

POST HARVEST ADVANCEMENT OF FRUIT SUPPLY CHAIN: A METHOD OF DEVELOPING MARKETING EFFICIENCY IN CENTRAL HIMALAYAN VILLAGES OF UTTARAKHAND, INDIA

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Abstract

As a State, Uttarakhand is favored with multitude agro-climatic conditions. Uttarakhand contributes 23 per cent to the state's domestic product. Because of the mountainous topography the state faces challenges in terms of logistics facilities, cold chain network and post-harvest management. The purpose of the study is to investigate the current scenario of cold chain logistics, post-harvest management and issues related to it in Uttarakhand. Improvement in the shelf life of perishables like fruits and vegetables can be made with the help of robust and efficient cold chain infrastructure. Thereby, adopting advance methods and strategies related to supply chain and post-harvest management, there are probabilities to elevate economic status of growers, more business opportunities and reduction in the percentage loss of perishables.

Keywords: Fruits Supply Chain, Cold chain, logistics, Post-harvest technology & management, Uttarakhand

1. Introduction

India is named as a fruit basket of the world. After China, India ranks second in the production of fruits (Arivazhagan *et al.*, 2012). Large variety of fruits is widely grown in India. Apple, Mango, Banana, Litchi, Guava, Papaya, Citrus and Pine Apple are some of them. The Indian fruit industry has been considered as one of the driving forces in stimulating the progress of Indian agriculture. Also, the end consumers of India are growing at a rapid rate and are inclined more towards the availability of fresh, toothsome, nourishing and healthy food (Parwez, 2014). ASSOCHAM states that in the upcoming years this sector is going to witness growth because of the rise in percentage of high value goods in the total value of agricultural output (Negi and Anand, 2015). In the year 2016-2017, the horticultural

produce reached 300.64 million tons with exports worth USD 1.6 billion (Horticultural Statistics at a Glance, 2018).

Over the past forty years, activities related to agriculture remain the mainstay of India which is why the nation is stated as an agrarian economy. Its contribution is about 14.5 percent of the GDP. Extensive surveys have stated that agriculture is one of the major sources of income for almost 2/3rd of the Indian population. India tops the chart in the production of fruits & vegetables because of broad range of agro-climatic conditions. At the same time, the market availability of fruits in India is lagging behind due to severe lack of robust supply chain facility mechanism and infrastructure to supply the same from farm to fork. Also, the agricultural supply chain of fruits is highly dominated by small holders (Sikka and Singh, 2009). There are other issues like shortage of cold chain, chain fragmentation, handling at different levels, high transportation cost, and lack of information to farmers as well responsible for the unavailability of fruits in the market. With the help of technical improvement, especially by adaptation of innovative channels for farms, farmers can increase their yield. Due to inefficient arrangement of market, there is a huge gap between the prices received by the farmers and the price paid by the end consumers. During transportation of fruits in India, there is wastage of 20-30 per cent. It has been noted that except Reliance retail, no other retailers are using cold chain facility even after knowing the fact that it helps in minimizing the spoilage of fresh produce like fruits. Also, 54 per cent of the retailers are not following any precautionary techniques in order to decrease the percentage of fruits. Only the organized retailers are able to forecast the demand without any calculation which is why they are able to lessen the intensity of losses.

Table1: Ranking and Share of India in the production of fruits across the world

Name of the fruit	India Ranks
Banana	1st
Mango	1st
Lemon	2nd
Orange	4th
Papaya	5th
Pineapple	5th
Citrus Fruits	8th

Apple	10th
Grapes	16th
<i>Source: Annual reports of Horticulture department Govt. of India</i>	

Present Scenario of fruit supply chain network in Uttarakhand

Uttarakhand is situated in northern Himalayan region of India, Geographically it falls between 77°34' and 81°02' E longitude and between 28°43' to 31°27' N latitude, covering an area of 53,119 km sq. (Fig.1). 'Garhwal' and 'Kumaun' are the two divisions of Uttarakhand. Together they comprise of 13 districts (Figure 1).



Uttarakhand state of India is considered to be a land of opportunities because of its strategic location at the foothills of Himalayas. In Tarai region & Himalayan range, various temperate fruits like apple, pears, orange, peaches, plums, litchis are widely grown. Uttarakhand as a state is endowed with varied climatic zones making it amenable to enormous opportunities in agriculture and horticulture (Farooquee and Maikhuri). Agro related activities not only

provide bread and butter to large sections of the Himalayan population, but also form constitutional part of their way of living. Environmental, biological, socio-cultural and economic factors are some of the main factors prevailing in the Indian Central Himalayan. Uttarakhand region has resulted into the evolution of diverse agro ecosystems.

