

Environmental Impact of Food, Fruit and Vegetable Waste during COVID-19 Pandemic: A Review

MAHD ZIA¹, SIRAJUDDIN AHMED², ANIL KUMAR³

ABSTRACT

Apart from the major health impact, Coronavirus Disease-2019 (COVID-19) has impacted almost all sectors across the world. One of them is food, Fruit and Vegetable Markets (FVM). Lockdown implementation had different impacts in different countries, like Canada and the United Kingdom (UK) where they have logistics and supply chain of food, fruits and vegetable items and noted a shift in supply from food service to the retail channel, although the fresh food supply remains unaffected. A similar trend was seen in the metro cities of India, where online shopping has increased. In the food supply sector, both retailers and farmers had to face difficulty in storing, transporting, and selling of the goods and had to bear losses due to increased wastage. Although with an increased demand, organic farming has increased but still increased expenditure, less yield, and selling of the products are the major challenges in front of them. Food, fruit and vegetable wastes have considerably reduced at the food supply due to the obvious impact of lockdown on food supplies, however, a shortage of cold storages and supply chain at the farmer level in developing countries has resulted in more wastage. Developed countries reported increased illegal dumping of wastes in the rural areas and the stoppage of the recycling services due to the lockdown. Also, a shift in the habits of the consumer due to health and food-related issues has been seen throughout the world resulting in reduced waste generation at the consumer level. Despite all this, agricultural producer and the retail industry appears to be best placed to weather the storm. The major challenges related to the industry are sustainability in the food chain and maintaining smooth logistics and necessary precautionary measures in the event of health crises in the future.

Keywords: Biomass, Coronavirus disease, Lockdown, Public health

INTRODUCTION

Currently, the COVID-19 is a crucial public concern across the globe. One of the most suggested precautions against the rapid spread of the coronavirus is the implementation of lockdown which is being followed by various countries around the world. A survey was done online which demonstrated the data on awareness, consumer behaviour, an estimate of the expenditure on food, percentage of food wasted, and information required to decrease the extent of household waste [1]. The survey involved 284 participants. Out of all the respondents, approximately 89% of respondents were aware of the household wastage. About 93% of participants' waste levels were affected due to the COVID-19 lockdown and about 80% of respondents claimed that this situation has affected their grocery buying habits. But on the other hand, the lockdown due to the pandemic situation have somehow improved the food shopping and eating habits. About 85% of participants reported that there was 0% waste of what they bought during the lockdown by utilising leftovers and saving food [1]. The most common reasons for the wastage of food were inadequate storing facility, over-cooking, and over-buying of food items.

In a study, the major effect of the national lockdown on waste management was analysed in the United Kingdom (UK). A huge rise in clearances of home and Do-It-Yourself projects was reported as most of the waste recycling organisations have been closed. An increase of 300% was seen in fly-tipping in the rural sector. Almost 50% of the recycling services in the UK have been forbidden due to COVID-19 lockdown [2]. The precautionary measures lead to the socio-economic change rather than focusing on environmental measures [3]. Canadian FVMs are adversely affected due to the rate of increasing cases of COVID-19 since March 2020. The supply has shifted from food services to the retail supplies as restaurants, schools and other producers have been closed. It is reported by the shippers that the labour constraint affects the transportation,

storage, and robustness of the fresh food supply. In a long period, one can estimate that the measures could last long and would affect the consumer's habits [4].

IMPACT ON FOOD SUPPLY CHAIN

The capacity of the food supply chain is an issue of utmost concern for national well-being as well as security. COVID-19 has been a test for the conventional system that was followed since the pandemic started. During this crucial period of the pandemic, it is significant to ensure continuous food supply that allows us to bring and implement new innovative ideas for survival during COVID-19. In India, annually 9,61,000 tons of Fruit and Vegetable Market Wastes (FVMW) are generated in FVMs [5] at the retailer level and the common method of disposal of these wastes is dumping at illegal sites [6,7] which encourage unsanitary conditions like pest breeding, foul odour and is also responsible for harmful greenhouse gases. Although the wastes have been reduced in the FVMs due to COVID-19 lockdown restrictions, still the overall wastage has increased at both the farmer and retailer level due to break in the supply chain, shortage of cold storage, and refrigerated transportation. These wastes were still being dumped in illegal dump sites and for proper waste management, harnessing the potential of energy from waste is necessary for future energy security [8,9].

