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This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

Published Version:

Masotti, M., van der Haar, S., Janssen, A., Iori, E., Zeinstra, G., Bos-Brouwers, H., et al. (2023). Food waste in time of COVID-19: The heterogeneous effects on consumer groups in Italy and the Netherlands. *APPETITE*, 180(1 January 2023), 1-11 [10.1016/j.appet.2022.106313].

Availability:

This version is available at: <https://hdl.handle.net/11585/895468> since: 2024-04-23

Published:

DOI: <http://doi.org/10.1016/j.appet.2022.106313>

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25 **Food waste in time of COVID-19: the heterogeneous effects on consumer groups in Italy**
26 **and the Netherlands**

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35
36 **Abstract**

37
38 Since COVID-19 outbreak, States adopted different combinations of measures to restrain its spread
39 that affected individual behaviors and the already fragile local and global food systems. The aim of
40 this research is to contribute to the scientific debate around food systems sustainability through the
41 analysis of behavioral shifts in household food waste drivers, specifically occurring during the recent
42 global pandemic. A survey was developed based on an extended version of the Motivation-
43 Opportunity-Ability (MOA) approach. A representative sample of 3,000 respondents in Italy and in
44 the Netherlands (1,500 per country) completed this survey in May 2020, while lockdown to mitigate
45 the first wave of COVID-19 outbreak was active in both countries. A cluster analysis based on
46 individual food-waste- related behaviors identified four homogenous groups of consumers in the
47 Italian sample and five in the Dutch sample. The comparative analysis of these groups led to the
48 identification of several communalities in behavioral patterns, both within and between the two
49 countries. Results suggest that in both countries, self-reported quantities of household food waste
50 actually decreased, with a stronger reduction reported by Italian consumers. The MOA approach
51 allowed to explain this perceived reduction as largely depending on the increase of opportunity to
52 dedicate more time - to food-related activities as compared to the pre-COVID-19 period, with positive
53 consequences on food management ability. These findings assist in drafting recommendations for
54 tailored interventions to reduce the amount of domestic food waste and preserve positive behaviors
55 emerged during lockdown, that could be continued in the absence of crisis.

56
57 **Keywords:** COVID-19; Food waste; Cluster analysis; Behavioral change; Motivation-Opportunity-Ability;
58 Food habits

59

1. Introduction

60 Household food waste is a complex problem with a negative economic, societal and environmental
61 impact. The Food and Agriculture Organization (FAO) estimates indicate that approximately one
62 third of all food produced globally is not consumed by humans (FAO, 2019) and, within the EU,
63 approximately 88 Mton of food is discarded as waste annually (Stenmarck et al., 2016). These
64 numbers indicate an urgent need to tackle the issue of wasted resources in the food system, by
65 improving the organization of our food systems and the behavior of consumers.

66 In this context, the COVID-19 crisis emerged in Europe during the first months of 2020, forcing
67 national governments to implement restrictions on freedom of movement and non-essential economic
68 activities to prevent the spread of the disease. This had strong and diverse impacts on both the food
69 supply chain management and the decisions of consumers (Ibn-Mohammed et al., 2021; Vidal-Mones
70 et al., 2021), including household practices related to food waste generation. (Aldaco et al., 2020;
71 Ibn-Mohammed et al., 2021; Vanapalli et al., 2021). On the supply side, lockdown measures
72 generated serious inefficiencies and distortions, potentially leading to generation of food losses (food
73 waste generated in the supply chain) due to labor shortage, limited production capacity and more
74 complex distributing logistic. On the demand side, the interruption of eating-out facilities generated
75 a peak in the consumption of food at home, influencing consumers' preferences and purchase
76 decisions (Roberts and Downing, 2020). Food access, food security and food safety emerged as major
77 concerns due to suspected transmission of COVID-19 by food and food packaging along the supply
78 chain (Galanakis, 2020; Rizou et al., 2020). Lifestyle modifications, reduced income, and job
79 insecurity together with changes in time availability, induced individuals to cope through changes in
80 behaviors, eating habits (Ben Hassen et al., 2021; Ibn-Mohammed et al., 2021; OECD, 2020) and
81 consequently affect the amount of food wasted.

82 The response to COVID-19 has not been the same across Europe. National advisory and regulatory
83 measures differed between Member States in timing, aim and intensity, depending on emergency
84 severity and national strategies. In general, two different approaches could be identified. Some EU
85 Member States, like Italy, where the pandemic hit hardest in its initial stages, adopted a very
86 restrictive approach. These countries imposed limiting or even prohibiting personal mobility and
87 economic activities, except for those strictly related to essential needs such as supermarkets or other
88 food stores (retail). Restaurants, catering and food services were forced to close. In other countries,
89 like the Netherlands, the restrictions on freedom of movement and non-essential economic activities
90 were less severe. Consequently, the associated impacts on food-related habits of citizens are assumed
91 to be different as well. Therefore, this study investigates two cases, Italy and the Netherlands, which
92 represent different contexts with regards to measures to mitigate the effects of the pandemic.

93 Moreover, both countries share a long tradition of food waste mitigation policies like the Gadda Law
94 promoted in Italy and the Realisation Plan Circular Agriculture, to achieve the SDG 12.3 target (halve
95 global per capita food waste by 2030) by focusing on awareness, activation and adaptation for the
96 Netherlands. Main action lines include monitoring, business collaboration, consumer awareness and
97 addressing inhibiting regulations at national and EU level. The COVID-19 outbreak and its
98 consequences provide a unique opportunity to analyze the impact of crisis-induced changes on
99 household food management and food waste related behaviors and this work aims to expand this field
100 of research. Although some studies underlined that some type of solid waste have increased during
101 the pandemic (like medical waste or plastic packages), the consequences of lockdown measures on
102 consumers' food waste and food-related behaviors at home are still a caveat on scientific literature.
103 Some works have tried to explore this link, but they were not based on a theoretical framework to
104 systematically explore consumer food waste drivers and were based on convenience samples that
105 precluded generalizations of results (Leal Filho et al., 2021; Liang et al., 2021; Valizadeh et al., 2021).
106 Therefore, the aim of this research is to explore how different COVID-19 related restrictive measures
107 imposed between February and June 2020 affected changes in food (waste) related behaviors of
108 Italian and Dutch consumers during the first wave of the COVID-19 pandemic using the Motivation-
109 Opportunity-Ability framework to analyze consumer food waste drivers of two nationally
110 representative samples.

111 The paper is organized as follows: section 2 describes the differences in the national responses in the
112 two countries to address the health crisis; section 3 describes the theoretical framework at the base of
113 this work; section 4 the methodology implemented for the survey development and the analysis;
114 section 5 describes the results; section 6 contains the discussion of results including policy
115 implications and strengths and limitations of the work; section 7 describes the conclusion that can be
116 drawn.

117 **2. COVID-19 outbreak and responses in Italy and the Netherlands**

118 Italy has been the first European country severely hit by the COVID-19 outbreak in late January 2020.
119 From February 23rd onwards, the Italian Government implemented several social restriction measures
120 to control the spread of COVID-19 infections leading up to a national lockdown two weeks later. At
121 first, the restrictions were limited to specific territories, with the establishment of the first “Red
122 Zones” in Lombardia and Veneto Regions, in which only retailers selling essential goods, including
123 food, could operate. Two days later, these restrictions were extended to other Northern territories and
124 new ones were introduced by March 1st. Schools of any grade, including universities, closed across
125 the whole country on March 4th. By March 11th, the lockdown was extended to the entire national

126 territory, and a 24/7 curfew affecting the freedom of movement was installed for all Italian citizens,
127 except for the workers providing essential services, like healthcare professionals or food retail staff.
128 In this context, leaving one's home was perceived as a danger for the risk of contracting COVID-19
129 and for the possibility to incur a fine due to the strict controls performed by police officers. Nearly
130 two months later, from May 18th onwards, citizens were allowed to leave their homes again for other
131 purposes than acquiring food or travelling related to essential jobs, while social distancing measures
132 (e.g. keeping a distance of at least 1.5m from each other) and other measures, like wearing mouth
133 masks and avoiding crowded places, were still enforced and encouraged.

