



Impact of COVID-19 pandemic on vegetable sector and its allies

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The novel coronavirus 2019 (COVID-19), has created an unanticipated pandemic, that has triggered severe panic among individuals worldwide. In this direction, countries are maximizing their efforts to fight the virus and reduce infection. Vegetables due to the presence of several bioactive compounds could help build and maintain immunity against degenerative diseases and COVID-19. Therefore, sustainable vegetable supply is needed continuously. For this to happen placidly vegetable producer and vegetable sector allies must work in close cooperation with each other. This document deals with the impact of COVID-19 pandemic on vegetable sector and its allies.

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Vegetable consumption is crucial for health and well-being. An intake of under 200 g of vegetables per person per day in most places today is recommended by the World Health Organization (WHO)^{1,2}. But it is hard to cope-up with the daily requirement due to several biotic and abiotic factors targeting successful vegetable production. With the global pandemic affecting human lives, the daily vegetable requirement per person per day is challenging to maintain even in the developed world^{3,4}. Although opportunities are available for even the most poor to enhance the access to vegetables⁵. Vegetable consumption is beneficial for human health, and the easy and constant availability vegetables will be a boom for the humans in the pandemic times. However, only vegetables cannot fulfill all the requirements of a balanced diet. So whole grains, millets, dairy products, juices, fruits, eggs, etc. are also equally important and must be added in our daily meals. These product literary declines heart, digestive, and respiratory problems⁶.

Countries have turned down the economy to impede the spread of the coronavirus. In order to stay

away from food shortages, countries must keep food supply chains going⁷. The sources of vegetable produce are operating nicely and restricting trade isn't needed, as it will harm consumers and producers and also generate anxiety in the marketplaces⁸. For ensuring optimum vegetable supply, countries need to strike a balance between the requirements to continue production along with the necessary steps related to the protection of the farmers⁹. Overall, as countries fight the coronavirus pandemic, they should also make every attempt to help keep the gears of the vegetable supply chains moving¹⁰. Fresh vegetable produce is accumulating at farms, and this is causing food loss. Also, the labourers as migrant seasonal employees are not able to go and help at the farms.

The measures are urgently needed as initially; they must provide collection centers nearer to smallholder farmers to decrease the demand for mobility^{11,12} whereas, the extensive collection centers must have a higher capacity to avoid losses of fresh produce. A variety of nations are introducing stimulus packages that lack specific rewards for smallholder farmers¹³. Vegetable growers require cash handouts as well as it will sustain productivity. Banks must wave

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costs on farmers' loans and also extend due payment dates. A proper supply chain to link smallholder farmers to market segments is required¹⁴. Moreover, governments must meet up with the standard power requirements of rural households and smallholder farmers. Countries must set measures available to guarantee the security of farm employees¹⁵. On-site healthcare professionals can make sure employees aren't sick from the COVID-19. If likely, employees must be examined for the coronavirus. At-home coronavirus exams may make this much more manageable. Vegetable shops must reduce the working hours, rotate employees, and double down on the delivery services. Warehouses and processing plants must allow their employees to maintain interpersonal distancing¹⁶. Also, the health experts must take temperatures of staff and ensure they are wearing masks, gloves along with other safety gears¹⁷. Whereas, the importance of logistics parts of the supply chain should be correctly analyzed and further given specific permits to progress commodities^{18,19}.

In a nutshell, the COVID 19 crisis is a chance to determine the bottlenecks and also target them. For vegetables, careful cleaning with water is adequate to eliminate every trace of the COVID. It's ideal for peeling vegetables. Lastly, since the coronavirus is hypersensitive to heat up, the most effective way to cook vegetables: exposure to the high heat of 63°C for 4 minutes will lessen the virus's affects. Research is additionally urgently required to show the wayss to deal with the probable increases in global pandemics like COVID-19²⁰. Ongoing pandemic might lead to even more stressed vegetables and overall less vegetable production. This manuscript details the importance of vegetables, and the effects to different divisions as a result of pandemic COVID-19 difficulties which should remain to be able to attain food and health protection for everyone.

