Food insecurity, food waste, food behaviours and cooking confidence of UK citizens at the start of the COVID-19 lockdown.

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Abstract

Purpose: The current pilot study explored food insecurity, food waste, food related behaviours and cooking confidence of UK consumers following the COVID-19 lockdown.

Methods: Data were collected from 473 UK based consumers (63% female) during the first UK lockdown in 2020. A cross-sectional online survey measured variables including, food insecurity prevalence, self-reported food waste, food management behaviours, confidence and frequency of use of a range of cooking methods, type of food eaten (ultra-processed, semi-finished, unprocessed) and packaging type foods are purchased in.

Findings: 39% of participants have experienced some food insecurity in the last 12 months. Being younger, having a greater BMI and living in a smaller household were associated with food insecurity. Green leaves, carrots, potatoes and sliced bread are the most wasted of purchased foods. Polenta, green leaves and white rice are the most wasted cooked foods. Food secure participants reported wasting a smaller percentage of purchased and cooked foods compared to food insecure participants. Overall, participants were most confident about boiling, microwaving and stir-frying and least confident with using a pressure cooker or sous vide. Food secure participants were more confident with boiling, stir-frying, grilling and roasting than insecure food participants.

Practical Implications: This has implications for post lockdown policy, food policies and guidance for public-facing communications.

Originality: We identified novel differences in self-report food waste behaviours and cooking confidence between the food secure and insecure consumers, and observed demographics associated with food insecurity.

Keywords: food waste, COVID-19, food insecurity, cooking confidence, UK

Article classification: Research Paper

1. Introduction

Ending food insecurity, improving nutrition and providing a sustainable food system are some of the biggest challenges featured in the United Nations Sustainable Development Goals (SDG), (United Nations, 2015). The UK government has pledged to reduce food waste, end hunger and provide food security for all by 2030 (UK Government, 2015). However, UK consumers throw away 6.6 million tonnes of food waste a year (WRAP, 2020a) and an estimated 2.2 million UK consumers experienced food insecurity in 2018 (Food and Agriculture Organization of the United Nations, 2018). Though the UK has improved mechanisms to monitor food insecurity to assess SDG progress (see Office for National Statistics, 2019), there is little in-depth understanding of the prevalence of food insecurity, and association with food waste and wider food management behaviours. The COVID-19 pandemic has highlighted issues in the UK's food system relating to food insecurity, poverty and health inequalities.

1.1. Food (in)security in the UK

Food security is achieved "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2015 p. 53). It is estimated that (pre-

COVID-19) 21% of the UK population experienced some form of food insecurity in 2016 (NatCen Social Research, Food Standards Agency, 2017; Food Standards Agency, 2020a). However, there is a paucity of evidence which comprehensively documents the prevalence of food insecurity in the UK, and the impact of COVID-19 (EFRA, 2020; House of Lords, 2020). It is essential that we develop a greater understanding of food insecurity in the UK, as identifying the scale and underlying causes of food insecurity, impact of significant events, and impact on public health, will provide a basis to tackle the issues (House of Lords, 2020; Long *et al.,* 2020). COVID-19 has exacerbated the prevalence of food insecurity within the UK. Following the UK lockdown (23rd March 2020), demand for emergency food parcels from food banks increased by 81% (Trussell Trust, 2020). In addition, 43% of consumers highlight concern about the cost of additional food (Hubbub, 2020). Younger adults (16-24 years) and those with children have been disproportionately impacted, forming the majority of new food bank users (National Food Strategy, 2020).

A survey conducted between 7th-9th April 2020 gave insight into the prevalence of UK food insecurity in the beginning of the COVID-19 pandemic (MacMillan, 2020). The research revealed that 16% of adults had experienced food insecurity, 21% didn't have enough money to buy adequate food supplies, 50% were unable to get the food they needed from the shops due to shortages and 25% were unable to leave their homes and had no other way to get the food they needed. 14% of respondents reported that someone in the household had to reduce or skip meals because they could not access or afford sufficient sustenance, 6% indicated that someone in the household had gone hungry in the first three weeks of lockdown and 3% reported that at least one person had gone a whole day without eating. Subsequent research conducted in April and May 2020 echoed these findings (University of Essex, Institute for Social and Economic Research, 2020).

A greater incidence of food insecurity has also been reported in vulnerable groups, such as adults with physical or mental disabilities, households with children, and households with a member shielding or with COVID-19 symptoms (Food Standards Agency, 2020b; Loopstra, 2020; National Food Strategy, 2020). Vulnerable adults are eating fewer portions of fruit and vegetables, and children from lower socio-economic status (SES) households are eating more junk food and snacks but fewer portions of fruit and vegetables compared to peers from higher SES households (National Food Strategy, 2020). Since lockdown there has been an increase in some 'negative' food behaviours, such as eating food past the use-by date, presenting food safety issues. The consumption of foods past the use-by date is more prevalent in those experiencing food insecurity (Food Standards Agency, 2020a, 2020b).

1.2. Food behaviours and cooking skills

COVID-19 has had an impact on the diet of the UK population. Consumers experiencing poverty are less able to access healthy and sustainable diets as healthy diets cost approximately three times the costs of less healthy alternatives (House of Lords, 2020, Reynolds *et al.,* 2019, Scott *et al.,* 2018). Financial stress and not having sufficient money to buy food has been associated with a decrease in the planning and preparation of healthier foods (De Backer et al., 2021). In addition, food recommended for a healthier diet carries a higher risk of waste, requires more preparation, kitchen equipment and cooking time, each of which has an associated cost. Low income consumers are more likely to live in 'food deserts' (Wrigley, 2002), and the need to use public transport presents a barrier to accessing larger supermarkets which stock fresh produce. Consequently, low income consumers are nudged to source foods at local convenience shops which typically stock more processed foods (House of Lords, 2020), and typically eat less minimally processed foods (e.g. tinned lentils, frozen chicken) (Adams and White, 2015), less wholemeal or high fibre foods (Nelson et al., 2007),

and fewer portions of fruit and vegetables, compared to the general population (Food Foundation, 2016, 2020). Similarly, vulnerable adults are eating fewer portions of fruit and vegetables, and children from lower socio-economic status (SES) households are eating more junk food and snacks but fewer portions of fruit and vegetables compared to peers from higher SES households (National Food Strategy, 2020). Since lockdown there has also been an increase in 'negative' food behaviours, such as eating food past the use-buy date, presenting potential safety issues. 58% of UK consumers surveyed indicated that someone in their household had eaten food past the use-by date. Bagged salad, cheese and cooked meat are most often eaten past the use-by date. The consumption of foods past the use-by date is especially prevalent in those experiencing food insecurity (Food Standards Agency, 2020a, 2020b).

