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How The COVID-19 Pandemic has Impacted Food Waste: Lessons Learned and Future Challenges †

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Abstract: The present paper aims to review and assess the impact of 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 on mobility restrictions, labor and products shortage along the supply chain, and management of an important amount of household FLW. Measures such as secondary feeding strategies, alternative distribution channels, and e-commerce stand out to achieve 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

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1. Introduction

Food insecurity has always been one of the greatest challenges facing humanity, being discussed in different targets of the Sustainable Development Goals (SDG), such as SDG 2, related to zero hunger, or SDG 12, referred 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, economy, and environment, as almost one-third of the total production globally is discarded [4]. In addition, it is important to consider the sensitivity of this problem, since external changes can have a great influence on its generation, creating huge shifts in terms of both food access and security [5].

In the first half of 2020, the emergence of COVID-19 pandemic led to changes in all human daily activities, impacting both socially, environmentally, and economically. Obviously, food systems are not exempt from such disruptions. FSC were severely affected by the outbreak, influencing the generation of FLW due to increased household consumption, changes in dietary habits, confinement of producers and distributors, among other reasons [6]. Food systems at all levels – globally, locally, and domestically – felt the impact, and they needed to adjust to new realities [7]. 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 analyze the impact of the COVID-19 outbreak on 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 consumers, producers, and authorities on how to act and achieve a resilient and sustainable food sector.

2. Methods

With the aim of compilating the consequences of coronavirus on FLW, and the measures and solutions adopted, a bibliographic search was conducting for finding and accessing reviews and original articles on this topic. Obviously, only articles from the last two years (2020 and 2021) were consulted. The search was carried out using the database of Scopus [8], since it is the most reliable and complete source of journals and references [9]. 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 practices", and "food system". In addition, these terms must appear in the abstract, keywords, or title. Among the studies found, three types of information were considered for the review: 1) direct impact of COVID-19 on FLW generation, including trends, sources, and type of food waste, among other data, 2) indirect impact of COVID-19 on FLW, i.e., environmental, nutritional, and economic consequences, and 3) challenges and recovery strategies by the sector to deal with this unprecedented situation.

3. Results and Discussion

3.1. 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 [10]. Based on the results of a survey made to Tunisian consumers, 85% respondents declared 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 [6]. Quantitatively, the amount of FLW generated *was* slightly influenced by the pandemic. According to Aldaco et al. [5], 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 the food waste (FW) generated in households increased about 12%, it compensated the decrease in extra-domestic generation [5]. Part of this household FW has arisen from the over-buying trend, which causes products to expire before consumption [11]. 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 [6]. Likewise, in restaurants, fresh products were accumulated without being sold, leading to foods losses, loss of income, and higher prices [12]. It is remarkable that the highest contribution to FLW came from fruits, vegetables, and cereals, following the same trend than in 2019 [13]. The major difference resides on F*LW* of beverages, which decreases from 13.1% to 7.9%, problaby motivated by the closure of bars and restaurants [5]. On the other hand, food loss (FL) grew from farm to fork, i.e., in the first stages of the FSC, due to the disposal of perishable foods because of foodservices locking [12].

From a nutritional, economic, and environmental perspective, the repercussions of COVID-19 on FLW were quite significant. Aldaco et al. [5] reported a disminution 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

[14], snacks [15], and other unhealthy options was produced, making the nutritional content of food intake decreased during the lockdown, and, therefore, those of FLW. At the same time, demand moved from restaurants to grocery stores, which increased the prices of virtually all of their products due to uncontrolled consumer demand [16] and product shortages due to disruptions in the supply chain, affecting both producers, procesors, and distributors [17]. Finally, due to its high organic content, FW created a variety of adverse effects on the environment, partly as consequence of its major disposal in landfills [11].

3.2. Challenges and Recovery Strategies

The COVID-19 pandemic generated a new era in the FSC and the food industry [18]. 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 is imperative to identify hurdles and solutions. Figure 1 illustrates the main challenges addressed by the food sector, which have a direct or indirect impact on FLW, as well as the key lessons learned for guiding future extraordinary situations.

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 [19]. COVID-19 pandemic has forced supply chain stakeholders to adapt their routines and discover their strengths and weaknesses [5]. Scarcity of food products is unavoidable in such a strict lockdown where most of logistic activities were stopped [20]. 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 [19]. Hence, open borders for the flow of essential goods were a priority during the crisis [21]. Promoting the development of alternative distribution channels, for instance, e-commerce, gave a chance to the stakeholders [22]. The shortening of FSC through the implementation of online platforms that directly link consumers to farmers provides a great opportunity to deliver food efficiently [12]. In face 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 [5]. In addition, this problem was compounded by the lack of labor in farms and processing-plants due to quarantines and contagions [23]. Inclusive programs to support women [7] and youth engagement in these sectors was required in some countries [24], as well as including small local producers in the supply chains, which led to autonomy and flexibility on operation [10], fostering a more decentralized sector. As consequence of the pandemic, now firms have a widow opportunity in which planning 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 [17]. Despite the scarcity of resources and products, stakeholders were often forced to discard food because of the large quantities they had to store and could not distribute [25]. Favoring secondary feeding strategies, such as food donations of those stores that closed or farmers who could not send their products [26], as well as the valorization of high organic content waste into animal feed [6] 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 [27], demonstrating their flexibility and adaptation ability. Finally, at consumer level, the great demand and deficit of 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 pandemic [24]. In addition, the lockdown accelerated the learning process of food purchase management and responsible consumption [5], changing consumer's minds, and acquiring a sense of control and responsibility in food preparation, supporting overcoming difficulties. Proof of this is that some citizens opted during confinement for

