# Cold Chain Development for Fruits & Vegetables in India
## Kinnow Supply Chain Study

# ACKNOWLEDGEMENTS

**ISB Team**

*Professor Man Mohan S. Sodhi, Principal Investigator*
Cass Business School,
City, University of London

*Sukhmeet Singh, Project Manager*
Indian School of Business

*Chetna Agnihotri, Analyst*
Indian School of Business

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# EXECUTIVE SUMMARY

Fruit-and-vegetable distribution in India suffers significant post-harvest losses in the supply chain primarily due to the perishable nature of fresh produce and its sensitivity to handling damages. Cold chain is one possible solution for reducing post-harvest losses. Moreover, cold chain can help increase value of the produce by enabling sales out of season and in far-away markets. However, the stakeholders in the value chain may be deterred by setup complexity, dependence on other stakeholders investing along the supply chain, and high cost of investment, despite government incentives. This report assesses investment in cold chain by analyzing profitability in a particular supply chain to encourage stakeholders along the entire supply chain to make similar assessments.

Our study focuses on a particular supply chain for kinnow, a citrus fruit. The supply chain we studied originates from Abohar in Punjab in northern India to Bangalore in southern India. This supply chain allows us to analyze the time- and distance-related aspects of cold-chain investment. We conclude that with cold chain intervention:

- x10 profit by reefer truck

- -16% $CO_2$ emissions

- ÷4 spoilage of kinnow

Cold chain has the potential for increasing volume of flows, which can result in better returns for farmers. The benefits really come through when the cold chain is a refrigerated chain all the way from the farmer to the retailer so any inducements the government wishes to give to investors by way of subsidies should consider all stakeholders along the supply chain.

Eventually, we have also provided a general decision framework for aggregators and distributors to analyze profitability for any crop when using the cold chain.

# 1. INTRODUCTION

India is the second largest producer of fruits and vegetables amongst all countries in the world after China. Fruits and vegetables are traditionally consumed close to where they are grown, but with urbanization and changing consumer preferences across India, cold chain connectivity is the solution needed to enable farmers and aggregators to distribute produce over a wider area and in off-season months. Moreover, besides expanding the domestic market in the country, cold chain can help with exports, considering that India currently exports merely 1% of the production.

Despite potential benefits, there is a noticeable lack of investment in the cold chain infrastructure. According to the National Centre for Cold-chain Development's (NCCD) 2015 study of the status of the nation's cold chain infrastructure, India has a shortage of reefer transportation vehicles- having fewer than 10,000 vehicles against an estimated 62,000 needed vehicles. There are at least two possible reasons for this reluctance for investment. One reason is that cold chain investment may be perceived as being too high with benefits that are questionable. The second reason may be the complexity of the investment: A complete cold chain solution requires investing in pre-cooling and cold storage, in refrigerated vehicles for transporting food and in the refrigerated distribution centres. To get benefits pertaining to reaching distant markets, the entire supply chain needs to be refrigerated – hence the phrase 'cold chain' – requiring investment by all the stakeholders along the supply chain from aggregator to distributors to retailers as well as the transporters linking them.

To shed light on cold chain investment, we investigated a particular supply chain for kinnow, a particular citrus fruit grown primarily in Punjab, India. This supply chain begins with aggregation in Abohar, Punjab and ends with retail in Bangalore in southern India under four scenarios. Two scenarios are base or status quo scenarios of no cold chain for the months of January and February respectively with no cold chain. The two other scenarios, for February and March respectively, entail intervention by way of the introduction of cold chain to shed light on cold-chain economics and environmental impact across this particular supply chain. Under these scenarios, we analyzed the profitability of investing in and/or using the cold chain for all the stakeholders in this particular supply chain.

# 2. A KINNOW SUPPLY CHAIN STUDY

This study deals with the business viability of cold chain applied to kinnow supplied from Abohar in Punjab in north India to Bangalore in south India. Doing so enables us to assess any benefits of the cold chain pertaining to distributing over long distances as Bangalore is 2,530 km away from Abohar and it takes approximately four-five days to get from Abohar to Bangalore by truck. It also allows us to look into the value generated during off-season sales because, as we found, there is high demand for kinnow as well as freshly-squeezed kinnow juice in Bangalore in the months of March and April, well after harvesting ends in January or February.

## 2.1 Why Kinnow?

We selected kinnow as the fruit for this study for following reasons:

**Geographically concentrated cultivation and saturated local markets:** Kinnow is a high-yield variety of mandarin orange grown primarily in Punjab region of North India. It requires only five years before first harvest. Punjab is India's leading producer of kinnow with 29% of total national production. Kinnow orchards are in five locations in Punjab: Abohar, Hoshiarpur, Mansa, Muktsar and Bathinda (Exhibit "District Map"). In 2014-15 farmers in Punjab produced 1.1 million tonnes of kinnow, with about 48,000 hectares or two-thirds of the total acreage devoted to fruit production in Punjab. Local markets cannot consume all the production. Growing yield over time has only exacerbated the price pressure on farmers. Kinnow farmers earned Rs. 12-13 per kg in Dec. 2013, but only Rs. 6-7 per kg in Dec. 2014 and Rs. 7-8 per kg in Dec. 2015 in wholesale markets in Punjab. In January 2016, Punjab Agro (of the State Government) had to intervene to stabilize the price by buying 5,000 tonnes of kinnow.



**Kinnow fruit, grown primarily in Punjab-India**
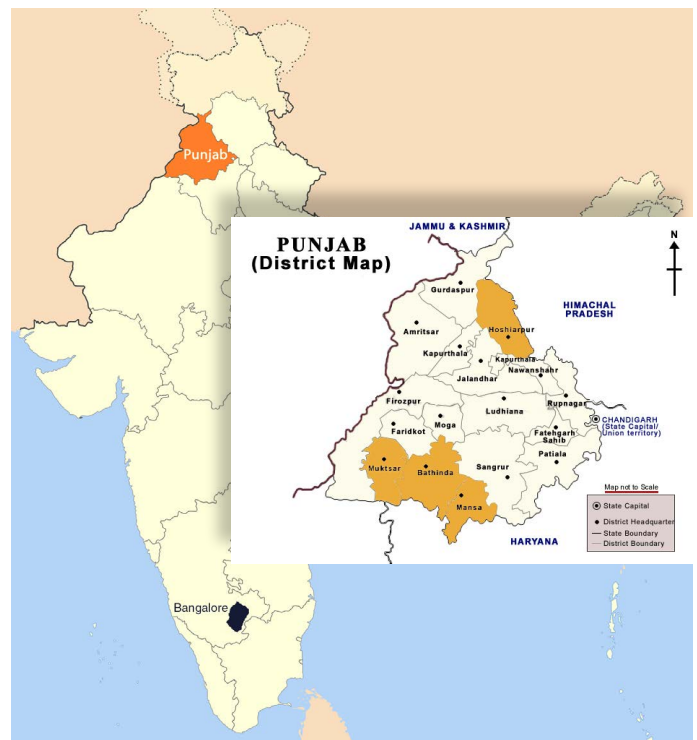


**District map of Punjab as well as the map of India showing the state of Punjab and the city of Bangalore**

**Post-harvest losses and compatibility with cold chain:** Like many other fruits, kinnow deteriorates rapidly after harvest and needs to be kept cool at 4-5 degrees and a relative humidity of 85-90% to keep spoilage at a minimum. Post-harvest losses in kinnow from Abohar to Bangalore are estimated at 28% in the supply chain from the orchard to the retailer. Such losses reduce the potential revenues for farmers, aggregators, transporters, distributors and retailers. Storage life is about five to seven days at ambient conditions in winter months of December and January but can be extended to about 20 days if the fruit is waxed or wrapped. The cold chain makes a significant increase to life in storage for up to two months, which enables sale of kinnow off-season from March and April and even as late as May well after harvest ends in January or February.

**Popular and low value:** Other fruits that could have been used are, say, kiwi or strawberry, but the

business case for cold-chain investment for these is obvious due to their high perishability as well as the high prices they command in the market. In contrast, kinnow is a popular low-cost fruit. Therefore, if a business case could be made for cold-chain investment using kinnow, then the results could be generalized to many other types of fruits.