In a study, aimed at reporting the response and robust nature of the FVM in the UK during COVID-19 an assessment of the market and supply chain was done based on the interviews conducted with 23 market sectors [10]. Mitchell R et al., 2020 demonstrated that about half of the producers constitutes of the fresh supply chain which dominates over other supply chains. The present period of the pandemic has shown the significance of Research and Development (R and D) in the market sector to estimate the future stages of the situation [10].

In a recent study in America, food wastes were investigated in five different food supply chain sub divisions viz., food producers, food processors, food service operators, retailers and households. Closure of schools and coffee shops due to COVID-19 led to dumping of huge quantities of excess milk by milk producers. Chicken producers did not face any shortage in buyers however, outbreaks in meat packaging led to labour shortages and reduced output which also effected meat processing food wastes [11]. In the food service sector initially the food wastes increased due to dumping of existing food stocks but as the lockdown progressed, food service sector wastes reduced and then when the restaurants were allowed to open, the consumer uncertainty to dine in or take out may had led to increased food wastes. At the retailer level overstocking of putrescible wastes like food and fruits and vegetable led to their increased wastages. Household level food wastes may have increased due to bulk purchasing, mismanagement of food surplus and date labels confusion. However, households with less income, rising food prices and unemployment may also have led to reduced food wastes [11].

To improve the food security, it is necessary to augment food supply chain with local chain which can reduce the pressure on the natural resources. Also, Food Loss and Wastes (FLW) need to be minimised by assessing the eating habits. In a case study in Spain due to strict lockdown measures as a result of COVID-19 significant changes in the food consumption, nutritional content, FLW, GHGs emissions and economy was observed [12]. The life cycle methodology included material flow analysis of the inputs and outputs of the Spanish food basket supply chain which also involved economic and nutritional assessment. Household FLW increased by 12% due to extra domestic consumption while the nutritional content decreased by 8%. The economy and GHGs emissions increased by 11% and 10%, respectively [12]. The study also indicates that to meet the future unforeseen circumstances measures should be adopted to prevent and control FLW and also make proper reuse of food surpluses.

In another study, it was revealed that the eating habits may have major consequences on the generation of waste and its components [13]. Ouhaine O et al., investigated the ways to work on the waste generated in the period of lockdown and to follow the habits related to how to consume goods effectively in Morocco [13]. The study revealed that around 87% of participants disposed of cleaning and protective devices with the house waste. Adding to this, they also showed that 87% of respondents mix coronavirus protective equipment with household waste. The outcomes showed that the waste generated increased rapidly from February to March 2019. While it is reported from the city of Khenifra and Centre of Tighassaline that waste has reduced from 11.41% to 3.8% and from 4.73% to 1.23% [13]. The outcomes demonstrated the effect of lockdown on the products, and a large decrease in meat consumption amongst people was reported due to COVID-19. However, since most of the people stayed at home an increase in the overall domestic food wastes was reported. Thus, it is evident that there is an increase in domestic food wastes including the cleaning products during the COVID-19. Galanakis CM presented the workflow of the food systems during the period of a COVID-19 pandemic. It specified the analytical data regarding the characteristics of foods that can strengthen and boost the immunity of people during COVID-19 [14]. The study highlighted the significance of sustainable development and adapting to a better food chain resulting in avoiding health and food crises. The world economy is declining due to the pressures aroused between nations. Agricultural producers and the retail industry have emerged as the best amongst other food chains [14]. News showing the vacant shelves in grocery markets resulting in the pouring of milk into the drain has been going viral [15]. Just after the announcement of national lockdown, the Indian government declared the agricultural sector amongst the essentials. However, the

condition has given immense opportunities to bring and implement several new ideas that could last for a longer period. Agriculture holds 11% of the GDP and still plays a vital role for the 52% of the working majority of the country [16].

