



How the COVID-19 Pandemic Has Impacted Food Loss and Waste: Lessons Learned and Future Challenges [†]

Ana Fernández-Ríos ^{1,*}, Jara Laso ¹ , Israel Ruiz-Salmón ¹, Daniel Hoehn ¹, Cristina Campos ¹, Jorge Cristóbal ¹, Francisco José Amo-Setién ², Rebeca Abajas-Bustillo ² , Carmen Ortego ² , María Margallo ¹ and Rubén Aldaco ¹

¹ Department of Chemical and Biomolecular Engineering, University of Cantabria, 39005 Santander, Spain; jara.laso@unican.es (J.L.); israel.ruizsalmon@unican.es (I.R.-S.); daniel.hoehn@unican.es (D.H.); cristina.campos@unican.es (C.C.); jorge.cristobal@unican.es (J.C.); maria.margallo@unican.es (M.M.); ruben.aldaco@unican.es (R.A.)

² Department of Nursing, University of Cantabria, 39005 Santander, Spain; franciscojose.amo@unican.es (F.J.A.-S.); rebeca.abajas@unican.es (R.A.-B.); carmen.ortego@unican.es (C.O.)

* Correspondence: ana.fdezrios@unican.es

[†] Presented at the 2nd International Electronic Conference on Foods—Future Foods and Food Technologies for a Sustainable World, 15–30 October 2021; Available online: <https://foods2021.sciforum.net/>.

Abstract: The present paper aims to review and assess the impact of the COVID-19 lockdown on food loss and waste (FLW), evaluating the environmental, social, nutritional, and economic repercussions, as well as the challenges addressed by the food sector and the recovery strategies. The main outcomes reveal that the major challenges reside in mobility restrictions, labor and products shortage along the supply chain, and the management of an important amount of household FLW. Measures such as secondary feeding strategies, alternative distribution channels, and e-commerce stand out in achieving a more sustainable and resilient food system.

Keywords: food loss and waste (FLW); nutritional impact; FLW cost; food supply chain (FSC); environmental impact; GHG emissions; food system; resilience



Citation: Fernández-Ríos, A.; Laso, J.; Ruiz-Salmón, I.; Hoehn, D.; Campos, C.; Cristóbal, J.; Amo-Setién, F.J.; Abajas-Bustillo, R.; Ortego, C.; Margallo, M.; et al. How the COVID-19 Pandemic Has Impacted Food Loss and Waste: Lessons Learned and Future Challenges. *Biol. Life Sci. Forum* **2021**, *6*, 109. <https://doi.org/10.3390/Foods2021-11021>

Academic Editor: Theodoros Varzakas

Published: 14 October 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Food insecurity has always been one of the greatest challenges facing humanity, addressed by several of the Sustainable Development Goals (SDG), such as SDG 2, related to zero hunger, or SDG 12, referring to sustainable production and consumption patterns [1]. Until now, solutions to food shortage and resources limitations have been sought as the key in dealing with this global problem [2]. Nevertheless, food loss and waste (FLW), which is defined as a deterioration in food quantity or quality along the food supply chain (FSC) [3], is currently recognized as a serious threat to food security, the economy, and the environment. The distinction between food loss (FL) and food waste (FW) is an outstanding aspect not only for its conceptual relevance but also from a policy point of view [4]. FL occurs at the beginning of the FSC and results from decisions and actions by food suppliers, whereas FW takes place at the end of the FSC, influenced by retailers and consumers behavior [5]. Although some authors suggest that approximately one-third of food is lost or wasted [6], unfortunately, there is still important uncertainty regarding the actual magnitude of FLW. Rough estimations situate the average percentage of FL in the world at around 14%, with higher values in Central and Southern Asia, and in Northern America and Europe, and lower ones in the remaining regions, highlighting Australia with 6% [4]. On the other hand, approximately 17% of the available food is wasted, representing 931 million tons of garbage, with 61% of this value coming from households, 26% from food services, and 13% from retailers [7]. The higher rates of FLW are identified in roots and

tubers, fruits and vegetables, and fish and seafood, and primarily produced in household consumption [8].

