most important factors in the control of the acrylamide level in coffee (Bagdonaite, Derler and Murkovic, 2008; Lantz et al., 2006). Many studies investigated the formation of AA at the different roasting stages and concluded that asparagine is the limiting compound in reactions leading to AA formation in coffee. Furthermore, there was a significant inverse correlation between the content of sucrose in green coffee bean and the concentration of AA or there was no relation with glucose (Lantz et al.,

2006). Akgün and Arıcı (2019) confirmed that the reducing sugars were not the limiting factor for AA formation in coffee.

Moreover, 3-Aminopropionamide (3-APA) compound had recorded in coffee with the possibility to be a potential precursor for acrylamide formation (Intermediate in the reaction pathway) (Morales and Mesias, 2015; Bagdonaite, Derler and Murkovic, 2008; Granvogl and Schieberle, 2007).

Among roasting experiments, studies confirmed there are inverse correlations between coffee roasting degree (light, medium or dark) and acrylamide content. During shorter roasting times, or at an early time in the roasting process and under low temperatures, the incidence of higher acrylamide formation occurred. In higher-degree roasting temperatures or long-time roasting, results on darker roasted coffee had low AA concentrations more often (Lachenmeier et al., 2018; Mojska and Gielecińska, 2013; Alves et al., 2009; Bagdonaite, Derler and Murkovic, 2008; Summa et al., 2007; HEATOX, 2007b; Lantz et al., 2006; Gökmen and Şenyuva, 2006; Bagdonaite and Murkovic, 2018) .

The levels of AA in coffee is also influenced by the types and species of beans. For instance, Arabica coffee contains less AA compared to Robusta coffee (Alves et al., 2009; Bagdonaite, Derler and Murkovic, 2008; Bagdonaite and Murkovic, 2018). In contrast, Mojska and Gielecińska (2013) argued that the type of coffee species did not show a role in the level of AA formation in coffee. Their results showed the difference in mean AA level between Robusta coffee and Arabica coffee was just 18ug/kg, compared to the roasting process, which has a significant impact on AA levels. Andrzejewski et al. (2004) explained the differences in AA levels in retailer coffees (drink) related to many factors such as coffee type, brand, consumer preferences and freshness of coffee

In regard to the relation between coffee types and AA levels, it was found that the highest levels usually accompanied dry coffee substitutes, then dry instant coffee and lastly dry roasted coffee (Akgün and Arıcı, 2019; EFSA, 2015; Mojska and Gielecińska, 2013). In consideration to coffee substitutes, chicory-based coffee showed higher AA levels than in cereals-based coffee, with MB (middle bound) mean 2942µg/kg and 510µg/kg respectively (EFSA, 2015). Terebinth coffee (Turkish coffee substitute) showed 240.3µg/kg AA (Akgün & Arıcı, 2019).

Likewise, Khan et al. (2017) reported that in regard to the type of coffee, Arabic coffee (Qahwa) showed low level (73-108µg/kg) of AA compared to roasted coffee, which was 152-682µg/kg. Additionally, Turkish coffee types had been recently recorded with 131.1-283.0µg/kg AA (Akgün & Arıcı, 2019). Similar findings were observed in other studies (Ölmez et al., 2008; Tawfik and El-Ziney, 2008; HEATOX, 2007a).

EFSA (2015) claims that the level of AA in coffee beverages are considered low consequent to dilution factor. JECFA (2011) estimated AA levels in ready-to-drink coffee to be from 0.9 to 22.7µg per cup (300ml). Moreover, Andrzejewski et al. (2004) calculated the acrylamide consumed per cup (300ml) among different types of coffee from different brands and locations. For example, instant coffee (2.5 g per cup) recorded between 0.42 and 1.34µg acrylamide; ground/brewed coffee was between 0.74-3.63µg acrylamide per cup (300ml); brewed black coffee was 1.77-3.24 µg. Mojska and Gielecińska (2013) calculated that one cup (160ml) of roasted coffee delivered about 0.45ug AA, and 3.21ug per cup of institute coffee.

Grob (2007) estimated the average amount of AA per cup of coffee (8gm dry coffee) was 2.3ug, which equates to 286 ug/kg AA in dry coffee. The author argued that, though a cup of coffee contains low AA content, frequent consumption of coffee will strongly contribute to mean daily exposure to AA. In other work recorded, dry coffee (200ml) contained 4-5.8µg of AA. An instant coffee drink in concentration of 1gm coffee/cup (200ml) recorded less than 2µg AA

(Eerola et al., 2007). Recently, Lachenmeier et al. (2018) calculated the average and 95th percentile exposure for AA per cup of roasted coffee (14gm dry coffee) were 0.05/0.10 µg/kg bw/day respectively. In regard to dry roasted coffee, it contains 249/543 µg/kg AA.

Espresso coffee shows higher AA concentration when it is compared to other regular coffee drinks, but it contributes less in AA intake due to the small volume per cup (Alves et al., 2009).

1.3.3.2. Storage Effects

Storage time seems to be play a major factor in decreasing the existing level of AA in coffee products, where longer storage periods of 3-6 months had been degraded AA in roasted coffee by about 31% compared with the fresh sample, different from that soluble coffee and coffee substitutes, which showed stable AA levels during storage stage (Hoenicke and Gatermann, 2005). In other studies, similar effects related to storing time were observed in reducing the amount of AA in roasted coffee (Lantz et al., 2006; Andrzejewski et al., 2004). In contrast, Delatour et al. (2004) recorded that storing for 12 months had reduced AA in soluble coffee by 66.8%, while Michalak et al. (2016) recorded that reduction reached 33% in instant coffee that was stored at room temperature (25◦C) for 12 months. Delatour et al. (2004) noticed a reduction in AA contents among all coffee categories (roasted, instant and alternative coffee such as chicory) after 5-12 months storage.

Hoenicke and Gatermann (2005) concluded that the causes behind degradation of AA in coffee by storing is related to the reaction between SH group-compounds in coffee and AA.

1.4.3.3. Coffee Consumption

Some food items that are relatively low in AA content, such as coffee or bread, will still contribute significantly to AA dietary intake when consumed in large quantities (Becalski et al., 2011; Grob, 2007). Coffee consumption is a major dietary component among many population groups and considered as one of the main sources for dietary exposure to acrylamide. This is because in many countries all over the world it is usually consumed in large quantities. For example, the coffee contribution to the total acrylamide exposure formed 20% among the Danish population (Granby and Fagt, 2004), 27.7% in French consumers (Sirot et al., 2012), 28-29% in Norway (Dybing and Sanner, 2003), while the contribution reached 39% among Swedish adults (Friedman and Levin, 2008). In Ireland, the contribution of coffee consumption in the total dietary exposure to AA was estimated to be 2% (FSAI, 2009a).

Among EU coffee consumers, the median average coffee consumption (g/day) was estimated in mean and 95th percentile within adult, elderly and very elderly age groups. The results for mean were 14, 21, 17gm dry equivalent coffee per day respectively. For 95th percentile respectively, consumption was 37, 45, 40gm dry equivalent coffee per day (EFSA, 2015).
According to the European Coffee Federation (ECF), EU consumption was 51.9million bags (60kg) of coffee in 2017. That is equal to consumption of over four kilos of roasted coffee per-capital in EU per year. In 2017, the 'Western Europe' region imported 3.42million tons of green coffee. Furthermore, Ireland showed growth in green coffee importation by 51% since 2015 (European Coffee Federation (ECF), 2018).

In 2016, research conducted by Empathy Research Company revealed that about 56% of Irish adults are drinking coffee at least once a day, while 34% drink more than one cup daily. The survey added that, although there is a significant increase in coffee pod/capsule consumption

(46%), ground/filter coffee (35%) and coffee from coffee shops (30%), instant coffee is still the most common type of coffee consumed amongst the Irish adult population (Checkout, 2018).

In line with this, instant coffee was also recorded as the most common type of coffee consumed at home and work in Ireland among 45-54year-olds, which was representative of 57% of the participants. Ground coffee was consumed by 32% in this category and coffee pods were consumed by 21% (Mintel, 2018b). Bord Bia (2011) presented information stating that cappuccinos are the most frequently drank coffee type outside of home in Ireland, representing 53%.

In regard to ground coffee preferences among Irish consumers, it has been found that there is a positive correlation between ground coffee being a drink of choice in high social levels (Mintel, 2018a).

Saeed et al. (2019) and O'Keefe, DiNicolantonio and Lavie (2018) conducted a comprehensive overview about the health benefits and risks of consumption of coffee, with the study finding that consumption of up to 3-4 cups per day has health benefits effects to the most consumers. These health benefits consist of, for example, reduction in the incidence of some chronic liver diseases, as well as aiding mental health problems, some of which are associated with people believed to be suicide risks.

1.4. Home Food Preparation and Cooking Practices

A recent Bord Bia survey demonstrated that almost half of Irish consumers prepare food from scratch at least once a day, with oven-baked and roasted being the most popular methods of

food preparation in the home. Over 75% of females in Ireland are responsible for preparation of meals at home. Taste and quality of home-prepared food ranked as the most important factors among Irish consumers. The consumers placed slightly less emphasis on the freshness and safety of the food (Bord Bia, 2017).

Grob (2007) claims that about 50% of AA intake is generated from homemade meals or restaurant meals. Claeys et al. (2010) investigated the AA intake among the Belgian population, concluding that the consumer is equally as responsible as industry for reducing AA formation in food. This can be done by applying good cooking practices such as avoiding dark colouration during cooking (frying, baking or roasting) of carbohydrate-rich foods.

Although domestic food practices play a significant role in consumers' exposure to AA, studies relating to the generation of AA during home food preparation and actual cooking practices have only been addressed in infrequent studies. These include Jackson and Al-Taher (2005), HEATOX (2007a,b), Brook Lyndhurst (2014), Mesias et al. (2018) and Mesias, Delgado-Andrade and Morales (2018).

A field pilot study in 2018 investigated the contribution of home practices to the increase of the level of AA in chips (French fries) in Spanish houses. The study revealed that formation of AA in home-prepared chips from fresh potatoes samples were about 45.2%. Samples exceeded the EU benchmark level for French fries (500ug/kg) by two to four times and hit all the average AA exposures intake sceneries, as considered by EFSA. For instance, 6.9% of the collected home-prepared chips recorded 2000ug/kg AA contents, while the average of the other samples was 644 µg/kg in home-made fried chips (Mesias et al., 2018).

1.4.1. Storage Practices

In 2014, a field project in the UK was conducted to investigate the impact of home practices in the formation of AA. Most of the participants in this project stated that they stored raw potatoes outside the fridge for an average period of less than two weeks. They explained that the reasons behind their storage choices were shortage of space in the fridge or that they inherited this action from parents. Those who stored potatoes in the fridge (a low percentage did this) did it to keep the potatoes fresh (Brook Lyndhurst, 2014)

1.4.2. Cutting Size

Generally, a larger surface-to-volume ratio resulted in a much higher content of AA in cooked potatoes. In other words, smaller and/or thinner pieces result in a higher level of AA content after heat treatment. AA formed mainly on the outer surface of the food, which contacts directly with the high heat treatment during cooking or toasting. Therefore, the size and the cut-shape of cooked products, i.e. the surface-to-volume ratio (SVR) will significantly influence the final level of AA (Kalita and Jayanty, 2017; Matthäus, Haase and Vosmann, 2004; Taubert et al., 2004).

Matthäus, Haase & Vosmann (2004) showed that large-cut potato strips (14x14mm) resulted in significantly lower AA content than thin-cut potato strips (8x8 mm). In line with this, Mesias et al. (2018) demonstrated a reverse correlation between the potato cuts thickness and acrylamide contents in home-prepared fried potatoes. The explanation for this was that a large surface area improves evaporation of water, leading to a reduction in humidity of the surface cuts during frying or baking that enhance AA formation in the outer surfaces (Matthäus, Haase and Vosmann, 2004). In contrast, Michalak, Gujska and Klepacka (2011) did not find a clear relation between shape and size of fried potatoes and the level of AA formation.

Contrary findings were recorded when Taubert et al. (2004) discovered a systematic correlation between lower SVR and increasing AA levels. This occurs in tandem with increases in temperature and cooking time. An opposite correlation was also recorded in regard to medium-to-large SVR, which reached the highest AA level at 160-180°C. Any further increase in temperature or cooking time will lead to a degradation in AA level.

1.4.3. Pre-cooking treatment

Blanching or soaking of potatoes before frying has been shown to significantly reduce the acrylamide content in fried potatoes.

Blanching

The main aims behind blanching or soaking potatoes, from a food-safety perspective, are to decrease the concentration of reducing sugars and asparagine in potato cuts, as well as reducing the time required to cook under high heat treatment (frying, roasting),this is reflected in the reduction of AA content in the final product, in contrast to potatoes that haven't been blanched (Viklund et al., 2010; Matthäus, Haase and Vosmann, 2004). Elimination of AA precursors from the surface through blanching or soaking depends on immersion time or the temperature of the blanching. Zhang et al. (2018) illustrated that blanching time had a more significant impact than blanching temperature in reducing the concentration of AA precursors and, subsequently, AA formation in fried potato chips. Zhang et al. (2018) recommended an ideal blanching condition, which was 68.7 to 75°C for 8.8 to 9.7 minutes, with optimal reduction in precursor concentration reaching 49.8% for asparagine, 64.2% for reducing sugars and 61.3% for AA. In a similar study, Shojaee-Aliabadi et al. (2013) demonstrated that ideal blanching conditions were a temperature of 75˚C for nine minutes, which led to a 74% reduction in AA formation in fried potatoes.

Mestdagh et al. (2008b) reported that a decrease of about 65% in the level of AA in chips had been achieved through a blanching process with water at 70°C for 10 to 15 minutes. A similar percentage of AA reduction had been recorded by Matthäus, Haase & Vosmann (2004) at 82°C for 2.5 minutes for blanching of potato crisps, or soaking at 50°C for 15 minutes.

Therefore, Viklund et al. (2010) recommended potato blanching as an efficient way to reduce AA content in potato crisps, and referred to a blanching process of three minutes in water at 80°C which would reduce AA content of fried potatoes by 51% to 73%, while reducing the precursor contents by 17% to 66%. The authors stated that the reduction rate of AA and precursors related to blanching, which restricted movement of precursors to the surface and decreased chances for AA formation on the outer surface.

The effect of blanching with a shorter roasting time demonstrated a reduction in AA levels between 46% and 60% in roasted potato wedges (Skog et al., 2008).

It was noted that blanching potato sticks in water at 50°C for 80 minutes had shown a greater reduction in AA content compared to blanching at 70°C for 10 and 45 minutes, or at 90°C for three and 10 minutes (Pedreschi, Kaack and Granby, 2006).

In a UK survey, the level of blanching practice in the home was recorded. However, the data revealed that soaking before frying was uncommon, with just one case. Parboiling was more common. Among the respondents' reasons for parboiling were that it shortens the roasting time and helps to achieve a desired texture (Brook Lyndhurst, 2014).

Soaking

Soaking potato strips in water for two hours showed a reduction of 33%, 21% and 27% in acrylamide formation when potatoes were fried at 150, 170 and 190°C respectively (Pedreschi, Kaack & Granby, 2006). Therefore, HEATOX (2007a) advised consumers to wash and soak

potatoes in cold water for at least 30 minutes, or blanch them in hot water for a few minutes. Also, FSAI (2009a) recommended the soaking or blanching of potatoes as well as draining well before cooking.

On the other hand, Williams (2005) argued that two hours' soaking of potato chips in water under room temperatures did not show an effect in reduction of AA content. He added that soaking does not have a role in leaching of precursors in water during the soaking process. Additionally, the author suggested that parboiling reduces the level of AA due to the reduction in frying time, rather than losses of precursors in water (Williams, 2005).

In a different experiment, soaking potato chips in salt solution (NaCl) of 0.002 gm/liter for five minutes resulted in a reduction of AA levels by an average of 90% (it depended on the applied frying temperature), while it reached 97% reduction at 120°C frying temperature (Pedreschi et al., 2007a). Soaking potatoes in NaCl provided the similar surface colour degree as the control sample, while also lowering the AA content (Gökmen and Şenyuva, 2007).

In an early study comparing the impact of both NaCl and calcium chloride ($CaCl_2$) in AA reduction, $CaCl_2$ was more effective in limiting AA formation. The reduction in AA formation reached 95% by soaking potato strips in $CaCl_2$ 0.1 M solution for one hour at room temperature, while it maintained the desired appearance in colour (Gökmen & Şenyuva, 2007).

The practice of soaking potatoes was evaluated in British domestic kitchens by researchers and they concluded that washing potatoes after peeling was uncommon among participants. This is because they relied on peeling or blanching to provide a hygienic purpose. Participants did not really consider soaking potatoes as a step in the potato preparation process. Furthermore, many viewed it as a waste of time when they could be carrying out other cooking tasks (Brook Lyndhurst, 2014).

pH value

It has been observed that the formation of acrylamide decreases with a lower pH of the food mixture (Kalita and Jayanty, 2013; Levine and Ryan, 2009; Jung, Choi and Ju, 2003). Yuan et al. (2007) and Rydberg et al. (2003) also confirmed that higher acrylamide formation occurred near a pH of 8.0. Jung, Choi and Ju (2003) tested the effect of citric acid on reduction of AA formation in chips by soaking potato cuts in 1% and 2% citric acid solutions for one hour before frying. This showed a reduction in the AA content of fried chips of about 73.1% to 79.7%, and explained that reduction as a result of the lower pH of the potatoes. Pedreschi, Kaack and Granby (2006) reported that reduction reached 53% by immersing potato strips in 1% citric acid solution for one hour before frying. A similar observation led to an 80% reduction of AA contents by using 0.5% citric acid solution for one hour (HEATOX, 2007b).

1.4.4. Cooking

The effect of cooking foods on AA formation depends on the method of cooking which has been used, such as boiling, baking, frying or microwaving. The other factors are the cooking temperature, length of time cooking and other food additives. Generally, reducing undesirable reactions during cooking can be achieved through the use of relatively low cooking temperatures and shorter cooking times.

1.4.4.1. Cooking Temperature and Time

Cooking temperature and time were identified as relevant factors on AA generation in food. Increasing frying temperature has been shown to lead to a significant increase in acrylamide formation.

Several studies have confirmed a link between AA formation and cooking temperatures and time in various food products (Norén, 2019; Daniali et al., 2018; Shojaee-Aliabadi et al., 2013; Michalak, Gujska and Klepacka, 2011; Majcher and Jeleń, 2007; Pedreschi, Kaack and Granby, 2006; Fiselier et al., 2006; Williams, 2005; Matthäus, Haase and Vosmann, 2004; Rydberg et al., 2003).

Matthäus, Haase and Vosmann (2004) detected a simultaneous relation in temperature reduction with increasing the cooking time and reduction of acrylamide concentration in final food. They described that as a linear relation between AA level and cooking time, but it was not linear between AA formation and temperature, and the recommended condition for frying potatoes was 175℃ for 2.5 minutes. Granda, Moreira and Tichy (2004) illustrated a 51% reduction in AA content in potato chips was achieved by dropping frying temperature about 15 degrees, from 180°C to 165°C, during a traditional frying method. Pedreschi et al. (2005) tested the impact of different frying temperatures on AA formation levels in fried chips. The final results showed a significant elevation of the AA level, reaching an average 54-fold when the frying temperature increased from 120°C to 180°C.

It was recorded that there is a relationship between frying time and acrylamide content among traditional frying methods under all temperatures (Granda, Moreira and Tichy, 2004), or in the oven under low temperatures for a long time (Norén, 2019).

In regard to the role of frying oil in acrylamide formation, controversial observations were recorded in various studies.The majority of studies showed there was not any link in the AA formation (Mestdagh, De Meulenaer and Van Peteghem, 2007; Williams, 2005; Matthäus, Haase and Vosmann, 2004). On the other hand, papers discussed the probability of some oils being involved in AA formation (Zhang et al., 2015; Capuano et al., 2010; Napolitano et al., 2008; Becalski et al., 2003; Gertz and Klostermann, 2002). The explanation for the presence of

a link between oil and AA formation is related to the unsaturated fatty acid contents in oil. These fatty acids displayed the probability to form acrylamide by other paths through degradation of acrolein as an alternative to the Maillard reaction (Marchettini et al., 2013; Becalski et al., 2003).

1.4.4.2. Influences of Cooking Method on Acrylamide Formation

The method of cooking is an important factor involved in AA formation. For instance, in a home-cooking practices study it was revealed that grilling of potato wedges generated higher levels of AA on average 1520 ug/kg, while potato wedges that were shallow fried in oil generated 525 ug/kg. Deep fried in oil produced 375 ug/kg, with the lowest level of AA being observed in oven-baked potato wedges 245 ug/kg (Ahn et al., 2002).

Another study concluded that the vacuum frying method is a healthy alternative way for frying chips compared to the traditional way of frying chips. It revealed that reduction in AA formation reached 94%. However, this comparative analysis between both methods of frying were under different temperatures, with traditional frying at 150, 165 and 180°C, while for vacuum frying it was conducted at 118, 125 and 140°C (Granda, Moreira and Tichy, 2004).

Based on the Food and Drug Administration's (FDA) comparative research about the contribution of frying, roasting and baking potatoes on AA formation, it was concluded that baking whole potatoes is the lowest producer of AA in potatoes. This was in contrast to frying, which is the highest producer of AA, followed by roasting. Boiling whole potatoes did not show AA formation (FDA, 2017).

Another comparative study examined boiling, frying and microwaving methods on the formation of AA in cooking chips. The results showed that microwaving contributed to a significant increase in the level of AA compared to other conventional methods of cooking under the same conditions. The authors referred to a positive relation between microwave power and the level of AA generated (Yuan et al., 2007). The same conclusion about the significant level of AA correlating with the microwave power, cooking time and temperature has been confirmed by Elfaitouri et al. (2018). These findings are similar to those of other studies, which were conducted to evaluate the effect of different cooking methods such as roasting, pan-frying, deep-frying and microwaving on the generation of AA in pre-cooked croquettes and fried potatoes. It showed the highest level of AA among microwave treatment and the lowest level among pan-frying processes (Michalak et al., 2017; Michalak, Gujska and Klepacka, 2011). Palazoġlu, Savran and Gökmen (2010) pointed out that the cooking method has the major impact on the AA level rather than the temperature of cooking applied. In terms of the impact of baking and frying methods on the formation of AA in potato chips, results revealed that baking chips at 170°C produced AA over double higher than what was formed upon frying at the same temperature. However, frying at 180°C and 190°C formed higher levels of AA (39 ng/g and 95 ng/g respectively) in chips than what was generated by baking at the same temperature (19.3 ng/g and 29.7 ng/g respectively).

Sansano et al. (2015) examined the effect of the air-frying method in reduction of AA formation in potatoes against the traditional deep-frying method. Both were carried out at 180°C on potatoes that were not pre-treated. The researchers found a 90% reduction in AA level among the air-fryer method in comparison with the conventional frying method. In an additional experiment, the effect of pre-treatment on the level of AA reduction in air-frying was 77% compared to potatoes that were not pre-treated with the same air-frying method.

Regarding the boiling or steaming method, no effect has been recorded in the level of acrylamide in potatoes (Hogervorst et al., 2010; Dybing et al., 2005; Ahn et al., 2002; Tareke et al., 2002).

1.4.4.3. Evaluating or Judging When Food is 'Done'

Following the manufacturer's instructions

Under Regulation (EU) 2017/2158 it is stated "the FOBs shall indicate recommended cooking methods specifying time, temperature, quantity for oven/deep fryer/pan on packaging" (European Commission, 2017, p.31), for good cooking practices and protecting consumers' health. Following on from this, FoodDrinkEurope published the updated version of Acrylamide Toolbox 2019, which stated the following advice to chefs and consumers: "Follow exactly the product-specific cooking instructions on the packaging" (FoodDrinkEurope, 2019, p.68).

Behaviour to food-package instructions were studied in a field research project in the UK, with the observations revealing that the reality was people did not pay attention to the manufacturer's instructions. It found that people had their own systems for evaluating if food is properly cooked, such as time guide, visual assessment or combinations of both (Brook Lyndhurst, 2014).

1.4.4.4. Colour Indication

Since the Maillard reaction is responsible for colour changes (browning) in foods and, furthermore, acrylamide generation, measuring the degree of colour in foods can be used as a method to indicate the level of AA present. Thus, AA level can be compared to specific chromatic indicators "a*", "b*" and luminance indicator "L*", with *a** value representing

redness (green to red scale), *L** value representing lightness and *b** representing yellowness (blue to yellow scale) (Yam and Papadakis, 2004).

A noticeable correlation between browning levels in food surfaces and AA concentrations in different food products have been tested over many studies, as shown in cooked potatoes (Mesias et al., 2018; Serpen and Gökmen, 2009; Mestdagh et al., 2008a; Gökmen et al., 2007; Majcher and Jeleń, 2007; Pedreschi et al., 2007b; Pedreschi, Kaack and Granby, 2006; Pedreschi et al., 2005), coffee, wheat flour (Gökmen and Şenyuva, 2006) and bread (Mustafa et al., 2005; Surdyk et al., 2004).

Measurement of the food colour degree and AA content at different temperatures and roasting times in chips showed that there is a substantial correlation between *L**, *a**, *b** and acrylamide concentration as a function of time. While *L**and *a** correlated positively with acrylamide content as a function of temperature, *b** did not show any correlation in regard to the temperature (Majcher and Jeleń, 2007).

