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Caring more about food: the unexpected positive effect of the Covid-19 lockdown on household food management and waste

Ludovica Principato
Department of Business Studies
Roma Tre University
Via Silvio D'Amico 77, 00145, Rome, Italy
ludovica.principato@uniroma3.it

Luca Secondi
Department for Innovation in Biological, Agro-food and Forest Systems
University of Tuscia
Via san Camillo de Lellis snc, 01100, Viterbo, Italy
secondi@unitus.it

Clara Cicatiello (corresponding author)
Department for Innovation in Biological, Agro-food and Forest Systems
University of Tuscia
Via san Camillo de Lellis snc, 01100, Viterbo, Italy
cicatiello@unitus.it

Giovanni Mattia
Department of Business Studies
Roma Tre University
Via Silvio D'Amico 77, 00145, Roma, Italy
giovanni.mattia@uniroma3.it

ABSTRACT

Over half of the total amount of food wasted in Europe concerns household food waste which is mainly due to incorrect food management habits and behaviour. During the Covid-19 outbreak, food management and consumption habits changed dramatically due to the tough lockdown restrictions imposed by governments to reduce infection. This study investigated how these dramatic changes in the daily lives of consumers influenced the generation of food waste at household level. A CAWI questionnaire was administered to a sample of 1,078 Italian consumers during the lockdown (March-April 2020). The respondents were asked to self-estimate the percentage of food their households wasted before and during the lockdown and to explain their food management habits. We focused the analysis on the differences between the food the respondents declared to have wasted before and during lockdown, which revealed that most households threw away less food during the Covid-19 lockdown compared to the pre-Covid situation. We referred to Seemingly Unrelated Regression models to evaluate the association between the food waste behaviour in the two periods considered in the study and the other factors observed. The results disclosed that young consumers and people who started implementing good food management practices (shopping list, meal planning etc.) more frequently considerably reduced the food they wasted during lockdown. Also, the logistical difficulties of grocery shopping experienced by consumers during lockdown made them manage their household food consumption more carefully, which led to a reduction in the amount of food wasted.

KEYWORDS

Household food waste; Covid-19 lockdown; Seemingly Unrelated Regression; food management; Household Wasteful Behaviour Framework

HIGHLIGHTS

- Household food management dramatically changed during Covid-19 lockdown
- 1,078 Italian households self-estimated percentages of food wasted before and during lockdown
- During lockdown most households reported a reduction in food waste
- This reduction was mainly due to a more careful food planning and management
- Contextual variables played an important role in reducing food waste during lockdown

COMPETING INTERESTS

The authors declare no competing interests.

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1. INTRODUCTION

Over the last few years, the Food Waste (FW) phenomenon and its negative economic, environmental and social effects has been considered as one of the most important sustainability issues to be addressed at global level (FAO, 2019; FAO, 2013; BCFN-EIU, 2018). In fact, FW reduction has been included among the 17 Sustainable Development Goals of the UN's 2030 Agenda and specifically in target 12.3 that aims to: "*halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains*" (UN, 2020) by 2030.

The economic, environmental and social costs associated to FW amount to approximately USD 2.6 trillion per year (FAO, 2014). FW is also responsible for 8% of global greenhouse gas emissions and occupies approximately 30% of the world's agricultural land used to produce food that is later wasted, which has a significant impact on the environment and climate change (FAO, 2019).

In the Global North, large amounts of food are wasted at the end of the food supply chain (Monier et al., 2010; USDA, 2017) which is mainly due to incorrect consumer behaviour, habits and attitudes (Principato et al., 2020; Principato, 2018; Canali et al., 2017; Parfitt et al., 2010; Bond et al., 2013). Indeed, the annual rate of FW generation rate per capita is approximately 39% in North America and 31% in Europe (FAO, 2013).

In the EU-28 it is estimated that 88 million tonnes of food are wasted annually, thus amounting to 173 kilograms per capita which is mostly composed of Household FW (Stenmarck et al., 2016). The measurement of the exact quantities of FW at the household level deliver different results due to the array of the existing quantification methods (Cicatiello and Giordano, 2018). Studies using direct quantification methods estimate that FW in Europe ranges between 23 kg per capita per year (Koivupuro et al., 2012) and 48 kg per capita per year (Edjabou et al., 2015). According to Giordano et al. (2019b), Italian consumers waste 530 grams of food per week at home, which is approximately 27.5 kg per capita per year. The European project REFRESH estimates that each household wastes 94.64 kg of food each year (Masotti et al., 2019), amounting to approximately 4.9 Euros per week and corresponding to 6.5 billion of Euros per year at national level (WasteWatchers, 2020).

Reducing FW is financially, environmentally and socially essential and it is important to gain a better understanding of how the Covid-19 pandemic has affected household consumption and FW habits and behaviour (WRAP, 2020).

It is evident that epidemics and pandemics pose a serious threat to public health and social stability. Following the 2002 SARS epidemic in China, the Ebola epidemic in West Africa and the 2015 Middle East respiratory syndrome (MERS) outbreak, at the end of 2019 a new type of coronavirus was discovered in China which rapidly caused a pandemic within three months (March 10, 2020) which affected 216 countries causing several millions cases and almost 600,000 deaths (WHO, 2020[1]). The SARSCoV-2 virus that causes Covid-19 is predominantly spread from person to person and it is extremely contagious with a very high mortality rate especially for the elderly (CDC, 2020). In Italy the Covid-19 pandemic spread rapidly; Italy was the first Western Country to implement self-isolation and social-distancing policies and total lockdown from March 9th until May 4th, during which most people were forced to stay home, avoid any social contact and go out only for essential reasons and basic needs such as grocery shopping, work or health issues. Non-essential economic activities and services were stopped, and all of the schools were closed. According to the Italian Statistical Institute (ISTAT, 2020a), at least 7.1 million workers and 10.8 million students of all ages were forced to stay at home during the lockdown, while 55.7% of private sector workers continued to go to work during lockdown.

Consequently, individuals and households dramatically changed their food consumption habits and behaviour. Grocery retail grew by 18% in March-April 2020 compared to the same period in 2019, local shops and supermarkets saw a strong increase in volume of sales and grocery and food delivery services experienced demand (+160%) at record levels (ISMEA, 2020). ISTAT (2020b) reported that food was the only sector that grew by 3.5% in value and 2.1% in volume on a trend basis in March 2020. ISMEA (2020) reports a rise in the demand of several food categories in March-April 2020:

[1] Data updated at 19 July 2020.

flour purchases increased by 145%, pasta and rice by 14% and 25% respectively, +78% oranges, +60% apples, +57% mozzarella, +57% eggs, +32% cheeses, +31% cured meats, long-life milk made a +22%, while fresh milk dropped by -5%. These data suggest that during the lockdown Italians cooked their meals at home and enjoyed spending meal times with their families. Households spent more on groceries during lockdown (Baker et al., 2020) since they were forced to stay at home. However, many families experienced severe financial hardship, due to reduction in disposable household income and risk of bankruptcy/unemployment. Together with mobility restrictions, these issues made it harder for consumers to gain access to food (Cattivelli and Rusciano, 2020). New food provision solutions have emerged as a reaction to food insecurity and difficulties in food shopping (Cattivelli and Rusciano, 2020; Cappelli and Cini, 2020). It is likely that these changes in consumption patterns have affected quantities and types of food available/disposed at home. Therefore, it is essential to gain a better understanding of how lockdown have affected household FW behaviour.

To date studies on this topic have focused on Great Britain and Tunisia (WRAP, 2020; Jribi et al., 2020; FSA and Ipsos, 2020), highlighting the fact that further research is required in order to gain valuable insights on how a crisis of this kind can influence food consumption and waste consumer habits, attitudes and behaviors at household level. A first exploratory study conducted in Italy highlighted that FW at household level has dropped to 430 grams per week per household (Waste Watcher-SWG, 2020) however the reasons and the factors underlying this reduction have not yet been explored.

The aim of this paper is to determine how these changes have affected the amount of FW generated at home by focusing on the underpinning factors of these dynamics. The main research questions that triggered our analysis: (i) How were FW quantities affected by Covid-19 lockdown?; (ii) Did the eating and food management habits acquired during lockdown help to revolutionize/rationalize household food consumption and management; (iii) Did eating at home more often than usual help to reduce FW?; (iv) Is the context in which individuals live related to these changes?

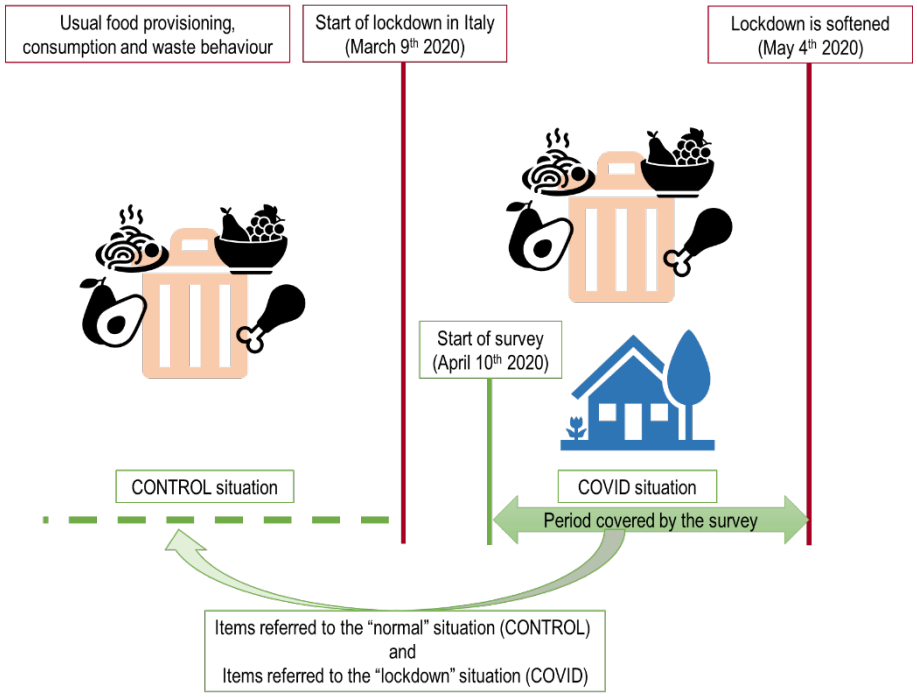
77 The remainder of the paper is structured as follows. Section 2 describes the methodological
78 approaches adopted for the data collection process, the theoretical framework underlying the
79 construction of the questionnaire as well as the statistical techniques and methods used for analysing
80 the data. Section 3 reports the results of the data analysis focusing on the respondents' profiles and
81 determining using Seemingly Unrelated Regression (SUR) models if and to what extent the factors
82 associated with FW at household level changed before and during lockdown. Lastly, Section 4
83 discussed the results obtained and draws some concluding remarks.
84
85 **2. METHODOLOGY**
86 *2.1 Study design*
87 This study is based on a sample survey carried out through a Computer Assisted Web Interview
88 (CAWI) based questionnaire aimed at investigating if and to what extent changes in food-related
89 habitudes due to the Covid-19 restrictions have impacted on the quantity of FW produced at home.
90 Questionnaires are one of the tools available to conduct a direct measurement of FW at households
91 (World Resource Institute, 2016) with the aim of collecting primary data (Corrado et al, 2019) and
92 are based on respondents' self-assessment of the quantity of food wasted. In the context of household
93 FW studies, questionnaires are largely used to investigate consumers' perception of the quantity of
94 food discarded at home (Falasconi et al., 2019), to explore the underlying causes for this waste
95 (Koivupuro et al., 2012), or to provide an estimate of the extent of the food wasted (Abeliotis et al.,
96 2014; Jörissen et al., 2015, Visschers et al., 2016). However, studies comparing the results of different
97 assessment methods show that, when respondents are called to self-assess the amount of food
98 discarded, they systematically underestimate the quantity of FW produced at their household
99 (Giordano et al., 2019b). For this reason, some studies have considered appropriate using different
100 quantification methods on the same sample (Koivupuro et al., 2012; WRAP, 2013) or using self-
101 declared quantities of FW to compare the situation across times and regions (Secondi et al., 2015)
102 rather than to provide an absolute measure of household FW. Moreover, questionnaires are considered

a reliable tool to investigate the linkage between the amount of food discarded and other variables related to food shopping behaviour or ethical/social norms (Cicatiello and Giordano, 2018).