134 The Netherlands was hit by the COVID-19 outbreak a few weeks after Italy. On March 15th, the Dutch
135 government announced several measures to slow down the spread of the virus and to prevent hospital
136 intensive care units from running out of capacity. During the so-called 'intelligent lockdown', a set
137 of rules and measures were implemented on national level, including social distancing and the closing
138 of all eating and drinking establishments (except for hotels), which were only allowed to offer take-
139 away concepts. The number of visitors in households was restricted to three 13+-year old guests, and
140 it was strongly advised that whenever possible, to work from home. Furthermore, schools and daycare
141 organizations at all levels were closed and a protocol for responsible shopping was introduced, taking
142 hygiene and social distancing measures into account. From May 11th, the first measures were lifted.
143 Primary schools partially reopened, and children went back to school at half-time. From June 1st,
144 more measures were lifted. Bars and restaurants reopened, and schools reopened completely. Social
145 distancing and all other basic rules, like washing and disinfecting hands, staying at home in case of
146 symptoms were still in place. Table 1 summarizes the different measures in Italy and the Netherlands
147 related to shopping, eating-out/take-away and freedom of movement during the first wave of
148 lockdowns. The COVID-19 pandemic has not kindled out since this first wave during the first half of
149 2020, seeing surges of new COVID-19 variants happening across the world and Europe throughout
150 2021 and into 2022.

151 When comparing both countries, the measures during February – June 2020 were stricter in Italy than
152 in the Netherlands, regarding shopping measures and limitations of movement. Most noticeable is the
153 installment of a fulltime curfew in Italy, which did not happen in the Netherlands in the first wave of
154 the pandemic. These differences allow to explore differences in food (waste) related behaviors due to
155 different patterns of COVID-19 related restrictive measures.

156

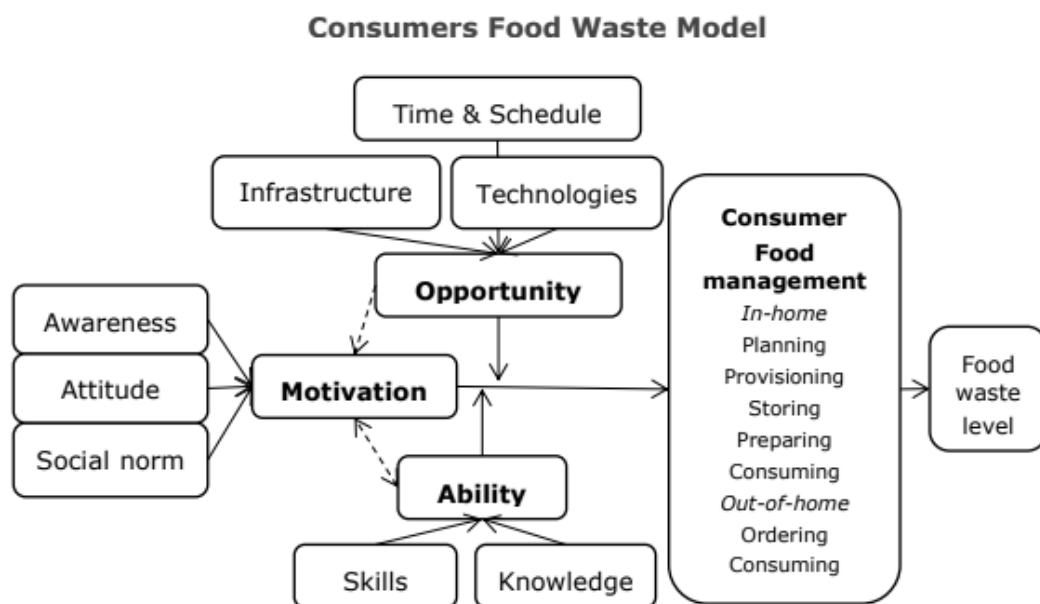
Table 1 Measures in place relating to grocery shopping, eating out and take-away of food and freedom of movement during the first lockdown between February and June 2020 in Italy and the Netherlands.

Country	Grocery shopping	Eating out and take-away	Freedom of movement
<i>Italy</i>	<p>Only stores within the municipality of residence reachable</p> <p>Only 1 person per household allowed in food store at once</p> <p>Shopping baskets/carts cleaned with disinfectant solutions</p> <p>Social distancing (1.5 m) in the shop</p> <p>All shops handled a maximum number of customers at once</p> <p>Face masks and gloves mandatory</p> <p>Farmers' markets closed</p>	<p>All eating and drinking establishments closed</p> <p>Only delivery allowed</p>	<p>Remote working was mandatory except for the workers providing essential services, like healthcare professionals or supermarket staff</p> <p>Going out allowed to obtain food for the household</p> <p>Going for a walk outside allowed within 200 meters around the house and only alone</p> <p>Only necessary travel allowed (examples are a crucial job or health reasons)</p>
<i>Netherlands</i>	<p>All stores reachable for every citizen. Only 1 person per household allowed in food store at once</p> <p>Shopping baskets/carts cleaned with disinfectant solutions</p> <p>Social distancing (1.5 m) in the shop</p> <p>All shops handled a maximum number of customers at once, based on available m² of shopping area</p> <p>Face masks and gloves not mandatory</p> <p>In some cities, food markets closed, in some they remained open (municipality could decide)</p>	<p>All eating and drinking establishments closed</p> <p>Delivery, take-away and to-go concepts allowed</p>	<p>Advice to stay home as much as possible</p> <p>Working from home is the standard, unless this is really not possible (e.g., job that is essential and has to be carried out on location)</p> <p>Advice to avoid crowded places</p> <p>Going for a walk outside allowed, with a maximum of 2 persons, unless from same household. No restrictions on distance from house</p> <p>Only necessary travel allowed (examples are a crucial job or taking care of an ill relative)</p>

3. Theoretical Framework

To understand the complexity of the multiple and interconnected behaviors leading to the generation of food waste, a number of conceptual frameworks have been developed in recent years. This research relies on the well-established Motivation-Opportunities-Abilities (MOA) theoretical framework as starting point to investigate food waste behavior under the restrictive COVID-19 measures in Italy and the Netherlands. The MOA framework considers food waste as an unintended consequence of iterative decisions and behaviors related to household food management practices, that are driven by

166 both internal (Motivation and Abilities) and external (Opportunities) factors (Van Geffen et al., 2017).
 167 The MOA framework has been tested recently within the household food waste issue on its capacity
 168 to consider both internal and external factors, its adaptability and its validation, using large-scale
 169 surveys in several EU countries, including Germany, Hungary, Italy, Spain, and the Netherlands (Van
 170 Geffen et al., 2017). The framework was developed within the European H2020 REFRESH project
 171 (van Geffen et al., 2016), building on the earlier work of, amongst others, Rothschild (1999).
 172 REFRESH was a Horizon 2020 project focused on the reduction of avoidable waste and improved
 173 valorization of food resources. Backed by research to better understand the drivers of food waste, the
 174 project supported better decision-making by industry and individual consumers.¹ Within REFRESH,
 175 monetary and non-monetary drivers of household food waste were investigated on the base of a
 176 version of the Motivation-Opportunity-Ability framework adapted to describe individual behaviors
 177 related to the food management domain. The individual decisions and behaviors described in the
 178 framework are largely part of habits, routines and semi-conscious intentions executed to manage the
 179 food supply in the household, structured as provisioning, storing, preparing and consuming. Each
 180 stage in household food management practice covers different but interconnected sets of behaviors
 181 that, at any point, can lead to intended or unintended food discards (van Geffen et al., 2020). For
 182 example, preparing too much food can displace existing meal plans, meaning that originally planned
 183 food items may get wasted (Quested et al., 2013; Schmidt, 2016).