Gökmen and Şenyuva (2006) reported a relationship between the chromatic parameter *a** changes and AA levels in green coffee, wheat flour and potato chips during heat treatment. Therefore, the redness parameter *a** has been suggested to be used as an indicator to evaluate AA levels in thermally processed products. This was in keeping with the results of Pedreschi , Kaack & Granby (2006), and Jackson & Al-Taher (2005), with regard to the presence of high correlations between the colour indicator parameters *L** and *a** with acrylamide content in French fries and toasted bread. The same observation about a linear correlation between AA and *a** value was observed , but a low relation was recorded between AA and *L** value in potato chips (Zhang et al., 2018). Therefore, Mesias et al. (2018) concluded that the parameter *a** could be used to sort the fried potatoes according to AA levels .

Sun, Rosen and Thompson (2018) linked dark colouration in fried potatoes with the tubers glucose concentration. There was a strong correlation recorded between glucose concentrations for chip cultivars with fry colour, whereas there was a medium correlation in the case of French fry cultivars. Also, the paper confirmed that a positive correlation existed between glucose concentration and AA level in fried potatoes.

In relation to bread, a highly significant correlation between the colour degree and AA formation in wheat bread crust was recorded in early studies by Surdyk et al. (2004). On the contrary, Taubert et al. (2004) suggested that the degree of browning was not a reliable indicator for AA content in large-surface cooked foods.

Claus et al. (2006) argued that there was not clear correlation between the surface colour in bread and AA contents. Thus, Mustafa et al. (2005) explained that surface colour parameters a^* and b^* were significantly affected by both time and temperature of baking, without direct correlation to the AA level in bread. However, the authors stated that time and temperature of baking correlated to acrylamide formation. Additionally, a significant correlation between AA formation and browning intensity and baking time has been recorded in gingerbread baked at 180°C to 200°C for 10 to 20 minutes (Amrein et al., 2004). The authors argued that lower temperature with a prolonged baking time did not lower AA content. On the contrary, the level of AA was higher in low temperatures with long baking times in gingerbread. Therefore, the suggestion was a short time (10 minutes) at 200°C, which formed half the amount of AA produced under 160°C for 20 minutes (Amrein et al., 2004).

In the toasting process, Jackson and Al-Taher (2005) pointed out the positive correlation between AA contents in home-toasted bread and the dark colour of the toasted bread surface.

AA had been recorded (43.7 to 610.7ug/kg) in dark toasting compared to light toasting (8.27 to 217.5ug/kg) or medium toasting (10.9 to 213.7ug/kg). Thus, the authors found a positive correlation between the surface colour (a^* and L^* values) and AA level, while also suggesting that the degree of surface browning could be used as a tool indicator of AA formation in cooked foods (Jackson and Al-Taher, 2005). Similarly, Nachi et al. (2018) found the L^* and b^* parameters of crusts correlated positively with the level of AA in bread samples.

Ahn et al. (2002) argued that browning degree during toasting and AA level is a causal relation rather than a direct correlation. In other words, under the same toasting conditions, the colour degree of white toast differs from brown toast.

1.5. Previous Acrylamide Awareness Studies

This section presents a review on recent literature about studies that have been conducted to investigate acrylamide awareness among different nations and various demographics. In Poland, a study has been conducted among medical school students about AA awareness and eating habits. It revealed that only 7% of the participants had heard about AA before. Moreover, those who had heard about AA were not aware of details relating to AA formation in food (Kowalska et al., 2017). A similarly low percentage 5.1% had heard about AA risk in a survey among Chinese university students, while 65.3% of the students were not familiar with acrylamide (Meng et al., 2012).

The lowest percentage of awareness of AA formation and the associated health risks was recorded among West African countries, with less than 2% awareness of the possible adverse health impact of AA. About 28.4% were aware of acrylamide formation in cooked foods (Akinosun, Ojinnaka and Aouzelleg, 2018).

The level of awareness about AA and its potential risks reached 22% in a recent survey focusing on France, UK and USA, carried out by DSM Research Company. The percentage reached 54% in Germany for the same survey, with 2000 individuals overall. Of the 22% who had heard about AA, 50% were aware of its formation, while 19% of the participants believed that AA is not harmful at all (DSM, 2018).

In 2014 a field study project for Food Standards Agency in the UK examined the effects of home-cooking practices on acrylamide formation. It concluded that there was a low level of awareness of acrylamide exposure among British participants. That project focused on the different home practices for instant potato storage, preparation of potatoes, cooking preferences and bread-toasting practices. Furthermore, the study referred to the presence of a relation between consumer preferences and AA exposure, and a correlation between desired food colour and AA levels in examined foods (Brook Lyndhurst, 2014).

In the Republic of Ireland, there is not any paper that has investigated the level of knowledge about acrylamide awareness and domestic food practices. However, McCarthy et al. (2007) conducted a quantitative study among 1025 residents on the island of Ireland to examine knowledge levels about food safety practices and food safety. The authors discovered that most of the population know what they should be doing in their kitchen from a food safety perspective, but they are not often applying what they know. The authors also considered it less than ideal that food-handling practices are considered safe among some people. Moreover, Moreb, Priyadarshini and Jaiswal (2017) investigated the level of food safety knowledge among the residents of Ireland and they concluded that, in total, the participants showed an average level of 67% of food safety practices knowledge.

Most Irish adults (83%) positioned themselves as very healthy, mainly among 35 to 44-year-olds. Nearly 50% of Irish adults say that they are often confused about what they should eat to

stay healthy, while most of the Irish population (88%) agree that living a healthy life depends mainly on proper eating habits (Bord Bia, 2017).

In June 2019, EFSA published the Eurobarometer report on food safety in the EU. With relation to Ireland, the report showed that 76% of the population of Ireland say that food safety is a concern for them, while one-third of the participants consider it as a main issue. It stated that around half of the Irish respondents consider food safety as important during the purchasing of food items.

Furthermore, a strong majority of Irish participants (77%) rely on the opinions of national authorities to get their food-risk information, while just over half (55%) believe there are regulations in place to protect food safety. Just under a quarter of the respondents (22%) consider sold food to be safe (EFSA, 2019).

The EFSA report also stated that the major outlets for receiving food-risk information in Ireland are TV (59%) and internet searching (47%), while paper media, radio and social media are nearly the same, between 37 to 39%. Person-to-person information (family and friends) was recorded as being 32%.

In addition, the EFSA barometric report measured the tendency of the Irish participants to change their habits in light of food-safety risks information. The report's results show that about 40% of them believe they will constantly change their consumption habits, while 34% will temporarily modify their behaviours and 14% cannot change their food habits (EFSA, 2019).

1.6. Research Gap Analysis

In 2002, the FAO/WHO consultation on the health implications of acrylamide in food stated that, for obtaining a reliable AA intake estimation, the data about how food is cooked and processed in domestic level as well as industrial level should be collected (WHO, 2002).

Thirteen years after WHO spoke of a need for data about domestic food practices, EFSA stated that home-cooking habits and preferences could have a heavy impact on dietary AA exposure, and mentioned a gap still existed relating to the data on the actual food consumption habits within the exposure assessment. Furthermore, the available consumption data has been generally collected at the level of raw ingredients stage, without detailed information on how raw food stuffs had been prepared or cooked before consumption at the home level. Therefore, EFSA mentioned in their risk assessment of exposure of AA in food that there was uncertainty in regard to potato preparation, coffee choice and consumers' preferences regarding the degree of potato frying and bread toasting due to shortage of this specific data (EFSA, 2015).

Recently, Mesias et al. confirmed the importance of collecting home foods practices data for accurate evaluation of AA intake. Mesias et al. (2018, p.51) stated that "it is necessary to consider the frying practices in a domestic setting as a key factor to assess the real dietary acrylamide exposure of the European population". This was said after conducting research among Spanish home preparation practices in regard to the cooking of chips (French fries). It confirmed that AA formation during domestic preparation of French fries hit nearly double the average value estimated by EFSA (2015) and four times the benchmark level of AA (Mesias et al., 2018).

This clearly highlights the crucial role that is played by domestic food practices in dietary AA intake. To focus on the Irish context and, in particular, there being no study (to my knowledge),

a knowledge gap has developed where the extent to which consumers are exposed to acrylamide is unknown. Similarly, cooking practices and behaviours are not widely known, even though these are the aspects that influence their level of exposure. Collection of data is needed. This data needs to focus on home practices and awareness among Irish residents for reliable evaluation. This deficiency of inherently Irish empirical data contributed to inspire the basis of this study.

1.7. Research Questions

This study looks to answer the following questions:

- What is the existing knowledge about acrylamide formation and its risk among Irish residents?
- How do the residents in Ireland engage in home-food practices (preparation, storage, cooking) and what are their food preferences that may contribute to the level of exposure to acrylamide?
- Is there any suspected high exposure to AA through home-made food practices or food preferences?

1.8. Aim and Objective

The aim of this study is to explore the level of awareness regarding acrylamide in home-prepared foods and, in particular, domestic cooking/preparation practices consumers are engaging in that have the potential to influence acrylamide generation. An additional aim of this research is to provide an indication of the extent that consumers may be exposed to AA risks from home-made food and food preferences.

The overall aim is to overview to what extent could domestic contribute in exposure to acrylamide, in particular, home-made food preparation practices and food preferences among the adult residents in Ireland. Additionally, to assess the impact of this knowledge on the actual cooking practices and food preferences. Moreover, to identify the potential food practices for follow-on investigations or education initiatives.

The study objective was achieved by surveying residents in different regions, including all ranges of ages over 18, from different genders and nationalities. People with different education levels will also be covered, as well as different personal statuses. Furthermore, the survey collected data based on multiple aspects in acrylamide formation in domestic foods to include food preparation, storage, cooking preferences and the consumption rate of the selected food items. Additionally, information relating to general acrylamide formation and health risks was collected.

METHODOLOGY

Chapter 2 . METHODOLOGY

According to the literature review gap analysis and previous studies conducted in other countries in regard to the contribution of home practices in AA formation and AA awareness levels, there has not been data collected or investigatory research conducted in Ireland. This is an important subject which can have a great impact on the general health of the nation. Therefore, this study is based on covering the gap regarding acrylamide awareness, domestic food practices and food preferences.

2.1. Research Methodology

There are times when quantitative and qualitative data are practically inseparable (Atieno, 2009). A mixed strategy has been employed in this study, which included a combination of quantitative and qualitative questions in order to achieve a clear insight through employing both methods in research. Therefore, the data collection strategy is based on closed-end multiple and single-choice questions, as well as open-ended questions.

Qualitative questions were used to accurately interpret and assess the personal responses to closed-end questions, as well as avoiding any associated bias with multiple-choice questions (Malhotra, 2004).

2.2. Research Method

The study was conducted using a questionnaire which was developed in order to assess acrylamide awareness and home-food practices among residents of Ireland. The questionnaire was completed by random people aged between 18 to 64 and living in Ireland. The survey was carried out either by electronic questionnaire or hard copy from March to June 2019.

2.3. Justification of the Research Method

The questionnaire provides access to a significant number of participants during a relatively short timeframe while it was also cost-affordable. Further online activity allowed for wide distribution of surveys without bias.

The quantitative method is considered the best way to collect a large number of respondents, test broader patterns and provided broad scope for generalising the findings (Panke, 2018). However, qualitative research questions provide more chances to collect important clues about a wide range of answers, instead of being confined to a limited and often self-fulfilling perspective. Additionally, qualitative research questions allow participants to express their answers with authenticity and, consequently, the collected data becomes more accurate and can lead to more reliable conclusions. Also, the responses to open questions provided in-depth information, especially about issues not present in the questionnaire, which reflects the participants' knowledge.

Therefore, the mixed-method approach keeps the advantages of both approaches, while helping to overcome the disadvantages of using one strategy alone (Panke, 2018).

Participants were afforded anonymity and confidentiality, as per the ethics guidelines. In addition to this, they had freedom to skip questions or withdraw from the survey at any stage if they did not feel comfortable answering. This all combined to support the assumption of truthfulness of the responders' answers.

2.4. Research Design Process

2.4.1. Questionnaire design

The questionnaire was designed to capture information about the aspects of food preference and home-food preparations that can influence acrylamide levels. Moreover, evaluate the level of awareness about acrylamide formation aspects. A copy of the questionnaire is presented in appendix A.

The questionnaire development was guided by questions used in published literature to assess knowledge and eating habits of a population in the field of acrylamide, as well as home-cooking practices and acrylamide formation (Mesias et al., 2018; Kowalska et al., 2017; Brook Lyndhurst, 2014). Appropriate modifications were made to the questions to fit the objective of the study. For validation of the questionnaire, a pilot test was conducted via 16 food-safety management professionals to assess the clarity of the questions and associated pictures, suitability of wording and the average time needed for its completion. The required amendments and enhancements were made according to the feedback, then re-evaluation occurred before final distribution online or manual paper questionnaire.

According to Bryman (2016), when a measure is reliable it can be valid, because a valid measure reflects the concept it is supposed to be measuring. Therefore, in order to test the home-food practices and their contributions in AA exposure and the general awareness, the reliable indicators were employed to investigate the practices and awareness in regard to AA generation

in home-made foods. Thus, the questionnaire focused on collecting data, which covers the home-food practices and preferences among those specific food items (potatoes, bread and coffee).

Based on the previous literature review, it was emphasised that the major food stuffs that correlate with formation of acrylamide are potatoes (such as French fries and potato crisps), bread and coffee (EFSA, 2015; WHO, 2011; Claeys et al., 2010). Moreover, the relation between cooking methods used during preparation of potatoes and the levels of AA in meals was confirmed. Also, the role of bread toasting degree and concentration of AA in bread. Additionally, the contribution of coffee preferences and consumption rate in AA exposure level. Overall, the questionnaire consisted of 43 questions. The multiple-choice questions formed four questions (Q6, Q12, Q25, Q33), while there were 33 single answer-choice questions and six open-ended questions. The questionnaire was designed on SurveyMonkey platform and organised in a logical automatic order (as shown in Figure **2-1**) which depended on the participants' responses to questions, without distinguishing separated sections in order to avoid any influence during the experiment and to prevent bias. Furthermore, the closed-end questions contained options stating "other" or "I do not know" to avoid limiting responses to a predetermined list of options.

The first two questions of the questionnaire aimed to screen participants and fulfil criteria (age and country of living).

Questions relating to acrylamide knowledge and awareness were displayed directly to distinguish the knowledgeable participants from others for further investigative questions in different automatic questionnaire pathways. The direct questions that tested acrylamide information knowledge were Q3, Q4, Q5, Q6, Q32 and Q33. Indirect awareness questions

aiming to measure accurately the levels of awareness and knowledge that the respondents had appeared in Q8, Q14, Q17, Q23, Q27 and Q31. Overall this category formed 12 questions.

In the consumer preferences category, which focused on cooked foods surface colouration, five questions were displayed (Q20, Q22, Q25, Q26, Q29), while three questions asked the consumption rate of potatoes, bread and coffee (Q24, Q28, Q30).

Domestic food practices which included storage, preparation, pre-treatment and cooking were represented in 11 questions (Q7, Q9, Q10 ,Q11 ,Q12 ,Q13, Q15, Q16, Q18, Q19 and Q21). Three questions helped to discover the participants' attitudes and opinions with regard to AA labelling suggestions (Q34, Q35 and Q36).

In accordance with Malhotra (2004), to increase the likelihood of obtaining demographic information the last group consisted of seven questions covering the respondents' demographic data (Q37 to Q43). The demographic characteristics questions covered residence, age, per capita annual income, educational level, gender, family status and background culinary origin.

In order to obtain the information in an unambiguous way, more than one question strategy is essential (Malhotra, 2004). In other words, by applying a number of questions it helps to assess a wider range of aspects of the concept (Bryman, 2016). Thus, in this survey some questions were asked from a different aspect for the purpose of assessing reliability or validity of the data, such as question Q31 which was very similar to Q3. This was done to achieve reliable data and prevent bias. Additionally Q4, Q5 and Q6 were confirmation of the answer to Q3. Moreover, Q32 verified Q31 answer.

Since one image is a better and more accurate description than 100 words, photo questions were illustrated among four questions. This was done to achieve the reliability of the answers and avoid misinterpretation of the words, particularly with reference to the colour of chips, roasted

potatoes and toasting degree of bread (Q20, Q21 and Q23) or size of potatoes (Q12). Question 12 used images to illustrate cut sizes of potatoes used.

In regard to the degree of cooking preferences for roasted potatoes (Q20), validated images (Figure 2-2) have been used (adapted from Brook Lyndhurst, 2014, p.42). The photo of chips (Q21) was adapted from EUPPA (2019) GoodFries initiative web page (Figure 2-3), which is used in a flyer as a tool for learning good frying practices. Q23 contained a validated photo (Figure 2-4) demonstrating the degrees of surface browning in toasted bread. This image had been presented by Jackson (slide no.16) in a Food Safety Symposium in Brazil in 2008 (Jackson, 2008).

Figure 2-1 The questionnaire's questions pathways according to participants' responses.

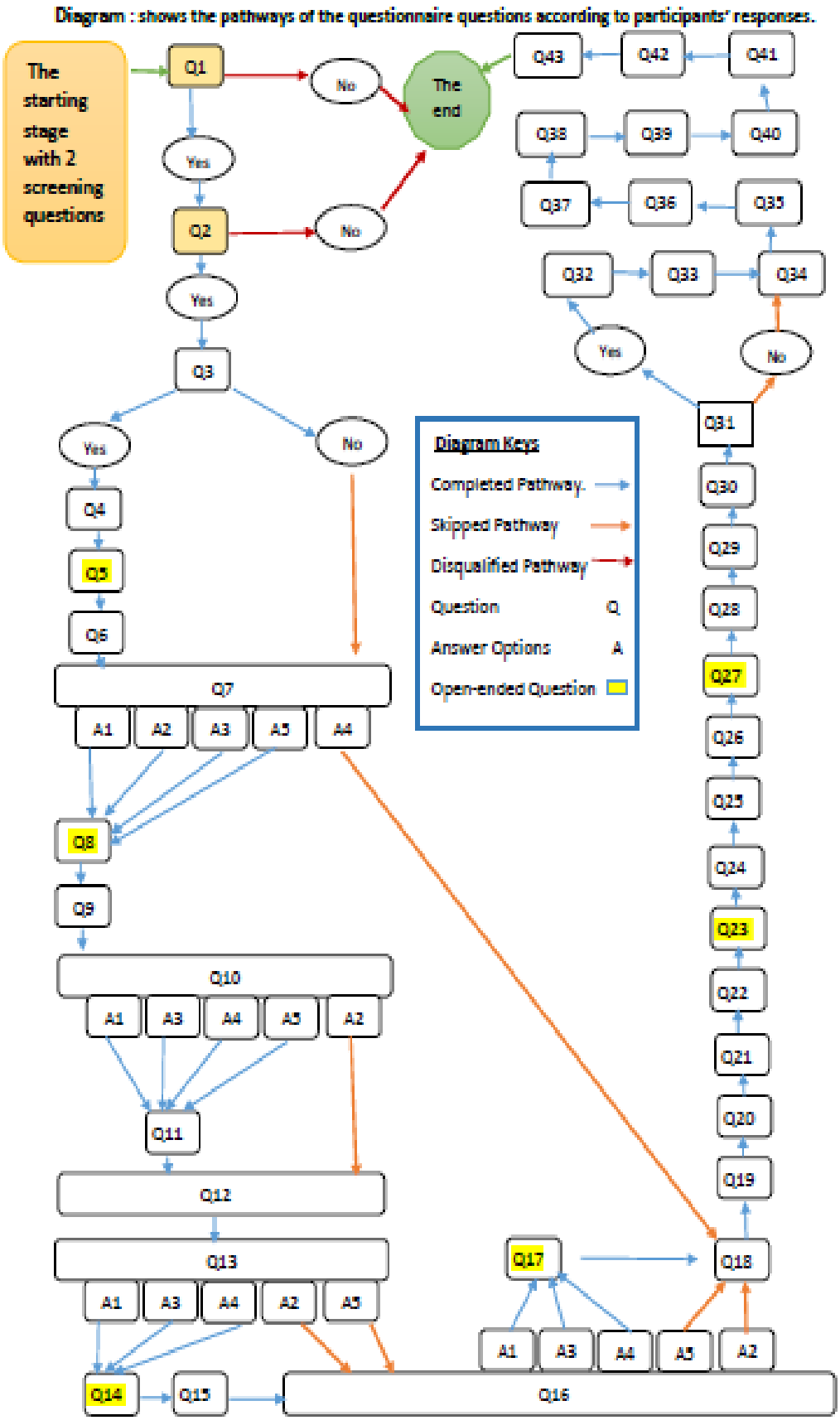


Figure 2-2 Roasted potatoes home-made validated samples (Source, Brook Lyndhurst, 2014, p.42).

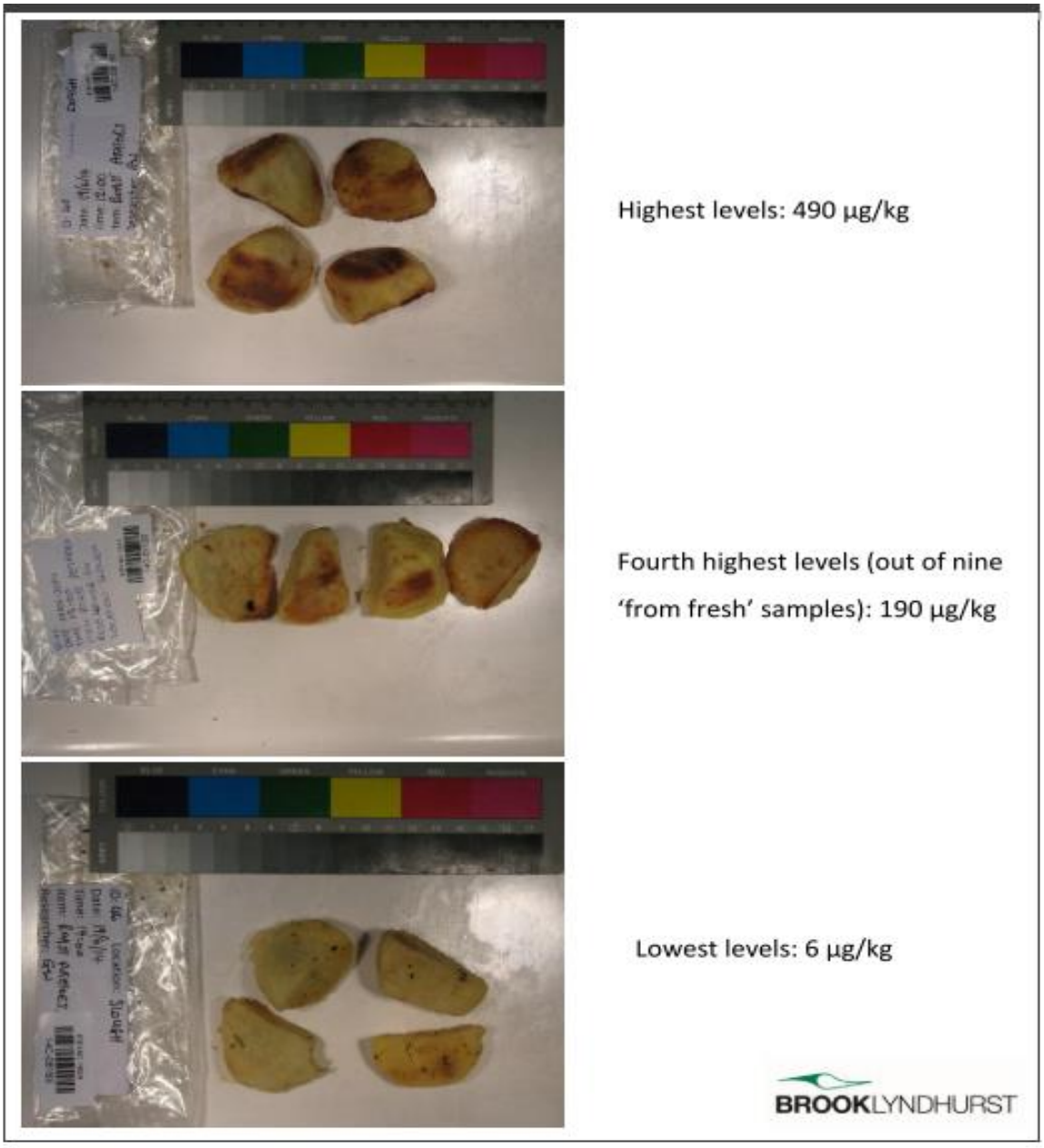
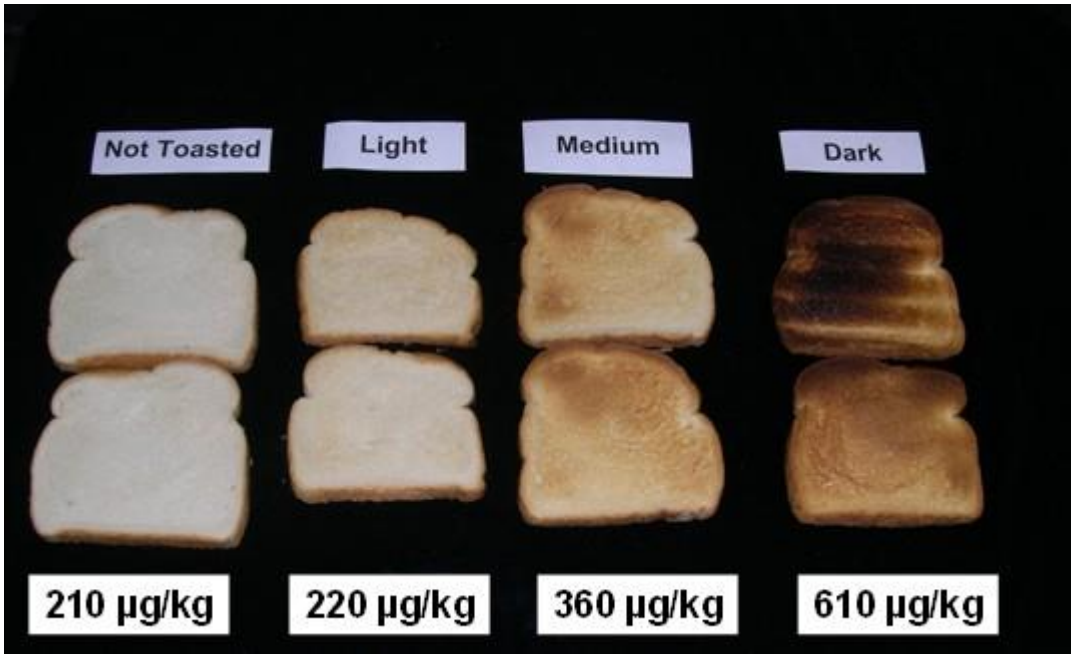


Figure 2-3 Potato Chips Good Fry Practices, Source, EUPPA (www.goodfries.eu).