In this study, a questionnaire was implemented to explore the impact of the Covid-19 restrictions in Italy on the quantity and type of household FW. In the questionnaire, respondents were asked to self-assess the percentage of food wasted, with respect to the food purchased, prior and during lockdown. The analysis focuses on the difference between this two information, by studying the variables that exerted an influence on the quantity of self-declared FW by the surveyed households before and during the Covid-19 lockdown.

The conceptual design of the study is visually represented in Figure 1.

Figure 1 – Conceptual design of the study



2.2 Structure of the questionnaire

The survey was conducted through a self-administered questionnaire written in Italian and implemented in Google Forms. The questionnaire consisted of 35 single-option and multiple-choice items structured in five sections. These sections draw from the most recent and relevant literature on FW at household level, and are defined as follows: i) Situational, psychological and social factors; ii)

food provisioning habits and shopping behaviors before and during lockdown; iii) food management and waste habits and behaviors before and during lockdown; iv) rediscovery of culinary traditions; v) household socio-demographic characteristics.

The literature arguments from which we have drawn the structure of the survey are reported in this section.

FW has become a major global concern because it derives from complex and multifaceted behaviors and for its implications on the different food supply chains (Quested et al., 2013; Canali et al., 2016; Parfitt et al., 2010; Piras et al., 2016). Analyzing the past literature on consumer FW, Principato et al. (2020) sought to better explain wasteful behavior drawing from consumer decision making theories and consumer food management process through the Household Wasteful Behaviour Framework (HWBF). According to this model, individual's wasteful behavior is driven by different psychological, social, situational, and socio-demographic factors; and by incorrect habits and behaviors during the food management process, that is during the food planning, in-store, pre-consumption, consumption and disposition phases. For psychological factors we intend some non-cognitive elements of FW behaviour such as habits, FW knowledge and FW involvement, defined as one's level of awareness of the impacts of FW as well as perceived behavioural control (the degree to which individuals believe that they are capable of modifying a particular behaviour, like reducing the amount of food they waste). All these factors have been proven to influence individual's wasteful behaviors (Visschers et al., 2016; Principato et al., 2015; Barr, 2007; Mondejar-Jimenez et al., 2016; Stancu et al., 2016) and have been considered in section 1 of our questionnaire. Moreover, since it has been demonstrated that households waste larger amounts of food when they buy it from large supermarket chains rather than from small shops or local markets (Jorissen et al., 2015; Setti et al., 2016; Ganglbauer et al., 2013), we decided to include in section 1 an additional item about the main channels of food provisioning used by respondents before and during the lockdown, including: hypermarket and supermarket, small shops (butchers, food shops, bakeries ...); local markets and street vendors; discounts; internet purchase (online shopping).

146 Section 2 of the questionnaire includes some quantitative items concerning food provisioning and
147 shopping habits that were likely affected by the lockdown (Istat, 2020a; Ismea, 2020). We added one
148 item about food planning, to investigate whether individuals had improved their meal planning and/or
149 were drawing a shopping list. Indeed, both these food management habits were found to be negatively
150 correlated to FW (Parizeau et al., 2015; Exodus, 2006; WRAP, 2007; Gustavsson et al., 2011) thus
151 proving to effective in reducing the generation of household FW.
152 Considering the other phases of the food management process, we have included in section 3 of the
153 questionnaire items about habits and incorrect behaviors that are likely linked with the HWBF: (i)
154 purchases mistakes in-store (i.e. buying too much food, marketing "buy one get one free" offerings,
155 too large packs) (Evans, 2011; Mallinson et al., 2016; Radzyminska et al., 2016; Evans, 2011;
156 Radzyminska et al., 2016; Giordano et al., 2019a); (ii) expiration dates (FSA, 2008; Sen and Block,
157 2009; Wansink and Wright 2006; Secondi, 2019); (iii) incorrect storage (Waitt and Philips, 2016;
158 Aschemann-Witzel et al., 2015; Graham-Rowe et al., 2014; Cox and Downing, 2007); (iv) cooking
159 or serving too much food (Van Geffen et al., 2016; Principato et al., 2015; Cox and Downing, 2007);
160 (v) food preferences (Evans, 2011, 2012); (vi) poor cooking skills (Van Geffen et al., 2016); and (vii)
161 food left by kids (Evans, 2011, 2012; Cappellini and Parsons, 2012; Exodus, 2006; Giordano et al.,
162 2019b).
163 Following the evidence that the rate of waste is likely to change among food categories (Fanelli and
164 Di Florio, 2016; Shanes et al., 2018; Szabó-Bódi et al., 2018), we decided to collect data on the
165 declared FW overall and by food category (pasta-rice; meat-fish-eggs; milk and dairy products;
166 vegetables; fruits; bread), using specific items that were duplicated in order to assess the rate of waste
167 for each category before and during the lockdown. These items were included in section 3.
168 Section 4 consists of two items about new habitudes of the household during lockdown. There is some
169 evidence that – given the increased time spent at home and a reduction in the hectic activities of the
170 life before the lockdown- families were spending more time cooking and were discovering nationals

171 and traditional meals (WasteWatcher, SWG, 2020). We therefore asked respondents about this
172 "(re)turn to traditions" and about the time they used to spend in the kitchen during the lockdown.
173 Finally, section 5 focuses on the socio-demographic features of the respondents according to HWBF
174 and the past literature. There is evidence that youths tend to waste more than elderly people (Osner,
175 1982; Hamilton et al., 2005; Brook Lyndhurst, 2007; Eurobarometer, 2014). Also, a relationship was
176 found between the individuals' level of education and the amount of food he/she wastes: the higher
177 the level of education, the larger the quantity of FW generated (Visschers et al., 2016; Secondi et al.,
178 2015). Furthermore, larger households tend to waste more than smaller ones (Quested et al., 2013),
179 although it has been seen that the amount of per capita FW decreases as the number of family
180 members rises (Parizeau et al., 2015). Another study (Quested and Luzecka, 2014) established that
181 families with children tend to waste more food than adult-only households of equal size, mainly due
182 to children food preferences and for food safety reasons.
183 Moreover, literature offers contradictory findings about the relation between FW and income level:
184 while some researchers found that higher-income households tend to waste more than lower-income
185 ones (Brook Lyndhurst, 2007; Buzby and Guthrie, 2002; Van Garde and Woodburn, 1987; Osner,
186 1982; Koivupuro et al, 2012; Stefan et al., 2013), others suggest the opposite (Cox and Downing
187 2007; Stancu et al., 2016). Lastly, according to Secondi et al. (2015), individuals living in urban areas
188 tend to waste more than those living in rural areas, therefore we decided to add this situational
189 (contextual) factor in the questionnaire, also considering that this information can have noteworthy
190 policy implications.
191
192 *2.3 Sampling strategy*
193 The period covered by the survey strictly followed the schedule of the Covid-19 restrictions applied
194 in Italy. The questionnaire was launched on April 10th 2020, one month after the start of the national
195 lockdown (March 9th, 2020), and it remained open until May 3rd 2020, just before the beginning of

196 the so-called “phase 2”, when the restriction measures were slightly softened. In total, it covered 24
197 out of 56 days of full Covid-19 restrictions.
198 The questionnaire was implemented online through Google Forms, with a short link enclosed in a
199 message calling for volunteers willing to participate to “a research on food management habitudes
200 during Covid-19 lockdown”. The message was published on the personal social media of the
201 promoters, including Facebook, LinkedIn and Instagram, and it was also shared via email and Google
202 Groups in some (research) networks operating in the fields of food consumption and food policy
203 studies across all the country. Readers were asked to share the message on own social networks, to
204 increase the number of people potentially reached.
205 The sampling strategy was therefore non-probabilistic, and self-selection of respondents cannot be
206 excluded. This limit is partially overcome by the large number of respondents, summing up to 1,097
207 in total.
208 All respondents provided their informed consent before starting the survey.
209 The final database consisted in 1,078 validated observations, after that 12 observations were excluded
210 because they were not based in Italy and 7 because they missed the key items of the questionnaire or
211 gave incoherent answers. 72.9% of the participants were recruited in the Lazio Region, with 534
212 observations in the province of Rome; the rest of the respondents was distributed across 73 (out of
213 the total 110) provinces of the country. The mean age of the respondents was 40.7 years old, that is
214 quite similar to the Italian average of 45.7 (Istat, 2020c). The large majority of the respondents were
215 women (73.7%), as it was largely expected considering that only about 40% of Italian men are
216 involved in households’ food management, against the almost 90% of women (Eurostat, 2019). The
217 size of the surveyed households was 3.2 persons on average. In non-probabilistic samples it is very
218 common to observe participants with a high level of education (Falasconi et al., 2019) and this study
219 does not make an exception, with 55.7% of the participants owning a university degree, against the
220 19.6% national average (Istat, 2020d). The share of respondents declaring to be employed was 60.9%,
221 which is very similar to the Italian occupancy rate of 59.2% (Istat, 2020e). Nearly half of the surveyed

222 households (41.8%) declared a total net income lower than 2,000 Euro, and 45.7% were based in a
223 large city, with more than 100,000 residents.
224
225 *2.4 Data elaboration*
226 *2.4.1 Statistical approach*
227 Data related to food management behaviour and FW at home were first treated with statistical
228 descriptive tools to show the changes occurred during the Covid-19 lockdown compared to the control
229 situation before the restrictions. To this aim, comparisons between pairs of questions referring to the
230 same behaviour (performed before and during lockdown) were carried out. Namely, food purchasing
231 habitudes, expenditure and channels for the household food provision, patterns of food consumption
232 at home and the quantity of FW produced were considered to this regard. It should be remarked that
233 the latter issue (quantity of FW generated) was self-estimated by the respondents by indicating a
234 percentage of the food discarded out of the total food purchased. Respondents were invited to only
235 consider the avoidable fraction of FW and to break down their estimation by food category before
236 providing an overall estimation of the ratio of food wasted at home.
237 Cluster analysis was used as a second-step elaboration to further describe the FW-related behaviour
238 of the respondents, while the factors associated with possible changes observed during the lockdown,
239 with respect to the control situation, were studied through a Seemingly Unrelated Regression (SUR)
240 approach.
241
242 *2.4.2 Cluster analysis*
243 The profile of respondents with respect to their FW-related behaviour was investigated by means of
244 a cluster analysis (non-hierarchical k-means clustering, determinant W clustering criterion)
245 conducted via the XLStat software on the database. In the cluster analysis, the 14 variables concerning
246 the self-estimated amount of FW in the control and lockdown situations were considered. The number
247 of clusters was gradually increased until the between-classes explained variance reached 50%.