184
 185 **Figure 1 MOA framework - source:** (van Geffen et al., 2016)

¹ <https://www.eu-refresh.org/about-refresh.html>

186 In the MOA framework, *Motivation* (M) equates to a person's willingness to perform actions that
187 avoid food waste generation (Principato et al., 2015; Setti et al., 2018; Vittuari et al., 2020) and
188 includes awareness, concerns about monetary and environmental impact, and food safety. In addition,
189 Stancu et al. (2016) indicate attitudes, injunctive norms and moral norms as well as perceived
190 behavioral control, intention, awareness of environmental, social and economic impacts as important
191 elements. Visschers et al. (2016) also include perceived health risks, subjective norms and good
192 provider identity as Motivation elements (Aktas et al., 2018; Schanes et al., 2018; Stangherlin and de
193 Barcellos, 2018).

194 *Opportunity* (O) refers to the availability and accessibility of materials and resources needed to
195 change behavior (Shwom and Lorenzen, 2012). Time and schedule, materials, technologies and
196 infrastructure further shape this driver of food waste, e.g., portion or package size, discount
197 promotions in shops, etc. (Stancu et al., 2016; van Geffen et al., 2020).

198 Finally, *Ability* (A) is a driver for food waste generation. Prior findings suggest items related to
199 knowledge and skills on the use of date labelling and estimating food edibility to contribute to
200 household food waste (Smith and Landry, 2020; van Geffen et al., 2020). Ability also refers to a
201 person's proficiency to solve the problems that he or she encounters when changing behavior,
202 including breaking well-formed habits and routines or countering the arguments of peers (Rothschild,
203 1999).

204 Next to behavioral drivers, various socio-demographic factors play a role in the generation of
205 household food waste. In van Herpen et al. (2019), socio-demographic characteristics correlated to
206 food waste level, household management practices, motivation, abilities and opportunities. Therefore,
207 age, household size, gender and country need to be considered when applying the MOA framework.
208 Furthermore, employment status, income and education level have shown to influence food waste
209 generation at the household level (van Geffen et al., 2020).

210 The analytical framework used in this study was extended with novel elements of *Uncertainty* (U)
211 that consumers experienced due to the COVID-19 restrictions. Uncertainty is defined as incomplete
212 information or knowledge about a situation – meaning, the possible alternatives or the probability of
213 their occurrence or their outcomes are not known. (Scholz, 1983). This was the case for the
214 restrictions adopted to contain the COVID-19 outbreak, due to the unknown potential sanitary and
215 economic consequences of the pandemic. Behavioral economics proved that the presence of events
216 that cannot be estimated precisely undermines the rationality of decisions, including those related to
217 purchasing habits. This can lead to potential irrational behaviors (Setti et al., 2018; Tversky and Fox,
218 1995; Tversky and Kahneman, 1992) that should be considered in analyzing food waste drivers. In
219 this work, Uncertainty is investigated in relation to the domain of household food waste generation.

220 To do so, Uncertainty items like fear of being exposed to the COVID-19 virus during grocery
221 shopping, social pressure inside the shops (e.g. the repeated requests of spending a low amount of
222 time inside supermarkets and the fear of being in contact with other people inside shops), the change
223 in number of meals consumed at home, and the occurrence (or absence) of unforeseen events
224 influencing the management of meals) were added to the questionnaire. In the current study, an
225 extended “MOA+U” framework is applied (Vittuari et al 2021).

226 **4. Method and Materials**

227 The study used a cross-sectional design in which a questionnaire was submitted to two representative
228 samples of Italian and Dutch consumers (1500 respondents each) in May 2020, when lockdown
229 measures were active in both countries as described in Section 1. In Italy data were collected from
230 the 24th to the 30th of May, just after the end of the most restrictive measures. In the Netherlands data
231 collection took place between the 8th and the 17th of May, which was still in the lockdown period.
232 Halfway this period (11th of May), the advice to ‘stay home as much as possible’ was changed to
233 ‘avoid crowded places’. Since questions were clearly referred to the lockdown period that ended just
234 a few days before in Italy and was still partly in place for the Netherlands, the reliability of answers
235 was considered high, and behaviors were most probably still influenced by the restrictions.

236 The questionnaire was based on items tested and validated across several EU countries as a consistent
237 tool to investigate food waste drivers at consumer level (van Herpen et al., 2019). The Likert scale
238 was adopted for the answers after a careful review of existing literature on the method for measuring
239 food-related behaviors (Grainger et al., 2018).

240 Respondents were 18 years and older, and responsible for at least half of the food shopping and
241 cooking in the household and were not sick for more than two weeks during the lockdown. The
242 selected samples were nationally representative in terms of key demographics: household size,
243 gender, age, income, education, region and urban-rural living area. Respondents were randomly
244 drawn from the online panel based on the available profile data (age, gender and region) and pre-
245 defined sub-sample sizes (quota) based on official population statistics in terms of key demographics.
246 Quotas allow for generalization to national household level and cross-country comparison during data
247 collection. A professional market research organization, MSI-ACI EUROPE BV, was contracted for
248 the recruitment and data collection of the survey for both countries. The sampling methodology
249 adopted by MSI-ACI EUROPE BV is based on the blending of different panel and sample sources
250 for each study through one controlled platform to ensure quality sampling. Non-probability/volunteer
251 online access panels were used as a sampling frame. Recruitment of respondents continued until the
252 agreed sample size was achieved while always considering sampling quotas. The survey was

253 conducted online through computer-assisted web interviewing (CAWI) and was compliant with the
254 General Data Protection Regulation (GDPR). All respondents gave informed consent before filling
255 out the survey. It was explained to respondents that the aim of the survey was to investigate how the
256 COVID-19 restrictions taken by the government affect shopping routines, purchasing behavior and
257 the way food is handled in households. As an incentive, respondents earned points for a personal
258 saving system. These points could then be used for specific discounts or products. Answers were
259 checked for consistency by verifying answering speed (per question, per screen, and overall
260 completion time per questionnaire) and machine-generated or speed clicked answers. These outliers
261 were removed from the dataset.

262 **4.1 Questionnaire development**

263 The questionnaire was designed following the conceptual MOA framework, integrated with elements
264 related to Uncertainty and included 42 questions. The questionnaires for the Dutch and Italian sample
265 shared a common basis as well as specific questions targeting the characteristics of the COVID-19
266 measures and the food culture context in each country. Questionnaires were developed in English, on
267 the base of the REFRESH framework, and then translated in Dutch and Italian. Before the submission,
268 the questionnaires were tested for clarity and readability by submitting them to colleagues of both
269 research teams not involved in this research and in the REFRESH project. Then it was technically
270 revised and piloted by the market research company. In line with the research aim, the questionnaire
271 focused on discerning differences in food (waste) related behaviors of Italian and Dutch consumers
272 during the period of implementation of restrictive measures, compared to the pre-COVID-19
273 situation. Respondents were asked to self-compare their food (waste) behaviors on changes in
274 prevalence before and during the COVID-19 restrictions on a 7-point Likert scale (from 1=much less
275 to 7=much more). Items of each question were presented in randomized order to avoid item ordering
276 effects.

277 The 42 questions were structured in 7 sections. Section 1 (S0-S4) was dedicated to the screening of
278 respondents, section 2 (Q1-Q11a) concerned grocery shopping habits and planning, section 3 (Q12
279 to Q16) referred to meal preparation, section 4 (Q17, Q18) investigated behaviors and habits related
280 to stock management, and section 5 (Q19-Q25) was related to self-reported food waste amounts and
281 handling of meal leftovers. Finally, section 6 (Q26-Q29) referred to a set of behaviors and habits
282 adopted by the household during the lockdown, and section 7 (Q32-Q38) concerned the socio-
283 demographic characteristics of the respondent's household.

284 In each section, the theoretical constructs of the MOA+U framework were explored using dedicated
285 different questions to capture all different aspects and nuances of these theoretical constructs. For the

286 complete list of questions and their differences across countries, see Appendix A. Completing the
287 questionnaire took 15 to 20 minutes.