The soil conditions in hilly areas are so good to grow sub-tropical and temperate fruits and vegetables. In the state, more than 70 per cent of the people are dependent on agriculture in order to earn their bread and butter. The contribution of agriculture to the state's domestic product is around 22.4 per cent. The hilly topography and plain topography of the state present different scenarios for agriculture. Commercial agriculture is practiced in plains whereas subsistence farming takes place in hills. Uttarkashi is the district where the area under fruit cultivation is high. Subsidy of around 75 per cent on area expansion under fruit crops is given by the Government of Uttarakhand. There has been a gradual modification from conventional crop production to high value crops production because of the proactive approach adopted by the farmers and incentives provided by the Government of Uttarakhand (Food Processing Sector Profile, State Horticulture Mission, 2019).

Apricot, Kaafal, Litchi, Maalta, Plum and Peach are the other major fruits grown in Uttarakhand. Pinder valley in Chamoli district aims to produce fruits and vegetables by the utilization of poly houses. (Bangla and Road) (Bangla & Road). Uttarakhand tops the list in India in the production of Pear (0.788 lakh MT), Peach (0.579), Plum (0.362 lakh MT) and Apricot (0.282 lakh MT). Uttarakhand ranks second in the country in production of Walnut (0.19 lakh MT), Uttarakhand rank third in the country in production of Apple (0.62 lakh MT) followed by J&K (13.68 lakh MT) and HP (6.25 lakh MT). Also, the state is known for its sound infrastructure including 2 Mega Food Parks (Patanjali Mega Food Park and Himalayan Mega Food Park) and 7 industrial parks and growth centres. Food processing clusters or fruits and vegetables are present in Haridwar, Dehradun, Tehri Garhwal, Udham Singh Nagar and Nainital (Department o Horticulture, Uttarakhand, 2019)

Table 2: Production of Fruits (metric tons) in Uttarakhand (District wise) in the year 2018-2019

NAME OF THE DISTRICT	AREA (IN HECTARES)	YIELD IN METRIC TONNES
Nainital	10993.67	109389.31
Udhamsingh Nagar	7894.00	53463.00
Almora	24293.00	176799.00
Bageshwar	3671.00	12722.89
Pithoragarh	16566.50	49553.97
Champawat	8262.00	13670.00
Dehradun	27286.00	42519.00
Pauri	21468.00	35177.99
Tehri	20996.05	28698.41
Chamoli	4172.99	12827.96
Rudraprayag	3224.38	2483.16
Uttarkashi	15648.55	27397.29
Haridwar	15991.10	100250.00
Total	1,80,468.79	6,64,655.41
<i>Source: http://shm.uk.gov.in/pages/display/6-state-profile</i>		

Table 3: Production of major fruits (metric tons) in Uttarakhand in the year 2018-2019

Fruits	Area in hectares	Production in MT
Mango	36774.88	154031.88
Citrus	21607.36	90922.92
Pear	13193.13	77254.13
Apple	25675.87	57753.49
Peach	7855.77	57933.81
Plum	8990.65	36196.69
Apricot	7954.21	28197.76
Litchi	10610.48	24260.73

Walnut	17623.01	20054.25
Guava	3977.76	20099.49
Aonla	1395.66	2433.65
Others	24361.14	95132.93
Total	180468.79	665465.41
<i>Source:</i> http://shm.uk.gov.in/pages/display/6-stat		

Dehradun ranks the highest in terms of area with 26408 hectares in Uttarakhand whereas Rudraprayag ranks the lowest in terms of area with 3110.25 hectares in Uttarakhand. Almora ranks the highest with production of 175647.00 metric tons of fruits in Uttarakhand despite being the second highest in terms of area whereas Rudraprayag ranks the lowest with production of 2366.90 metric tons of fruits in Uttarakhand. Mango ranks the highest in Uttarakhand in terms of area of 35911.50 hectares and production of 149727.23 metric tons whereas Aonla ranks the lowest in terms of area of 814.10 hectares and production of 2369.07 metric tons. The data described here has been mentioned in the respective tables given below.