Vegetable consumption and COVID-19 prevention

While the world is still waiting for a coronavirus cure, eating nutritious food, exercising, and controlling anxiety can lead to the enhancement of immunity. As we come to know that old-age people, people with poor diet, smoking and those who are suffering from respiratory diseases, high blood pressure problems and diabetes are more prone to COVID-19. Besides, we have changed our lifestyle entirely for the next year to maintain the immune power. Healthy food is highly recommended and at the proper time. However, there is no specific food or

any supplement which can prevent coronavirus. Still, there are many vegetables and fruits which improve immunity and even promote weight loss²¹. They check the blood sugar level and lower the risk of heart, eye and digestive problems. Vegetables simply mean edible plants or plant parts, whether raw or cooked, cultivated and collected for human consumption for their nutritive value²². These vegetables optimize our health which must be at the forefront. Vitamin A and C are the most important for immune function^{23,24}. Many of these vegetables can be eaten as raw, but it is advised to use them by washing or boiling them at 70°C, only then the Coronavirus infection can be eradicated because coronavirus does not disable in refrigerators even in subzero temperature²⁵. Maintaining optimal health is the best defenses against any pandemic until an appropriate cure is accessible. Many studies showed that a healthy nourished body is less likely to develop physical injury and mental problems²⁶.

Simply, the Mediterranean diet type should be followed, which is primarily based on plant products that can be helpful for cardiovascular disease management up to 30% (ref. 27). Cole crops are a good source of vitamin C and help in fighting oxidative stress. These vegetables also help in infection or chronic inflammation. Onion and garlic are the herbaceous plants and the essential ingredients of Indian food. They both have vegetables flavoring, spice and medicinal properties. They both are used as a raw and cooked form because of their anti-microbial, hepato-protective, anti-thrombotic, anti-hypertensive, hypoglycemic, anti-inflammatory, anti-carcinogenic, anti-diabetic and cardio-protective effects as well as an antioxidant, due to presence of saponins, steroid, and flavonoids²⁸. Similarly, ginger is also a herbaceous plant used for flavoring food and used as medicine. It is usually used in flavoring tea and very useful for throat problems, especially during cold. It is also used for treating respiratory and cardiovascular issues, anti-microbial, anti-ulcerogenic, antiparasitic, food preservative, cancer, bleeding disorders, and most crucially act as immunomodulators because of lots of antioxidants present^{29,30}.

Lettuce, cabbage, spinach, and other green leafy vegetables are highly active against oxidative stress and a rich source of vitamin E and B6 (Pyridoxine). The leafy vegetables are very efficient for the body because they inhibit destabilizing processes, plus they have anti-microbial properties³¹. Red bell pepper, spinach, carrots, and sweet potatoes help in regulating

the immune system by enhancing vitamin A level^{22,30,32,33}. Although all types of vegetables are having some important benefits for the human body this is the list of most used products in our daily life, and the easy availability of these vegetables proved them to be a superfood⁶. However, only vegetables cannot fulfill all the requirements of a balanced diet. So whole grains, millets, dairy products, juices, fruits, eggs, etc. are also equally important and must be added in our daily meals. These products literary decline heart, digestive and respiratory problems.

Vegetable market and COVID-19

In the present scenario, COVID-19 is the most devastating and pandemic for the whole world and the ongoing health crisis due to COVID-19 has affected the world economy and all walks of life³⁴. People living in rural areas depend on agriculture for their livelihood. Agriculture is the base of all the industries and it also has a significant contribution to its allied sector. Government of India now focuses on nutrition security and raising farmers' income. India is the world's largest producer of many fruits and vegetables. The potential negative impacts of coronavirus on agricultural production, market stability, and food supply have been affected, but it is still challenging to predict and quantify the exact damage accurately. The impact of COVID-19 on vegetable markets has restricted the supply chain in India during the end month of March 2020³⁵. Lockdown in the country have led to the closure of hotels. During this period, fresh produce supply from the local vegetable growers remained robust.

Therefore, the onset of the COVID-19 outbreak did not interrupt the demand for vegetables and the supply for fresh vegetables continued from local farmers to the markets. Shifting of vegetable consumption from restaurants to home-based meals has potentially significant implications for food waste. In India, vegetable produce is more during the period between March and May. However, this year, due to the pandemic outbreak vegetable growers are struggling to sell their products as the supply chain has been restricted and fall in prices³⁶. Mobile-based applications are set in motion like National Agriculture Market (e NAM) Platform released by Indian government which seeks to enhance agriculture marketing by decreasing the demand for growers and to use the general market for marketing their harvested produce; is an inviting action to decongest markets³⁷. This can further revive farmer's curiosity in

the *Kharif* season and thus food production won't be influenced. Furthermore, the migration of employees from several components to their native locations has also caused panic buttons, as they're vital for both harvesting activities as well as post-harvest managing of creating in storage space as well as advertising centers.