288 **4.2 Data management and cluster analysis**

289 Since the aim of the work is to explore different groups of consumers adapted to different types of
290 COVID-19 related restrictions, descriptive statistics and clustering analysis were performed for each
291 country. The comparability of the survey design both in terms of questionnaire and sampling strategy
292 with national representative quotas allows the comparison of results in both countries. Cluster
293 analysis identified homogeneous groups of consumers in each of the two countries based on food
294 management habits and adaptation strategies implemented to cope with the COVID-19 measures.
295 Variables have been recoded from the 7-point Likert scale to a -3 (highest decrease or strongest
296 disagreement) to +3 (highest increase or strongest agreement) scale and were then standardized. Then,
297 several hierarchical (single, average, complete, weighted-average, median, centroid, and Ward's
298 linkage) and partition (k-means and k-medians) clustering algorithms were implemented. Output for
299 the Ward's minimum variance clustering was retained, since it returned the most balanced number of
300 clusters in terms of size. In addition, Ward's minimum variance method, minimizing the intra-cluster
301 variance and maximizing the variance among the clusters, allows identifying the most coherent
302 groups of subjects, and avoids overlap among clusters. The cluster analysis resulted in the
303 identification of four Italian and five Dutch homogeneous groups of consumers that presented
304 internally homogeneous and externally heterogeneous food-related behaviors during the sampling.
305 The number of clusters of consumers considered for each of the two countries is defined by the values
306 of the pseudo-F index calculated for the two samples, presented in Table 2.

307

308 **Table 2 Pseudo-F for Italy and the Netherlands**

Number of Clusters	Pseudo-F Italy	Pseudo-F the Netherlands
2	143.02	95.45
3	109.98	72.04
4	83.33	60.85
5	70.61	52.67
6	61.94	47.63
7	55.65	44.34
8	50.92	41.57
9	47.4	39.50
10	44.08	37.34
11	41.15	35.43
12	38.43	33.71
13	36.15	32.09
14	34.19	30.65
15	32.46	29.42

309

310 The differences across clusters were statistically tested within each country then a descriptive cross-
 311 country comparison was conducted among the different theoretical constructs of the MOA framework
 312 explored with the survey items. ANOVA models and Bonferroni multiple-comparison tests were used
 313 to assess whether the clusters differed significantly in terms of socio-demographic characteristics,
 314 and for the items related to food management and COVID-19 measures' responses. The use of
 315 parametric tests as ANOVA and Bonferroni to test differences for Likert scales is widely used in
 316 literature and is proven to be robust, also given the size of the two samples analyzed in this work.
 317 (Carifio and Perla, 2008, 2007; Norman, 2010).

318 **5. Results**

319 **5.1 Description of the clusters**

320 The Clusters identified in Italy and the Netherlands were named with acronyms related to the country
 321 (I for Italy, NE for the Netherlands) the level of adaptation of their members to the new context
 322 generated by the COVID-19 related restrictions and to the declared level of concern about the
 323 consequences of the pandemic. Concerning the level of adaptation, *W* indicates *weakly adapting*
 324 consumers, *M* stands for *moderately adapting* members, and *S* represents *strongly adapting*
 325 consumers. The level of concern of consumers for the consequences of COVID-19 is described by
 326 the letter *U* for *unconcerned* or by the letter *C* for *concerned*.

327 The four Italian clusters were called *Weakly Adapting & Unconcerned (I-WU)*, *Moderately Adapting*
 328 *& Unconcerned (I-MU)*, *Moderately Adapting & Concerned (I-MC)*, and *Strongly Adapting &*

329 *Concerned (I-SC)*. The five Dutch clusters were defined as *Moderately Adapting & Unconcerned (NE-*
 330 *MU)*, *Non-adapting & unconcerned (NE-NU)*, *Weakly adapting & unconcerned (NE-WU)*, *Weakly*
 331 *adapting & unconcerned old women (NE-WUO)*, and *Strongly adapting & concerned (SC)* (Table 3).
 332 The NE-WUO group has not been further considered in the analysis for purposes of clarity, in
 333 particular because of its very small size (2% of the total sample for the Netherlands) and its similarity
 334 with the NE-WU cluster.

335 **Table 3: Homogeneous clusters for the Italian and the Dutch samples**

Italian sample		Dutch sample	
<i>Label</i>	<i>Cluster name</i>	<i>Label</i>	<i>Cluster Name</i>
I-WU	<i>Weakly adapting & unconcerned</i>	NE-MU	<i>Moderately Adapting & Unconcerned</i>
I-MU	<i>Moderately Adapting & Unconcerned</i>	NE-NU	<i>Non-adapting & unconcerned</i>
I-MC	<i>Moderately Adapting & Concerned</i>	NE-WU	<i>Weakly adapting & unconcerned</i>
I-SC	<i>Strongly Adapting & Concerned</i>	NE-WUO	<i>Weakly adapting & unconcerned old women</i>
		NE-SC	<i>Strongly adapting & concerned</i>

336
 337 Table 4 shows the main demographics, the average shifts in self-reported quantity of household food
 338 waste compared to the pre-COVID-19 period, and the average intensity (in absolute values) of shifts
 339 in the theoretical constructs of the MOA+U framework for the whole sample and the different clusters
 340 of each country and the proportion of responses in the different parts of the aggregated scale. Larger
 341 positive shifts stand for an increase/agreement for the mentioned item, while larger negative shifts
 342 mean a decrease/disagreement. Values close to zero represents no changes in behavior as compared
 343 to pre-COVID-19.

344 Comparing both countries on a descriptive level, it is noticeable that shifts in (self-reported) food
 345 waste generation and average shifts regarding behaviors connected to food waste differ. This suggests
 346 a different impact of COVID-19 restrictions and the development of different adaptation strategies in
 347 the two countries. Both Italian and Dutch consumers self-reported to have produced less food waste
 348 within their household, and increased Motivations, Abilities and Opportunities, but these shifts were
 349 larger in Italy than in the Netherlands.

350 **Table 4: Main characteristics of the clusters in Italy and in the Netherlands**

	Italy					The Netherlands				
	Weakly adapting & unconcerned (I-WU)	Moderately Adapting & Unconcerned (I-MU)	Moderately Adapting & Concerned (I-MC)	Strongly Adapting & Concerned (I-SC)	Total sample	Moderately Adapting & Unconcerned (NE-MU)	Non-adapting & unconcerned (NE-NU)	Weakly adapting & unconcerned (NE-WU)	Strongly adapting & concerned (NE-SC)	Total sample
% of total sample	38%	8%	38%	16%	100%	36%	20%	29%	13%	98%**
Mean age (years) ± SD	46.3±14.6	51.9±13.7	45.4±13.2	40.4±12.6	45.4±14	46.9±14.6	56.2±15.1	45.3±16	43.9±15.2	48±15.8
Household size	2.8±1.2	2.7±1.4	3.2±1.1	3.3±1.2	3.0±1.2	2.3±1.2	2.0±1.0	2.4±1.2	2.6±1.4	2.3±1.2
% Women	48%	64%	66%	67%	61%	59%	63%	55%	58%	58%
% Working from home	36%	30%	43%	48%	40%	27%	17%	31%	41%	28%
Average declared shift in food waste	-1	-1	-1	-2	-1	0	0	0	-1	0
% < 0	36.2%	43.0%	58.9%	74.4%	51.6%	13.7%	16.4%	29.9%	70.1%	26.4%
% = 0	56.2%	57.0%	32.5%	12.2%	40.1%	82.6%	82.6%	63.7%	20.1%	68.9%
% > 0	7.6%	0%	9.6%	13.4%	8.3%	3.7%	1.0%	6.4%	9.8%	4.7%
Motivation*	0	1	0	1	0	0	0	0	1	0
% < 0	7.4%	14.3%	27.1%	6.2%	13.4%	4.1%	0.3%	2.7%	5.4%	2.5%
% = 0	13.0%	28.6%	29.5%	13.9%	18.6%	90.3%	97.7%	89.3%	89.2%	84.3%
% > 0	79.6%	57.1%	43.4%	79.9%	68.0%	5.6%	2%	8%	5.4%	13.2%
Opportunity*	0	1	1	1	0	0	0	0	1	0
% < 0	30.4%	5.0%	21.3%	13.8%	22.2%	19.2%	37.1%	13.1%	15.5%	17.5%
% = 0	3.9%	0.8%	2.8%	3.7%	3.2%	78.3%	60.0%	74.4%	46.5%	69.0%
% > 0	65.7%	94.2%	75.8%	82.5%	74.6%	2.5%	2.9%	12.5%	38.0%	13.5%
Ability*	0	1	1	2	1	0	0	0	1	0
% < 0	11.0%	6.2%	0.8%	0.0%	4.8%	3.3%	1.5%	1.2%	-	1.8%
% = 0	82.1%	78.4%	45.9%	11.9%	56.0%	92.6%	92.3%	80.6%	26.9%	78.5%
% > 0	7.0%	15.5%	53.4%	88.11%	39.2%	4.1%	6.2%	18.2%	70.1%	19.8%
Uncertainty*	0	1	1	1	1	0	0	0	1	0
% < 0	14.4%	38.1%	4.11%	0.5%	8.4%	52.8%	70.6%	13.0%	22.0%	35.4%
% = 0	65.5%	57.1%	38.6%	13.9%	46.1%	42.3%	26.5%	59.0%	37.0%	46.5%
% > 0	20.1%	4.8%	57.3%	85.7%	45.4%	4.9%	2.9%	28.0%	41.0%	18.1%
MOA+U*	0	1	1	1	1	0	0	0	1	0
% < 0	13.9%	0.0%	1.5%	0.0%	3.81%	17.1%	0.0%	0.8%	0.0%	5.1%
% = 0	80.6%	75.0%	66.2%	15.6%	52.1%	81.6%	100%	87.3%	42.9%	77.1%
% > 0	5.6%	25.0%	32.3%	84.4%	44.1%	1.3%	0.0%	11.9%	57.1%	17.8%