In this context, taking into consideration the sensitivity of this problem is crucial to prevent it from getting worse, since external changes can have a great influence on FLW generation, creating huge shifts in terms of both food access and security [9]. In the first half of 2020, the emergence of the COVID-19 pandemic has led to changes in all human daily activities, impacting socially, environmentally, and economically. Obviously, food systems are not exempt from such disruptions. FSC was severely affected by the outbreak, influencing the generation of FLW due to increased household consumption, changes in dietary habits, or the confinement of producers and distributors, among other reasons [10]. Food systems at all levels—globally, locally, and domestically—felt the impact, and they needed to adjust to new realities [11].

For these reasons, it is essential to analyze how FLW generation was modified during the lockdown and what type of measures were adopted to handle the problem. Hence, this study aims to review and report the impacts of the COVID-19 outbreak on the food sector and FLW generation, with the final objective of identifying the main consequences and adaptation measures. This would provide a frame of reference for dealing with future crises, whether health or environmental (e.g., tsunamis, earthquakes, etc.), guiding all stakeholders, i.e., consumers, producers, and authorities, on how to act and achieve resilient and sustainable food systems.

2. Methods

With the aim of compiling the consequences of COVID-19 on FLW, and the measures and solutions adopted, a bibliographic search was conducted in order to find and access reviews and original articles on this topic. Obviously, only articles from the last two years (2020, 2021, and 2022) were consulted. The search was carried out using the database of Scopus [12], since it is the most reliable and complete source of journals and references [13]. To achieve the highest number of results and greatest flexibility, the term “COVID-19” was combined with the following keywords: “food loss”, “food waste”, “food loss and waste”, “FLW”, “food supply chain”, “consumption habits”, “measures”, and “food system”. In addition, these terms must appear in the abstract, keywords, or title. Among the studies found, three types of information were extracted for the review: (1) direct impacts of COVID-19 on the food sector and challenges, (2) impacts of COVID-19 on FLW, including an overview of the generation, sources, trends, and indirect impacts on the environment, nutrition, and economy, and (3) mitigation and recovery strategies addressed by stakeholders to deal with this unprecedented situation.

3. Results and Discussion

3.1. Challenges of the Food Sector as Consequence of the COVID-19 Pandemic

The emergence and spread of COVID-19 led all countries around the world to take measures to control the infection, such as confinements, mobility restrictions, quarantines, or market closures, among others. These actions had positive consequences in the field of public health, but negative ones in other aspects, such as food security, which indirectly influences FLW generation. All articles and reports analyzed in this review reported practically the same direct and indirect effects on the food sector during the first wave for all territories (Figure 1). To begin with, a potential loss of productivity and production due to the shortage of raw agricultural goods was observed around the globe, joint with a shortage of labor [14], which inevitably had an impact on FL generation because of the lack of personnel to prepare and maintain the crops, harvest, etc. Lockdowns prevented local and migrant workers moving to farms and processing and packaging facilities, many of which reduced their production or were already closed due to quarantine and sick staff [15]. On the other hand, trade plays a key role in global and regional food security. Despite the scarcity of resources and products, stakeholders were often forced to discard food because of the large quantities that they had to store and could not distribute [16]. On the supply

side, importations and exportations were both positively and negatively influenced by the pandemic. For instance, agri-food exports and imports between Africa and the rest of the world showed moderate to minimal changes. However, intraregional flows of countries in sub-Saharan Africa appeared to be less resilient [14]. On the contrary, South America and the Caribbean recorded an increase in food exports of 8.3% compared to 2019, as food is a basic necessity and the demand for main destinations did not change significantly [17]. On the demand side, stay-at-home measures changed consumers' sentiment and behavior toward the food industry. Panic buying and hoarding drove up prices of certain stable foods at the onset of lockdowns in some countries [18], limiting the access of vulnerable population to diverse sources of adequate and nutritious foods, as well as producing stock out of a wide range of products. In this regard, citizens who collected an excessive amount of food had to throw it away because of their inability to consume it before it became spoiled.

