sustainability

MDPI

Article

Impact of COVID-19 on Food and Plastic Waste Generated by Consumers in Bangkok

Chen Liu [1,*], Pongsun Bunditsakulchai [2,*] and Qiannan Zhuo [3]

[1] Sustainable Consumption and Production Area, Institute for Global Environmental Strategies, 2108-11 Kamiyamaguchi, Hayama 240-0115, Japan
[2] Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, 254 Phayathai Road, Phathum Wan, Bangkok 10330, Thailand
[3] Graduate School of Media and Governance, Keio University, 5322 Endo, Fujisawa 252-0882, Japan; s12381ss@gmail.com
* Correspondence: c-liu@iges.or.jp (C.L.); pongsun.b@chula.ac.th (P.B.)

Abstract: The crisis ignited by COVID-19 has transformed the volume and composition of waste generation and requires a dynamic response from policy makers. This study selected Bangkok as a case study to semi-quantitatively examine the impact of the COVID-19 outbreak on consumer-generated food and plastic waste by examining changes in lifestyles and consumption behaviour through a face-to-face questionnaire survey. Travel bans and diminished economic activity due to COVID-19 have led to a dramatic reduction in waste from the business sector and in the total amount of municipal waste generated. However, the results of the survey showed that both food and plastic waste generated by households in Bangkok increased during COVID-19. The shift from eating out to online food delivery services led to an increase in plastic bags, hot-and-cold food bags, plastic food containers, and food waste. Reasons for the increase in household food waste during COVID-19 varied, with respondents citing excessive amounts of food and unappetising taste, followed by exceeding the expiration date and rotting/foul odours. These reasons may be the result of the inability to predict quantity and quality when ordering online, and inadequate food planning and management by consumers. To achieve more effective food and plastic waste management, home delivery services, consumer food planning and management, and the formation of a circular economy based on localised supply chains may be considered as important intervention points.

Keywords: COVID-19; food waste; plastic waste; household; lifestyle; Bangkok

Citation: Liu, C.; Bunditsakulchai, P.; Zhuo, Q. Impact of COVID-19 on Food and Plastic Waste Generated by Consumers in Bangkok. *Sustainability* **2021**, *13*, 8988. https://doi.org/10.3390/su13168988

Academic Editors: Dimitrios Komilis, Yasuhiko Hotta, Tomohiro Tasaki and Shunsuke Managi

Received: 11 July 2021
Accepted: 6 August 2021
Published: 11 August 2021

1. Introduction

With shifts in lifestyles and consumption habits, supply chain interruptions, changes in material flows, waste sorting and recycling logistics, falling oil prices, and reduced demand for recycled waste, the COVID-19 outbreak has posed significant challenges for waste management, waste recycling, and the circular economy around the world [1–3]. This waste is not only medical, infectious, and healthcare waste but also general waste such as food waste (FW) and plastic waste (PW).

Within the past decade, food waste and plastic pollution have become key sustainability issues of international concern to policymakers, corporations, local communities, and researchers who are searching for solutions to the resulting environmental impacts across a range of academic disciplines [4–6]. There have been a number of literature review papers on FW and PW issues published in recent years. For example, Muriana [7] assessed the use of mathematical models in food waste and loss, and clarified food waste's dependency on supply chain strategies, while Amicarelli and Bux [8] outlined global approaches, characteristics, limitations, opportunities, and results of food waste measurement methodologies through a systematic and configurative literature review. Bernstad Saraiva Schott et al. [9] reviewed existing life cycle assessment studies on food waste management to clarify the

impacts of each treatment method on global warming and decisive factors in setting system boundaries. De Menna et al. [10] systematically reviewed different aspects and approaches for life cycle costing methodologies to evaluate FW management and valorisation routes.

The number of review studies on consumer-generated food waste in particular has risen since private households were first identified as key actors in food waste generation in developed economies [11]. For example, Reynolds et al. [12] reviewed literature on FW prevention at the consumption stage. Roodhuyzen et al. [13] developed a framework that conceptualised the generation of consumer food waste in relation to stages of the household supply chain and categorised 116 potential factors of consumer food waste into four groups (behavioural, personal, product, and societal factors). Schanes et al. [14] reviewed the rising number of empirical studies on consumer food waste practices and the factors that foster and impede the generation of food waste at the household level. These studies reveal food waste to be a complex and multi-faceted issue that cannot be attributed to a single variable. Given its complex nature, the growing body of literature sheds light on food-related practices and routines, ranging from planning and shopping, to storing, cooking, eating, and managing uneaten food within the context of food waste generation by adopting practical theories and other conceptual approaches.

With respect to PW studies, Heidbreder et al. [15] provided an overview of the existing social-scientific literature on plastic, ranging from awareness and consumer preference to political and psychological intervention strategies through a review of 187 studies. The review concludes that future studies should further investigate plastic-specific behaviour and implement behaviour-based solutions.

Meanwhile, many FW and PW reduction targets had been set before the onset of this global crisis, including Sustainable Development Goal 12.3 which aims to 'halve per capita global food waste at the retail and consumer levels' by 2030, as well as manage and control waste emissions and reduce marine pollution, with specific reference to targets 12.4, 12.5, and 14.1 [16]. In particular, several countries had issued bans on specific plastic products, optimistic in the hope of reducing serious environmental pollution [17]. For example, the Thai government released a 'Plastic Waste Management Road Map' to phase out the use of plastic by 2030 and issued a ban on single-use plastics in January 2020. However, the advent of the COVID-19 pandemic has enhanced the complexities of FW and PW management. Single-use plastic usage is expected to snap back due to growing concerns with hygiene (such as gloves, masks, packaging, etc.) and increased demand for online shopping during the pandemic. However, household food waste generation may abate along with the trends of more conscious food management during lockdowns due to fear and anxiety associated with logistic systems amidst concerns about food shortages [2,18,19].

Although there have been a number of studies conducted on the impacts of COVID-19 on household food waste, there has been no research on developing Asian countries or cities, and little is known about the conditions and determinants of consumer food waste during the pandemic. Lockdowns may affect consumer behaviour and attitudes towards FW and PW due to changes in lifestyle habits. It is especially urgent to view this as an opportunity to promote studies that examine the implications of food waste reduction policies in the cities of Asian developing countries where levels of FW and PW are spiking, but where both existing data and the capacity to tackle this issue are limited.

In an earlier study conducted by the authors in 2018 in Bangkok that investigated FW generation trends in Bangkok and the relationship between daily lifestyles and FW [20], it was found that FW issues in Bangkok have quite distinctive features when compared with existing studies (although most are case studies from developed countries). For example, although the proportion of organic waste and FW normally decreases in the context of growing urbanisation, this type of waste has increased in Bangkok since 2015 due to the growth of tourism and changes in food consumption lifestyles. Furthermore, it has been reported that the largest single contribution to FW in developed countries is at the consumption stage (mostly at the household level), while in developing countries, greater food losses occurred at the production and post-harvest stages [21]. However, FW

generation in Bangkok is still high compared to developed cities. Moreover, consumers in Thailand eat out frequently and consume ready-made food, which has resulted in the broad distribution of FW throughout the entire supply chain. However, since the advent of the pandemic, people have isolated themselves at home and avoided eating out, giving rise to the research question: What impact, if any, does the pandemic have on behaviour in relation to FW and PW? For these reasons, Bangkok was selected as a case study to investigate the effects of COVID-19 lockdown conditions on household FW, PW, and correlating behaviour. To the authors' best knowledge, this is the first paper to report changes in household FW and PW in Bangkok due to COVID-19 lockdowns and is the only face-to-face questionnaire survey conducted during the outbreak in 2020.

Specifically, the objectives of this study are: (1) to examine the impact of COVID-19 on food and food-related plastic waste generated by consumers, and (2) to evaluate options for preventing and reducing FW and PW even after the crisis to assist the Bangkok Metropolitan Administration (BMA) in implementing medium- to long-term improvements. For this purpose, a cross-sectional questionnaire survey was conducted to capture shifts in respondents' lifestyles during the pandemic, including a focus on behavioural changes in working on-site versus remotely, eating styles, cooking and shopping practices, as well as waste generation before and during the COVID-19 pandemic. Survey results provided insights into policy implications for addressing issues.

Following this introduction, the paper first outlines the state of COVID-19 and FW and PW generation trends in the Bangkok metropolitan area based on existing data in Section 2. The methods employed in the study are presented in Section 2, and results are discussed in Section 3. Section 4 delves further into policy recommendations. Finally, Section 5 outlines the main conclusions and identifies both limitations to the study and recommendations for further research.

2. Review of the State of COVID-19 and Food Waste and Plastic Waste Generation

2.1. COVID-19 in Thailand

The national government published a notice declaring COVID-19 to be a dangerous infectious disease on 29 February, about six weeks after the first case of the virus was found in Thailand on 12 January 2020. An emergency decree and travel ban were issued on 26 March in response to the rising number of cases following a super-spreader event at a boxing stadium on 6 March and additional cases of local transmission. As the number of cases rose, a national curfew was imposed on 3 April, which was lifted in stages in May and June. Of the 3162 cases found between 12 January and 27 June 2020, a total of 3053 people recovered, 51 patients were hospitalised, and 58 deaths were recorded. This survey was conducted between 16 and 19 June, just after the first national curfew was lifted, which means the respondents of this survey had been under lockdown for more than two months. The main timeline of the COVID-19 outbreak in Thailand around this survey is shown in Figure 1.

The Thai government instituted a number of preventive measures for COVID-19. The emergency decree on 26 March restricted domestic and international travel, banned entry into and closed high-risk areas, encouraged masks to be worn and promoted hand washing and social distancing. Restaurants and food stalls were allowed to remain open, but only for take-out. The first national curfew that started on 3 April restricted people to their homes between 10 p.m. and 4 a.m.