351 *Notes: *The average size in absolute values of the shift in self-reported food waste and of the theoretical constructs of MOA+U*
352 *framework are indicated; values range from -3=strongly decreased to 3=strongly increased, with 0=remained the same;*

353 *** For the sake of clarity, the NE-WUO group has not been considered further in the analysis, because of its very small size (2%*
354 *only) and its similarity with the NE-WU cluster*

355
356 I-WU and I-MC are the two largest clusters identified for the Italian sample, followed by I-SC and I-
357 MU groups. Average age of I-WU cluster is 46 years old and the 69% of its members does not have
358 children living with them. I-MU cluster has the highest average age among the Italian groups of
359 consumers, 52 years old, 15% of its members is single and the 79% does not live with children. I-MC
360 cluster registers an average age of 45 years old, includes the lowest share of single members (4.5%)
361 and the 46% of its members live in families with 1 or more children. Finally, I-SC cluster has the

362 lowest average age and includes the highest shares of women (67%) and of highly educated members
363 (43%). Half of its members live in families with 1 or more children under 12 years old.
364 For the Netherlands, NE-MU is the largest cluster identified, including the 36% of respondents,
365 followed by NE-WU, NE-NU and NE-SC groups. NE-MU cluster include respondents with an
366 average age of 47 years old. This group is the one with the highest share of singles among the Dutch
367 clusters. NE-WU cluster includes members with an average age of 45 years, who are living in small
368 families with a number of children in line with the Dutch National value (around 1 per family). The
369 NE-WU cluster includes one fifth of Dutch respondents, with an average age of 56 years old, being
370 the eldest group identified in the country. Families included in this cluster register the highest share
371 of families without children. Finally, the NE-SC cluster is the smallest of the Dutch sample (includes
372 the 13% of respondents), while being the youngest, with an average age of 44 years, and the one
373 including the highest share of highly educated people.

374

375 **5.2 Food waste related behavioral changes**

376

377 The behavioral changes registered for the Italian and Dutch samples can be divided in a) common
378 shifts, which do not present statistically significant differences between clusters but are significant
379 for the overall national samples, and in b) cluster-related shifts, which are related to the items of the
380 questionnaire that presented statistically significant differences among the clusters identified within
381 the two national samples. Both types of shifts in behavioral change are described in the next two
382 sections. Figure 2 and 4 represent the common shifts for Italy and the Netherlands and Figures 3 and
383 5 represent the cluster-related shifts for the two countries, along with the items of the questionnaire
384 included in the cluster characterization and the theoretical construct to which they belong. In Figures
385 3 and 4, clusters are superimposed, to provide a direct comparison of the different adaptation
386 strategies related to COVID-19 adopted by the groups of consumers.

387 **5.2.1 The Italian case**

388 Significant shifts in Motivation shared by the entire Italian sample across all four clusters (Figure 2)
389 consisted of an increase in awareness of food waste consequences and of sense of responsibility
390 connected to the wastage of food.

391



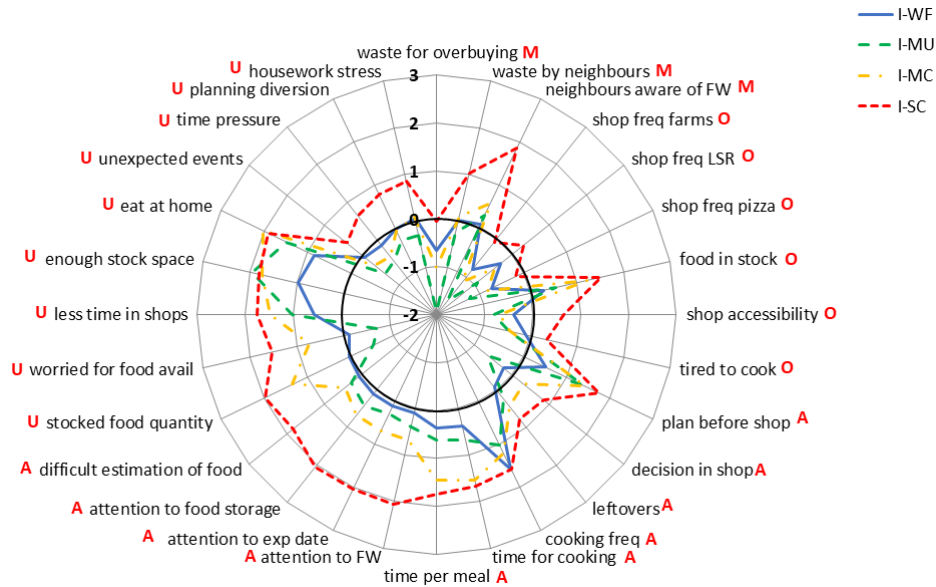
392
 393 **Figure 2: Common shifts for Italy**
 394 FW = food waste; freq. = frequency
 395 Values range from -3=strongly decreased to 3=strongly increased, with 0 (= no shifts) as reference point

396 Common changes in behaviors related to Opportunity were a decrease in shopping frequency in
 397 markets, local shops, and takeaways and, as expected, by an increase in online shopping. In addition,
 398 Italian consumers reported a general increase in the overall amount of purchased food.

399 Common behavioral changes related to Ability are mainly connected with the increased knowledge
 400 and organization of in-home food stock and in the increased propensity to try new recipes.

401 Common changes related to Uncertainty concerned a general increase of the amount of food
 402 purchased per shopping trip, the fear of going to the shops too often, and of fear of contacts with
 403 others inside supermarkets. At the same time, the Italian respondents reported a decrease in forgetting
 404 to buy previously planned food items.

405 Considering differences between the four Italian clusters, results displayed in Figure 3 show that I-
 406 SC cluster consumers present the highest level of adaptation (see also Table 4 above).



408

409 **Figure 3 Differences in behavioral shifts for the four Italian clusters**

410 FW=food waste; freq=frequency.

411 *values range from -3=strongly decreased to 3=strongly increased, with 0 (= no shifts) as reference point

412

413 Members of this cluster showed the highest average intensity value of the combined MOA+U
 414 behavioral shifts (with 84.4% of the sample declaring positive shifts), followed by the members of *I-*
 415 *MC* group (with 32.3% of respondents reporting positive shifts). *I-WU* however, appeared to be the
 416 least adaptive cluster, with only 5.6% of the sample declaring positive shifts (Table 4). These shifts
 417 in adaptation strategies correspond with shifts in household food waste self-reported levels, i.e. *I-SC*
 418 showed the highest perceived decrease in food waste generated (-2 with 74.4% of the sample
 419 declaring a perceived decrease), while this was lowest for *I-WU* (-1 with 36.2% perceiving less food
 420 waste).