**Possibility for export:** Kinnow has potential for export, but organized export from Punjab has yet to develop as of this writing, even from designated Agro-Export Zones. Kinnow from Punjab currently does reach Bangladesh via markets in Kolkata in eastern India. And in 2016, aggregators from Punjab exported directly to Russia, Ukraine and the UAE but these sales were opportunistic. Cold chain could help in exporting kinnow on a regular and predictable basis by preserving quality of the fruit across long distances.

# 2.2 Research methodology

Distribution of kinnow in India mainly relies on open trucks. As such, a typical supply chain goes from the farmer to the aggregator, then to the mandi or to the distributor via open truck transportation, and then on to the retailer. We observed the supply chain for the months of January 2016 and February 2016 as the two base or status quo scenarios. Furthermore, our study entailed two interventions: (1) use of pre-cooling and then use of refrigerated or "reefer" trucks in-season to transport from a pack-house to distributors without using cold storage in February 2016, and, (2) taking kinnow from cold storage (having pre-cooled it earlier) and then transporting with reefer trucks for out-of-season transportation to distributors in March 2016. Thus, we made our observations under four scenarios (Exhibit "Scenarios")



**BASE MODE:**
**(1) January and (2) February**

CULTIVATION — AGGREGATION — OPEN TRUCK TRANSPORTATION — MANDI/ DISTRIBUTION — RETAIL

**IN-SEASON INTERVENTION MODE 1: (3) February**

CULTIVATION — AGGREGATION — PRE-COOLIING — REEFER TRANSPORTATION — MANDI/ DISTRIBUTION — RETAIL

**POST-SEASON INTERVENTION MODE 2: (4) March**

CULTIVATION — AGGREGATION — PRE-COOLIING — COLD STORAGE — REEFER TRANSPOR-TATION — MANDI/ DISTRIBUTION — RETAIL

**Four scenarios with the first two using the traditional supply chain with open-truck transportation in season (Jan'16 and Feb'16), and the next two with intervention: one using reefer trucks in-season (Feb'16) and the other using both cold storage and reefer-truck transportation out of season (March'16).**

Data collection was based on interviews of different managers at different nodes in the supply chain and on some third party data. We interviewed the following for this study:

Farmers at festival organized by Punjab Agriculture University (PAU)

Aggregator in Abohar - Balaji Cold Store

Distibutors in Bangalore - IG International, KTM Fruit Traders

Retailers in Bangalore - D-Mart, METRO and Namdhari Fruits & Vegetables

Distributor of trucks - PASCO Motors, Chandigarh

Distributors of reefer equipment - Coolways Automate Pvt. Ltd, Chandigarh

We also visited the sites of Balaji Cold Store in Abohar and those of the distributors and retailers in Bangalore to understand the operations and the overall context.

We calculated the costs and revenues in the supply chain at different points from Abohar orchard to retailers in Bangalore for the two base scenarios (January and February) using open trucks as well as the two intervention scenarios (February and March) using the cold chain. We included costs of aggregation; pack-house processing like waxing and grading; pre-cooling and cold-storage; transport to Bangalore in open and reefer trucks, food loss and carbon footprint in the four scenarios. Then we analyzed the profits for the aggregator, distributor, transporter and retailer and also estimated the payback period for cold-chain investment. Finally, we estimated $CO_2$ emissions to quantify the environmental impact (Table 1).

### Table 1: Overview of research methodology by supply-chain actor

|  | Aggregator | Distributor | Retailer | Transporter |
|---|:---:|:---:|:---:|:---:|
| **Site visit** | ✓ | ✓ | ✓ | ✓ |
| **Primary data collection** | ✓ | ✓ | ✓ | ✓ |
| **Profitability Analysis** | ✓ | ✓ | ✓ | ✓ |
| **Payback period of investment** | ✓ |  |  | ✓ |

Besides primary data, we used third party research to identify the relevant parameters for our analysis, especially for estimating spoilage and $CO_2$ emissions.

# 3. THE SUPPLY CHAIN

The 'orchestrator' of the supply chain of interest is a fruit aggregator, Balaji Cold Store, who is also a wholesaler, a fruit exporter as well as fruit importer involved in nearly all stages of the supply chain from the orchard to retail. The company is based at Abohar, Punjab, and is privately owned and managed by Sh. Surinder Charaya. Balaji supplies kinnow and other fruits to local markets in Punjab, and in a limited way to markets in other parts of India including Bangalore and Gujarat. Occasionally he would also supply for export to markets in Dubai, Russia and Ukraine.

Sh. Charaya sees the benefit of the cold chain investment in being able to reach markets in southern India selling high-quality kinnow in season as well as off-season, and reducing spoilage substantially. He hopes to establish Bangalore as a primary centre for distributing fruits in southern India, for which he believes proper integration of his supply chain with pre-coolers and refrigerated trucks would be required. Also he believes he can get more value from using a complete cold chain solution as it will increase reach to new markets and also help maintain quality.

> " Reefer trucks are required for supply chain to Bangalore- that makes a huge difference and extends the kinnow market for us even off-season. We use reefer trucks, along with pre-cooling and cold storage facilities to supply kinnow. "
>
> *- Sh. Surinder Charaya, Managing Director of Balaji Cold Store Pvt. Ltd., Abohar*





**Sh. Surinder Charaya, Managing Director of Balaji Cold Store**

The post-harvest supply chain process for Balaji for this particular pilot study comprises:

**2.** Processing in Abohar pack-house, including grading/ sorting, waxing and packing

**4.** Open-truck or reefer-truck transportation to Bangalore

**1.** Picking the fruit from the orchard in Abohar or vicinity

**3.** Pre-cooling and cold storage in Abohar pack-house (optional)

**5.** Distribution and retail in Bangalore
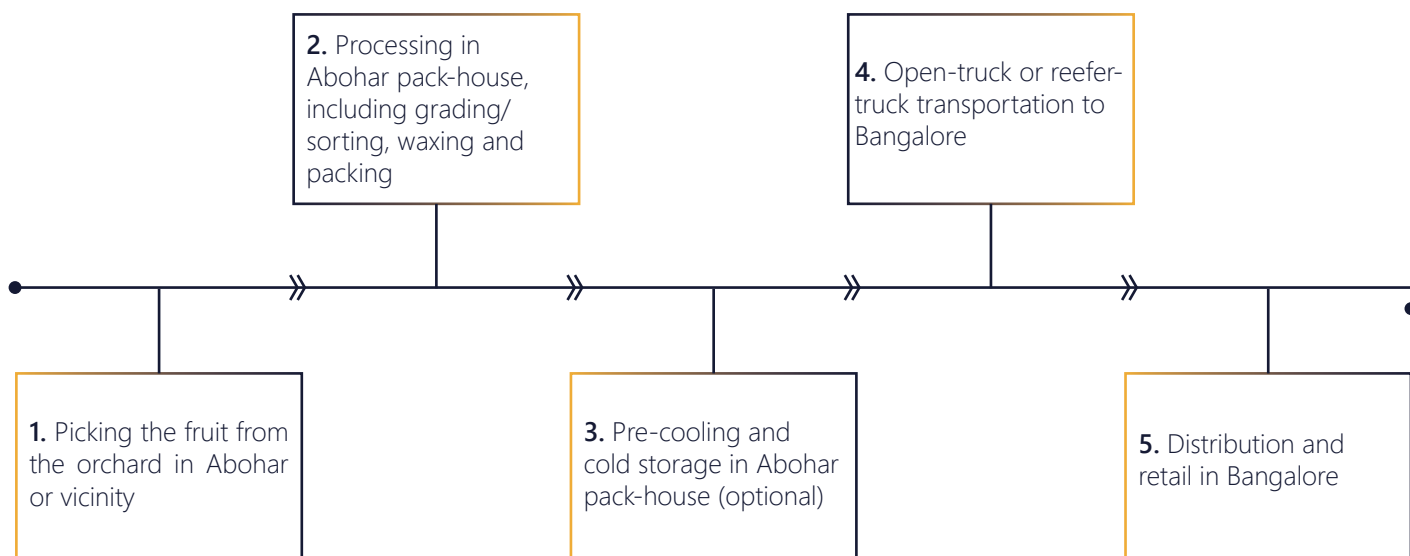
The precooling and cold store is used to buffer produce intended supply beyond the peak season, while in season market continued to be supplied in the cool winter months without needing to use the pre-cooling system.