2. Methods

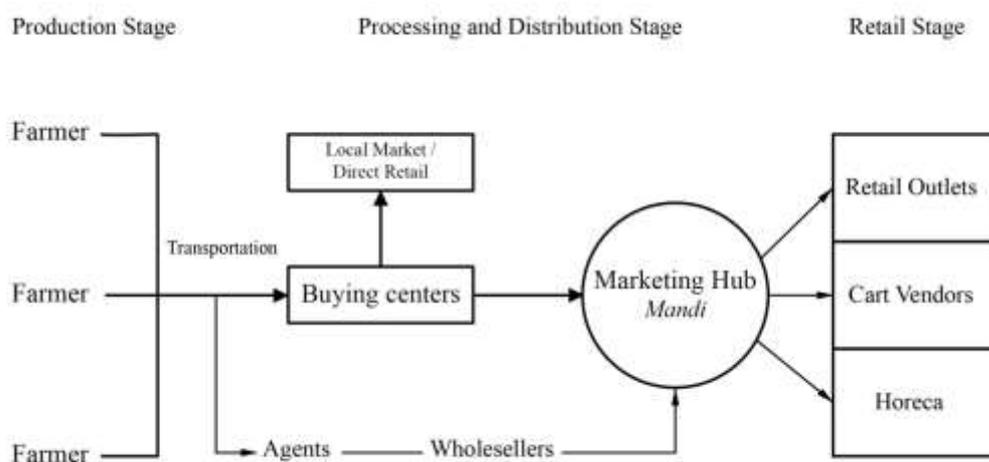
This study is exploratory in nature, primary data were collected by the help of direct and telephonic interviews with farmers, agents, transporters, officials of *mandis*, at different level of fruit supply chain. We obtain qualitative data from personal interviews of farmers, intermediaries and experts. A detailed study of production of major fruits and their post harvest losses and information about cold chain infrastructure of Uttarakhand has been conducted with the help of secondary data gathered from annual reports department of horticulture, Uttarakhand. The authors have examined the challenges and opportunities associated with the supply chain of fruits in the hilly region of India i.e. Uttarakhand. Also, the authors have attempted to determine the mitigation strategies to overcome the challenges associated with the supply chain. The current study undertakes a thorough review of literature both contemporary & basic research.

3. Purpose of the study

The main purpose of the research paper is to highlight the status of agricultural supply chain of fruits and cold chain logistics of fruits in Uttarakhand. In this study, the researchers intend to address the factors responsible for post-harvest losses during the process of storage and transportation. The study will be able to help the supply chain managers to reduce post-harvest losses with the help of some mitigation strategies. Also, the farmers will be able to enjoy remunerative prices for their fresh produce with the elimination of middlemen in the model of traditional supply chain. This study will provide direction to policy makers to facilitate the development of effective and efficient fruit supply chain management system, contributing to poverty elevation and fostering economic growth of hilly region of Uttarakhand. Identifying the challenges& risks associated with the supply chain of fruits in the hilly region of Uttarakhand and highlighting the research gaps in agricultural supply chain and cold chain logistics of fruits for further scope of work are the principal objectives of this research paper.

4. Traditional post harvest supply chain of fruits in Uttarakhand

Traditional agricultural supply chain is a complex entity with existence of various stake holders. These stakeholders are growers (farmers), processors, traders, wholesalers, retailers and end consumers. Especially in case of fruits and vegetable, wholesalers, traders and retailers obtain their supply from diverse sources in order to meet their production and marketing targets.



The current traditional supply chain of fruits in Uttarakhand has a lot of intermediaries involved. Basically, the farmers (growers) grow the fresh produce (fruits), sell to the intermediaries who further sell the fruits to traders or commissioned agents most of these are local traders. They look for big buyers/traders who purchase the fresh produce in bulk. The big traders collect the quantities from various sources and sell it further to the wholesalers. The major problem with this kind of a traditional supply chain is that there is a presence of various middlemen and intermediaries throughout the supply chain which make the transaction cost too high. In Uttarakhand, the current supply chain of fruits consists of various middlemen & commissioned agents who eat up the major chunk of profit (approx. 75 per cent) of small landholding farmers. These agents and intermediaries collect the commodity (fresh produce) from the small landholding farmers and sell to big traders who further transport the produce to the *mandi* (Government regulated market hub) after value addition. Then, the wholesalers buy the commodity (fresh produce) from *mandi* through auction and further sell it to the retailers. The whole process results into less price realization by the farmers who are the actual and ultimate source of the fresh produce i.e. fruits.

This type of supply chain leads to poor price realization to the actual growers (farmers). They only get the 35-40 per cent of the end price and the other part is enjoyed by the intermediaries and middlemen (Choudhary, 2016).