Vegetable production and COVID-19

COVID-19 an infectious disease caused by SARS-CoV-2³⁸ and declared as pandemic on March 11, 2020, by WHO³⁹. Till now, no vaccine has been made for this disease, the scientists, doctors and leaders of the nations are seeking knowledge and information for the management of this pandemic⁴⁰. Fresh fruits and vegetables are an essential source of many micronutrients, minerals, and vitamins for providing several health benefits for human beings. Regular intake of vegetables maintains good health as dietary fibers in vegetables helps in lowering the blood cholesterol and Vitamin A is good for eyes and skin⁴¹. Vegetable demand is increasing in the market due to increasing population and income from vegetable production. Three to fourteen times more profit was observed in vegetable production as compared to rice production⁴². Due to the short life cycle, and fewer pieces of machinery are required, vegetable production offers a profitable opportunity for the youth for generating income sources⁴³.

But, COVID-19 pandemic directly affects food production and its supply as it breaks the connection between farmers and consumers⁴⁴. Under these situations, farmers are compelled for long time storage of their farm produce. But due to the perishable nature of agriculture commodities such as fruits and vegetables, long time storage reduces the food quality and enhances the production cost⁴⁵. Due to the transport ban and fear of infection, the traders have limited their movement to a rural area for the purchase of vegetable commodities. Due to a lack of purchaser, many farmers left their vegetable produce in the field to rot. The supply of relevant material such as quality seeds, fertilizers, fungicides required for vegetable production is increasing. Similarly, restaurants and hotels are closed due to lockdown, which also affected the demand for fruits and vegetables. Vegetable production is labor-intensive as labor is required from sowing to agronomic practice, irrigation, fertilizer and pesticide spray, harvesting. Likewise, many post-harvest operations such as cleaning, sorting, grading, packing and transport are

dependent on laborers, were significantly affected during this COVID-19 era⁴⁶. Travel ban and gathering of laborers at a particular location directly changed the vegetable production. Urban vegetable production is encouraged to maintain an optimum vegetable supply under COVID-19 crisis (Fig. 1).

Vegetable processing and COVID 19

On-going of this unprecedented pandemic, several developing and developing countries have imposed temporary lockdown. Following social distancing rules to combat this infectious disease processing plants are operating understaffed⁴⁷. In this direction, the vegetable processing plants are being operated under their normal capacity. Although, among the several agricultural commodities, vegetable and horticulture produce are expected to face a more substantial decline in trade prospects and revenues that approximately tolls to a financial loss of 12-20%³⁶. So, it is evident that COVID-19 pandemic is not just a public health issue but a food supply issue as well although it was also determined that the vegetable intake increased during this pandemic. On the other side, the demand for processed food like potatoes increased significantly during the lockdown⁴⁸. Processing and exporting companies rely on contract farming to supply produce – in Kenya, reports suggest that the use of contract farming decreased by nearly 50% in March 2020⁴⁹. Although there is no food shortage, the absence of anyone ingredient or packaging material can create hindrance in proper supply⁵⁰. Sustainable Development Goals

require the optimum utilization of all products by the food systems and integrated activities at every stage of the food chain⁵¹. The recapture of bioactive compounds from food processing by-products and their re-utilization in the food chain can do miracles in food availability^{52,53}.

In a nutshell, the COVID-19 pandemic had significant consequences on food processors. The business has seen a development in retail demand for prepared foods, a decline in foodservice need for prepared foods, a slowdown in foods processing activities due to work and raw content inputs shortages, along with a decrease in export and import activity. The effects of this pandemic might count on the kind of things and also the dimensions of the processors. This might prove to be a crucial time for the entrepreneurs of equally new and refined vegetable firms to keep, attract and grow their customer base⁵⁴. The COVID-19 pandemic has had and will proceed to have consequences on food processors. Moreover, the initiatives, as well as investments processors undertake to handle disruptions.