Beyond access to food, COVID-19 has changed consumer food habits and skills. Post-lockdown consumers engaged in more positive food management behaviours such as writing a shopping list, meal planning, batch-cooking and the use/consumption of leftovers . However, consumers are also shopping less frequently, eating less takeaway, cooking and eating in the home more (Murphy et al., 2021; WRAP, 2020a). Although cooking skills in isolation cannot ensure a healthy diet (Wilson, 2007), having the skills to prepare and cook food is considered an essential element in the ability to consume a healthy and sustainable diet Perceived cooking skills can vary by a range of demographic factors, such as age, gender, SES (Anderson, 2007; Caraher *et al.,* 1999; Nelson *et al.,* 2007; Lam & Adams, 2017). Cooking interventions which improve cooking skills and confidence have been shown to have a positive impact on consumption of healthy diets (Sprake *et al.,* 2018), consumers with high levels of cooking skills are less likely to consume moderately or highly processed foods (Brunner *et al.,* 2010). In addition, improving cooking skills has also been reported to reduce food waste (Dyen & Sirieix,

2016).

1.3. Food waste

The food life cycle contributes to 20-30% of global greenhouse gas emissions (Kause *et al.*, 2009; Poore and Nemecek, 2018). UK consumers throw away 6.6 million tonnes of food waste a year (WRAP, 2020a), contributing to global greenhouse gas emissions and climate change (Camilleri *et al.,* 2019). Reducing food waste is a critical element in reducing the impact of the food lifecycle on the environment (Clark, 2019; Reynolds *et al.,* 2020; Tirado-Von Der Pahlen, 2017). Consequently, it is important to identify which types of foods and how much are typically being wasted, and how waste links to wider consumer food habits.

The UKs annual household food waste is reducing (2007-2018: 1.4 million tonnes reduction) but still equates to 10 billion meals (WRAP, 2020b). Though 37% of food waste is inedible (e.g. bones, peelings), (Nicholes *et al.,* 2019), 61% of waste could be avoided through better food management with 15% of food being wasted because it has passed the expiry date. Fresh vegetables and salad constitute 28% of household food waste with potatoes, bread and milk being among the most wasted foods. Waste from cooked meals (home-made and pre-prepared) significantly contributes to food waste, with cooking or preparing too much food producing 12% of waste and on-plate 'leftovers' producing 19% of waste (Quested and Murphy, 2014).

COVID-19 and lockdown has had an impact on food waste, with 33-48% of UK consumers reporting less food waste following lockdown (Hubbub, 2020; Macmillan, 2020; WRAP, 2020a). Initial research following lockdown showed that 57% of consumers who engage in 10+ food management strategies reported a reduction in food waste since lockdown (WRAP, 2020a). Adopted food management behaviours appears to have been retained as lockdown

restrictions have eased (WRAP, 2020c). However recent research indicates that food waste has increased by 31% from the initial lockdown period, moving toward pre-lockdown levels as restrictions ease (WRAP, 2020c). Reduced food waste is more prevalent in consumers who have children at home, women, are aged 18-34 or 35-44 years, are impacted by COVID-19 (e.g. furloughed, home working) or have seen the "Love Food Hate Waste" campaign (WRAP, 2018; WRAP, 2020a; WRAP, 2020c). However, research which has explored food (in)secure groups (e.g. Anderson, 2007; Nelson et al., 2007) has not (pre-COVID-19) explored the impact of food (in)security on food waste.

Although evidence regarding COVID-19 impacts on food security (EFRA, 2020; House of Lords, 2020; Trussell Trust, 2020; National Food Strategy, 2020; MacMillan, 2020; University of Essex, Institute for Social and Economic Research, 2020; Food Standards Agency, 2020b; Loopstra, 2020), food behaviours (House of Lords, 2020; Food Foundation, 2020; National Food Strategy, 2020; Food Standards Agency, 2020a, 2020b), cooking skills (Benson et al, 2021; Murphy et al., 2021; WRAP, 2020a) and food waste (Hubbub, 2020; Macmillan, 2020; WRAP, 2020a; WRAP, 2020c) within the UK population are already known, we are not aware of any research to date which explores all these factors combined within a sample of the UK population. Addressing a gap in current understanding, the current research aims to explore the relationship between food insecurity, food waste, food related behaviours and cooking skills of UK consumers following the COVID-19 lockdown.

2. Method

2.1. Participants

UK based participants (n=473) were recruited during the first UK lockdown (25th to 31st March 2020), (age M=35.73 years, SD= 12.67, 63% female). All

participants were aged 18 years or over and registered Qualtrics (an online survey tool and participant pool) users who saw an advert for the study, which contained a link to the survey. We sampled at a power calculation (confidence level: 95%, margin of error: 5%, population proportion 50% (due to pilot), population size:66650000, N=385). A convenience sample stratified by age (see Otten et al., 2009; WHO 2020) was used in order to ensure greater representation across age groups and reduce sampling error. Participants received payment for completing the survey. Twenty participants were removed from the analysis due to incomplete data.

2.2. Design and materials

A cross-sectional survey was hosted on Qualtrics. The survey combined questions from existing measures and novel questions, and consisted of two sections. The first section of the survey addressed dietary preferences, dietary motivations, cooking habits and skills, and food shopping habits. The second section of the survey presented a series of questions about 15 foods commonly consumed in the UK. The foods were selected from the Waves 1-4 National Diet and Nutrition Survey (Public Health England, 2018) and were chosen to represent a range of popular food categories including meat (beef, chicken), grains and cereals (white rice, bread roll, sliced bread, spaghetti / noodles, polenta) and vegetables (green leaves, beans in sauce, lentils, carrot, tomato, green beans, sweet potato, potato).