In fig. 2 there are three stages in the fruit supply chain from farmer to consumer production stage, processing and retail stage. Fruits are difficult to handle at all the stages starting from the point of origin to the point of end consumption. It requires special storage facility and handling techniques (Marriott and Proctor, 1976). There are various issues & challenges which act as hurdles in the smooth functioning of the supply chain of fruits in Uttarakhand. They are cold chain infrastructure issues, integration and linkage problems throughout the supply chain, processing and value addition issues, post-harvest management issues, technological issues and storage & packing issues. These issues are required to be addressed as soon as possible. Fruits like peach, plum, and kaafal are one of the widely grown fruits in Uttarakhand. The supply chain of fruits is highly laden with challenges in terms of infrastructure inefficiencies, presence of middle men and intermediaries further resulting into post-harvest losses, poor price realization of farmers and hefty amount paid by the end consumers.

Artificial price rise in the produce, presence of asymmetric information, limited reach to *mandis* due to weak management of the supply chain, lack of grading and standardization, spoilage and damage of fruit due to frequent handling of the fresh produce at different levels in the whole supply chain, high cost of transportation and reduction in farmer's profit share and insufficient credit facilities available with farmers are some of the disadvantages of traditional supply chain of fruits.

Fruits	Harvesting	Collection	Sorting/ Grading	Packaging	Transportation	Total Loss in farm	Farm level Storage	Cold Storage	Wholesale Storage	Retailer	Processing	Total Storage loss	Overall Total Loss
Apple	4.56± 1.41	0.42± 1.03	4.79± 1.51	0.10± 0.08	1.19 ± 0.22	11.06± 1.08	2.26± 0.99 (0.04±0.02)	1.47±1.2 1(0.12±0 .10)	0.99±0.6 3(0.52±0 .32)	1.10±0. 49(0.23 ±0.10)	1.70±4.24(0.29±0.73)	1.20±0.8 1	12.26 ±1.05
Banana	1.33±8.5 9	0.36± 0.54	0.93± 0.35	0.44± 0.46	1.14 ± 1.29	4.18± 5.08	1.60± 1.02(0.04± 0.03)	3.34±0.1 1(0.016± 0.01)	2.39±1.0 6(1.85±0 .82)	2.44±1. 51(0.36 ±0.23)	0.26±0.16(0.01±0.00)	2.24±0.8 5	6.60± 3.43
Citrus	0.92±1.3 9	0.48± 1.01	1.79± 1.16	0.35± 0.94	1.30 ± 1.67	4.84± 1.30	1.94±2.96 (0.03±0.07)	NIL	1.28±0.6 4(0.69±0 .35)	2.29±0. 79(0.77 ±0.27)	0.21±0.26(0.01±0.02)	1.54±0.4 5	6.38± 1.15
Grapes	0.94±1.9 4	0.24± 1.10	3.21± 1.26	0.26± 0.98	1.93 ± 1.13	6.57± 1.39	5.54±0.56 (0.02±0.00)	NIL	1.61±0.8 4(0.54±0 .28)	2.17±0. 74(0.84 ±0.29)	2.69±1.03(0.30±0.12)	1.73±0.4 2	8.30± 1.00
Guava	4.36±1.5 3	1.20± 1.05	4.64± 1.18	0.94± 0.69	2.77 ± 0.73	13.92± 1.17	2.10±1.27 (0.41±0.26)	NIL	5.91±1.0 9(1.83±0 .34)	3.79±1. 57(1.80 ±0.75)	5.71±0.66(0.06±0.01)	4.13±0.8 6	18.05 ±1.12
Mango	4.11±2.3 7	0.68± 0.71	2.80± 1.54	0.51± 0.54	2.53 ± 2.49	10.64± 1.89	1.50±0.59 (0.06±0.03)	NIL	2.50±1.1 4(0.92±0 .42)	2.67±1. 70(0.93 ±0.59)	0.87±0.39(0.19±0.09)	2.1±0.73	12.74 ±1.57

Table: 5 Post Harvest Losses of Major Fruits in Uttarakhand for the Year 2018

Source :(Goleman et al. 2019)

Figures in parentheses show contribution of storage % in relation to total production.* Sum of the loss as % of the total produce from all storage channels (i.e. sum of the figures in parentheses).

Guava ranks the highest in terms of overall post harvest losses with total percentage of 18.05 ± 1.12 whereas banana ranks the lowest in terms of overall post harvest losses with total percentage of 6.60 ± 3 .

5. Cold chain logistics infrastructure: As one of the facilitators in the supply chain of fruits in Uttarakhand

Cold chain facility is a temperature controlled facility network along with other operations like storage & distribution carried out to maintain the quality of fresh produce like fruits for a longer time span (White *et al.*, 2013). It acts as an enabler by preserving the quality of the fresh produce, improving the product life cycle of the produce, by connecting the agriculture and industry and energizing the supply chain. When we club logistics facility with temperature controlled facility, it becomes cold chain logistics.