248 Despite some of the variables were not significantly contributing to the clustering of observations,
249 none of them was removed, with the aim to retain all information related to FW behaviour in the
250 results of the analysis. At the end of the process, 7 classes emerged, with a between-classes explained
251 variance of 51.9%.
252 After completing the description of the sample via descriptive and clustering techniques, other
253 elaborations were conducted to investigate more in depth the changes occurred in the FW-related
254 behaviour of the respondents during the Covid-19 lockdown, against the control situation. Such
255 elaborations specifically focused on the difference between the two self-estimates rather than on their
256 absolute values, in order to increase the reliability of the analysis. Indeed, literature reports that
257 respondents systematically underestimate household FW data when they are asked to self-estimate
258 the quantities of food discarded at home (Cicatiello and Giordano, 2018 ; Giordano et al., 2019b).
259 This is likely due to a positive illusion bias or, in general, to other forms of cognitive dissonance
260 leading to a genuine conviction of the respondents to waste less than they actually do (Giordano et
261 al., 2019b), to avoid the feeling of guilt associated to FW (Falasconi et al., 2019)
262
263 *2.4.3 The Seemingly Unrelated Regression (SUR) approach*
264 The core of the statistical elaborations were carried out by comparing Control and Covid-19 situations
265 and referring to the SUR multiple-equation models firstly introduced by Zellner (1962) and frequently
266 applied in economics even for modelling household and individuals' behaviour (Bilodeau and
267 Duchesne, 2000; Baltagi, 2008) which enabled us to test the existence of (and in case of presence, to
268 correctly account for) contemporaneous correlations between FW behaviour assessed in these two
269 different moments as well as among the amount of FW generated for the studied food categories
270 contemporaneously.
271 The SUR method estimates the parameters of all equations simultaneously, so that each equation –
272 which can include a set of explanatory variables different from the others – also considers the
273 information provided by the other equations. Individual FW behaviour can properly fit with this type

of model since it has been defined as a complex behaviour (Quested et al., 2013; Secondi et al., 2015) related to different individual and contextual factors and even more multifaceted to be studied if two different temporal situations are considered as well as (partial) food categories are taken into account. Furthermore, the correlation among equations could be due to unobservable household specific attributes that influence the generation of FW for the food categories/groups (Baltagi, 2008).

Concerning the SUR model specifications, we distinguished between two different multiple-equation models:

i) initially we modelled the overall declared percentage of FW generated (before and during lockdown);
ii) then, we modelled the percentage of the food discarded out of the total food purchased for each of the six food categories considered in the study (pasta-rice; meat-fish-eggs; milk and dairy products; vegetables; fruits; bread).

Concerning the overall self-declared percentage of FW, we specified a two-equation SUR model. Without loss of generality and by considering the household i (i=1,…n) as unit of analysis, the specified model can be expressed as:

$$y_{it} = \sum_{j=1}^{J_t} x_{jit}\beta_{jt} + u_{it} \quad \text{for each equation } t = 1 \dots T \qquad [1]$$

with t=1,2 identifying the number of equations and therefore y_{i1} referring to the self-declared percentage of FW before lockdown (control situation) while y_{i2} to the self-declared percentage during lockdown (Covid period). In each equation t and for each household i, x_{ijt} is the i-th observation on j-th explanatory variable appearing in the t-th equation (with J_t as the number of explicative variables in each equation), β_{jt} refers to the j-th estimated coefficient in the t-th equation, while u_{it} is the error term. The model explicitly allows for contemporaneous correlation, i.e. $E(u_{it}, u_{it'}) = \sigma_{ij}\ with\ t \neq t'$.

On the other hand, for each food category k (k=1,…K) with K=6 (pasta-rice; meat-fish-eggs; milk and dairy products; vegetables; fruits; bread) we formerly calculated the difference between the FW self-declared percentage[2] as follows:

$$\Delta FW_k = FW_k^{Covid19} - FW_k^{Control} \quad [2]$$

This difference ΔFW_k shows the increase, stability (no observed change), or decrease in FW for each category k during lockdown compared to the control (pre-Covid19) period, depending on whether its value is greater, equal or lower than zero. By computing this difference we also intended to reduce the error linked to the discrepancy between self-estimated and actual quantities of FW (Corrado et al., 2019; Secondi et al., 2015; Giordano et al., 2019b).

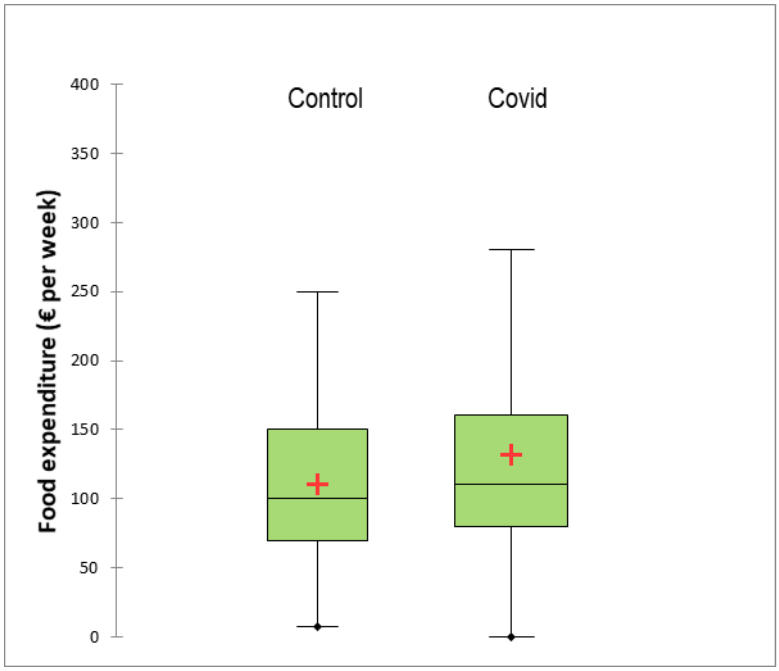
Starting from the quantity ΔFW_k defined above, the specification of the six-equation SUR models was carried out as follows:

$$STD(\Delta FW_{ik}) = \sum_{s=1}^{s_k} x_{sik}\beta_{sk} + u_{ik} \quad \text{for each equation } k = 1,2,\dots 6 \quad [3]$$

with $STD(\Delta FW_{ik})$ representing the standardized FW difference observed for the i-th household and regarding the k-th food category (corresponding to the k-th equation), x_{isk} is the i-th observation on s-th explanatory variable appearing in the k-th equation, β_{sk} to the s-th estimated coefficient in the k-th equation, while u_{ik} is the error term. The model explicitly allows for contemporaneous correlation between error terms, with the SUR estimator that accounts for interrelations among the single equations obtained by means of a weighting matrix based on the covariance matrix of the error terms. In this perspective, the SUR model can be considered an application of the Generalized Least Squares

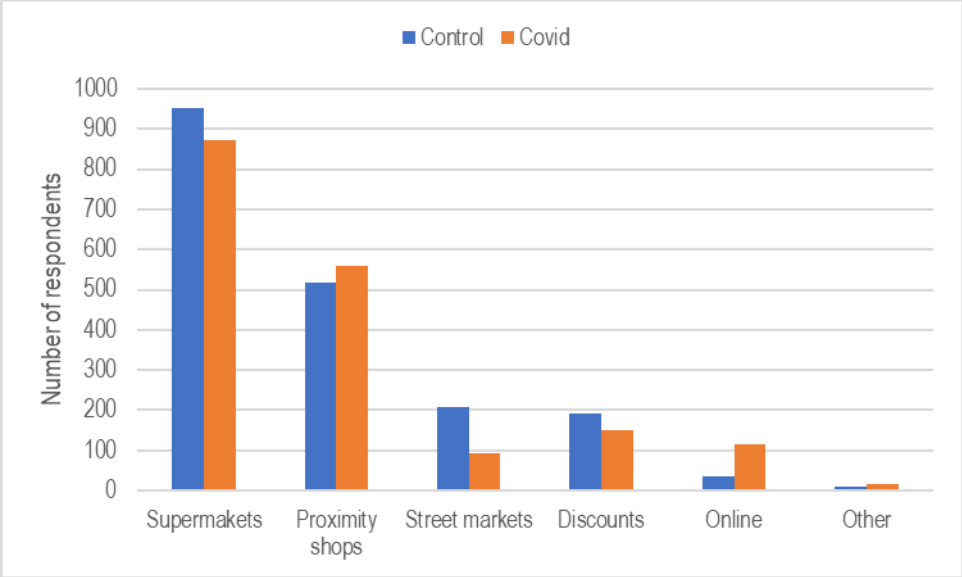
[2] It is worth noting that respondents were asked to declare the percentage of FW generated for each food category. Therefore, possible values of the FW variable range between 0 and 100.

322 (GLS) approach with the unknown residual covariance matrix is estimated from the data (Cadavez
323 and Henningsen 2012).
324 The Breusch-Pagan test (Breusch and Pagan, 1980) was used to verify the assumption that the errors
325 across equations were contemporaneously correlated. By rejecting the null hypothesis of
326 independence among equations residuals, SUR models provides more efficient estimates than
327 separate (classical) Ordinary Least Square (OLS) estimations with the gain in efficiency (Cadavez
328 and Henningsen, 2012) increasing when the linear dependence among error terms of the different
329 equations is high (Judge et al., 1988), for large sample size and high levels of multicollinearity among
330 covariates (Yahya et al., 2008).
331
332 **3. RESULTS**
333 *3.1 Effects of lockdown on food purchasing/consumption/management habitudes*
334 Answers to section 2 of the questionnaire report several changes in the behaviour of the respondents
335 concerning food purchasing, management and consumption. The average expenditure for food raised
336 from 110 € to 132 € per week during the Covid-19 restrictions. Figure 2 shows that, despite the
337 important increase in the average expenditure during the lockdown, with respect to the previous
338 habitudes, the observed median remained relatively stable. This is probably the consequence of
339 different changes occurred in different households, with 57.3% of the observations reporting an
340 increase in the food expenditure, while 28.5% did not report any changes and the rest reporting a
341 decrease. This may partly reflect the higher number of meals consumed at home, considering that
342 before the Covid-19 restrictions respondent households declared to consume on average 10 meals per
343 week at home out of the 14 weekly meals.
344 Figure 2 – Food expenditure before and during the Covid-19 lockdown



Results highlight a sudden and deep change of the food purchasing habitudes among the respondents. Before the Covid-19 outbreak, 56.5% of the sample declared to shop for food 2-3 times per week (56.5% of the respondents), while during the restrictions a frequency of once a week was much more common (63% of the respondents). The channels used for food provisions also showed a change: while supermarkets remained a source of food for over 80% of the respondents, online shopping was mentioned three times more often during the lockdown (10.7% of the respondents) than before (3.2%). Home delivery of the groceries was not very common in the control situation (83.4% never used this option) while it was a solution to avoid social contacts during the Covid-19 lockdown (39.1% used this option at least "sometimes").

Figure 3 – Food provision channels before and during the lockdown



The habitude to compile a shopping list was rather common among the respondents in the control situation (59% of the respondents used to make it "always" or "very often"), but its frequency increased very much during the lockdown (86.5% made it "always" or "very often").

The management of food leftovers showed some improvements. All the three leftover management strategy proposed in the questionnaire (freezing, keeping for the next meal, use as ingredient in another preparation) were largely used in the sampled households before the restrictions, but they all showed an increase in frequency during the Covid-19 lockdown, especially the habitude to use leftover to cook other preparations, which was mentioned by 65 more households with reference to the Covid-19 period.

Answers provided in section 4 of the questionnaire showed that many households took advantage of the increased time spent at home to rediscover traditional recipes, especially making bread (45.5% of the sample), pizza (65.2%) and cakes (67.5%).