To curb the rise in infections, the government distributed masks, offered subsidies for healthcare services, provided free COVID-19 screenings, subsidised the costs of testing, and instituted programmes to assist persons with disabilities. The government also implemented a number of relevant measures to support individuals and companies, including deferrals and exemptions for personal income tax payments, extensions for filing tax returns, and lower taxes for small- and medium-sized enterprises (SMEs) and corporations, as well as subsidies for electricity charges to support people working from home. The subsidy period for compressed natural gas (CNG) was extended for entrepreneurs, and

the withholding tax rate was reduced, while cash subsidies were offered for employees at SMEs and value-added tax (VAT) refunds were expedited.

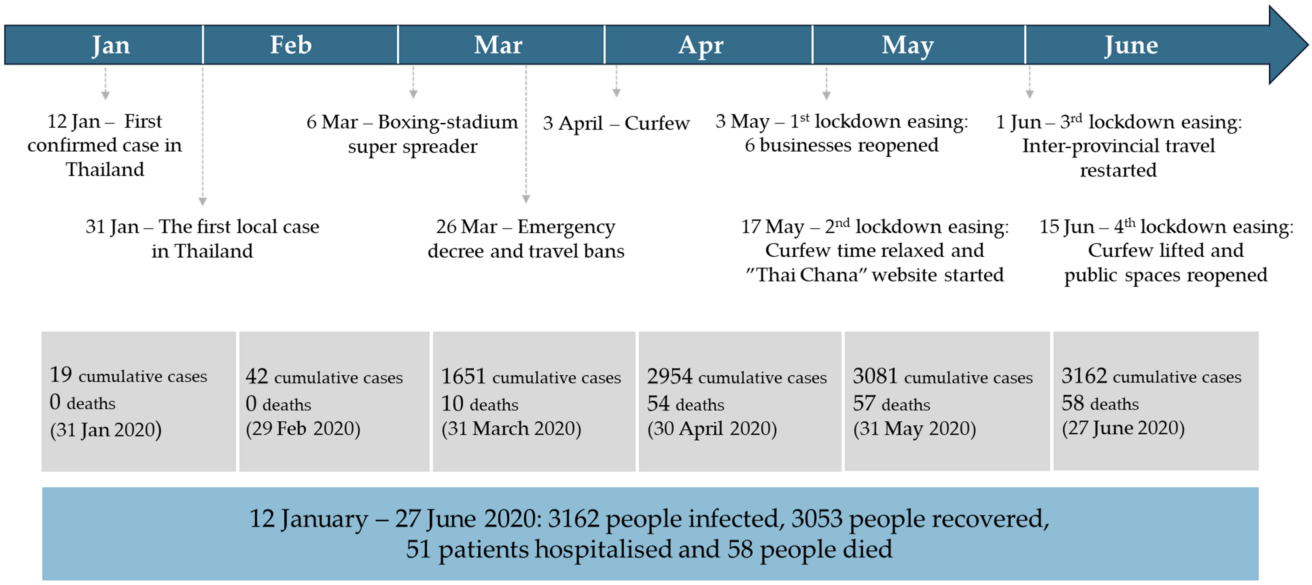

Figure 1. Timeline of COVID-19 outbreak in Thailand.

2.2. Review of Food Waste and Plastic Waste Generation in Bangkok

Based on the data collected in the authors' previous study [20] and officially reported data by the BMA's Department of Environment, time-series changes in FW, PW, and municipal solid waste (MSW) generation between 2003 and 2020 in Bangkok are shown in Figure 2. MSW is solid waste generated by municipal activities (including by residences, supermarkets, retail shops, businesses, service providers, marketplaces, and institutions) that is collected and treated by BMA. The amount of MSW generated fell by about 1000 tonnes per day in early 2020 after the COVID-19 outbreak due to the closure of hotels and restaurants, following a steady increase in the decade prior to the pandemic. Food waste accounts for 50–60% and plastic waste for 20–30% of the total MSW, but COVID-19 has prompted a reduction in food waste and an increase in plastic waste at the city level. Food waste contains unavoidable items such as peels, stems, and bones, as well as leftovers and other avoidable items, but excludes surplus food from the commercial sector and reused and recycled food such as animal feed, which increased rapidly in the late 2010s, mainly due to growing tourism and lifestyle changes. Since the COVID-19 outbreak and the resulting lockdowns, the total weight of MSW has fallen significantly due to a significant reduction in food waste from hotels and restaurants. On the other hand, the amount of plastic waste generated rose and fell along a gentle curve before the COVID-19 outbreak, averaging 2115 tonnes per day in 2019, but increased sharply by 62% in 2020, reaching an average of 3432 tonnes per day between January and April. In addition, contaminated plastic items from food delivery services, such as takeaway bags, containers, bottles, and cups, that are difficult to reuse and recycle comprised more than 80% of MSW in 2020.

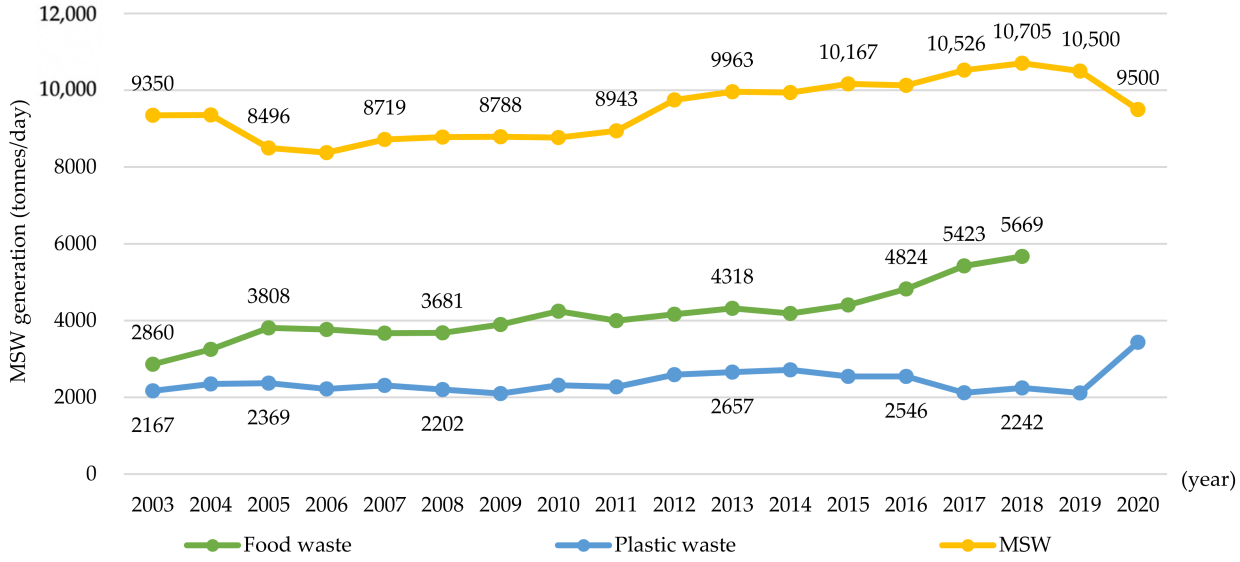

Figure 2. Food waste, plastic waste, and municipal solid waste generated in the Bangkok metropolitan area. Note: Data on PW and MSW generation in 2020 are the average between January and April 2020 as reported by the BMA's Department of Environment to BBC Thai. No data on food waste generation are available in 2019 and 2020.

3. Materials and Methods

3.1. Sampling Size and Analytical Approach

An extensive face-to-face questionnaire survey of residents in the Bangkok metropolitan area conducted between 16 and 19 June 2020 (just after the first national curfew was lifted) presented a snapshot of changes in respondents' lifestyles during the COVID-19 pandemic. This study applied the calculation formula developed by Yamane [22] to determine sample sizes. Considering the budget and labour required to conduct the survey, the confidence level was set at 93% (or at a precision level of ±7%); accordingly, the appropriate sample size was 222. In this survey, passers-by were randomly sampled on the streets [23] of the Bangkok metropolitan area. The questionnaire included queries about working days, eating habits, and purchasing routes for food both before and after the preliminary outbreak of COVID-19 in January 2020, and responses were expected to reflect the ways in which food and plastic waste has been generated by consumers. Statistical tests (*t*-test, Kruskal–Wallis test, and Dunn's multiple comparisons test) were used to detect behavioural differences before and during the preliminary outbreak. Food delivery services were also evaluated as a potential key component in the COVID-19 success story. Related environmental impacts on food waste, plastic waste, and other problems caused by new food consumption paradigms were also discussed and statistically tested.

3.2. Content of Questionnaire

The questionnaire survey (see Supplementary Material) for consumers on food waste mainly consisted of four sections and covered a range of daily activities. The first section included questions designed to elicit basic information about the respondents, such as gender, age, occupation, educational level, and household income, as well as working days in the office prior to and during the pandemic. The second section posed questions about changes in respondents' food-related habits in their daily routines, including purchasing, cooking, eating, and disposal. The third section highlighted trends in the food delivery service sector prior to and during the pandemic, including primary reasons cited by respondents for the use of food delivery services, main factors considered when selecting specific food delivery services from several alternatives, and frequency of ordering different types of food (Thai, Chinese/Japanese/Korean or western cuisine, fast food, street food, desserts, and beverages) using online food services prior to and during the pandemic. The

fourth section focused on behavioural changes in relation to the generation of household waste, as well as the respondents' attitudes towards and intentions in reducing food waste.