Surface storage and refrigerated transportation are the major elements of a mere cold chain facility. Surface storage involves refrigerated warehouse for storage of the fresh produce whereas refrigerated transportation involves reefer trucks, ships, containers, trains specially designed for perishable products. Modern pack-house, long haul transport, cold storage hubs, cold storage bulk, ripening chamber, last mile transport, retail front end and food processing units are the other important components of cold storage infrastructure. Static as well as mobile cold chain infrastructure is required to be developed for the development of the cold chain segment. The first cold chain setup in India can be traced back to cold storage facilities in the 1892 in Kolkata. Fruits have a shorter product life cycle therefore a robust cold chain facility has been considered as the best possible way to maintain the quality of the fruits which are prone to mechanical damage, ageing and decay (Gundewadi *et al.*, 2013). The controlled climate environment enhances the shelf life of the fruits by reducing the metabolism rate of harvested fruits and other horticulture produce (Chain, 2018). A strong cold Chain infrastructure is considered to be one of the key components for the economic growth and progress of developing nations like India (Sharma, Kumar and Anand, 2016). According to National Centre for Cold Chain Development, in cold chain segment, there is a lack of appropriate work force having proper operational and management skill sets to handle cold chain infrastructure (Kohli, 2012).

6. Cold Chain Facility: As an obstacle in the agricultural supply chain of fruits

According to PHD Chamber of Commerce and Industry, approximately 35-40 per cent of fruits & vegetables get damaged and wasted annually due to lack of efficient cold chain facility in Uttarakhand. Earlier, efforts pertaining to cold chain storage facility development emphasized on building the storage capacity which further resulted into single commodity storage establishment like potatoes. In Uttarakhand, there is an inadequacy of cold chain network and warehousing facilities especially in the hilly areas. In India, Uttarakhand is one

such state whose individual storage capacity is below is 1 per cent). This adequacy further leads to post – harvest losses of fruits and other horticulture. It has been noted that in most of the states of India the major chunk of the facility which is around 80% is used for stocking up single commodity potato and potato seeds and only 17% for multipurpose storage including fruits. Therefore, establishment of cold chain facility especially for fruits has gained the utmost importance in the last few decades as it is one of the reasons affecting the smooth functioning of the supply chain of Fruits in Uttarakhand.

6.1 Cold storage Infrastructure in Uttarakhand

According to Horticultural Statistics 2018, Uttarakhand has a dearth of cold storage facilities with only 47 cold storages with total capacity of 162821 metric tons. . Uttarakhand has 17 cold storages and 3 CA storages with capacity of 59900 MT whereas 7916 is the total number of cold stores in India with total capacity of 36229675 MT. Uttar Pradesh as a state ranks the highest in terms of number of cold storage facilities in India with total capacity of 14500773 metric tons.