3.2. An overview of self-declared FW before and during lockdown

The results of the survey enabled us to assess if and how households' FW behaviour changed during the lockdown, with respect to the control situation. To this purpose the self-estimated percentages of edible food that was wasted were studied. Table 1 shows descriptive (sample) statistics concerning the distribution of FW before (control) and during lockdown (COVID-19) by distinguishing the self-

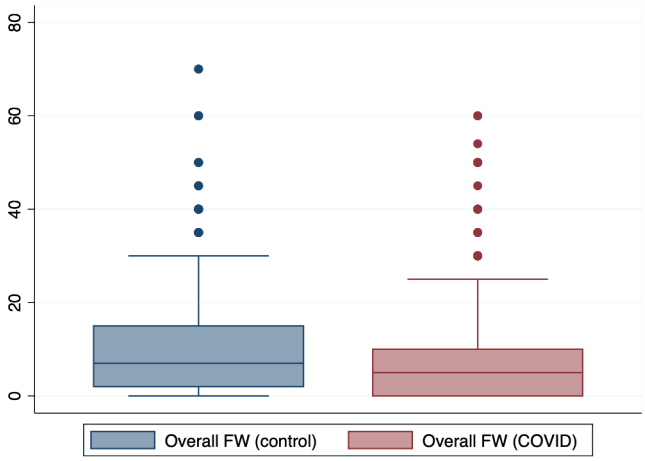
declared percentages among food categories (pasta/rice; meat-fish-eggs; milk-dairy products; vegetables; fruits) and the household overall FW generated.

Table 1 – Summary statistics: overall FW and FW per categories before and during lockdown

	mean	sd	cv	IQR
CONTROL (before lockdown)				
Pasta/Rice	5.180	9.341	1.803	10
Meat-fish-eggs	4.639	8.560	1.845	5
Milk- dairy products	6.749	10.936	1.620	10
Vegetable	10.036	12.540	1.250	15
Fruits	10.188	12.753	1.252	15
Bread	10.526	15.492	1.472	15
Overall FW	*9.996*	*10.360*	*1.036*	*15*
COVID19 (during lockdown)				
Pasta/Rice	2.866	6.463	2.255	5
Meat-fish-eggs	2.300	5.457	2.373	1
Milk- dairy products	3.278	6.933	2.115	5
Vegetable	5.088	8.632	1.696	10
Fruits	5.112	8.300	1.624	10
Bread	4.219	8.962	2.124	5
Overall FW	*6.325*	*8.337*	*1.318*	*10*
Δ (Differences COVID19 - Control)				
Pasta / Rice	-2.382	6.682	-2.806	0.49
Meat-fish-eggs Meat-fish-eggs	-2.398	7.691	-3.207	1
Milk / dairy products	-3.554	9.180	-2.583	5
Vegetable	-4.985	9.604	-1.927	10
Fruit	-5.076	10.193	-2.008	10
Bread	-6.378	12.746	-1.999	10
Overall FW	-3.622	8.756	-2.417	5

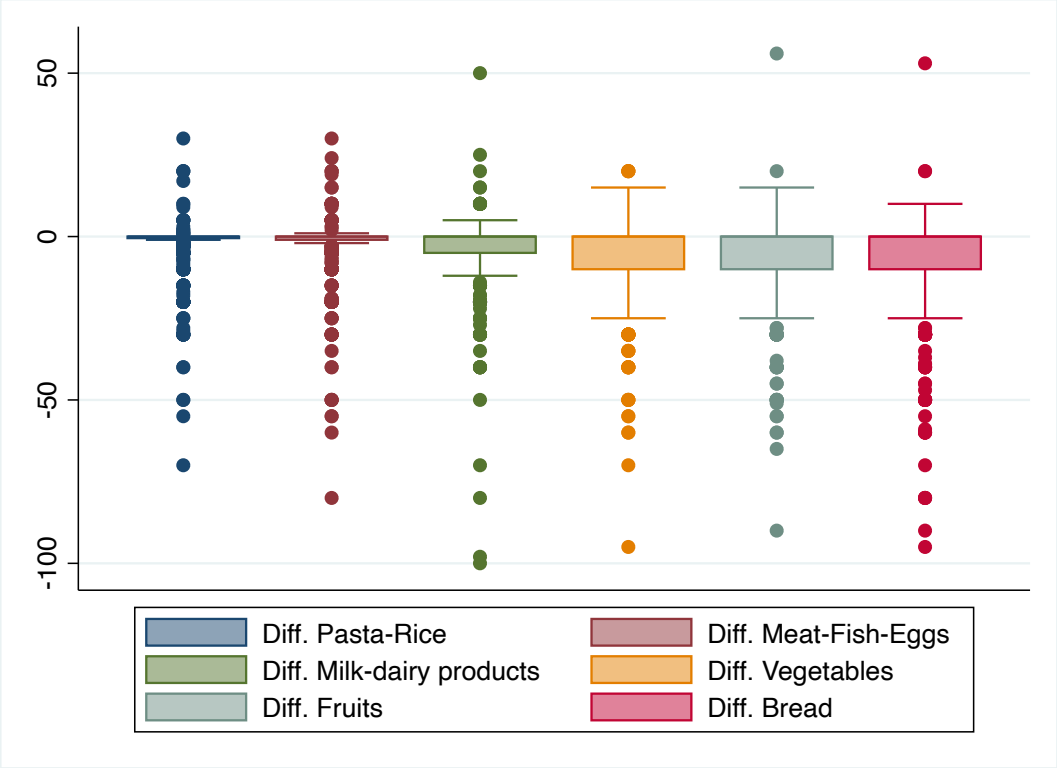
The first descriptive result emerging from our study is that the overall average FW decreased from almost 10% before the COVID-19 outbreak (control period) to 6.3% during the lockdown. The average difference registered is equal to -3.6%. The median reduction was equal to -7%, showing a quite strong shrinkage of household FW even if referring to a subjective individuals' perception. This difference is also shown in Figure 4 which compares the empirical distribution of self-declared percentages of FW before (control) and during lockdown.

Figure 4 - Total self-declared FW at household level: before (control) vs. during (Covid) lockdown



As a further step of the descriptive analysis, we analyzed the changes occurred for each of the six food categories considered in the questionnaire. By focusing on the period before lockdown (control), the highest (average) percentage of FW was found for bread, vegetable and fruits, whose values are slightly greater than 10%. with the same median and Interquartile Range (IQR) values. The lowest average values equal to 4.6% was found for the meat-fish-egg categories. With respect to this control situation, the participants declared that their households reduced FW for all food categories during the Covid-19 lockdown: the greatest (average) difference was still found for bread whose percentage of waste generated was approximately equal to 4%, with an observed mean difference equal to about -6.4% compared to pre-Covid period. A remarkable reduction was also observed for fruits and vegetables. Figure 5 shows the entire distributions of the empirical ΔFW for the k=6 food categories which from the left (pasta-rice) to the right (bread) show an increasing variability in the mid-range (central) part of the distribution.

Figure 5 - Distribution of the empirical ΔFW for the k=6 food categories



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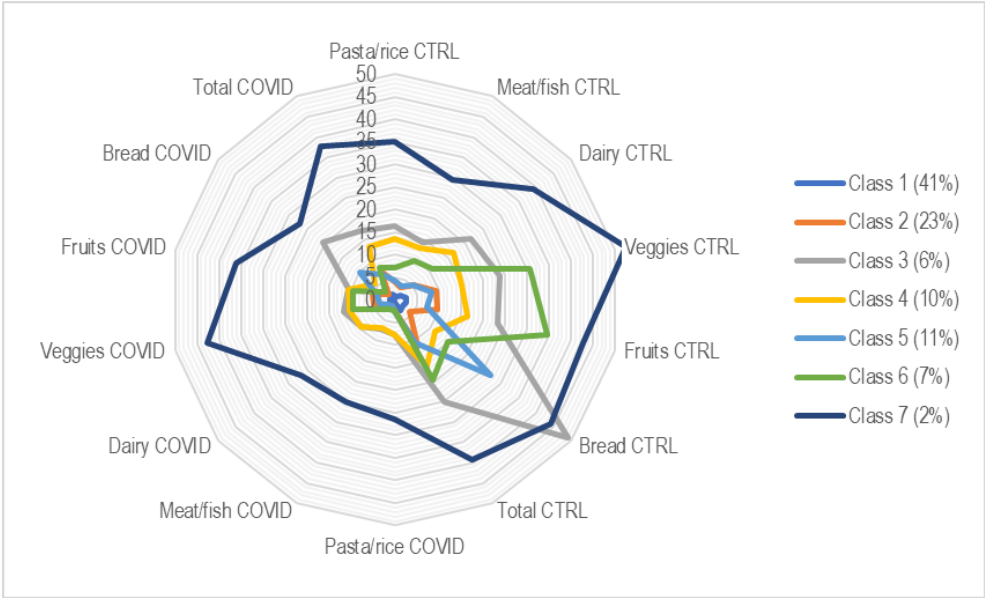
404 *3.3 FW-related profiles of respondents*

405 A cluster analysis was used to describe the profile of groups of participants with similar features with
406 respect to FW generation. The results show clear differences among the 7 classes emerged from the
407 analysis with respect to the FW-related variables considered. Figure 6 reports the profile of the groups
408 against the seven items considered (waste of pasta/rice, meat/fish, dairy products, vegetables, fruits,
409 bread, total FW) before (CTRL) and during (COVID) the Covid-19 lockdown. Class 7, a small group
410 composed of only 20 observations, stands out for the high wasteful behaviour, very different from
411 the other respondents, for all food categories. In contrast, Class 1 is characterised by a very low
412 amount of declared FW, for all food categories; this group is the largest, counting 41% of the
413 observations, i.e. 439 respondents. As for the other groups, interesting profiles can be noticed. Class
414 3 and 6 show a different pattern of FW with respect to the others because they mostly waste,
415 respectively, bread and fruits/vegetables; however, both groups show a reduced percentage of waste
416 for these categories during the lockdown, with respect to the control situation. Class 5 shows the same

pattern of Class 3, but with a lower amount of waste declared. Class 2 and 4 show an intermediate wasteful behaviour with respect to the other classes.

Except for Class 7, all groups show percentages of FW remarkably lower in the left-side part of the graph (situation during the lockdown) than on the right-side (situation before the lockdown).

Figure 6 – Profile of clusters based on FW-related behaviour



3.4 FW before and during lockdown: what has changed?

In this sub-section the estimates of the SUR models are reported both for the overall self-declared percentage of FW (Table 2) and for the k=6 food categories (Table 3).

The estimates of the two-equation SUR model reported in Table 2 compares the self-declared percentages of FW generated by the households before (control) and during (COVID19) lockdown. It is worth noting that the two models show the same groups of covariates: i) socio-economic characteristics of the household and the "householder" (h-head) identified as the person responsible for food purchase and management; ii) contextual variables (and opinions) related to the (administrative/municipal) area in which individuals live; iii) shopping habits and behaviour

434 regarding food purchase; iv) habits and practices towards meals and leftover management; v) attitudes
435 towards FW issues.