# 3.1 Picking

Balaji Aggregators get kinnow from multiple farmers and orchards in Abohar, covering an area of about 2,000 acres. Sh. Charaya himself owns 14 acres of kinnow farms. For picking, the aggregator incurs the cost of labor and of transportation to one of four pack-houses that Balaji have in Abohar or in the vicinity. Traditionally, fruit is harvested with pruning shears, letting the fruit drop to the ground. In orchards owned by Balaji, the fruit is harvested with clipper and is collected the fruit in crates/ bags without letting the fruit drop to the ground to keep spoilage to a minimum. However, most of the kinnow that Balaji sells is obtained from other orchards so the fruit in this supply chain is primarily picked from the ground after using shears.



**Kinnow trees in orchards in Abohar**



**Kinnow fruit being handpicked**

The harvested fruit is then transported to the aggregator's pack house.

## 3.2 Processing in pack-house

Upon arrival at the pack-house, the fruit is processed. There are about 200 employees per pack-house, in charge of processing and packaging facilities. Processing of the fruit includes waxing, grading, sorting, and packing. Balaji have installed a mechanical waxing and grading machine for supply intended for far-away markets including exports.



**Processing (grading, waxing and sorting) equipment at Balaji**



**Packing operations at Balaji pack-house in Abohar**

Workers pack the fruit manually in corrugated fiberboard (CFB) boxes, each carrying approximately 10 kg of fruit. Balaji had started looking into smaller plastic containers that allow for improved circulation of air and hence more effective cooling; these containers also have the benefit of not requiring unpacking for retail sales.

# 3.3. Pre-cooling and cold storage

Balaji have been using cold storage for fruits since 2000 at their storage facility in Ludhiana in Punjab, and have installed cold storage installed at the Abohar pack-house as well. In 2015, Balaji initiated cold storage trials for kinnow for a period of three months and in 2016, installed pre-cooling for kinnow for staging prior to cold storage or cold transportation. At a part of this pilot study, they had already bought pre-cooling and had committed to using reefers for the interventions under consideration for this study. Fruit is not pre-cooled throughout the season at Balaji. But once the temperature starts to rise around February end, and it becomes difficult to maintain the quality of fruit for supply to a distant distributor. To supply far away customers in proper quality and quantity, pre-cooling the fruit becomes imperative but this was not being done in the past. Storing the produce in a cold store without precooling, resulted in moisture losses, poor quality and shorter holding life. The pre-cooling unit at Balaji has a capacity of 30 tonnes per batch and load of 22kWh. The kinnow at point of input is typically at 15 degrees Celsius and the temperature is brought down to 4-5 degrees within 6 hours.

Cold storage unit at Balaji had a capacity of 1500 tonnes initially and a load of 65kWh. As part of the intervention, part of this capacity gave way to a pre-cooling unit leaving the cold storage with a capacity of 1000 tonnes. The unit runs for 10-12 hours a day.



**Precooling at Balaji packhouse at Abohar**



**Cold storage at Balaji in Abohar**

## 3.4 Transportation from Abohar to Bangalore

After packing, Balaji sends the supply across to different distributors within and outside Punjab, and, in for this study in particular, to distributors in Bangalore. Prior to the start of this study, Balaji used only conventional open trucks vehicles for sending fruits by road. During this study, Balaji rented reefers for the first time as intervention. Open trucks have a holding capacity of 15tonnes with a length of 25 feet, and reefers have a reduced holding capacity of 13.5 tonnes and 24-feet length to accommodate the cooling equipment. For the initial phase of the intervention, Balaji rented a truck with 28ft long container equipped with an Oasis 350 – 10300watts refrigeration unit from Carrier Transicold. After this phase, Balaji purchased a truck with a 30ft long container equipped with Supra 1150 – 10,500 watts refrigeration unit from Carrier.



**Open truck used by Balaji getting ready to be loaded for Bangalore**



**Reefer truck purchased by Balaji**

## 3.5 Distribution and retail in Bangalore

We visited two of Balaji's distributors in Bangalore, IG International and KTM Fruit Traders. IG International is a fresh produce import/export company and working towards the object of preserving the fresh produce with long shelf life and reducing the high level of wastages by using cold chain. IG Group has wholesale outlets, distribution centers and cold storage across 21 branches all over India and overseas. These distributors sell kinnow supplied by Balaji to retailers and to other distributors, taking a commission from Balaji on the sale.



**IG International, a distributor, based in Bangalore**

**IG International, a distributor, based in Bangalore**

IG International have 50 reefer trucks of different sizes and capacity, which carry a total of 25,000 tonnes of fresh produce each year. These vehicles are used for the transportation of fruits under controlled temperature to the sales outlets to ensure safety and quality. The company currently owns three cold storages with total capacity of 10,000 tonnes and, at the time of the study, was aiming to increase capacity in the near future.

> " We earn higher profits if kinnow market is extended after March. The quality of kinnow received in reefer truck even in the month of Feb is much better that the quality of kinnow received in open truck. The price difference reflects the same. "
>
> *- Mr. Kamal Arora, IG International, Bangalore*

The other distributor, KTM Fruit Traders, received kinnow only from Balaji Aggregators for supply to the local retailers. In past years they received kinnow from Balaji Aggregators in open trucks from December only till mid-February. Having experienced considerable spoilage with the supply coming in non-refrigerated (open) trucks, they have felt the need to invest in reefer trucks for increasing profits. Along with Balaji, they have tried using open trucks with thermcol, a common lightweight packing material that provides good insulation but doing so did not reduce spoilage much in their experience.

> " Without reefer trucks, I incurred considerable spoilage in February 2016. The use of reefer trucks for transport can reduce that. "
>
> *- Mr. Mohan Das, Manager, KTM Fruit Traders, Bangalore*

We visited two retailers in Bangalore for the case study, D-MART and METRO. These retailers sold kinnow at prices ranging from Rs.79-149 per kg, with higher prices in March compared to those in the cooler months of January or February. These retailers felt that the high prices of kinnow in March indicate huge demand, and the continued supply off-season would be beneficial. Another retailer confirmed the popularity and price of kinnow both in- and off-season in Bangalore. While the kinnow was no longer available in April, orange from Valencia, Spain was available at Rs.90-110 per kg. As such, the retailers felt they could achieve that same price for kinnow if it were available in April.



Retailers D-Mart and Metro
in Bangalore

Orange from Valencia, Spain
on sale in Bangalore in April

# 4. Findings

We first estimated the revenues and costs across the supply chain for comparison of the four scenarios taken up for this study. For the calculations, we started with the retailer selling 1 metric tonne (MT) of kinnow and then go upstream from the retailer to the aggregator and identify the quantity sold, operational costs, revenues and spoilage at each level- retailer, distributor and aggregator to make this one 1 MT of retail possible in Bangalore. Next we estimated the profitability for the retailer, distributor, transporter and aggregator and also calculated the payback period for the cold-chain investment used in the intervention scenarios.

## 4.1 Revenues and costs in the supply chain

The interviews provided us with selling prices and transport costs at various levels across the supply chain. We also use third party data for parameters such as spoilage, cross-checking these data to the extent possible with the information from the interviews. As mentioned earlier, the capacity for cold storage at Balaji was 1,500 tonnes but was reduced to 1000 tonnes to make room for pre-cooling. So for the profitability analysis, we took the capacity as 1000 tonne. However, for the purpose of calculating return on the investment, we took 1,500 tonne as the investment was made in getting a 1500 tonne cold storage, not a 1000 tonne cold storage. So the calculations for payback will have 1500 tonne capacity (withRs.4 crore investment) and for running costs for profitability and $CO_2$, will have 1000 tonne. For the spoilage estimates, we started with numbers from a 2007 study that provides these at different stages of the supply chain from orchard in Abohar to retailers in Delhi and Bangalore; we then adjusted these numbers for the intervention scenarios. Thus we obtained parameters for profitability analysis; Table 2 indicates the parameters and the source of our information.