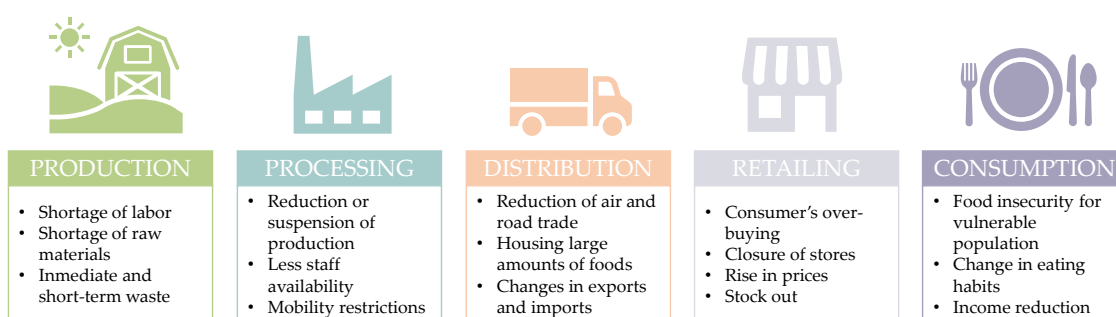


Figure 1. Food sector challenges caused by COVID-19 that directly or indirectly affect FLW generation.

During the second wave, food industries were impacted to a much lower extent than the first wave. Some producers were able to adapt to new demand and adjusted packaging, labelling, and production. Additionally, borders remained open, and consumers refrained from over-buying and stockpiling and avoiding shortages, and FSC remained resilient [19].

3.2. Overview of the COVID-19 Impact on FLW

The COVID-19 outbreak not only had a physical impact on the food system, but also influenced consumer behavior and their perception of the sector, especially on the importance of food waste reduction, local food consumption, and organic farming [20]. Based on the results of a survey made to Tunisian consumers, 85% respondents declared that nothing of what they bought during the lockdown would be discarded, whereas, in the pre-COVID-19 situation, only 30% of people could claim this [10]. Likewise, a very high percentage of the respondents of a questionnaire made in Macedonia (94.16%) expressed a high awareness of FLW and tried to avoid wasting food as much as possible [21], as well as Serbian citizens [22]. Quantitatively, the amount of FLW generated was slightly influenced by the pandemic. According to Aldaco et al. [9], a similar overall production and consumption of food was produced during the lockdown in Spain, and no significant changes in the amount of FLW were reported. This is because, even though FW generated in households increased by approximately 12%, it compensated for the decrease in extra-domestic generation [9]. Part of this household FW has arisen from the over-buying trend, which causes products to expire before consumption [23]. However, between 30% and 35% of consumers declared that the main reasons for discarding these products were food over cooking or improper warehouse; for instance, too long fridge-storage [10]. Likewise, in restaurants, fresh products were accumulated without being sold, leading to food losses, a loss of income, and higher prices [24]. It is remarkable that the highest contribution to FLW came from fruits, vegetables, and cereals, following the same trend as in 2019 [25]. Similar results regarding discarded food groups were obtained in Macedonia, the Netherlands, Finland, Morocco, Egypt, or Italy, among others [21]. The major difference resides in the FW of beverages, which decreased from 13.1% to 7.9%, probably motivated by the closure

of bars and restaurants [9]. On the other hand, FL grew due to the disposal of perishable foods because of foodservices locking [24].

From a nutritional, economic, and environmental perspective, the repercussions of COVID-19 on FLW were quite significant. Aldaco et al. [9] reported a diminution of the nutritional content of FLW, whereas the cost and greenhouse gas (GHG) emissions grew during the emergence situation in comparison with the previous year (considering, in this reference, both household and extra-domestic consumption). These disruptions were caused by several factors. Firstly, an increment in the consumption of alcoholic beverages [26], snacks [27], and other unhealthy options was produced, making the nutritional content of food intake decrease during the lockdown, and, therefore, those of FLW. At the same time, the demand moved from restaurants to grocery stores, which increased the prices of virtually all of their products due to uncontrolled consumers demand [28] and product shortages due to disruptions in the supply chain, affecting both producers, processors, and distributors [29]. Finally, due to its high organic content, FW created a variety of adverse effects on the environment, partly as a consequence of its major disposal in landfills [23].

3.3. Mitigation and Recovery Strategies

The COVID-19 pandemic generated a new era in the FSC and the food industry [30]. Despite the clear negative and devastating consequences of the disease, the emergence situation has provided a unique opportunity to stop and think, analyze, and take action in the best possible way. Although it was not easy to make decisions under pressure, it was possible to re-orient and transform the sector, making it more resilient and sustainable, for which, it is imperative to identify hurdles and solutions. At this point, it is important to consider that, since all processes and stages in a supply chain are strongly connected to each other, a slight delay or glitch can trigger a butterfly effect, resulting in a big loss in the yield and outputs [31].