7. Cold Chain Infrastructure of Uttarakhand: SWOT Analysis

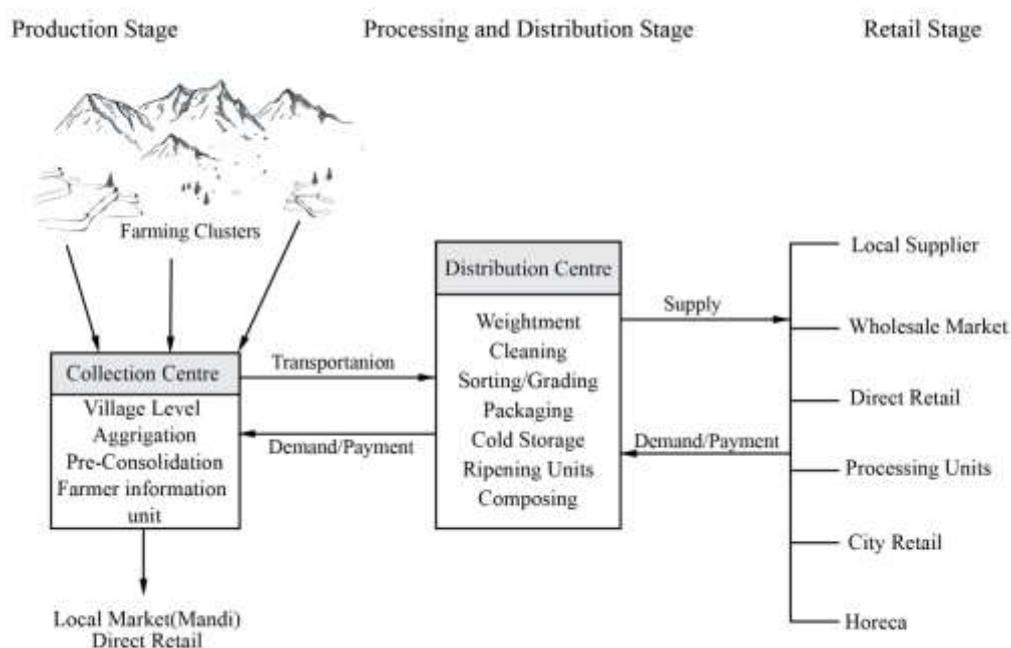
Strengths	Weaknesses
✓ Uttarakhand ranks 1 st in India in the production of pear, plum and peach with productivity 6.07 MT/hectare	✓ Cold chain linkage throughout the complete supply chain is limited because of crumbling road infrastructure
✓ Total 125 FPU's are operating out of which 52 FPU's are horticulture based	✓ Lack of awareness in terms of operations and storage among farmers
✓ National Centre for Cold Chain Development has taken number of initiatives to promote Indian cold Chain sector and this resulted in many business opportunities in the sector (Cargo Talk, 2015)	✓ Absence of government regulations on technical standards and protocols
✓ Scheme of Capital Investment Subsidy for advancement of Cold Chain facilities	✓ Power outages are more and high cost due to increased transit time
✓ An outlay of INR 38.50 cr. for the development of Horticulture under “Mission for Integrated Development of	✓ High setup cost for cold chain facility because of high cost of real estate. High tax burden
	✓ Specific regulatory requirements are multilayered which are highly prone to misuse at ground level
	✓ Manual warehouses leads to poor

<p>Horticulture</p> <ul style="list-style-type: none"> ✓ As compared to other states of India, growers of Uttarakhand have a good access to electricity at subsidized rates 	<p>visibility of the fresh produce further leading to delay.</p>
<p style="text-align: center;">Threats</p> <ul style="list-style-type: none"> ✓ Replication by other counterparts and development of cheaper alternatives ✓ Risk of failure of technology is high because of which the infrastructure collapses ✓ Clearance delays due to lack of due diligence in inspections and documentation ✓ Global variables and local variables can affect the operating environment of the cold supply chain ✓ Breakdown of cooling technology and vehicle breakdown can hamper the whole cold chain operations 	<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> ✓ Emphasis on operational and handling procedures can lead to efficient and strong cold chain facility ✓ Establishment of special power grid for the cold Chain sector can lead to uninterrupted energy supply ✓ Awareness on the importance of manual handling training in the sector can reduce the losses while handling the fresh produce ✓ Development of minimum qualification standards for the human force and service providers ✓ By the year 2024, Indian cold chain market is expected to reach INR 2,618 billion ✓ Promotion of mobile cold chain infrastructure by reducing basic custom duty to 5 percent and excise duty to 6 percent ✓ New cluster development of Kiwi, Banana, strawberry and papaya is a potential investment opportunity

8. Advanced Post Harvest Supply Chain of fruits in Uttarakhand

Post harvest supply chain consists of management and planning of various activities like procurement, consolidation, and delivery system. Post harvest supply chain of fruits crops is risky and complex due to the nature of farm produce which is bulky, seasonal and perishable. The post harvest management system includes interrelated activities starting from the time of harvest to the final decision made by the consumers to further sell the produce or discard it. Post harvest management is all about maintaining the quality of fresh produce like fruits & vegetables. It includes activities like cooling, handling & storage of fresh produce, processing, packing, transportation of the produce from one point to another. The losses involve measurable qualitative and quantitative losses in the post-harvest system (Kiaya, Victor, 2014). Qualitative losses affect the nutrient and calorific composition of the fresh produce whereas the quantitative losses affect the amount of the fresh produce. Quantitative losses are more common in developing nations like India (Kader, 2005). Significant importance should be given to demand, attitude of potential buyers, cultivation practices, handling techniques packaging, transportation and nature of produce harvested.

Post-harvest innovation is a significant area of agricultural development that could further assist farmers in different ways like increase in production, reducing wastage and spoilage, value addition, and reduction in logistics costs. The diagrammatic representation below shows the advanced post harvest supply chain of fruits in Uttarakhand.



The advanced post harvest supply chain has basically three stages. They are production stage, processing & distribution stage and Retail stage.

The production stage of an advanced post harvest supply chain of fruits consists of farming clusters. Farming clusters can be formed on the basis of production capacity or geographical area. Each farming cluster will have an aggregation centre which will serve as a collection point, procurement centre, information centre, and service centre to people involve in the supply chain.