# Table 2: Parameters for revenues and costs and the source for this information

| S.no. | Parameters taken for profitability calculations (source) | Units | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|---|
| 1. | Retailer's selling price (in Bangalore) | (Rs/MT) | 70,000 | 75,000 | 80,000 | 100,000 |
| 2. | Spoilage at retailer (adapted from Gangwar et al. 2007) | % | 13.7% | 13.7% | 5% | 5% |
| 3. | Operational costs for retailer (estimated using a 1% normal margin for the retailer in the base scenarios) | (Rs/MT) | 38000 | 38000 | 42000 | 50000 |
| 4. | Retailer's purchase price = aggregator's selling price (from Balaji) | (Rs/MT) | 27000 | 30000 | 35000 | 40000 |
| 5. | Spoilage from transportation/ distribution (adapted from Gangwar et al. 2007) | % | 5.7% | 15% | 1% | 1% |
| 6. | Labour cost for distributor (our estimates based on time and daily cost of labour) | Rs/MT | 2000 | 2000 | 2000 | 2000 |
| 7. | Cold storage cost for distributor (estimate based on Rs 7 per unit electricity cost) | - | - | - | 42 | 42 |
| 8. | Transportation cost (Abohar-Bangalore)(taken from Balaji with Rs 80,000 for an open truck of 15 tonne capacity and a reefer at Rs 1.25 lakhs with13.5tonne capacity) | Rs/MT | 5333 | 5333 | 9259 | 9259 |
| 9. | Spoilage at orchard and packhouse | % | 2.5% | 3% | 3% | 3% |
| 10. | Procurement cost for aggregator (our choice – actual prices vary) | (Rs/MT) | 12000 | 12000 | 12000 | 12000 |
| 11. | Operational cost(harvesting till shipment) (our estimate) | (Rs/MT) | 4900 | 4900 | 4900 | 4900 |
| 12. | Pre-cooling cost (25kWhfor 30 MT for 6 hours at Rs 7 per kWh) | (Rs/MT) | - | - | 35 | 35 |
| 13. | Pre-cooling loading and unloading cost (our estimate for labour costs) | (Rs/MT) | - | - | 250 | 250 |
| 14. | Cold storage cost (based on 39 kWh and Rs 7 per kWh) | (Rs/MT) | - | - | - | 273 |
| 15. | Cold storage loading and unloading cost (same as for pre-cooling above) | (Rs/MT) | - | - | 250 | 250 |

These parameters are the basis for calculating the supply chain surplus – the revenues from selling 1 MT at the retail end of the supply chain less the supply chain costs and procurement costs at the orchard and other costs incurred (Table 3).

## Table 3: Revenues for the retailer in Bangalore for 1 metric tonne (MT) of kinnow under each of the four scenarios, the first two in 'base' mode, and the next two as cold-chain interventions, as well as various costs incurred at different stages in the supply chain: retailer, distribution, transportation and aggregation

**Revenues and costs at different levels**

| Level | S.no. | Activity for one MT sold by retailer | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|---|
| Retailer level | 1. | Retailer's revenues | 70,000 | 75,000 | 80,000 | 100,000 |
| | 2. | Spoilage | 13.7% | 13.7% | 5% | 5% |
| | 3. | Quantity purchased | 1.16 | 1.16 | 1.05 | 1.05 |
| | 4. | Operational costs for retailer | 38000 | 38000 | 42000 | 50000 |
| | 5. | Procurement cost adjusted for spoilage/Revenues from distribution | 31286 | 34762 | 36842 | 42105 |
| Distributor level | 6. | Spoilage from transportation/distribution | 5.7% | 15% | 1% | 1% |
| | 7. | Quantity received | 1.23 | 1.36 | 1.06 | 1.06 |
| | 8. | Distributor's commission at 9% | 2816 | 3129 | 3316 | 3789 |
| | 9. | Labour cost | 2458 | 2726 | 2127 | 2127 |
| | 10. | Cold storage cost | - | - | 45 | 45 |
| Aggregator Level | 11. | Quantity transported | 1.23 | 1.36 | 1.06 | 1.06 |
| | 12. | Transportation cost | 6554 | 7271 | 9845 | 9845 |
| | 13. | Spoilage at orchard and pack-house | 2.5% | 3% | 3% | 3% |
| | 14. | Quantity purchased | 1.26 | 1.41 | 1.10 | 1.12 |
| | 15. | Procurement cost | 15123.6 | 16864.7 | 13153.8 | 13430.7 |
| | 16 | Operational cost (Harvesting till shipment) | 6175.5 | 6886.4 | 5371.1 | 5484.2 |
| | 17. | Pre-cooling cost | 0 | - | 37.21 | 37.21 |
| | 18. | Pre-cooling loading and unloading cost | - | - | 265.82 | 265.82 |
| | 19. | Cold Storage cost | - | - | - | 290.27 |
| | 20. | Cold Storage loading and unloading cost | - | - | 266 | 266 |
| | 21. | Cumulative losses | 22% | 32% | 9% | 9% |

With the revenues and costs estimated for the supply chain as a whole, we used these numbers to estimate profitability for the individual players and the payback on the cold-chain investment. While these numbers are only indicative because of assumptions around the parameters we used, they do afford comparison of revenues and costs in the cold-chain intervention scenarios vis-à-vis the base scenarios without cold-chain.
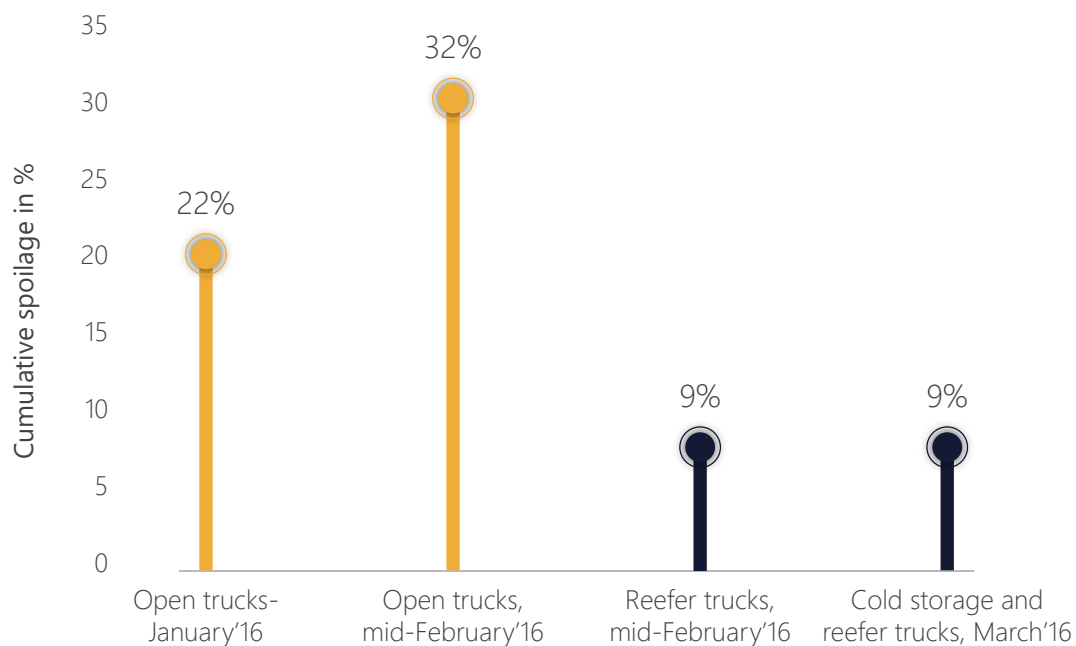


## 4.2 Profitability and Pay back for Aggregator

For the two base scenarios in January and February season and with open truck transportation- the aggregator earns 2% and 1.8% respectively. Continued supply in open trucks in later months would likely reduce the profits further due to high spoilage even if this were at all possible. In contrast, in the intervention scenarios, when using reefer truck for transport in February 2016, the margin of profits increased to12%. This continued in March when Kinnow was shipped from cold storage via reefer trucks and was selling now out-of-season in Bangalore and the margin increases to 20% (Table 4).