their own food waste management by means of organic composting [28]. 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, the sector will achieve resilience [29].

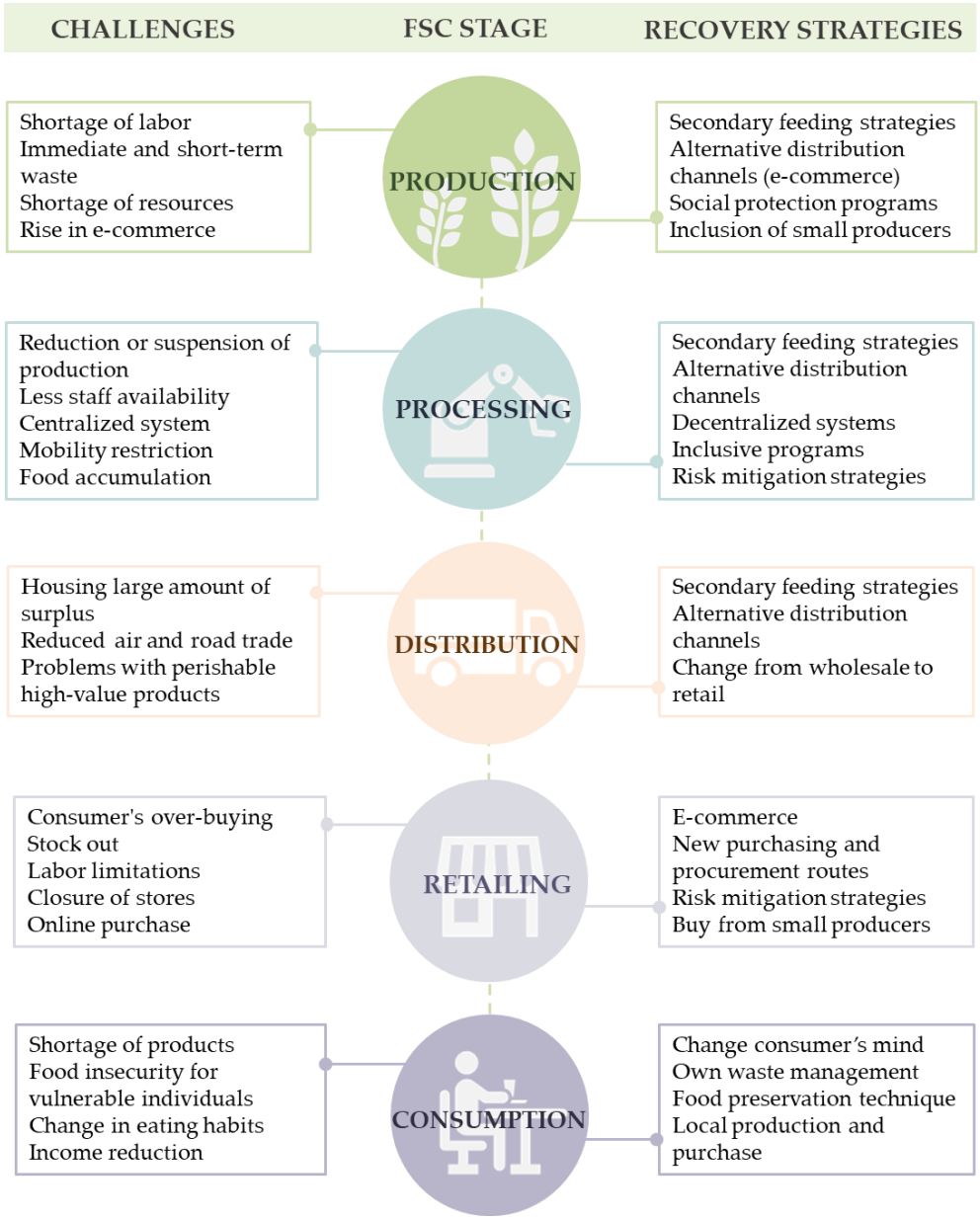

Figure 1. Challenges and recovery strategies from the impact of COVID-19 in FSC and FLW.

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, shortage of resources, products and labor, and 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, 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 the sector can remain efficient and sustainable. However, it is also imperative for 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.

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