

India's Post-Harvest Paradox: Exploring Infrastructure Deficits and Opportunities for Food Security

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Abstract

This research delved into India's substantial post-harvest losses, highlighting the consequential effects on the country's food and nutritional security. Despite its position as a leading global agricultural producer, India faces pronounced food wastage, largely attributed to suboptimal post-harvest management and infrastructure. The study's objectives were to quantify these losses, ascertain their repercussions on food security, and evaluate the prevailing state of post-harvest facilities. Leveraging secondary data from governmental agencies, including the Ministry of Agriculture & Farmer's Welfare and the National Centre for Cold Chain Development, the research juxtaposed horticultural data against WHO benchmarks, scrutinized wastage rates of key agricultural products, and gauged the efficacy of the existing cold chain mechanisms. The results revealed a significant increase in agricultural yield, yet a substantial fraction remains unutilized, with perishables like fruits and vegetables bearing the brunt of the wastage. The primary culprits identified were the insufficiency of cold chain amenities and ineffective post-harvest practices. With India's population trajectory on an upward curve, addressing these post-harvest challenges is imperative for fortifying food security. The research accentuates the pressing need for technological advancements, bolstered investments in post-harvest infrastructure, and strategic policy overhauls to curtail these losses and enhance India's food security framework.

Keywords: Post-harvest losses, Nutritional security, Cold chain infrastructure, Food wastage, Agricultural commodities.

Introduction

India, with its diverse agro-climatic conditions, is one of the world's leading producers of a wide variety of agricultural commodities, ranging from staple grains to exotic fruits and vegetables (Government of India, 2020; Saima Khan and Dr Shiv Kumar, 2021; Singh et al., 2013). However, the nation's agricultural sector faces significant challenges, particularly in post-harvest management. The importance of understanding and addressing post-harvest

losses cannot be overstated, especially in a country where millions still grapple with food insecurity and malnutrition (Revenko, 2022). Post-harvest losses refer to decreased edible food mass throughout the supply chain, from harvest to consumption (Debebe, 2022). These losses can be attributed to various factors, including mechanical damage, pests, diseases, and inadequate storage conditions. In India, the losses are exacerbated by the lack of modern infrastructure, outdated agricultural practices, and the vast distances that often separate farms

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from markets (Sagana et al., 2023; Saravanan et al., 2023).

The implications of these losses are manifold. From an economic perspective, they represent a direct loss of income for farmers and other stakeholders in the supply chain. Environmentally, the food wastage also means the wastage of resources such as water, land, and energy that went into producing the lost commodities (Williams, 2019). Moreover, in a country where a significant portion of the population is undernourished, these losses have dire nutritional implications. The inability to efficiently store and transport perishable goods like fruits and vegetables means that large sections of the population do not have access to a balanced diet, leading to widespread micronutrient deficiencies (Bailey et al., 2015). The United Nations' Sustainable Development Goals (SDGs) underscore the importance of reducing food waste and losses¹. Specifically, Goal 12 aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains by 2030². Achieving this target is crucial not only for food security but also for climate change mitigation, as food waste is a significant contributor to greenhouse gas emissions (Ahmad et al., 2023). India's challenges in post-harvest management are common. Many developing countries face similar issues. However, what sets India apart is the scale of the problem, given its vast agricultural output. Addressing this challenge requires a multi-pronged approach that combines technological innovation, infrastructural development, policy interventions, and capacity building at the grassroots level (Khan et al., 2020; Nag, 2022).