Figure 2-4 Toasted bread degree and acrylamide contents, source Jackson (2008, slide no.16).



2.4.2. Target participants

The criteria for selecting the suitable participants were the people who reside in the Republic of Ireland and who were 18 or older.

To reduce a potential non-coverage bias, a sampling frame covering age, gender, income, culinary origin and educational level was used.

2.4.3. Data collection

The present study was conducted using both a web-based survey and paper-based questionnaire. The web-based survey was established via SurveyMonkey platform. The participants have been reached in a non-systematic way in different forums, common public areas, community-based centres and community training centres. Also, the survey link had been advertised in different public places and universities in Ireland via direct emails, social media platforms or via paper advertisement which were distributed to cover multiple areas in the Republic of Ireland. The hard copies were distributed and later collected. An automatic approach via online link was used for completing the survey and submitting the answers directly. The survey was conducted between March to the end of June, 2019.

2.4.4. Data Analysis

The data from paper responses was entered manually in the same survey platform as the output data, which was received in the same Excel data sheets for further analysis and interpretations. For the data analysis, the software package of SPSS version 25 by IBM Corporation was used to statistically analyse some variables relations. Pearson's Chi-squared Test were performed to

examine if there was a significant association between variables, where it was considered significant if $p < 0.05$. Whereas, the alternative test was Fisher's Exact Test. Which was used particularly when more than 20% of cells have expected frequencies < 5 samples (Kim, 2017; Marshall and Boggis, 2016).

Meanwhile, answers to the open-ended questions were firstly manually categorised by conducting a thematic analysis and creating classification for the responses in SurveyMonkey platform. After tagging the answers, re-evaluation and sorting took place. Then the coded data results were exported to Microsoft Office Excel sheets, where the data was expressed in frequencies, percentages and graphs.

According to Bryman (2016) the thematic analysis is applied through extracting core meanings that could be distinguished in and between the text words responses.

2.5 Study Limitations

- The sources about domestic food preparations as well as acrylamide awareness studies are limited for using to compare or contrast. Furthermore, some papers are in different languages, such as Polish and Chinese.
- The limiting of questionnaire time to be within 15 minutes, as more questions increase the required time for answering, subsequently leading to the probability of participation rejection or partial participation. Thus, some aspects in the research require more investigation, such as types of potato variants used and the knowledge about this difference and following their specific use. Also, the temperature for frying and types of used oil. However, those types of questions would be better contributed to a field study rather than a questionnaire alone.

- Due to the respondents' tendency to answer open questions in different 'dimensions', when the answers were coded and reduced to manageable categories, the outcome was many categories. This hindered conducting further analysis as the number of responses per-category was small, which restricted applying further analysis.

- Single coding the open-answer questions mainly depended on personal perceptions. Therefore it could be considered uncertain evaluated data. However, in this study all the open-end questions were dependent questions. Therefore, in coding it was more specified and clearer because that associated to previous specific answers.

- Self-reported practices are doubtful as they possibly do not reflect actual behavior. Thus, containment of some self-reported practices in the current study may be considered a limitation. Therefore, all practical questions are followed by open-end questions to confirm and validate the previous one, aiming for avoiding bias.

- The other limitations were shortage in the available time and resources to expand the research topic to include field work, in particular home-made practices related to acrylamide generation. This would need a sponsor as this topic issue is known to have a huge impact at national level. Thus, it would be worthwhile if future field research can be undertaken.

- Relatively small size sample , however it covered the all demographical characteristics.

RESULTS AND DISCUSSION

Chapter 3 . RESULTS & DISCUSSION

The Chapter Outlines

The chapter topics are organised to represent the results and the findings of discussions as follows:

Part 1: Participants' Profile.

Part 2: Acrylamide Knowledge.

Part 3: Home-food Practices.

Part 4: Frequency of Consumption of Selected Foodstuffs and Respondents' Preferences.

Part 5: Cooking End-point Preferences in Regard to Roasted and Fried Potatoes and Toasted Bread.

Part 6: Consumers' Perceptions and Attitudes to Acrylamide Labelling.

3.1 Participants' Profile

The total number of participants was 642. There were 68 disqualified respondents, with disqualification criteria such as 'do not live in Ireland' (60) and 'under 18 years old' (8). In addition to incomplete responses (19), the final number of qualified participations was 555.

Table 3-1 presents the collected demographic characteristics of the participants' sample, as shown among the age groups there was similar representation in the lower age groups, with 18-24-years-old, 25-34 and 35-44 forming approximately 75% of the represented age groups. In

terms of gender, females formed more than 80% of the respondents, which is expected since Bord Bia (2017) recorded that about 75% of Irish women are responsible for meal preparation.

Among the living area, 86.5% were from the cities. Regarding education levels, 84.3% of participants have university qualifications. There were moderate differences in per capita annual income between groups, with 40.2% earning between €30,000-€60,000, 30.4% earning under €30,000) while 28.8% had an income of more than €60,000. The marital status distribution showed that 39.7% were parents with children, 33.6% were single and 21% were couples without children. The last census survey in Ireland by the Central Statistics Office (CSO) illustrates that parents with children represent about 52.8% of the total numbers of families and 13.5% of the country's total population. Single status represents 32.7% of the total population, while 29.2% of the total number of families are couples without children (CSO, 2016). Lastly, concerning the culinary practices status profile, the majority were of Irish origin (46.5%). No-Irish nationals who are resident in Ireland account for about 12.2% of the total population, according to the CSO (2018).

In comparison to the last census, there was a difference in the participant sample percentages. Overall, the present sample covered all of the demographic groups. There is about 17.5% missed demographic data (voluntarily skipped by the participants) which is considered as the limitation to have all the demographical data. However, this limitation does not affect the present study as it is out of the scope of the present study. Which mainly focused on the actual home-foods practices and consumers' practices, and its influences in the level of exposure to acrylamide.

Table 3-1 The demographic characteristics of the resident participants' sample.

Characters	Category	Respondents (n.)	Percentage (%)
Age	18-24	107	23.4%
	25-34	120	26.2%
	35-44	121	26.4%
	45-54	67	14.6%
	55-64	39	8.5%
	65+	4	0.9%
Gender	Male	90	19.7%
	Female	367	80.1%
	Other	1	0.2%
Place of Residence	City	396	86.5%
	Countryside	62	13.5%
Education Level	University and Above	386	84.3%
	Leaving Cert.	59	12.9%
	Junior Cert.	11	2.4%
	No qualification	2	0.4%
Per capita Annual Income (Euro)	Under 30,000	139	30.4%
	30,000-60,000	184	40.2%
	Above 60,000	133	28.8%
	I do not like to answer	2	0.4%
Family Status	Single	154	33.6%
	Single with children	19	4.2%
	Couple without children	96	21.0%
	Couple with children	182	39.7%
	Other	7	1.5%
Culinary Practices Origin	European-Irish	213	46.5%
	European- non-Irish	85	18.6%
	North American	10	2.2%
	South American	14	3.1%
	Asian	49	10.7%
	African	34	7.4%
	Australian	1	0.2%
	Middle Eastern	52	11.4%
Total responses / question		458	
Total Skipping / question		97	

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3.2 The Respondents' Awareness about Acrylamide

There were seven questions used to assess the acrylamide awareness topic, as shown in Table 3-2. The first of these questions (Q3) in this section determined the pathway through the survey for the respondents according to their responses. Across the total 555 respondents, there

were 473 respondents 85.2% who had not heard about acrylamide. Therefore, they were brought automatically to the second section of this questionnaire (to Q7).

On the other hand, the positive responses to Q3, those who heard about acrylamide (as a term) amounted to 82 respondents (14.8%). Whereas, when this question was asked using the terminology (in Q31) "hearing about a harmful compound that forms when some carbohydrate foods are overheated", the results rose to 183 from the 465 respondents and represented 39.4% from the total respondents.

Table 3-2 The Acrylamide Term Awareness Responses Frequency.

Q3. Have you previously heard about acrylamide in food?			
Total Respondents (N)	**Category**	**Respondents (N)**	**Percentage (%)**
555	Yes	82	14.8%
	No	473	85.2%
Q31.Have you previously heard about the formation of a harmful compound when some carbohydrate foods (eg. bread, potatoes) are overheated to a brown colour appearance?			
465 Missed responses 90	Yes	183	39.4%
	No	282	60.7%

It is noted in Table 3-3 that there are 125 respondents who gave a negative reply to Q3, while they answered positively to Q31. On the other hand, 11 participants reacted positively to Q3 and responded negatively in Q31. There was significant evidence of a relationship between the Q3 and Q31, which was confirmed among the Pearson Chi-Square test (value 67.84,df =1 and *p=0.000).*

Table 3-3 Relationship between Responses to Q3 and Q31

			Q 31. Have you previously heard about the formation of a harmful compound when some carbohydrate foods(eg. bread, potatoes) are overheated to brown colour appearance?		
			No	Yes	Total
Q4. Have you previously heard about acrylamide in food ?	No	Count	271	125	396
		%	68.4%	31.6%	100.0%
		% of Total	58.3%	26.9%	85.2%
	Yes	Count	11	58	69
		%	15.9%	84.1%	100.0%
		% of Total	2.4%	12.5%	14.8%
Total		Count	282	183	465
		%	60.6%	39.4%	100.0%
		% of Total	60.6%	39.4%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	67.840[a]	1	.000		
Continuity Correction[b]	65.659	1	.000		
Likelihood Ratio	68.992	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	67.695	1	.000		
N of Valid Cases	465				

a. 0 cells (.0%) have an expected count of less than 5. The minimum expected count is 27.15.

b. Computed only for a 2x2 table

In the present study, the frequency of hearing the term "Acrylamide" was double compared to the results from Poland, which recorded that 7% of the participants had heard about acrylamide (Kowalska et al., 2017). Additionally, the results from China, among Chinese university students, revealed that 5.1% of participating students heard about acrylamide risk. Access to more information regarding this study was limited due to a Chinese language barrier (Meng,

Zhao and Qian, 2012). Moreover, acrylamide awareness levels in Ireland are similar to the level of awareness in the UK, USA and France, which recorded that 22% had previously heard about acrylamide (DSM, 2018). The above countries recorded less than the result from Germany, where 54% had heard about acrylamide in food.

The positive respondents to Q3 entered the other pathway (Q4), a multi-choice question that would further evaluate their knowledge. Therefore, as shown in Table 3-4, from the 82 respondents approximately three-quarters (75.6%) chose potatoes as a potential food source contributing to high acrylamide exposure. Also, bread, biscuits and crackers were chosen by more than half of the positive respondents (52.4%), while 37.8% selected coffee as a main contributor in acrylamide consumption source.

In Table 3-5, those who had heard about acrylamide showed average information of 59.2% in regard to the main acrylamide contributor food items such as potatoes, bread, coffee, bread and biscuits.

Meat was chosen by almost a third of the respondents as one of the main food contributors in acrylamide exposure. This is contrary to Tareke et al. (2002), who reported that in general, protein-rich foods such as fish, meat and poultry under heat-treatment showed lower amounts of acrylamide than carbohydrate-rich foods.

The data about choosing meat as a main source for acrylamide generation in this study is presumed to have developed due to a mis-differentiation between acrylamide and heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs) compounds. HCAs and PAHs can commonly be generated in some cooked meats under high temperature, such as grilling and pan cooking (Cross and Sinha, 2004; Skog et al., 1998).

Therefore, this area of information needs more investigation about the awareness level in regard to heat-induced toxicants in food such as HMF and Furan rather than acrylamide. As shown by Akinosun, Ojinnaka and Aouzelleg (2018), the awareness of N-nitrosamines, furans and PAH present in food and their risks, among participants from Ghana, Nigeria and UK, was almost less than 3%.

Table 3-4 The percentages of the responses for every foodstuff

Q4. Which of the following foods have the potential to contribute to high acrylamide exposure? (Tick as many as are relevant).		
Category	**Respondents (N)**	**Percentage (%)**
Green vegetables	9	11.0%
Fruit	4	4.9%
Milk	8	9.8%
Meat	27	32.9%
Fish	16	19.5%
Bread	43	52.4%
Eggs	12	14.6%
Potatoes	62	75.6%
Poultry	15	18.3%
Coffee	31	37.8%
Biscuits & Crackers	43	52.4%
Cereals	40	47.6%
Beer	8	9.8%
Total Respondents (N)	82	
Skipped to other pathway	473	

Table 3-5 Frequency of responses to the main foodstuffs contributing in acrylamide generation.

		Responses		Percent of Cases
		N	Percent	
Responses[a]	Bread	43	19.6%	58.1%
	Potatoes	62	28.3%	83.8%
	Coffee	31	14.2%	41.9%
	Biscuits/ Crackers	43	19.6%	58.1%
	Cereals	40	18.3%	54.1%
Total		219	100.0%	295.9%

a. Dichotomy group tabulated at value 1.

To gain further insight into the knowledge of the respondents, an open question (Q5) tested the reasons behind their selections in regard to potential sources that contribute to high acrylamide exposure and aiming to test the reliability of the answers. The responses were sorted manually and coded for further analysis.

Table 3-6 shows that about one-third of respondents who selected the food which contributed in acrylamide formation did not know the reasons. On the other hand, 56 participants gave reasons. The reason for acrylamide forming was attributed to the starchy nature of the foods in 37.5%. High temperature as a cause was represented by 19.6%, while just knowledge was selected by 26.8% as the reason behind their responses. In addition, other reasons such as cooking methods, cooking time and presence of asparagine in foodstuffs were also mentioned by only two participants.

Overall, the results confirmed that about 31% of those who heard about acrylamide did not know the reasons behind their choices for those food options. Conversely, the results in regard to the reasons for choosing specific foodstuffs as main sources in acrylamide exposure revealed

that about 41% referred to carbohydrate, grain and asparagine contents in those food items as being behind their choice, while cooking conditions were the reasons in about 44.6% of choices.

Table 3-6 The reasons for choosing specific foodstuffs that may contribute in Acrylamide exposure.

Q5. Why do you think so?			
Total Respondents (N)	**Category**	**Respondents (N)**	**Percentage (%)**
82	I do not know	26	31.7%
	Presented a reason	56	68.3%
Presented reason 56	Starchy /Carb foods	21	37.5%
	Asparagine	2	3.6%
	Burn cooking	3	5.4%
	Cooking Methods	5	8.9%
	Cooking Time	2	3.6%
	Food Process	4	7.1%
	High Temp.	11	19.6%
	Knowledge	15	26.8%
	Other	3	5.4%

For further, in-depth understanding and evaluation of the awareness, another confirmative question was asked about the conditions which may be responsible for the formation of acrylamide in foods. The overall 82 answers, as illustrated in Figure 3-1, it is shown that cooking at high temperatures represented 85.4% (70 N). This percentage reflects the high level of awareness about the main causes for acrylamide formation in food which also, consequently, confirmed the reliability of positive responses in regard to hearing about acrylamide. Differing from that, 5.2% participants from the UK knew about the link between high-temperature and chemical hazards generation in food (Akinosun, Ojinnaka and Aouzelleg, 2018).

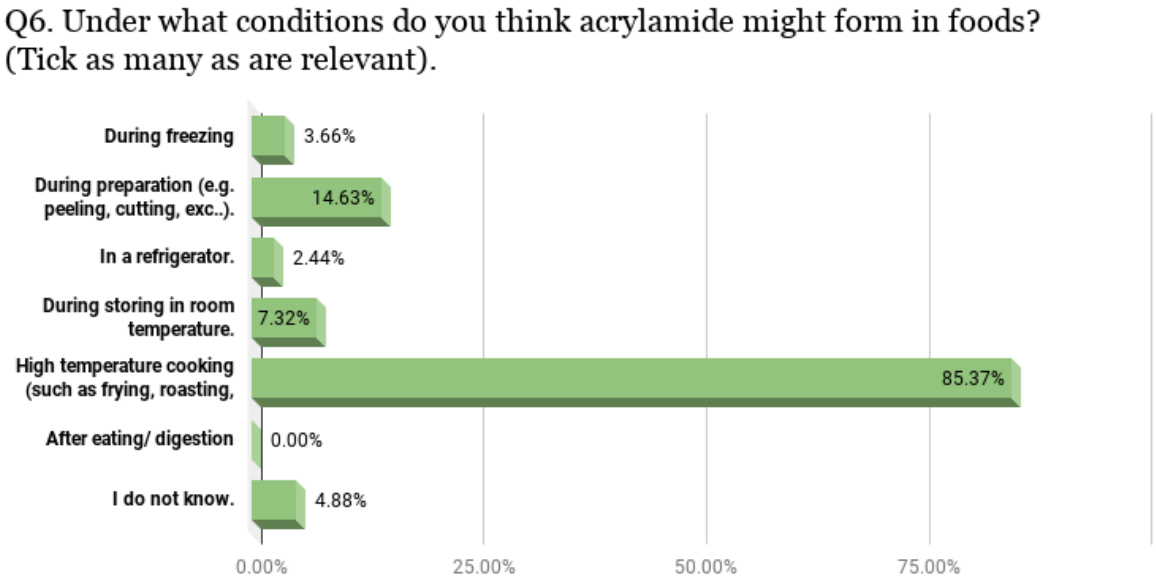

Figure 3-1 Responses relating to perceived conditions for acrylamide formation.

Q32 tested the knowledge about the adverse health impact associated with chronic exposure to acrylamide or overheated carbohydrate foods. This question followed Q31 which informed the participants about the acrylamide term.

The results showed that there was nearly a full consensus (94.5%) that there were carcinogenic risks associated with consumption of acrylamide. This was shown in an open-ended question (Q32) among the 177 respondents who heard about harmful compounds associated with overheating of carbohydrate-based foods. Moreover, Table 3-7 displayed that about 38.4% out of 177 were aware of the health risks of this substance.

Table 3-7 The negative health effects of acrylamide, according to respondents' answers

Q32.What do you think are the negative health effects from this harmful compound?			
Total Respondents (N)	**Category**	**Respondents (N)**	**Percentage (%)**
177	I do not know	68	38.4%
	I know that (please specify)	109	61.6%
The negative health effects N 109	Carcinogenic	103	94.5%
	Neurotoxic	1	0.9%
	Other	4	3.7%
	N/A	3	2. 8%

The recent EFSA report in regard to the main sources for food safety information in Ireland revealed that TV formed the highest source of information about food safety topics 59%, followed by internet searching 47%, while paper media, radio and social media are nearly the same (between 37-39%). Additionally, person-to-person information reached just under one-third (32%)(EFSA, 2019). These results indicate that food safety issues are relatively well addressed among the media. This is better than depending on person-to-person knowledge or experiences, which is often inaccurate and mostly depends on individual opinions rather that scientific bases.

Comparing to the present study data as represented in Table 3-8, the main sources of information for those who answered that they "had previously heard about harmful compounds arising from overheating carb foods" (Q33), were as follows; the dominant channels were via person-to-person (family/friends), which represents 41.57%, followed by internet and social media as a channel for information 33.7%, while TV shows 18.5%.

The results indicate a shortage in media, press and TV channels to highlight acrylamide topics compared to other food safety topics. This has led to most people taking information from

families' daily activates (habits) or searching for information online, as shown from the answers distribution. This way of gaining information will open the door for exposure to misunderstanding and personal opinions rather than scientific information, leading to unclear and incorrect perceptions about the potential risk. This conclusion is supported when compared with the EFSA (2019) report. Additionally, this conclusion is supported by the participants' responses, as they claimed to know about acrylamide but further questions pointed out that there were limitations in their claim. This is best illustrated by those who referred to person-to-person as the source of information.

Receiving information from the internet was also recorded as the main source for acrylamide information among a Polish-chosen population (Kowalska et al., 2017).

Table 3-8 The channels of acrylamide information among the participants

Q33. From what source did you get your information about this harmful compound? (Tick as many as are relevant)		
Category	**Respondents (N)**	**Percentage (%)**
TV	33	18.5%
Internet/ social media	60	33.7%
Journal/Magazine	41	23.0%
From person (Family/friends)	74	41.6%
School/College	45	25.3%
Food Safety Authority of Ireland.	14	7.9%
Other	13	7.3%
Total Respondents (N)	178	
Skipped	377	

3.3. Home Food Practices

3.3.1. Potato Storage Practices

As shown in the literature review, storage conditions play a role in the acrylamide formation level in potato-based foods, through controlling reducing sugars generation.

Under this part, three questions (Q7, Q8, Q9) investigated the domestic practices in relation to the storage of potatoes.

The present results show that the majority of participants store their fresh potatoes outside the fridge, such as in a closet, pantry, cupboard, garage, or in an open area such as shelves and baskets. Therefore, over a total of 555 participants there was 459 (82.7%) who store fresh potatoes in a room temperature environment. The percentage of those who store potatoes outside the fridge, in a closet or closed space at room temperature, was 78%. In the smaller bracket, 26 respondents 4.7% preferred to keep fresh potatoes in an open-air space such as shelves (Table 3-9).

Only 70 respondents store fresh potatoes in the fridge, while five store them in a freezer. It was noticed that from 70 responders, who store fresh potatoes in the fridge, there were eight participants who mentioned previously that they had heard about acrylamide. Moreover, six respondents chose potatoes as one of the major food contributors in acrylamide formation.

Table 3-9 The frequent locations of raw potato storage (participants and corresponding %).

Q7. Where do you usually store raw potatoes?			
Total Respondents (N)	**Category**	**Respondents(N)**	**Percentage (%)**
555	Fridge	70	12.6%
	Freezer	5	0.9%
	In a closet or a pantry at room temperature	433	78.0%
	I do not use raw potatoes	21	3.8%
	Other (open-air space)	26	4.7%

The reasons behind their choices to store fresh potatoes were collected through an open question (Q8) among a total of 516 respondents (Table 3-10), after the data had sorted and categorised to 16 reasons behind the respondents' storage potatoes behaviours in Table 3-11 . Most frequent reasons to store potatoes in the fridge was to keep tubers fresh, followed by increased shelf life, cold condition and preventing sprout. Moreover, shortage of space outside the fridge was also recorded eight times.

Frequent causes for storing potatoes outside the fridge were: transferable habits such as from parents, friends or copy markets display. The other habits referred to non-specific roots to the habits, space availability and convenience causes, in addition to the suitability of the condition from coolness, darkness and dryness. It is noted among those responses that stated limitation of space, which raised the question of availability of space in the fridge their choices may change. This tendency to keep fresh potatoes in the fridge as an ideal solution was also mentioned among participants from the UK (Brook Lyndhurst, 2014).

Table 3-10 The participants' reasons for storing potatoes according to the chosen place.

Q8. For what reason do you store raw potatoes there?		
Total Respondents (N)	**Store place choices**	**Responses (N)**
Answered 516	Fridge store responses reasons	68
	Freezer	5
Skipped 39	A closet or a pantry / room temperature.	443

Table 3-11 Reasons behind potato storage in terms of places, choices and frequency.

Reason Category	**Cold Storage (n) responses**	**Room temp. Storage (n) responses**	**Answer Frequency (%)**
Cool, dark condition	6	73	15.3%
Keep fresh	24	22	9%
Long shelf life	17	15	6.2%
Needs to be cold	10	-	2%
Prevents sprout	8	15	4.4%
Space availability	7	50	11%
Transferred habit	5	98	19.9%
Habit	3	54	11%
Short time store	1	3	0.8%
Convenience	-	50	9.6%
Keep at room temp.	-	7	1.4%
No need for cold	-	35	6.8%
Suitable place	-	55	10.7%
Storing	-	24	4.7%
Open-air space	-	26	5.0%
N/A	5	30	6.8%

Overall, the majority of the participants store fresh potatoes at room temperature above 8°C. This indicates the level of free sugars in potatoes does not increase significantly and generation of high acrylamide levels in cooked potatoes are unlikely (Viklund et al., 2008; Matsuura-Endo et al., 2006; De Wilde et al., 2005; Silva and Simon, 2005; Amrein et al., 2004b). The potato-storing behaviour' findings appear consistent with prior research results among UK consumers' in regard to keeping potato tubers at room temperature rather than in the fridge (Brook Lyndhurst, 2014). Comparing to the potato storage behaviour among Spanish potato home-cooking volunteers, it showed that nearly 71% store fresh potatoes in room conditions while 19% store outdoor, where the storage duration reached 14 days and 54 days respectively, moreover there was not any mention of using the fridge for keeping tubers (Mesias et al., 2018).

As the storage temperature influences the levels of acrylamide in potatoes, so too does the storing duration. The collected data showed that about 70% store potatoes over a week. Over half usually store potatoes for between seven to14 days and about 17% store for longer than two weeks (Table 3-12).