Figure 2 illustrates specific mitigation measures for guiding future extraordinary situations addressed in different regions. Although the measures are quite diverse, as they involve actions of all stakeholders among FSCs, in general, they are common among the territories.

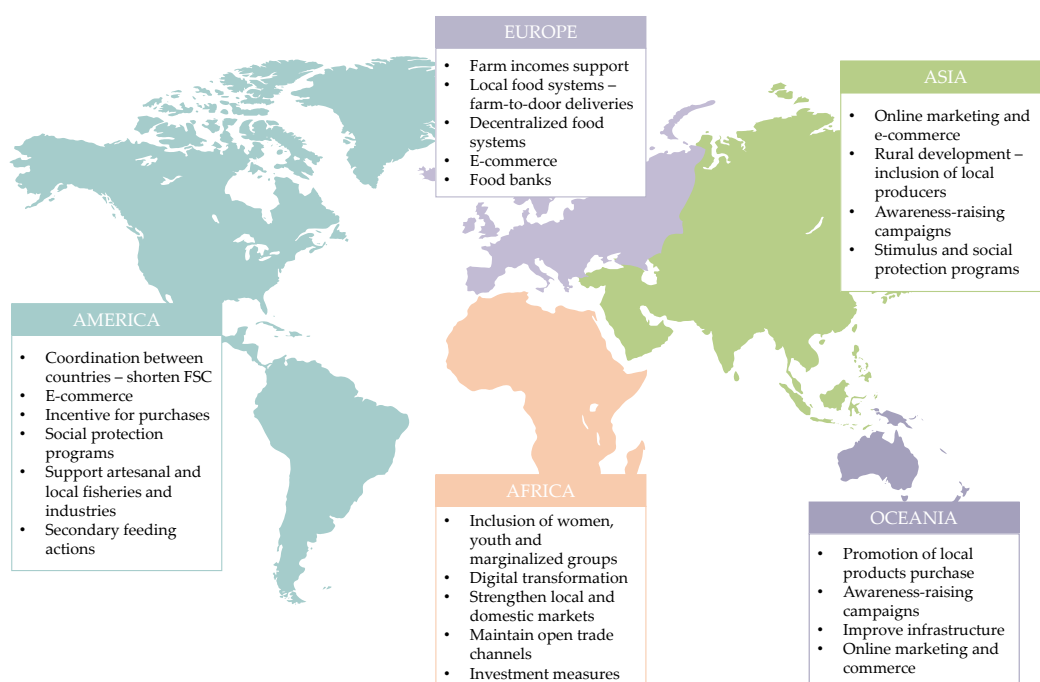


Figure 2. Some strategies and actions to deal with FLW generation and achieve the recovery of the food sector during COVID-19.

The scarcity of food products is unavoidable in such a strict lockdown where most of the logistic activities were stopped [32]. For agriculture production, a shortage of fertilizers, pesticides, or seeds was produced, while, in the remaining stages of FSC, there were not enough products to process or commercialize [31]. Hence, open borders for the flow of essential goods were a priority during the crisis [33]. When promoting the development of alternative distribution channels, for instance, e-commerce was a common mitigation strategy addressed by most of the regions [34]. The shortening of FSCs through the implementation of online platforms that directly link consumers to farmers provides a great opportunity to deliver food efficiently [24]. In light of this situation, it was essential that governments make a huge effort to support this essential activity in terms of digitalization, economy planification, and quality product labeling [9]. In addition, this problem was compounded by the lack of labor in farms and processing plants due to quarantines and contagions [15]. Inclusive programs to support women [11], youth, and marginalized groups engagement in these sectors were required in some countries, mainly located in Asia, Africa, and Latin America [35], as well as including small local producers in the supply chains, which led to autonomy and flexibility during operation [20], fostering a more decentralized sector. As a consequence of the pandemic, firms now have a window of opportunity to plan risk mitigation strategies; for instance, developing contingency plans to continue operating these key businesses in the event of sudden labor shortage, as well as taking steps to ensure a safe working environment [29]. Despite the scarcity of resources and products, stakeholders were often forced to discard food because of the large quantities that they had to store and could not distribute [16]. Favoring secondary feeding strategies, such as food donations of those stores that closed or farmers who could not send their products [36], as well as the valorization of high organic content waste into animal feed [10], which is an outstanding action of Europe, offered potential solutions to minimize and take advantage of these essentials.