The cold chain, which involves the storage and transportation of temperature-

1 <https://www.un.org/en/observances/end-food-waste-day> <https://www.un.org/sustainabledevelopment/hunger/>

2 [https://en.wikipedia.org/wiki/Sustainable_Development_Goal_12#:~:text=The%20full%20title%20of%20Target%2012.3%20is%3A%20%22By%202030%2C,waste\)%20measured%20by%20two%20indicators.](https://en.wikipedia.org/wiki/Sustainable_Development_Goal_12#:~:text=The%20full%20title%20of%20Target%2012.3%20is%3A%20%22By%202030%2C,waste)%20measured%20by%20two%20indicators.)

sensitive products under controlled conditions, is a critical component of post-harvest management. In developed countries, sophisticated cold chain systems ensure that perishable goods are stored and transported in optimal conditions, minimizing losses. In contrast, India's cold chain infrastructure is still in its nascent (Bharti & Goyal, 2017). The lack of cold storage facilities, especially in rural areas, and the need for refrigerated transport options are significant bottlenecks (Nuthalapati et al., 2022). This is further compounded by erratic power supplies, making maintaining consistent storage temperatures challenging. The food processing industry can also play a pivotal role in reducing post-harvest losses. By converting perishable goods into processed products with longer shelf lives, the industry can ensure that a larger portion of the agricultural output reaches the end consumer. However, the food processing sector in India is still underdeveloped, with only a small fraction of the total agricultural produce being processed³. In light of these challenges, this research article delves deep into the current status of post-harvest losses in India, the implications of these losses on nutritional security, and the existing post-harvest management infrastructure. Through a comprehensive analysis of secondary data from various government and non-government sources, the study aims to provide a holistic understanding of the issue and offer actionable insights for policymakers, industry stakeholders, and the agricultural community at large.

Review: Addressing Post-Harvest Losses in India

Magnitude and Implications of Post-Harvest Losses

India, with its vast agricultural landscape, stands as one of the world's largest producers of agricultural commodities. This distinction, however, is shadowed by the significant post-harvest losses that the country grapples with. ³ <https://www.investindia.gov.in/siru/indian-food-processing-sector-untapped-growth-opportunity>

with. Parfitt & Barthel (2010) examines the top issues for reducing food waste globally, especially in the context of food supply chains (FSCs) functioning in the burgeoning BRIC (Brazil, Russia, India, and China) countries. The data presented in the study underscores the severity of these losses, particularly for perishable items such as fruits and vegetables, which can experience losses ranging from 3% to a staggering 15% (CIPHET, 2018–19). At the grassroots level, farmers bear the brunt as their potential income diminishes (Boansi et al., 2021; Gustavsson et al., 2011). This not only affects their economic stability but also has ripple effects on the larger agricultural economy (Boansi et al., 2021; S. Kumar et al., 2018). The losses translate to missed opportunities for trade, both domestic and international, and can hinder the growth potential of the agricultural sector (Vejan et al., 2019). On a broader scale, these post-harvest losses pose challenges to the nation's food security (Pritchard et al., 2013; Sarpal et al., 2022). With a burgeoning population, ensuring that every individual has access to sufficient, safe, and nutritious food is paramount. However, the losses mean that a significant portion of the produce never reaches the consumer, leading to gaps in the supply chain and potential price hikes due to reduced availability (Misra & Choudhry, 2020; Panda et al., 2022).

The environmental implications of these losses are equally concerning. Food production is resource-intensive (Medici et al., 2020; Volanti et al., 2022). It requires water for irrigation, energy for cultivation and harvesting, and land that often undergoes deforestation to make way for agricultural expansion. When a portion of this produce is lost in post-harvest, it means that all the resources expended on growing it have been in vain (Kovalchuk & Mudrak, 2021; Mohamed, 2022). This wastage is particularly poignant in the context of global challenges like water scarcity, energy crises, and environmental degradation (Lu et al., 2022). Gustavsson et al. (2011) highlights that food wastage is not just a loss of food but a loss of

resources, which has broader environmental and economic implications. Furthermore, the financial implications of these losses are staggering. The NITI Aayog's study offers a grim perspective, estimating the annual post-harvest losses to be close to Rs 90,000 crore. This figure is not just a testament to the lost potential income for farmers but also indicates the economic value that the nation loses each year. Addressing these post-harvest losses is not just about improving the income of farmers or the GDP of the nation; it's about creating a sustainable agricultural ecosystem (Qiao et al., 2019; Shahmohamadloo et al., 2021). It's about ensuring that the resources expended in the production process are justified by the end product reaching the consumer. It's about building a resilient food system that can cater to the needs of the present without compromising the ability of future generations to meet their own needs (Tawodzera, 2022). In conclusion, while India's prowess in agricultural production is commendable, the post-harvest losses paint a picture of missed opportunities and challenges. Addressing these losses requires a holistic approach that considers the economic, environmental, and social implications. Only then can India truly harness the potential of its agricultural sector.