The questions used a series of visual analog scales to rate the frequency which participants typically consume the 15 foods (6 point scale: every meal - less

than once a month), how many portions they would typically prepare at once (scale: 0-25 portions), how long typical preparation (scale: 0-60 minutes) and cooking (scale: 0-120 minutes) of the food would take, and the estimated proportion of purchased (scale: 0-100%) and cooked (scale: 0-100%) food that is wasted. Participants were asked to indicate the method (i.e. boiling, poaching, steaming, shallow frying, stir frying, microwaving, grilling, over-baking/roasting, stewing, pressure cooker, sous vide, deep frying, barbecue) that was typically used to cook each of the 15 foods, and their confidence in using each method (3 point scale: "Not confident" to "Very confident", and "I don't know this method" option). Responses were selected using the corresponding "radio/option button" for each category. Additional questions which addressed portion size, carbon footprint, energy content, food safety and animal welfare were asked, however these will not be discussed in the current research.

The survey (excluding the USDA food security questions) was developed by the research team which included experts in cooking practices, food and climate change, and calculations of GHGE from food production and cooking. A pilot of the survey was conducted in 2019 from which the survey was further developed. For example, a greater variety of cooking techniques and appliances were included, and more detailed definitions of scratch, semi-scratch cooking, and ultra-processed ingredients were added. The modified version of the survey went through face validation and was used for data collection in 2020 (Armstrong et al., 2021).

2.3. Procedure

Participants were recruited via an advert on Qualtrics, a link directed participants to the survey. Before taking part in the survey, participants were asked to read the study information and provide consent. Participants then completed the online survey. Each participant was presented with all questions and the survey took approximately 20 minutes to complete.

2.4. Ethical Considerations

This study was conducted according to the guidelines laid down in the Declaration of Helsinki. All procedures involving research study participants were approved by the Geography Department, University of Sheffield ethics panel (reference, Piloting Zooniverse to help us understand citizen food perceptions - 2nd phase no. 024356). Each participant was presented with an information sheet prior to the survey, with information about how the data would be used in research, and a statement which specified that proceeding with the study would be taken as informed consent.

2.5. Data Analysis

The survey presented six dietary preference options: vegan, lacto-vegetarian, ovo-lacto vegetarian, pescetarian, omnivore, and 'other'. These options were condensed to four categories: vegan, vegetarian (lacto-vegetarian, ovo-lacto vegetarian), omnivore (pescetarian, omnivore), and 'other' due to low counts in some categories and for ease of analysis. BMI was calculated using the height (cm) and weight (kg) values provided by participants, using the formula: BMI=weight kg/height m^2 (NHS, 2019). As less than 1% of UK

consumers have a BMI below 15 or above 50 (Farooqi, 2014, Withings, 2020), 0.4% of participants indicated a BMI below 15 and 4.9% indicated a BMI over 50, these participants were removed from analyses addressing BMI only. 17.9% of participants did not complete the measure of height and weight which were used to calculate BMI, these participants were removed from analyses addressing BMI only. Participants were classified as food insecure if they answered 'often true' and 'sometimes true' to any of three food security questions. All other participants were classified as food secure. Two participants declined to answer food security questions and were removed from analyses relating to food (in)security. Data from n=451 participants were used to explore food (in)security questions. To calculate participant cooking confidence, confidence ratings were converted to numerical values: 0 - I don't know this method; 1 - Not confident, 2 - Little confident, 3- Confident, 4- Very confident. Overall cooking confidence was calculated from the confidence level indicated for each cooking method.

The software SPSS (Statistical Package for the Social Sciences) version 26 (IBM, 2019) was used to conduct the analyses. A series of descriptive, Chi-square, Kruskal Wallis H and correlation analyses were conducted to explore the data.

3. Results

3.1. Demographics, dietary preference and motivations.

Data from 453 UK based participants were used (63% female, mean age =35.73 years). 65% of participants were employed (11% not working, 10%

student, 8% homemaker, 4% other, 2% seasonal worker) with the majority living in small (33%) or medium (29%) sized cities. Fewer participants indicated that they lived in large cities (18%) or rural areas (21%). The majority of participants report living in a two person household (49%), and 33% have at least one child in the household. The average household income is £1090.74 per week (SD= 999.59, median =£718.50). The average individual weekly income is £506.67 (SD=640.98, median=£372.00).

An omnivore diet (77%) is most common, with fewer participants following a vegetarian (9%), vegan (5%) or pescatarian (4%) diet. A small number (5%) of participants follow other diets due to food allergies, religious beliefs or health reasons. The majority of participants indicated concern about how the food they eat affects their health (81%), animal welfare (73%), the environment (66%) with fewer indicating concern about how the food they eat affects the welfare of other humans (55%).

We next explored whether participants limit their meat intake, and why. We observed that 62% of participants limit their intake of meat. The primary reasons indicated for limiting meat intake include environmental concerns (33%), animal welfare (32%), health (28%), cost of meat (19%) with fewer indicating meat intake is limited due to taste preference (11%), religious reasons (2%) or other reasons (4%).

3.2. Food (in)security

39% of participants indicated that they have experienced an element of food insecurity within the last 12 months. The most common experience of food insecurity was worrying about running out of food (32%), followed by not being able to afford to eat (27%) and food running out (21%). We observed that having children in the household ($\chi^2(1)=.36$, p=.45), employment status ($\chi^2(5)=10.61$, p=.06), gender ($\chi^2(2)=.06$, p=.97), individual income (mean rank insecure= 3161.69, secure = 3514.13, H(1)=52.76, p<.001), household income (mean rank insecure = 2969.14, secure = 3638.96 , H(1)=190.31, p<.001), and living in a urban/rural area ($\chi^2(3)=.3.37$, p=.34) were not associated with experience of food insecurity. However, participants who are younger (mean rank insecure= 208.31, secure= 236.65, H(1)=5.11, p=.02), living in a smaller household (mean rank insecure= 215.32, secure= 232.10, H(1)=5.08, p=.02), and have a higher BMI (mean rank insecure= 2856.71, secure= 2447.74, H(1)=89.24, p=.001) are more likely to report experience of food insecurity. Food (in)security did not vary between vegans (46%), vegetarians (49%) and omnivores (36%), however, those with 'other' dietary preferences reported a greater incidence of food insecurity (Fisher's Exact=9.87, p=.02).