In developing countries mostly people shop offline by visiting physical markets that is from mandis, shops, roadside stalls, etc. Shopping of food, clothes and a house which are the basic needs depend on the consumers buying behaviour. In this global era, online shopping is a way of saving time and shaking hands with technology. Economic times cited a Boston Consulting Group (BCG) report which demonstrated that in India 70% of about 90 million online buyers are influenced by the information they collect from internet and only 16% online shoppers end up buying on the internet [17]. It includes all products for example durable and perishable goods. According to the litany of online grocery platforms, almost all fresh-food purchases are made offline while 1-2% transactions are online. Because of lockdown (COVID-19), essential goods are available at the online and offline market. In metro cities, online shopping of food and perishable goods have increased due to supply of these items by e-commerce companies viz., Big basket, Grofers, Bazaar Cart, during COVID-19 lockdown. However, people living in small cities don't want to take the risk and prefer the physical market. Another preferred choice of purchasing is by calling in the conventional market and taking delivery at home by paying some delivery charges.

In this scenario, cooking and food management skills are playing a vital role in improving efficiency of food production and reducing the food wastage by consumers. Reduction in earnings and higher food prices have resulted in improved food management and reducing the overall wastage. In UK, wastage from vital items such as bread, milk, chicken and potatoes reduced from 24% in November 2019 to 14% in April 2020 [18].

Also, both the food supply chain and food service sector had to face difficulty in storing, transporting, and selling their goods at the markets and had to bear losses due to increased wastage. Saha T and Bhattacharya S reported that the agricultural sector including farmers and labourers had faced considerable losses during lockdown [19]. Despite monetary assistance by the Indian Finance Ministry and Reserve Bank of India to farmers, still, the agricultural sector faces export shortages and restrictions due to lockdown. The impact of COVID-19 on food, fruits and vegetable markets and supply chain is summarised in [Table/Fig-1] [2,4,11-13,16,19].

The present situation demands increasing the expenditure on the agricultural sector viz., increasing monetary assistance to farmers, increasing the capacity and number of the cold storage facilities, distribution, transportation, creating an export supportive infrastructure. Developed nations are shifting to organic food products due to their nutritional benefits. For developing countries like India people need to realise the importance of traditional/organic foods which is believed to be rich in nutritious value and improve immunity which makes them more resistant to infection.

CHALLENGES

The COVID-19 outbreak has provided an opportunity to find effective treatments to improve the short term and long-term declination of food waste and intervene in food waste practices within households. A sustainable way to the problem of food waste could be implemented from the feedback of the consumers [1]. The major short-term effect of the COVID-19 pandemic is the realignment of the fresh food supply chain. The market-specific distribution networks remain disrupted during the disease spread and check supply-chain relationships a while later. In the longer term of time, the possible impacts will be felt across input markets, most notably on labour, and structural changes in the sector, which can lead to fundamental and potentially irreversible shocks such as restructuring and online shopping. Canada is importing much of its requirements for fresh produce but it doesn't isolate it