Underlying Causes of Post-Harvest Losses

India's post-harvest losses are a result of a complex interplay of various factors, both infrastructural and operational (Debebe, 2022; Dsouza et al., 2023; Gebreegziabher & Van Kooten, 2020). One of the primary contributors to these losses is the fragmented and extended supply chain that spans from the farm gate to the market. This lengthy chain often lacks the necessary infrastructure and efficient practices to ensure the preservation of agricultural produce (Smith & Haddad, 2015). A significant infrastructural gap lies in the cold chain domain. The National Centre for Cold Chain Development (NCCD, 2021) highlights the pressing need for comprehensive cold chain facilities, which include cold storages, refrigerated transport, and integrated

packhouses. These facilities are essential for transporting temperature-sensitive products and maintaining optimal storage conditions for perishable farm products (Aung & Chang, 2014). However, the existing cold chain infrastructure is insufficient to cater to the vast agricultural output of the country (Nordtvedt & Widell, 2020; Nuthalapati et al., 2022). Most cold storages are designed to store single commodities, leading to underutilization during off-seasons. Moreover, the majority of horticultural produce is still transported in non-refrigerated trucks, compromising their quality and shelf life (Sibomana et al., 2016). Operational challenges further compound the problem. Outdated harvesting techniques, rough handling of produce, and the absence of immediate pre-cooling facilities are prevalent issues. These practices not only reduce the quality of the produce but also significantly shorten its shelf life. The lack of training and awareness among farmers about modern post-harvest management techniques exacerbates these operational challenges (Basavaraja et al., 2007). In conclusion, addressing the underlying causes of post-harvest losses in India requires a multi-pronged approach. This approach should encompass infrastructural development, modernization of agricultural practices, and capacity-building among farmers.

Potential Solutions to Address Post-Harvest Losses

Addressing the issue of post-harvest losses in India necessitates a multi-dimensional approach that combines technological, infrastructural, and policy-driven solutions (Agarwal et al., 2021; Cardoen et al., 2015). One of the most promising solutions lies in the development and expansion of cold chain infrastructure (Dong et al., 2022; Samant et al., 2007). As highlighted by the National Centre for Cold Chain Development (NCCD, 2021), a robust cold chain system, encompassing cold storages, refrigerated transport, and integrated packhouses, can significantly reduce perishable produce losses. Investing in this infrastructure

can ensure that temperature-sensitive products are maintained in optimal conditions from the point of origin to consumption (Kumar & Kalita, 2017).

Additionally, promoting food processing can play a pivotal role in mitigating post-harvest losses. As India is the sixth-largest food and grocery market globally (M.Manida, 2022), there's a vast potential for processing agricultural produce into a variety of products for extended preservation. This not reduces wastage and adds value to the produce, benefiting both farmers and consumers (Jha et al., 2006). Training and capacity-building among farmers are also crucial. By equipping farmers with knowledge about modern harvesting techniques, post-harvest handling, and storage practices, the losses at the farm level can be significantly reduced (Basavaraja et al., 2007). Furthermore, initiatives like the establishment of Farmer Producer Organisations (FPOs) can enable small and marginal farmers to collectively invest in post-harvest infrastructure and access larger markets (NABARD, 2018). Lastly, policy interventions can drive change. Drawing inspiration from countries like France and Canada, India could consider enacting legislation that mandates the redistribution of unsold food to charitable institutions or its use as cattle feed or fertilizer, thereby reducing wastage (Engström & Carlsson-Kanyama, 2004). In conclusion, while the challenge of post-harvest losses in India is significant, combining the technological, infrastructural, and policy-driven solutions can pave the way for a more sustainable and efficient agricultural sector.