Being food secure is associated with greater concern about how the food affects the environment (mean rank insecure= 208.66, secure= 237.20, H(1)=5.94, p=.02) and the welfare of other humans (mean rank insecure= 209.57, secure= 236.61, H(1)=5.11, p=.02). However, food (in)security was not associated with differences in concern about how food affects health (mean rank insecure= 227.14, secure = 225.26, H(1)=.03, p=.87), or animal welfare (mean rank insecure= 220.51, secure= 229.54, H(1)=.60, p=.44).

When we considered motivations of meat consumption, we observed that food (in)security was not associated with limiting meat intake overall ($\chi^2(1)=.25$, p=.62), or individual reasons for limiting meat intake (reason: religious, $\chi^2(1)=.40$, p=.72; environmental concern, $\chi^2(1)=2.50$, p=.11; animal welfare, $\chi^2(1)=.26$, p=.61; taste, $\chi^2(1)=.74$, p=.39; health, $\chi^2(1)=.63$, p=.43, price, $\chi^2(1)=2.56$, p=.11; other, $\chi^2(1)=1.83$, p=.18).

Next we considered whether food (in)security was associated with the types of food consumed. The data indicated that food insecure participants eat bread rolls more frequently than food secure (means rank secure=213.35, insecure= 245.58, H(1)=6.97, p=.01), however, no differences were observed for any other type of food featured (beef, chicken, green leaves, beans in sauce, lentils, white rice, sliced bread, potato, spaghetti/noodles, polenta, carrots, tomato, green beans, sweet potato). In addition, food (in)security was not associated with frequency of fast-food consumption (mean rank insecure= 229.38, secure= 223.82, H(1)=.25, p=.62) or frequency of preparation of food in the home (mean rank insecure= 229.35, secure= 223.84, H(1)=.23, p=.63).

Food (in)security was not associated with greater use of particular cooking techniques, with the exception of using oven-baking or roasting to reheat food, which was more common amongst food secure participants (mean rank insecure= 207.71, secure= 237.75, H(1)=5.97, p=.02). Food (in)security was not associated with greater use of particular food related activities including use of a shopping list (H(1)=.01, p=.95), checking what food is in the house before shopping (H(1)=.25, p=.62), preparing weekly meal plans (H(1)=.02,

p=.89), cooking more than one meal at a time (H(1)=.03, p=.88), cooking and freezing meals in advance (H(1)=.24, p=.63), buying unknown foods (H(1)=3.59, p=.06), baking bread from scratch (H(1)=.02, p=.90), eating communially as a family (H(1)=.17 p=.68), enjoying food preparation and cooking (H(1)=1.51, p=.22), teaching children to cook (H(1)=2.12, p=.15), inviting children to cook (H(1)=2.81, p=.09), using a food processor (H(1)=.65, p=.42) or following a recipe (H(1)=.18, p=.67).

3.3. Food waste

3.3.1. What type of food is wasted most?

We considered two types of food waste, all food which has been purchased and thrown away uneaten (purchased waste), and food which has been cooked before being thrown away (cooked waste). First we considered all purchased food waste. Participants estimated that on average 9% of the featured purchased foods are thrown away. More green leaves (13%), carrots (11%), potatoes (11%) and sliced bread (11%) are thrown away than beef (7%) and chicken (7%). When considering cooked food, participants estimated that 7% of the featured foods are thrown away. A greater percentage of polenta (9%), green leaves (8%) and white rice (8%) are thrown away than beef (6%), chicken (5%) and bread (roll 5%, slice 6%).

3.3.2. Do demographics and food insecurity impact reported food waste?

Gender did not impact levels of cooked waste (H(1)=1.60, p=21), however, males reported more purchased waste, (H(1)=7.27, p=.007). There was no

association between habitation area and cooked waste (H(3)=5.68, p=.13), however, those living in small cities reported greater amounts of purchased waste than those in rural, large or medium size cities (H(3)=25.85, p<.001).

Household income was weakly associated with waste, higher income households report more cooked (*r*(6778)=.05, p<.001) and purchased food (*r*(6778)=.06, p<.001) waste. Households with children report more purchased (mean rank: children = 3656.72, no children = 3273.71, H(1)=56.97, p<.001) and cooked waste (mean rank: children = 3872.29; no children = 3170.16, H(1)=193.60, p<.001). Age was weakly associated with waste, younger participants reporting more purchased and cooked waste (purchased, *r*(6778)=.-41, p<.001; cooked, *r*(6778)=-.07, p<.001). We observed a weak positive correlation between size of household and level of purchased (*r*(6778)=.11, p<.001) and cooked waste (*r*(6778)=.09, p<.001). BMI is weakly associated with waste, those with a higher BMI reported more purchased (*r*(5190)=.08, p<.001) and cooked waste (*r*(5383)=.04, p=.01).

Next, we considered the association between self-reported food waste and food (in)security. Food insecure participants reported more purchased (mean rank insecure = 3738.59, secure = 3153.29, H(1)=145.36, p<.001), and cooked food waste (mean rank insecure = 3739.19, secure= 3152.91, H(1)=147.51, p<.001) than food secure participants. Food secure participants reported throwing away less of all purchased and cooked foods of all food types (see Table 1).

3.4. Cooking confidence

3.4.1. Cooking methods and confidence

Participants were confident with the majority of cooking methods. The majority of participants were confident (response: confident or very confident) about boiling (98%), roasting (95%), grilling (94%), microwaving (93%), stir frying (91%), shallow frying (77%), steaming (75%), stewing (72%), BBQing (60%) or poaching (59%) food. Fewer were confident about deep frying (46%), using a pressure cooker (25%) or sous vide (6%) to cook food. Sous vide was the least known cooking technique (51%). See Supplementary Materials (SM2) for information about preparation and cooking time for each food type.