4. Results and Discussion

4.1. Respondent Attributes

The attributes of respondents are shown in Table 1. Primary data were collected from 238 individuals (50% male and 50% female). The sample showed a broad range of employment conditions, with the majority of respondents employed at companies (41%), followed by students (22%), the self-employed (16%), and government officials (12%), with the remainder comprising full-time homemakers (5%), the unemployed (3%), and others. The highest percentage of respondents (31%) take home a monthly income of THB 50,001–100,000, with 29% earning more than THB 100,000. The remainder earn between THB 15,001 and 50,000 (34%), while 6% earn less than THB 15,000. Fifty-one percent of respondents live with other adults, 17% with elderly family members, 15% live alone, 10% reside with children, and 7% live with both children and older family members.

Table 1. Attributes of respondents.

Characteristics	Number of Respondents (N = 238)	Percentage
Gender:		
Female	120	50%
Male	118	50%
Occupation:		
Company employee	98	41%
Student	53	22%
Self-employed	38	16%
Government official	27	12%
Full-time homemaker	12	5%
Unemployed	7	3%
Other	3	1%
Education:		
Undergraduate	173	73%
Master's degree or higher	36	15%
High school degree or lower	17	7%
Vocational or technical university	12	5%
Household type:		
Only adults	121	51%
Family with older adults	40	17%
Living alone	37	15%
Family with children	23	10%
Family with children and older adults	16	7%
Other	1	0%
Income:		
>THB 100,000	68	29%
THB 50,001–100,000	75	31%
THB 30,001–50,000	41	17%
THB 15,001–30,000	40	17%
<THB 15,000	14	6%
Residence type:		
Detached house	89	7%
Apartment/Condominium	41	13%
Town house	62	20%
Shop house (Shop is on the first floor)	23	27%
Dormitory/Share house	23	33%

4.2. Changes in Work–Life Balance

Changes in the number of days respondents worked or attended classes outside the home are shown in Figure 3. Before COVID-19, almost half of all respondents (49.58%) commuted to their workplace/school five days a week, with 13.5% of respondents working/studying outside the home more than 5 days a week, and 18.5% of respondents either working/studying on a flexible schedule or travelling to their workplace/school less than five days a week. After the start of the COVID-19 pandemic, respondents either switched over to teleworking

full-time (33%), at least five days/week (21%), or three days/week (19%), respectively. These figures show a substantial shift in work–life balance due to the COVID-19 outbreak.

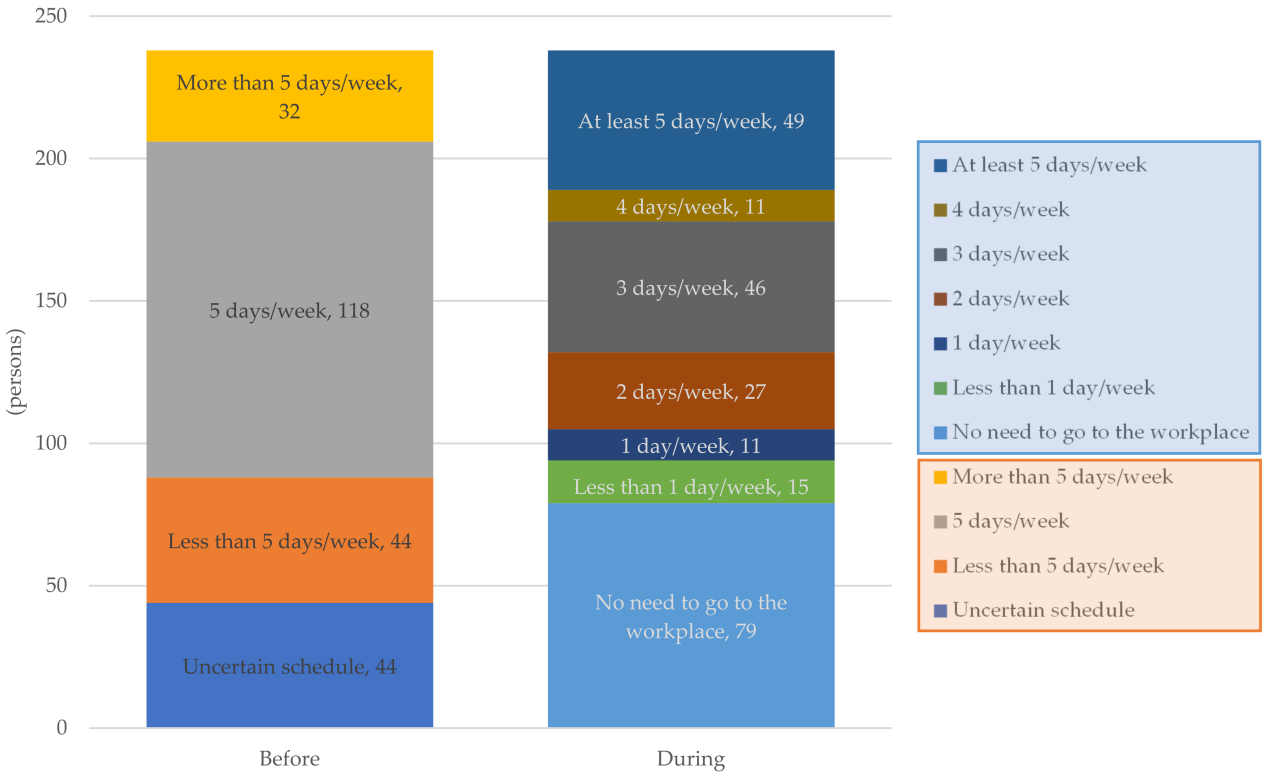

Figure 3. Working days at offices before and during the COVID-19 pandemic.

4.3. Changes in Eating Styles and Food Consumption Behaviour

4.3.1. Eating Styles

Changes in eating styles are shown in Figure 4, and the results of the *t*-test are shown in Table 2. Before COVID-19, respondents ate out on average 6.31 times a week. However, the number of times respondents dined out fell to an average of 2.42 meals a week after the outbreak began and were replaced by other styles, including the consumption of ready-made meals (an increase of 1.1 times from 5.14 to 5.80 meals/week), use of food delivery services (an increase of 1.6 times from 2.42 to 3.90 meals/week), and eating at home (an increase of 1.3 times from 6.12 to 8.26 meals/week). This may be attributed to the government's social distancing and 'stay-at-home' policies to prevent the spread of the virus. The study also found a slight increase in the number of people cooking for themselves or with meals prepared by other family members.

Table 2. *p*-value of eating styles.

Eating Style	Alternative Hypothesis	*p*-Value
Eating out	after–before < 0	$<2.2 \times 10^{-16}$
Ready-made meals	after–before > 0	0.00052
Food delivery services	after–before > 0	4.09×10^{-15}
Eating at home	after–before > 0	2.66×10^{-14}

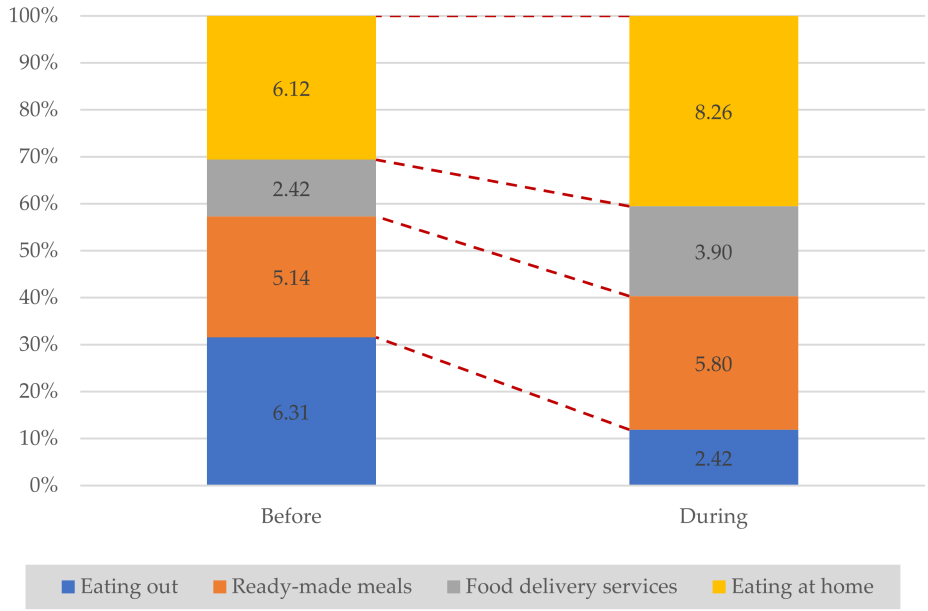

Figure 4. Eating styles before and during the COVID-19 pandemic (meals/week).

4.3.2. Food Consumption

Changes in food consumption in each category are shown in Figure 5, and the results of the *t*-test are shown in Table 3. The amount of food consumed by people in Thailand changed as they complied with the government's 'stay-at-home' orders. Because more food was consumed at home, they needed to purchase and stock up on greater amounts of rice and other ingredients than usual. The survey also found that respondents increased their consumption of meat, vegetables and fruit, eggs and dairy products, and ready-to-eat food. In contrast, there was a significant reduction in the amount of seafood and alcoholic beverages consumed (Table 3). The decreased consumption of seafood may indicate respondents' strong health concerns during the COVID-19 pandemic, while the reduced consumption of alcoholic beverages may be due to temporary bans imposed by the government during lockdowns.

Table 3. *p*-value of change in consumption.