### Table 4: Profitability for Balaji Aggregator

| | S.no. | Profit based on one MT sold by aggregator | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|---|
| | 1. | Profit for aggregator per tonne shipped | 503 | 449 | 4315 | 8179 |
| Aggregator Level | 2. | Revenues for aggregator per tonne shipped | 25461 | 25500 | 34650 | 39600 |
| | 3. | Aggregator's margin | 2.0% | 1.8% | 12.5% | 20.7% |
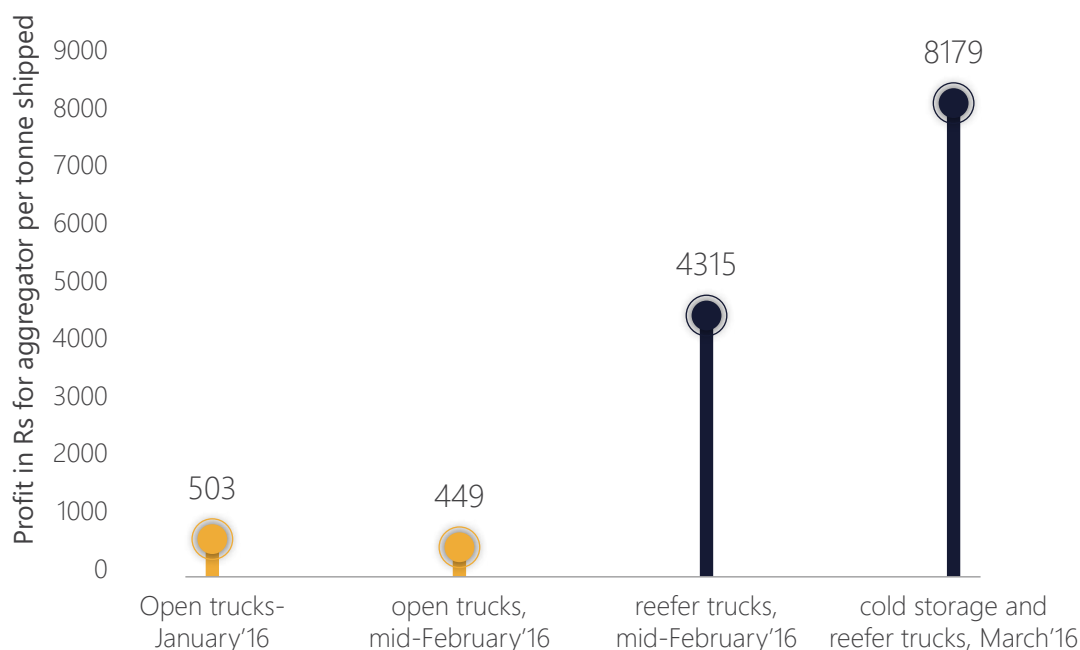
The increased margin is based solely on operational profits without taking capex or investment costs into account. Therefore, we separately calculated the payback period for investment in pre-cooling and cold storage by considering fixed costs, straight-line depreciation and maintenance. Assuming that Balaji invests Rs. 40 lakhs in pre-cooling and taking 40 trips and 540 MT as quantity shipped per year using pre-cooling, the payback period for pre-cooling is only 2.3 years (Table 5). This suggests that investing in pre-cooler can be quite attractive for kinnow even if these were used for just a few months a year.

## Table 5: Payback period calculations for pre-cooling equipment at Balaji

| Payback for pre cooler | Units | |
|---|---|---|
| Pre-cooler capital cost | Rs | 2,500,000 |
| Installation | Rs | 1,500,000 |
| Total investment | Rs | 4,000,000 |
| Annual costs including depreciation @1.5% / month | Rs | 720,000 |
| Operating profit per MT | Rs | 4,185 |
| No. of reefers shipped per year to Bangalore | No.s | 40 |
| Quantity shipped in year @ 13.5 MT/reefer | MT/year | 540 |
| Annual operating profits | Rs/year | 2,477,260 |
| Annual profits net of depreciation and maintenance | Rs/year | 1,757,260 |
| Payback in years | years | 2.28 |

Estimating the payback period for cold storage is more complicated because cold storage is used for much of the year and for storing many other types of produce, including for rental to other aggregators or farmers. To make our estimates, we assumed 20 trips and 270 MT as quantity shipped per year using cold storage. We also took the cold storage usage for other fruits and vegetables throughout the year and calculate profits based on rental value only. The payback period in this case turns out to be 16 years without kinnow but only 9 years with kinnow (Table 6). These numbers are indicative only but they do show that making cold storage part of the cold chain, rather than it being stand-alone, can unlock tremendous value from this investment.

**Table 6: Payback period calculations for cold storage equipment at Balaji**

| Payback for cold storage | Units | |
|---|---|---|
| Cold storage capital cost | Rs | 3,25,00,000 |
| Installation | Rs | 75,00,000 |
| Total investment (as per Balaji, without taking any subsidies into account) | Rs | 4,00,00,000 |
| Annual costs including depreciation over 20 years | Rs | 20,00,000 |
| Operating profit per MT of kinnow | Rs | 7,770 |
| No. of reefers shipped per year to Bangalore | Nos. | 20 |
| Quantity shipped in year @ 13.5 MT/reefer | MT/year | 270 |
| Annual operating profits from kinnow | Rs/year | 20,97,982 |
| Annual revenues from renting space for other produce (Capacity x70% loading x Rs 15/month rental for 50kg of vegetables x 9 months of usage) | Rs/year | 50,40,000 |
| Cost of electricity (50kW x 6hours/day x 30days/month x 9 months/year x Rs7 per kWh) | Rs/year | 5,67,000 |
| Annual operating profits from renting space for other produce | Rs/year | 44,73,000 |
| Annual profits net of depreciation-other produce only | Rs/year | 24,73,000 |
| Annual profits net of depreciation - including kinnow | Rs/year | 45,70,982 |
| Payback in years without kinnow (base) | years | 16 |
| Payback in years with kinnow (with cold chain intervention) | years | 9 |

Capital cost of infrastructure is not validated and as reported by the promoter.

# 4.3 Profitability for Transporter

Our indicative calculations assuming two trips a month from Abohar to Bangalore and the rental income on the outbound journey with kinnow to be Rs. 1,25,000 show that the transporter would make an annual profit of Rs. 12.5 lakh on an investment of Rs 29.5 lakhs. This gives a payback period of just above 4 years (Table 7).

## Table 7: Profitability calculations per year from a transporter owning a reefer truck

| Transporter | |
|---|---|
| **Fixed costs (13.5 Ton)** | **Rupees** |
| Chassis (data from truck dealer) | 21,00,000 |
| Cabin + Insulated Body (box) (from truck dealer) | 4,00,000 |
| AC unit (from AC unit dealer) | 4,50,000 |
| Total investment (from truck dealer) | 29,50,000 |
| **Revenues** | |
| Revenue from outbound journey (source: Balaji) | **1,25,000** |
| Return trip revenue percentage (our assumption) | **50%** |
| Revenue per return trip | 187500 |
| No. of trips/month per truck to Bangalore (based on time taken and on expected utilization) | 2 |
| Revenue per month | 3,75,000 |
| No. of months of truck usage in one year | 8 |
| Revenues in one year | 30,00,000 |
| **Yearly costs** | |
| Monthly Driver + helper compensation (Pay of Rs 25,000 to driver + helper. Rs 8000 as allowance for two trips (Rs 4000 per trip) | 33,000 |
| Annual driver + helper | 3,96,000 |
| Annual insurance (Balaji) | **65,000** |
| Annual depreciation | 2,95,000 |
| Fuel cost for a reefer truck: Abohar to Bangalore (Distance/Avg of truck + reefer fuel usage * cost of per liter diesel) | 48,150 |
| Annual fuel cost depending upon the trips | 15,40,800 |
| Total annual costs | 22,96,800 |
| **Profitability and payback** | |
| Profits in one year | 7,03,200 |
| Payback in years | 4.20 |

# 4.4 Profitability for Distributor

The distributor earns a commission of 9% on the revenues it generates in Bangalore for the aggregator. In doing so, the distributor incurs labor and cold storage costs. Spoilage is also observed when the truck arrives from the aggregator, depending on scenario. The resulting calculations show that the profit for the distributor triples for in-season shipments when using reefers and becomes more than four times the initial profits when using cold storage and reefers (Table 8).