Vegetable seed industry and COVID-19

Worldwide ongoing lockdown due to the expansion of COVID 19 affected the seed industry and negative impact on supply and demand of seed might lead food security at risk⁵⁵. Most of the countries adopted preventive measures like transit ban, business closure, and home confinement to overcome the epidemic situation. Such a crisis has been affecting the seed supply chain, which majorly impacts on the shortage of seed availability. It is estimated that global trade is declined by 13% to 22% due to COVID 19⁵⁶. This epidemic situation has been creating a challenge for farmers for the upcoming *Kharif* season seed requirement for sowing. India itself needs approximately 250 lakh quintals of seed in *Kharif* season for crop production⁵⁷. International seed trade is a critical aspect to satisfy growing demand for agricultural product across the globe. In 2018, Asia and the Pacific's region exported seed for more than 4.1 billion dollars, accounting for around 14% of the world seed trade. This trade meets the food nutrition security and economic prosperity of the region. To overcome this situation, official authorities have to act quickly and need to establish a digital platform to scale up and provide an online outlet for seed availability. Such platforms can provide a solution to the farmers.



Fig. 1 — Urban production gains for vegetables in response to the COVID-19 pandemic.



Fig. 2 — An organizational strategy against COVID-19 pandemic to maintain an optimum supply of vegetables

Across the globe, different organizations and government agencies are putting efforts into delivering the necessary inputs to the farmers. Like, Asia and Pacific Seed Association⁵⁸ in collaboration with the Department of Agriculture (DA) in Thailand has recently announced that all imported seed trade services will continue to be offered as previously and that shipments of all agriculture inputs, including seed, will not be affected⁵⁹. In the Philippines, "Food Lane" passes have been allocated to the producers, manufacturers, and traders in the food and agriculture sector by the DA to pass quarantine checks. Besides, DA released a Memorandum Circular, pointing out that all agricultural supply stores must be allowed to operate under a skeletal workforce⁵⁹.

Seed Industry Association of Philippine has also given its support by reaffirming to local government units that agricultural supply shops are essential to ensuring adequate food supply and should be allowed to operate, as long as health and sanitation protocols are in place⁶⁰. While in India, seed manufacturing companies requested the government to ensure the transport of seed and agricultural farm inputs without any interruption. The seed industry is trying to ensure adequate production and on-time supply of seed for coming *Kharif* season as *Kharif* crops occupy the larger area (about 14 Mha) than the *Rabi* crops⁶¹. Many reports showing the fear of food shortages were an immediate concern across the globe and people decide to start growing their vegetables. In this concern, the global seed industry needs to build a bigger net for the fulfillment of upcoming growing demand. International Seed Federation has reported

that its representatives intend to work hard to ensure the supplies without any interruption to farmers⁶².

Conclusion and future directions

The impact on vegetable breeding research is huge as breeders, as well as product development staff, will be restricted visiting the trials of theirs in the target areas. Staff can only swap the information by phone, email and web meeting instead. Make the seed business recognized as an essential business in each nation, as well as allow continuous activities under a lengthy (maybe) battle against the pandemic. Although in the developing countries, the vegetable breeders didn't have the complete information about the coronavirus and were against the lockdown. Although, the majority felt the lockdown, with its apparent security measures, was affirmative action. In the new farming scenario, a strategic approach will be needed to make productive processes more environmentally, economically and social sustainability.

The lockdown aided them to strengthen family relations, resulting in a cleaner planet and much better efficiency at office activities that were being performed from home. Furthermore, cooperation and mutual understanding tend to be more required in the market since seed industry environments call for cost and time more than ever. This also affected farm logistics, and frequent delays in transportation are also noticed. This might result in a more significant quality control workload and then delayed shipments of goods (Fig. 2). Stay at home requests can encourage individuals to get into or even to increase home gardening. Though self-reliance is going to

be crucial, local cooperation will additionally be essential in assuring food along with vitamin security. Establishment of green corridors for a smooth and hustle free supply of vegetables and their production inputs are required for a constant supply of vegetables. The utilization of developments in engineering, mechanization, AI, etc. is being contemplated.

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Conflicts of Interest

The authors declare no conflict of interest.

Authors' Contributions

PK conceived and designed the project. PK supervised the study. VS, IS, PK, GS, HK, and AS wrote the manuscript. PK corrected the final draft. All authors read and approved the final manuscript.

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