Food and Ingredients	Alternative Hypothesis	*p*-Value
Rice, powder, bread, noodles	Greater	$<2.2 \times 10^{-16}$
Meat	Greater	$<2.2 \times 10^{-16}$
Seafood	Less	0.007796
Vegetables and fruit	Greater	$<2.2 \times 10^{-16}$
Eggs and dairy products	Greater	$<2.2 \times 10^{-16}$
Oil for cooking	Greater	0.008256
Semi-processed food	Greater	8.06×10^{-16}
Instant processed food	Greater	0.001344
Ready-to-eat food	Greater	1.10×10^{-16}
Frozen food	Greater	0.006507
Snacks, desserts, soft drinks	Less/Greater	0.784
Alcoholic beverages	Less	$<2.2 \times 10^{-16}$

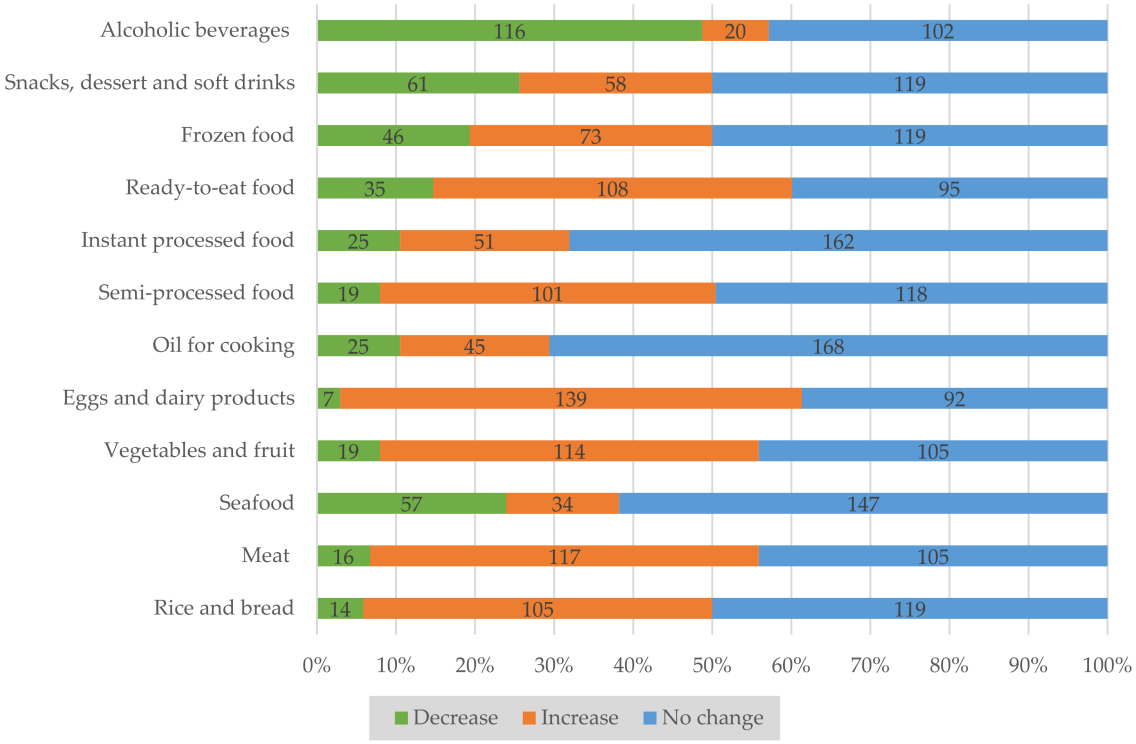

Figure 5. Change in consumption (number of respondents).

4.4. Changes in Shopping Behaviour

4.4.1. Purchasing Routes

The types of routes used to purchase food and other ingredients and the frequency in which they were used before and during the COVID-19 pandemic are shown in Figure 6, and the results of the *t*-test are shown in Table 4. Responses demonstrated that since the outbreak, there has been a considerable rise in the frequency of online shopping. Respondents also indicated that they have significantly reduced the number of times they visit temporary markets, mom-and-pop stores, street stalls, fresh markets, and supermarkets, although there has not been much change in the frequency of shopping at convenience stores and co-ops.

Table 4. *p*-value of frequency of purchases at different types of markets.

Market	Alternative Hypothesis	*p*-Value
Fresh market	Less	1.871×10^{-8}
Temporary market	Less	$<2.2 \times 10^{-16}$
Supermarket	Less	0.000157
Convenience store	Less/Greater	1
Mom-and-pop store	Less	4.50×10^{-16}
Co-op	Less/Greater	0.5078
Street stall	Less	$<2.2 \times 10^{-16}$
Online store	Greater	1.77×10^{-14}

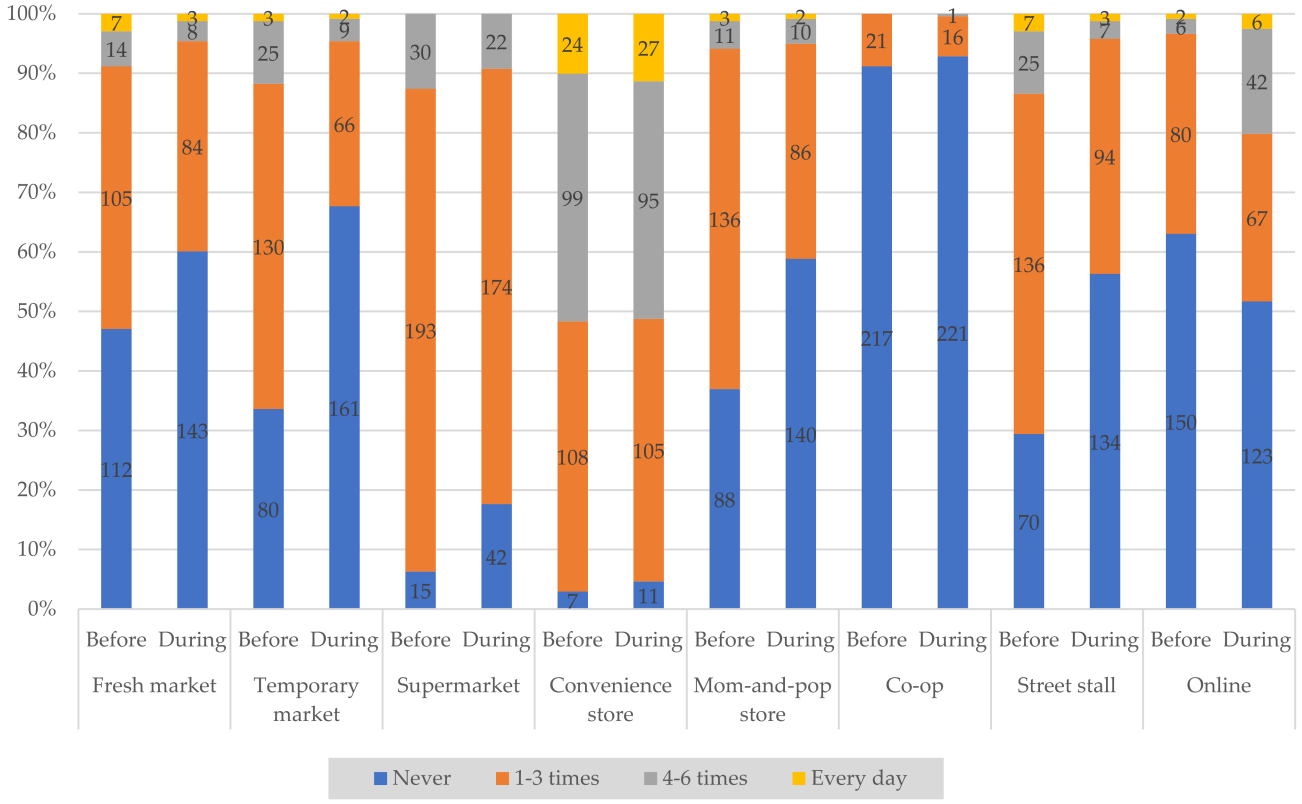

Figure 6. Purchasing routes and frequency before and during the COVID-19 pandemic (unit: number of respondents and percentages).

4.4.2. Food Delivery Service Trends

Similar to people around the world who are apprehensive about COVID-19, residents in Thailand also refrained from leaving home to shop for food. According to the results of the survey, respondents used food delivery services because this option allowed them to stay at home or in the office. A second factor cited was that respondents did not want to wait in long queues, while the third factor driving the increased use of food delivery services was the prevalence of discount coupons or promotions. Furthermore, respondents cited discount coupons and promotions, reasonable delivery costs, and user friendliness as the primary reasons for choosing online applications (Grab Food, Foodpanda, and LINEman). Moreover, according to the *t*-test results, respondents increasingly used applications for food delivery services, official restaurant websites, and phone calls when ordering food after the outbreak started. In addition, data from the survey showed variations in the types of frequently ordered foods, including an increase in the consumption of Thai, Chinese, Japanese, and Korean food, as well as fast food. The frequency of orders for desserts and beverages also rose slightly, although the frequency of orders for street food stayed flat, while that for Western cuisine fell.

4.5. Changes in Food and Food-Related Plastic Waste by Household

4.5.1. Changes in Food Waste Generation

Changes in food waste generated in households are shown in Figure 7. Seventy-six percent of respondents indicated that they felt the amount of waste generated had increased and that most of this could be attributed to a rise in the use of online food delivery services and other ready-made meals.