Objective of the study

To quantify and analyze the extent of post-harvest losses in India, identifying the primary infrastructural and supply chain challenges contributing to these losses.

To evaluate the current cold chain infrastructure and food processing industry in India, proposing actionable solutions and understanding their implications on national food security and economic stability.

Methodology

This research adopts a descriptive approach, primarily relying on secondary data sources to understand the intricacies of post-harvest losses in India. The data for this study was meticulously sourced from several authoritative publications and institutions. Specifically, the Horticulture statistics from the Ministry of Agriculture & Farmer's Welfare provided a foundational dataset. Additional data was extracted from the annual reports of the Ministry of Food Processing Industries (MOFPI), Agricultural and Processed Food Products Export Development Authority (APEDA), Central Institute of Post-Harvest Engineering & Technology (CIPHET), National Centre for Cold chain Development (NCCD), and the Directorate General of Commercial Intelligence and Statistics (DGCI&S), Kolkata. To gauge the implications of food losses on nutritional security, data from the 2018 Horticulture statistics was employed. This data was juxtaposed against the World Health Organization's daily intake recommendations to discern the potential nutritional deficit. The study then delved into the cumulative wastage metrics of key agricultural commodities, presenting them as percentage values to offer a clearer perspective on the scale of post-harvest losses. Leveraging the comprehensive reports from CIPHET, the research further dissected the food losses associated with fruits and vegetables, analyzing the waste across various stages of the supply chain.

A pivotal aspect of the study was identifying the discrepancies in the current

post-harvest infrastructure. To achieve this, a comparative analysis was conducted on the availability of agricultural infrastructure data spanning from 2014 to 2020, as detailed in the NCCD reports. The evolution of food processing from 2014 to 2021 was also scrutinized, utilizing data from the MOFPI's 2021–22 annual reports. Lastly, to understand India's position in the global agricultural market, the research examined the percentage share of food exports from 2017 to 2021, drawing data from the Directorate General of Commercial Intelligence and Statistics (DGCI & S), Kolkata.

Analysis and Discussion

Implications of Post-Harvest Losses on Nutritional Security

Despite India's vast agricultural potential, the consumption of essential nutrients from fruits, vegetables, and other vital food groups remains alarmingly low, leading to health concerns like non-Communicable diseases (NCDs). The World Health Organization (WHO) linked nearly 3.9 million global deaths in 2017 to inadequate fruit and vegetable intake. Recognizing the importance of these food groups, the United Nations (UN) declared 2021 as the International Year of Fruits and Vegetables, aiming to raise awareness about their health benefits. Aligning with the Sustainable Development Goals (SDG), this initiative also addresses challenges faced by small-scale farmers and promotes balanced nutrition. The WHO recommends a daily intake of 400 grams of fruits and vegetables, a target highlighted by the per capita availability data from 2013 to 2017.

Table 1
Percapita Availability of Fruits and Vegetables in Grams

Availability of Fruits and Vegetables	2013–14	2014–15	2015–16	2016–17	2017–18
Production of Fruits (MT)	69.87	74.06	78.50	92.84	94.38
Production of Fruits (MT)	154.42	165.22	176.79	175.00	182.03
Projected population	122.30	123.80	125.40	126.80	128.30
Percapita gross availability of fruits in gms/day	156.51	163.89	171.51	200.6	201.50
Percapita gross availability of vegetables in gms/day	345.92	365.65	386.25	378.13	388.72
Percapita net availability of fruits in gms/day (25% food loss+5% export and processing)	110	115	120	126	141
Percapita net availability of fruits in gms/day (25% loss+5% export and processing)	242	256	270	286	272

Note. Horticultural Statistics at a Glance 2018, Ministry of Agriculture & Farmer’s Welfare.