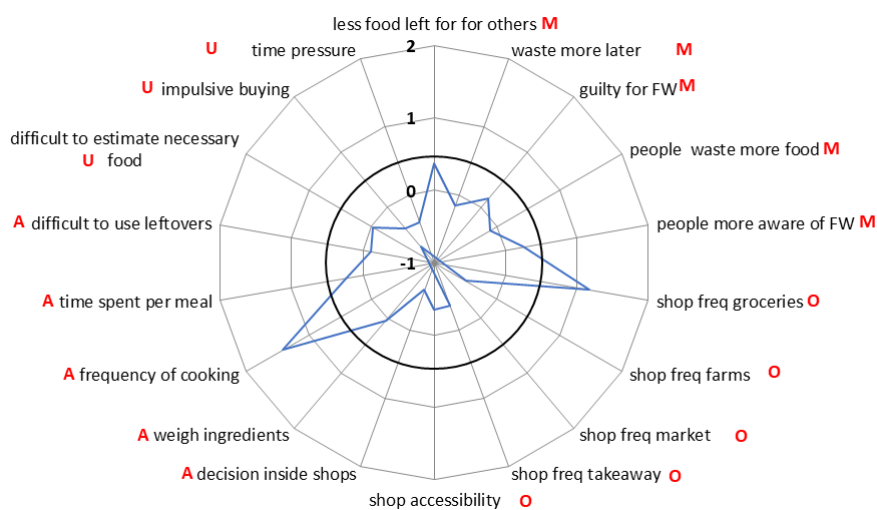
421 Concerning the shifts for items related Motivation, *I-MC* showed the highest increase in the perceived
 422 subjective and injunctive social norms on their food waste related behaviors; the other three groups
 423 all showed a decrease in the concern for food waste due to overbuying where this was unchanged for
 424 *I-SC* (Figure 3). For Opportunity, *I-WU*, *I-MU*, and *I-MC* displayed several commonalities. Members
 425 of these clusters reported a significant decrease in shopping frequency in all three types of shops and
 426 a decrease in both perceived accessibility of shops as well as a feeling of tiredness for cooking.
 427 Moreover Figure 3 and Table 4, show that *I-MU* cluster showed the largest negative average shift for
 428 the Opportunity items, while members of *I-WU* cluster registered the weakest adaptations. Finally, *I-*
 429 *SC* cluster presented the largest positive shift and the largest average shift for the Opportunity items.
 430 For Ability items, behavioral shifts in the four Italian clusters are similar in direction (increase), but
 431 different in intensity, except for impulsive buying (unplanned shopping decisions taken inside shops).

432 This is also reflected in the highest average shift value (Table 4), the *I-SC* cluster showed the highest
 433 increase for the Ability items, in particular for the attention paid to a) the perceived level of food
 434 waste produced, b) expiration dates of foods, and c) the correct storing techniques. *I-MU* members
 435 were most extreme in adapting their impulsive buying habit, by indicating to do this less frequently
 436 than the other clusters.

437 Finally, the shifts related the Uncertainty construct depict different patterns for the four Italian
 438 clusters. Also, in this case, the *IT-SC* group showed only increases (see also highest average shift for
 439 U in Table 4), with the highest values for the frequency of stocking up food and for the reduction of
 440 time spent inside shops. *I-WU*, *I-MU*, and *I-MC* clusters showed similar patterns, but the
 441 magnitude/size of their behavioral changes differed. These three groups reported decreases in the
 442 occurrence of unexpected circumstances potentially generating food waste, for the perceived time
 443 pressure, and for the divergence of food planning. Shifts for the other Uncertainty items to were into
 444 the positive direction (indicating that these items happened more often).

445 5.2.2 The Dutch case

446 Starting with common Motivation shifts in the Dutch sample (see Figure 4), an increase in awareness
 447 about food security can be noticed, because of less food available for other consumers, together with
 448 small changes in the importance of descriptive and injunctive social norms.



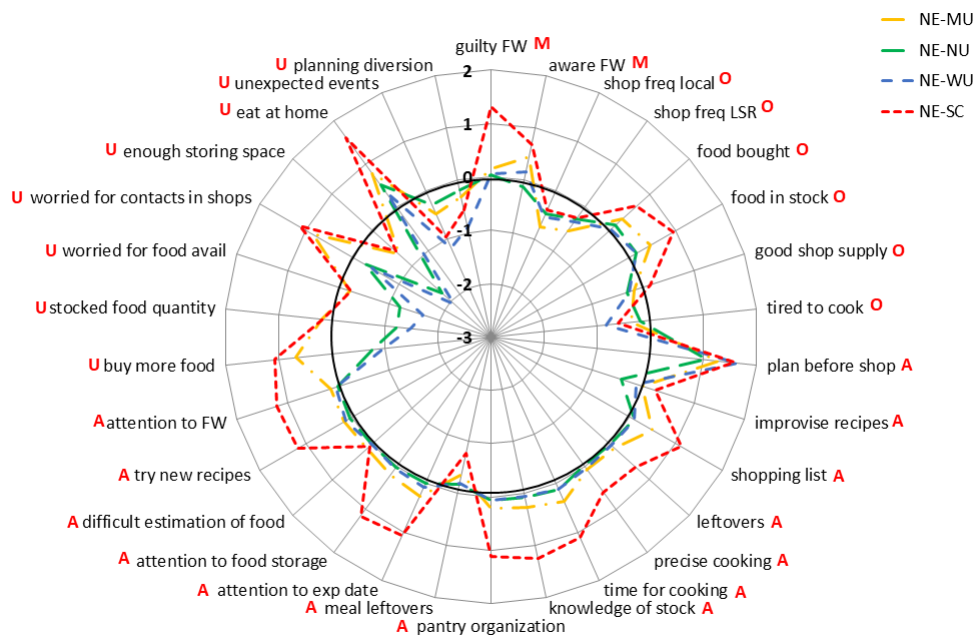
449
 450 **Figure 4: Common shifts for the Netherlands**

451 FW=food waste; freq=frequency.
 452 *values range from -3=strongly decreased to 3=strongly increased, with 0 (= no shift) as reference point
 453

454 Common changes related to Opportunity consist by an increase in shopping frequencies of groceries
 455 and a decrease in shopping frequency in farms, local markets and take-away and by a decrease in
 456 perceived accessibility of shops. Concerning Ability, common shifts are related to a strong increase

457 in the frequency of cooking, as well as small changes in frequency of weighing ingredients (slightly
 458 increased), in the difficulty in reusing leftovers (decreased), and in the total amount of time dedicated
 459 to preparation of single meals (increased). Finally, common Uncertainty trends can be seen in the
 460 decreased frequency of impulsive buying and in feeling time pressure less often.

461 Regarding the differences between the clusters, cluster *NE-SC* members showed the strongest
 462 adapting attitude, characterized by both the highest average intensity of behavioral shifts in food
 463 waste-related behaviors (with 57.1% of positive answers) and the largest reduction in self-reported
 464 food waste during the pandemic (-1 with 70.1% of respondents perceiving lower levels of food waste),
 465 see Table 4 and Figure 5 below.



466
 467 **Figure 5 Differences in behavioral shifts for the four Dutch clusters**
 468 FW=food waste; freq=frequency.
 469 *values range from -3=strongly decreased to 3=strongly increased, with 0 (= no shift) as reference point
 470

471 At the other end, cluster *NE-MU* represents those a segment of consumers who changed very little in
 472 in their food-related behaviors as reaction to the restrictions (81.6% declared no change, Table 4) and
 473 is characterized by the smallest decrease in self-reported food waste generated during the lockdown
 474 (only 13.7% declared a perceived decrease in food waste generation, Table 4). In between of these
 475 two extremes are the *N-MU* and *NE-WU* clusters. Consumers/members of these clusters are quite
 476 different in terms of demographic characteristics but registering an intermediate level of change of
 477 their food waste related habits. Also, these clusters respectively self-reported the second and third
 478 biggest reduction in food waste generation during the lockdown (Table 4).