3.4.2. Demographics and confidence

Overall, cooking confidence was not associated with gender (H(2)=4.10 p=.13), size of household (r(448)=.07, p=16), children in the household (H(1)=.65, p=.42), habitation area (H(3)=3.23, p=.36), BMI (r(379)=.07, p=16), dietary preference (H(3)=1.67 p=.64) or household income (r(448)=.07, p=16). However, learning to cook at a younger age (r(449)=-.27, <.001) and being older (r(448)=.25, p<.001) were associated with greater cooking confidence.

Food (in)security was not associated with overall cooking confidence (mean rank secure = 235.58, insecure = 211.17, H(1)=3.78, p=.05). However, we observed an association between food (in)security when individual cooking methods are considered. Food secure participants

reported greater cooking confidence with a range of cooking methods including boiling, (mean rank secure= 235.33, insecure=211.56, H(1)=6.87, p=.01), stir frying (mean rank secure= 234.37, insecure= 213.0, H(1)=4.43, p=.04), grilling (mean rank secure= 232.46, insecure= 216.00, H(1)=8.00, p=.01) and roasting (mean rank secure =236.62, insecure= 209.56; H(1)=8.39, p=.004). However, food (in)security was not associated with greater confidence in the majority of cooking methods (Poaching H(1)=1.85, p=.17; Steaming H(1)=1.49, p=.22; Shallow frying H(1)=1.07, p=.30; Stewing H(1)=.22, p=.64; Microwaving H(1)=1.74, p=.19; Sous Vide H(1)=.21, p=.65; Deep Frying H(1)=.20, p=.65; BBQ H(1)=1.7, p=.19).

We explored the relationship between cooking confidence and food waste, and observed that cooking confidence is weakly correlated with lower amounts of purchased (r(4385)=-.13, p<.001) and cooked food waste (r(5385)=-.09, p<.001).

3.5. Ultra-processed, semi-finished or from scratch?

59% of participants indicated that they typically cook food from scratch (e.g. vegetables, sugar, butter), with fewer (36%) using semi-finished products (e.g. pasta with ready-made sauce) and only 5% of participants indicated that they primarily cook with ultra-processed foods (e.g. frozen lasagne, instant noodles), (χ^2(2)=202.33, p<.001). Food (in)security (χ^2(2)=.36, p=.83), size of household (H(2)=1.63, p=.44), age (H(2)=1.63, p=.44) and gender (χ^2(2)=3.23, p=.20) were not associated with greater use of foods from scratch, semi-finished or ultra-processed products. However, cooking confidence

(H(2)=34.25, p<.001) and higher household income (H(2)=6.78, p=.03) were associated with a greater use of from scratch or semi-finished products than ultra-processed foods.

Next we explored the association between remaining demographic factors and the type of ingredient used. Due to the low number of participants who primarily used ultra-processed food it was not possible to include this group in analyses (due to minimum expected counts not being achieved). Having children in the household ($\chi^2(1)=.66$, p=.42), dietary preference ($\chi^2(3)=1.22$, p=.75) and urban/rural living ($\chi^2(3)=1.69$, p=.64), was not associated with greater use of cooking from scratch or semi-finished products (employment status could not be calculated due to minimum expected counts not being achieved).

The most common reasons to cook were out of necessity (34%), to care for family (21%) or because it's less expensive (18%) with fewer indicating they primarily cook for pleasure (10%) or for health reasons (9%). Only 3% of participants indicated that they do not cook (are cooked for by another), and only 1 participant (0.2%) stated that they don't cook, instead tending to eat out, eat takeaway or ready meals (1.8% indicate 'other' reasons for cooking), ($\chi^2(7)=336.28$, p<.001). Next, we explored whether the main reason for cooking is associated with the use of certain types of ingredients. Those who cook from scratch typically do so for pleasure (86%), for health reasons (83%) and to care for family (68%). Participants who cook because it is less expensive primarily cook from scratch (60%) but also use semi-finished

products (35%). Those who cook out of necessity (which forms that largest group) primarily use semi-finished products (55%) and fewer from scratch foods (40%), (see Figure 1).

3.6. Food packaging

Overall, participants purchase most food (featured in the current research) raw or fresh in packaging, raw or fresh not in packaging or dried. Fewer foods were purchased canned , cooked and ready to eat, ready to cook, frozen (2%), as a long-lasting product or refrigerated and ready to cook, ($\chi^2(9)=6223.30$, $p<.001$), (see Table 2). We observed that several demographic factors were associated with purchasing food in certain packaging types. Participants from larger households reported purchasing more ready to cook products (mean rank= 2798.81) and raw/fresh in packaging (mean rank= 2632.32), with participants from smaller households being more likely to purchase products which are refrigerated and ready to cook (mean rank= 2446.47), ($H(8)=22.05$, $p=.01$). Gender, urban/rural living and having children in the household did not impact the packaging type which food was purchased in (see Supplementary materials SM3). Next we considered whether food (in)security is associated with purchasing food in particular packaging types. Though the analysis of food (in)security and packaging type was significant ($\chi^2(8)=5773.11$, $p<.001$), this is driven by differences in frequency of packaging type present in both the food secure ($\chi^2(8)=3725.17$, $p<.001$) and insecure ($\chi^2(8)=2078.83$, $p<.001$), rather than differences between the groups, (see Table 2).

We observed that the type of packaging varies by food type ($\chi^2(112)=7983.76$, $p<.001$), with beans primarily being purchased in a can (77%), beef (72%) and chicken (66%) being purchased raw or fresh in packaging. Vegetables are typically purchased raw/fresh not in packaging or raw/fresh in packaging (carrots: no pack 63%, in packaging 30%; cavassa: no pack 41%, in packaging 31%; green leaves: no pack 40%, in packaging 42%; tomato no pack 51%, in packaging 36%; potato no pack 53%, in packaging 38%; sweet potato: no pack 67%, in packaging 26%). Beans are most commonly brought tinned (77%) whereas lentils (56%), rice (61%), spaghetti / noodles (64%) and polenta (53%) are typically purchased dried. Bread is typically purchased cooked and ready to eat (43%) or raw / fresh in packaging (34%), (see Figure 2). See Supplementary Materials (SM4) for an overview of packaging type varies by food of secure and insecure participants.