Table 1 highlighted the disparities in fruit and vegetable production and availability in India from 2013 to 2017. While there was a noticeable increase in the production of these essential food items, a staggering 25% of the produce was wasted. Specifically, the per capita net availability of fruits saw an increase from 110 gms/day in 2013–14 to 141 gms/day in 2017–18. Similarly, the net availability of vegetables rose from 242 gms/day in 2013–14 to 272 gms/day in 2017–18. However, these figures still fall short of the World Health Organization’s recommended daily intake. The data suggests that the primary issue isn’t

necessarily with production but rather with higher-level management and post-harvest processes. Fruits and vegetables, given their perishable nature, are susceptible to spoilage at various stages, from harvesting to distribution. The significant wastage can be attributed to inadequate post-harvest management practices and a glaring lack of cold chain facilities. This inefficiency in the management and distribution systems has led to a situation where, despite increased production, the population is still not receiving the necessary nutritional value from fruits and vegetables.

Post-harvest food losses

Table 2
Percentage of Post-harvest Losses of Major Agricultural Products in India

Commodity	Cumulative Wastage (%)	
	2010	2015
Cereals	3.9–6.0	4.65–5.99
Pulses	4.3–6.1	6.36–8.41
Oil seeds	2.8–10.1	3.08–9.96
Fruits and Vegetables	5.8–18.0	4.58–15.88
Milk	0.8	0.92
Fisheries (In land)	6.9	5.23
Fisheries (Marine)	2.9	10.52
Meat	2.3	2.71
Poultry	3.7	6.74

Note. GOI, ICAR-CIPHET, 2015

India’s fragmented and extended supply chain from the farm gate to the market results in significant post-harvest losses, both quantitatively and qualitatively. These losses diminish farmers’ earnings and the nation’s food accessibility and affordability. Specifically, fruits and vegetables experience losses ranging from three to 15 per cent, leading to a monetary setback of nearly Rs 1 lakh Crores (CIPHET, 2018–19). Table 2, based on reports from the Indian Council of Agricultural Research (ICAR) in collaboration with the Central Institute of Post-harvest

Engineering and Technology (CIPHET), presents the percentage of post-harvest losses for major agricultural products in 2010 and 2015. The data reveals that while cereals have minimal losses, fruits and vegetables suffer the most, with losses ranging from 5.8% to 18.0% in 2010 and 4.58% to 15.88% in 2015. These ICAR-derived loss estimates serve as a pivotal benchmark for assessing post-harvest losses in India. The degree of post-harvest loss is contingent on the specific crops, with perishable items like fruits and vegetables being more susceptible to spoilage.

Table 3
Percentage Share of Harvest and Post-harvest Losses of Fruits

Fruits	Total loss in farm operation	Total loss in storage	Overall total loss
Apple	11.06	1.20	12.26
Banana	4.18	2.42	6.60
Citrus	4.84	1.54	6.38
Grapes	6.57	1.73	8.30
Guava	13.92	4.13	18.05
Mango	10.64	2.11	12.74
Pappaya	5.06	2.28	7.36
Sapota	4.31	1.46	5.77

Note. ICAR CIPHET, 2015

Table 3 underscores the significant post-harvest losses in fruits, particularly during farm operations. Guava experienced the most substantial loss at 18.05%, with 13.92% attributed to farm activities and 4.13% to storage inadequacies. Mangoes and apples followed closely, with respective overall losses of 12.74% and 12.26%. Notably, farm-

level losses for mangoes stood at 10.64%, while storage-related losses were 2.11%. These findings highlight the pressing need to address farm-level inefficiencies. Factors such as suboptimal harvesting techniques, rough handling, delayed harvesting, unsuitable tools, and the lack of immediate pre-cooling facilities contribute significantly to these losses.