## Table 8: Profitability for Distributor

| | S.no. | Profit based on one MT sold by distributor | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|---|
| Distributor level | 1. | Profit for distributor per MT shipped | 309 | 347 | 1087 | 1537 |
| | 2. | Revenues for distributor per MT shipped | 27000 | 30000 | 35000 | 40000 |
| | 3. | Distributor's margin | 1.14% | 1.16% | 3.11% | 3.84% |

# 4.5 Profitability for Retailer

Spoilage at retailers is the highest in the supply chain. A retailer earns a profit of Rs. 7,895 per tonnes when using a complete cold chain. Calculating retailer's profit is not straightforward as retailers sell many categories of items, not just kinnow. We estimated operational costs to ensure margins were about 1 percent in the base scenario overall (see Table 2 for parameters) and then adjusted these costs upwards for the intervention scenarios to take cooling and reduced space into account. The results show that the cold-chain intervention can increase the margin for the retailer (Table 9).

## Table 9: Profitability for retailer

| | S.no. | Profit based on one MT sold by retailer | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|---|
| Retailer level | 1. | Revenues/MT sold by retailer | 70,000 | 75,000 | 80,000 | 100,000 |
| | 2. | Profit/MT sold by retailer | 714 | 2,238 | 1,158 | 7,895 |
| | 3. | Retailer's margin | 1.02% | 2.98% | 1.45% | 7.89% |

# 4.6 Environmental Impact

Environmental impact is an important consideration as regards the cold chain. We considered all the activities from harvesting at orchards to the retailer in Bangalore. Even though there is further downstream spoilage in the consumers' homes, the present study is limited up to retail. The numbers for the $CO_2$ based on spoilage without cold chain are taken from the interviews and third party sources.

As with the profitability calculations, we started out with 1 tonne at the retailer and then adjusted quantities for spoilage. We also took into account the impact of the refrigerant leaked from reefer trucks. This increases $CO_2$ for the two intervention scenarios in February and March. This is because the refrigerant beingR404a, leaked refrigerant has a multiplier of 3,940 for $CO_2$ equivalence as regards greenhouse impact. We did not take the leakage from cold storage at retail because there are less moving parts at retail as compared to reefer, so the leakage is quite low compared to that associated with a reefer truck. Also, the quantity is stored for a short period in the retail store, where sometimes it is sold within a day and this reduces the impact on a per tonne basis.

Another source of $CO_2$ is the methane ($CH_4$) produced by rotting kinnow. This increases the (equivalent) $CO_2$ quantity for the scenarios with high spoilage. Estimation of the $CO_2$-equivalent emissions from spoilage is not straightforward. We have assumed 324 kg $CO_2$-equivalent per tonne of spoilage in the calculations here. This is computed as follows: we took a typical figure of 20.8 kg of methane emitted per tonne of food waste for perfectly managed anaerobic decomposition. To this we applied a methane conversion factor of 0.21, extrapolated from IPCC suggested numbers to get 4.5 kg methane per tonne of spoilage for open-dump disposal. Our reasoning is that the conversion factor recommended by the IPCC for unmanaged storage below 5 metres is 0.8 and that for unmanaged storage shallower than 5 metres is 0.4. We took 0.21 (given the state of open-dump disposal observed in this supply chain) to get 4.5 kg methane per tonne of spoilage. Next we sought to choose the $CO_2$ equivalent of methane, which varies from 72 over a 20-year period to 25 for a 100-year period. We took the impact for the shorter 20-year period given the global urgency around greenhouse gases rather than the lower 100-year number. This means the methane produced has an impact of 324 kg per tonne of rotting kinnow in our calculation.

We further assumed that 1kWh of electricity produces 1kg $CO_2$ forcoal thermal power stations as in the state of Punjab. Even though there is hydroelectric power in the state, recent power plants use coal. For transportation using diesel, we took 1 liter of diesel to produce 2.68 kg of $CO_2$. Further the cold storage at Balaji, where fruit is stored for two months, has the load of 65kWh, and taking electricity cost at Rs. 7/kWh, and assuming it runs for 10 hours a day, we calculate the units. For the environmental impact of cultivation, we assumed that 123 kg $CO_2$ is emitted per tonne of citrus fruit cultivation adapting these numbers from the cultivation of orange in Brazil.

There are second-order effects that we did not take into account owing to their impact being negligible. Rotting fruit produces $CO_2$ as well, in roughly 1:1 proportion to methane and other gases depending on aerobic or anaerobic decomposition but we ignore this given that the impact of methane is 72 times more. Another second-order effect, the emissions from transporting spoilage to open dump/landfill via diesel truck, was not included as quantities obtained turn out to be less than 1 kg $CO_2$ per tonne of kinnow retailed across the supply chain. Given the small size of the impact relative to other sources and the heroic assumptions involved in choosing among different ways such a number can be computed, we dropped this from consideration. We also mentioned not including refrigerant leakage from cold storage or pre-cooling earlier as a second-order effect relative to refrigerated trucks.

The results show that cold chain can reduce $CO_2$ emissions overall. For February the figures are readily comparable: without cold chain the emissions are 486 kg per tonne of kinnow sold in retail and with the intervention of reefer trucks, the number reduces to 408 kg. As can be expected, in-season sales and transportation in January have the least environmental impact at 403 kg, but using cold chain, off-season sales in March using cold chain have less impact at 449 kg relative to in-season sales in February without cold chain at 408 kg (Table 10; Exhibit "$CO_2$ emissions").

# Table 10: Carbon emission in supply chain

| Activity | Units | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|
| Retail quantity sold | MT | 1 | 1 | 1 | 1 |
| Spoilage (source: Gangwar et al., 2007) | % | 13.7% | 13.7% | 5% | 5% |
| Quantity purchased | MT | 1.16 | 1.16 | 1.05 | 1.05 |
| Quantity spoiled | MT | 0.16 | 0.16 | 0.05 | 0.05 |
| $CO_2$ equivalent for $CH_4$ from spoilage (4.5 kg $CH_4$ from 1 tonne spoilage, factor of 72 for $CH_4$) | kg $CO_2$ | 51.43 | 51.43 | 17.05 | 17.05 |
| $CO_2$ for cooling at retailer (1KW/MT * 24 hours * Quantity) | kg $CO_2$ | - | - | 25.26 | 25.26 |
| Transportation diesel (4+1) lts/14 km trip (Assuming 14 kms of travel: truck diesel consumption 4 lts and reefer 1 lts) | lts diesel | 0.31 | 0.31 | 0.39 | 0.39 |
| $CO_2$ for diesel consumed | kg $CO_2$ | 0.83 | 0.83 | 1.04 | 1.04 |
| | | | | | |
| Distributor quantity shipped | MT | 1.16 | 1.16 | 1.05 | 1.05 |
| Spoilage | % | 5.7% | 15.0% | 1.0% | 1.0% |
| Quantity received | MT | 1.23 | 1.36 | 1.06 | 1.06 |
| Quantity spoiled | MT | 0.07 | 0.20 | 0.01 | 0.01 |
| $CO_2$ equivalent for $CH_4$ from spoilage (4.5 kg $CH_4$ from 1 tonne spoilage, factor of 72 for $CH_4$) | kg $CO_2$ | 22.69 | 66.25 | 3.44 | 3.44 |
| $CO_2$ for cooling at distributor (Assuming 6 hours of cold storage) | kg $CO_2$ | - | - | 6.32 | 6.32 |
| | | | | | |
| Quantity transported | MT | 1.23 | 1.36 | 1.06 | 1.06 |
| Transportation diesel consumed (200 lts for AC cooling) | lts | 722.86 | 722.86 | 922.86 | 922.86 |
| Transportation $CO_2$ for diesel consumed(2.68 kg $CO_2$/lts) | kg $CO_2$ | 158.70 | 176.06 | 194.79 | 194.79 |
| Transportation leakage of R404a (Cooling unit- "Oasis 350" with 6.8 kg of R404a refrigerant with a GWP of 3940, annual leak at 11% and assuming 20 round trips) | kg $CO_2$ | - | - | 5.46 | 5.46 |
| Pre-cooling at aggregator (5 units for cooling 1MT for 6 hours) | kg $CO_2$ | - | - | 5.32 | 5.32 |
| Cold storage at aggregator (Rs 273 for cold storage/ Rs 7 per unit) | kg $CO_2$ | - | - | - | 41.47 |