436 Table 2 - Two-equation SUR model for overall FW: estimates referring to before (control) and
437 during (Covid) lockdown

	I EQUATION: before lockdown (Control)			II EQUATION: during lockdown (COVID19)		
	Coeff	SE	Sign	Coeff	SE	Sign
Household and "H-head" socio-economic characteristics						
Age	-0.699	0.215	***	-0.596	0.172	***
Age^2	0.006	0.002	***	0.006	0.002	***
Gender (ref. Female)	-4.421	2.059	**	-0.299	1.646	
Gender_age	0.068	0.050		0.000	0.040	
Education (year)	-0.681	0.677		-0.434	0.540	
Marital status (ref. Married or cohabiting)						
Unmarried	-1.074	0.947		-0.192	0.757	
Separated/Divorced	-0.094	1.454		0.505	1.165	
Widower	5.439	2.915	*	5.622	2.324	**
Job status (ref. Employed)						
Temporary employed	-1.654	1.123		-0.723	0.898	
Looking for employment	0.817	1.441		1.260	1.149	
Retired	-4.681	1.896	**	-2.172	1.515	
Student	-2.511	1.501	*	-0.914	1.194	
Housewife	-0.112	1.439		1.221	1.142	
Self-employed	-0.264	1.314		0.208	1.053	
Other condition	-1.317	2.500		-0.131	1.998	
Household size	0.427	0.328		0.361	0.262	
Number of children (0-14)	0.351	0.223		0.134	0.178	
Income (ref. Up to 1,000 Euros)						
1,001-2,000 Euros	0.709	1.319		-0.143	1.053	
2,000-4,000 Euros	-0.926	1.383		-0.835	1.102	
More than 4,000 Euros	-0.620	1.599		-1.341	1.272	
Number of income earners	0.898	0.542	*	1.082	0.434	**
Contextual variable – milieu of residence						
Municipality size (ref. up to 50,000)						
More than 50,000 inhabitants	-1.786	0.730	**	-1.099	0.584	*
Area (ref. rural zone)						
Urban zone	1.502	0.901	*	1.185	0.718	*
The place where I live seems a dirty place	0.529	0.271	**	0.044	0.217	
Shopping habits and behaviour for food purchase						
Weekly food expenditure	0.003	0.004		0.0002	0.0029	
Shopping list (ref. *Always*)						
Often	1.161	0.624	*	0.258	0.491	
Sometimes	0.674	0.659		2.004	0.659	***
Never	0.781	0.846		1.835	1.142	
Shopping places for food						
Hypermarket and supermarket	0.881	0.900		0.232	0.616	
Proximity shops	0.007	0.616		-0.197	0.489	
Street markets	0.065	0.756		-0.148	0.768	
Discounts	0.037	0.601		0.114	0.651	
Online	-0.735	1.404		-0.113	0.708	

Other	-4.711	2.658	*	-0.152	1.758	
Habits and practices towards meals and leftover management						
Food leftover management						
Food freezing	-1.043	0.589	*	0.350	0.482	
Storage for the next meal	-0.220	1.151		0.297	1.032	
Reuse leftovers for new recipe	-2.098	0.620	***	-1.774	0.533	***
Sharing food with neighbours	-1.192	0.787		-0.383	0.577	
Number of meals eaten at home (pre-COVID)	-0.322	0.095	***	-0.108	0.076	
No tradition rediscovered (only during Covid)				-0.276	0.533	
Attitude towards FW issues						
The phenomenon of FW is widespread	0.983	0.363	***	0.580	0.290	**
It is important for ME to reduce FW	-0.750	0.519		-0.481	0.412	
It is important for my FAMILY to reduce FW	-1.272	0.428	***	-1.029	0.341	***
Constant	33.178	5.837	***	22.947	4.631	***

Notes: ***p-value<0.01; **p-value<0.05; *p-value<0.10

The aim of this model was to identify the changes occurred within these sets of explicative variables under the two food management situations (control and COVID19), thus identifying groups of variables related with FW individual behaviour. However, before analyzing the estimated coefficients and their statistical significance, it is important to focus on the Breusch-Pagan test whose results (correlation between residuals equal to 0.6345; Chi2(1) = 422.047, P-value<0.001) lead us to reject the null hypothesis of independence among residuals and therefore to prefer SUR model estimates towards classical separate OLS estimations.

Concerning socio-economic characteristics, age and its squared term were found to be significantly related with the amount of FW generated. Specifically, the introduction of the age^2 term gave us the opportunity to analyze in-depth the existence of a significant non-linear relationship. According to Agresti (2018) the sign of the squared term determines whether the relationship is bowl shaped (opens up or convex functions if the squared term if greater than zero) relative to the x-axis or mound shaped (opens down or concave functions if the squared term is lower than zero). Both before and during lockdown we found a bowl-shaped (convex) functions since the parameter age^2 was statistically significant and greater than 0 (while the estimated coefficient for age was negative and statistically significant). This type of non-linear relationship proves that the amount of FW decreases when the age increase, but also that there is a minimum (age) after which the relationship between age and FW

grows again. This happens at the value of age = $-\beta_{age}/2\beta_{age\hat{}2}$. The estimated age corresponding to the minimum FW was approximately 68 years in the control situation, while it raised to about 63 years during the lockdown, ceteris paribus. Focusing on marital status, we also found a stability in the relationship across the two studied periods, with widowers showing a significant and positive relation with the amount of FW generated. A similar relationship was found for the number of income earners whose increase within a household leads to an increase of FW generated.

Focusing on contextual variables, we found a stability of the positive relationship between urban areas and quantity of FW generated at household level with individuals living in urban areas more likely to generate greater amounts of FW. However, the size of the city (and, specifically, regarding municipalities with more than 50,000 residents) was negatively associated with the quantity of declared FW. It follows that, apparently, individuals living in larger cities tend to waste less, holding constant the other variables in the model. We included in this set of variables an individual subjective perception of the cleanliness of the milieu of residence (neighborhood) in which respondents live. In this case, we found a positive and significant relationship with the quantity of FW declared in the control situation, whilst no relation was found with reference to the period of the Covid-19 lockdown.

The importance of best practices to avoid food discard is confirmed in our analysis. Both before and during lockdown, reusing leftovers for new recipe was strongly associated with a reduction of the quantity of FW declared (p-value<0.01 in both equations), while freezing food was negatively associated with the dependent variable only in the equation focusing on the control period, before the COVID-19 outbreak.

Variables related to shopping habits and expenditure were not (or only weakly) significantly associated with the overall FW generated at household level. The only exception concerns the habitude to compile a shopping list, that was found to have a strong (p-value<0.01) and positive association with the quantity of FW declared during lockdown. This means that individuals who plan their food purchase using only "sometimes" the shopping list rather than "always" tend to generate a higher amount of FW.

Lastly, focusing on attitudinal variables we found a confirmation of the importance of the personal awareness to the problem of FW. In fact, both in the control period and during the COVID-19 lockdown, the participants' own perceived importance of reducing waste translates into realizing the connected (conservative) behavior of producing low level of FW.

A more detailed and in-depth analysis was carried out for the k=6 food categories considered in the survey. As specified in section 2.4 above, we studied changes in FW behaviour for each food category (pasta/rice; meat-fish-eggs; milk and dairy products; vegetables; fruits; bread). This analysis was intended to support a supply-chain perspective in tackling household FW. Table 3 shows the parameter estimates while Table 4 shows the correlation matrix of residuals as well as the results of the Breusch-Pagan test which confirmed the existence of dependence among residuals thus confirming SUR models as a suitable choice for modelling FW behaviour per category.

Table 3 - Food category (six-equation) SUR model estimates

	Δ (PASTA)			Δ (MEAT-FISH-EGGS)			Δ (DAIRY PRODUCTS)			Δ (VEGETABLES)			Δ (FRUITS)			Δ (BREAD)		
	Coef.	SE	P>z	Coef.	SE	P>z	Coef.	SE	P>z	Coef.	SE	P>z	Coef.	SE	P>z	Coef.	SE	P>z
Age	0.068	0.021	***	0.078	0.021	***	0.055	0.021	***	0.052	0.021	**	0.036	0.021	*	0.047	0.021	**
Age^2	-0.001	0.000	***	-0.001	0.000	***	-0.001	0.000	**	-0.001	0.000	**	0.000	0.000		0.000	0.000	**
Gender (ref. Female)	0.037	0.071		-0.059	0.070		-0.042	0.070		0.015	0.070		0.062	0.070		0.071	0.071	
Education (ref. Up to secondary school)																		
Degree or post degree	-0.064	0.067		-0.064	0.067		0.027	0.066		-0.043	0.067		0.042	0.067		0.024	0.067	
Marital status (ref. Married or cohabiting)																		
Unmarried	0.211	0.094	***	0.370	0.093	***	0.183	0.093	**	0.095	0.094		0.380	0.093	***	0.173	0.094	*
Separated/Divorced	0.045	0.144		0.068	0.143		0.127	0.142		0.056	0.144		0.090	0.143		0.111	0.145	
Widower	0.222	0.289		0.351	0.287		0.270	0.285		0.103	0.288		0.179	0.287		0.055	0.290	
Municipality size (ref. up to 1,000 inabithants)																		
1,001-5000	0.027	0.229		0.108	0.227		0.160	0.226		0.394	0.228	*	0.082	0.227		-0.135	0.229	
5,000-10,000	0.082	0.227		0.133	0.225		0.438	0.224	**	0.253	0.226		-0.201	0.225		-0.262	0.227	
10,001-50,000	0.061	0.222		0.085	0.221		0.362	0.219	*	0.218	0.222		-0.081	0.221		-0.111	0.223	
50,001-100,000	0.225	0.222		0.151	0.220		0.394	0.219	*	0.229	0.221		-0.065	0.220		-0.137	0.223	
More than 100,000 inabhitants	0.271	0.218		0.253	0.217		0.333	0.215		0.262	0.218		-0.036	0.217		0.006	0.219	
Job (ref. Employed)																		
Temporary employed	0.073	0.111		0.058	0.111		0.070	0.110		-0.015	0.111		-0.015	0.111		0.028	0.112	
Looking for employment	0.115	0.142		-0.189	0.141		-0.351	0.140	**	-0.202	0.141		-0.009	0.141		-0.089	0.142	
Retired	0.165	0.187		0.147	0.186		0.237	0.185		0.454	0.187	**	0.245	0.186		0.182	0.188	
Student	0.225	0.148		0.288	0.147	**	0.174	0.146		0.307	0.147	**	0.069	0.147		0.068	0.148	
Housewife	-0.012	0.140		-0.021	0.139		0.053	0.138		0.231	0.139	*	0.014	0.139		-0.138	0.140	
Self-employed	-0.021	0.131		0.050	0.131		0.151	0.130		0.163	0.131		0.159	0.131		0.001	0.132	
Other condition	0.163	0.242		0.340	0.240		0.378	0.239		0.385	0.241		0.332	0.240		-0.032	0.243	
Area (ref. Rural zone)																		
Urban zone	-0.366	0.091	***	-0.092	0.090		0.031	0.090		0.045	0.091		-0.077	0.090		-0.111	0.091	
Household size	-0.034	0.032		-0.011	0.032		0.019	0.032		-0.032	0.032		-0.018	0.032		0.047	0.032	
Number of children (0-14)	-0.003	0.022		0.021	0.022		-0.064	0.022	***	0.012	0.022		0.050	0.022	**	-0.082	0.022	***
Net available income – Ref. up to 500 Euros																		
501-1000 Euros	0.085	0.262		-0.112	0.260		0.015	0.258		0.069	0.261		-0.285	0.260		0.082	0.263	
1,000-1500	0.025	0.237		-0.248	0.236		0.050	0.234		0.005	0.237		-0.377	0.236		-0.099	0.238	
1501-2000	-0.035	0.234		-0.029	0.232		0.051	0.231		-0.020	0.233		-0.455	0.232	**	-0.078	0.235	
2001-3000	0.184	0.235		0.116	0.234		0.207	0.232		0.101	0.235		-0.206	0.234		-0.038	0.236	
3001-4000	0.234	0.240		0.144	0.239		0.245	0.237		0.069	0.240		-0.127	0.239		-0.030	0.241	
More than 4,000 Euros	0.269	0.245		0.065	0.243		0.189	0.242		0.134	0.244		-0.202	0.243		-0.117	0.246	
Q3- Weekly food expenditure PRE-COVID	0.000	0.001		0.002	0.001	**	0.001	0.001	*	0.000	0.001		-0.001	0.001		0.000	0.001	
Q9- Weekly food expenditure DURING COVID	-0.001	0.001		-0.001	0.001	**	-0.001	0.001		0.000	0.001		0.001	0.001		0.000	0.001	
Q6 – Shopping list habit PRE-COVID (ref. Always)																		
Often	-0.113	0.081		-0.058	0.081		-0.172	0.080	**	-0.149	0.081	*	-0.126	0.081		-0.071	0.082	
Sometimes	-0.134	0.089		-0.215	0.088	**	-0.219	0.087	**	-0.249	0.088	***	-0.271	0.088	***	-0.200	0.089	**
Never	0.008	0.117		0.081	0.116		0.001	0.115		-0.138	0.116		-0.129	0.116		-0.081	0.117	
Shopping list habit during COVID (ref. Always)																		
Often	-0.014	0.082		-0.072	0.081		0.157	0.081	*	0.186	0.082	**	0.110	0.081		-0.042	0.082	
Sometimes	-0.047	0.111		0.043	0.110		0.125	0.109		0.226	0.110	**	0.215	0.110	*	0.119	0.111	
Never	-0.023	0.192		-0.392	0.190	**	-0.127	0.189		0.298	0.191		0.422	0.190	**	0.122	0.192	
Food leftovers management: PRE-COVID																		
Food freezing	0.225	0.115	**	0.100	0.114		0.185	0.113	*	0.195	0.114	*	0.002	0.114		0.187	0.115	
Storage for the next meal	0.196	0.168		0.264	0.167		0.150	0.166		-0.138	0.168		0.040	0.167		-0.105	0.169	
Reuse leftovers for new recipe	0.301	0.112	***	0.188	0.111	*	0.461	0.111	***	0.235	0.112	**	0.428	0.111	***	0.436	0.113	***
Sharing food with neighbours	0.149	0.113		0.188	0.112	*	0.168	0.112		0.080	0.113		0.040	0.112		0.124	0.114	