Table 3-12 Raw potatoes storage period (participants and corresponding %).

Q9. For how long would you say you usually store raw potatoes from date of purchase?			
Total Respondents (N)	**Category**	**Responses (N)**	**Percentage (%)**
Answered 515	0-3 days	21	4.1%
	4-6 days	106	20.6%
	7-9 days	135	26.2%
Skipped 40	For 2 weeks	134	26.0%
	More than 2 weeks	88	17.1%
	I cannot remember	31	6.0%

In Figure 3-2 almost half of the respondents who are storing potatoes in the fridge usually keep it for 2 weeks or longer. In particular, 29.4% usually store potatoes in the fridge for two weeks, while 22% store potatoes for more than two weeks in the fridge. This is consistent with the fact that cold storing prolongs the shelf-life of the fresh vegetables as potatoes (Eltawil, Samuel and Singhal, 2006).

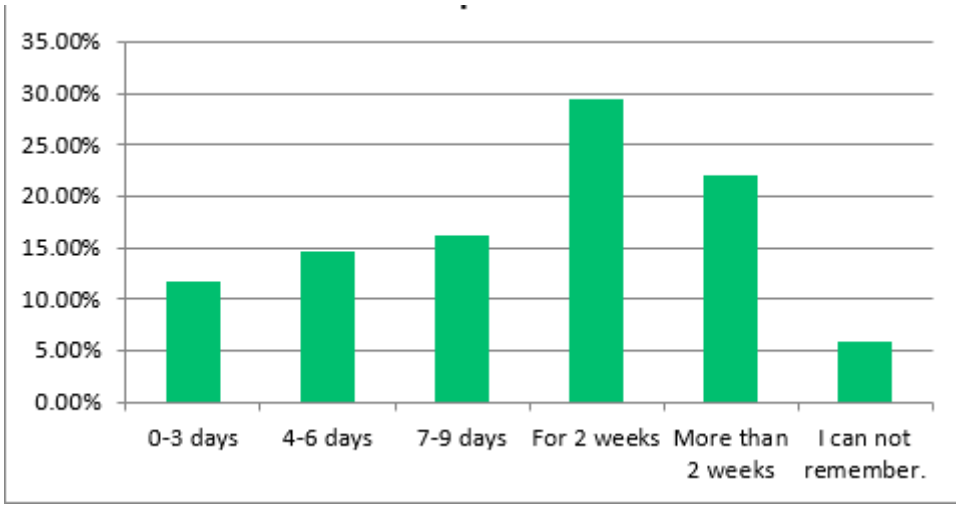

Figure 3-2 The storage time among fridge-storage responders.

In regard to storing potato tubers at room temperature, about three-quarters of the respondents who chose this option store potatoes between one to two weeks 74.9%. Beyond that, 16.3% of them store potatoes for more than two weeks (Figure 3-3).

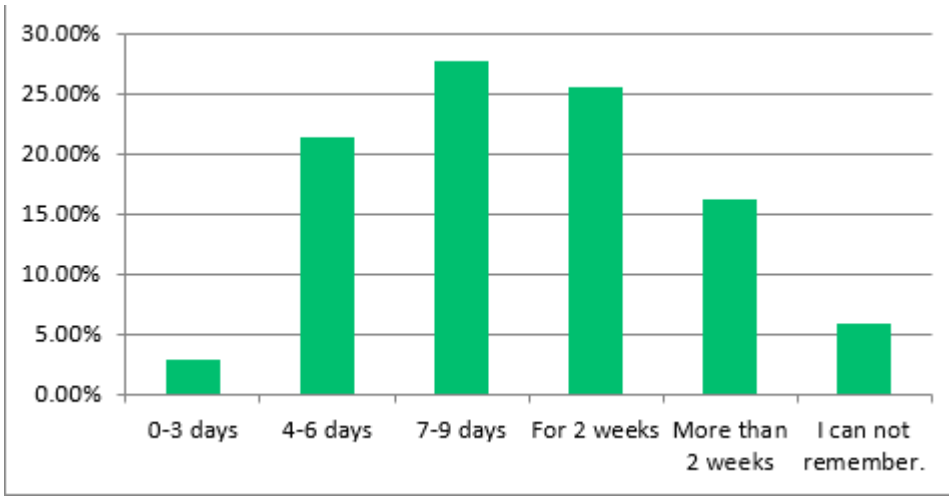

Figure 3-3 The storage time among room-temperature storage responders.

It seems that potatoes are stored mostly over a week, as shown from the results. The percentage of respondents keeping tubers in a cold temperature represented less than 15%, however the tendency to keep fresh tubers in a low temperature for a long time in the fridge for two weeks or more represented almost 50%. Among room temperature respondents, the storing period decreased slightly and represented 52% storing mostly between seven to 14 days.

The storage behaviours in the current study referred to there being a tendency to store potatoes for more than two weeks, this result almost agrees with the storage behaviours among Spanish sample (Mesias et al., 2018). The storage tendency time differed with previous notices among the Uk participants. Which referred to all the participants kept fresh potatoes less than two weeks (Brook Lyndhurst, 2014).

3.3.2. Peeling and washing potatoes practices

The results show in **Table 3-13** that, among 516 total responses, the majority (over 80%) peel potatoes. In particular, 201 participants always peel potatoes, in addition to 220 who usually peel, while about 18% do not peel potatoes (Figure 3-4). Moreover, washing potatoes practices after peeling was also recorded as a high percentage which reached 85% (**Table 3-14**). To conclude, peeling and washing potatoes practices among the participants was high. The percentage in regard to washing potatoes results among the participants matched with the results of washing practices, which was recorded among Spanish participants in a pilot study (Mesias et al., 2018).

By contrast, in a British field study about domestic food practices, it was recorded that most of the participants often did not wash peeled potatoes, as they rely on peeling and parboiling. Furthermore, the researchers described peeling practice behaviours as being reliant on what

recipes were made. For example, jacket potatoes and potato wedges were kept unpeeled among the English participants (Brook Lyndhurst, 2014).

Table 3-13 Peeling Potatoes Responses Frequency.

Q10. Do you usually peel the potatoes before cooking?		
Answer Choices	**Responses (N)**	**Responses (%)**
Always	201	39%
Usually	220	42.6%
Never	22	4.3%
Rarely	71	13.8%
Not sure	2	0.4%
Answered	516	
Skipped	39	

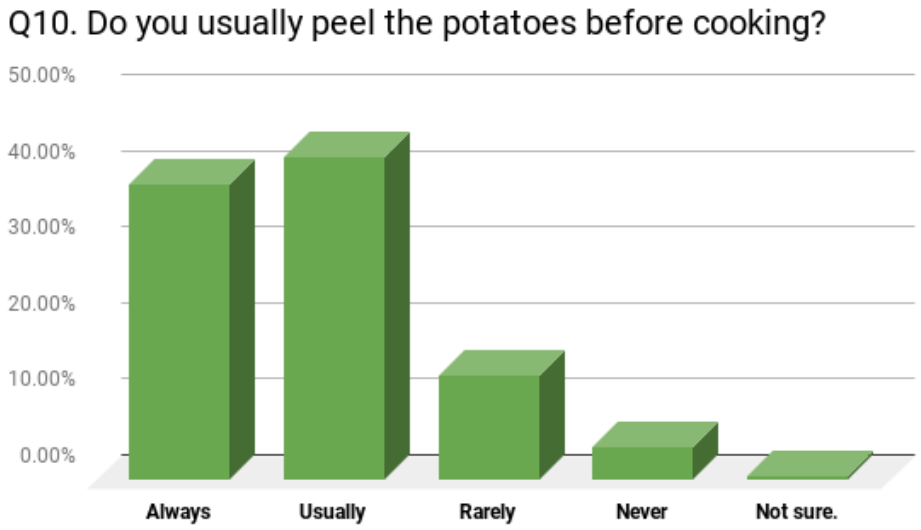

Figure 3-4 Potato-peeling practice attitudes.

Table 3-14 Washing peeled potatoes responses frequency.

Q11. Do you usually wash the potatoes after peeling?		
Answer Choices	**Responses (N)**	**Responses (%)**
Always	310	65.1%
Never	34	7.1%
Usually	98	20.6%
Rarely	30	6.3%
Not sure	4	0.8%
Answered	476	
Skipped	79	

3.3.4. Cutting potato sizes for roasting

Over 495 total respondents, the medium cubes potatoes size was the most common size at 41.8%, then halved potatoes at 30.9%, while wedges, circles and chips size were nearly the same with an average 22.7%. Thin-chopped potato cuts were less than 6% (

Table **3-15**). When the average dimensions of medium potato cubes are 12.7mm x 12.7mm x 12.7mm (Auguste Escoffier School of Culinary Arts, 2014), that refers to the potatoes chopped. Sizing practices do not tend to be fine cuts. Thus, the expected risk from fine size cuts to generate more acrylamide is relatively low in the present study. Whereas, the tendency to cut potato chips to large size was noticed by Brook Lyndhurst (2014).

Table 3-15 Potato Cuts Preferences Responses

Q12 which size do you usually cut potatoes for roasting? (Tick as many as are relevant)			
Answer Choices	**Responses (N)**	**Responses%**	**Cases (%)**
Whole size	126	12.5%	25.5%
Halves	153	15.1%	30.9%
Quarters	140	13.8%	28.3%
Wedges	111	11.0%	22.4%
Thin size	29	2.9%	5.9%
Medium size cubes	207	10.9%	41.8%
Medium size circles	110	20.5%	22.2%
Chips size	117	11.6%	23.6%
Crisps size	8	0.8%	1.6%
Smaller than above	5	0.5%	1.0%
Never roasting	8	0.6%	1.6%
Total participants	**495**		
Skipping	**60**		

3.3.5. Soaking Potatoes

In regard to soaking potato practices, there were three questions that covered the applicability, duration and perceptions behind soaking activity (Q13, Q14 and Q15). Table 3-16 represents that, from a total 494 participants using fresh potatoes from scratch, there were 39.9% who practiced soaking potatoes before cooking. On the other hand, there are 56% who did not soak fresh-peeled or chopped tubers.

Table 3-16 Frequency of soaking potatoes before cooking

Q13.Do you soak peeled or cut potatoes before frying or roasting?		
Answer Choices	**Responses (N)**	**Responses (%)**
Always	85	17.2%
Never	165	33.4%
Usually	112	22.7%
Rarely	112	22.7%
Not sure	20	4.1%
Total participants	**494**	
Skipping	**61**	

The underlying perceptions behind soaking raw potatoes before cooking were investigated through open-ended question (Q14), and the results showed that the reasons behind soaking potatoes were categorised into 17 categories. As illustrated in Table 3-17, different reasons were mentioned by the respondents, and there appears to be no discernible reason to concur over the total responses.

However, among those who did not soak potatoes, almost 21% believe that there is no need for that, or they have no idea about soaking practice, 11% stated that the shortage of time was the reason, while others were worried about losing nutrients or absorbing water (Figure 3-5).

On the other hand, the reasons for soaking potatoes before cooking in Figure 3-6 shows that reasons relating to starch extraction, and reasons relating to preventing potatoes browning (enzymatic reaction) represented the most repeated response, with 23.4% and 22.8% respectively. Some mentioned soaking for hygienic purposes and others referred to transferrable habit from the family.

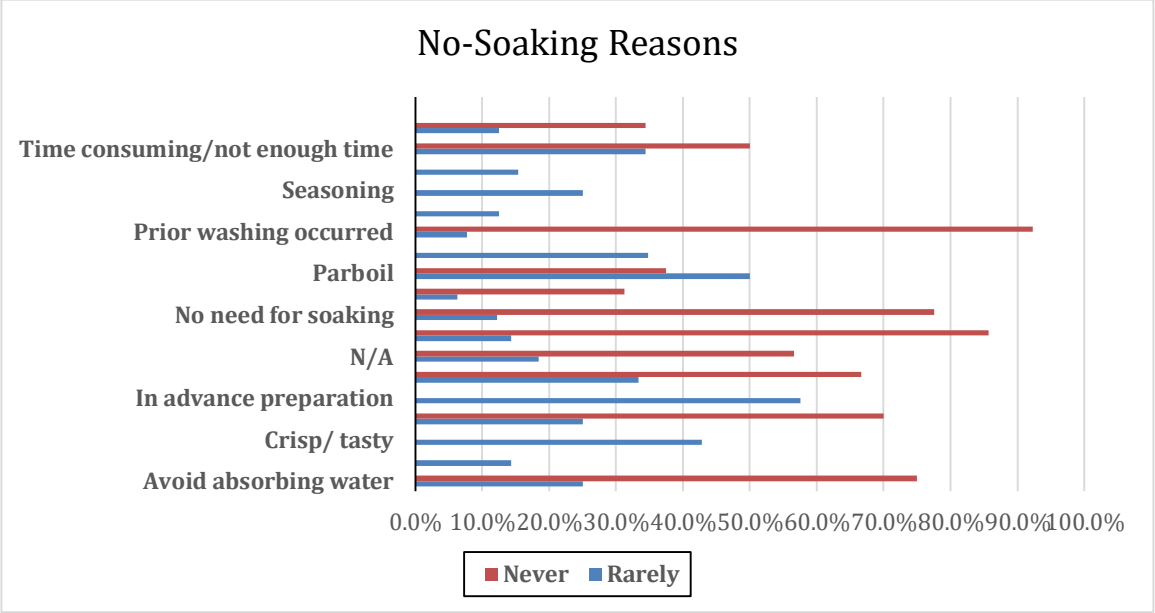

Figure 3-5 The reasons behind no-soaking (never & rarely) potatoes.

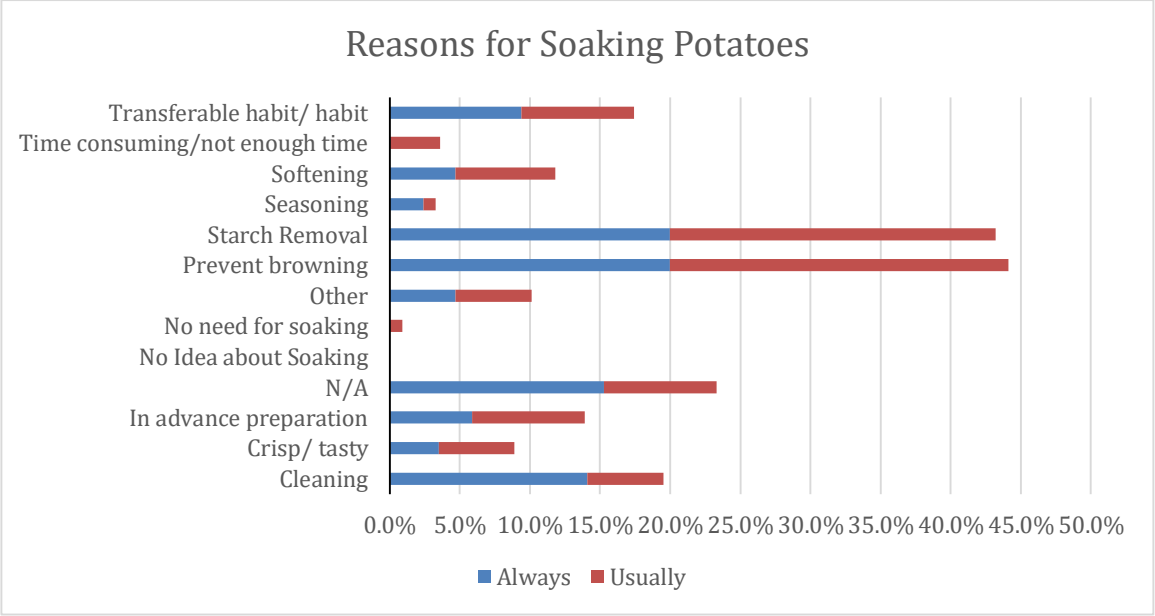

Figure 3-6 The reasons behind soaking (always & usually) potatoes

Table 3-17 Reasons behind soaking fresh potatoes

Q14 For what reason do you soak, or not soak raw potatoes?		
Category	Responses (N)	Responses (%)
Avoid absorbing water	6	1.2%
Hygiene/clean	24	4.9%
Crisp/ tasty	16	3.2%
Immediately cooking	21	4.3%
In advance preparation	34	6.9%
Avoid loss of nutrients	9	1.8%
Prevent browning	67	13.6%
Remove the starch	54	10.9%
Seasoning	6	1.2%
Softening	17	3.4%
Time consuming	35	7.1%
Transferrable habit	24	4.9%
Parboil preparation	9	1.8%
No need for soaking	68	13.8%
No idea about soaking activity	15	3.0%
Other	20	4.1%
N/A	87	17.6%
Total participants	494	
Skipping	81	

In accounts of the average time for soaking processes, which was applied by 309 participants,

Table **3-18** illustrates that the most common duration for soaking potatoes was five minutes or less, representing 28.2%. In addition, almost 25% soak potatoes when it is convenient, while soaking potatoes for 30 minutes or more represented the lowest practice percentage, with 17%.

Table 3-18 Frequency of average time for soaking responses

Q15 If you soak raw potatoes, what is the average time for soaking?		
Answer Choices	**Responses (N)**	**Responses (%)**
5 minutes or less	87	28.2%

15 minutes	48	15.5%
30 minutes	31	10.0%
1 hour or more	22	7.1%
I don't know the exact time	44	14.2%
Whatever is convenient between preparation and cooking	77	24.9%
Total participants	**309**	
Skipping	**226**	

There was detected significant evidence of a relationship between soaking time and the three main reasons for soaking (prevent potatoes browning, starch extraction and in-advance preparation) as appeared in

Table **3-19** and Chi square test table, where $p<0.05$.

Table 3-19 Frequency of main soaking reasons code and soaking raw potatoes average time

Soaking reason and Soaking raw potatoes average time								
Soaking Reason		Soaking raw potatoes average time						Total
		1 hr. or more	15 min	30 min	5 min or less	I don't know the exact time.	Whatever is convenient between preparation and cooking	
In advance preparation	N	9	1	3	5	6	9	33
	%	27.3%	3.0%	9.1%	15.2%	18.2%	27.3%	100.0%
Prevent browning	N	5	13	8	9	7	23	65
	%	7.7%	20.0%	12.3%	13.8%	10.8%	35.4%	100.0%
Remove the starch	N	3	10	7	17	4	6	47
	%	6.4%	21.3%	14.9%	36.2%	8.5%	12.8%	100.0%
Total	N	17	24	18	31	17	38	145
	%	11.7%	16.6%	12.4%	21.4%	11.7%	26.2%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	28.238[a]	10	.002
Likelihood Ratio	28.451	10	.002
Linear-by-Linear Association	.009	1	.925
N of Valid Cases	145		

a. 3 cells (16.7%) have expected count less than 5. The minimum expected count is 3.87.

Overall, the data about soaking potatoes practices among the respondents states that almost 40% of those who prepare potatoes from scratch practice soaking as part of a potato preparation process. This results is considered double percentage compared to the soaking practices results among Spanish consumers, which was recorded with 19.2% (Mesias et al., 2018).

However, the overall applicable times for soaking practice were relatively short or non-specific duration. Whereas HEATOX (2007b) recommended the soaking time to be at least for 30 minutes or more. Likewise, the result from a previous British field study, which recorded that the participants did not consider soaking potatoes before cooking as a part of the preparation procedures. But they did it whenever it was convenient or when potatoes were peeled in advance time just for saving time to do other cooking tasks. In other words, to prevent the developing of browning during preparation of other tasks (Brook Lyndhurst, 2014).

Moreover, the present findings show that there are perceptions about the reasons behind soaking potatoes, such as removal of starch from potatoes, which formed 10.9% as a reason for soaking potatoes, which is reported in literature reviews as a powerful way to reduce acrylamide generation (Pedreschi, Kaack and Granby, 2006). Conversely, “no-need for soaking” reason was also presented among those who totally denied the necessity of soaking practice, while some attributed that to shortage of available time for preparation and cooking.

Therefore, although there is awareness about the soaking process, the common practice times were not enough to fulfil the purpose to extract the large portion of acrylamide precursors.

3.3.6. Parboiling Potatoes

Aiming to reduce generation of higher amount of acrylamide when dealing with fresh potatoes, many projects and bodies recommended applying of parboil, soak, and blanch for fresh potatoes before cooking to eliminate starch contents from potatoes, subsequently limiting acrylamide level in end-cooked meal (UKHospitality, 2018; FSAI, 2009a; HEATOX, 2007a). From a total of 493 who shared in a question about parboil fresh potatoes before cooking, there were 51 respondents who confirmed that they always blanch potatoes before further use (roasting or frying) in addition to 112 other usually practice it, with overall together formed almost 33%. The majority do not blanch potatoes before cooking and they represent 58.4% (Table 3-20). In contrast to the current results, Brook Lyndhurst (2014) noted that all home-made fresh potatoes had been parboiled before roasting by the British participants, aiming to save roasting time and gaining desirable texture.

Table 3-20 Frequency of blanching potatoes before cooking

Q16 Do you parboil the potatoes before cooking?		
Answer Choices	**Responses (N)**	**Responses (%)**
Always	51	10.3%
Usually	112	22.7%
Rarely	138	28.0%
Never	150	30.4%
Not sure	42	8.5%
TOTAL	493	

For insight, respondents reasons for parboiling potatoes before further cooking was investigated. The data had been collected from 275 respondents through open-ended question (Q17), and the responses were sorted and coded in 11 categories, as shown in Table 3-21.

The most recorded reason was reducing the cooking time 41.5%, also to achieve the desired tenderness and fluffiest taste represented 15.6%. Those main reasons are in line with the reasons that were mentioned previously by Brook Lyndhurst (2014).

The results in regard to blanching fresh potatoes in water before cooking in total does not seem a common practice at home. However, it is an important step in reducing acrylamide formation in the end-meals, subsequently minimising exposure to acrylamide via home-made potatoes (Zhang et al., 2018; Shojaee-Aliabadi et al., 2013; Viklund et al., 2010).

Table 3-21 Categories of the reasons behind blanching potatoes

Q17 Why do you parboil the potatoes before cooking?		
Category	**Responses (N)**	**%**
Cooking time reduction	114	41.5%
Achieve texture	10	3.6%
Help crispness	26	9.5%
Routine process with roasted potatoes	27	9.8%
Healthy	1	0.4%
Hygiene	5	1.8%
Tender/fluffy effect	43	15.6%
Tasty	13	4.7%
Remove starch	3	1.1%
Other	40	14.6%
N/A	28	10.2%
Total Respondents (N)	275	

3.3.7. Potato cooking

This section represents the results of the three questions in relation to the potato-cooking process. They were the methods for evaluation of food 'doneness', usual temperature used in oven for roasting potatoes and the usual method applied for frying potatoes.

3.3.7.1 Cooking Time Estimation for Pre-cooked Potato Products

With a total of 465 participations in Q18, the majority 60% rely on visual or tasting assessment, or both, for evaluating the pre-cooked food doneness in foods such as frozen chips, while almost 35% follow the specific food's label instructions. These collected responses are illustrated in Figure 3-7.

Table 3-22 displays the individual data. Visual assessment represented almost half, followed by 31.6% for strictly following the food's label instruction for cooking. Some people referred to mixing the instruction with other assessment methods.

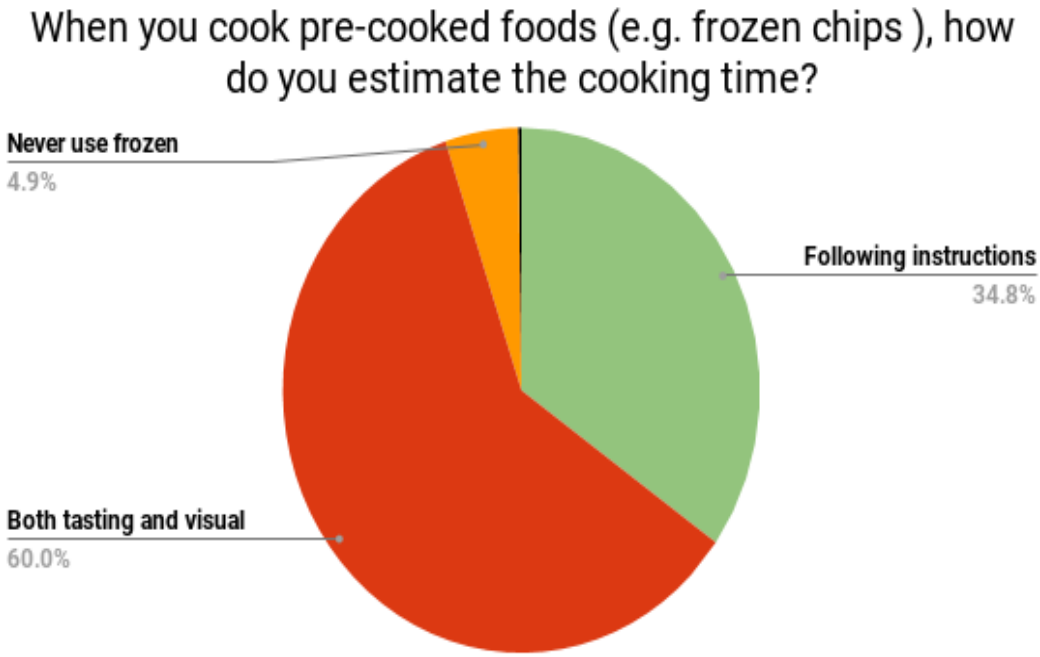

Figure 3-7 The Food Doneness Assessment Methods

Table 3-22 Percentage of the Food Doneness Assessment Methods

Q18.When you cook pre-cooked foods (e.g. frozen chips), how do you estimate the cooking time?		
Answer Choices	**Responses (N)**	**Responses (%)**
Visual assessment (i.e. of colour and texture)	232	49.9%
Abiding strictly to the instructed time on the label	147	31.6%
Tasting assessment	45	9.7%
Both tasting and visual assessment	2	0.4%
Following instructions plus other assessments (visual, taste)	15	3.2%
Never use frozen potatoes or chips	23	5.0%
Other	1	0.2%
Total responses	**465**	

The findings reflected that just one in four persons follow the label instructions regarding temperature and time for cooking. Meanwhile, over 60% of people depend on their other ways of judgment for doneness. This opens the door for unexpected higher levels of acrylamide generation in home-made potatoes, as shown among Spanish home-made potatoes. In the Spanish case, researchers analysed fried potatoes samples from home-made chips in Spanish households in a pilot study and the results revealed there was a markedly high level of acrylamide reached to the double estimated level by EFSA (Mesias et al., 2018). However, in the same year, by the same researchers, a survey study was conducted in Spain with regard to domestic frying habits. This recorded that the percentage of those who followed the instruction

on food packages reached 58.6% among Spanish consumers (Mesias, Delgado-Andrade and Morales, 2018).