Table 4
Percentage Share of Harvest and Post-harvest Losses of Vegetables

Vegetables	Total loss in farm operation	Total loss in storage	Overall total loss
Cabbage	4.6	2.3	6.9
Cauliflower	4.8	2.0	6.8
Green Pea	8.6	1.7	10.3
Mushroom	11.0	1.5	12.5
Onion	5.2	2.3	7.5
Potato	6.7	2.3	9.0
Tomato	9.9	2.5	12.4
Tapioca	7.5	2.3	9.8

Note. ICAR CIPHET, 2015

Table 4 presents the post-harvest losses of various vegetables, emphasizing the disparities between farm-level operations and storage-related losses. Mushrooms exhibited the highest overall loss at 12.5%, with farm operations accounting for 11% and storage losses at 1.5%. Tomatoes followed closely with a total loss of 12.4%, of which 9.9% was attributed to farm activities and 2.5% to storage challenges. Green peas also showed significant losses, with an overall percentage of 10.3%. It's evident from the data that farm-level operations, which encompass activities such as harvesting, collection, cleaning, drying, packaging, and transporting, are the primary contributors to post-harvest losses. This highlights the need for improved handling and management practices during these stages to mitigate wastage.

Post-harvest loss management infrastructure

The study underscores the pressing need for robust post-harvest loss management

infrastructure in India, with a particular emphasis on cold chain facilities. Cold chain infrastructure, encompassing cold storages, refrigerated transport, and integrated packhouses, plays a pivotal role in preserving perishable farm products like fruits and vegetables from their origin to consumption. Despite the anticipated growth of the cold chain sector by 19% from 2017–22 (NCCD, 2021), challenges persist. A majority of India's cold storages cater to single commodities, resulting in underutilization during off-seasons. Furthermore, the distribution of these facilities is skewed, with about 60% concentrated in West Bengal, Uttar Pradesh, and Bihar. The reliance on grid electricity, often inconsistent, further hampers their efficiency. The study by NCCD-NABCONS, titled 'The All-India Cold Chain Infrastructure Capacity' (AICIC-2015), further delineates these gaps, as illustrated in Table 5.

Table 5
Cold-chain Infrastructure in India during 2014

Infrastructure component	Existing Capacity (2014)	Approximate Requirement	% share of gap
Integrated Pack house (Nos.)	250	70000	99.6
Reefer transport (Nos.)	10000	62000	85
Coldstorage(bulk)(Million Tonne)	32	35	10
Ripening chambers	800	9000	91

Note. All India cold-chain infrastructure capacityReport- NCCD(2015)

Table 5, sourced from the “All India cold-chain infrastructure capacity Report” by NCCD (2015), highlights the significant disparities between the existing cold chain infrastructure in India in 2014 and the actual requirements. The most glaring deficiency is observed in integrated pack houses, where a staggering 99.6% gap exists, indicating that out of the required 70,000, only 250 were in place. Similarly, while 62,000 reefer transports were needed, only 10,000 were operational, marking an 85% shortfall. The

cold storage capacity was closer to meeting its target, with a 10% gap between the existing 32 million tonnes and the required 35 million tonnes. Ripening chambers, essential for fruit maturation, also faced a significant deficit, with only 800 available against a requirement of 9,000, translating to a 91% gap. This data underscores the pressing need for substantial investments and interventions in India’s cold chain infrastructure to bridge these gaps.

Table 6 shows the percentage share of gap in cold chain infrastructure during 2020–21.

Table 6
Cold-chain Infrastructure in India during 2020

Infrastructure component	Existing Capacity (2020)	Approximate Requirement	% share of gap
Integrated Pack house (Nos.)	207*(APEDA Registered)	82,372	99.7
Reefer transport (Nos.)	12,700*	72670	82.5
Cold storage(bulk) (Million Tonne)	37	41	10

Note. All India cold-chain infrastructure capacity (2015)-NCCD and Ministry of Agriculture and Farmers welfare.