Food leftovers management: during COVID																
Food freezing	-0.130	0.117		-0.050	0.116		-0.162	0.116		-0.219	0.117	*	0.087	0.116		-0.076	0.118	
Storage for the next meal	-0.502	0.189	***	-0.444	0.188	**	-0.161	0.187		-0.018	0.189		-0.046	0.188		0.034	0.190	
Reuse leftovers for new recipe	-0.145	0.121		-0.019	0.120		-0.378	0.119	***	-0.291	0.120	**	-0.367	0.120	***	-0.314	0.121	***
Sharing food with neighbours	-0.122	0.104		-0.134	0.103		-0.031	0.103		0.002	0.104		-0.056	0.103		-0.116	0.104	
Having rediscovered food preparation at home (ref. At least one tradition)																		
No tradition rediscovered	0.067	0.086		0.070	0.085		0.035	0.084		0.109	0.085		0.107	0.085		0.170	0.086	**
Number of meals eaten at home (pre-covid)	0.020	0.009	**	0.032	0.009	***	0.031	0.009	***	0.047	0.009	***	0.036	0.009	***	0.020	0.010	**
The phenomenon of FW is widespread	-0.038	0.036		-0.013	0.036		-0.067	0.036	*	-0.106	0.036	***	-0.099	0.036	***	-0.058	0.036	
it is important for ME to reduce FW	0.035	0.051		0.033	0.051		0.067	0.051		0.110	0.051	**	0.089	0.051	*	0.089	0.051	*
It is important for my FAMILY to reduce FW	0.019	0.042		-0.022	0.042		-0.038	0.042		-0.037	0.042		-0.003	0.042		-0.046	0.043	
The place where I live seems a dirty place	-0.003	0.027		-0.018	0.027		-0.003	0.027		-0.016	0.027		-0.021	0.027		-0.008	0.027	
Constant	-1.611	0.616	***	-2.192	0.612	***	-2.037	0.608	***	-1.558	0.615	**	-1.074	0.612	*	-1.181	0.619	*

Notes: SE: standard error; ***p-value<0.01; **p-value<0.05; *p-value<0.10

Table 4 - Food category (six-equation) SUR model estimates

	Δ (PASTA)	**Δ (MEAT-FISH-EGGS)**	**Δ (DAIRY PRODUCTS)**	**Δ (VEGETABLES)**	**Δ (FRUITS)**	**Δ (BREAD)**
Δ (PASTA)	1					
Δ (MEAT-FISH-EGGS)	0.4473	1				
Δ (DAIRY PRODUCTS)	0.347	0.4519	1			
Δ (VEGETABLES)	0.2862	0.3931	0.3318	1		
Δ (FRUITS)	0.2296	0.3591	0.2539	0.4801	1	
Δ (BREAD)	0.3244	0.2603	0.3384	0.255	0.3488	1

Breusch-Pagan test of independence: chi2(15) = 1938.568, Pr = 0.0000

In the interpretation of the estimated coefficients, it should be remarked that the dependent variable is standardized, and it refers to the difference between the amount of FW generated (declared) during the COVID19 lockdown compared to the control period. This difference is negative or equal to zero for at least 90% of the sample, thus signifying an observed reduction of FW also within the various categories of food involved in the survey. Bearing this evidence in mind, it is therefore interesting to study which factors have influenced the reduction of FW.

On one hand, for a specific covariate an estimated positive coefficient is related with a limited change on the household FW behaviour across the two periods considered. On the other hand, a negative value of the estimated coefficient lead to show a greater divergence between the FW generated during the Covid compared to the control period. In these cases, those characteristics that exerted the greatest effect on FW during and pre lockdown are highlighted[3].

[3] For a complete reading of the results, models in which the dependent variable is not standardized, have also been estimated, with results available on request. However these models, even if suitable for reading results by food category, do not consider the different magnitude (in terms of position and variability) of the observed differences.

With the aim of facilitating an overall reading of the results obtained, Table 5 below summarizes signs and significance levels of statistically relevant relationships only.

Table 5 - (six-equation) SUR model estimates: summary of the statistically significant relationships

Variable	Δ (PASTA)		Δ (MEAT-FISH-EGGS)		Δ (DAIRY PRODUCTS)		Δ (VEGETABLES)		Δ (FRUITS)		Δ (BREAD)	
Age	+	***	+	***	+	***	+	**	+	*	+	**
Age^2	-	***	-	***	-	**	-	**			+	**
Marital status (ref. Married or cohabiting)												
Unmarried	+	***	+	***	+	**			+	***	+	*
Municipality size (ref. Up to 1,000 inabithants)												
1,001-5000							+	*				
5,000-10,000					+	**						
10,001-50,000					+	*						
50,001-100,000					+	*						
More than 100,000 inabhitants												
Job (ref. Employed)												
Temporary employed												
Looking for employment					-	**						
Retired							+	**				
Student			+	**			+	**				
Housewife							+	*				
Self-employed												
Other condition												
Area (ref. Rural zone)												
Urban zone	-	***										
Number of children (0-14)					-	***			+	**	-	***
Net available income – Ref. Up to 500 Euros												
1501-2000									-	**		
Q3- Weekly food expenditure PRE-COVID19			+	**	+	*						
Q9- Weekly food expenditure DURING COVID19			-	**								
Q6 – Shopping list habit PRE-COVID19 (ref. Always)												
Often					-	**	-	*				
Sometimes			-	**	-	**	-	***	-	***	-	**
Shopping list habit DURING COVID19 (ref. Always)												
Often					+	*	+	**				
Sometimes							+	**	+	*		
Never			-	**					+	**		
Food leftovers management: PRE-COVID19												
Food freezing	+	**			+	*	+	*				
Reuse leftovers for new recipe	+	***	+	*	+	***	+	**	+	***		***
Sharing food with neighbours			+	*								
Food leftovers management: DURING COVID19												
Food freezing							-	*				
Storage for the next meal	-	***	-	**								
Reuse leftovers for new recipe					-	***	-	**	-	***	-	***
Having rediscovered food preparation at home (ref. At least one tradition)												
No tradition rediscovered											+	**
Number of meals eaten at home (pre-COVID19)	+	**	+	***	+	***	+	***	+	***	+	**
The phenomenon of FW is widespread					-	*	-	***	-	***		
It is important for ME to reduce FW							+	**	+	*	+	*

Notes: ***p-value<0.01; **p-value<0.05; *p-value<0.10

Focusing on socio-economic variables, we found a significant and non-linear relationship for age with regard to pasta, meat-fish-eggs, dairy products and vegetables. The increase in age generally

519 decreases the Δ differences. This means that as the age increases, changes in FW-related behavior are
520 less likely to occur; therefore, youth – i.e. the type of consumers that is commonly believed to have
521 a less attentive behavior towards FW - have experienced a greater reduction/contraction of the amount
522 of waste, due to the lockdown.
523 Even more specifically about this non-linear relationship, the combination of the +/- signs in the
524 estimated coefficients for the categories of pasta, meat-fish-eggs, milk and dairy products and
525 vegetable, indicate the existence of a quadratic relationship with a concave function (since the
526 estimated coefficient of age^2 is lower than zero) and therefore the existence of an increasing effect
527 which reaches a maximum and then start to decrease. The estimate of the maximum point identified
528 with the method already described for the general model (Table 2), highlights an age for which there
529 is the highest positive marginal positive contribution of age to the dependent variable (and therefore
530 the minimum observed Δ): this age is identified in 52 years for pasta and meat-fish-eggs, and about
531 48 years for milk and dairy products and vegetables.
532 Concerning fruits, there is a positive linear relationship as age increases, therefore the differences in
533 wasted quantities (during the lockdown and compared to the control period) tends to vary linearly
534 with age, observing little differences for older people. Lastly, a quadratic positive relationship was
535 found for bread.
536 Relationships with a positive and statistically significant signs are associated to the coefficients linked
537 to the "unmarried" status: in fact, there is a positive relationship for all foods except vegetables for
538 which there is not statistical validity of the relationship. Single (unmarried) people have observed a
539 lesser difference in the quantity of FW produced across the two periods, compared to families with
540 married or cohabiting status.
541 When households were already familiar with food management practices such as “Food freezing” or
542 “Reuse leftovers for new recipes”, a lower contraction of FW across the two periods was observed.
543 Instead, when these practices have been used during the lockdown for the first time, a greater
544 difference (i.e. reduction) in the amount of FW produced at the household was observed.

Planning food purchases by compiling a shopping list has helped reducing FW. In fact, by observing the estimated relationship for this variable before the lockdown (pre COVID19), it can be observed that planning of food provisions (even occasionally) was associated with a greater reduction of FW, especially with regard to milk/dairy products and vegetables.

The number of meals consumed at home before the Covid-19 outbreak was found to be a good predictor of a conservative behaviour before and during the lockdown. As the number of meals consumed at home increased, there was a lesser contraction in the difference in FW for all categories of food analyzed during the lockdown compared to the control period. Similarly, the importance of the attitude towards FW played a role in shaping the change of behaviour: a greater awareness of the FW issues resulted in smaller differences observed between the quantity of FW generated during the lockdown compared to the previous period.

4. DISCUSSION AND CONCLUSIONS

The Covid-19 outbreak is challenging many aspects of human society, however it has offered unexpected opportunities towards sustainable food production and consumption (Sarkis et al., 2020) in line with the UN Sustainable Development Goals. In accordance with other early studies (WRAP, 2020; Waste Watchers and SWG, 2020; Jribi et al., 2020), our research found that the Italian families who participated in the survey reduced their household FW considerably during the Covid-19 lockdown. Contrastingly, another study conducted in Spain estimated an increase in household FW during the lockdown (Aldaco et al., 2020) even if these estimations are based on secondary data and not on direct measurement.