Although, following the instructions in food packages is advised by HEATOX (2007b) and Regulation (EU) 2017/2158, mentioned in details to obligate the FBOs under "Information to the end users" (European Commission, 2017). There was lower attempts to follow manufactures' instructions, as also noticed by Brook Lyndhurst (2014); Brook Lyndhurst and WRAP (2011); Wright, Canham and Masrani (2011).

Brook Lyndhurst (2014) recorded, during an actual cooking practice study among participants, that visual assessment was an important part for judging the food cooking status as well as the other factors such as time guide. This is in line with the current results, where visual assessment alone represented 50% of the end-point evaluation tool in roasted potatoes.

3.3.7.2. Oven Temperature

The vital role of cooking temperature in influencing acrylamide levels have been extensively demonstrated through studies, as shown in the literature review. Therefore, the data was collected regarding common temperature degree that is used in the oven for roasting potatoes.

The present findings in Table 3-23 illustrate the usual oven temperature choices among 462 total respondents. It is clear that 200°C (180°C in fan oven) is the most common option used for roasting fresh potatoes, followed by 150°C (130°C in fan oven), which represented 23.2% and 21.9% respectively. Meanwhile, 220°C (200°C in fan oven) represents about 15%. The sum of over 200 °C choices represent 20%, as shown in detail in Table 3-23.

Table 3-23 Frequency of oven temperature degree choices for roasting fresh potatoes.

Q19.What heat setting on your oven do you often select for roasting fresh potatoes?		
Answer Choices	**Responses (N)**	**Responses (%)**
Gas oven Fan/ Electric oven temp.		
1 (120)/(275°F/140°C)	45	9.7%
2 (130)/(300°F/150°C)	101	21.9%
3 (150)/(325°F/170°C)	20	4.3%
4 (160)/(350°F/180°C)	49	10.6%
5 (170)/(375°F/190°C)	23	5.0%
6 (180)/(400°F/200°C)	107	23.2%
7 (200)/ (425°F/220°C)	71	15.4%
8 (210)/(450°F/230°C)	5	1.1%
9 (220)/(475°F/240°C)	17	3.7%
I cannot remember	24	5.2%
Total responses	**462**	
Skipped	**93**	

The tendency for keeping the oven temperature between 180°C-220°C for roasting fresh potatoes was recorded in an actual field study project in the UK. Furthermore, this field project report pointed out that, in home conditions, the oven temperature usually fluctuated during the cooking process and it was not constant during the cooking duration (Brook Lyndhurst, 2014). In line with the recommended oven temperature for baking (not over 200°C /180°C on hot air oven) as recommended by HEATOX (2007b) and FSAI (2009a), the present study's findings referred to almost 75% of the participants keeping oven temperature for roasted potatoes within 200°C (180°C fan oven) or less.

3.3.7.3. Fried Potatoes Cooking Methods

In the present work, the most frequent way to cook chips is with an oven. As the findings in Table 3-24 show, roasting chips represented the most frequent choice from responses (48.6%). The other chip-frying traditional methods, such as deep-frying and pan-frying, formed just 15.5% and 5.4% respectively. Meanwhile, 15.7% of the participants do not cook chips at all. The present findings show that closer to half prefer the roasting method for chips, in addition to about 12% cooking in an air-fryer. That indicates that the level of generation of acrylamide during home-chips cooking in this study is at a relatively low level compared to the frying and grilling options. This statement is in line with the conclusion of Ahn et al. (2002) and FDA recommendations about the preferable methods for cooking potatoes, which concluded that baking and roasting potatoes generate lower levels of acrylamide compared to frying methods (FDA, 2017). Furthermore, Sansano et al. (2015) demonstrated that air-frying methods are better than deep-frying methods in the reduction of acrylamide generation by 90% .

Table 3-24 The common methods for frying potatoes

Q21.How do you normally cook chips?		
Answer Choices	**Responses (N)**	**Responses (%)**
Deep-frying	72	15.5%
Air fryer (healthy)	55	11.8%
Pan/shallow frying	25	5.4%
Roasting/ oven	226	48.6%
Grilled	11	2.4%
Microwaved	1	0.2%
I do not cook chips at all.	73	15.7%
Other	2 (boiling)	0.4%
Answered	465	
Skipped	90	

3.4. Cooking End-Point Preferences

As this section is about the cooking preferences degree, it depended on visual assessment, therefore the answer choices were displayed in the form of validated images from literature sources.

3.4.1. Potatoes

Roasted Potatoes

Relating to roasted potatoes doneness degree, validated photos were adapted from Brook Lyndhurst (2014, p. 42) Figure 2.2 .Where, the images pointed out the acrylamide level according to the lab analysis results were; dark surface colour photo 490µg/kg acrylamide, medium surface colour 190µg/kg and light surface colour 6µg/kg.

Relating to roasted potatoes preferences (Q20), among 465 total responses, the present results illustrated that in Table 3-25, over half prefer medium colour degree for roasted potatoes 52.7%. Moreover, 26.2% like brown surface colour sample photo. Those who prefer to eat light colour roasted potatoes represents 12.5%, in addition to 8.6% who expressed that they refrain from cooking roasted potatoes in general.

Table 3-25 Colour-degree preferences for roasted potato cooking

Q20. Which photo represents your preference for roasted potatoes?		
Answer Choices	**Responses (N)**	**Responses (%)**
Dark surface colour	122	26.2%
Medium surface colour	245	52.7%
Light surface colour	58	12.5%
I do not cook roasted potatoes at all	40	8.6%
Total respondents	465	
Skipped answers	90	

There are differences in roasted potato colour preferences among those who eat roasted potatoes. However, most of the participants chose the middle roasted potatoes photo to describe their preferences. This surface colour degree provided about 190µg/kg acrylamide (Brook Lyndhurst, 2014).

Furthermore, there are 28.7% among those who eat roasted potatoes that prefer brown surface colour degree, which reached 490ug/kg acrylamide (Brook Lyndhurst, 2014).

The tendency for golden brown colour was also described as almost universally desired among UK domestic food practices in a field study by Brook Lyndhurst (2014). Moreover, the researchers pointed out that the term “golden “colour was not specific among the people when they described the degree of doneness. Therefore, the current study relied on photos to avoid misinterpretation in the wording of questions.

Fried Potatoes

Concerning the preference colour for chips (Q22), as shown in Table 3-26, the preferred colour ranged between yellow and brown degree. The findings demonstrate that there is a similarity in numbers of participants who like golden yellow chips and golden brown chips. Together, those preferences represent the majority, with about 93% among those who eat chips. On the other hand, only 6.7% like cooking chips to a light degree.

Table 3-26 The chips colour-degree preferences

Q22.Which photo represents your preference for chips?		
Answer Choices	**Responses (N)**	**Responses (%)**
Light golden colour	31	6.7%
Golden yellow colour	211	45.4%
Golden brown colour	207	44.5%
I do not like /eat at all	16	3.4%
Total respondents	465	

When searching for the reasons behind the cooking preferences, particularly for roasted potatoes and chips, almost all the reasons for both were the same per individual. Where the responses were through open-ended question (Q23). Thus, the answers had been reviewed and sorted in 11 categories, as shown in Table **3-27**.

The desire for a tastier end-product appeared clearly behind their reasons, such as crispy, tasty, crunchy and soft.

From the present results, the desire for crispness was the most mentioned reason. Furthermore, some other reasons described did not differ from the main one, which is the taste, such as

crunchy and tasty. Consistent with this finding, Brook Lyndhurst (2014) summarised that most people look for crispness and golden colouration in the potatoes. In addition, the researcher pointed out the desire for specific food preferences originating from childhood experiences. In line with that, in the Spanish home-cooking pilot study, Mesias et al. (2018) recorded that the end-point for frying chips was the colour of fried potatoes and represented 87.7%. Golden degree preferences hit 92% aiming for crunchiness and softness, which were considered the major reason 85%.

The other indication from the present study is that the desired taste depends on the specific colour degree. Therefore, the link between taste and colour or appearance of the food helps people in their choices, and that was also showed in above British and Spanish studies

Most people prefer golden to brown colour and believe it to be more tasty. Some also assume that if, at the research level, potato varieties could obtain a golden colour early at the cooking stage without increasing the level of acrylamide that may help to overcome the present level of exposure which is linked to visual appearance.

Table 3-27 The frequency of reasons behind chips and roasted potatoes preferences.

Q23. For what reasons do you have these colour preferences?		
Category	**Responses (N)**	**%**
Cooked assurance	58	12.5%
Crispy	135	29.0%
Crunchy	29	6.2%
Tasty	88	18.9%
Healthy	4	0.9%
Texture	13	2.8%
Visually appealing	21	4.5%

Soft	12	2.6%
I do not cook it	11	2.4%
Other	66	14.2%
N/A	61	13.1%
Total Respondents (N)	465	

3.4.2. Toasted Bread

Concerning the bread-toasting degree, the validated photos had been used in the answer choices (Jackson, 2008, slide no.16). (Figure 2.4)

The toasted bread preferences results in this study refers to medium toasted degree being the predominant choice, with 354 / 465 responses, as illustrated in

Table **3-28** .

Less than 5% was recorded for preferences to dark colour toasted and untoasted, which was represented by 22 and 15 participants respectively. The light-toasting option is the less risky one and recommended by HEATOX (2007a). However, in the present results the percentage of those who prefer light toasted bread was under 15%, with 66 responses.

The findings from the previous studies (Granby et al., 2008; Eerola et al., 2007;

HAETOX, 2007a) confirmed that greater elevation in acrylamide contents in medium toasting may reach to fivefold than untoasted bread. The level of acrylamide does not influence solely by the toasting degree, but also by the type of the bread.

Consequently, in the present study, the findings refer to 76.1% (354) of participants who prefer medium brown colouration of the bread. Regarding the types of bread preferences there are among brown and wholemeal bread, about 76.5% (250) of consumers also preferred medium toasting (Figure 3-8 and Table 3-29). Thus, the number forms about 70.6% (250) from the total number of whom desire a medium toasting degree for bread.

Furthermore, the findings about dark toasting preferences pointed out that about 22 participants like this degree, as it was displayed in the validated photo, with 610µg/kg acrylamide contents. Moreover, about 77% from them prefer dark toasted bread and also prefer brown or wholemeal bread.

Table 3-28 The frequency of toasted bread degree

Q26.Which photo represents your preference for toasting bread?		
Answer Choices	**Responses (N)**	**Responses (%)**
Untoasted bread	15	3.23%
Light	66	14.19%
Medium	354	76.13%
Dark	22	4.73%
Other (specify): - Not eating bread - Well done - Between medium & dark	8 (6) 1 1	1.72%
Total respondents	465	

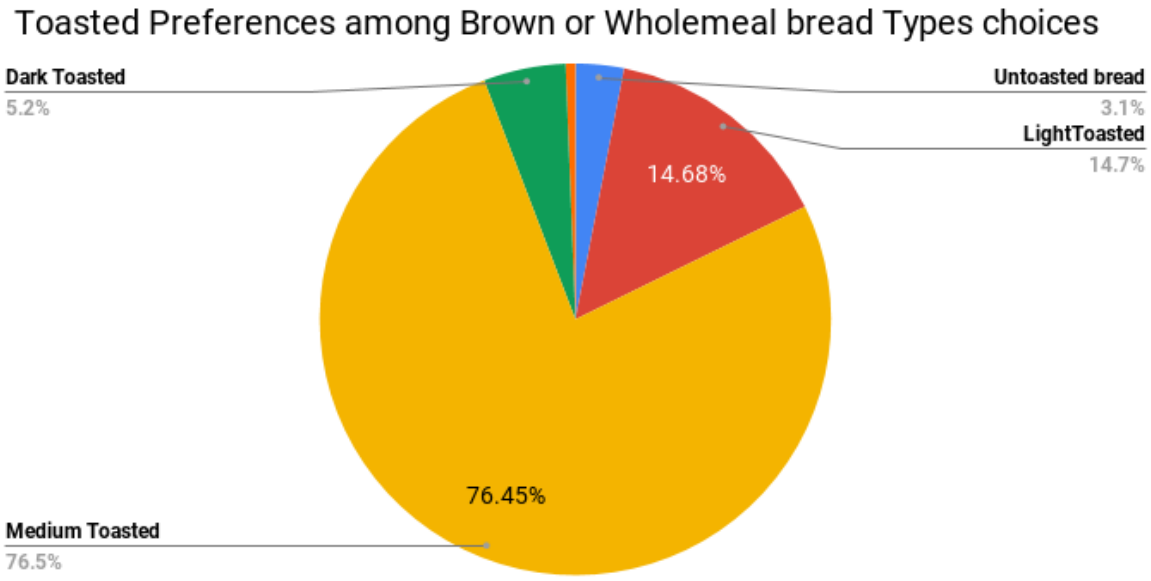

Figure 3-8 The Percentage of toasted degree preferences in wholemeal /brown bread.

Table 3-29 Bread-toasting preferences among brown/wholemeal bread responses

			Bread Type		
			Wholemeal	Brown	Total
Bread preference	Dark toasted	Count	15	12	**17**
		% within Bread Preference	88.2%	70.6%	
		% within Brown wholemeal	6.1%	6.3%	
	Light toasted	Count	27	29	**48**
		% within Bread Preference	56.3%	60.4%	
		% within Brown wholemeal	11.0%	15.3%	
	Medium toasted	Count	193	139	**250**
		% within Bread Preference	77.2%	55.6%	
		% within Brown wholemeal	78.8%	73.5%	
	Other	Count	2	1	**2**
		% within Bread Preference	100.0%	50.0%	
		% within Brown wholemeal	0.8%	0.5%	
	Untoasted bread	Count	8	8	**10**
		% within Bread Preference	80.0%	80.0%	
		% within Brown wholemeal	3.3%	4.2%	
Total		Count	245	189	**327**

Percentages and totals are based on respondents.

a. Dichotomy group tabulated at value 1.

Through an open-ended question (Q27), about 464 participants described their reasons behind their particular toasting degree preferences. The results were displayed in Table 3-30. The respondents' reasons were categorised into 13 categories. Where the findings indicated that, the most frequently recorded reasons were, in general, the taste characteristic of the specific toasting degree 23.5%, specifically the desire for crispness 19.6% and crunchiness12.5%.

For further insight, the link between the toasting-degree preferences with the different reasons has been summarised in Table 3-31. It was noticed that there is an ascending trend, with the

tendency for darker toasted bread preferences. “Tasty” reasons form about 20% in light and untoasted bread responses, and reached over 40% among dark toasting responses. The same pattern was observed in regard to crunchiness desire, while crispness dominates in medium toasting choices.

This results pattern agrees with the fact that the Maillard reaction is responsible for producing the aroma, flavour and the colour of the cooked food, which is also linked to acrylamide generation (Nursten, 2005).

It is clear that among light toasting preferences, the tendency to just warm the toast in order to help melt the butter was the purpose behind toasting the bread. Also, fewer responses 6.2% referred to light or untoasted choices for health aims.

Furthermore, the degree of toasting term such as “medium” is not fully understood among the participants, in spite of the answers displayed in photo formats to avoid misleading scenarios. Some responses among light-toasting options considered this degree to be medium, while other groups believe the medium degree was the other photo. This evidence is in line with the previous findings about the description of the degree of doneness under the term “middle”. It is uncertain among the people as some see light brown or golden as medium degree, whereas others considered it to be dark (Brook Lyndhurst, 2014).

Table 3-30 The reasons behind toasting degree preferences

Q27. Why do you like your preference for how well toasted you like your bread?		
Category	**Cases (N)**	**Cases (%)**
Visually appealing	23	5.0%
Texture	38	8.2%
Aroma	4	0.9%
Tasty	109	23.5%
Crispy	91	19.6%
Crunchy	58	12.5%
Warm/hot	25	5.4%
Soft	11	2.4%
Healthy	6	1.3%
Medium toasted	28	6.0%

I don't like burnt toast	3	0.7%
Other	77	16.6%
N/A	37	8.0%
Total Respondents	464	

Table 3-31 Frequency of reasons for specific toasting degree Vs toasting preferences

Toasting preference	**Untoasted+Light**		**Medium**		**Dark**		**Total**	
Reason Category	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Visually appealing	1	1.2%	21	5.9%	1	4.6%	24	4.8%
Texture	5	6.2%	33	9.3%	0	0.0%	38	7.6%
Aroma	2	2.5%	1	0.3%	1	4.6%	4	0.8%
Tasty	17	21.0%	83	23.5%	9	40.9%	109	21.7%
Crispy	8	9.9%	77	21.8%	4	18.2%	89	17.7%
Crunchy	2	2.5%	52	14.7%	4	18.2%	58	11.5%
Warm/hot	8	9.9%	16	4.5%	1	4.6%	25	5.0%
Soft	6	7.4%	5	1.4%	0	0.0%	11	2.2%
Healthy	5	6.2%	1	0.3%	0	0.0%	6	1.2%
Medium toasted	11	13.6%	17	4.8%	0	0.0%	28	5.6%
I don't like burnt toast	2	2.5%	1	0.3%	0	0.0%	3	0.6%
Other	16	19.8%	57	16.1%	1	4.6%	74	14.7%
N/A	6	7.4%	25	7.0%	3	13.6%	34	6.8%
Total responders	**81**	**100%**	**354**	**100%**	**22**	**100%**	**503**	**100%**

3.5. Frequency of Consumption of the Selected Products and Respondents' Preferences

It is accepted that fried and roasted potatoes, bread and coffee are considered as major foodstuffs that contribute in the exposure to acrylamide. Therefore, this section highlights the actual consumption rate among the respondents' sample. Subsequently, it reflects the acrylamide exposure level among those food groups.

3.5.1 Potatoes Consumption

The frequency of consumption of either chips or roasted potatoes is illustrated in Figure 3-9. Among 465 total responses, there are 227 responses that eat potatoes once a week. This group forms close to half (48.8%) and the once-a-month consumption group represents 31.6% (147 responses). Meanwhile, 71 persons 15.3% consume potatoes two to three times weekly, while potato consumption on a daily basis is the lower portion (0.7%).

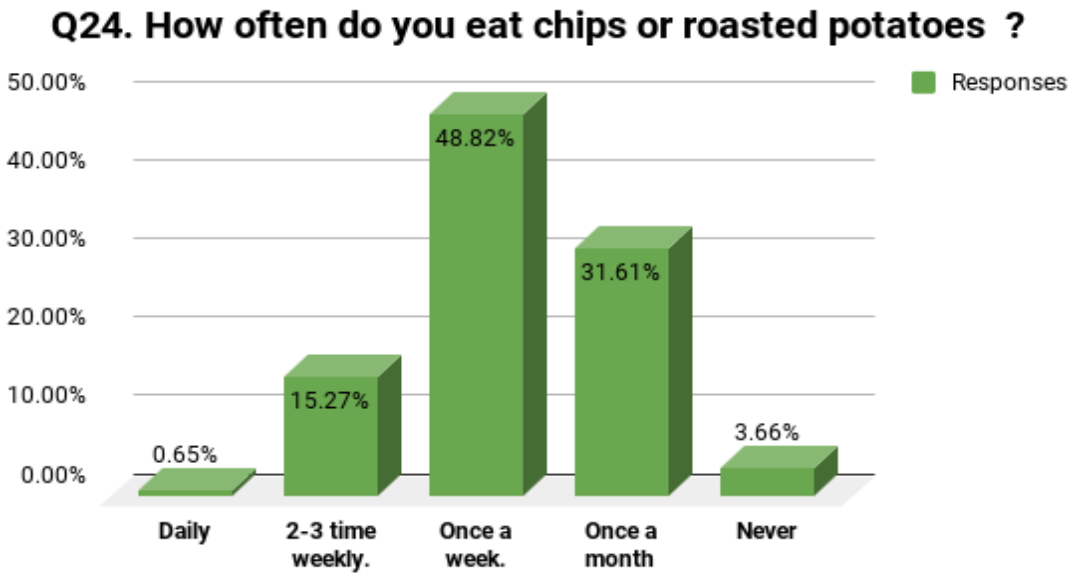

Figure 3-9 Frequency of roasted and potato-chip consumption

The present consumption rate findings are separate from the previous consumption rates of potatoes in Ireland, which were recorded by ShelfLife (2015) and by Neary (2019). They reported that between 50-60% in Ireland consume potatoes between two to three times weekly, while 29% eat potatoes daily (ShelfLife, 2015).

The differences between the findings may be attributed to the fact that in the current results, the consumption levels of fried and roasted potatoes did not mention boiled potatoes or other cooked forms.

According to Brunton et al. (2006), in the Irish population a portion of home-made fried potatoes are estimated to contribute 0.94µg/kg bw for males and 0.69µg/kg bw for females per portion. Overall, the results indicate the consumption of fried and roasted potatoes, once a week, forms almost half. Moreover, 48.6% of the participants use the oven for cooking chips rather than traditional frying methods, as shown previously in Table 3-24. This findings suggests that, depending on the current consumption rate of potatoes and the common method used for cooking (oven), the contribution in exposure to potential levels of acrylamide is limited.

3.5.2 Bread Consumption

The quantity of bread eaten per person daily, as shown in Figure 3-10, illustrates that among 465 responders, the majority either eat 1-2 slices per day or rarely consume bread. Over half of the respondents (241) are eating between one to two slices daily, and 132 others are rarely eating bread. Consumption of 3-5 slices daily represents 62 responses, and more than five slices are just 11 participants. Moreover, there are 15 answers that specified other options, such as seven cases eat 2-5 slices weekly, five cases eat bread once per week and three cases mentioned eating bread sometimes.

In light of the present findings, the majority do not consume more than two slices per day. That is consistent with a prior research survey by the Irish Universities Nutrition Alliance, which reported that among Irish adults, the mean daily intake of toast was 32.8g and 51.2 g approximately (0.9 -1.3 slices/ day for white and wholemeal slices respectively) (IUNA, 2016).

For example, if the average weight of one slice was 38g (IUNA, 2016), and the acrylamide median level was recorded at 34 µg/kg for toast samples (white and brown toast) from home-

toasted bread (Brook Lyndhurst, 2014), then the average estimate exposure to acrylamide from daily consumption of 1-2 slices of bread will be about 1.3 to 2.6µg respectively. Whereas, FSAI (2009a) estimated that bread consumption contributed to 34% of mean dietary exposure to acrylamide. The average exposure to acrylamide among Irish adults was 0.6 µg/kg and 1.75 µg/kg bw/day for higher consumers, which equals 42µg and 122.5µg/ adult/day (average body weight is 70kg). Consequently, 3.1% -6.2% are the contribution of 1-2 slices of bread in dietary exposure to acrylamide in current study.

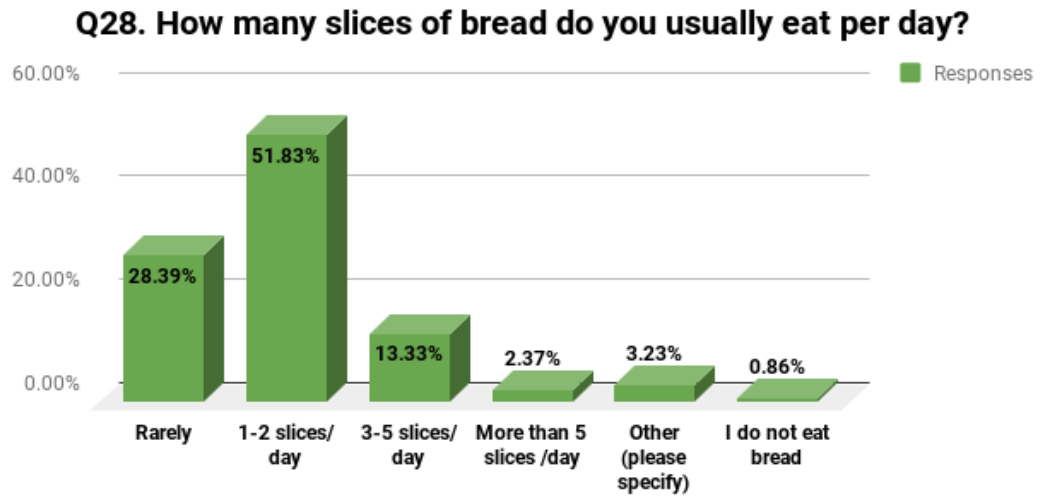

Figure 3-10 The rate of bread consumption daily

Regarding bread-type preferences among the participants, the findings in Table 3-32 show that wholemeal bread is the most frequently bought with 52.7%, followed by brown bread 40.7%, while white pan shows 38.0% responses, flatbread 26.2% and soda bread 18.9%. There were minority responses to other bread types. Some responders specified other answer options, such as gluten free, sourdough and other soft bread, however those other types showed low percentages.