Authors [Reference]	Country/City	Interpretation
Report by Univeristy of Southampton [2]	United Kingdom	In this report, an analysis of impact of lockdown measures on waste management by Professor Ian Williams, Anne Stringfellow and Keiron Roberts highlighted a huge rise in clearances of home and Do-It-Yourself projects as most of the waste recycling organisations have been closed. An increase of 300% was seen in fly-tipping in the rural sector. Almost 50% of the recycling services in the UK have been forbidden due to the COVID-19 lockdown.
Richards TJ and Rickard B. [4]	Canada	Canadian FVM are adversely affected due to the rate of increasing cases of coronavirus-2019 since March 2020. The supply has totally shifted from food services to the retail supplies as restaurants, schools and other producers have been closed. It is reported by the shippers that the labour constraint affects the major change and about the robustness of the fresh food supply.
Ellison B and Kalaitzandonakes M [4,11,19]	United States of America	The study reviewed the food wastes from the entire food supply chain namely food producers, processors, suppliers and consumers during COVID-19 lockdown. Food producers who are dependent on the food service sector were the major contributors of the food wastes due to the closure of food service operators. Food processors and retailers have not contributed to major food wastes although the retailers may have contributed to increased wastes due to overstocking of perishable food and fruits and vegetable wastes when the lockdown measures were relaxed. Stockpiling, mismanagement, rising food prices, negative or reduced income were the factors which were responsible to the changes in the household food wastes.
Aldaco R et al., [12]	Spain	The study reported that the fluctuations in the food supply chain and small changes in the eating habits due to the COVID-19 lockdown had a major impact on the environment, health and economy. Household FLW increased by 12% due to extra domestic consumption while the nutritional content decreased by 8%. The economy and GHGs emissions increased by 11% and 10%, respectively.
Ouhine O et al., [13]	Morocco	The study clearly reports the ways to work on the waste generated in the period of lockdown and to follow the habits related to how to consume goods effectively in Morocco. Therefore, there is a rapid increase in the waste including the cleaning products. A survey showcased that around 87% of participants involved cleaning and protective devices with the house waste.
Van Landbouw M [16]	India	The study reported that the Indian government declared agricultural sector amongst the essentials. However, the condition has given immense opportunities to bring and implement new ideas that could last for a longer period of time. Agriculture holds 11% of the GDP and still plays a vital role for the 52% of the working majority of the country.
Saha T and Bhattacharya S. [19]	India	The study reported that agricultural sector including farmers and labourers had faced considerable losses during lockdown (COVID-19).

[Table/Fig-1]: Impact of COVID-19 on food, fruits and vegetable markets and supply chain [2,4,11-13,16,19].

from these shocks [4]. Therefore, the price of imported goods has increased with production costs in the United States and with any improvements in the exporting industry structure. These changes can change the distribution of fresh fruit and vegetables for the long terms as well [4].

COVID-19 pandemic has initiated the start of a new era. More research is needed in the food safety and food security sector, introducing new measures to reduce food losses and wastes and meeting the consumer nutritional requirements by new harmless sources. Moreover, new developments should be implemented effectively enough with the imminent economic crisis in the COVID-19 pandemic period, offering appropriate and economically competitive goods and developing functional foods strengthened with bioactive compounds and antioxidants that promote safety and help the immune system of consumers. There is no doubt that we need to stop the "normal" activities, think out of the box, and speed up efforts to establish safe and modern food systems. The food things network plus has introduced a series of workshops to identify how robotics could be used to alleviate the shortage of labour. These innovations are now being considered by public funders for the betterment of survival in the time of a pandemic. The report outcomes suggest a short-term measure which is still not enough to push the industry for the absolute solution. Excellent technologies such as industrial robotics have been utilised [10].

Indian economy is largely based on agriculture and even now it is witnessed that the rural economy is not much affected due to the pandemic lockdown. Although the number of organic farmers has increased still food sector face a huge challenge in making a profit due to fewer yields, increased expenditure, and selling the produce. In today's scenario, consumers are ready to spend additional for getting quality and healthy food but finding a reliable source is a challenge [17]. The lockdown period has made the consumer think that Food and Shelters are the most essentials of life and particularly the importance of the traditional foods as the food which we have can have an impact on our health. There should be a way to fill the gap between both the farmer community and consumers in which both can get the benefit, farmers can make some additional money, and also the consumer can get healthy and fresh foods. Concepts

like contract farming or even personalised farming could be tried [17]. Farmers need to look at this situation as an opportunity and need to use communication channels like social media to build the consumer base and market their produce.

COVID-19 pandemic has caused fear which has led to the stockpiling of food items breaking the food supply chain, closure of foodservice outlets in the world, increase in retail purchases, and generation of a large amount of food waste [20]. It is very challenging to see a rise in fresh supply chains during the times of a pandemic. Innovation efforts suggested by Peck H included relaxation of working hours, amendment of rules to allow staff to work more without being penalised and amendment in the job retention scheme which may enable producers to see rapid increases in demand capable of using surplus labour in the foodservice sector [21]. Determination of local production, consumption, and variation across seasons of different food items could fix the problem of the supply chain in the future. For food wastes, basic principles like reduction and re-use of food, recycling of nutrients by composting could be applied in the food system.

