

## Impact of Covid-19 on Indian Food Industry

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### Abstract:

A pandemic is not a new event encountered in the history of humanity, because mankind has faced various pandemics in history. The common point of pandemics is their severe negative effects on the global economy. COVID-19, the global pandemic specifically second wave, has brought India to its laps. As of 20 April, 2021, the virus has spread to almost all the states with 1.5 Cr confirmed cases and 1.8 L deaths. Panic-disturbed country has come to a stoppage with quarantine, home imprisonment, job losses and economic distresses. However, impact of COVID-19 pandemic on Indian food, agribusiness and food industry is largely experienced. Interruption through present pandemic is related to almost all the sectors of economy. Especially, the restrictions disrupted the agriculture and food supply chain that in turn made farmers to experience enormous losses. Adding to that, immense post-harvest losses due to shortage of labours and transportation blockages and price hikes due to panic buying and commercial were observed. In the light of recent challenges in food supply chain also, there is now considerable concern about the food production, processing, distribution, and demand. Facing extraordinary challenges, the Government has introduced measures like free ration, essential food kits and economic incentive plans to aid the people to survive the current emergency. This chapter discusses the impacts of COVID-19 on the food system in India followed by the collective approach by the National and State Governments along with the private sector to protect the lives and the livelihood of the fragile groups in India. It is expected that these actions could encourage effective solutions for greater food security and food authority in countries currently suffering from the pandemic and for India itself.

**Key words:** *India, pandemic, COVID-19, food and challenges.*

### Introduction:

As the COVID-19 disease spread rapidly to six continents by the novel corona virus SARS-nCoV-2, many countries around the world have declared state of health emergency. On March 11, 2020, the World Health Organization (WHO) declared the rapidly spreading disease as a pandemic and called on countries to plan preparatory and response actions in line with the Global Strategic Preparedness and Response Plan (WHO, 2020a; Vasavada, 2020). WHO explained that a pandemic caused by a corona virus has not been seen before, and this disease is the first pandemic caused by the corona virus.

COVID-19 is the fifth pandemic, following 1918 influenza virus (H1N1), 1957 influenza virus (H2N2), 1968 influenza virus (H3N2), and 2009 Pandemic flu (H1N1), that resulted in the human deaths of around 50 million, 1.5 million, 1 million, and 3,00,000, respectively (Liu *et al.*, 2020). As of 20 April, 2021, the virus has spread to almost all the states of India with 1.5 Cr confirmed cases and 1.8 L deaths. WHO indicated that this outbreak is not just a public health crisis, it is a crisis that will touch every sector.

The implementation of these measures caused the shutting of work places and educational institutions, and temporary travel restrictions and social meetings. Flexible working from home or attending meetings by online applications are now recognized as standard practices. However, people works in the food industry do not have work from home opportunities and need to keep their typical office routine procedures (Nicola *et al.*, 2020; FAO and WHO, 2020).

As a consequence of the COVID-19 crisis, reply plans for food workers were industrialized to provide guidance for continuing the operations in food processing amenities to manage corona virus in the food industry. Especially meat and poultry processing industries can be defined as the serious infrastructure in the food and agriculture. The plan includes categorizing of control necessities for cleaning, sanitation, disinfection in facilities, screening and monitoring of workers for COVID-19, managing the sick employees and education programs for workers and supervisors to prevent the spread of corona virus (CDC, 2020a).

Every industry in the world expects to see how the COVID-19 outbreak will affect the working, and the food industry is no different from other industries. However, the difference of the food industry from

other industries; is to produce products that are essential for daily life. Everybody knows that if one factory closes, a certain number of people who works at these factories have the probable to starve, but if processors and distributors are affected, whole people are at the risk (Staniforth, 2020). In addition, the food industry is a very important sector in regard to economy. However, food sector faces different sets of challenges compared to other sectors that are not life-threatening for daily life such as tourism and aviation during a pandemic. Some food companies face various challenges due to a drop in income, while others are working hard to meet the growing demand of retailers. During the current COVID-19 outbreak, some tough decisions had to be made, including temporarily shut down of the various businesses. The fact clearly demonstrated that different companies from different industries are closely connected to each other in the world (Shahidi, 2020; Sebastian, 2020).

A major concern shared by all food companies is preserving the employee health and maintaining availability of workers due to sickness or rejecting to work because of corona virus fear. It is very important to protect and maintain the health of people working in the food supply chain during this time of crisis (FAO and WHO, 2020). However, keeping the distribution chain alive by the supply management plans is also important to meet the consumer demands (De Sousa Jabbour et al., 2020). Maintaining the flow of food and commodities throughout the supply chain should be ensured with the contribution of all stakeholders. Safeguarding the confidence of consumers is also essential for food safety and security (FAO and WHO, 2020). Serious risk for food security is not associated with food obtainability, its related to consumers' access to food (OECD, 2020a).