Table 3-32 The bread-type preferences

Q25.What type of bread do you usually buy? (Tick all that apply)		
Answer Choices	**Cases (N)**	**Cases (%)**
White sliced pan	177	38.1%
Brown sliced pan	189	40.7%
Wholemeal bread	245	52.7%
Soft flatbread /wraps	122	26.2%
Soda bread	88	18.9%
Potato bread	9	1.9%
Ginger bread	3	0.7%
Rye bread	28	6. %
Crisp bread	25	5.4%
I do not use bread.	27	5.8%
Others (Specified answers)		
Gluten free	14	3.0%
Soft bread (baguette/bagel)	11	2.4%
Sourdough bread	12	2.6%
Other	14	3.0%
Total Respondents	**465**	
Skipping	**90**	

Overall, the results revealed that wholemeal and brown bread are the most frequently consumed among the participants.

Although the high health benefits of wholemeal and brown bread compare favourably to white bread, exposure to acrylamide is higher from wholemeal bread and brown than from white bread types (Gündüz and Cengiz, 2015). Moreover, the level of acrylamide generation in brown /wholemeal were much higher than in white toast (Ahn et al., 2002; Brook Lyndhurst, 2014; HEATOX, 2007a).

Despite this, the current total consumption rate of wholemeal and brown bread was equal 93.3% and white bread (white pan & white soft) was 40.8%. This appears higher than the consumption rate of wholemeal 72% and lower than white bread 57% which were reported by IUNA (2016) among Irish adult consumers. These differences can be expected and are related to the consumption attitude for healthier diets, with more fibre and nutrients sources, as recommended in the Healthy Eating Guidelines by Healthy Ireland and Department of Health (Healthy Ireland, 2019). That encourages Irish society to shift to more whole grain products such as wholemeal brown bread and cereals. As shown from about 20 years ago, the consumption rate of white bread was 94%, as reported in North/South Ireland Food Consumption Survey (IUNA, 2001).

3.5.3 Coffee Consumption

The consumption rate of coffee among 465 respondents shows that more than one-third of the participants 170 do not drink coffee at all and represents the largest group. Less than 2% (9) drink five cups or more per day (**Figure 3-11**).

Meanwhile, among coffee-drinker groups, drinking one cup daily represented 43.7%, two cups 33.2%, 14.2% consume three cups of coffee daily, four cups 5.8% and five cups or more formed 3% of responses.

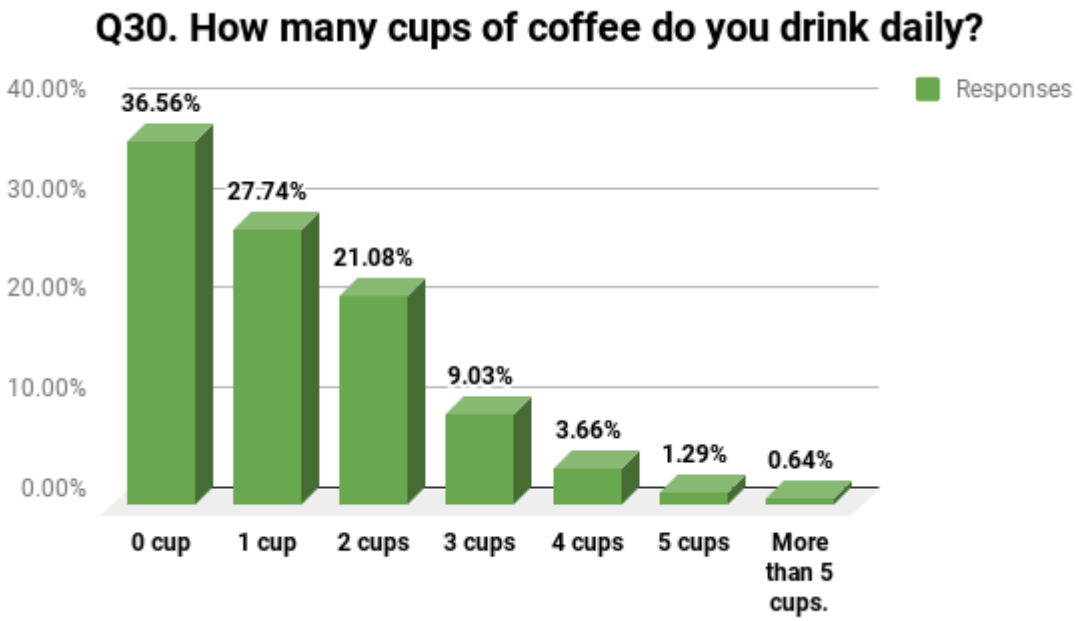

Figure 3-11 Rate of Drinking Coffee Daily

Consumption of more than one cup of coffee per day among the coffee drinker about 56% and equals 35.7% over the total respondents. This consumption rate is consistent with the percentage 34% that had been recorded in 2016 by Empathy Research Company (Checkout, 2018).

Comparing to other European nations' consumption rates, the coffee consumption rate in the current study was slightly lower than in a Polish study, where it was reported that 51% consumed one cup of coffee daily, 38% drink two cups and 11% consume three cups daily (Kowalska, et al., 2017).

Regarding coffee-type preferences among the participants, nearly one-third 31.4% do not prefer coffee, as demonstrated in Table 3-34. About one-third of the female participants in this study

do not drink coffee and 28.9% of males do not drink coffee from the total male participants. Distribution of those percentages among the age subgroups is illustrated in Table 3-35.

There was evidence of statistically medium significant difference between males and females in regard to the amount of coffee consumption per day, as shown in **Table 3-33** through Pearson Chi-Square (p =0.019), the degree of freedom df = 4 and Cramer's V value was 0.202 (Kim, 2017; Cohen, 1988).

Table 3-33 Coffee consumption rate among genders

Cups consumption/ day			Gender		Total
			Female	Male	
	1 cup	Count	106	20	126
		% within gender	46.9%	30.8%	43.3%
		% of Total	36.4%	6.9%	43.3%
	2 cups	Count	73	24	97
		% within gender	32.3%	36.9%	33.3%
		% of Total	25.1%	8.2%	33.3%
	3 cups	Count	33	11	44
		% within gender	14.6%	16.9%	15.1%
		% of Total	11.3%	3.8%	15.1%
	4 cups	Count	7	8	15
		% within gender	3.1%	12.3%	5.2%
		% of Total	2.4%	2.7%	5.2%
	5 cups or more	Count	7	2	9
		% within gender	3.1%	3.1%	3.1%
		% of Total	2.4%	0.7%	3.1%
Total		Count	226	65	291
		% within gender	100.0%	100.0%	100.0%
		% of Total	77.7%	22.3%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.846[a]	4	.019
Likelihood Ratio	10.569	4	.032
Linear-by-Linear Association	6.424	1	.011
Number of Valid Cases	291		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 2.01.

Over the coffee drinker group, as shown in Figure 3-12 , the majority prefer drinking roasted ground coffee (60.5%), compared to instant coffee preferences which formed over one-third (35.4%). Fewer drink coffee substitutes (2.5%) and other types (decaffeinated coffee and mixed choices).

The type of coffee with the amount of consumption according to the gender was illustrated in Table 3-36. The frequency of drinking one cup of instant coffee per day formed about 50% in both genders, while roasted coffee was consumed at a rate of two cups more among males than females. The Pearson Chi-Square test revealed that there was a significant correlation between the gender type and the type of the coffee (p =.044) and the strength of the correlation was small (Cramer's V value = .115 and *df* 1), as shown in **Table 3-37**.

In regard to age groups, 35-44 consumed the most coffee, representing 30.2% overall. Also, this group represents the highest consumers of roasted coffee in both genders.

Consumption of instant coffee among males shows high frequency among 18-24 year-olds, while among female age groups, 35-44 formed the highest instant coffee consumption group.

The current findings state that roasted ground coffee is the most common type of coffee consumed amongst the Irish adult participants. That is different to what was reported about instant coffee being the most common type (Checkout, 2018; Bord Bia, 2011). Mintel (2018) recorded that ground coffee was the common type among the high social class in Ireland.

Overall, acrylamide concentration in dry instant coffee is higher than in dry roasted coffee, as demonstrated in the literature. However, the contribution of roasted ground coffee in the acrylamide total exposure is higher due to the dilution factor (EFSA, 2015).

Table 3-34 Frequency of common coffee-type preferences among the total participants

Q29.Which type of coffee do you usually drink?		
Answer Choices	**Responses (N)**	**Responses (%)**
Instant coffee	113	24.3%
Roasted/ground coffee	193	41.5%
Coffee substitutes	8	1.7%
I don't drink coffee	146	31.4%
Other (please specify)	5	1.1%
Total Responses	**465**	

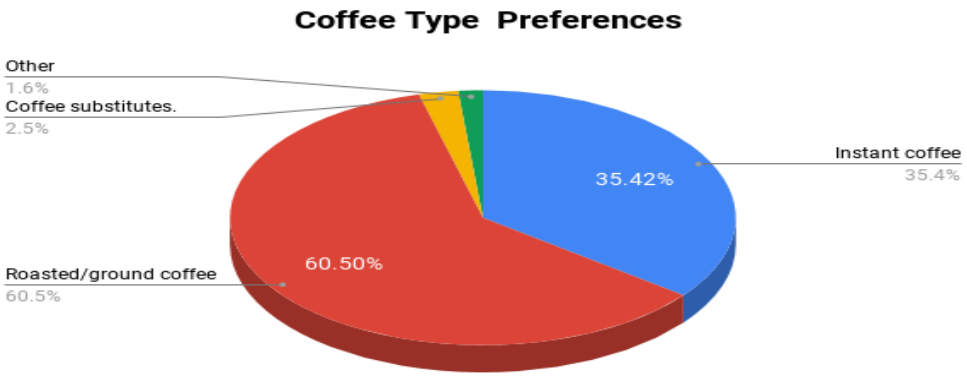

Figure 3-12 Percentage of coffee-type preferences among coffee consumers

Table 3-35 Frequency of who do not drink coffee, according to gender and age

	Female		Male	
Age Range	%	N	%	N
18-24	9.26%	34	7.78%	7
25-34	10.63%	39	7.78%	7
35-44	5.99%	22	5.56%	5
45-54	3.00%	11	4.44%	4
55-64	3.27%	12	3.33%	3
65+	0.27%	1	0.00%	0
Total	**32.43%**	**119**	**28.89%**	**26**

Table 3-36 Coffee consumption rate according to gender, age and the type of coffee

Coffee type	**Roasted/ground coffee**				**Instant coffee**				**Total**	
Gender	**Female**		**Male**		**Female**		**Male**			
	%	N	%	N	%	N	%	N	N	%
1 cup	44.7%	59	27.9%	12	49.4%	43	50.0%	8	122	43.9%
2 cups	35.6%	47	44.2%	19	25.3%	22	18.8%	3	91	32.7%
3 cups	15.9%	21	16.3%	7	13.8%	12	12.5%	2	42	15.1%
4 cups	3.0%	4	9.3%	4	6.9%	6	12.5%	2	16	5.8%
5 cups	0.8%	1	2.3%	1	2.3%	2	6.3%	1	5	1.8%
More than 5 cups	0.0%	0	0.0%	0	2.3%	2	0.0%	0	2	0.7%
Age Range										
18-24	17.4%	23	16.3%	7	23.0%	20	37.5%	6	56	20.1%
25-34	23.5%	31	16.3%	7	28.7%	25	18.8%	3	66	23.7%
35-44	31.1%	41	30.2%	13	32.2%	28	12.5%	2	84	30.2%
45-54	18.2%	24	23.3%	10	12.6%	11	25.0%	4	49	17.6%
55-64	9.9%	13	9.3%	4	2.3%	2	6.3%	1	20	7.2%
65+	0.0%	0	4.7%	2	1.2%	1	0.0%	0	3	1.1%
Total responses	**100.0%**	**132**	**100.0%**	**43**	**100.0%**	**87**	**100.0%**	**16**	**278**	**100.0%**

Table 3-37 The relation between gender type and coffee consumption type

Coffee Type		Gender		Total
		Female	Male	
Instant coffee	Count	94	18	112
	% within which type of coffee do you usually drink?	83.9%	16.1%	100.0%
	% of Total	30.9%	5.9%	36.8%
Roasted/ground coffee	Count	142	50	192
	% within which type of coffee do you usually drink?	74.0%	26.0%	100.0%
	% of Total	46.7%	16.4%	63.2%
	Count	236	68	304
	% within which type of coffee do you usually drink?	77.6%	22.4%	100.0%
	% of Total	77.6%	22.4%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.049[a]	1	.044		
Continuity Correction[b]	3.496	1	.062		
Likelihood Ratio	4.199	1	.040		
Fisher's Exact Test				.047	.029
Linear-by-Linear Association	4.036	1	.045		
Number of Valid Cases	304				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 25.05.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.115	.044
	Cramer's V	.115	.044
N of Valid Cases		304	

3.6. Consumers Perceptions and Attitudes to Acrylamide Labelling

This part demonstrates the participants' opinions and attitudes to acrylamide labelling and information in food packages through three questions (Q34, Q35 and Q36), as seen in Table 3-38 .

Concerning the labelling information about the acrylamide content level on the food packages suggestion question, the majority 338 of 458 respondents perceived a need for further information, while 103 others do not have strong opinion about that, with negligible responses against this idea. From the results, it is clear that most of participants 73.8% positively respondent to the suggestion about more information about the level of acrylamide in the foodstuffs. While, the other responses with "no strong opinion" supposing to be related to the lake of information about the acrylamide potential effects or that information will not affect their habits at all. That suggestion agreed with the findings in a Polish study about the attitude of the consumers in relation to acrylamide labelling in food packages. In that study, 35% argued that information is useless, and they persist with their food behaviours. However, in the same study there were 55% who agreed that information about presence of any harmful compounds in food, even small levels, will be important (Kowalska et al., 2017).

Regarding the appearance of acrylamide precautionary information on food packages, particularly mentioning the potential formation of acrylamide if cooking instructions are not properly followed, highly positive responses reached to over 80%.

The percentage fell down to 55.7% when testing the influence of recorded acrylamide content level on the products containers and their choice of purchase. Furthermore, there was a doubt among 42.4% about the acceptance to purchasing that labelled products. Approximately 7% confirmed their rejections to deal with any acrylamide warning products.

Also, in this question's responses, results indicate a deficiency of knowledge about the existence or formation of acrylamide in daily food practices. Where the participants choose not to consume products with known acrylamide levels, meanwhile, acrylamide is present in most of the processed and home-made foods without any attention. Or may interpret as it is due to healthcare reasons.

Table 3-38 Details of the responses to the questions related to acrylamide information in food packages

Q34. "Acrylamide is a harmful compound produced when some carbohydrate foods become brown due to overheating", should food packaging contain information about the content and safe level of acrylamide (for example the maximum daily limit)?		
Answer Choices	**Responses (N)**	**Responses (%)**
Yes, definitely	338	73.8%
Definitely not	17	3.7%
I don't have a strong opinion either.	103	22.5%
Total Responses	458	
Q35. In your opinion, should food packaging contains information about the potential formation of acrylamide in the product if the cooking instructions are not properly followed?		
Yes, definitely	370	80.8%
Definitely not	13	2.8%
I don't have a strong opinion either.	75	16.4%
Total Responses	458	
Q36. In your opinion, if a product's label listed acrylamide at a safe level (or below the recommended daily limit), would you buy the product?		
Yes, definitely	232	50.7%
Definitely not	32	7.0%
Not sure	194	42.4%
Total Responses	458	
Skipped	97	

A FSAI research survey about the Irish attitudes to food labelling revealed that about one-quarter of the Irish consumers were always interested to read food labels during shopping for food or before using the food products. On the other hand, there were nearly the same percentage who did not review the food label at all (FSAI, 2009b).

However, the results from previous studies recorded that consumers commonly do not follow manufacturer cooking instructions or guide labels (Brook Lyndhurst, 2014; Brook Lyndhurst and WRAP, 2011; Wright, Canham and Masrani, 2011). Thus, acrylamide warning messages in food packages may help consumers to notice and comply with the product's cooking instructions and be aware about the acrylamide potential risks. Moreover, there is a vital need for public information campaigns to help consumers reduce exposure to acrylamide and elevate the awareness through reading the food packages information rather than just warnings. The recommendation for including nutritional advices about the healthy culinary methods in regard to reducing acrylamide in food stuffs was mentioned in the European Consumer Organisation (BEUC) letter to the director of DG SANTA, European Commission, for requesting more protection to the EU consumers from acrylamide levels in EU market products (BEUC, 2019). There was a noted appetite for clear information regarding good cooking practices and acrylamide generation among the participants in the current study, through personal communication with researching for more information and verification for their actual practices. This further suggests the need for massive education awareness programmes and campaigns to fulfill the needs for information and cover this gap scientifically, rather than individuals' suggestions and inherited beliefs.

CONCLUSION & RECOMMENDATIONS

Chapter 4 . CONCLUSION and DISCUSSIONS

4.1 Conclusion

The existing knowledge about acrylamide formation and its risk among Irish residents suggested that the scientific term “acrylamide” was not recognised widely among the inhabitants 14.8%, in contrast to the definition as a harmful component formed during heat treatment of carbohydrate-rich food, which showed about 39% recognising that.

However, the awareness about the health risk of this harmful compound (acrylamide) showed significant high percentage about the carcinogenic effects, which reached 94.5% among those who heard about this harmful compound. The awareness about the role of high cooking temperature as the main contributor in AA generation represented 85.4% in responses. Additionally, the results indicated that linking the major foodstuff contributors in acrylamide formation showed that potatoes 75%, bread, biscuits and cracks 52%, cereals 48% and coffee 38% were among the foodstuffs people associated with acrylamide.

Regarding home-food practices which may influence in dietary exposure to acrylamide:

- Domestic potatoes storage behaviours do not indicate to significantly increase of acrylamide exposure.
- Pealing, washing fresh potatoes practices and preferences to not cutting potatoes to small or thin cuts helped decrease the risk of high acrylamide exposure in prepared meals.
- In contrast, soaking fresh potatoes practices before cooking, and the duration of soaking, showed that almost 40% soaking potatoes and 17% from them soaking potatoes for 30 minutes or more.

- The process of parboiling and proper soaking fresh potatoes were not considered common practices among the participants, which reflects the possibility of keeping the levels of the precursors high, consequently increasing risk of acrylamide exposure.
- Oven temperature options for fresh roasted potatoes and common methods for frying chips do not appear to significantly contribute in risk of acrylamide exposure, except the end-point cooking estimation assessments. There were less than one-third strictly following the manufactures' instructions in the foods packages in relation to cooking time and temperature. That rose the possibility for exposure to acrylamide higher than the expected level as estimated by the food product manufacturers.

Regarding the foods preferences and consumption rate:

- The tendency for medium golden degree of the roasted potatoes surface was the most common, with over half of the preferences. Furthermore, 28.7% preferred brown surface degree.
- The desire for more golden brown increased to form with the golden yellow preferences about 93% among the chips consumers' participants. Thus, the roasted potatoes and chips' surface-colour-degree preferences indicate a significant risk of acrylamide exposure.
- Concerning toasted bread, the tendency for medium toasted degree was the most popular choice with 76% responses that raises the risk. Moreover, preferences for wholemeal brown bread type indicates significantly elevated acrylamide exposure, with consuming of more brown and wholemeal bread types than white bread.
- The consumption rate of the selected foodstuffs among the participants in general did not point to significant over-consumption.

- Concerning bread types, the majority prefer wholemeal and brown bread than white bread.
- The frequency of drinking roasted/ground coffee was 10% more than the frequency of drinking instant coffee.

Regarding the suggestion to add acrylamide information label in foods packages, the majority 73.8% agreed for further information in food containers about the level of AA contents in food products. This agreement showed an increase to 80%, and confirmation particularly in relation to precautionary information about potential formation of acrylamide if the cooking instructions are not properly followed. Nevertheless, the participants' attitudes to purchase the acrylamide labelled food products showed a decline 55.66%.

Therefore, overall the suspected high exposure to AA through home-made food practices or food preferences in this study emerge from lack of knowledge of good cooking practices. This particularly relates to fresh potato soaking and parboiling before cooking and potato storage time. This is also in addition to the tendency for golden yellow to brown degree for cooked foods surfaces such as roasted potatoes, chips and toasted bread. That highlights the need for extensive efforts at different levels to teach and improve knowledge about good cooking practices and changing food habits to minimise exposure to acrylamide from home-prepared meals. Those awareness programmes should cover all age groups, with sharing of all relative bodies and agencies as well as education sectors, food safety and industry.

4.2 Recommendations

In general, it is clear form this study that there is a deficiency of knowledge in regard to acrylamide issues. Therefore, clear information campaigns are necessary for dealing with acrylamide topics, accompanied by intense publicity, as previously recommended by Meng,

Zhao and Qian (2012). The promotion of knowledge over all ages is required as well (Zajac et al., 2013).

It is recommended for educators, food safety communicators, relevant agencies and the media to send the correct message to Ireland's inhabitants about acrylamide and its causes for formation. They should be taught to avoid high exposure through an educational approach to behavioural changes, such as ideal choice of foodstuffs, proper ways for storage, preparations, cooking meals at home and how to modify their preferences.

At home level, adapting additional measures in order to guarantee reducing the probability of risk exposure through home-made meals such as: readjust the toaster to be at less time setting heat degree, oven temperature not over 200°C, adapt healthier frying methods.
Further field work should be carried out as a national initiative and with collaboration from relevant bodies such as the universities, FSAI, EFSA and other relevant agencies.

4.3 Future Work

- Since the investigation about the relationship between different demographic characteristic and exposure risks to acrylamide is out of the scope of the present study, it would be worthwhile to carry out further work aimed at detecting the correlation between the culinary background origin and the food practices and food preferences. It was noticed that in the current results there was a correlation between origin and food preferences. That will help to highlight if there are groups in the population under high exposure risk to acrylamide. The future work will be more reliable if conducted through field investigations and observations.

- Further investigate the actual domestic food practices, particularly in regard to potato varies used, and compile suitable methods for cooking according to potato varies recommendations, amount of oil used, temperature of frying oil and types.
- For gaining accurate and reliable data about the actual acrylamide exposure level among Irish inhabitants, it is recommended to conduct analytical lab tests about the level of acrylamide present from home-made meal samples include potatoes, toasted bread and home prepared coffee, as well as samples from commercial ready-to-eat foods and restaurants meals.

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JOURNAL ARTICLE

Chapter 6 . JOURNAL ARTICAL

Acrylamide Awareness and Related Domestic Food Practices among the Residents of the Republic of Ireland

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ABSTRACT

Limited knowledge about acrylamide risks, combined with a lack of good food preparation practices, is leading to daily exposure to high levels of acrylamide contamination from home-made meals across a number of different nations. The aim of this study was to explore to what extent the actual specific domestic food practices and food preferences with regard to potatoes, bread and coffee can give indication of the extent that consumers may be exposed to AA risks, while also gauging the level of acrylamide knowledge among adult inhabitants in Ireland over 18 years old.

In this study, mixed open-end and closed-end questions have been used in a questionnaire (online and hardcopy). A questionnaire (N=555, over 18, Irish inhabitants, from March to June 2019).

The results showed that 39% had heard about a harmful component formed during heat treatment of carbohydrate-rich food, while 14.8% recognised the term ‘acrylamide’. Awareness of the carcinogenic effects of acrylamide reached 94.5% among those who had heard about this harmful compound. Realisation that high cooking temperature is the main contributor in acrylamide generation represented 85.4%, while linking the major foodstuff contributors in acrylamide formation showed that potatoes accounted for 75%, bread, biscuits and crackers 52 %, cereals 48% and coffee 38%.

Some domestic practices pointed to a concern, such as the practice of soaking fresh potatoes before cooking and the duration of soaking. This showed that although 40% were soaking potatoes, 17% were soaking potatoes for 30 minutes or more. In addition, almost one-third of the respondents practiced the process of parboiling in their preparation. In terms of the duration of cooking times, 50% of respondents made this decision based on visual assessments of food as it cooked. Those who strictly followed food-package instructions accounted for 31.6%. The most commonly preferred appearance of roasted potatoes, chips and toasted bread was a medium golden colour

Overall, these results substantiate the need for educational initiatives tailored towards developing knowledge about good cooking practices and changing food habits to minimise exposure to acrylamide from home-prepared meals and food preferences.

Keywords: Acrylamide, Home Food Practices, Coffee, Toasted Bread, Soaking, Parboil, Roasted Potatoes, Chips.

1. Introduction

Although domestic food practices play a significant role in consumers' exposure to acrylamide (Michalak, Gujska, Czarnowska-Kujawska, & Nowak, 2017), studies relating to the generation of acrylamide (AA) during home-food preparation and actual cooking practices have been few and infrequent, and include Jackson and Al-Taher (2005), HEATOX (2007b), Brook Lyndhurst(2014), Mesias, Delgado-Andrade, Holgado & Morales (2018) and Mesias, Delgado-Andrade and Morales (2018). Mesias, Delgado-Andrade, Holgado, et al.(2018) investigated the contribution of home practices to the increased level of AA in chips (French fries) in Spanish houses. The study revealed that formation of AA in home-prepared chips from fresh potato samples were about 45.2%. Samples exceeded the EU benchmark level for French fries (500ug/kg) by two to four times and exceeded EFSA estimated l. For instance, 6.9% of the collected home-prepared chips recorded 2000ug/kg AA contents, while the average of the other samples was 644 µg/kg in home-made fried. In 2014, a field study project for Food Standards Agency in the UK examined the influence of home-cooking practices on acrylamide formation (Brook Lyndhurst, 2014). It concluded that there was a low level of awareness of acrylamide exposure among British participants. That project focused on the different home practices for instant potato storage, preparation of potatoes, cooking preferences and bread-toasting practices. The study reported a correlation between consumer preferences and AA exposure, as well as a link between desired food colour and AA levels in examined foods.