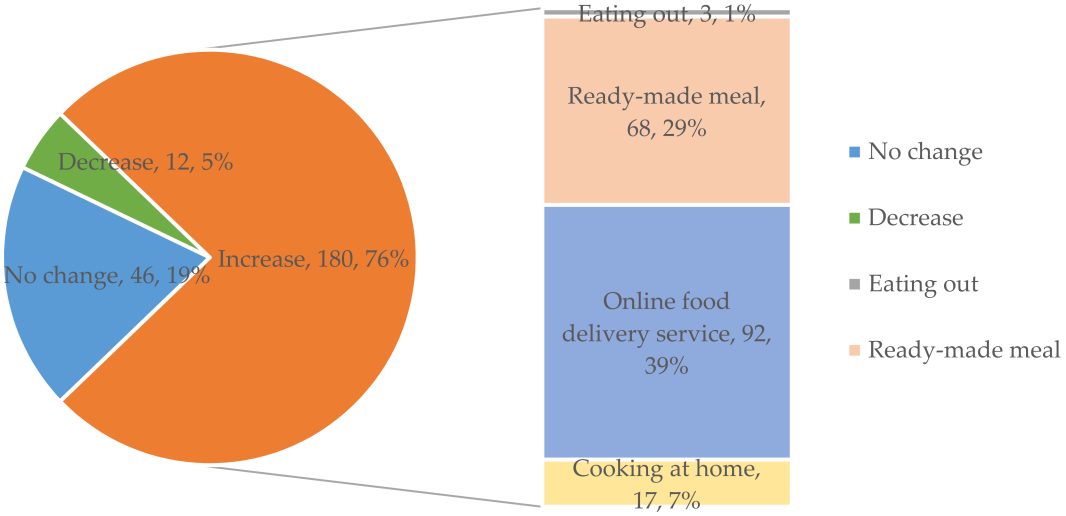

Figure 7. Change in food waste generation.

4.5.2. Changes in Causes of Increased Food Waste Generation

Respondents were queried about the primary reasons for increased food waste generated during the COVID-19 pandemic and changes before and during the COVID-19 pandemic. The top five reasons for food waste, as indicated by respondents, included products that had exceeded their expiration date, rotting/foul odours, excessive amounts of food, unappetising taste and deteriorated quality (Figure 8). Meanwhile, the results of the *t*-test indicated an increase in every cause of food waste since the outbreak (deteriorated quality, rotten/foul odours, exceeding expiration date, excessive amounts of food, taste, and no plans to consume further).

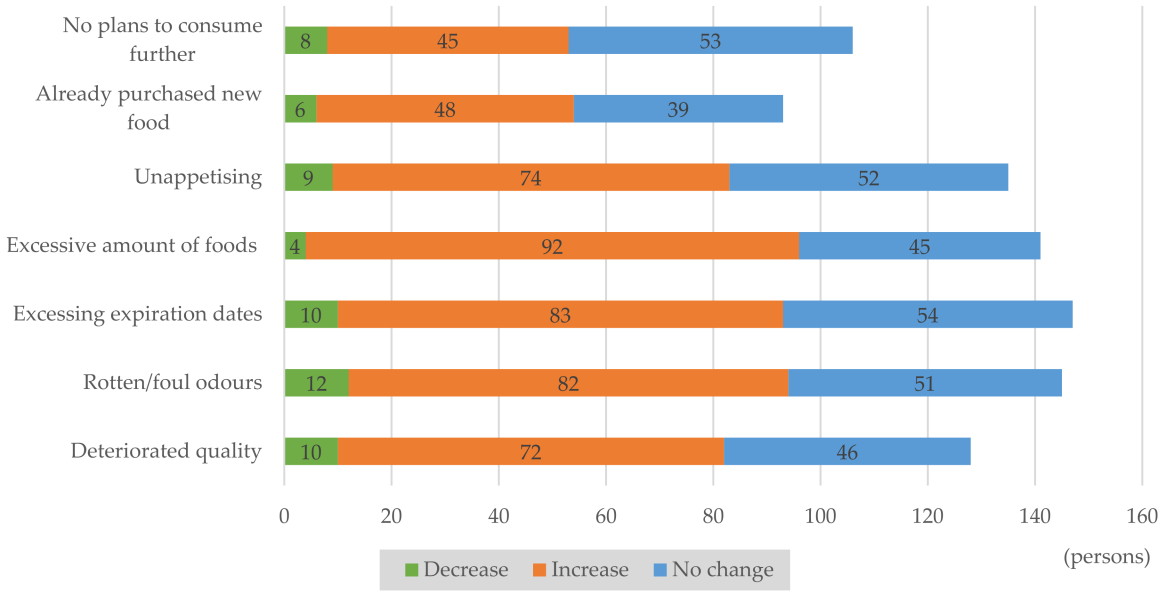

Figure 8. Trend of changes in main reasons for food waste.

The same question was investigated in an earlier study by the authors in 2018 [20,24], which identified the two dominant reasons for increased FW at home as exceeding expiration dates and deteriorated quality, while other reasons, such as excessive amounts, were not cited as a primary cause for FW. In contrast, the reasons mentioned in this survey during the

COVID-19 pandemic are more varied, with the top five listed as exceeding expiration dates, rotten food or foul odours, excessive amounts, unappetising taste, and deteriorated quality (Figure 7). Changes in the primary reasons for FW in households (decrease, increase, and no change) were also queried in this survey, with 'increase' higher than 'decrease' for all reasons (Figure 7), which may be related to online food delivery. For example, reasons selected by respondents (exceeding expiration dates and rotten/foul odours) may be due to a shorter shelf life for prepared food, while other reasons (such as that the food is unappetising) may be related to the inability to predict taste when using online food delivery services. Furthermore, excessive amounts of food became one of the primary reasons for increased FW in households during the pandemic. The inability to predict quantities when ordering online may have caused respondents to over-order, which in turn led to food waste. On the other hand, the results also indicated inadequate food planning and management tendencies by consumers at home during the pandemic.

4.5.3. Waste Generated from the Use of Online Food Delivery Services

Respondents considered plastic bags (E), hot-and-cold food bags (B), plastic food containers (K), and food waste (A) to be the top four types of waste generated from the use of online food delivery services (Table 5). The results of Dunn's multiple comparisons test also showed that the top three types of waste (E, B, A) have significant statistical differences (Table 6).

Table 5. Average score for each type of waste.

No.	Type of Waste	Average Score
A	Food waste	0.70
B	Hot-and-cold food bags	1.27
C	Plastic spoons/forks	0.57
D	Seasoning packages	0.54
E	Plastic bags	1.44
F	Rubber bands	0.17
G	Paper napkins	0.01
H	Toothpicks	0.02
I	Staples	0.05
J	Chopsticks	0.01
K	Plastic food containers	0.86
L	Other food packages such as paper or foam	0.40

Table 6. Dunn's multiple comparisons test for various waste types.

	A	B	C	D	E	K	L
A							
B	3.31×10^{-7}						
C	0.178479	7.72×10^{-11}					
D	0.20438	1.62×10^{-10}	0.894884				
E	1.33×10^{-13}	0.027823	1.97×10^{-18}	4.35×10^{-18}			
K	0.177766	0.000312	0.006085	0.008516	2.81×10^{-9}		
L	0.008463	5.1×10^{-15}	0.19965	0.17456	7.99×10^{-24}	4.28×10^{-5}	

Note: The darker the background color, the lower the *p*-value indicating the significant differences among various waste types as the cause of environment problems due to the online food delivery service.

4.6. Environmental and Social Concerns and Efforts to Reduce Waste

4.6.1. Environmental and Social Problems Caused by Food Delivery Services

In terms of the environmental and social problems caused by food delivery services, most respondents expressed concern about the increased amount of both food and plastic waste. Air pollution caused by the increased volume of traffic from the use of food delivery services was cited as a secondary concern, followed by higher food prices.

4.6.2. Concerns about Food Due to COVID-19

The top three concerns about COVID-19 and food include an upward swing in food prices (A), uncertainty about the safety of food and ingredients (G), and government epidemic control measures that caused many restaurants to temporarily suspend or permanently shutter their businesses (H) (Table 7).

Table 7. Average scores for concerns due to COVID-19.

No.	Concerns Due to COVID-19	Average Score
A	Upward swing in food prices	1.00
B	Deteriorating quality	0.59
C	Reduced variety of food/ingredients in the market because food manufacturers cannot operate as usual	0.75
D	Deteriorating freshness of food/ingredients due to logistical issues	0.78
E	Lack of time to cook	0.21
F	Uncertainty about the taste of home-cooked food in the family	0.11
G	Uncertainty about the safety of foods/ingredients	1.00
H	Government measures causing restaurants to temporarily suspend or permanently shutter their businesses	0.99
I	Increased amount of food and plastic waste leading to hygienic problems	0.56

4.6.3. Efforts to Reduce FW and PW

The survey showed that the top three actions taken by respondents to reduce food and plastic waste (Table 8) included advance meal planning, use of cloth bags or reuse of plastic bags when shopping, and regular checks of leftover food.

Table 8. Average score for actions to reduce food waste, plastic waste, and other waste.

No.	Specific Actions to Reduce Waste	Average Score
A	Avoid cooking excessive amounts of food	0.25
B	Regularly check leftover food in refrigerators or cupboards	1.03
C	Regularly check expiration dates to avoid throwing away food	0.41
D	Avoid over-shopping	0.51
E	Plan ingredients in advance	1.23
F	Consider how to make different meals from leftovers	0.25
G	Use cloth bags or reuse plastic bags when shopping	1.14
H	Try to consume all food prepared for meals to avoid leftovers	0.26
I	Avoid over-ordering when eating out or using online food delivery services	0.16
J	Request smaller amounts when ordering at restaurants	0.04
K	Request restaurants to avoid excessive packaging when using online food delivery services	0.32
L	Offer leftovers to other people or pets	0.08
M	Reuse tableware and food packaging that are still in good condition	0.35
N	Other	0.01

4.7. Practical Implications of this Study

There have been a few questionnaire-based academic studies on the impacts of COVID-19 on household FW, and Table 9 provides a summary of the survey sites, methods, and content, and the main outcomes that are relevant to this study. The resulting changes brought about by the pandemic have been confirmed by researchers at all stages, from purchasing, cooking and eating to disposal. Compared with the relevant outcomes of the existing literature, the results of this study mainly presented the following practical insights:

(1) The pandemic has had an impact on people's awareness towards health, as they have shown greater concern about nutritional balance. In looking at the categories of food that have been purchased and disposed, it is clear that people have consumed more fruits, fresh vegetables, and meat than usual [25–27]. The total amount of

food purchased, especially canned goods and frozen foods, also increased, as people may have experienced fear or anxiety about logistical systems as a result of food shortages [19,25,28]. Similar trends have been confirmed in Bangkok as well (see Section 4.3.2).