In our study, most of the participants (41%) were regarded as “mindful wasters”, meaning that they wasted little or no food both before and during the lockdown. It is important to note that the incidence of this type of consumers might be overestimated in our analysis as a possible self-selection bias during sampling. However, these consumers, who are extremely aware of FW issues are gradually increasing in number (Falasconi et al., 2019). Only a small percentage of “super wasteful” individuals

571 (2%) declared that they throw away one-third of the food they purchase, irrespective of lockdown or
572 not. The rest of the sample tend to waste only fruit and vegetables, or bread, who are probably
573 "occasional wasters" unaware of the importance of reducing the quantity of food they throw away at
574 home. Moreover, it was observed that this group greatly reduced the amount of household FW
575 produced during the Covid-19 lockdown than the other groups.
576 As might be expected, most of the participating households (57%) declared that they spent more on
577 groceries during the lockdown, which is consistent with early findings that emerged in other
578 countries, although this increase in food expenditure may not be linearly shaped. Baker et al. (2020)
579 found that in the UK food expenditure rose considerably at the beginning of the Covid-19 outbreak
580 probably due to panic buying and returned to "normal" levels after a while. In our sample, 28% of
581 the households did not change the amount of money they spent on food, while 15% spent less for
582 food during the lockdown probably due to economic constraints.
583 The pandemic drastically changed shopping routines for all households, since the frequency of food
584 shopping, which usually was 2-3 times a week before the outbreak, suddenly dropped to once a week
585 during the lockdown. Consumers probably found it difficult to go to supermarkets (Cattivelli and
586 Rusciano, 2020) and may have preferred local shops and online shopping as alternative food provision
587 channels (Cappelli and Cini, 2020). Indeed, these channels experienced a surge during the lockdown
588 which is in line with another study conducted in the UK during the Covid-19 outbreak (FSA and
589 Ipsos, 2020). Only shopping for groceries once a week may have triggered changes in household food
590 management. It was observed that consumers checked their food stocks more carefully, planned their
591 meals in advance and reported with compile a shopping list more frequently (86.5% made it "always"
592 or "very often") during the lockdown. All of these practices proved to effectively reduce the quantity
593 of FW generated at home (Parizeau et al., 2015; Exodus, 2006; WRAP, 2007; Gustavsson et al., 2011;
594 Secondi et al., 2015; Giordano et al., 2019a).
595 This study also provides evidence of the variables that are related with changes in FW-related habits
596 and behaviour observed during the Covid-19 lockdown. The role of socio-economic and behavioural

variables in shaping the quantity of household FW is well-established in the literature (Secondi et al., 2015; Koivupuro et al., 2012; Falasconi et al., 2019), however one of the aim of this study was to determine how these variables affect the changes observed in FW behaviour. Given that most households reported a reduction in the quantity of food they wasted during the Covid-19 lockdown compared to the control situation, the findings of our study reveal the factors that brought about this positive change. In particular, young people greatly reduced their FW, suggesting that the wasteful behaviour that is commonly reported for youths (Secondi et al., 2015) can be effectively corrected when individuals have more time to cook and manage their meals. It is interesting to note that the spread of planning-related food management practices (compiling a shopping list, planning food purchases and meals in advance, reuse of leftovers for other recipes) played a key role in reducing the quantity of food discarded by the participating households during the lockdown. It seems that, after the panic buying during the first few days of lockdown (Baker et al., 2020) people tended to plan their household food shopping and meals more carefully due to logistical shopping difficulties. Future research could focus on whether consumers had time to experience the food management advantages brought by the lockdown. It is possible that some of the good practices acquired during the lockdown may be continued thus reducing household FW in the long term, especially for "occasional wasters" who improved their FW-related behaviour to a larger extent.

The results also confirm the importance of training courses and information campaigns on these good food management practices in order to educate individuals to minimize the quantity of waste generated at home (Principato et al., 2015; Stefan et al., 2013; Stancu et al., 2016).

Another interesting result of this study concerns the role of contextual variables that have proved to be significant in previous studies on consumer FW (Falasconi et al., 2019). In our analysis, the urban/rural areas of residence and the size of the cities both played important and significant roles in reducing FW generated during lockdown. Moreover, the variable regarding the subjective perception of cleanliness of the area in which individuals live proved to be significantly related with the FW in the control situation: therefore, the dirtier the environment is perceived, the greater the amount of

623 FW generated, which is in line with a previous study (Secondi et al., 2015). Instead, no statistical
624 significance was observed for the same variable during the lockdown.
625 Although food losses at the early stages of the supply chain have increased during the Covid-19
626 lockdown (Veselovská, 2020; FAO, 2020) due to supply chains disruptions, limited access to markets
627 and perishable food left unsold at the retail level, it was observed that this may not be the case at
628 household level. Some FW hotspots have continued at household level during the Covid-19
629 lockdown: (i) panic buying, (ii) misinterpretation of expiration dates; (iii) incorrect food storage; (iv)
630 negative attitudes towards donating excess food to needy people (FAO, 2020; FSA and Ipsos, 2020).
631 Moreover, while greater attention to food management is observed during the lockdown (Jribi et al.,
632 2020), current worries regarding financial constraints and food affordability may have made
633 consumers eat foods that have passed the "use by" date, posing them at serious food safety hazards
634 (FSA and Ipsos, 2020). Policy measures highlighting the differences between "use by" and "best
635 before" dates (Secondi, 2019) should be implemented in order to spread the appropriate use of this
636 information. New strategies for tackling FW should focus on other levels of the supply chain where
637 date-based pricing strategies may be used to offer alternative safe choices to consumers facing
638 financial constraints (Cicatiello et al., 2019).
639 Considering the food insecurity aspects also in the developed countries due to Covid-19 and the
640 development of food sharing apps and food rescue and delivery operations (Michelini et al., 2018;
641 Secondi et al., 2019b*;* Nair et al., 2016), it is essential that individuals are able to donate their surplus
642 food to people in need according to a circular economy approach (Secondi et al., 2019a).
643 As implications for policy makers and practitioners, the results of our study highlight the importance
644 of awareness raising campaigns in order to maintain the good food management practices that
645 individuals acquired during lockdown. Particular attention should be paid to meal planning and food
646 shopping and citizens should be encouraged to compile a grocery list before going shopping and to
647 freeze their excess food. Information campaigns to this regard shall be especially targeted on youths,
648 who have considerably reduced the amount of food they waste during the lockdown; they also appear

to be more inclined towards positive nudging actions against FW, as emerged in previous studies (Von Kameke and Fischer, 2018), which may support the long-term uptake and maintenance of the good habits acquired during the Covid-19 outbreak. Similarly, since this study found a significant role concerning contextual variables, it might be proved useful to implement these recommendations in large cities and places perceived as dirty.

In conclusion, this study provides valuable insights on how the Covid-19 pandemic has influenced consumer food habits, routines and wasteful behaviour at household level. Future research should analyse in depth whether and to what extent the virtuous anti-waste food management practices acquired during lockdown will be maintained by consumers.

REFERENCES

Abeliotis, K., Lasaridi, K., & Chroni, C. (2014). Attitudes and behaviour of Greek households regarding food waste prevention. *Waste Management & Research*, *32*(3), 237-240.

Agresti, A. (2018). *Statistical methods for the social sciences (Fifth Edition)*. Pearson.

Aldaco, R., Hoehn, D., Laso, J., Margallo, M., Ruiz-Salmón, J., Cristobal, J., & Fullana-I-Palmer, P. (2020). Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach. *The Science of the total environment*, 742, 140524.

Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., & Oostindjer, M. (2015). Consumer-related food waste: Causes and potential for action. *Sustainability,* 7(6), 6457–6477.

Baker, S. R., Farrokhnia, R. A., Meyer, S., Pagel, M., & Yannelis, C. (2020). How does household spending respond to an epidemic? consumption during the 2020 covid-19 pandemic (No. w26949). National Bureau of Economic Research.

Baltagi, B.H. (2008). *Econometrics*, Springer.

Barr, S. (2007). Factors influencing environmental attitudes and behaviours: A UK case study of household waste management. *Environment and Behaviour*, 39(4), 435–473.

BCFN-EIU (2018). *Fixing food 2018: best practices towards the Sustainable Development Goals*. available at http://foodsustainability.eiu.com/whitepaper-2018/ [Accessed 14 September 2020]

Bilodeau, M., & Duchesne, P. (2000). Robust estimation of the SUR model. Canadian Journal of Statistics, 28(2), 277-288.

Bond, M., Meacham, T., Bhunnoo, R., & Benton, T. (2013). *Food waste within global food systems*. Swindon, UK: Global Food Security.

680 Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model
681 specification in econometrics. *The review of economic studies*, *47*(1), 239-253.
682 Buzby, J. C., & Guthrie, J. F. (2002). Plate waste in school nutrition programs. *The Journal of*
683 *Consumer Affairs*, *36*(2), 220-238.
684 Cadavez, V. A., & Henningsen, A. (2012). The use of seemingly unrelated regression to predict the
685 carcass composition of lambs. *Meat science*, *92*(4), 548-553.
686 Canali, M., Amani, P., Aramyan, L., Gheoldus, M., Moates, G., Östergren, K., & Vittuari, M. (2017).
687 Food waste drivers in Europe, from identification to possible interventions. *Sustainability*, *9*(1),
688 37.
689 Cappelli, A., & Cini, E. (2020). Will the COVID-19 pandemic make us reconsider the relevance of
690 short food supply chains and local productions?. *Trends in Food Science & Technology*, *99*, 566.
691 Cattivelli, V., & Rusciano, V. (2020). Social Innovation and Food Provisioning during Covid-19: The
692 Case of Urban–Rural Initiatives in the Province of Naples. *Sustainability*, *12*(11), 4444.
693 CDC (2020). *Coronavirus (COVID-19).* https ://www.cdc.gov/coronavirus/2019-ncov/index.html.
694 [Accessed on 19 May 2020].
695 Cicatiello, C., Secondi, L., & Principato, L. (2019). Investigating consumers' perception of
696 discounted suboptimal products at retail stores. *Resources*, *8*(3), 129.
697 Cicatiello, C., & Giordano, C. (2018). Measuring household food waste at national level: a systematic
698 review on methods and results. *CAB Reviews*, *13*(056), 1-8.
699 Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O. J., Hauser, H. E., van Holsteijn, F., ... &
700 Stenmarck, Å. (2019). Food waste accounting methodologies: Challenges, opportunities, and
701 further advancements. *Global food security*, *20*, 93-100.
702 Cox, J., & Downing, P. (2007). Food behaviour consumer research: quantitative phase. *Banbury UK:*
703 *Waste & Resources Action Programme*.
704 Edjabou, M. E., Petersen, C., Scheutz, C., & Astrup, T. F. (2016). Food waste from Danish
705 households: Generation and composition. *Waste management*, *52*, 256-268.
706 European Commission (2014a). Attitudes of European towards waste management and resource
707 efficiency. Report Flash Eurobarometer survey no. 388, June 2014. Eurobarometer.
708 European Commission (2014b). Flash Eurobarometer 388. Attitudes of Europeans Towards Waste
709 Management and Resource Efficiency. TNS Political & Social. GESIS Data Archive, Cologne.
710 Eurostat (2019). How do women and men use their time – statistics. https://ec.europa.eu/Eurostat
711 [Accessed on 20 July 2020]
712 Evans, D. (2011). Blaming the consumer–once again: the social and material contexts of everyday
713 food waste practices in some English households. *Critical public health*, *21*(4), 429-440.