Kharbikar HI et al., discussed the socio-economic implications of the COVID-19 pandemic and lockdown on the food and agribusiness sector in India [22]. The authors suggested cleanliness, social distancing and health-related measures, financial support from government and private industries, technological measures such as e-agribusiness, e-agrimarketing, infrastructural development, capacity building programs, modern techniques of transfer of technologies, and proper implementation of government schemes and programs to tackle the situation and overcome from the crisis. Such socio-economic initiatives will play an immense role in the overall enhancement of the socio-economic status of farmers, farm labourers, and allied industries in terms of employability, efficiency, health, and well-being [22].

A recent paper reported the Indian government's response to the coronavirus. It highlighted that the resource rich and controlling nations response to COVID-19 had an influence in selecting the India's strategy in confronting the issue. It was highlighted that the country's local knowledge, culture and capacity should have been used in deciding the response [23]. Decentralised decision-making

process, incentivising civil society, etc., were the anticipated short term and long term solutions to COVID-19 [22]. These findings could be helpful in tackling any national or worldwide health related issues similar to COVID-19 in the future.

Over the longer term, government and private industries need to improve and develop infrastructure, capacity building programs for farmers and labourers, an amalgamation of local knowledge and modern techniques of transfer of technologies such as e-agribusiness, e-agrimarketing, decentralised decision-making process, civil society and proper implementation of government schemes support. The government needs to address the needs of all the parties involved in food production to the food supply chain to the consumer for achieving sustainability in this sector. This is a very sensitive period, so cleanliness, social distancing, and health-related measures should be the priority in every future aspect of life to minimise the impact of infectious waste on human health.

CONCLUSION(S)

Impact of COVID-19 lockdown on the food, fruits and vegetable production, distribution and wastages showed that it ultimately affects the country's economy, environment and health of individuals handling such wastes. Shortage of cold storages and supply chain at the farmer and retailer level in developing countries has resulted in more wastage. The major challenges related to the industry are sustainability in the food chain, maintaining smooth logistics, and necessary precautionary measures in the event of health crises in the future.