(2) Numerous studies have shown that the COVID-19 pandemic has streamlined people's attitudes toward food waste reduction and more sustainable consumption models [18,29], and subsequent effects, such as stockpiling due to the fear of difficulty in finding food in the medium to long term and staying at home, have had a positive influence on reducing FW. In comparison with Thailand, bulk purchases have not caused significant food waste generation in Italy, Portugal, Spain, and many other countries (see Table 9). Pires et al. [30] revealed that people in Portugal reduced the frequency of food purchases and turned to local shops due to restrictions on outdoor movement, becoming more circumspect in their choices and purchases. However, according to this survey, respondents in Bangkok reported an increase in the amount of household food waste generated during the pandemic, with a significant amount generated from online food delivery or other ready-made meals.

(3) Contrary to what has been reported in the literature, where it has been verified that people in the U.S., Portugal, and several other countries (see Table 9) started cooking at home after the outbreak, most respondents in Bangkok relied on food delivery services. With support from the government and local residents' familiarity with food delivery services such as Grab Food, Foodpanda, and LINEman, the business practices of these services grew aggressively during the pandemic. While many studies indicated a reduction in the amount of food waste generated with more people cooking at home and trying to reduce leftovers, the use of online food delivery services in Bangkok actually resulted in an increase in the amount of food waste generated. This situation differs significantly from that in Brazil where nearly half of the respondents never purchased food online. The convenience of online food delivery services and excessive food supplies might overshadow the chance for people in Bangkok to improve their skills in food planning and management.

(4) Several studies [28,31–33] have clarified that socio-economic and demographic factors such as age, household size and composition, income, attitudes, subjective norms, perceptions of behaviour control, and personal values might impact food management behaviours. Everitt et al. [26] directly measured the quantity and composition of household FW disposed during the first wave of the COVID-19 pandemic and examined how household demographics, socio-economic conditions and local food environment characteristics may influence household FW in the city of London, Ontario, Canada. Further studies may combine waste component analyses and quantitative surveys with socio-economic and demographic components to provide a more in-depth understanding of the food waste situation in Bangkok.

(5) Due to social distancing and travel restrictions during the pandemic, almost all existing literature used online surveys. While it is possible to collect information from people who are interested in the research topic, it has proven difficult to obtain information from people with no access to social networks (e.g., low income, poorly educated, elderly, etc.). This may therefore affect how representative the sample of the population is. As this survey in Bangkok was conducted face-to-face, there is less sampling bias than may be found in an online survey.

Table 9. Relevant international studies and main outcomes on household food and plastic waste during the COVID-19 pandemic.

Country/City	Methods and Contents	Main Outputs
Japan [31]	Nationwide online survey (n = 1959) conducted on 2 July 2020 containing questions on thoughts and behaviours related to food purchase, management, consumption, and food waste during COVID-19.	Regions highly impacted by the pandemic appeared to be more careful about their food preparation, purchasing, and management, considering the amount, type, and cost of daily household food waste, while residents in low-impact regions appeared to buy more 'excessive' or 'unnecessary' food.
Tunisia [18]	An online self-administered questionnaire conducted from 24 March to 7 April 2020 (n = 284) asking about food purchase behaviour, knowledge of food labelling, attitudes toward food waste, information needs to reduce food waste, and sociodemographic characteristics.	A loss of income and the fear of food shortages led to well-planned shopping behaviours which effectively helped reduce food waste. According to the study, cooking excessive amounts and long-term storage were cited as the major reasons for food waste, indicating that further efforts are needed for food planning and management to reduce food waste and maintain positive changes in behaviour.
U.S. (New York State) [25]	Internet-based survey (n = 300) conducted in August 2020 containing 20 questions on household purchases and food waste between mid-March and mid-July 2020.	Food purchases, especially stockpiling food and cooking supplies, increased during the pandemic since more people started to cook at home. However, bulk purchases did not cause massive amounts of food waste to be generated; rather, the results of the study indicated a slight decrease. This may be due to the tendency of people to improve cooking and storage skills and to prepare plans before shopping during the pandemic.
U.S. [34]	Online survey conducted in the United States in October 2020 (n = 946) asking about individual demographic factors, household characteristics, COVID-19-related household changes, and changes in food-related behaviours due to the pandemic.	More people tended to cook at home since they spent more time in their houses, especially households with children, or as a result of lost income or a need to work from home. Thus, over 75% of respondents purchased more food during the pandemic. Stockpiling food was identified as a significant predictor of increased food waste. Of all food ingredients, fresh vegetables and frozen food accounted for the majority of food waste.
Italy [33]	Self-administered online survey (n = 1078) from 10 April to 3 May 2020 focusing on food management habits before and during lockdown.	The study showed that respondents spent more per week over lockdowns (an average of EUR 132 per week compared to EUR 110 pre-COVID), likely due to greater amounts of food consumed at home. Most households reported that they threw away less food during COVID-19 lockdowns. Fifty-nine percent of respondents prepared shopping lists for food purchases in regular times, compared to 86.5% during lockdowns. The spread of planning-related food management practices (compiling shopping lists, planning purchases and meals in advance, reuse of leftovers for other recipes) played a key role in reducing FW.
Italy [19]	Online survey (n = 1188) from 20 to 25 April 2020 that included a set of qualitative questions about changes in purchasing behaviour, food expenditures, waste production, and other food-related behaviours during the COVID-19 pandemic.	The increase in food purchases during the pandemic did not generally lead to a higher rate of food waste. About 33% and 16% of the sample reported that the amount of food waste decreased substantially or mildly, respectively, during lockdowns. About 45% reported no change, while only 5% and 1% indicated that food waste increased mildly or substantially, respectively. The decrease in food waste is related to the purchase of non-perishable foods.
26 Brazilian States and Federal District (27 states) [27]	Online self-administered questionnaire from 21 May to 30 May 2020 (n = 458) that included questions about food purchase behaviour, knowledge of food labelling, attitudes toward food waste, information needs to reduce food waste, and sociodemographic characteristics.	Empirical results confirmed that 'intentions to reduce wastage', 'management routines for leftover or uneaten food', and 'routines of purchasing food on sale' are positively related to the reduction of FW. However, 'planning purchases', 'knowledge about labels', and 'activities to avoid food waste' were not confirmed as having an effect on reducing FW. Additionally, the surveyed population preferred shopping in person, with 45.6% never having made purchases online, while in contrast, 33.0% of respondents reported an increased frequency of online purchases and 16.4% indicated no changes in their online purchasing habits. There was no substantial change in purchasing behaviours of Brazilian households in the specific context of the COVID-19 pandemic with in-person shopping and payment methods using cash.
Spain [28]	Online survey conducted from 14 May to 11 June 2020 (n = 6293) consisting of 36 questions on purchasing, storage, cooking habits, waste generation, and changes brought about by the pandemic.	Although most people reported that they did not generate more food waste than usual and some started to be more creative in cooking with leftovers, people who bought food due to fear or anxiety tended to waste more. Respondents who worked from home reported that were stressed since they needed to work more hours than usual and showed the same tendency as those who stored food to waste more due to fear or anxiety.

Table 9. *Cont.*

Country/City	Methods and Contents	Main Outputs
Portugal [30]	Online survey conducted from 22 May to 5 June (n = 841), which is the same 36-question survey used in Spain.	From the study, it appears that people in Portugal reduced the frequency of purchases and preferred local shops, but purchases online did not increase. Respondents also reported that they did not change their diet nor the type of waste. A reduction in the total amount of food waste was seen since people tended to buy food and be more circumspect in what and how they prepared food, although producers' associations reported that they had been forced to discard large quantities of perishable products due to the cancellation of purchases in food services/supermarkets.
Turkey [32]	Self-administered questionnaire conducted in January 2021 (n = 511) to investigate changes in food management behaviour during the pandemic.	This study divided people into three groups and provided suggestions to each. People who do not prepare detailed plans should improve both shopping and cooking skills. Resourceful planners and cooks have less problems in these areas so they can maintain their food management behaviours. Those who are poor at planning but are resourceful cooks with adequate food preparation skills only need to plan better to purchase and cook food.
Apulia Region, Italy [35]	Online survey conducted from 14 to 30 November 2020 (n = 323) that included questions on sociodemographic characteristics, shopping habits, time management, perceptions of food waste, and behaviours during the pandemic.	Based on the results of the survey, the respondents were divided into three groups according to food consumption and food waste habits. One group had a high level of environmental awareness but still generated a large amount of food waste. The second group has limited awareness on food waste but wastes less. Only the last group of responders had a sufficient level of knowledge on food waste and was able to put that knowledge into practice to reduce food waste. It is necessary to offer contrasting information and educational programmes to different group of people.
London, Ontario, Canada [26]	Collection and analysis of waste samples between 9 and 16 June 2020 (n = 100) to investigate the food waste situation during the pandemic.	Each week, 2.81 kg of food waste per household was disposed, with fruit and vegetables accounting for over half. Larger households generated more food waste than smaller households. People living closer to grocery stores generated less waste. This may be because the larger the family, the further away they may live and the larger the bulk purchases may be, which may lead to a larger amount of food waste being generated.