Information technology based e-procurement system facilitates farmers, intermediaries and vendors to integrate various activities involved in the supply chain and therefore it becomes helpful in improving the overall responsiveness and efficiency of the supply chain.

Most of the fruits like apple, pear and plum are produced at high altitude wherein there are issues related to road connectivity especially from orchard to village and collection centers. Thereby, in most of the areas, farmers transport fruits with the help of labors, horse or pony. In advanced model, farmers can use pulley system to carry fruits in downward direction. A study conducted by Dastagri in five states of India found that transportation cost and marketing cost has a negative effect on marketing efficiently.

In case of processing and distribution stage, the fresh produce gets transported to various distribution centers for the purpose of cleaning, sorting, grading, packaging and processing. The demand for the fresh produce gets created by the distribution centre in return of which they make the payments to the sellers. Finally in the retail stage, after proper cleaning, sorting, grading and packaging the distribution centres meet the demand of the local suppliers, wholesalers, retailers, processing units and horecas.

At the same time, there are various factors influencing post –harvest performance and post-harvest losses. They are as follows - pre – harvest production practices on losses, water supply balance, cultivation practice, and use of fertilizers increased moisture loss, fungal infections, mechanical damage & physiological effects. Therefore, post harvest losses of fruits can be significantly reduced and their product life cycle can be increased by giving careful attention to these above mentioned factors (Yahya and Mardiyya, 2019). Qualitative & Quantitative post harvest losses take place due to unavailability of storage structure, poor logistics infrastructure, negligible advancement in technology, unskilled or semi-skilled labor on cooling-strategies, and farmer’s non-connectivity with the market. Inappropriate environmental conditions like drought, excessive rainfall, humidity etc can result into severe post harvest losses. Also, loss of moisture, decay-producing fungi, high & low temperature,

mishandling during loading and unloading, in transit delays can add more to the post-harvest losses (Goldenberg, 1974).

In a developing nation like India, it gets difficult to keep a track of the post harvest losses. Still some authorities manage to estimate the losses of sweet potatoes, tomatoes, and citrus fruits as high as 50 per cent or half of what is grown. Post –harvest losses result not only into human hunger and financial losses to growers, but also enormous environmental waste (Prusky, 2011). It has been noted that approximately 35-40 per cent of fruits & vegetables get damaged and wasted annually in India. This percentage loss also reduces the per capita availability of the fresh produce (fruits& vegetables) (Singh *et al.*, 2014). As per the study conducted in the year 2015 by Central Institute of Post Harvest Engineering and Technology, 4.58 per cent to 15.58 per cent is the post –harvest loss among selected fruits & vegetables. These PHL can be downsized by sound product techniques, appropriate harvesting techniques, post-harvest innovation & handling techniques, education and training (Bachmann and Earles, 2000). This can further help the poor through better employment opportunities, value addition and reduced food price (Hall *et al.*, 2003).

At operational level, temperature abuse takes place from the production point to the consumption point. Proper packaging is one of the major reasons responsible in the prevention of chemical and physical damage of the produce. Dearth of cold chain experts and unskilled labor for handling the post harvest fresh produce also make the cold chain infrastructure weak (Sharma and Saxena, 2010). Improper packaging of fruits increases the risk of damage during loading and unloading and transportation of the same. A lot of emphasis has been paid on pre-harvest stages for reinforcing the level of production by innovative techniques like soil conservation, crop rotation, pest control, fertilizers, and irrigation but at the same time post-harvest stages have never been considered so seriously till date. Proper attention to post-harvest management stage will lead to good remunerative prices and reduction in prices to the farmers and the end consumer respectively (Choudhary, 2016). There is an urgent need to establish strong and sound cold chain facilities for fruits in India. Adoption of effective post-harvest technologies will be help in minimizing the losses of fruits. This will also enhance the availability of the fresh produce amongst the supply chain partners. There is a dire need of proper channel of communication among farmers, post-harvest engineers and fruits specialists. Extended shelf life, low cost of procurement, economies of scale in transportation, storage and handling of farm yield are some of the advantages of advanced post harvest supply chain.

9. Conclusion

Cultivation of fruits in hilly areas of any state plays a significant role in the overall economy of the state. Livelihood of large number of farmers, intermediaries and transports depends on production and supply of fruits. The authors conclude that due to faulty supply chain network and poor cold storage network facility, farmers are unable to fetch real value of their yield.