Consumers generally do not think much about how the food on their tables is produced. However, concerns about food safety in the center of the global epidemic have drawn attention to the enormous infrastructure and workforce responsible for creating a safe and reliable food supply worldwide. Especially at the beginning of this global crisis, consumer demand for food has increased and some store shelves have been temporarily emptied and resulted more purchases of essential products. However, despite this unprecedented demand, the food supply chain remained strong; since many supply chain actors, including farmers, producers, distributors and retailers, have worked hard to renew shelves (Nicola et al., 2020; Watts, 2020). Despite the large scale of the pandemic, there is no report that COVID-19 has been transmitted through food intake to date. Therefore, as stated by the European Food Safety Authority, there is no evidence that food carriage a risk to public health in relation to COVID-19.

However, it can be concluded that there is low risk of foods carrying the virus although the superficial risk is high. Considering the survival time of SARS-CoV-2 on different environments such as plastic, steel, or cardboard, it is possible that animal tissues (meat, fish or poultry) might be severe source for food borne transmission. Hygiene controls by food business operators are designed to prevent contamination of food by any pathogen, and will therefore aim to prevent contamination of foods by the virus responsible for COVID-19 too (Pressman et al., 2020; Arellano, 2020; Dalton, 2020; EC, 2020). It was reported that foods were not a source of spread ability of corona viruses including MERS and SARS-CoV due to the acidic environments of stomach (pH < 3.5) in previous outbreaks. However, some of cooking and eating habits may lead to reappearance of the corona virus from animals to humans (Rizou et al., 2020).

To summarize, four major issues have been raised up in the food industry and the food supply chain during the COVID-19 outbreak. Firstly, people tend to healthy diet for protecting themselves and their immune systems (Rodríguez-Pérez et al., 2020). Therefore, the demand for the functional foods which contain bioactive ingredients improved. Secondly, food safety has gained more attention to prevent the transmission of corona virus among producer, retailers, and consumers. Thirdly, food security concerns have risen because of the people on lockdown restrictions. Lastly, food sustainability problems have emerged in the era of pandemic (Galanakis, 2020).

In the light of recent challenges in food supply chain, there is now considerable concern about the food supply chain. Formal and informal sources were used to obtain information about the food supply chain during COVID-19 outbreak. The contents which were not reviewed by news editor, journal/magazine editor or scientific editor before they are published online were not used as a supplementary source of information. Most of the content was based on the well-known organizations such as Centers for Disease Control and Prevention (CDC), European Commission (EC), Food and Agriculture Organization (FAO), International Food Information Council (IFIC), International Food Policy Research Institute (IFPRI), International Labour Organization (ILO), International Trade Centre (ITC), The Organization for Economic Co- operation and Development (OECD), and World Health Organization (WHO).

### **Effects of Pandemic on Food Supply Chain:**

Food supply chain can be divided into five steps, including agricultural production, post-harvest handling, processing, distribution/retail/service, and consumption. Two systems are being used in the food supply chain concerning to food quality and safety. First one is based on regulations and laws that use mandatory standards which are inspected by state agencies.

Second one is trusting on voluntary standards which are defined by market laws or international associations (Bendekovic et al., 2015). Safety measures to ensure the continuity of food flow for each stage can be grouped in food employee's health issues, personal hygiene, using personal protective equipments such as helmets and glove, sanitization of surfaces and working environments, safe handling/preparation/delivery of food, and maintain social distancing. Protective measures in the last stages of the food supply chain are critical since more people can be potentially affected when we keep moving towards the last stages (Rizou et al., 2020).

In developing countries like India, temporary or seasonal workers are largely used, especially for planting, sorting, harvesting, processing, or transporting of crops to markets. Therefore, supply chain is significantly affected when workers absent from work due to sickness or travel restrictions of local and migrant workers due to lock down. It also weakens not only production abilities for others, but also their own food safety, in cases where the disease directly affects their health or movement (FAO, 2020k). Especially, labor shortage due to COVID-19 crisis caused severe disruptions in some sectors such as livestock production, horticulture, planting, harvesting and processing of crops which are relatively labor intensive (Stephens et al., 2020). However, shortage of farm workers was the major issue well before the COVID-19 outbreak, too (Richards and Rickard, 2020).

Most agricultural activities depend on the season and weather and therefore activities need to follow a fine-tuned schedule and speeding up when needed. Delay in an activity can have an impact on the yield and output throughout the making process. Because all processes in the supply chains include the activities such as supply of agricultural input, packaging, distribution, storage, and stock management (FAO, 2020k). Actually, there are many reports that farmers were forced to destroy their products by burning or leaving them on the field to spoil because of the restrictions. It was reported that tea plants were being lost because of the logistical challenges in India (BBC, 2020). Therefore, maintaining the logistical efficiency is a key factor for the food industry, especially in global crisis. The biggest issues in the food supply chain are obtaining raw materials from suppliers and ensuring the continuity of food flow from manufacturers to end users (Alonso et al., 2007). As countries struggle with that pandemic, they must make every effort to move the mechanism of the food supply chains. The impact of pandemic problems on agricultural systems largely depends on the intensity and composition of agricultural inputs and varies depending on the product produced and the country.

Food sector contains many diverse products such as meat, fruit, vegetable, dairy, ready-to eat foods and other edible products. However, the food and agriculture chain can be broadly classified in two categories regarding to capital investment and labor.