5. Policy Implications and Potential Intervention Actions

The authors' previous study on the FW situation in Bangkok before COVID-19 [20] found that the sources of FW are widely distributed throughout the supply chain due to the higher frequency of use of food services and ready-made products and diversification of diets and eating habits. However, due to inadequate management and insufficient detailed regulations and laws, the amount of FW generated is on the rise, with most mixed together with MSW and landfilled. In this study in Bangkok, we found that the COVID-19 pandemic shifted the main source of FW from businesses to households and that both food and plastic packaging waste from households rose due to the increased use of online food delivery services. Post-pandemic, FW and PW generated by households in Bangkok are expected to continue to rise due to hygiene concerns, infection prevention measures, and rebounds in economic activity. At the same time, online shopping is expected to grow even after the pandemic, as the Thai government is partnering with private financial institutions to develop a platform for online shopping to promote digitalisation and cashless shopping.

Food waste and plastic pollution are viewed as two key drivers for achieving the Paris Agreement and the SDGs, but the COVID-19 pandemic may intensify challenges for FW and PW. Therefore, we believe that the policy implications proposed in the previous study [20] must be further strengthened, aiming to: (1) develop comprehensive policies along the entire supply chain; (2) enhance concrete implementation plans with clear targets for reducing and recycling waste based on 3R strategies; (3) develop practical source separation and collection systems; (4) promote the application of appropriate waste management technologies together with 'recycling loop' business models; (5) promote platforms for stakeholder collaboration and community-based interventions; (6) create uniform standards and understanding of 'date labels'; (7) encourage the provision and consumption of smaller portions; (8) utilise health as a driving force to motivate public concern; and (9) develop a policy mix targeting consumers' daily lifestyles and social practices. In addition to these policies, more intense efforts will be needed to achieve the

SDGs. Based on the results of this study, consumer food planning and management, online platforms/delivery services, and the formation of local circular economy frameworks could be considered as three important intervention points for reducing waste and achieving more effective food and plastic waste management practices. Further discussion on these three intervention points is as follows.

5.1. Improve Consumers' Capabilities to Plan, Manage Food and Cook without Waste

The survey found that (1) the number of people cooking and eating at home rose during the pandemic (4.3.1); (2) the excessive amount of food was identified as one of the top reasons for food waste (4.5.2) as a result of poor food management; and (3) the top two actions that respondents would take to reduce food and plastic waste included meal preparation and regularly checking leftover food (4.6.3). These responses may present governments, the food industry, and businesses with an opportunity to support people's abilities to plan, manage, and cook food to reduce the amount of food that is leftover or wasted at home. Not much effort is being implemented by the Thai national government and Bangkok local government on these issues, which needs to be addressed. Qian et al. [31] show evidence to support this result, as people who prepare their own food demonstrate more concern for food management and food waste than those who do not cook. Meanwhile, routines related to planning food purchases and their preparation are highly influenced by the skills or confidence that consumers have in their ability to perform such activities. Cooking classes, refrigerator cameras, shopping lists, and information campaigns on reducing food waste have been widely proven through case studies worldwide to have positive effects, though credibility needs to be further verified [12]. Additionally, Hebrok and Heidenstrøm [36] identified decisive moments and contexts for food waste prevention and discussed examples of measures that could be further explored by applying a practice-oriented approach to food waste drivers through food management practices. Furthermore, preparing and ordering excessive amounts of food might be the result of difficulties in estimating the amount of food, so an important measure to avoid this could be to provide hints on enhancing consumers' food planning and management capabilities and cooking skills, thereby reducing the increased amount of food waste generated during COVID-19. For example, the food industry could indicate the number of servings on food packaging instead of weight, which may help consumers while purchasing. Similar suggestions will effectively help consumers manage food in households, such as by packaging smaller portions and showing consumers how to manage uneaten food and extend expiration dates. Social media platforms, including television programmes, recipe apps, and cooking videos will also play a role in improving the ability of people who may lack skills or have few ideas about what to cook. In a similar fashion, supermarkets may also be able to provide suggestions to consumers about food preparation by displaying the ingredients needed for certain meals.

5.2. Develop Eco-Friendly Online Platforms and Food Delivery Services

The rapid expansion of e-commerce and online food delivery services is a visible change that has occurred as a result of the COVID-19 pandemic. This study shows that during the pandemic, most food services shifted to online food delivery, resulting in an increase in both FW and PW. Although online food delivery services benefit society as a whole in terms of lowering the number of potential routes for infectious diseases, while simultaneously providing a certain level of comfort to consumers and stimulating economic activity, there is a risk that incentives may encourage a rise in the use of these services, leading to overconsumption and other adverse behaviours in terms of FW and PW. Therefore, the key to preventing and reducing both FW and PW is determining how to build eco-friendly online platforms/food delivery services and business models to encourage consumers to act in environmentally friendly ways.

The temporary relaxation of bans on the use of single-use plastics during the pandemic may indicate a breakdown in sustainable patterns of behaviour. To mitigate the problem of

plastic waste, research and development in materials science to streamline plastic packaging should be emphasised for sustainable development [37]. Consideration should also be given to establishing more sustainable options, such as deposit refund schemes, or default options, such as delivering food in reusable containers. At the same time, governments must institute educational curriculums and communication campaigns to highlight and promote environmentally friendly behaviour.

Meanwhile, along with the expansion of green food delivery options and online shopping, access to food has become easier and more efficient, which could lead to lower GHG emissions and achieve low-carbon lifestyles. Besides changes in shopping habits, Galanakis [29] points out that digital technologies, including information and communication technologies (ICT), apps, the Internet of things (IoT) platforms, big data and artificial technology, will enable food to be delivered precisely when demand arises, potentially leading to a reduction in FW. Additionally, digital platforms such as food rescue apps can be used as a mechanism for mobilising the active participation of stakeholders along the entire supply chain. Therefore, the system should be designed in advance to maximise the numerous synergies between the promotion of online platforms and the prevention of FW and PW, as well as to minimise trade-offs.

In a positive development, the Ministry of Natural Resources and Environment has joined together with private entities, including six food delivery platforms such as Food Panda, Grab Food, Gojek, and LalaMove in a push to reduce the use of plastic under the concept of the 'New Normal Food Delivery with Environmental Care'. Food delivery services involved in this initiative will add an opt-in button to their applications that will allow customers to decline single-use plastics as well as work with their restaurants to incorporate more environmentally friendly packaging (glass jars, metal straws, non-plastic bags, etc.).

5.3. Promote a Circular Economy via Localised Supply Chains to Improve Food Safety and Well-Being

A system-level approach to address issues surrounding FW, PW, and MSW is needed. Circular economy strategies have opened up new avenues for potential measures to reduce FW [38]. The concept of the 'circular economy' is central to European environmental thinking and policy-making, and the transition to a more circular economy is a major goal towards developing a sustainable, low-carbon, resource-efficient, and competitive economy in the EU [39]. Food waste and plastics are two of five priority sectors in the EU Circular Economy Action Plan, which helps contain all materials within infinite loops through sustainable consumption and production and sound waste management, including greater recycling and re-use, and also by creating a market for secondary raw materials. The concept of a circular economy also encompasses waste prevention in the first place, which is positioned at the top of the waste hierarchy.

As transportation and logistics have been highly restricted during the pandemic, the use of local food supply chains to improve food safety and revitalise the local economy has been an effective measure to counter COVID-19. Based on a systematic literature review study on COVID-19, food systems, and the circular economy by Giudice et al. [1], the 'localisation' of food systems might present more resilient and sustainable solutions: localised food systems reduce waste and stress nutrition; combining local and seasonal elements in short supply chains reduces storage and transportation needs, provides a better supply–demand balance, creates more transparency, improves tracking capability, and contributes to waste reduction; and consumers seem to place higher value on food purchased in local markets. The localisation of food systems will also help reduce the amount of plastic packaging waste and provide fiscal security to fight similar pandemics in the future.

6. Conclusions

In this paper, Bangkok was selected as a case study to examine the impact of the COVID-19 outbreak on the generation of food and plastic waste by consumers by exam-

ining shifts in consumer lifestyles and consumption behaviours through a face-to-face questionnaire survey. The potential of food delivery services in the starring role of a COVID-19 success story and the related environmental consequences of food waste, plastic waste, and other problems caused by a new food consumption paradigm were also examined. This paper also provides policy implications and innovative actions for tackling the issues raised to achieve more effective food and plastic waste management.

Although travel bans and diminished economic activity due to COVID-19 have led to a dramatic reduction in MSW, both FW and PW generated by households in Bangkok were observed to have increased during COVID-19. Furthermore, the total amount of FW and PW as well as MSW in Bangkok is expected to rise post-pandemic in the absence of appropriate institutional frameworks and a lack of policy-level directions and effective measurements to address FW and PW issues. This increase may also likely affect our mid- and long-term goals for transitioning towards sustainability.

Although the data presented in this study are relatively uncertain due to the limited number of samples, this is the first study to contribute to a better understanding of how COVID-19 affects consumer behaviour and can help constitute a basis to further promote behaviour that prevents and reduces FW and PW in households, even outlasting the COVID-19 crisis in Asian developing countries.

Of course, there are many research questions left unanswered. For example, there is still a poor understanding of the impacts made by socio-economic and demographic factors on food management behaviour, and on the amount of FW and PW generated by households, as well as throughout the supply chain. Furthermore, to achieve SDG 12, ensuring harmonised data collection on FW and PW remains a challenge in Asia, and practical policies, strategies and actions on household prevention and reduction is an area that can be considered for future study. In addition, the upheaval caused by the COVID-19 crisis has created not only a major challenge, but also an opportunity for reshaping existing policy frameworks and production-consumption style socio-economic systems, as well as a chance to identify the underlying drivers of food waste and their links with plastic packaging. It may also present an opportunity to engage with relevant stakeholders including consumers to tackle the dual challenge of food waste and plastic waste in a systemic way, which is also a topic for further work.

Supplementary Materials: The supplementary materials are available online at https://doi.org/10.6084/m9.figshare.15131100.v1.