REFERENCES

- [1] 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(5):3939-55.
- [2] Rubbish piling up: The environmental impact of the COVID-19 shutdown. *Phys Org*. 2020:May1. Available from- <https://phys.org/news/2020-05-rubbish-piling-environmental-impact-covid-.html> (accessed on 20 July 2020).
- [3] Stöckli S, Niklaus E, Dorn M. Call for testing interventions to prevent consumer food waste. *Resources, conservation and recycling*. 2018;136:445-62.
- [4] Richards TJ, Rickard B. COVID-19 impact on fruit and vegetable markets. *Cand J Agr Econ*. 2020;68:189-94.
- [5] Zia M, Ahmed S, Kumar A. Anaerobic digestion (AD) of fruit and vegetable market waste (FVMW): Potential of FVMW, bioreactor performance, co-substrates, and pre-treatment techniques. *Biomass Conv Bioref*. 2020:01-20. <https://doi.org/10.1007/s13399-020-00979-5>.
- [6] Joshi R, Ahmed S. Status and challenges of municipal solid waste management in India: A review. *Cogent Environmental Science*. 2016;2(1):1139434.
- [7] Parihar RS, Ahmed S, Baredar P, Sharma A. Characterisation and management of municipal solid waste in Bhopal, Madhya Pradesh, India. In *Proceedings of the Institution of Civil Engineers-Waste and Resource Management*. 2017;170(3+4): 95-106.
- [8] Joshi RK, Ahmed S. Municipal solid waste as a source of energy. In *2015 Annual IEEE India Conference (INDICON)*. 2015:01-06.
- [9] Khan MD, Khan N, Sultana S, Joshi R, Ahmed S, Yu E et al. Bioelectrochemical conversion of waste to energy using microbial fuel cell technology. *Process Biochemistry*. 2017;57:141-58.
- [10] Mitchell R, Maull R, Pearson S, Brewer S, Collison M. The impact of COVID-19 on the UK fresh food supply chain. *arXiv preprint arXiv:2006.00279*. 2020.
- [11] Ellison B, Kalaitzandonakes M. Food waste and Covid-19: Impacts along the supply chain. *Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign. Farmdoc Daily*. 2020;(10):164.
- [12] Aldaco R, Hoehn D, Laso J, Margallo M, Ruiz-Salmón J, Cristobal J, et al. Food waste management during the COVID-19 outbreak: A holistic climate, economic and nutritional approach. *The Science of the total environment*. 2020;742:140524.
- [13] Ouhssine O, Ouigmane A, Layati E, Aba B, Isaifan RJ, Berkani M. Impact of COVID-19 on the qualitative and quantitative aspect of household solid waste. *Global Journal of Environmental Science and Management*. 2020;6(4):01-02.
- [14] Galanakis CM. The Food Systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis. *Foods*. 2020;9(4):523.
- [15] Petetin L. The COVID-19 crisis: An opportunity to integrate food democracy into post-pandemic food systems. *Eur J Risk Regul*. 2020;11(2):01-14.
- [16] Van Landbouw M. Impact of COVID-19 on India's Agrifood sector-Nieuwsbericht-Agroberichten Buitenland. 2020. [Accessed on April 20, 2020].
- [17] Survey finds only 16% online shoppers end up buying on the Net, Retail News, ET Retail. *Economic Times*. 2017. <https://retail.economicstimes.indiatimes.com/news/e-commerce/e-tailing/survey-finds-only-16-online-shoppers-end-up-buying-on-the-net/62054680> (accessed 22 July 2020).
- [18] Roe BE, Bender K, Qi D. The Impact of COVID-19 on consumer food waste. *Applied economic perspectives and policy*. 2020. <https://doi.org/10.1002/aep.13079>.
- [19] Saha T, Bhattacharya S. Consequence of lockdown amid Covid-19 pandemic on Indian agriculture. *Food and Scientific Reports*. 2020;1:47-50.
- [20] Sharma HB, Vanapalli KR, Cheela VS, Ranjan VP, Jaglan AK, Dubey B, et al. Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resour Conserv Recycl*. 2020;162:105052.
- [21] Peck H. Resilience in the Food Chain: A Study of Business Continuity Management in the Food and Drink Industry. Final report to the Department for Environment, Food and Rural Affairs July 2006. Defra/The Resilience Centre, Department of Defence Management & Security Analysis, Cranfield University Shrivvenham/London. [Accessed on 20 April, 2020].
- [22] Kharbikar HL, Radhika C, Naitam RK, Daripa A, Malav L, Raghuvanshi MS. Consequences of COVID-19 pandemic and lockdown on food and agribusiness sector in India. *Food and Scientific Reports*. 2020;1(6):13-18.
- [23] Feler B. Make in India: An economic & policy analysis of India's response to the COVID-19 crisis. 2020. (Accessed on 25 April, 2020).

PARTICULARS OF CONTRIBUTORS:

1. Research Scholar, Department of Civil Engineering, Jamia Millia Islamia (A Central University), New Delhi, India.
2. Research Scholar, Department of Civil Engineering, Jamia Millia Islamia (A Central University), New Delhi, India.
3. Director, Department of Environment, Government of NCT, New Delhi, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Mahd Zia,
Research Scholar, Department of Civil Engineering, Jamia Millia Islamia (A Central University), Jamia Nagar, Okhla, New Delhi-110025, India.
E-mail: mahdzia@gmail.com

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? NA
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jul 02, 2020
- Manual Googling: Feb 24, 2021
- iThenticate Software: Apr 24, 2021 (6%)

ETYMOLOGY: Author Origin

Date of Submission: **Jul 01, 2020**
Date of Peer Review: **Sep 02, 2020**
Date of Acceptance: **Feb 25, 2021**
Date of Publishing: **Jun 01, 2021**