4. Discussion

This study demonstrates the incidence of self-reported food (in)security, food waste, cooking confidence and the types of ingredients being purchased by households following UK COVID-19 lockdown. We observed three key findings. First, 39% of participants have experienced food insecurity in the last 12 months. Second, approximately 9% of purchased and 7% of cooked foods are thrown away. Some foods were more likely to be thrown away as purchased (e.g. carrots, potatoes), whilst other foods were more likely to be wasted after having been cooked (e.g. rice, polenta). Food insecure participants self-reported a greater proportion of food waste than food secure participants. Third, participants were typically more confident with boiling, microwaving and stir fry cooking techniques. However, confidence varied by

food (in)security, with food secure participants having greater confidence with a range of cooking methods (boiling, grilling, roasting).

4.1. *Food (in)security*

Following the House of Lords (2020) report, which was the first comprehensive government report to explore the prevalence of food (in)security in the UK since 2010, we provide valuable additional insight which supplements the report. We observed that 39% of the participants indicate that they have experienced food insecurity in the last 12 months. The prevalence of food insecurity was greater for those who are younger, have a greater BMI, or living in a smaller household. Given that food insecurity often leads to the consumption of a less healthful diet (Hanson and Connor, 2014), which can have a negative impact on long term health and wellbeing (Gunderson and Ziliak, 2015; Laraia, 2013). It is suggested that the prevalence of food insecurity in younger adults must be targeted by policy makers, to prevent both the short term and long term negative impact on the health and economic costs of poor diet (Tarasuk *et al.,* 2015).

4.2. *Food waste and packaging*

Participants estimate that 9% of purchased and 7% of cooked foods are thrown away. Though self-report measures can be less accurate than objective measures (e.g. weighting of waste (WRAP, 2007; van Herpen et al., 2019; Ventour, 2008), we provided valuable insight into the amount of food waste consumers are aware of producing and identifying foods which are being wasted. In line with previous research, we identified that bread and fresh

vegetables (e.g. green leaves, potatoes, carrots) are the most commonly wasted foods (WRAP, 2020b; WRAP, 2018; Quested and Murphy, 2014). Our results also provided an update for the packaging and food waste in the UK which has had limited investigation since 2012.

We observed that green leaves are reported as the most wasted purchased food and second most wasted cooked food. Due to the high proportion of green leaf food waste, we suggested that green leaves would be a valuable target of a food waste consumer facing campaign, such as WRAP's '"Make Toast Not Waste" campaign", which highlighted how much bread is wasted, provided information about how to store and use sliced bread to prevent waste (WRAP, 2018). By modifying packing and portion type, improving supply chain efficiency and product life, and providing consumers with information about how to store green leaves (e.g. store in fridge with paper towel to absorb moisture, steaming and freezing fresh leaves) or how to use cooked left-overs (e.g. add to an omelette), consumers can minimise waste while retaining and benefiting from the nutritional value of the foods.

In line with previous research we observed that greater amounts of food waste are reported in certain demographic groups (Stancu, Haugaard and Lähteenmäki, 2016; Quested and Luzecka, 2014). We observed that some demographic factors (age, size of household, income, BMI) were only weakly associated with food waste. However, a study conducted with Turkish households found a segment of careless planners and cooks, mainly characterized by young, highly educated, full-time workers, living in a

household with no child, and that have low levels of planned shopping and cooking skills, had greater food wastage behaviours. In comparison, the segment of resourceful planners and cooks, mainly characterized by older, married, low education, low income, larged-sized family people that demonstrated excellent planned shopping and cooking skills, resulted in lower levels of food waste (Özbük, Coşkun, and Filimonau, 2021). Hence, we suggested that the improvement of certain food management behaviours, such as better food storage and meal planning may contribute to a reduction in purchased food waste. We observed that having children in the home was associated with greater amounts of purchased and cooked food waste. Based on the current findings and previous research (Quested and Luzecka, 2014) we suggest that on-plate leftovers due to preparing too much food may be a contributor to cooked food waste in many homes which could be targeted by food management interventions.

4.3. Cooking confidence

Addressing a gap in existing literature, we explored the relationship between food experience of food (in)security and food waste. We observed that food insecure participants self-report a greater proportion of purchased and cooked food waste. However, we interpreted these differences with caution . Though it is possible that food insecure homes produce more food waste, we must also consider that food insecure participants may perceive food to be of a relatively higher value and therefore are more aware of food being wasted. In addition, the types of food featured in the current study, such as predominantly fresh products (e.g. vegetables, meat) carry a higher risk of food waste than preserved and shelf stable foods. As food

insecure homes are nudged toward cheaper shelf stable foods which carry less risk of food (and financial) waste (House of Lords, 2020) it is likely that the insecure participants would purchase (and therefore waste) the featured foods on a less frequent basis than food secure households. This observation presents an interesting yet complex relationship between consumers and food choices which has been identified within the Low Income Diet and Nutrition Survey (Nelson *et al., 2*007; National Centre for Social Research *et al.,* 2008) and National Diet and Nutrition Survey (Public Health England, 2018), however would benefit from further research.

We observed that the majority of consumers are confident with boiling, roasting, grilling, microwaving, steaming and stir frying foods. However, consumers were less confident with cooking methods which require specialised equipment (e.g. sous vide, pressure cooker) or may be considered higher risk or harmful to health (i.e. deep frying), (Raber *et al.,* 2016, WHO, 2015). Notably, we observed that food insecure participants report lower levels of confidence using specific cooking methods including boiling, stir frying, grilling and roasting. The difference in the confidence of using specific cooking methods may be due to familiarity with the methods, or access to cooking equipment. As the cooking method used to prepare food can impact the nutritional content of foods consumed (Miglio *et al.,* 2008; Yuan *et al.,* 2009), we suggested that low levels of cooking confidence may impact the nutritional content of foods.

4.4. Ultra-processed, semi-finished or from scratch?

Contrary to expectation, food insecurity was not associated with greater use of processed or ultra-processed foods. However, greater higher income households report and those with greater cooking confidence report greater use of from ‘scratch’

and semi-processed foods than ultra-processed foods, suggesting that a combination of factors nudge consumers toward ingredient type, nutrition, and subsequently health.