Table 6, derived from the “All India cold-chain infrastructure capacity” report by NCCD and the Ministry of Agriculture and Farmers Welfare (2015), underscores the persistent gaps in India’s cold chain infrastructure as of 2020. Despite the evident growth in certain areas, significant deficiencies remain. The most pronounced gap is in the integrated pack houses, with a staggering 99.7% shortfall. While there has been a slight increase in reefer transport and cold storage capacities since 2014, the existing infrastructure still

falls short of the requirements by 82.5% and 10%, respectively. The report further highlights that a vast majority (97.4%) of India’s horticultural produce is transported via roadways, with a mere 2.6% utilizing the rail network. Alarming, most of this produce is transported in non-refrigerated trucks, compromising its quality and suitability for consumption or further processing. This infrastructure inadequacy is exacerbated by challenges like inconsistent power supply in rural areas, escalating electricity costs, reliance

on traditional fuels, and rising land prices for cold storage construction. These factors collectively contribute to the significant post-harvest losses in India, emphasizing the urgent need for infrastructural improvements and strategic interventions to address these gaps.

Food processing and post-harvest loss management

India ranks as the world’s sixth-largest food and grocery market, with its food processing industry accounting for 7.9% of the manufacturing Gross Value Added (GVA) and 9.5% in agricultural value addition. The rise in processed food consumption can be attributed to factors like urbanization, demographic shifts, increased incomes, better transportation,

and a growing women workforce. Notably, global retail sales of processed foods surpassed fresh food sales threefold in 2002. Despite its potential, India’s food processing sector faces challenges. For instance, a significant portion of perishable farm produce is lost annually due to inefficient post-harvest management. KPMG’s 2007 report highlighted that India’s share in processing perishables remains low, with only 2.2% for fruits and vegetables. However, enhancing food processing methods can curtail these losses. Studies by the Ministry of Food Processing Industries, conducted by the Institute of Economic Growth in 2014 and Deloitte in 2020–21, further explored these trends in the country’s food processing landscape.

Table 7
Comparative level of Food Processing India over the Years

Commodity	IEG study 2014		Deloitte study 2020–21	
	2005–06	2010–11	2015–16	2018–19
Coarse cereals	17.7	23.3	28.6	29.4
Fruits	1.75	2.4	2.9	4.5
Vegetables	3.69	2.27	2.22	2.70
Milk	11.4	5.7	20.1	21.1
Meat	6.12	11.4	22.7	34.2
Fish	14.08	7.66	8.3	15.4

Note. MOFPI annual Reports 2021–22.

Table 8
Export of Food Commodities

Export	2017–18	2018–19	2018–19	2019–20	2020–21 (Apr-Oct)
Food Exports	35467.9	35302.5	32732.0	38314.3	24901.7
Processed Food Exports	5273.9	6389.2	6264.0	8543.1	5183.4
% share of processed food in food exports	14.9%	18.1%	19.1%	22.3%	20.8%
India’s Total Exports	303526.2	330078.1	313361.0	291163.5	233912.6
% share of food exports in overall exports	11.7%	10.7%	10.4%	13.2%	10.6%

Note. DGCIS, Kolkata

Table 7, sourced from MOFPI annual reports (2021–22), and Table 8, based on data from DGCIS, Kolkata, provide insights into the evolution of food processing and exports

in India. Over the years, there has been a noticeable increase in the processing of certain commodities. For instance, fruit processing rose from 1.75% in 2005–06 to 4.5% in 2018–19.

However, the processing of fruits and vegetables remains relatively low compared to other agricultural products. On the export front, while the percentage share of food exports in total exports saw a decline from 11.7% in 2017–18 to 10.6% in 2020–21, the share of processed food in total food exports exhibited growth, reaching 22.3% in 2019–20 before slightly receding to 20.8% in 2020–21. Despite India's vast agricultural production capabilities, the nation's export of processed food remains modest in globally. A significant factor hindering potential growth is the lack of adequate cold chain infrastructure, leading to substantial post-harvest losses, estimated at around Rs 90,000 crore annually by NITI Aayog. This infrastructure deficit underscores the need for strategic interventions to bolster India's position in the global food processing and export market.