Moreover, distributors moved from wholesale and foodservices to retail channels in order to take advantage of the products due to the closure of restaurants [37], demonstrating their flexibility and adaptation ability. Finally, at a consumer level, the great demand of and deficit in products led some citizens to turn to local and home-grown production, including backyard gardens, livestock, and poultry, which played a key role in stabilizing food availability and access, as well as food security during the pandemic [35]. In addition, the lockdown accelerated the learning process of food purchase management and responsible consumption [9], changing consumer's minds and acquiring a sense of control and responsibility in food preparation, supporting overcoming difficulties. Awareness-raising campaigns were also an important action developed by some Asian and Oceanian countries [18]. Proof of this is that some citizens opted during confinement for their own food waste management by means of organic composting [38]. In short, only if the food system is viewed from the perspective of an "action cycle" framework, where the system absorbs a shock, reacts, restores, learns, and builds robustness to future events, will the sector achieve resilience [39].

4. Conclusions

The COVID-19 outbreak has importantly impacted FSC and food systems, having repercussions in their associated FLW. The nutritional content of FLW showed a decrease with respect to the pre-COVID-19 situation, whereas costs and GHG emissions significantly increased. In addition, the main challenges addressed by FSC came from mobility restrictions, a shortage of resources, products and labor, and a high amount of household organic waste. These issues can be combated with different recovery strategies, such as the development of secondary feeding strategies—for instance, donations or waste valorization into animal feed—alternative distribution channels and e-commerce, the promotion of local and responsible production and consumption, and fostering a more decentralized food system, among other potential measures. All in all, it is evident that each stakeholder of the FSC plays a key role in its own adaptation and resilience, but only by acting together

as a whole can the sector remain efficient and sustainable. However, it is also imperative for the government to take measures supporting these actions, whether by facilitating the means for digitalization, developing social protection programs for the most vulnerable collectives, or helping financially in adaptations.

Author Contributions: Conceptualization, R.A. and M.M.; methodology, A.F.-R., J.L., I.R.-S., C.C., J.C., D.H., F.J.A.-S., C.O., and R.A.-B.; investigation, A.F.-R., R.A., and M.M.; writing—original draft preparation: A.F.-R.; writing—review and editing, A.F.-R., J.L., I.R.-S., C.C., J.C., D.H., F.J.A.-S., C.O., and R.A.-B.; supervision, R.A. and M.M.; project administration, R.A.; funding acquisition, R.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Spanish Ministry of Science and Innovation, grant number KAIROS-BIOCIR Project PID2019-104925RB (AEO/FEDER, UE).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: This study has been conducted thanks to the financial support of the Project Kairos-Biocir: Enhancing the nexus water-energy-food to improve the agri-food sector in Spain (PID2019-104925RB) (AEO/FEDER, UE), financed by the Ministry of Science and Innovation of the Government of Spain. Ana Fernández thanks the Ministry of Science and Innovation of the Spanish Government with the State Program for the Promotion of Talent and Employability in R&D&I for the financial support via the research fellowship RE2020-094029.