Author Contributions: Conceptualization, methodology, data analysis, and writing (original draft) by C.L. and P.B.; investigation and data curation by P.B.; funding acquisition and project administration by C.L.; literature review and writing (revision) by C.L. and Q.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Institute for Global Environmental Strategies (IGES) under the Strategic Research Fund 2020–2021 and supported by the Environment Research and Technology Development Fund (S-16) of the Environmental Restoration and Conservation Agency of Japan, 'Policy Design and Evaluation to Ensure Sustainable Consumption and Production Patterns in Asian Region' (2016–2020).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Supplementary Material associated with this article are openly available in FigShare at https://doi.org/10.6084/m9.figshare.15131100.v1 (accessed on 8 August 2021).

Acknowledgments: The authors would like to thank Emma Fushimi and Christine Pearson Ishii for proofreading this paper and would also like to express gratitude to the referees for their useful comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Giudice, F.; Caferra, R.; Morone, P. COVID-19, the food system and the circular economy: Challenges and opportunities. *Sustainability* **2020**, *12*, 7939. [CrossRef]
2. Sharma, H.B.; Vanapalli, K.R.; Cheela, V.S.; Ranjan, V.P.; Jaglan, A.K.; Dubey, B.; Goel, S.; Bhattacharya, J. Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resour. Conserv. Recycl.* **2020**, *162*, 105052. [CrossRef]
3. Vanapalli, K.R.; Sharma, H.B.; Ranjan, V.P.; Samal, B.; Bhattacharya, J.; Dubey, B.K.; Goel, S. Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic. *Sci. Total Environ.* **2021**, *750*, 141514. [CrossRef] [PubMed]
4. Lemaire, A.; Limbourg, S. How can food loss and waste management achieve sustainable development goals? *J. Clean. Prod.* **2019**, *234*, 1221–1234. [CrossRef]
5. Löhr, A.; Savelli, H.; Beunen, R.; Kalz, M.; Ragas, A.; Van Belleghem, F. Solutions for global marine litter pollution. *Curr. Opin. Environ. Sustain.* **2017**, *28*, 90–99. [CrossRef]
6. Wang, J.; Zheng, L.; Li, J. A critical review on the sources and instruments of marine microplastics and prospects on the relevant management in China. *Waste Manag. Res.* **2018**, *36*, 898–911. [CrossRef]
7. Muriana, C. A focus on the state of the art of food waste/losses issue and suggestions for future researches. *Waste Manag.* **2017**, *68*, 557–570. [CrossRef]
8. Amicarelli, V.; Bux, C. Food waste measurement toward a fair, healthy and environmental-friendly food system: A critical review. *Br. Food J.* **2020**, *123*, 2907. [CrossRef]
9. Schott, A.B.S.; Wenzel, H.; La Cour Jansen, J. Identification of decisive factors for greenhouse gas emissions in comparative life cycle assessments of food waste management—An analytical review. *J. Clean. Prod.* **2016**, *119*, 13–24. [CrossRef]
10. De Menna, F.; Dietershagen, J.; Loubiere, M.; Vittuari, M. Life cycle costing of food waste: A review of methodological approaches. *Waste Manag.* **2018**, *73*, 1–13. [CrossRef]
11. Aschemann-Witzel, J.; de Hooge, I.; Amani, P.; Bech-Larsen, T.; Oostindjer, M. Consumer-related food waste: Causes and potential for action. *Sustainability* **2015**, *7*, 6457–6477. [CrossRef]
12. Reynolds, C.; Goucher, L.; Quested, T.; Bromley, S.; Gillick, S.; Wells, V.K.; Evans, D.; Koh, L.; Kanyama, A.C.; Katzeff, C.; et al. Review: Consumption-stage food waste reduction interventions—What works and how to design better interventions. *Food Policy* **2019**, *83*, 7–27. [CrossRef]
13. Roodhuyzen, D.M.A.; Luning, P.A.; Fogliano, V.; Steenbekkers, L.P.A. Putting together the puzzle of consumer food waste: Towards an integral perspective. *Trends Food Sci. Technol.* **2017**, *68*, 37–50. [CrossRef]
14. Schanes, K.; Dobernig, K.; Gözet, B. Food waste matters—A systematic review of household food waste practices and their policy implications. *J. Clean. Prod.* **2018**, *182*, 978–991. [CrossRef]
15. Heidbreder, L.M.; Bablok, I.; Drews, S.; Menzel, C. Tackling the plastic problem: A review on perceptions, behaviors, and interventions. *Sci. Total Environ.* **2019**, *668*, 1077–1093. [CrossRef] [PubMed]
16. United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*; Department of Economic and Social Affairs, United Nations: New York, NY, USA, 2015.
17. Van Rensburg, M.L.; S'phumelele, L.N.; Dube, T. The 'plastic waste era'; social perceptions towards single-use plastic consumption and impacts on the marine environment in Durban, South Africa. *Appl. Geogr.* **2020**, *114*, 102132. [CrossRef]
18. Jribi, S.; Ismail, H.B.; Doggui, D.; Debbabi, H. COVID-19 virus outbreak lockdown: What impacts on household food wastage? *Environ. Dev. Sustain.* **2020**, *22*, 3939–3955. [CrossRef] [PubMed]
19. Pappalardo, G.; Cerroni, S.; Nayga, R.M.; Yang, W. Impact of Covid-19 on Household Food Waste: The Case of Italy. *Front. Nutr.* **2020**, *7*, 585090. [CrossRef]
20. Liu, C.; Mao, C.; Bunditsakulchai, P.; Sasaki, S.; Hotta, Y. Food waste in Bangkok: Current situation, trends and key challenges. *Resour. Conserv. Recycl.* **2020**, *157*, 104779. [CrossRef]
21. Food and Agriculture Organization of the United Nations. *Food Wastage Footprint: Full-Cost Accounting*; FAO: Rome, Italy, 2014; Available online: http://www.fao.org/3/i3991e/i3991e.pdf (accessed on 8 August 2021).
22. Yamane, T. *Statistics, An Introductory Analysis*; Harper and Row: New York, NY, USA, 1967.
23. Richardson, A.J.; Ampt, E.S.; Meyburg, A.H. *Survey Methods for Transport Planning*; Eucalyptus Press: Melbourne, Australia, 1995.
24. Bunditsakulchai, P.; Liu, C. Integrated Strategies for Household Food Waste Reduction in Bangkok. *Sustainability* **2021**, *13*, 7651. [CrossRef]
25. Babbitt, C.W.; Babbitt, G.A.; Oehman, J.M. Behavioral impacts on residential food provisioning, use, and waste during the COVID-19 pandemic. *Sustain. Prod. Consum.* **2021**, *28*, 315–325. [CrossRef]
26. Everitt, H.; van der Werf, P.; Seabrook, J.A.; Wray, A.; Gilliland, J.A. The quantity and composition of household food waste during the COVID-19 pandemic: A direct measurement study in Canada. *Socio Econ. Plan. Sci.* **2021**, 101110. Available online: https://www.sciencedirect.com/science/article/pii/S0038012120307904 (accessed on 8 August 2021). [CrossRef]
27. Schmitt, V.G.H.; Cequea, M.M.; Neyra, J.M.V.; Ferasso, M. Consumption Behavior and Residential Food Waste during the COVID-19 Pandemic Outbreak in Brazil. *Sustainability* **2021**, *13*, 3702. [CrossRef]
28. Vidal-Mones, B.; Barco, H.; Diaz-Ruiz, R.; Fernandez-Zamudio, M.-A. Citizens' Food Habit Behavior and Food Waste Consequences during the First COVID-19 Lockdown in Spain. *Sustainability* **2021**, *13*, 3381. [CrossRef]

29. Galanakis, C.M. The Food Systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis. *Food* **2020**, *9*, 523. [CrossRef] [PubMed]
30. Pires, I.M.; Fernández-Zamudio, M.Á.; Vidal-Mones, B.; Martins, R.B. The impact of covid-19 lockdown on portuguese households' food waste behaviors. *Hum. Ecol. Rev.* **2020**, *26*, 59–69. [CrossRef]
31. Qian, K.; Javadi, F.; Hiramatsu, M. Influence of the COVID-19 pandemic on household food waste behavior in Japan. *Sustainability* **2020**, *12*, 9942. [CrossRef]
32. Özbük, R.M.Y.; Coşkun, A.; Filimonau, V. The impact of COVID-19 on food management in households of an emerging economy. *Socio Econ. Plan. Sci.* **2021**, 101094. [CrossRef]
33. Principato, L.; Secondi, L.; Cicatiello, C.; Mattia, G. Caring more about food: The unexpected positive effect of the Covid-19 lockdown on household food management and waste. *Socio Econ. Plan. Sci.* **2020**, 100953. [CrossRef]
34. Cosgrove, K.; Vizcaino, M.; Wharton, C. COVID-19-related changes in perceived household food waste in the united states: A cross-sectional descriptive study. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1104. [CrossRef]
35. Amicarelli, V.; Tricase, C.; Spada, A.; Bux, C. Households' Food Waste Behavior at Local Scale: A Cluster Analysis After the COVID-19 Lockdown. *Sustainability* **2021**, *13*, 3283. [CrossRef]
36. Hebrok, M.; Heidenstrøm, N. Contextualising food waste prevention-decisive moments within everyday practices. *J. Clean. Prod.* **2018**, *210*, 1435–1448. [CrossRef]
37. United Nations Environment program. *Exploring the Potential for Adopting Alternative Materials to Reduce Marine Plastic Litter*; UNEP: Nairobi, Kenya, 2018.
38. Borrello, M.; Caracciolo, F.; Lombardi, A.; Pascucci, S.; Cembalo, L. Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability* **2017**, *9*, 141. [CrossRef]
39. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. *Closing the loop—An EU Action Plan for the Circular Economy.* 2015. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614 (accessed on 8 August 2021).