First one can be defined as staple products such as wheat, corn, maize, soybeans, and oilseeds. Second one contains the high-value products such as fruit, vegetables, and fisheries. Staple products require large amounts of capital investments.

The challenges have been driven by movement restriction (National or International border closures) is not the only reason but also the changes in demand of consumers are vital, too. Because of the restrictions, consumers cannot go to restaurants and they prepare their meals at home. In addition, consumers do not want to go to markets and supermarkets due to catching the COVID-19 at the stores (FAO, 2020g).

The supply chain affects not only producers, distributors, and consumers, but also food-processing plants that are labor-intensive. Production was reduced, suspended or temporarily discontinued in many plants due to the workers who were found to be COVID-19 positive and who were unwilling to go to work, thinking that they would get sick at work, mostly in meat processing food companies at the time of the outbreak.

There are several reasons at play which make food processing facilities potential hotbeds for outbreak. Keeping social distance inside the food plants is difficult because workers stand side by side long shifts on production lines. In addition, talking loudly or shouting result more droplet releasing to the air due to noisy factory environments (Stewart et al., 2020). Employees also travel on same buses or use car sharing system allowing the virus to spreading further. Moreover, majority of workers have lower income and mostly don't have insurance coverage or paid sick leave. Therefore, food processing workers are taking risk to go work even they feel sick which increase the risk of infection. Cold and humid environment inside the food processing facilities is another factor that facilitates the spread of

the COVID-19. It is possible that cold and dark environments without any ultraviolet light can keep corona virus alive and might result an increase in the rates of transmission (Gulland, 2020; Artiga and Rae, 2020). The stability tests of the virus under 5 different temperatures (4, 22, 37, 56, 70°C) and 5 different surfaces (paper, tissue paper, wood, cloth, showed that SARS-CoV-2 is highly stable at 4°C, but sensitive to heat.

In addition, it was found that virus is stable on smooth surfaces, however susceptible to standard disinfectant reported by Van Doremalen et al. (2020) suggested that, SARS-CoV-2 remain stable in aerosols for 3 hours. Same study revealed that virus was viable for 4, 24, 48 and 72 hours on copper, cardboard, stainless steel, and plastic, respectively. These outcomes indicated that the cooking temperatures above 70°C are enough to kill the SARS-CoV-2, but sanitary recommendations (washing hands, separating raw and cooked meat etc.) should be followed while preparing and storing the foods (Rizou et al., 2020; Shahidi, 2020).

Governments are also facing financial pressures due to the economic shrinkage and reallocating their resources focusing on financial incentives and social assistance programs. Based on the information provided by WHO indicated that corona virus transmitted through direct contact or respiratory droplets, however the latest infections have been seen in market raised questions over spread of corona virus through food.

As a result, the COVID-19 pandemic ensured the use of mechanisms designed for emergency and affected contractual transactions in the food supply chains.

At the same time, it resulted into the changes in the supply-demand balance and left small producers and operators in a difficult situation (FAO, 2020i).

#### **Effects on Pandemic on Consumer Behavior:**

When the issue of how the COVID-19 pandemic affects consumers' food demand is examined, it is seen that the demand varies depending on the price of foodstuffs, income level of consumers, socio- demographic situation, consumption and shopping preferences and time constrains. In addition, number of visits to food store and spending money on food in per visit changed (Bakalis *et al.*, 2020; Cranfield, 2020).

COVID-19 outbreak interrupted the daily routine and resulted in tediousness which can be defined as high energy intake by the consumption of high amount of fat, carbohydrate, and proteins. In addition, quarantine caused stress in people and pushed them toward to sugary foods for feeling positive. However, carbohydrate-rich foods eating habits may contribute to the development of obesity linked to the never-ending inflammation and serious complications of COVID-19 (Muscogiuri *et al.*, 2020).

The closure of restaurants and limited service eating places affected the eating/purchasing habits and resulted in unusual demand shift from foodservice to retail. Reports showed that purchasing food from supermarkets and using food services had the same ratio as 50% before the outbreak, however it is almost 100% for supermarkets. Number of visits to food store was decreased whilst spending money on food was raised in per visit. Consumers experienced reduced availability of certain types of foods during the COVID-19 lockdown.

Concerns about COVID-19 are far-reaching and they cover both health and financial issues. In a study on 18 countries, it has shown that food buying behavior of the consumers have changed because of their willing to consume more healthily foods, but at the same time to achieve this without exceeding normal budget. Consumers adopted a basic approach that returning to natural food and beverage products which contain ingredients that provide nutritional supplements such as fruits and vegetables, legumes, whole grains, or olive oil. At the same time, most consumers are concerned about the effect of COVID-19 on their psychological effects, therefore many consumers are looking for food products to improve this temper (Muscogiuri *et al.*, 2020; Hughes, 2020).

#### **Effects of Pandemic on Global Food Trade:**

Although the current conditions seem exceptional, the weakness of food systems to problems related to climate and diseases has been seen long before the COVID-19 crisis. Food systems have actually been unstable from various events and shocks before such as the oil crisis in the 1970s, the SARS and Ebola outbreaks and the 2007-2008 food crisis. However, pandemic did not severely affect the production because agricultural areas were often in the geographic areas which are far away from urban densities (Agrilinks, 2020; Shahidi, 2020).