479 Exploring the results of the Motivation items more in detail, *NE-SC* is the only group that shows an
480 increase of both awareness and guilt around food waste during the lockdown, while consumers in
481 *NE-WU* declared a marginal but significant increase only in their general awareness about food waste.
482 For Opportunity, *NE-SC* consumers experienced the strongest increase in the amount of food bought
483 per trip and kept in stock. They reported the strongest increase in the quantity of purchased food and
484 a small decrease in the use of local shops and supermarket stores. They perceived food supply in the
485 stores as slightly better than before. *NE-WU* consumers reported the strongest decrease (compared to
486 other clusters) in the use of local shops and Large-Scale Retail shops and perceived a small decline
487 in the quality of food products available in shops. They also reported an increase in the amount of
488 food bought and of food in stock. *NE-NU* and *NE-MU* reported almost no increase in food bought
489 and kept in stock, and they showed a decrease in the use of local shops and Large-Scale Retailers
490 (LSR) and in perceived food availability. *NE-NU* and to a somewhat lower extent *NE-SC* reported a
491 rather large decrease in the frequency of feeling too tired to cook.
492 *NE-SC* showed the largest significant changes (increase) in almost all Ability items, that is also
493 reflected by the largest average shift for Ability (1 and 70.1% of respondents reporting a positive
494 shift, Table 4). For this cluster, especially the frequency of using shopping lists, the time spent for
495 cooking and new recipes tried, the organization, the knowledge and the awareness of food stocks and
496 of expiration dates increased. Also, precision cooking (e.g. the ability to cooking in relation to portion
497 sizes and the amount needed in a specific moment) and attention to not produce unnecessary leftovers
498 increased, along with a decrease in the perception of having produced leftovers during the lockdown.
499 *NE-WU* members displayed some minor similarities in their changes in the Ability items compared
500 to the *NE-SC* ones, especially small increases for the frequency of using a shopping list and time
501 spent for cooking. *NE-MU* and *NE-NU* cluster members for most Ability items did not or hardly
502 changed behaviors.
503 And lastly, regarding Uncertainty items, *NE-SC* and *NE-WU* consumers adaptation to Uncertainty
504 items was rather similar. The largest increases for both clusters were an increase in the concern of
505 contacts inside shops and a shift from eating outside to eat at home. This latter shift was larger for
506 *NE-SC* than for the *NE-WU* members. In contrast, members of the *NE-MU* cluster worried the least
507 about being in contact with others inside the shops and showed the smallest decrease in the occurrence
508 of unexpected events generating food waste and for the diversion in meal planning, which is also
509 reflected by the higher share of respondents reporting null or negative values of average shifts for
510 Uncertainty as compared to *NE-SC* (Table 4). Consumers in the *NE-NU* cluster reported the largest
511 decreases in the occurrence of unexpected circumstances potentially generating food waste and for
512 deviating from the meal plan.

6. Discussion

513

514 The aim of this study was to explore differences in food (waste) related behaviors of Italian and Dutch
515 consumers during the first wave of COVID-19 related restrictive measures (February – June 2020)
516 that significantly differed for intensity and severity. From results, some points of attention can be
517 highlighted specifically related to these two countries and also some general reflections can be drawn.
518 First, restrictive measures introduced by national governments to cope with the effects of COVID-19
519 pandemic, despite some initial concerns, did not lead to an increase in the perceived amounts of food
520 waste generated by Italian and Dutch households. In particular, more than 90% of respondents in the
521 two countries declared to have not increased the perceived amount of food waste generated. The 52%
522 of Italian respondents and the 26% of Dutch respondents instead declared a decrease in the perceived
523 food waste. These findings are coherent with results from similar studies conducted in other countries
524 as Romania (Burlea-Schiopoiu et al., 2021), USA (Cosgrove et al., 2021; Rodgers et al., 2021),
525 Canada (Laila et al., 2022), and Japan (Qian et al., 2020), as well as from meta reviews, as Iranmanesh
526 et al., 2022. Moreover, while some attention has been put on the potential underestimation of food
527 waste generated during the COVID-19 pandemic (Everitt et al., 2022), the decreasing of household
528 food waste seems confirmed

529 Second, results highlighted that households adopted different sets of behaviors connected to a
530 perceived increase of opportunity to dedicate time to a more accurate management of food and this
531 perception was higher for clusters declaring less food waste. Italian and Dutch consumers declared to
532 have adopted more efficient planning strategies like precision cooking even though, especially in
533 families with children, this can be difficult due to the unpredictability of children's intake., A more
534 efficient management of food stocks and leftovers that could have generated lesser waste than before.
535 These strategies were influenced by the lower occurrence of unforeseen circumstances potentially
536 generating food waste (all the clusters except *I-SC* declared a decrease of occurrence of unexpected
537 events), a direct consequence of the limitation of freedom of movement and of meeting with other
538 individuals. Italian consumers declared an improvement of their knowledge of food stocked at home
539 and planning before shop. Dutch consumers increased more the use of shopping list, and plan before
540 shop. These planning strategies were related to the increased availability of time which was also
541 consequence of the dramatic increase of working from home and to the loss of jobs. So, concerning
542 the theoretical constructs of the MOA+U framework, results reveal shifts for all the Italian and Dutch
543 clusters for items related to Opportunity and Uncertainty. These two theoretical constructs include
544 items strongly connected with the restrictions adopted by national governments (Opportunity) and
545 with the potential sanitary and economic consequences of the COVID-19 pandemic (Uncertainty).

546 Similar changes in food related behaviors were also found in studies conducted in countries as Canada
547 (Laila et al., 2022), USA (Rodgers et al., 2021) Japan (Qian et al., 2020), and Romania (Burlea-
548 Schiopoiu et al., 2021).

549

550 Results also highlight the presence of a positive spillover from Opportunity to Ability, as the
551 increased availability of time dedicated to food management also may have stimulated investments
552 in knowledge that increased consumers food-related skills and abilities. These trends are common for
553 the majority of consumers groups, both in Italy and in the Netherlands, and consistent with studies
554 conducted in other countries like US, Romania and Canada (Babbitt et al., 2021; Burlea-Schiopoiu et
555 al., 2021; Richter et al., 2021).

556 Third, few clusters, in particular the *IT-SC* and *NE-SC*, presented a stronger adaptation and higher
557 level of concern to the consequences of the COVID-19 pandemic and declared the highest decrease
558 in household food waste perceived quantities (*I-SC* and *NE-SC*). Those consumers apparently were
559 forced by the COVID-19 related restrictions to develop a stronger adaptation strategy that included
560 the strongest shifts in items related to Ability. They were the only groups that showed increase in
561 levels of awareness and guilt around food waste during the lockdown, both for Italy and the
562 Netherlands. This may be due to the higher propensity to change of those consumers, both in terms
563 of financial capability and flexibility of behaviors, as they proved to be the most receptive to the
564 consequences of the pandemic. This propensity to change is most likely also related to demographic
565 characteristics of these two groups, as they mostly include young families with young children who
566 were not going to school or daycare centers due to the lockdown. As these children needed to stay at
567 home and to be taken care of, this required consumers from these groups to change their normal daily
568 routines, including those related to food and household management. Moreover, these groups include
569 the highest share of respondents who worked from home during the lockdown.

570 On the other hand, both countries presented evidence on clusters of consumers (*I-WU*, *NE-MU* and
571 *NE-WU*) that showed smaller behavioral shifts for items related to the Uncertainty construct. This
572 implies that these people were less bothered by the changes occurred during the lockdown. As these
573 people were, on average, older than those of other groups and were more likely to have households
574 without children, the consequences of the lock down on their daily routine presumably were less than
575 those experienced by other consumer groups.

576 The different institutional responses resulted in different changes in behaviors during the lockdowns,
577 as can be seen from the different adaptation strategies emerging across and within the two samples.
578 Several items related to Opportunity and Uncertainty revealed significant changes for both countries,
579 as these items were more closely connected to routines habits affected by the imposed restrictions.