Since the role of domestic food practices, food preferences and consumption habits have a major impact on the total dietary level of exposure to AA (Mesias, Delgado-Andrade, Holgado, et al., 2018). Therefore, the scientific opinion of the European Food Safety Authority (EFSA) is that AA investigation among the population and related home-food practices is crucial to achieving a safe-level exposure to AA (EFSA, 2015). There is consensus that the major food contributors to total AA exposure are are potato chips and crisps (fried, roasted, baked), potato products, bread and bakery products, cereals and grain products including coffee (EFSA, 2015; JECFA, 2006; Scientific Committee on Food (SCF), 2002; Tareke, Rydberg, Karlsson, Eriksson, & Törnqvist, 2002; WHO, 2002). For example, potato chips contribute 10% to 60% of AA intake, potato crisps 10% to 22%, bread/toast 13% to 34%, and pastry and biscuits 10% to 15% (JECFA, 2011).

The main aims behind blanching or soaking potatoes, from a food-safety perspective, are to decrease the concentration of reducing sugars and asparagine in potato cuts, as well as reducing the time required to cook under high heat treatment (frying, roasting, this is reflected in the reduction of AA content in the final product,

when compared to un-blanched (Matthäus, Haase, & Vosmann, 2004; Viklund, Olsson, Sjöholm, & Skog, 2010). Elimination of AA precursors from the surface through blanching or soaking depends on immersion time or the temperature of the blanching. Soaking potato strips in water for two hours showed a reduction of 33%, 21% and 27% in acrylamide formation when potatoes were fried at 150, 170 and 190°C respectively (Pedreschi, Kaack, & Granby, 2006). 'The recommendations arising from the Heat-Generated Food Toxicants, Identification, Characterization, and Risk Minimization Project (HEATOX, 2007b) were to advise consumers to wash and soak potatoes in cold water for at least 30 minutes, or blanch them in hot water for a few minutes. Also, the Food Safety Authority of Ireland recommended the soaking or blanching of potatoes as well as draining well before cooking(FSAI, 2009).

A noticeable correlation between browning levels in food surfaces and AA concentrations in different food products have been reported in many studies, including cooked potatoes (Gökmen, Şenyuva, Dülek & Çetin, 2007; Majcher & Jeleń, 2007; Mesias et al., 2018; Mestdagh et al., 2008; Pedreschi et al., 2006, 2007; Pedreschi, Moyano, Kaack & Granby, 2005; Serpen & Gökmen, 2009), coffee and wheat flour (Gökmen and Şenyuva, 2006) and bread (Mustafa, Andersson, Rosén, Kamal-Eldin, & Åman, 2005; Surdyk, Rosén, Andersson, & Åman, 2004). In the toasting process, Jackson and Al-Taher (2005) reported the positive correlation between AA levels in home-toasted bread and the dark colour of the toasted bread surface, from dark toasting at 43.7 - 610.7ug/kg, medium toasting at 10.9 - 213.7ug/kg) and light toasting at 8.27 to 217.5ug/kg. Similarly, HEATOX (2017b) reported an increase in acrylamide content in medium-toasted bread, which reached 2-5 times that of untoasted samples. Nachi et al. (2018) found the L^* and b^* parameters of crusts correlated positively with the level of AA in bread samples.

A limited number of recent studies, based in a small number of countries, have investigated people's knowledge of acrylamide, as well as the influence of food practices and preferences in the level of exposure. For example, in Poland, a study has been conducted among medical school students (N=227) about acrylamide awareness and eating habits (Kowalska, Żbikowska, Onacik-Gür, & Kowalska, 2017). It revealed that only 7% of the participants had previously heard about acrylamide. Moreover, nobody from this group had knowledge of acrylamide occurrence and formation in food. A similarly low percentage (5.1%) had heard about acrylamide risk in a survey among Chinese university students participants (N=1000), while 65.3% of the students were unfamiliar with acrylamide (Meng et al., 2012). While, among West African nations (N=1103) Akinosun, Ojinnaka and Aouzelleg(2018) recorded that about 28.4% were aware of acrylamide formation in cooked foods and less than 2% aware about the possible adverse health impact of acrylamide.

The level of awareness about AA and its potential risks was 22% in a recent survey (N=2000) focusing on France, UK , USA and 54% among participants from Germany, that study carried out by DSM Research Company (DSM, 2018). Of these, 50% were aware of AA formation, while 19% of the participants believed that AA is not harmful at all. Despite considerable efforts, the author could not find a study that reviewed this issue in regard to home food practices and preferences among people living in the Republic of Ireland. Therefore, the aim of this study was to investigate AA and Related Domestic Food Practices among the residents of the Republic of Ireland.

2. Materials and methods

2.1. Questionnaire design

The design of the questionnaire was based on a mixture of closed end questions (multiple-choice with multiple-answer questions and single answer-choice questions), as well as open-ended questions. The questionnaire development was guided by questions used in published literature to assess knowledge and eating habits of a population in the area of acrylamide, as well as home-cooking practices and acrylamide formation (Mesias et al., 2018; Kowalska et al., 2017; Brook Lyndhurst, 2014). Appropriate modifications were made to the questions to fit the objective of the study. For validation of the questionnaire, a pilot test was conducted with 16 food-safety management professionals. These assessed the clarity of the questions and associated pictures, suitability of wording and the average time needed for its completion. The required amendments and enhancements were made according to the feedback that was received, then re-evaluation occurred before final distribution.

The questionnaire was designed on the SurveyMonkey platform and organised in a logical, automatic order. This depended on the participants' responses to questions, without distinguishing separated sections in order to avoid any influence during the experiment and to prevent bias. Furthermore, the closed-end questions contained options stating "other" or "I do not know" to avoid limiting responses to a predetermined list of options.

The questions were distributed as follows; two questions aimed to screen participants and fulfil criteria (age and country of living). Twelve questions related to acrylamide knowledge and awareness, while in the consumer preferences category there were five questions about cooking end-point preferences and three questions queried the consumption rate of potatoes, bread and coffee. The domestic food practices category, which included storage, preparation, pre-treatment and cooking, was represented by 11 questions. Three

questions aimed to discover the participants' attitudes and opinions towards acrylamide labelling suggestions. Additionally, there were seven questions about data relating to demographics.

2.2. Participant sample and data collection

The questionnaire was completed using sample of people aged over 18 and living in Ireland. The survey was carried out, either by electronic questionnaire via the SurveyMonkey platform or manual hardcopies, from March to June of 2019. The participants were reached in a non-systematic way in different forums, common public areas, community-based centres and community training centres. Also, the survey web link was advertised in different public places and universities in Ireland via direct emails, social media platforms or paper advertisements, which were distributed to cover multiple areas in the Republic of Ireland. On average, the participants spent around 10 to 14 minutes to complete the survey. The total number of participants was 642. The disqualified respondents numbered 68. Disqualification criteria such as 'do not live in Ireland' (60) and 'under 18 years old' (8), in addition to incomplete responses (19), brought the final qualified participants to 555.

2.3. Data analysis

The data from paper responses was entered manually in the same survey platform as the output data, which was received in the same Excel data sheets for further analysis and interpretations. For the data analysis, the software package of SPSS version 25 by IBM Corporation was used to statistically analyse some variables relationships. Meanwhile, in accordance with Bryman (2016), the thematic analysis was applied through extracting core meanings that could be distinguished in and between the text words responses. Thus, the responses to the open-ended questions were firstly manually categorised by conducting a thematic analysis and coding for the responses in SurveyMonkey. After coding the answers, re-evaluation and sorting took place, as well as further analysis as the data was expressed in frequencies, percentages and graphs.

3. Results and discussion

3.1 Samples profile

The demographic characteristics of the participants' sample is shown in Table 1.

Table 39 The demographic characteristics of the resident participants' sample.

Demographic Characters	**Category**	**Respondents (n.)**	**Percentage (%)**
Age	18-24	107	23.4%
	25-34	120	26.2%
	35-44	121	26.4%
	45-54	67	14.6%
	55-64	39	8.5%
	65+	4	0.9%
Gender	Male	90	19.7%
	Female	367	80.1%
	Other	1	0.2%
Place of Residence	City	396	86.5%
	Countryside	62	13.5%
Education Level	University and Above	386	84.3%
	Leaving Cert.	59	12.9%
	Junior Cert.	11	2.4%
	No qualification	2	0.4%
Per Capita Annual Income (Euro)	Under 30,000	139	30.4%
	30,000-60,000	184	40.2%
	Above 60,000	133	28.8%
	I do not like to answer	2	0.4%
Family Status	Single	154	33.6%
	Single with children	19	4.2%
	Couple without children	96	21.0%
	Couple with children	182	39.7%
	Other	7	1.5%
Culinary Practices Origin	European-Irish	213	46.5%
	European- non-Irish	85	18.6%
	North American	10	2.2%
	South American	14	3.1%
	Asian	49	10.7%
	African	34	7.4%
	Australian	1	0.2%
	Middle Eastern	52	11.4%
Total responses / question		**458**	
Total Skipping / question		**97**	

3.2. The Respondents' Awareness of Acrylamide

There were seven questions used to assess the acrylamide awareness topic, as shown in Table 40.

Table 40: Responses to questions related to acrylamide awareness

Q3, Have you previously heard about acrylamide in food?			
Total Respondents (N)	**Category**	**Respondents (N)**	**Percentage (%)**
555	Yes	82	14.8%
	No	473	85.2%
Q31 Have you previously heard about the formation of a harmful compound when some carbohydrate foods (eg. bread, potatoes) are overheated to a brown-colour appearance?			
465	Yes	183	39.4%
Skipped 90	No	282	60.7%
Q4 Which of the following foods have the potential to contribute to high acrylamide exposure? (Tick as many as are relevant)			
82	Green vegetables	9	11.0%
	Fruit	4	4.9%
	Milk	8	9.8%
	Meat	27	32.9%
	Fish	16	19.5%
	Bread	43	52.4%
	Eggs	12	14.6%
	Potatoes	62	75.6%
	Poultry	15	18.3%
	Coffee	31	37.8%
	Biscuits & Crackers	43	52.4%
Skipped	Cereals	40	47.6%
473	Beer	8	9.8%
Q5 Why do you think so?			
83	I do not know	26	31.7%
	Presented a reason	56	68.3%
Q6 Under what conditions do you think acrylamide might form in foods? (Tick as many as are relevant)			
82	During freezing	3	3.66%
	During preparation	12	14.63%
	In a refrigerator	2	2.44%
	During storing in room temperature	6	7.32%
	High-temperature cooking	70	85.37%
	After eating/ digestion	0	0.00%
	I do not know	4	4.88%
Q32 What do you think are the negative health effects from this harmful compound?			
177	I do not know.	68	38.4%
	I know that (please specify)	109	61.6%
The negative health effects N 109	Carcinogenic	103	94.5%
	Neurotoxic	1	0.9%
	Other	4	3.7%
	N/A	3	2. 8%
Q33. From what source did you get your information about this harmful compound? (Tick as many as are relevant)			
178	TV	33	18.5%
	Internet/ social media	60	33.7%
	Journal/Magazine	41	23.0%
	From person (Family/friends)	74	41.6%
Skipped 377	School/College	45	25.3%
	Food Safety Authority of Ireland	14	7.9%
	Other	13	7.3%

The first of these questions (Q3) in this section determined the pathway through the survey for the respondents according to their responses. Over the total of 555 respondents, there were 473 (85.2%) who had not heard about acrylamide. Therefore, they were brought automatically to the second section of this questionnaire. On the other hand, the positive responses to Q3, those who heard about acrylamide as a term, amounted to 82 respondents (14.8%). When this question was asked using the terminology in Q31 ("hearing about a harmful compound that forms when some carbohydrate foods are overheated") the results rose to 183 from the 465 respondents and represented 39.4% from the total respondents. In Table 41 there was significant evidence of a relationship between Q3 and Q31, which was confirmed among Pearson Chi-Square test (with value 67.84,df =1 and *p=0.000)*. In this study, the frequency of hearing the term 'acrylamide' was xx%, double compared to the results from the Polish study, which recorded that 7% (Kowalska et al., 2017), and almost treble the 5.1% of Chinese students (Meng et al., 2012).Furthermore, acrylamide awareness levels among Irish people is almost within the level of awareness among UK, USA and France (22%) (DSM, 2018), but considerably less than Germany (54%).

The positive respondents to Q3 progressed to Q4, a multiple-choice question, for further evaluation of their knowledge. Therefore, from the 82 respondents, 75.6% chose potatoes as a potential food source contributing to high acrylamide exposure. Bread, biscuits and crackers were chosen by 52.4%, while 37.8% selected coffee as a main contributory source of acrylamide (Table 3-5).

Meat was chosen by almost one-third of the respondents as one of the main food contributors in acrylamide exposure. This is contrary to Tareke et al. (2002), who reported that, in general, protein-rich foods such as fish, meat and poultry under heat-treatment showed lower amounts of acrylamide than carbohydrate-rich foods. It is suggested that the data about choosing meat as a main source for acrylamide generation in this study developed due to mis-differentiation between acrylamide and heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs) compounds. HCAs and PAHs can commonly be generated in some cooked meats under high temperature, such as grilling and pan cooking (Cross and Sinha, 2004; Skog et al., 1998).

To gain further insight about the knowledge of the respondents, and for data validity, an open question (Q5) tested the reasons behind their selections regarding potential sources that contribute to high acrylamide exposure. About one-third of respondents did not know their reasons, on the other hand, 56 participants gave reasons. The results showed that starchy nature of the foods (as the reason for acrylamide formation) was 37.5%, while high temperature as a cause was represented by 19.6%. Additionally, 'just knowledge' was selected by 26.8% as the reason behind their responses. Other reasons such as cooking methods, cooking time and presence of asparagine in foodstuffs also were mentioned by two participants.

In order to gain further, in-depth understanding and evaluation of awareness, another confirmative question (Q6) was asked about the conditions which may be responsible for the formation of acrylamide in foods. From the 82 respondents, the amount who chose cooking at high temperatures represented 85.4%. This percentage reflects the high level of awareness about the main causes for acrylamide formation in food, which also confirmed the reliability of positive responses in regard to hearing about acrylamide. Q32 tested the knowledge about the adverse health impact associated with chronic exposure to acrylamide or over-heated carbohydrate foods. This question followed Q31, which informed the survey participants (N=555) about the acrylamide term.

The results showed that there was nearly a consensus of 94.5% who stated that there were carcinogenic risks associated with consumption of acrylamide. This percentage was shown in an open-ended question (Q32) among the 177 respondents who heard about harmful compounds associated with overheating of carbohydrate-based foods.

The recent EFSA report regarding the main sources for food-safety information in Ireland reported that TV formed the highest source of information about food safety topics (59%), followed by internet searching (47%), while paper media, radio and social media are nearly the same, between 37% to 39%. Person-to-person information reached almost one-third (32%) (EFSA, 2019). These results indicate that the food-safety issues are relatively well addressed among the media, but person-to-person knowledge or experiences are sometimes not accurate and mostly depend on individual opinions rather than scientific facts. Comparing to the present study data, as represented in answers to Q33, the main sources of information for those who answered that "they had previously heard about harmful compounds arising from overheating carb foods" are as follows: The dominant channels were via person-to-person (family/friends) which represents 41.6%, followed by internet and social media as a channel for information (33.7%), while TV shows 18.5%.

The results indicate a shortage in media, press and TV channels to highlight acrylamide topics compared to other food-safety topics. Therefore, most people take information from their family's daily activities (habits) or through searching for information online, as shown from the answers distribution. This way of gaining information will open the door to the possibility of widespread misunderstanding and personal opinions rather than scientific information, leading to unclear and incomplete perceptions about the potential risk. This suggestion is confirmed when compared with the EFSA (2019) report. Additionally, this suggestion is supported by the participants' responses. While they referred to knowing about acrylamide, further questions

pointed out that there were limitations in their claims, such as person-to-person being the source of their information. Receiving information from the internet was also recorded as the main source for acrylamide knowledge among a Polish-chosen population (Kowalska et al., 2017).

Table 41: The Relation between Responses to Q3 and Q31

			Q 31. Have you previously heard about the formation of a harmful compound when some carbohydrate foods are overheated to brown colour appearance?		
			No	Yes	Total
Q4. Have you previously heard about acrylamide in food?	No	Count	271	125	396
		%	68.4%	31.6%	100.0%
		% of Total	58.3%	26.9%	85.2%
	Yes	Count	11	58	69
		%	15.9%	84.1%	100.0%
		% of Total	2.4%	12.5%	14.8%
Total		Count	282	183	465
		% of Total	60.6%	39.4%	100.0%

3.3. Home Food Practices

This section relates to food-practice responses from the questionnaire, particularly practices which showed noticeable findings related to acrylamide exposure levels.

3.3.1 *Soaking Potatoes*

In relation to the practice of soaking potatoes, there were three questions that covered the applicability, duration and perceptions behind the soaking activity. From a total of 494 participants in Q13, 39.9% practiced soaking potatoes before cooking (Table 42). The underlying perceptions behind soaking raw potatoes before cooking were investigated through open-ended questioning, while the reasons behind soaking potatoes were categorised into seventeen themes. Various reasons were mentioned by the respondents and there appears to be no discernible reason that concurs over the total responses. Among those who did not soak potatoes, 21% believe that there is no need for it, or they were not aware of the soaking practice, 11% stated that a shortage of time was the reason, while others were worried about losing nutrients or absorbing water (Figure 1). On the other hand, the reasons for soaking potatoes before cooking (

Figure 14) shows that starch extraction and preventing potatoes browning were the most repeated responses, at 23.4% and 22.8% respectively. Some mentioned that they carried out soaking for hygienic purposes and others referred to it being a transferable habit from the family.

Regarding to the average time for soaking fresh potatoes question, there was 309 participants, revealed that the most common duration was five minutes or less 28.2%, whilst 25% soak potatoes for a 'convenient' time, meanwhile soaking for 30 minutes or more represented the lowest group at 17%.

Table 42: Frequency of Soaking Potatoes before Cooking

Q13. Do you soak peeled or cut potatoes before frying or roasting?

Answer Choices	**Responses (N)**	**Responses (%)**
Always	85	17.2%
Never	165	33.4%
Usually	112	22.7%
Rarely	112	22.7%
Not sure	20	4.1%
Total participants	**494**	
Skipping	**61**	

Figure 21: The Reasons behind No-Soaking (Never and Rarely) Potatoes.

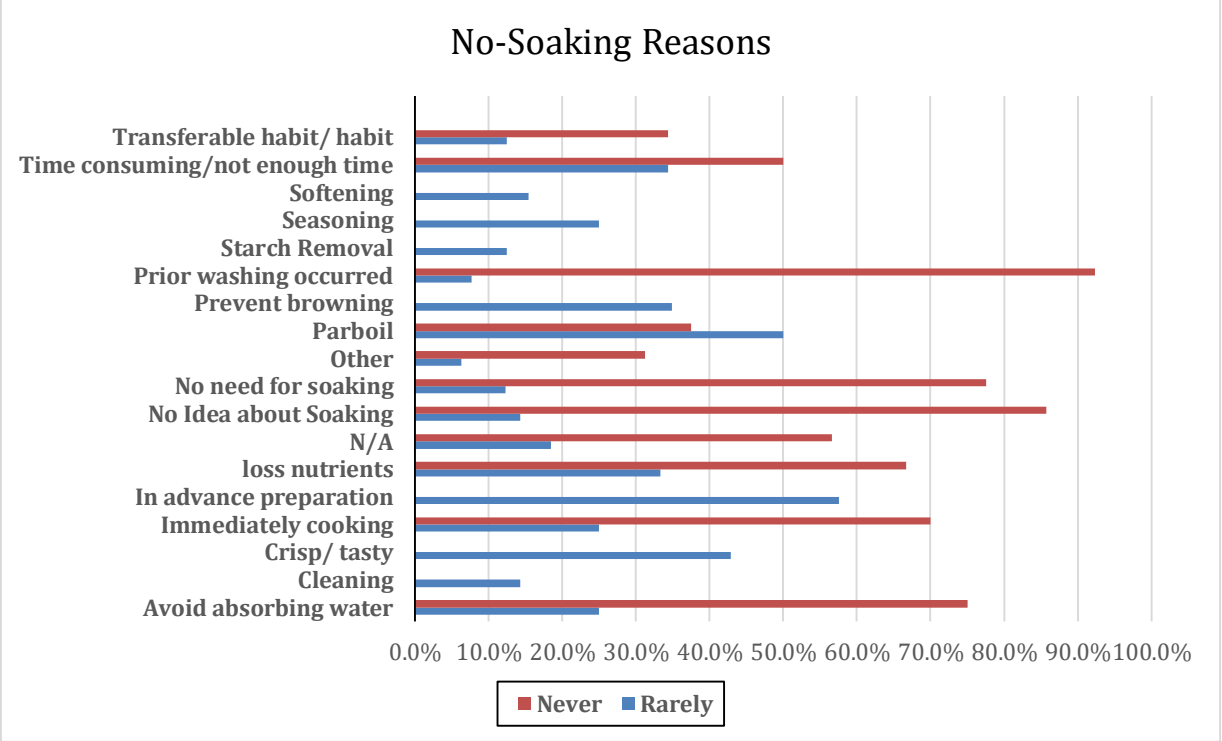
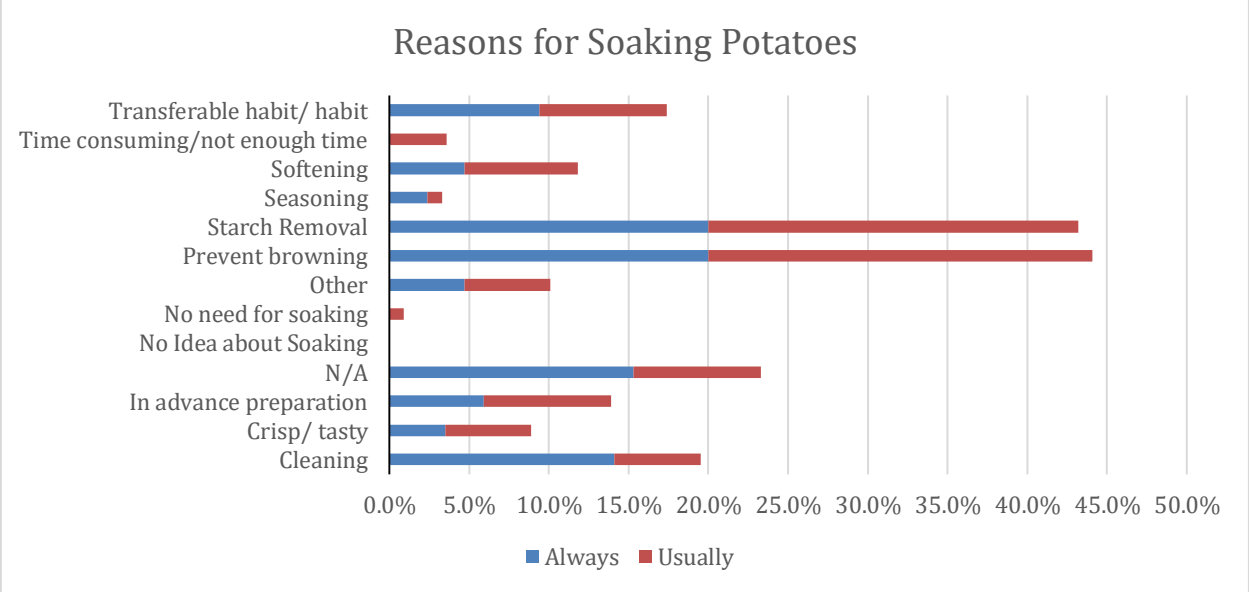


Figure 14: The Reasons behind Soaking (Always& Usually) Potatoes



Overall, the data about potato-soaking practices among the respondents indicates that almost 40% of those who practice soaking as a part of the potato-preparation process. This result is more than double the soaking-practice results among Spanish consumers, which was recorded to be 19.2% (Mesias, Delgado-Andrade,

Holgado, et al., 2018). However, the overall applicable times for soaking was a relatively short or non-specific duration. Whereas, HEATOX (2007b) recommended the soaking time to be at least for 30 minutes or more. In comparison, the result from a British field study showed that the participants did not consider soaking potatoes before cooking as part of the preparation procedures. However, they did it whenever it was convenient or when potatoes were peeled in advance to save time for other cooking tasks i.e. to prevent potato browning (Brook Lyndhurst, 2014). Moreover, the present findings show there are perceptions about the reasons behind soaking potatoes, such as removal of starch from potatoes, which was recorded as the most common reason for soaking potatoes. This is reported as a powerful way to reduce acrylamide generation (Pedreschi et al., 2006). Conversely, 'no need for soaking' as a reason was also presented among those who denied the necessity for soaking, while some attributed it to shortage of available time for preparations and cooking. Therefore, although there is awareness about soaking processes, the common actual time was not long enough to fulfil the purpose of extracting the large portion of acrylamide precursors.