| Activity | Units | Sell in cold season open truck (mid Jan16) | Sell in cold season open truck (mid-Feb'16) | Sell in cold season reefer truck (mid Feb 16) | Sell post season from cold storage and reefer truck (mid Mar 16) |
|---|---|---|---|---|---|
| Operational (Harvesting to shipment) $CO_2$ @4 kg/MT (1 person * 2 days * 2kWh/day * 1 KgCO$_2$/1kWh) | kg $CO_2$ | 4.92 | 5.45 | 4.25 | 4.25 |
| Spoilage during picking | % | 2.50% | 3% | 3% | 3% |
| Quantity harvested | MT | 1.26 | 1.41 | 1.10 | 1.10 |
| Quantity spoiled | MT | 0.03 | 0.04 | 0.03 | 0.03 |
| $CO_2$ equivalent for $CH_4$ from spoilage (4.5 kg $CH_4$ from 1 tonne spoilage, factor of 72 for $CH_4$) | - | 10.21 | 13.66 | 10.65 | 10.65 |
| Harvesting @123 kg/MT | kg $CO_2$ | 155.02 | 172.86 | 134.83 | 134.83 |
| Total $CO_2$ per MT sold at retailer | kg $CO_2$ | 403.79 | 486.56 | 408.42 | 449.89 |
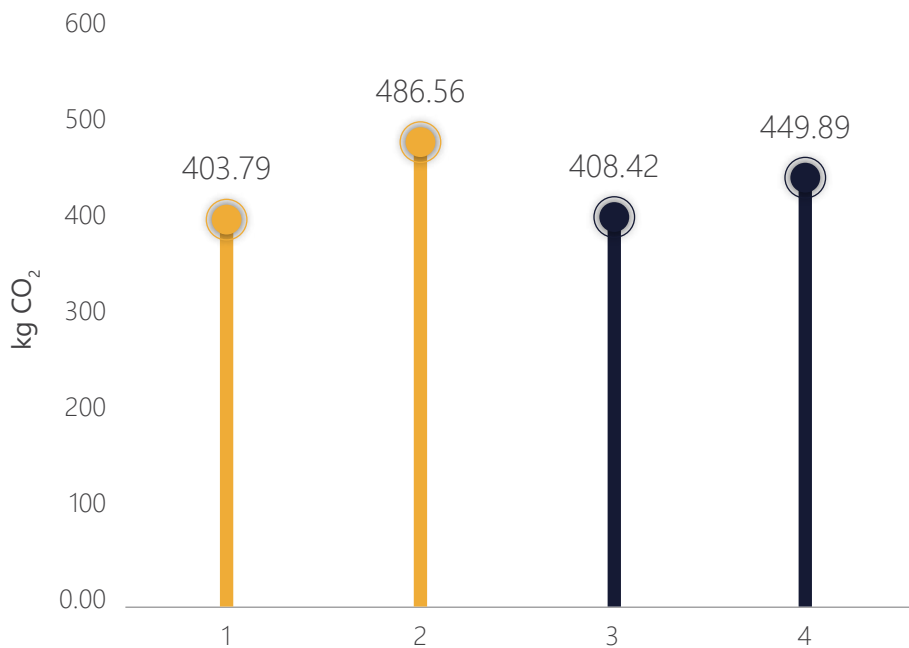


$CO_2$ emissions in the supply chain per tonne of Abohar kinnow retailed in Bangalore for the four scenarios: (1) Open trucks- January'16, (2) open trucks, mid-February'16, (3) reefer trucks, mid-February'16 and (4) cold storage and reefer trucks, March'16.

# 5.
# IMPLICATIONS

For the specific supply chain, we studied, cold chain investment is beneficial to all of the stakeholders. These findings can be summarized as follows:

- As an aggregator using the cold chain, Balaji benefits a great deal, getting attractive payback periods for the investments needed. Making the cold storage part of a cold chain greatly reduces the payback period thus unlocking value in a highly capital intensive investment.

- Transporting the supply to Bangalore in reefer trucks reduces spoilage of the fruit supply and prevents considerable losses to aggregators. Investment in reefer trucks is profitable for a transporter with a fairly short payback period.

- For the aggregator's investment of Rs.40 lakhs in pre-cooling, the payback period is only 2.3 years. For an investment of Rs. 4crore in cold storage, the payback period for aggregator is 16 years in the base mode without kinnow (with cold storage space rented for other fruits and vegetables) but reduces to only 9 years when this cold storage becomes part of the kinnow cold chain using reefers and pre-cooling.

- Commission-based distributors in the supply chain also increase their profitability and margins by becoming part of the cold chain.

- For the transporter, an investment of Rs 29.5 lakhs in reefer trucks gets paid back in just above 4 years.

- Note that we did not assume any government incentives that are available – these would only further the attractiveness of the investment.

Therefore, there is a strong business case for all the stakeholders to invest in the cold chain for supplying kinnow to Bangalore in off-season. This is not just hypothetical: we have already seen that Balaji have moved from renting to purchasing reefers along with investing a considerable amount in pre-cooling. The distributors and retailers at the Bangalore end are strong advocators for cold-chain for kinnow supply and one distributor had already made considerable investment in reefers and cold storage while the other one was beginning to invest in cold chain towards the end of this study.

This type of profitability analysis can be readily extended to other fruits and vegetables. In general, for other supply chains with other origins and destinations and other fruits and vegetables, our approach shows one way to do profitability analysis for all the commercial entities in the supply chain. We have developed a generic framework for any fruit or vegetable for estimating the business case for an aggregator. For quantity, any applicable volume-or weight based unit can be used (kg, case, crate, etc.). These calculations assume operating costs and the resulting operational profits can allow computation of payback period on investment in cold storage, pre-cooling and reefer trucks. As in our approach, the calculations can take all these activities at each level in the supply chain and for different scenarios: (1) – In the peak season, with no cold chain intervention, (2) – Towards the end of season, with no cold chain intervention, (3) – Towards the end of season and using reefer trucks for transportation and (4) - Out of season, with complete cold chain i.e. cold storage and reefer trucks. The spoilage content at different levels of supply chain needs to be considered carefully: in our reading of the literature, these numbers based on overall estimates can vary quite a bit so it is worthwhile examining stage-by-stage spoilage from the farmer to the retailer. See the **Appendix** (Table A1) for a generic model for the different considerations to include (or not) in any scenario.

The process to decide whether cold chain is viable or not for a specific crop can be the following:

1. Identify crop volume and cold infrastructure that would be needed and when

2. Assess holding life extension of the fruit/ vegetable using cold storage

3. Identify potential new markets reach with cold chain – in-season with pre-cooling and reefer and off-season with cold storage and then shipment with reefer trucks

4. Assess crop potential on those new markets in terms of prices

5. Apply the cold chain framework provided above to determine operational profitability and payback period of the investment

6. Rollout the cold in a structured manner (starting from the field with pack house to the reefer), keeping in mind that the cold chain unlocks the value of the investment when used in its entirety from the pack-house to the retailer.

The Appendix (Table A2-1-A2-4) provides a framework for calculation of payback periods for any aggregator investing in cold chain (pre-cooler and cold storage) and payback period for a transporter wishing to invest in reefers (Table A2-5).

Besides the implications for aggregators, distributors and transporters, there are implications for farmers and the government. Our interviews with farmers clearly pointed to price and its volatility as a major challenge. Cold chain has the potential for increasing volume of flows, which will result in better returns for farmers. Improved quality results in better prices too. With contract farming, prices could be settled in advanced, thus lowering price volatility as well. Moreover, as the government – encouraging creation of cooperatives FPOs, then these can reap the same benefits as aggregators as shown in our study. NCCD has frequently highlighted that the benefits really come through when the cold chain is an integrated chain of activities all the way from the farmer to the retailer. Therefore, any incentives by way of subsidies should be designed taking a supply-chain perspective.