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

References

1. United Nations. *Transforming our World: The 2030 Agenda for Sustainable Development*; United Nations: New York City, NY, USA, 2015.
2. Shafiee-Jood, M.; Cai, X. Reducing food loss and waste to enhance food security and environmental sustainability. *Environ. Sci. Technol.* **2016**, *50*, 8432–8443. [CrossRef]
3. FAO. Food Loss and Waste Database. Available online: <http://www.fao.org/food-loss-and-food-waste/flw-data> (accessed on 10 September 2021).
4. FAO. *The State of Food and Agriculture. Moving Forward on Food Loss and Waste Reduction*; FAO: Rome, Italy, 2019.
5. Laso, J.; Campos, C.; Fernández-Ríos, A.; Hoehn, D.; del Río, A.; Ruiz-Salmón, I.; Cristóbal, J.; Quiñones, A.; Amo-Setién, F.J.; Ortego, C.; et al. Looking for answers to food loss and waste management in Spain from a holistic nutritional and economic approach. *Sustainability* **2021**, *13*, 125. [CrossRef]
6. Ishangulyev, R.; Kim, S.; Lee, S.H. Understanding food loss and waste—Why are we losing and wasting food? *Foods* **2019**, *8*, 297. [CrossRef]
7. UNEP. *UNEP Food Waste Index Report 2021*; UNEP: Nairobi, Kenya, 2021.
8. Read, Q.D.; Brown, S.; Cuéllar, A.D.; Finn, S.M.; Gephart, J.A.; Marston, L.T.; Meyer, E.; Weitz, K.A.; Muth, M.K. Assessing the environmental impacts of halving food loss and waste along the food supply chain. *Sci. Total Environ.* **2020**, *712*, 136255. [CrossRef]
9. Aldaco, R.; Hoehn, D.; Laso, J.; Margallo, M.; Ruiz-Salmón, I.; Cristóbal, J.; Kahhat, R.; Villanueva-Rey, P.; Bala, A.; Batlle-Bayer, L.; et al. Food waste management during the COVID-19 outbreak: A holistic climate, economic and nutritional approach. *Sci. Total Environ.* **2021**, *742*, 140524. [CrossRef]
10. 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]
11. Ragasa, C.; Lambrecht, I. COVID-19 and the food system: Setback or opportunity to gender equality? *Food Sec.* **2020**, *12*, 877–880. [CrossRef]
12. ELSEVIER. Scopus. Available online: www.scopus.com (accessed on 10 September 2021).
13. Falagas, M.E.; Pitsouni, E.I.; Malietzis, G.A.; Pappas, G. Comparison of PubMed, Scopus, Web of Science, and Google Scholar: Strengths and weaknesses. *FASEB J.* **2008**, *22*, 338–342. [CrossRef]
14. FAO. *Assessing the Impact of COVID-19 Pandemic on Agriculture, Food Security and Nutrition in Africa*; FAO: Rome, Italy, 2021.
15. Luckstead, J.; Nayga, R.M., Jr.; Snell, H.E. Labor issues in the food supply chain amid the COVID-19 pandemic. *AEPP* **2021**, *43*, 382–400. [CrossRef]
16. Barman, A.; Das, R.; Kanti De, P. Impact of COVID-19 in food supply chain: Disruptions and recovery strategies. *Curr. Res. Behav. Sci.* **2021**, *2*, 100017. [CrossRef]