3.3.2 *Parboiling Potatoes*

Aiming to reduce the generation of higher amounts of acrylamide when dealing with fresh potatoes, many projects and bodies recommended parboiling, soaking and blanching fresh potatoes before cooking to eliminate starch contents from potatoes. This would subsequently limit acrylamide level in end-cooked meals (FSAI, 2009; HEATOX, 2007a; UKHospitality, 2018). From a total of 493 who answered a question about parboiling fresh potatoes before cooking, there were 51 respondents who confirmed that they always blanch potatoes before further use (roasting or frying) in addition to 112 others who usually practice it, which together formed almost 33%. The majority do not parboil potatoes before cooking, representing 58.4%. In contrast to the current results, Brook Lyndhurst (2014) noted that all home-made fresh potatoes had been parboiled before roasting by the British participants, aiming to save roasting time and gaining desirable texture (N=275 respondents, open-ended questioning). In the current study, the most popular reason was reducing the cooking time at 41.5%, while achieving desired tenderness and fluffiest taste represented 15.6%. These are in line with the reasons that were mentioned previously by Brook Lyndhurst (2014). The results in regard to blanching fresh potatoes before cooking suggest it is not a common practice at home in Ireland, although it is an important step in reducing acrylamide formation in the end meals, and consequently minimising exposure to acrylamide via home-made potatoes (Zhang et al., 2018; Shojaee-Aliabadi et al., 2013; Viklund et al., 2010).

3.3.3 Cooking Time Estimation for Pre-cooked Potato Products

Table 43 displays methods for judging food's 'doneness'. The findings showed that just one in four people follow the label instructions regarding temperature and duration for cooking. Meanwhile, over 60% of people depend on other ways of judging doneness. This leads to the possibility of higher levels of acrylamide generation in home-made potatoes, as shown among Spanish home-made potatoes (Mesias, Delgado-Andrade, Holgado, et al., 2018). Fewer attempts to follow manufactures' instructions was also noticed by Brook Lyndhurst (2014); Brook Lyndhurst and WRAP (2011); Wright, Canham and Masrani (2011). Brook Lyndhurst (2014) recorded during an actual cooking practice study among participants that visual assessment was an important part for judging the food-cooking status besides the other means, such as time guide. This is in line with the results of the current study, where visual assessment alone represented 50% of the end-point evaluation tool in roasted potatoes.

Table 43: Percentage of Food Doneness Assessment Methods

When you cook pre-cooked foods (e.g. frozen chips), how do you estimate the cooking time?

Answer Choices	Responses (N)	Responses (%)
Visual assessment (i.e. of colour and texture)	232	49.9%
Abiding strictly to the instructed time on the label	147	31.6%
Tasting assessment	45	9.7%
Both tasting and visual assessment	2	0.4%
Following instructions plus other assessments (visual, taste)	15	3.2%
Never use frozen potatoes or chips	23	5.0%
Other	1	0.2%
Total responses	**465**	

3.3.4 Cooking End-Point Preferences

3.3.4.1 *Potatoes*

Regarding roasted potato preferences, over half prefer a medium colour degree for roasted potatoes (52.7%). Additionally, over a quarter (26.2%) like a brown surface colour. Those who prefer to eat light-colour roasted potatoes were represent by12.5%, in addition to 8.6% who express their refrain from cooking roasted potatoes

in general. The preference for a golden brown colour was also described as almost universally desired among UK domestic food practices in a field study by Brook Lyndhurst (2014). Moreover, the researchers pointed out that the term "golden" colour was not specific among the people when they described the degree of doneness. Therefore, the current study used photos to avoid confusion or misinterpretation of the questions' words.

The preferences of colour for chips ranged between yellow and brown. The findings demonstrate that there is a similarity in the number of participants who like golden-yellow chips and golden-brown chips. Combined, both preferences represent the majority, with approximately 93% among those who eat chips. On the other hand, only 6.7% like cooking chips to a light degree.

When searching for the reasons behind cooking preferences, particularly for roasted potatoes and chips, almost all the reasons for both were the same per individual, where the responses were through open-ended questioning. The desire for tastier potatoes appeared clearly behind reasons such as crispy, crunchy and soft. From the present results, the desire for crispness was the most mentioned reason. However, some other reasons described did not differ from the comprehensive item, which is the taste, such as crunchy and tasty. Consistent with this finding, Brook Lyndhurst (2014) summarised that most people look for crispness and golden colouration of the potatoes, and reported that the desire for specific food preferences originated from childhood experiences. In line with that, in a Spanish home-cooking pilot study, Mesias et al. (2018) recorded that the colour of fried potatoes was considered as the major estimated parameter using for frying chips cooking end-point and represented 87.7%, furthermore, golden degree preferences hit 92% aiming for crunchiness and softness, which were considered the major reasons . The indication from the present study is that the desired taste depends on the specific colour degree. Therefore, the link between taste and colour, or appearance of the food, helps people in their choices, and that is also shown in previously mentioned British and Spanish studies.

Most people prefer golden-to-brown colour, this suggests there may be scope to engineer potato varieties that obtain a golden colour early at the cooking stage without increasing the level of acrylamide that may help to overcome the present level of exposure which is linked to visual appearance.

3.3.4.2 Toasted Bread

The toasted bread preferences in this study shows the predominant choice is medium-toasted with 354 out of 465 respondents. Less than 5% recorded preferences for dark-coloured toast. The light toasting option is the lowest risk, and is recommended by HEATOX (2007a), however the present study shows those who prefer light toasted bread was under 15%.

Since, the findings from previous studies (Granby et al., 2008; Eerola et al., 2007; HAETOX, 2007a) confirmed that elevated levels of acrylamide in medium toasting may reach fivefold higher than untoasted bread. The level of acrylamide is also related to the type of the bread. In the present study, the findings refer to there were among brown and wholemeal bread consumers about 76.5% (250) preferred medium toasting degree (Table 44). This number forms about 70.6% (250) from the total number of whom desire a medium toasting degree for bread in this current study. In the same time, the desire to medium toasting degree formed 76.1% (354) among the overall types of bread toasting preference degrees.

Table 44 Bread Toasting Preferences among Brown/Wholemeal Bread Responses

Bread Preference		**Bread Type**		Total
		Wholemeal	Brown	
Dark Toasted	Count	15	12	**17**
	% within Bread Preference	88.2%	70.6%	
	% within Brown wholemeal	6.1%	6.3%	
Light Toasted	Count	27	29	**48**
	% within Bread Preference	56.3%	60.4%	
	% within Brown wholemeal	11.0%	15.3%	
Medium Toasted	Count	193	139	**250**
	% within Bread Preference	77.2%	55.6%	
	% within Brown wholemeal	78.8%	73.5%	
Other	Count	2	1	**2**
	% within Bread Preference	100.0%	50. %	
	% within Brown wholemeal	0.8%	0.5%	

Untoasted bread	Count	8	8	**10**
	% within Bread Preference	80.0%	80. %	
	% within Brown wholemeal	3.3%	4.2%	
Total	Count	245	189	**327**

Percentages and totals are based on respondents.

a. Dichotomy group tabulated at value 1.

Through an open-ended question, 464 participants described the reasons behind their particular toasting degree preferences. The most frequently recorded reasons were in general the taste characteristic of the specific toasting degree (23.5%), specifically the desire for crispness (19.6%) and crunchiness (12.5%). For further insight, the link between the toasting degree preferences with the different reasons has been summarised in Table 45. It was noticed that "tasty" reason showed ascending trend with the tendency for more darker toasted bread preference, as " tasty" reason forms about 20% in light and untoasted bread responses and reached to over 40% among dark toasting responses. Also, the same pattern was observed in regard to crunchiness desire, while crispness dominates in medium toasting choices. This results pattern is in line with the fact that the Maillard reaction is responsible for producing the aroma, flavour and colour of the cooked food, which is also linked to acrylamide generation (Nursten, 2005).

Table 45 Frequency of Reasons for Specific Toasting Degree Vs Toasting Preferences.

Toasting preference	**Untoasted+Light**		**Medium**		**Dark**		**Total**	
Reason Category	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Visually appealing	1	1.2%	21	5.9%	1	4.6%	24	4.8%
Texture	5	6.2%	33	9.3%	0	0.0%	38	7.6%
Aroma	2	2.5%	1	0.3%	1	4.6%	4	0.8%
Tasty	17	21.0%	83	23.5%	9	40.9%	109	21.7%
Crispy	8	9.9%	77	21.8%	4	18.2%	89	17.7%
Crunchy	2	2.5%	52	14.7%	4	18.2%	58	11.5%
Warm/hot	8	9.9%	16	4.5%	1	4.6%	25	5.0%
Soft	6	7.4%	5	1.4%	0	0.0%	11	2.2%
Healthy	5	6.2%	1	0.3%	0	0.0%	6	1.2%
Medium toasted	11	13.6%	17	4.8%	0	0.0%	28	5.6%
I don't like burnt toast	2	2.5%	1	0.3%	0	0.0%	3	0.6%
Other	16	19.8%	57	16.1%	1	4.6%	74	14.7%
N/A	6	7.4%	25	7.0%	3	13.6%	34	6.8%
Total responders	**81**	**100%**	**354**	**100%**	**22**	**100%**	**503**	**100%**

4. Conclusion

The existing knowledge about acrylamide formation and its risk among Irish residents suggested that the scientific term “acrylamide” was not recognised widely among the inhabitants 14.8%, in contrast to the definition as a harmful component formed during heat treatment of carbohydrate-rich food, which showed about 39% recognising that. However, the awareness about the health risk of this harmful compound (acrylamide) showed significant high percentage about the carcinogenic effects, which reached 94.5% among those who heard about this harmful compound. The awareness about the role of high cooking temperature as the main contributor in AA generation represented 85.4% in responses. Additionally, the results indicated that linking the major foodstuff contributors in acrylamide formation showed that potatoes 75%, bread, biscuits and cracks 52%, cereals 48% and coffee 38% were among the foodstuffs people associated with acrylamide.

Overall, the suspected high exposure to AA through home-made food practices or food preferences in this study emerge from a lack of knowledge of good cooking practices. In particularly, parboiling, soaking and the surface colour degree preferences for cooked food. The process of parboiling and proper soaking fresh potatoes were not considered common practices among the participants, which reflects the possibility of keeping the levels of the precursors high, consequently increasing risk of acrylamide exposure. Where almost 40% soaking potatoes and 17% from them soaking potatoes for 30 minutes or more. While just 33% of the participants are practicing parboiling before cooking. In addition to this, the tendency for golden yellow to brown degree for cooked foods surfaces such as roasted potatoes, chips and toasted bread.

This highlights the recommendations for extensive focused efforts at different levels to teach and improve knowledge about good cooking practices. Food habits must change to minimise exposure to acrylamide from home- prepared meals. Awareness programmes should cover all age groups, with input from all relative bodies and agencies, such as education sectors, food safety and industry. Those campaigns such as

a public awareness campaign *Go for Gold*, which aims to help consumers reduce their exposure to acrylamide when cooking at home, which was launched by the Food Standards Agency (FSA) in the UK. Hand washing campaign, food waste and other food safety campaigns by Safefood.

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APPENDICES

APPENDICES

Appendix A: The study questionnaire

Domestic Food Practices & Acrylamide Awareness in the Republic of Ireland 2019

Dear Sir or Madam,

I am studying Food Safety Management. This survey is designed to measure the acrylamide risk awareness and related domestic food practices of the residents in Ireland. The survey is carried out as part of my master thesis. The questionnaire can help researchers identify whether or not there are any common practices or misconceptions that should be addressed. It takes about 7 minutes.

This survey is anonymous and your participation is voluntary. The data will be kept confidentially, will not be disclosed to third parties and will be used solely for the scientific purpose of this study. By completing this survey you are agreeing that that anonymous data you provide will be analysed and may later be published by the author. Kindly ask you to answer the questions completely and truthfully.
Please do not worry about spelling mistakes or grammar. I am only interested in your actual daily food practices.

You are welcome to contact me with any questions or for more information.
E-mail: amany.aly@mydit.ie

Thank you for participating in this survey.

* 1 . **Residence**

- ◯ I live in Ireland
- ◯ I do not live in Ireland

* 2. **Is your age over 18 years old?**

- ◯ Yes
- ◯ No

* 3 . **Have you previously heard about acrylamide in food?**

- ◯ Yes
- ◯ No (ship to question No. 7)

*** 4. Which of the following foods have the potential to contribute to high acrylamide exposure? (Tick as many as are relevant).**

- ☐ Green vegetables
- ☐ Fruit
- ☐ Milk
- ☐ Meat
- ☐ Fish
- ☐ Bread
- ☐ Eggs
- ☐ Potatoes
- ☐ Poultry
- ☐ Coffee
- ☐ Biscuits /Crackers Cereals.
- ☐ Beer.
- ☐ Cereals.

* 5. **Why do you think so?**

◯ I do not know

◯ I chose those foods because: (*Please specified in the below box*)

I think :

* **6. Under what conditions do you think acrylamide might form in foods? (Tick as many as are relevant).**

☐ During freezing

☐ During preparation (e.g. peeling, cutting, exc..).

☐ In a refrigerator.

☐ During storing in room temperature.

☐ High temperature cooking (such as frying, roasting, or baking).

☐ After eating/ digestion

☐ I do not know.

* **7. Where do you usually store raw potatoes?**

◯ Fridge

◯ Freezer

◯ In a closet or a pantry at room temperature.

◯ I do not use raw potatoes at all . ((ship to question No. 18)

◯ Other (please specify)

8 For what reason do you store raw potatoes there?

9. For how long would you say you usually store raw potatoes from date of purchase?

- 0-3 days
- 4-6 days
- 7-9 days
- For 2 weeks
- More than 2 weeks
- I can not remember.

* **10. Do you usually peel the potatoes before cooking?**

- Always
- Never (skip to question No. 12)
- Usually
- Rarely
- Not sure.

* 11 **Do you usually wash the potatoes after peeling?**

- Always
- Never
- Usually
- Rarely
- Not sure.

* **12. Which size do you usually cut potatoes for roasting? (Tick as many as are relevant)**

☐ Whole

☐ Medium size cubes

☐ Halves

☐ Medium size circles

☐ Quarters

☐ Chips size

☐ Wedges

☐ Crisps size

☐ Smaller size than above

Smaller size than above

☐ Thin size

☐ Other (please specify)

* **13. Do you soak peeled or cut potatoes before frying or roasting?**

- ○ Always
- ○ Never (skip to question No. 16)
- ○ Usually
- ○ Rarely
- ○ Not sure (skip to question No. 16)

* **14. For what reason do you soak, or not soak raw potatoes?**

15. If you soak raw potatoes, what is the average time for soaking?

- ○ 5 min or less
- ○ 15 min
- ○ 30 mins
- ○ 1 hr. or more
- ○ I don't know the exact time.
- ○ Whatever is convenient between preparation and cooking

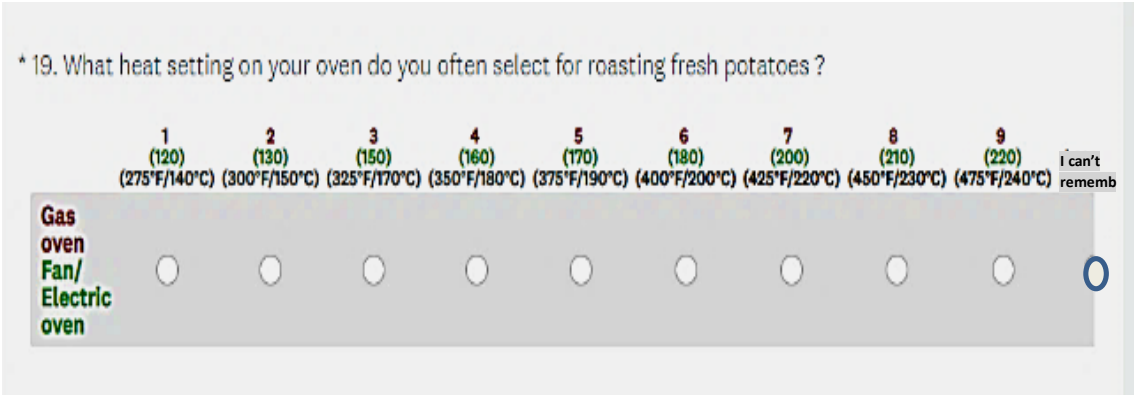
16. Do you parboil the potatoes before cooking?

- ○ Always
- ○ Never (skip to question No. 18)
- ○ Usually
- ○ Rarely
- ○ Not sure. (skip to question No. 18)

* 17. Why do you parboil the potatoes before cooking?

* 18. When you cook pre-cooked foods (e.g. frozen chips), how do you estimate the cooking time?

- ◯ Visual assessment (i.e. of colour and texture).
- ◯ Abiding strictly to the instructed time on the label.
- ◯ Tasting assessment.
- ◯ Other (please specify)

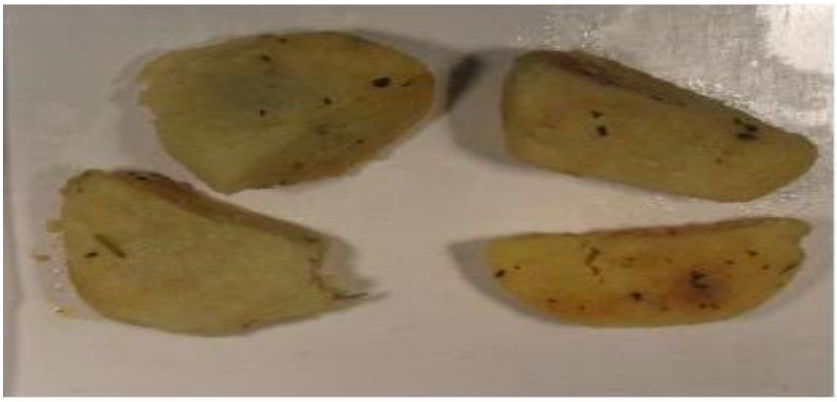


* **20. Which photo represents your preference for roasted potatoes?**

○ A

○ B

○ C



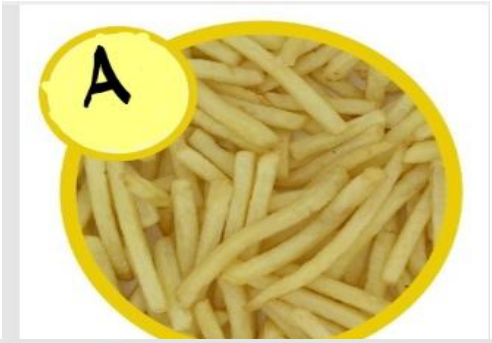
○ D. I do not cook roasted potatoes at all.

21. How do you normally cook chips?

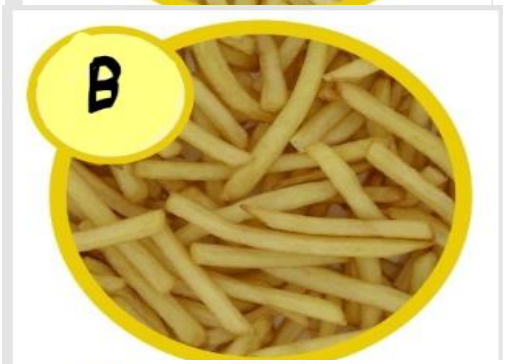
- ◯ Deep-frying
- ◯ Air fryer
- ◯ Pan/shallow
- ◯ Roasting/
- ◯ Grille
- ◯ Microwaved
- ◯ I do not cook chips at all.
- ◯ Other (please

*** 22. Which photo represents your preference for chips?**

◯ A.



◯ B



◯ C.

◯ D. I do not like / eat at all.

* 23. **For what reasons do you have these colour preferences?**

For roasted potatoes:

For chips :

* 24. **How often do you eat chips or roasted potatoes?**

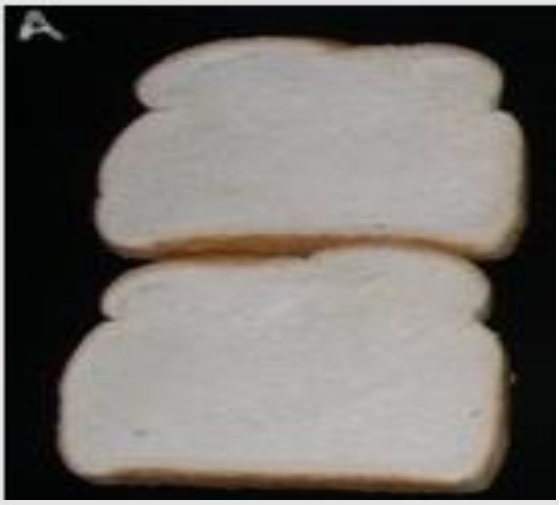
- ○ Daily
- ○ 2-3 time weekly.
- ○ Once a week.
- ○ Once a month
- ○ Never

* **25. What type of bread do you usually buy? 'tick all that apply'**

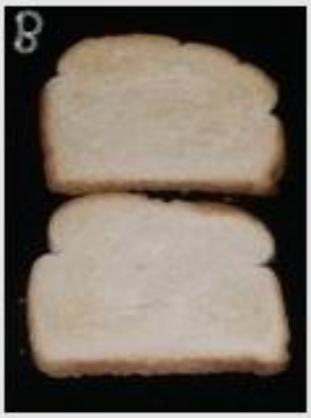
- ☐ White sliced pan
- ☐ Brown sliced pan
- ☐ Whole meal bread
- ☐ Soft bread /wraps
- ☐ Soda bread
- ☐ Potato bread
- ☐ Ginger bread
- ☐ Rye bread
- ☐ Crisp bread
- ☐ I do not use bread.
- ☐ Other (please specify)

26. Which photo represents your preference for toasting bread?

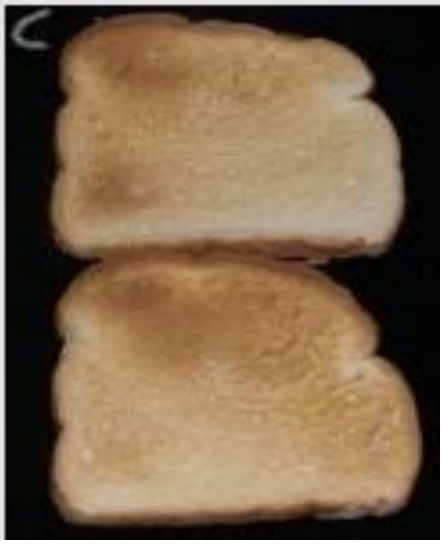
○ A. Untoasted bread



○ B



○ C



○ D

○ Other (please specify):

. 27 Why do you like your preference for how well toasted you like your bread?

28. How many slices of bread do you usually eat per day?

- ◯ Rarely
- ◯ 1-2 slices/ day
- ◯ 3-5 slices/ day
- ◯ More than 5 slices /day
- ◯ Other (please specify)

*29. **Which type of coffee do you usually drink?**

- ◯ Instant coffee
- ◯ Roasted/ground coffee
- ◯ Coffee substitutes.
- ◯ I don't drink coffee.
- ◯ Other (please specify)

***30. How many cups of coffee do you drink daily?**

- ◯ 0 cup
- ◯ 1 cup
- ◯ 2 cups
- ◯ 3 cups
- ◯ 4 cups
- ◯ 5 cups
- ◯ More than 5 cups.

***31. Have you previously heard about the formation of a harmful compound when some carbohydrate foods (eg. bread, potatoes) are overheated to brown colour appearance?**

- ◯ Yes
- ◯ No (skip to question No. 34)

32. What do you think are the negative health effects from this a harmful compound?

- ◯ I do not know.
- ◯ I know that *(Please specified in the below box)*

The negative health effects may be :

* **33. From what source did you get your information about this harmful compound? ((Tick as many as are relevant).**

- ◯ TV
- ◯ Internet/ social media
- ◯ Journal/Magazine
- ◯ From person (Family/friends)
- ◯ School/Collage.
- ◯ Food Safety Authority of Ireland.
- ◯ Other (please specify)

* **34.** ***"Acrylamide is a harmful compound produced when some carbohydrate foods become brown due to overheating",*** **should food packaging contain information about the content and safe level of acrylamide (for example the maximum daily limit)?**

- ◯ Yes, definitely
- ◯ Definitely, not
- ◯ I don't have a strong opinion either.

* **35. In your opinion, should food packaging contain information about the potential formation of acrylamide in the product if the cooking instructions are not properly followed?**

- ◯ Yes, definitely
- ◯ Definitely not
- ◯ I don't have a strong opinion either.

* **36. In your opinion, if a product's label listed acrylamide at a safe level (or below the recommended daily limit), would you buy the product?**

- ◯ Yes, definitely
- ◯ Definitely not
- ◯ Not sure

* **37. What is your residence area?**

- ◯ City/Town
- ◯ Countryside

* **38. What is your age range?**

- ◯ Under 18
- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55-64
- ◯ 65+

39. Average household Income is

- ◯ Below € 30,000
- ◯ € 30,000- € 60,000
- ◯ Above € 60,000

* **40. What is the highest level of education you have completed?**

- ◯ University or other higher qualification
- ◯ Leaving cert.
- ◯ Junior cert.
- ◯ No qualification

* 41**. What is your gender?**

- ◯ Male
- ◯ Female
- ◯ Other

* 42**. Family status:**

- ◯ Single
- ◯ Single with children
- ◯ Couple without children
- ◯ Couple with children
- ◯ Other

43. From what continental origins would your family's culinary practices be most influenced by?

- ◯ European-Irish
- ◯ European- non Irish
- ◯ North American
- ◯ South American
- ◯ Asian
- ◯ African
- ◯ Australian
- ◯ Middle Eastern

Thank You ….Your participation is greatly appreciated

Appendix B: Author Guidelines for the Food Control Journal

FOOD CONTROL

An official scientific journal of the European Federation of Food Science and Technology (EFFoST) and the International Union of Food Science and Technology (IUFoST).

GUIDE FOR AUTHORS

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INTRODUCTION

Food Control is an international journal that provides essential information for those involved in food safety and process control.

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