4.5. Theoretical implications

There is a lack of appropriate theoretical constructs related to cooking and food skills measures and research, and previous attempts to find appropriate theoretical models have been unsuccessful (McGowan et al., 2017). We were unable to identify an existing theoretical model which was applicable to the current research. Therefore, we propose that learning cooking skills at an early age and experience of cooking may impact cooking confidence, which in turn is associated with cooking behaviours such as cooking from scratch and levels of food waste. Given that food security was associated with greater confidence with certain cooking methods, such as roasting and stir frying, we suggest that experience of different cooking methods may be associated with socio-economic status. However, as the relationship between SES, cooking skills and cooking methods is unclear (Adams et al., 2015; Assumpção et al., 2020), we suggest that the proposed relationship could be explored by future research.

4.6. Practical implications

Building on the House of Lords (2020) report, which was the first government report to comprehensively explore the prevalence of food security in the UK since 2010, we provided further evidence of the prevalence of food insecurity and highlighted vulnerable demographic groups. In addition, we observed how food (in)security is associated with food related to wider food behaviours and attitudes, such as food waste, cooking confidence and food buying behaviours. Given the impact of poor diet on long term health and well being, and subsequent

economic costs (House of Lords, 2020) we highlighted that 39% of participants have experienced food insecurity within the last 12 months.

The House of Lords (2020) and current research present data collected following the outbreak of the COVID-19 pandemic. Yet, as stated by Professor Defeyter (House of Lords, 2020), it is unknown whether the prevalence of food insecurity observed prevalence of food insecurity is due COVID-19 or has simply been exposed following COVID-19. Regardless of the cause, there is an urgency for policy makers to tackle food insecurity within the UK in order to minimise the immediate and long term impacts on the health, wellbeing and economy of the UK.

We have identified how the type of food wasted varies between cooked and purchased foods. This highlights which foods could be targeted by campaigns and education inventiontions, such as the "Love Food Hate Waste" campaign (WRAP, 2018), which provide consumers with tips on how to reduce food waste. By targeting the foods which are wasted most often, the impact of such campaigns can be maximised. As UK consumers waste 6.6 million tonnes of food a year (WRAP, 2020a), reducing the amount of food waste produced would provide a key element in reducing the impact of the food system on the environment (Camilleri *et al.,* 2019; Clark, 2019; Tirado-Von Der Pahlen, 2017).

4.7. Limitations

The current research presented data collected during the first UK lockdown, providing a snapshot of behaviour and attitudes at the time. However, behaviours and attitudes have changed in response to lockdown restrictions being eased (WRAP, 2020c), highlighting the need for a longitudinal approach to this area of research. The current research reported

consumer experience of food insecurity in the last 12 months. Although COVID-19 triggered an increase in the incidence of food insecurity (House of Lords, 2020; Trussell Trust, 2020) we were unable to distinguish between consumers who experienced food insecurity in response to COVID-19, and those who had previously experienced food insecurity. We suggested that those who have previously experienced food insecurity may have different food related attitudes and behaviours compared to those who had recently become food insecure, which may have introduced a confound to the research.

The use of convenience sampling offers an efficient method of recruitment with many advantages (see Jager, Putnick, and Bornstein, 2017). Due to the use of this method these data are not generalisable to the wider UK and international populations, however, could be applied to populations with similar demographic characteristics. Finally, due to this being a pilot study, we did not have sufficient resources to explore the validity, reliability and common method bias of our survey instrument. A full independent validation will be published in the future, however, due to the critical and time sensitive nature of these results, we have chosen to publish the findings first.

4.8. Future Research

Consumer food behaviours have changed between initial lockdown (WRAP, 2020a) and in response to lockdown restrictions being eased (WRAP, 2020c). It is probable that as we return to "normal" and in response to the impactful WRAP "Love Food Hate Waste" campaign, additional changes in food behaviours will be observed. These rapidly changing behaviours highlight the need for a longitudinal approach to understand how consumers attitudes and behaviours are changing. This understanding would allow further campaigns and interventions to be developed which utilize the motivations which triggered positive food

attitudes and behaviours following lockdown. Implementing effective campaigns and interventions could provide a long term impact on food waste, nutrition and public health.

4.9. Conclusions

The current research provided an insight into the prevalence of food insecurity, food waste, food behaviours and cooking confidence of UK consumers following the COVID-19 lockdown. We replicated earlier findings which demonstrate that specific foods are more likely to be thrown away. In addition, we identified which foods are more likely to be wasted when purchased or after being cooked. We observed that green leaves are the most commonly wasted food and suggest a public facing campaign (based on Wraps "Make Toast Not Waste" campaign (WRAP 2018)), and additional supply chain and operations research to improve total open and closed shelf life. By providing a novel insight into the relationship between food insecurity, cooking skills, food waste and types of food purchased in a post-COVID UK food system, our results provide an evidence base for post lockdown food policies and actions, including interventions which could improve access to healthy and sustainable diets and reduce nutrition related health inequalities, and guidance for public-facing communications. Subsequently this could improve the health and wellbeing of the UK population, while reducing the environmental impact of the food system.

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Figure 1. UK adults main reason for cooking and type of ingredients used.