The current COVID-19 crisis has changed the food trade policies of some governments, moving towards restricting exports and facilitating imports. The main reason that countries impose export restrictions is to ensure the maintenance of the number of products in the domestic market. Although the export restriction typically produces this result in the short term, it also has some negative effects. First, export restrictions cause domestic prices to drop, which will hurt farmers financially resulting the decrease in crop production and reduced incentives in the industry. Secondly, countries will lose their competitive advantage by losing their place in international markets. Third, export restrictions undermine exporter's reputation and encourage importers to reduce confidence in the world market, thereby reducing trust in international trade and destroying future business opportunities for exporters (Espitia et al., 2020; FAO, 2020).

To summarize, trading provides to move the products from surplus to deficit areas, preventing the shortages and food insecurity related to reliance only on domestic production (Fitton et al., 2019; Baldos and Hertel, 2015). However, COVID-19 pandemic caused significant impact on food trade and lead to disruption in food supply chain due to the export restrictions.

### **Strategies for Food Supply Chain:**

Before the pandemic, one third of all food produced for human consumption was lost or waste across the food supply chain stages including production, postharvest handling, processing, distribution, and consumption. Therefore, food waste has gained more attention than ever before in the era of corona virus. A study performed by Aldaco et al., (2020) indicated that, COVID-19 had a minor impact on the overall food waste and loss generation but resulted in 12% higher creation of food waste on the household level. Valuable bioactive components such as phenols, carotenoids, pectins, flavonoids, essential oils, glucosinolates, isothiocyanates, whey protein isolate, etc. can be derived from food wastes to reutilize them in food chain.

These functional compounds can be used as preservatives, gelling agents, food, or nutritional supplements. Conventional or innovative techniques can be applied in the extraction, fractionation, and isolation stages of bioactive components from food wastes (Galanakis, 2012; Deng et al., 2015; Galanakis, 2013). However, additional collection and processing centers are required to recover food wastes that generated during production, processing, or consumption stages.

The European Food Safety Authority indicated that food is not a source of corona virus and virus cannot be transmitted through the consumption of food. Environmental surfaces such as doorknobs, light switches or foods contaminated with COVID-19 virus, remains a potential risk of becoming infected (EC, 2020). However, latest work performed by Richard et al., (2020) showed that SARS-CoV-2 can be efficiently transmitted via air. Therefore, people should always care about hand washing. In addition, retailers must follow the hygiene requirements with handling food. Food preparation workers must wear mask and gloves and change them frequently when cutting, slicing, or packaging of foods. Consumers are also responsible to prevent contamination by not touching the foods other than what they willing to purchase in the stores (Morawsha and Cao; 2020).

Various robot systems can be used to ensure the food safety in food facilities by preventing the transmission of microorganism by humans. The fourth industrial revolution now plays an important role by making data-driven autonomous decision in production. Automation opens up new opportunity to increase the productivity by 25% and to complete the task such as loading/unloading, placing and

packaging more efficiently than human being. Robots can also help to service the foods to consumers in food serving industry. In addition, Cyber Physical System (CFS) can monitor the unsafe or low-quality products in food supply chain (Bowler et al., 2020; Iqbal et al., 2017).

The COVID-19 outbreak also resulted in difficult requirements for human resource management. These challenges include the change of working conditions, adopting new workplace policies and actions to reduce human contact (Carnevale and Hatak, 2020). Therefore, organizations must respond to the challenge of COVID-19 by some measures. Firstly, COVID-19 symptoms of the workers, visitors, suppliers, and contractors should be monitored prior to entering the facility. The food safety or HACCP teams can perform temperature screening of all staff at the entrance of plant. Monitoring workers to wear face protection equipment's and gloves is important, too. Secondly, facilities should consider reducing working hours and rotating employees. The overall number of workers in each shift should be divided into three or four groups and their break time should be adjusted to avoid overcrowding. Lastly, warehouses and processing facilities should be redesigned to allow employees to implement social distances. Building dividers or barriers which cover the upper part of the body of workers can be used to maintain social distance. Diagonal arrangement should be used if employees use two side engagements in food processing (Shahbaz et al., 2020). Robotic machines also can be used to lower the risk associated with the COVID-19 infected workers during the corona virus outbreak. Furthermore, robots can replace humans in food processing operations to maintain social distancing by reducing the number of food workers. These precautions against the COVID 19 will result a stable international market mechanism. Countries should maintain the balance between the production quantity and safety of workers (FAO, 2020j).

Changes in demand will be another factor that affects the supply chain performance. Therefore, demand should be determined by forecasts and simulations. Especially, the products which are essential for daily life, such as sanitizers and food items gained more demand at the beginning of crisis. However, the perishable nature of food products makes them more prone to impacts of COVID-19 on the supply chain. Therefore, statistical models can be used by manufacturer to propose optimal decision for tackling supply and demand disruptions due to COVID-19 outbreak. As a consequence of this, production, processing, and distribution can be adapted using that result (Paul and Chowdhury, 2020)

#### **Strategies adopted in India to face the extraordinary challenges of COVID-19**

India, having a denser population comparatively, was forced to take immediate actions to curb the spread of the virus. As the majority of the population came under susceptible group authorities feared a bigger problem than the pandemic which was food shortage. The government officials expedited to take flexible measures for protecting the livelihood of many accompanied by the virus.