Post harvest supply chain management of fruits involves a complex relationship between farmers and supply chain partners. Real time information system is a prerequisite for an efficient supply chain in fruits due its perishable nature; information network can integrate supply chain partners including transporters, agents, wholesalers retailers and customers. Supply chain of fruits in Uttarakhand is based on traditional method of supply with the presence of large number of intermediaries, obsolete storage and packaging facilities which is resulting into huge losses and wastage of fruits. The authors estimated a gap between marketable and marketed yield of fruits, approximately 25-30 percent of fruits get wasted annually in Uttarakhand. Advancement in cold chain infrastructure and post harvest technology will help to increase the shelf life of fruits and customers will be able to get fresh fruits at fair price. . Advanced model of supply chain of fruits and mitigation strategies would be helpful in overcoming the challenges in terms of infrastructure, supply chain integration, value addition, and management of post-harvest activities, storage and packaging. Demand of fresh and processed fruits is growing in all over the world, consumers want year round availability of fruits. Therefore farmers and traders have a lot of intact opportunities for the fruit market.

10. Findings of the study

Uttarakhand as a state faces a lot of hindrances which affect the smooth functioning of the supply chain of fruits. The categorization of issues along with some mitigation strategies has been done to understand the issues more evidently. They are as follows:

Cold Chain Storage Issues – There is an inadequacy of robust cold chain facility in order to serve the needs of the fruit industry in the state. This issue makes business difficult for farmers and that is why they are not able to get decent remuneration for their produce.(Negi and Anand, 2015a)

Mitigation Strategy – Establishment of cold chain facilities in the center area of the production belt of fruits. They can be set up by either private players or cooperative societies.

Backward & Forward Integration Issues - There is a lack of backward & forward integration from farm to fork (farmer to end consumer) in the hilly region like Uttarakhand. This issue of proper linkage and integration is throughout the supply chain involving all the stakeholders.

Mitigation Strategy – Contract farming can be one of the strategies to reduce integration challenges in the supply chain of fruits.

Knowledge issues of farmers – Farmers lack knowledge regarding the use of latest technologies and equipment in order to work efficiently and effectively. They are unaware on the use of advanced post- harvest technologies and quality of seeds.

Mitigation Strategy – Support from Research Institutions to provide knowledge on latest technologies.

Infrastructure Issues – Infrastructure issues are related to lack of warehousing and storage facilities in the villages, lack of processing facilities, proper packaging infrastructure, handling infrastructure, connectivity of roads in the hilly terrain areas.

Packaging Issues – High packaging cost of the produce makes it challenging for the (growers) farmers to opt for good packaging for their fresh produce.

Mitigation Strategy: Packing units can be established by federations which will provide employment opportunities to the local residents. (Hall *et al.*, 2003).

Technical Issues – There is a dire need of advancement in technology related to agriculture. The advancement in technology will further lead to reduction in post – harvest losses of fruits in the state.

Mitigation Strategy: New technology adoption can be communicated through exhibitions and seminars by the institutions.

Value addition & Processing Issues – There is a low degree of value addition done to the fresh produce like fruits because of the inefficient and improper infrastructure facilities.

Mitigation Strategy: Semi processing units can be established in collaboration with the government.

Post- harvest losses Issues – 35-40 percent of the fruits get wasted after harvestation annually because of the inefficiency of supply chain in India.

Mitigation Strategy: Establishment of cold chain facility in the area where there is poor road connectivity. Emphasis must be laid on the establishment of processing units.

11. Implications of the study

Supply chain managers especially in mountainous area will be able to transform post harvest supply chain of fruits into more efficient supply chain. Advanced supply chain management with combination of cold storage infrastructure will help the farmers in reducing the overall spoilage and wastage. Mitigation strategies will benefit farmers, intermediaries, transporters, food processing plants, government and customers. Students and researchers would be able to recognize major challenges and issues in post harvest supply of fruits in hilly regions. Effective mitigation strategies will improve economic status of people in farming & allied activities. Also, it will further reduce the migration of people from hilly regions of Uttarakhand to metropolitan cities in search of employment opportunities.

12. Limitations & scope of the study

The authors have focused mainly on cold chain issues, technological issues, issues at the level of farmers, and post-harvest losses of fruits in Uttarakhand. Researchers may also focus on other aspects like food processing, transportation and distribution. This study is conducted in the geographical area of Uttarakhand only, Empirical research may be further conceded out in the entire Himalayan region of India for the supply chain of fruits & vegetables. The researchers may obtain primary data for the study so that the results can be validated. Cross-sectional and longitudinal data can be collected by the researchers to establish the association among the variables and also set up causal relation among them.

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