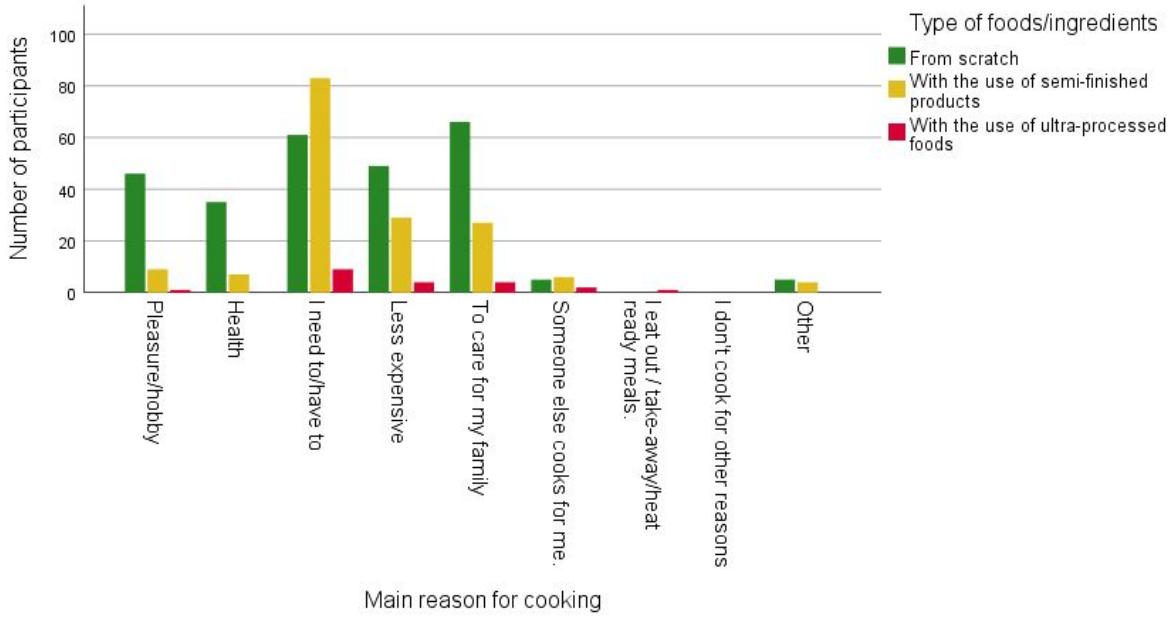

Figure 2. Packaging type in which UK adults purchase foods.

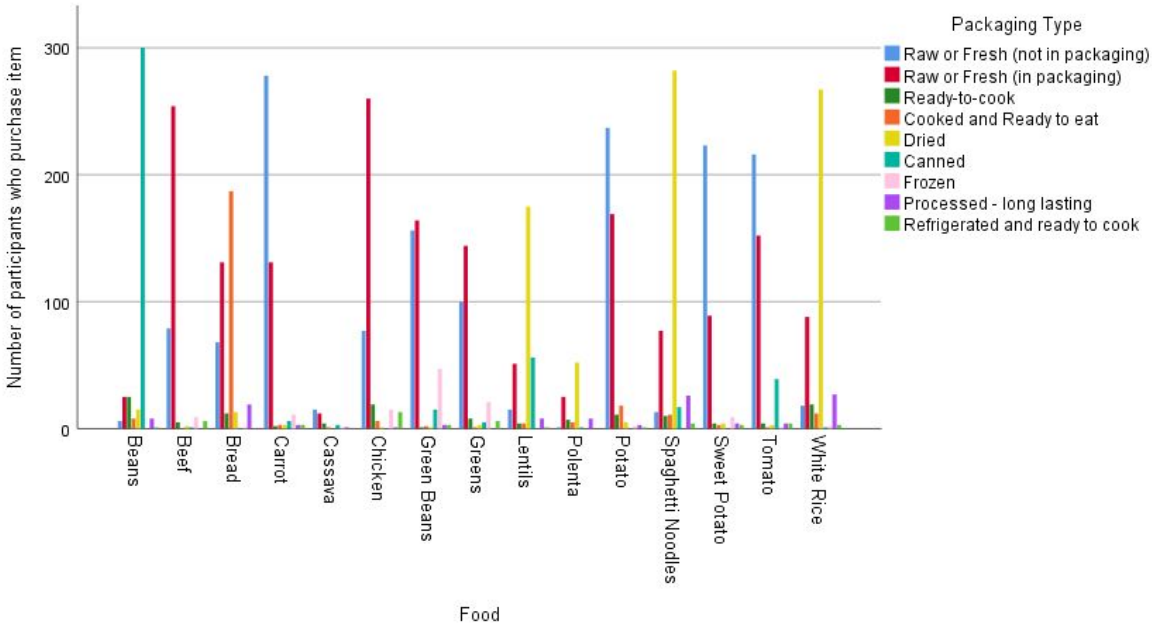

Table 1. Estimated food waste of food secure and insecure UK adults.

	Mean percentage of food waste			
	Purchased		Cooked	
	Insecure	Secure	Insecure	Secure
Beans	9.33	6.80**	8.27	5.59**
Beef	10.46	4.02**	8.27	3.70**
Bread Roll	9.54	6.12**	6.09	3.89**
Bread Slice	12.98	9.10**	7.23	4.66**
Carrot	13.32	9.58**	7.66	5.27**
Chicken	9.33	5.19**	6.89	4.35**
Green Beans	12.02	7.57**	9.12	4.91**
Green Leaves	16.66	10.96**	10.75	6.78**
Lentils	10.37	5.85**	10.01	5.65**
Polenta	10.99	5.39**	12.47	6.13**
Potato	12.54	9.58**	8.47	5.89**
Spaghetti/Noodles	8.77	6.50**	7.38	5.94**
Sweet Potato	12.40	6.35**	9.19	4.22**

Tomato	11.64	8.73**	8.32	4.56**
White Rice	9.28	6.90**	9.18	7.64**

Sig vs insecure, p<.001**

Table 2. Number of products purchased in each packaging type of food secure and insecure UK adults.

	Packaging Type (%)									
	Raw or fresh no packaging	Raw or fresh in packaging	Ready to cook	Cooked - ready to eat	Dried	Canned	Frozen	Processed - long lasting	Ready to cook	Do not purchase
Insecure	607 (22.9)	664 (24.3)	78 (2.9)	110 (4.1)	305 (11.5)	186 (7.0)	36 (1.4)	54 (2.0)	20 (0.8)	615 (23.2)
Secure	886 (21.6)	1125 (27.4)	57 (1.4)	151 (3.7)	516 (12.6)	256 (6.2)	82 (2.0)	61 (1.5)	28 (0.7)	948 (23.1)
Total	1493 (22.1)	1769 (26.1)	135 (2.0)	261 (3.9)	821 (12.11	442 (6.5)	118 (1.7)	115 (1.7)	48 (0.7)	1563 (23.1)