Kerala, one of the first hit states in India by the COVID-19 outbreak, was successful in setting an example for the rest of the country. Kerala's Chief Minister took immediate actions to reduce the risk of hunger and starvation of the poorest population. The government announced free ration for all for one month, meaning that the government will provide 35 kg rice for below poverty line families<sup>2</sup> which constitutes 11.3 per cent of the total population in the state, and 15 kg of rice for others through the Public Distribution systems (PDS) and Kerala State Civil Supplies Corporation (SUPPLYCO). The government of Kerala has gone an extra mile by initiating the distribution of food kits, irrespective of income status. It is distributed through the ration shops under the Public Distribution System. These food commodities are sourced from the suppliers registered under Kerala State Civil Supplies Corporation and National Agriculture Cooperative Marketing Federation of India.



### Recommendations to Minimize the Effect of Covid-19:

The COVID-19 outbreak seriously threatens food safety, security, and nutrition. The economic disorder due to the pandemic threatens economic entrance and physical availability of food. Disruptions and possible problems in marketing, logistics, and trade systems may restrict access to food in some places and therefore hunger and malnutrition problems may appear (FAO, 2020g). Report from World Food Program showed that the number of people facing extreme hunger can be increase to 265 million in 2020 as a result of COVID-19 (WFP, 2020a).

### Conclusions:

During a pandemic, continuing the flow of the supply in agriculture and food sector, which is one of the most important sectors with health, is vital to prevent the food crisis and reducing the negative impact on the global economy. Although no major problems have been observed in the food supply chains and food industry until now, it remains unclear in the face of an uncertain future. As a result, each country has to realize the strictness of the situation and sometimes should tighten or loosen the measures according to spread ability of the pandemic.

### References:

1. Agrilinks (2020), "Preventing global food security crisis under COVID-19", available at: <https://www.agrilinks.org/post/preventing-global-food-security-crisis-under-covid-19-emergency> (accessed 20 March 2020).
2. Aldaco, R., Hoehn, D., Laso, J., Margallo, M., Ruiz-Salmón, J., Cristobal, J., ... & Fullana- I-Palmer, P. (2020), "Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach", *The Science of the total environment*, 742, 140524, doi: 10.1016/j.scitotenv.2020.140524
3. Artiga, S., Rae, M. (2020), "The COVID-19 Outbreak and Food Production Workers: Who is at Risk?", Kaiser Family Foundation, available at: <https://www.kff.org/coronavirus-covid-19/issue-brief/the-covid-19-outbreak-and-food-production-workers-who-is-at-risk/> (accessed 5 July 2020).
4. Arellano, N. (2020), "Norway denies seafood link to new COVID-19 infections in China", Rastech Magazine, available at: <https://www.rastechmagazine.com/norway-denies-seafood-link-to-new-covid-19-infections-in-china/> (accessed 6 July 2020).
5. Bakalis, S., Valdramidis, V. P., Argyropoulos, D., Ahrne, L., Chen, J., Cullen, P. J., Cummins, E., Datta, A. K., Emmanouilidis, C., Foster, T., Fryer, P. J., Gouseti, O., Hospido, A., Knoerzer, K., LeBail, A., Marangoni, A. G., Rao, P., Schlüter, O. K., Taoukis, P., Xanthakis, E., ... Van Impe, J. (2020), "Perspectives from CO+RE: How COVID-19 changed our food systems and food security paradigms", *Current Research in Food Science*, 3, 166–172, doi: 10.1016/j.crf.2020.05.003
6. Baldos, U. L. C., & Hertel, T. W. (2015), "The role of international trade in managing food security risks from climate change", *Food Security*, 7, 275-290, doi: 10.1007/s12571-015-0435-z
7. BBC (2020a), "Coronavirus: Five ways the outbreak is hitting global food industry", available at: <https://www.bbc.com/news/world-52267943> (accessed 6 July 2020).
8. BBC (2020b), "Coronavirus: Virus outbreaks push Germany to clean up abattoirs", available at: <https://www.bbc.com/news/world-europe-52738356> (accessed 5 July 2020).
9. Bendeković, J., Naletina, D., & Nola, I. (2015), "Food safety and food quality in the supply chain", *Trade Perspectives*, 151, 1-13.
10. Bowler, A. L., Bakalis, S., & Watson, N. J. (2020), "A review of in-line and on-line measurement techniques to monitor industrial mixing processes", *Chemical Engineering Research and Design*, 153, 463-495, doi: 10.1016/j.cherd.2019.10.045.
11. Carnevale, J. B., & Hatak, I. (2020), "Employee adjustment and well-being in the era of COVID-19: Implications for human resource management", *Journal of Business Research*, 116, 183-187, doi: 10.1016/j.jbusres.2020.05.037
12. CDC (2020a), "COVID-19 Critical Infrastructure Sector Response Planning", Centers for Disease Control and Prevention, available at:



- <https://www.cdc.gov/coronavirus/2019ncov/community/organizations/meat-processing-workers-employers.html> (accessed 22 July 2020). poultry-
13. CDC (2020b), "Agriculture Workers & Employers", Centers for Disease Control and Prevention, available at: <https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-agricultural-workers.html> (accessed 5 August 2020).
  14. Cranfield, J. A. L. (2020), "Framing consumer food demand responses in a viral pandemic", unpublished manuscript, Canadian Agricultural Economics Society, pp. 1-6.
  15. Dalton, J. (2020), "Coronavirus: Fears of second wave in China as dozens test positive in outbreak at Beijing food market", Independent, available at: <https://www.independent.co.uk/news/world/asia/coronavirus-beijing-china-outbreak-xinfandi-food-meat-market-a9564816.html> (accessed 5 July 2020).
  16. Deng, Q., Zinoviadou, K. G., Galanakis, C. M., Orlie, V., Grimi, N., Vorobiev, E., ... & Barba, F. J., (2015), "The effects of conventional and non-conventional processing on glucosinolates and its derived forms, isothiocyanates: extraction, degradation, and applications", *Food Engineering Reviews*, 7, 357-381, doi: 10.1007/s12393-014-9104-9.
  17. De Sousa Jabbour, A. B. L., Jabbour, C. J. C., Hingley, M., Vilalta-Perdomo, E. L., Ramsden, G., & Twigg, D. (2020), "Sustainability of supply chains in the wake of the coronavirus (COVID-19/SARS-CoV-2) pandemic: lessons and trends", *Modern Supply Chain Research and Applications*, 1-10, doi: 10.1108/MSRA-05-2020-0011
  18. EC (2020), "COVID-19 and food safety-questions and answers", European Commission, available at: [https://ec.europa.eu/food/sites/food/files/safety/docs/biosafety\\_crisis\\_covid19\\_qandas\\_en.pdf](https://ec.europa.eu/food/sites/food/files/safety/docs/biosafety_crisis_covid19_qandas_en.pdf) (accessed 10 April 2020).
  19. Espitia, A., Rocha, N., & Ruta, M. (2020), "Covid-19 and Food Protectionism: The Impact of the Pandemic and Export Restrictions on World Food Markets", *World Bank Policy Research*, 1-30.
  20. FAO (2011), "Lessons from the world food crisis of 2006–08", Food and Agriculture Organization, available at: <http://www.fao.org/3/i2330e/i2330e04.pdf> (accessed 02 April 2020).
  21. FAO (2020a), "Adjusting business models to sustain agri-food enterprises during COVID-19", Food and Agriculture Organization, available at: <http://www.fao.org/3/ca8996en/CA8996EN.pdf> (accessed 15 May 2020), doi: 10.4060/ca8996en
  22. FAO (2020b), "Ample supplies to help shield food markets from the COVID-19 crisis", Food and Agriculture Organization, available at: <http://www.fao.org/documents/card/en/c/ca8445en> (accessed 10 April 2020), doi: 10.4060/ca8445en
  23. FAO (2020g), "Impacts of coronavirus on food security and nutrition in Asia and the Pacific: building more resilient food systems", Food and Agriculture Organization, available at: <http://www.fao.org/3/ca9473en/CA9473EN.pdf> (accessed 12 June 2020), doi: 10.4060/ca9473en
  24. FAO (2020i), "Legal mechanisms to contribute to safe and secured food supply chains in time of COVID-19", Food and Agriculture Organization, available at: <http://www.fao.org/3/ca9121en/CA9121EN.pdf> (accessed 29 May 2020), doi: 10.4060/ca9121en
  25. FAO (2020j), "Policy responses to keep input markets flowing in times of COVID-19", Food and Agriculture Organization, available at: <http://www.fao.org/3/ca8979en/CA8979EN.pdf> (accessed 8 May 2020), doi: 10.4060/ca8979en
  26. FAO (2020k), "Responding to the impact of the COVID-19 outbreak on food value chains through efficient logistics", Food and Agriculture Organization, available at: <http://www.fao.org/3/ca8466en/CA8466EN.pdf> (accessed 24 April 2020), doi: 10.4060/ca8466en  
FAO (2020l), "Why export restrictions should not be a response to COVID-19: Learning lessons from experience with rice in Asia and the Pacific", Food and Agriculture Organization, available at: <http://www.fao.org/3/ca9362en/CA9362EN.pdf> (accessed 5 June 2020), doi: 10.4060/ca9362en
  27. FAO and WHO (2020), "COVID-19 and Food Safety: Guidance for food businesses: Interim guidance", Food and Agriculture Organization, World Health Organization, available at: <http://www.fao.org/3/ca8660en/CA8660EN.pdf> (accessed 17 April 2020), doi:



10.4060/ca8660en

28. Fitton, N., Alexander, P., Arnell, N., Bajzelj, B., Calvin, K., Doelman, J., ... & Krisztin, T. (2019), "The vulnerabilities of agricultural land and food production to future water scarcity". *Global Environmental Change*, 58, 101944, doi: 10.1016/j.gloenvcha.2019.101944
29. Galanakis, C. M., (2020), "The Food Systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis", *Food*, 9, 1-10, doi: 10.3390/foods9040523.
30. Galanakis, C. M., (2013). "Emerging technologies for the production of nutraceuticals from agricultural by-products: a viewpoint of opportunities and challenges". *Food and Bioprocess Technology*, 91, 575-579, doi: 10.1016/j.fbp.2013.01.004.
31. Galanakis, C. M., (2012), "Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications", *Trends in Food Science & Technology*, 26, 68- 87, doi: 10.1016/j.tifs.2012.03.003.
32. Gulland, A. (2020), "Revealed: why meat processing plants are the ideal incubator of the coronavirus", *The Telegraph*, available at: <https://www.telegraph.co.uk/global-health/science-and-disease/revealed-meat-processing-plants-ideal-incubator-coronavirus/> (accessed 5 July 2020).
33. Hughes, M. (2020), "Evolving eating habits as a result of COVID-19", available at: <https://www.newfoodmagazine.com/article/109890/evolving-eating-habits-as-a-result-of-covid-19/> (accessed 15 May 2020).
34. ILO (2020), "COVID-19 and the impact on agriculture and food security", International Labour Organization, available at: [https://www.ilo.org/wcmsp5/groups/public/---sector/documents/briefingnote/wcms\\_742023.pdf](https://www.ilo.org/wcmsp5/groups/public/---sector/documents/briefingnote/wcms_742023.pdf) (accessed 24 April 2020).
35. Iqbal, J., Khan, Z. H., & Khalid, A. (2017), "Prospects of robotics in food industry", *Food Science and Technology*, 37, 159-165, doi: 10.1590/1678-457X.14616.
36. Liu, K. (2020), "Will COVID-19 lead to a global food crisis?", available at: <https://news.cgtn.com/news/2020-04-07/Will-COVID-19-lead-to-a-global-food-crisis--Pv0dKM776E/index.html> (accessed 17 April 2020).
37. Morawska, L., & Cao, J. (2020), "Airborne transmission of SARS-CoV-2: The world should face the reality", *Environment International*, 105730, doi: 10.1016/j.envint.2020.105730
38. Muscogiuri, G., Barrea, L., Savastano, S., & Colao, A. (2020), "Nutritional recommendations for COVID-19 quarantine", *European Journal of Clinical Nutrition*, 74, 850-851, doi: 10.1038/s41430-020-0635-2.
39. Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., ... & Agha, R. (2020), "The socio-economic implications of the coronavirus pandemic (COVID-19): A review", *International journal of surgery*, 78, 185-193, doi: 10.1016/j.ijssu.2020.04.018
40. OECD (2020a), "Food Supply Chains and COVID-19: Impacts and Policy Lessons", The Organisation for Economic Co-operation and Development, available at: <http://www.oecd.org/coronavirus/policy-responses/food-supply-chains-and-covid-19-impacts-and-policy-lessons-71b57aea/> (accessed 5 August 2020).
41. OECD (2020b), "COVID-19 and international trade: Issues and actions", The Organisation for Economic Co-operation and Development, available at: <http://www.oecd.org/coronavirus/policy-responses/covid-19-and-international-trade-issues-and-actions-494da2fa/> (accessed 24 July 2020).
42. Paul, S.K. and Chowdhury, P. (2020), "A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19", *International Journal of Physical Distribution Logistics Management*, doi: 10.1108/IJPDLM-04-2020-0127
43. Pressman, P., Naidu, A. S., & Clemens, R. (2020), "COVID-19 and food safety: risk management and future considerations", *Nutrition Today*, 55, 125-128, doi: 10.1097/NT.0000000000000415
44. Staniforth, J. (2020), "COVID-19 update: Worker health, absenteeism present large risks to U.S. food supply chain", <https://www.foodqualityandsafety.com/article/covid-19-update-worker-health-and-absenteeism-present-largest-risk-to-u-s-food-supply-chain/>