Conclusion

India's population is projected to reach 1.64 billion by 2050, demanding an increase in food supplies by 60% (Myers et al., 2017). While increasing food production is one solution, reducing post-harvest losses is equally crucial. The study embarked on a comprehensive exploration of India's post-harvest losses, its implications on nutritional security, and the current state of the nation's cold chain and food processing infrastructure. The findings, derived from a meticulous analysis of data and juxtaposition of various reports, offer profound insights that align with the study's objectives. Firstly, the research underscored the criticality of addressing post-harvest losses, especially in a country like India, where a significant portion of the population grapples with malnutrition and food insecurity. The data revealed that while there has been a consistent increase in the production of fruits and vegetables over the years, a substantial percentage still succumbs to waste. This wastage not only translates to economic losses but also exacerbates the challenge of ensuring adequate nutritional intake for the populace. The WHO recommends consuming

400 grams of fruits and vegetables daily as a benchmark, but study's findings show that per capita availability still needs to be higher. This shortfall isn't merely a production issue; it's exacerbated by post-harvest losses stemming from inadequate infrastructure, poor management, and lack of cold chain facilities.

The study's deep dive into cold chain infrastructure painted a picture of a sector with immense potential yet riddled with challenging. The demand for cold chain facilities, encompassing cold storage refrigerated transport, and integrated packhouses, is burgeoning. However, the existing capacity, as highlighted by the data, lags behind the actual requirement. The disparity is particularly stark in the availability of integrated packhouses and reefer transport. The lack of a robust cold chain infrastructure not only leads to post-harvest losses but also impedes the nation's ability to tap into its vast agricultural export potential. Furthermore, the research illuminated the state of the food processing industry in India. As the sixth-largest food and grocery market globally, India's food processing sector holds the promise of addressing hunger, ensuring food accessibility, and bolstering the nation's food security. However, the consumption of processed food, despite its upward trajectory, is hampered by the low processing levels of perishables, especially fruits and vegetables. The comparative analysis of studies conducted over different periods provided a clear perspective on the evolution of food processing in India. While there have been strides in certain areas, the overall landscape underscores the need for more concerted efforts. In light of the findings, it's evident that addressing post-harvest losses is not just about enhancing production but requires a holistic approach. This approach should strengthen the cold chain infrastructure, promote efficient post-harvest management practices, and bolster the food processing sector. The study's data serves as a clarion call for policymakers, industry stakeholders, and the agricultural community to collaborate and innovate. By doing so, India can not only curtail post-harvest losses but

also ensure that its populace has consistent access to nutritious food, thereby advancing the nation's journey towards achieving food security and nutritional well-being.

In conclusion, the study offers a comprehensive perspective on the multifaceted challenge of post-harvest losses in India. The findings underscore the urgency of the situation and chart a path forward, emphasizing the need for infrastructural development, policy interventions, and industry collaboration. As India continues its journey towards becoming a global agricultural powerhouse, addressing post-harvest losses will be pivotal in ensuring that the fruits of this growth are equitably shared and savoured by all.

Implication of the Study

The research underscores the urgent need to holistically address India's post-harvest losses, emphasizing the intertwined nature of economic, environmental, and food security concerns. Key implications include the paramount importance of enhancing cold chain infrastructure through partnerships and technological innovations, tapping into the untapped potential of the food processing industry, and empowering farmers with modern knowledge and techniques. The role of Farmer Producer Organisations (FPOs) is highlighted as crucial in pooling resources and ensuring better market prices, while the adoption of robust policies, inspired by global best practices, can pave the way for a sustainable agricultural ecosystem. In essence, the study advocates for a multi-faceted approach, integrating various agricultural value chain components, to sculpt a prosperous agricultural future for India.

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