580 Due to the different restrictions, these shifts were, in general, less strong within the Dutch sample
581 where restrictions were lighter. However, the number of common shifts for every construct of the
582 MOA+U framework was higher for the Netherlands, with the Italian situation being more diversified
583 in terms of behavioral changes caused by the restrictions due to the COVID-19 pandemic.

584 **6. 1 Policy Implications**

585 Due to the relatively high proportion of food waste generated in households compared to the full
586 supply chain, attention from national and European policy makers to tackle consumer food waste has
587 grown over the past decade. To achieve the Sustainable Development Goal 12.3 of halving food losses
588 and food waste by 2030, significant efforts need to be pursued. Although food and food waste
589 behaviors are not easy to be modified in normal times, the outcomes of this study show that during
590 the first wave of the COVID-19 lockdown period in Italy and the Netherlands, individuals were forced
591 to change their food behaviors. While being forced, those changes were not homogeneous for
592 individuals, and it was possible to identify different clusters of consumers. These clusters, both for
593 Italy and the Netherlands, presented specific shifts in food waste related drivers along with different
594 sized decreases in self-reported reported quantities of household food waste. These findings feed into
595 several potential policy implications.

596 The heterogeneity of adaptation strategies embraced by consumers groups, suggests that there is no
597 single solution to reduce domestic food waste that fits all consumers. Policy makers should provide
598 a diversified mix of interventions and tools tailored to different types of consumers, according to their
599 characteristics (e.g., demographic, lifestyle and motivations). This approach allows the design of
600 more specific and potentially more effective interventions. The MOA approach emphasize how these
601 interventions might be based on the relevant Motivation, Opportunity, and Ability domains (Michie
602 et al., 2011).

603 The results of this study highlighted the importance of the affordability and accessibility of food for
604 the reduction of domestic food waste. So, at the public level, policies should aim to increase the
605 accessibility and affordability of food for the consumers, especially those living in urban and peri-
606 urban areas. Innovative urban food policies should stimulate the diffusion of local and corner shops,
607 which could both offer quality food at affordable prices, and decrease the amount of time and
608 resources that must be dedicated to shopping, thereby improving time efficiency.

609 As emerging from the results of this study, the strongest decreases in the self-reported amounts of
610 food waste were associated with the strongest improvements in food management and cooking
611 activities in the household, paired with the strongest decrease in the frequency of unforeseen events.

612 For this reason, interventions to prevent household food waste should focus especially on improving
613 the amount of time dedicated to cooking, food management and the efficiency of food-related
614 behaviors, thereby decreasing the impact of unforeseen events in the generation of food waste. So, it
615 is likely that upon lifting of lockdown measures, the frequency (prevalence) of unforeseen events will
616 return back to ‘normal’. Measures targeting better planning and meal flexibility can support less
617 wasteful household management practice.

618 **6. 2 Strengths and limitations**

619 This study relies on consumer surveys in which they self-reported on their behavior, motivation and
620 perceived amounts of food wasted. This methodology potentially suffers from cognitive biases, such
621 as social comparison and social desirability bias as respondents tend to underreport food waste in
622 self-report measures (Van der Werf et al., 2020). While these weaknesses in surveys have been well
623 recognized and discussed in literature, the survey through CAWI method remains a solid method to
624 explore food waste and its related behaviors (van Geffen et al., 2016). Moreover, in this specific
625 context, characterized by a widespread viral pandemic, this method represented the most efficient
626 tool to cope with the obstacles posed by the COVID-19 situation. In addition, the use of Likert-scales
627 covering both positive and negative values, mitigated the effects of potential social desirability biases,
628 allowing responders to provide a large variety of answers (Giordano et al., 2019; Quedstedt et al., 2020;
629 Vittuari et al., 2020).

630 Furthermore, this data collection methodology allowed to obtain data with a high explanatory power
631 and to draw representative and generalizable results. The results led also to the elaboration of solid
632 conclusions about the impact of COVID-19 related restrictions on behavioral drivers of household
633 food waste.

634 Finally, research on the impact of Uncertainty on food-related behaviors and household food waste
635 generation are still limited. Future research should further investigate this connection, for example
636 with longitudinal studies based on repeated measurements over time, with the aim to understand the
637 evolution of behavioral drivers of household food waste and to have a better understanding of the
638 discrepancies between what consumers perceived and what they reported. In addition, this
639 longitudinal approach could lead to the identification of innovative policy initiatives aimed to
640 reinforce and exploit the unexpected positive consequences of COVID-19 related restrictions, in
641 particular the reduction of household food waste, by stimulating more sustainable food consumption
642 and management behaviors.

643

644

7. Conclusions

645 The outbreak of COVID-19 and the institutional response that followed were different for Italy and
646 the Netherlands. Italian government introduced restrictions to freedom of movement earlier and more
647 severe than the Dutch government. This study explored how different COVID-19 related restrictions
648 affected changes in food (waste) related behaviors with the support to the MOA+U theoretical
649 framework to break down which food waste drivers were most affected. This study shows that during
650 the first wave of COVID-19 related restrictive measures, on average Italian and over the Dutch
651 consumers self-reported same or lower levels of food waste, compared to the pre-COVID-19
652 situation. Namely, more than 90% of respondents in the two countries declared not to have increased
653 the amount of food waste generated, and 52% of Italian respondents and 26% of Dutch respondents
654 declared a decrease. A more efficient management of food via precision cooking, food stocks and
655 leftovers, and an increased overall attention to food planning might have allowed consumers to adopt
656 more sustainable behaviors. These findings highlight the presence of a positive spillover from
657 Opportunity to Ability, as the increased availability of time dedicated to food management also may
658 have stimulated investments in knowledge that increased consumers food-related skills and abilities.
659 Besides these general trends, different consumer clusters were identified in each country. These
660 clusters varied in the size and direction of their change in food-waste related behaviors due to the
661 restrictions, which suggests that different interventions are needed to target the consumers in these
662 different clusters.

663 Given the relations between consumption and disposal food-related habits that emerged from the
664 cluster analysis, policies and interventions aiming at reducing household food waste should consider
665 a comprehensive approach, with the aim to promote changes in a broad variety of behaviors.
666 Examples of targets for policies are the constant increase of awareness of the impact of food waste,
667 the increase of personal abilities related to management of food, including food literacy and cooking
668 skills, and, with a prominent role, the increase of consumers' opportunity to adopt more sustainable
669 behaviors and habits. From this point of view, the increase of availability of time to be dedicated to
670 kitchen activities, together with the improvement of kitchen-related abilities should have a positive
671 impact on the reduction of the amount of food waste generated in households. Moreover, future
672 policies and interventions aimed to the reduction of food waste, should aim to strengthen sustainable
673 behaviors that consumers were forced to develop during the lockdown periods. This can be achieved
674 by providing citizens the adequate cultural and financial capabilities, with the aim to reduce the
675 amount of food waste they produce, going beyond the simple increase of awareness of consequences
676 and impacts of food waste.

677 Restrictive measures adopted to mitigate the effects of the COVID-19 pandemic led to a generalized
678 reorganization of working activities, with a dramatic increase of the out-of-office work situations.
679 This approach to work will most probably also be adopted in the post-pandemic era, and the daily
680 habits of many workers will substantially change, including those related to food. Therefore, the
681 elaboration of new organizational policies that allows citizens to dedicate more time to food-related
682 activities could contribute to reduce the quantity of food waste generated by households.

683 **Acknowledgment:** The questionnaire developed within this article was inspired by the work
684 conducted within the H2020 project REFRESH and designed jointly with Wageningen Food &
685 Biobased Research working on the project “Food waste in times of Corona”, partly funded by
686 Wageningen Food & Biobased Research and partly by The Netherlands Nutrition Centre

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688 **Ethical statement:** All of the authors declare that this study followed the ethical research procedure
689 and reported relevant information in the manuscript. The survey was conducted in compliance with
690 the General Data Protection Regulation (GDPR), as well as data storage and conservation. All
691 respondents gave informed consent for participating in the survey.

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