45. EC (2020), "COVID-19 and food safety-questions and answers", European Commission, [https://ec.europa.eu/food/sites/food/files/safety/docs/biosafety\\_crisis\\_covid19\\_qandas\\_en.pdf](https://ec.europa.eu/food/sites/food/files/safety/docs/biosafety_crisis_covid19_qandas_en.pdf)
46. FAO (2020g), "Impacts of coronavirus on food security and nutrition in Asia and the Pacific: building more resilient food systems", Food and Agriculture Organization <http://www.fao.org/3/ca9473en/CA9473EN.pdf> doi:10.4060/ca9473en
47. FAO (2020i), "Legal mechanisms to contribute to safe and secured food supply chains in time of COVID-19", Food and Agriculture Organization <http://www.fao.org/3/ca9121en/CA9121EN.pdf> doi: 10.4060/ca9121en
48. FAO (2020j), "Policy responses to keep input markets flowing in times of COVID-19", Food and Agriculture Organization <http://www.fao.org/3/ca8979en/CA8979EN.pdf> doi: 10.4060/ca8979en
49. FAO (2020k), "Responding to the impact of the COVID-19 outbreak on food value chains through efficient logistics", Food and Agriculture Organization <http://www.fao.org/3/ca8466en/CA8466EN.pdf> doi: 10.4060/ca8466en
50. FAO (2020l), "Why export restrictions should not be a response to COVID-19: Learning lessons from experience with rice in Asia and the Pacific", Food and Agriculture Organization <http://www.fao.org/3/ca9362en/CA9362EN.pdf> doi: 10.4060/ca9362en
51. FAO and WHO (2020), "COVID-19 and Food Safety: Guidance for food businesses: Interim guidance", Food and Agriculture Organization, World Health Organization, available at: <http://www.fao.org/3/ca8660en/CA8660EN.pdf> doi: 10.4060/ca8660en
52. Richard, M., Kok, A., de Meulder, D., Bestebroer, T. M., Lamers, M. M., Okba, N. M., ... & Fouchier, R.A. (2020), "SARS-CoV-2 is transmitted via contact and via the air between ferrets", *Nat Commun*, 11, 3496. doi: 10.1038/s41467-020-17367-2
53. Richards, T. J., Rickard, B. (2020), "COVID-19 impact on fruit and vegetable markets", *Can J Agr Econ.*, 68, 189–194, doi: 10.1111/cjag.12231
54. Rizou, M., Galanakis, I. M., Aldawoud, T.M.S., Galanakis, C.M. (2020), "Safety of foods, food supply chain and environment within the COVID-19 pandemic", *Trends in Food Science & Technology*, 102, 293- 299, doi: 10.1016/j.tifs.2020.06.008.
55. Rodríguez-Pérez, C., Molina-Montes, E., Verardo, V., Artacho, R., García-Villanova, B., Guerra- Hernández, E. J., & Ruíz-López, M. D. (2020), "Changes in Dietary Behaviours during the COVID-19 Outbreak Confinement in the Spanish COVIDiet Study", *Nutrients*, 12, 1730, doi:10.3390/nu12061730.
56. Sebastian, J. (2020), "Crisis Communication Best Practices for Food Safety Professionals", available at: <https://www.foodqualityandsafety.com/article/crisis-communication-best-practices-for-food-safety-professionals/> (accessed 27 March 2020).
57. Shahidi, F. (2020), "Does COVID-19 Affect Food Safety and Security? ", *Journal of Food Bioactives*, 9, 1-3, doi: 10.31665/JFB.2020.9212
58. Shahbaz M., Bilal M., Akhlaq M., Moiz A., Zubair S., & Iqbal H. M. N. (2020), "Strategic Measures for Food Processing and Manufacturing Facilities to Combat Coronavirus Pandemic (COVID-19) ", *J Pure Appl Microbiol.*, 14, 1087-1094. doi: 10.22207/JPAM.14.2.01
59. Staniforth, J. (2020), "COVID-19 update: Worker health, absenteeism present largest risks to U.S. food supply chain", available at: <https://www.foodqualityandsafety.com/article/covid-19-update-worker-health-and-absenteeism-present-largest-risk-to-u-s-food-supply-chain/> (accessed 20 March 2020).
60. Stewart, A., Kottasova, I. Khaliq, A. (2020), "Why meat processing plants have become Covid-19 hotbeds", available at: <https://edition.cnn.com/2020/06/27/health/meat-processing-plants-coronavirus-intl/index.html> (accessed 3 July 2020).
61. Van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., ... & Lloyd-Smith, J. O. (2020), "Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1", *New England Journal of Medicine*, 382, 1564-1567, doi: 10.1056/NEJMc2004973

62. Vasavada, P. (2020), "COVID-19 and the food industry: What we know", available at: <https://www.foodqualityandsafety.com/article/covid-19-and-the-food-industry-what-we-know> (accessed 27 March 2020).
63. Watts, J. (2020), "World Food Safety Day Is an Opportunity to Thank Those at Every Step along the Food Chain", available at: <https://www.foodqualityandsafety.com/article/guest-column-world-food-safety-day-is-an-opportunity-to-thank-those-at-every-step-along-the-food-chain/> (accessed 12 June 2020).
64. WFP (2020a), "COVID-19 will double number of people facing food crises unless swift action is taken", World Food Programme, available at: <https://www.wfp.org/news/covid-19-will-double-number-people-facing-food-crises-unless-swift-action-taken> (accessed 5 August 2020).
65. WFP (2020b), "COVID-19: Potential impact on the world's poorest people", World Food Programme, available at: <https://www.wfp.org/publications/covid-19-potential-impact-worlds-poorest-people> (accessed 5 August 2020).
66. WHO (2020a), "2019 Novel Corona virus (2019-nCoV): Strategic preparedness and response plan", World Health Organization, available at: [https://www.who.int/docs/default-source/coronavirus/srp-04022020.pdf?sfvrsn=7ff55ec0\\_4&download=true](https://www.who.int/docs/default-source/coronavirus/srp-04022020.pdf?sfvrsn=7ff55ec0_4&download=true) (accessed 13 March 2020).