714 Evans, D., Campbell, H., & Murcott, A. (2012). A brief pre-history of food waste and the social
715 sciences. *The Sociological Review*, *60*, 5-26.
716 Exodus (2006). Quantitative assessment of the nature, scale and origin of post consumer food waste
717 arising in Great Britain. *Banbury UK: Waste & Resources Action Programme*.
718 Falasconi, L., Cicatiello, C., Franco, S., Segrè, A., Setti, M., & Vittuari, M. (2019). Such a shame! A
719 study on self-perception of household food waste. *Sustainability*, *11*(1), 270.
720 Fanelli, R. M., & Di Florio, A. (2016). Domestic food waste, gap in times of crisis. *Italian Review of*
721 *Agricultural Economics*, *71*(2), 111-125.
722 Food and Agriculture Organization of the United Nations (FAO) (2013). *Food Wastage Footprint:*
723 *Impacts on Natural Resources: Summary Report*. FAO.
724 Food and Agriculture Organization of the United Nations (FAO) (2014). *Food Wastage Footprint:*
725 *Full-cost accounting: Final Report*. FAO. http://www.fao.org/3/a-i3991e.pdf [Accessed on 21
726 July 2020]
727 Food and Agriculture Organization of the United Nations (FAO) (2020). *Mitigating risks to food*
728 *systems during COVID-19: Reducing food loss and waste*. FAO.
729 http://www.fao.org/3/ca9056en/ca9056en.pdf [Accessed on 21 July 2020].
730 FSA (2008). *Consumer attitudes to food standards, food standards agency*. London.
731 https://www.food.gov.uk/multimedia/pdfs/consatts_scotland.pdf [Accessed 21 July 2020]
732 FSA and Ipsos (2020). *Covid-19 Consumer Tracker Waves 1-4*. London.
733 https://www.food.gov.uk/sites/default/files/media/document/covid-19-wave-1-4-report-final-
734 mc.pdf [Accessed on 14 September 2020]
735 Giordano, C., Alboni, F., Cicatiello, C., & Falasconi, L. (2019a). Do discounted food products end
736 up in the bin? An investigation into the link between deal-prone shopping behaviour and quantities
737 of household food waste. *International journal of consumer studies*, 43(2), 199-209.
738 Giordano, C., Alboni, F., & Falasconi, L. (2019b). Quantities, determinants, and awareness of
739 households' food waste in Italy: A comparison between diary and questionnaires quantities.
740 *Sustainability*, 11(12), 3381.
741 Graham-Rowe, E., Jessop, D. C., & Sparks, P. (2014). Identifying motivations and barriers to
742 minimising household food waste*. Resources, Conservation and Recycling*, 84, 15–23.
743 Gustavsson, J., Cederberg, C., & Sonesson, U. (2011). *Global Food Losses and Food Waste,Swedish*
744 *Institute for Food and Biotechnology* (SIK), Gothenburg.
745 Hamilton, C., Denniss, R., & Baker, D. (2005). *Wasteful consumption in Australia*. Discussion Paper
746 Number 77. Manuka, Australia: The Australia Institute.

747 Ismea (2020). *2° Rapporto sulla domanda e l'offerta dei prodotti alimentari nelle prime settimane di*
748 *diffusione del virus, aprile 2020*.
749 http://www.ismea.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/11036 [Accessed 19 May
750 2020]
751 Istat (2020a), *Nota Mensile sull'andamento dell'economia italiana*, Marzo 2020.
752 https://www.istat.it/it/files//2020/04/notamensile_marzo_def.pdf [Accessed 21 May 2020]
753 Istat (2020b). *Contributo e posizionamento all'interno del sistema produttivo italiano dei settori di*
754 *attività economica, secondo la classificazione Ateco a 5 cifre*.
755 https://www.istat.it/it/files//2020/04/nota-esplicativa_posizionamento.pdf [Accessed 21 May
756 2020]
757 Istat (2020c), *Statistiche report: indicatori demografici anno 2019*.
758 https://www.istat.it/it/files//2020/02/Indicatori-demografici_2019.pdf [Accessed 14 September
759 2020]
760 Istat (2020d), *Statistiche report: livelli di istruzione e ritorni occupazionali anno 2019*.
761 https://www.istat.it/it/files/2020/07/Livelli-di-istruzione-e-ritorni-occupazionali.pdf [Accessed 14
762 September 2020]
763 Istat (2020e), *Statistiche flash: il mercato del lavoro IV trimestre 2019*.
764 https://www.istat.it/it/files//2020/03/Mercato-del-lavoro-IV-trim_2019.pdf [Accessed 14
765 September 2020]
766 Jörissen, J., Priefer, C., & Bräutigam, K. R. (2015). Food waste generation at household level: Results
767 of a survey among employees of two European research centers in Italy and Germany.
768 *Sustainability*, 7(3), 2695-2715.
769 Jribi, S., Ben Ismail, H., Doggui, D., & Debbabi, H. (2020). COVID-19 virus outbreak lockdown:
770 What impacts on household food wastage?. *Environment, Development and Sustainability*, 22,
771 3939-3955.
772 Judge, G. G., Hill, R. C., Griffiths, W. E., Lütkepohl, H., & Lee, T. C. (1988). *Introduction to the*
773 *Theory and Practice of Econometrics* (No. 330.015195 I61 1988). J. Wiley.
774 Koivupuro, H. K., Hartikainen, H., Silvennoinen, K., Katajajuuri, J. M., Heikintalo, N., Reinikainen,
775 A., & Jalkanen, L. (2012). Influence of socio-demographical, behavioural and attitudinal factors
776 on the amount of avoidable food waste generated in Finnish households. *International journal of*
777 *consumer studies*, *36*(2), 183-191.
778 Lyndhurst, B. (2007). Food behaviour consumer research—findings from the quantitative
779 survey. *Briefing Paper*. Banbury UK: Waste & Resources Action Programme.

780 Masotti, M., Stewart, G., Close, A., Setti, M., & Vittuari, M. (2019). D4. 6-Pan-European scenarios
781 of food waste levels. Refresh H2020 project.
782 Mondejar-Jimenez, J. A., Ferrari, G., Secondi, L., & Principato, L. (2016). *Journal of Cleaner*
783 *Production*, Part 1, 138(1), 8–18.
784 Monier, V., Mudgal, S., Escalon, V., O'Connor, C., Gibon, T., Anderson, G., & Montoux, H. (2010).
785 Final report–Preparatory study on food waste across EU 27; European Commission [DG ENV–
786 Directorate C]. Paris: BIO Intelligence Service, 1-205.
787 Osner, R. (1982). Food wastage. *Nutrition and Food Science*, 82(4), 13–16.
788 Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains:
789 quantification and potential for change to 2050. *Philosophical transactions of the royal society B:*
790 *biological sciences*, *365*(1554), 3065-3081.
791 Parizeau, K., von Massow, M., & Martin, R. (2015). Household-level dynamics of food waste
792 production and related beliefs, attitudes, and behaviours in guelph, Ontario. *Waste Management*,
793 35, 207–217.
794 Principato, L., Secondi, L., & Pratesi, C. A. (2015). Reducing food waste: an investigation on the
795 behaviour of Italian youths. British Food Journal, 117(2): 731-748.
796 Principato L. (2018). *Food Waste at Consumer Level. A comprehensive Literature Review*. Springer,
797 Cham (ZG)Switzerland.
798 Principato L., Mattia G., Di Leo A., Pratesi C.A. (2020). The Household Wasteful Behaviour
799 Framework: a Systematic Review of Consumer Food Waste, *Industrial Marketing Management*,
800 in press.
801 Quested, T. E., Marsh, E., Stunell, D., & Parry, A. D. (2013). Spaghetti soup: the complex world of
802 food waste behaviours. *Resources, Conservation and Recycling*, 79, 43–51.
803 Sarkis, J., Cohen, M., Dewick, P., & Schroeder, P. (2020). A brave new world: lessons from the
804 COVID-19 pandemic for transitioning to sustainable supply and production. *Resources,*
805 *Conservation & Recycling*, in press.
806 Secondi L., Principato L., Ruini L., Guidi M. (2019a). Reusing Food Waste in Food Manufacturing
807 Companies: The Case of the Tomato-Sauce Supply Chain, *Sustainability,* 11, 2154.
808 Secondi L., Principato, L., Mattia G. (2019b). Can digital solutions help in the minimization of out-
809 of-home waste? An analysis from the client and business perspective, *British Food Journal*, in
810 press.
811 Secondi, L. (2019). Expiry Dates, Consumer Behavior, and Food Waste: How Would Italian
812 Consumers React If There Were No Longer "Best Before" Labels?. *Sustainability*, 11(23), 6821.
813 Secondi, L., Principato, L., & Laureti, T. (2015). Household food waste behaviour in EU-27

countries: A multilevel analysis. *Food policy*, *56*, 25-40.

Sen, S., & Block, L. G., 2009. Why my mother never threw anything out: The effect of product freshness on consumption. *Journal of Consumer Research*, 36(1), 47–55.

Shanes, K., Dobernig, K., & Gözet, B., 2018. Food waste matters: A systematic review of household food waste practices and their policy implications. *Journal of Cleaner Production*, 182(1), 978–991.

Stancu, V., Haugaard, P., & Lähteenmäki, L. (2016). Determinants of consumer food waste behaviour: Two routes to food waste. *Appetite*, *96*, 7-17.

Stefan, V., van Herpen, E., Tudoran, A. A., & Lahteenmaki, L. (2013). Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. *Food Quality and Preference*, 28, 375–381.

Szabó-Bódi, B., Kasza, G., & Szakos, D. (2018). Assessment of household food waste in Hungary. *British Food Journal*, 120, 625–638.

United Nations (2020), *#Envision2030 Goal 12: Responsible Consumption and Production* [WWW Document]. https://www.un.org/development/desa/disabilities/envision2030-goal12.html [Accessed 20 July 2020]

Van Garde, S. J., & Woodburn, M. J. (1987). Food discard practices of householders. *Journal of the American Dietetic Association*, 87, 322–329.

Van Geffen, L.E.J., Van Herpen van Trijp, J.C.M. (2016). Causes and determinants of consumer food waste: A theoretical framework. Refresh H2020 project report. https://eurefresh.org/sites/default/files/Causes%20%26%20Determinants%20of%20Consumers%20Food%20Waste_0.pdf [Accessed 20 July 2020]

Von Kameke, C., & Fischer, D. (2018). Preventing household food waste via nudging: An exploration of consumer perceptions. Journal of Cleaner Production, 184, 32-40.

Veselovská, L. (2020). Supply chain disruptions in the context of early stages of the global COVID-19 outbreak. *Problems and Perspectives in Management*, 18(2), 490.

Visschers, V. H. M., Wickli, N., & Siegrist, M. (2016). Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households. *Journal of Environmental Psychology*, 45, 66–78.

Visschers, V. H., Wickli, N., & Siegrist, M. (2016). Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households. Journal of Environmental Psychology, 45, 66-78.

Wansink, B., & Wright, A. O. (2006). 'Best If Used By?' how freshness dating influences food acceptance. *Journal of Food Science*, 71(4), 354–357.

WasteWatcher-SWG, (2020). #IoRestoaCasa, report. https://www.sprecozero.it/2020/05/14/italiani-e-cibo-in-tempo-di-lockdown-iorestoacasa-e-spreco-meno-i-dati-del-rapporto-waste-watcher-allalba-della-fase-2/ [Accessed 19 May 2020]

World Health Organization (WHO) (2020). *Coronavirus disease (COVID-19) Pandemic*. https ://www.who.int/emerg encie s/disea ses/novel -coron aviru s-2019 [Accessed on 19 May 2020].

World Resource Institute (2016). *Food Loss and Waste Accounting and Reporting Standard*. Washington DC.

WRAP (2020). *The Covid-19 lockdown – food purchasing, management and waste*. Banbury UK: Waste & Resources Action Programme.

Yahya, W. B., Adebayo, S. B., Jolayemi, E. T., Oyejola, B. A., & Sanni, O. O. M. (2008). Effects of non-orthogonality on the efficiency of seemingly unrelated regression (SUR) models. *InterStat Journal*, (1), 1-29.

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American statistical Association*, *57*(298), 348-368.