17. ADB. *Food security in Asia and the Pacific amid the COVID-19 Pandemic*; ADB: Mandaluyong, Philippines, 2020.
18. Elbehri, A.; Temel, T.; Burcu Ceylan, F.; Mittal, S.; Kularatne, D.; Dawe, D. *COVID-19 pandemic impacts on Asia and the Pacific. A Regional Review of Socioeconomic, Agrifood and Nutrition Impacts and Policy Responses*; FAO: Rome, Italy, 2022.
19. De Vet, J.M.; Nigohosyan, D.; Núñez Ferrer, J.; Gross, A.; Kuehl, S.; Flickenschild, M. *Impacts of the COVID-19 Pandemic on EU Industries*; European Parliament: Strasbourg, France, 2021.
20. Blazy, J.M.; Causseret, F.; Guyader, S. Immediate impacts of COVID-19 crisis on agricultural and food systems in the Caribbean. *Agric. Syst.* **2021**, *190*, 103106. [[CrossRef](#)]
21. Bogevska, Z.; Berjan, S.; El Bilali, H.; Sadegh Allahyari, M.; Radosavac, A.; Davitkovska, M. Exploring food shopping, consumption and waste habits North Macedonia during the COVID-19 pandemic. *Socio-Econ. Plan. Sci.* **2022**, *82*, 101150. [[CrossRef](#)]
22. Berjan, S.; Vazko, Z.; Ben Hassen, T.; El Bilali, H.; Allahyari, M.S.; Tomic, V.; Radosavac, A. Assessment of household food waste management during the COVID-19 pandemic in Serbia: A cross-sectoral online survey. *Environ. Sci. Poll. Res.* **2022**, *29*, 11130–11141. [[CrossRef](#)]
23. Heikal Ismail, M.; Ghazi, T.I.M.; Hamzah, M.H.; Manaf, L.A.; Tahir, R.M.; Nasir, A.M.; Omar, A.E. Impact of movement control order (MCO) due to coronavirus disease (COVID-19) on food waste generation: A case study in Klang Valley, Malaysia. *Sustainability* **2020**, *12*, 8848. [[CrossRef](#)]
24. Boyaci-Gündüz, C.P.; Ibrahim, S.A.; Wei, O.C.; Galanakis, C.M. Transformation of the food sector: Security and resilience during the COVID-19 pandemic. *Foods* **2021**, *10*, 497. [[CrossRef](#)]
25. Vicente-Vicente, J.L.; Doernberg, A.; Zasada, I.; Ludlow, D.; Staszek, D.; Bushell, J.; Hainoun, A.; Loibl, W.; Piore, A. Exploring alternative pathways toward more sustainable regional food systems by foodshed assessment—City region examples from Vienna and Bristol. *Environ. Sci. Pol.* **2021**, *124*, 401–412. [[CrossRef](#)]
26. Castaldelli-Maia, J.M.; Segura, L.E.; Martins, S.S. The concerning increasing trend of alcohol beverages sales in the U.S. during the COVID-19 pandemic. *Alcohol* **2021**, *96*, 37–42. [[CrossRef](#)]
27. Gordon-Wilson, S. Consumption practices during the COVID-19 crisis. *Int. J. Consum. Stud.* **2022**, *46*, 575–588. [[CrossRef](#)]
28. Malone, T.; Schaefer, K.A.; Lusk, J.L. Unscrambling COVID-19 Food Supply Chains. 2020. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3672018 (accessed on 10 September 2021).
29. Hobbs, J.E. The COVID-19 pandemic and meat supply chains. *Meat Sci.* **2021**, *181*, 108459. [[CrossRef](#)]
30. Rizou, M.; Galanakis, I.M.; Aldawoud, T.M.S.; Galanakis, C.M. Safety of foods, food supply chain and environment within the COVID-19 pandemic. *Trend. Food Sci. Technol.* **2020**, *102*, 293–299. [[CrossRef](#)]
31. Aday, S.; Aday, M.S. Impact of COVID-19 on the food supply chain. *FQS* **2020**, *4*, 167–180. [[CrossRef](#)]
32. Singh, S.; Kumar, R.; Panchal, R.; Tiwari, M.K. Impact of COVID-19 on logistics systems and disruption in food supply chain. *Int. J. Prod. Res.* **2021**, *59*, 1993–2008. [[CrossRef](#)]
33. Hobbs, J.E. Food supply chain resilience and the COVID-19 pandemic: What have we learned? *Can. J. Agric. Econ.* **2021**, *69*, 189–196. [[CrossRef](#)]
34. Thilmany, D.; Canales, E.; Low, S.A.; Boys, K. Local food supply chain dynamics and resilience during COVID-19. *AEPP* **2021**, *43*, 86–104. [[CrossRef](#)]
35. Dixon, J.M.; Weerahewa, J.; Hellin, J.; Rola-Rubzen, M.F.; Timsina, J. Response and resilience of Asian agrifood systems to COVID-19: An assessment across twenty-five countries and four regional farming and food systems. *Agric. Syst.* **2021**, *193*, 103168. [[CrossRef](#)]
36. Sereenonchai, S.; Arunrat, N. Understanding food security behaviors during the COVID-19 pandemic in Thailand: A review. *Agronomy* **2021**, *11*, 497. [[CrossRef](#)]
37. Ali, J.; Khan, W. Impact of COVID-19 pandemic on agricultural wholesale prices in India: A comparative analysis across the phases of the lockdown. *J. Public Affairs* **2020**, *20*, e2402. [[CrossRef](#)]
38. Babbitt, C.W.; Babbitt, G.A.; Oehman, J.M. Behavioral impacts on residential food provisioning, use, and waste during the COVID-19 pandemic. *Sust. Prod. Cons.* **2021**, *28*, 315–325. [[CrossRef](#)]
39. Love, D.C.; Allisson, E.D.; Asche, F.; Belton, B.; Zhang, W. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. *Global Food Sec.* **2021**, *28*, 100494. [[CrossRef](#)]