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# APPENDIX: A GENERIC FRAMEWORK FOR COLD CHAIN INVESTMENT

## Table A1: Generic model for evaluating supply chain surplus on fruits and vegetable

| Level | S.no. | Activity for one MT sold by retailer | Peak season - No intervention | End of season : No intervention | End of season : Reefer truck | Off season: Cold storage and reefer |
|---|---|---|---|---|---|---|
| Retailer level | 1. | Retailer's revenues | Revenue from one unit quantity sold, for example, 1 MT or 1Kg, etc. | | | |
| | 2. | Spoilage | Spoilage at retailer level | | | |
| | 3. | Quantity purchased | Quantity purchased at retailer | | | |
| | 4. | Operational costs for retailer | Operational costs for retailer | | | |
| | 5. | Procurement cost adjusted for spoilage/Revenues from distribution | If retailer had to purchase 1.1 units to sell 1 unit (adjusting for wastages) the procurement cost of 1.1 units will come here | | | |
| Distributor level | 6. | Spoilage from transportation/ distribution | Spoilage from transportation/distribution | | | |
| | 7. | Quantity received | Quantity received by the distributor from the aggregator | | | |
| | 8. | Distributor's commission | Distributor's commission, e.g., 9% of the aggregators' revenues from selling to the retailer | | | |
| | 9. | Labour cost | Labour cost at distributor level | | | |
| | 10. | Cold storage cost | Cold storage cost at distributor level | | | |
| Aggregator Level | 11. | Quantity transported | The quantity the aggregator has to sell so that the retailer is able to sell one unit after adjusting for wastages at each stage | | | |
| | 12. | Transportation cost | Transportation cost | | | |
| | 13. | Spoilage at orchard and pack-house | Post-harvest spoilage at orchard and pack-house | | | |
| | 14. | Quantity purchased | The quantity the aggregator has to buy so that the retailer is able to sell (for E.g. 1 MT or 1Kg) after adjusting for wastages at each stage | | | |
| | 15. | Procurement cost | Procurement cost | | | |
| | 16 | Operational cost (Harvesting till shipment) | Cost of all operations, primarily labour and transportation from harvest to pack-house | | | |
| | 17. | Pre-cooling cost | Pre-cooling cost | | | |
| | 18. | Pre-cooling loading and unloading cost | Labour-related pre-cooling loading and unloading cost | | | |
| | 19. | Cold Storage cost | Cold storage cost of electricity | | | |
| | 20. | Cold Storage loading and unloading cost | Labour-related cold storage loading and unloading cost | | | |

| TABLE A2-1: Investment-related costs for pre-cooler | Units |
|---|---|
| Pre-cooler capital cost | Rs |
| Installation | Rs |
| Monthly Installment for capital cost: X% for Y years | Rs |
| Months of pre-cooler usage with one batch per day | Months |
| Total quantity processed per year @ X MT/per batch | MT |
| Monthly Installment / MT | Rs |
| Monthly Installment / MT sold in 3rd scenario (End of season : Reefer truck) | Rs |
| Monthly Installment / MT sold in 4th scenario (Off season: Cold storage and reefer) | Rs |

| TABLE A2-2: Fixed costs for cold storage | |
|---|---|
| Cold storage capital cost | Rs |
| Monthly Installment for capital cost: X% for Y years | Rs |
| Capacity | MT |
| Capacity Utilization @ X % | MT |
| Inventory turnover | per year |
| Total MT processed/month | MT |
| Monthly Installment / MT | MT |
| Monthly Installment / MT sold in 4th scenario (Off season: Cold storage and reefer) | Rs |

| Table A2-3: Payback for pre cooler | |
|---|---|
| Cold storage capital cost | Rs |
| Installation | Rs |
| Total investment | Rs |
| Annual costs including depreciation @X % / month | Rs |
| Operating profit per MT | Rs |
| No. of reefers shipped per year to Bangalore | No.s |
| Quantity shipped in year @ 13.5 MT/reefer | MT/year |
| Annual operating profits | Rs/year |
| Annual profits net of depreciation and maintenance | Rs/year |
| Payback in years | years |

| Table A2-4: Payback for cold storage | |
|---|---|
| Cold storage capital cost | Rs |
| Installation | Rs |
| Total investment | Rs |
| Annual costs including depreciation over X years | Rs |
| Operating profit per MT of kinnow | Rs |
| No. of reefers shipped per year to Bangalore | No.s |
| Quantity shipped in year @ 13.5 MT/reefer | MT/year |
| Annual operating profits from kinnow | Rs/year |
| Annual revenues from renting space for other produce | Rs/year |
| Cost of electricity | Rs/year |
| Annual operating profits from renting space for other produce | Rs/year |
| Annual profits net of depreciation-other produce only | Rs/year |
| Annual profits net of depreciation - including kinnow | Rs/year |
| Payback in years without kinnow | years |
| Payback in years with kinnow | years |

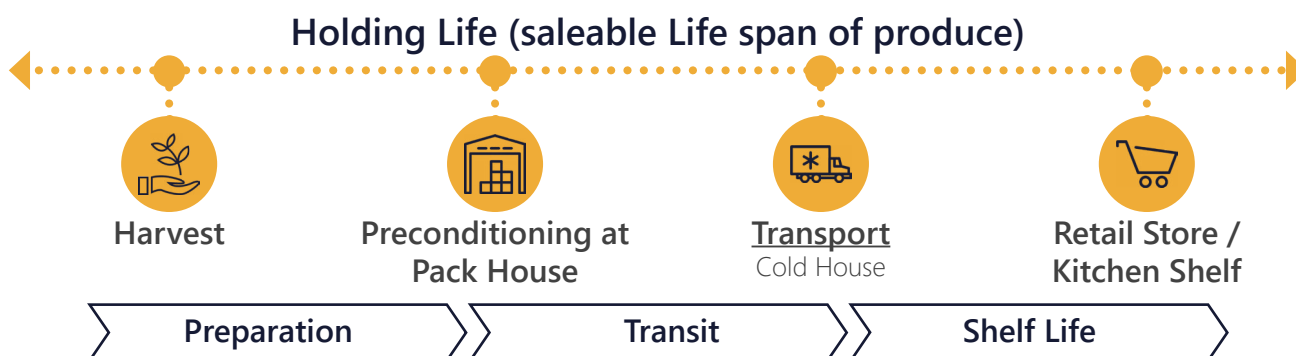| TABLE A2-5:  Payback period calculation for Transporter | |
|---|---|
| **Fixed costs (13.5 Ton)** | **Rupees** |
| Chassis | |
| Cabin + Insulated Body (box) | |
| AC unit | |
| Total Fixed Cost | |
| Revenues | |
| Revenue from outbound journey | |
| Return trip revenue percentage | |
| Revenue per return trip | |
| No. of trips/month  per truck to destination | |
| Revenue per month | |
| No. of months of truck usage in one year | |
| Revenues in one year | |
| Yearly costs | |
| Monthly Driver + helper compensation | |
| Annual Driver + helper | |
| Annual Insurance | |
| Annual Depreciation | |
| Fuel cost for a reefer truck: From - To | |
| Annual fuel cost depending upon the trips | |
| Total annual costs | |
| Profitability and payback | |
| Profits in one year | |
| Payback in years | |

# GLOSSARY OF COLD-CHAIN

## The common terminology of cold-chain and terms used for the purpose of this study are given as under:

1. **Cold-chain:** An environment controlled logistics chain, ensuring uninterrupted care from source-to-user, consisting only of storage and distribution related activities in which the inventory is maintained within predetermined ambient parameters. Cold-chain does not alter the essential characteristics of the produce or product handled. Cold-chain is not just about the "cold" but that it refers to all logistical process applied, to maintain multiple parameters, during the pre-conditioning, handling, transport, storage and retail of products. The cold-chain includes varied aspects of packaging, atmospheric gases, biology, injury, humidity, traceability, infrastructure, people & product flow, besides temperature. In fact, temperature control can only work with all others in synch

2. **Pack-House:** A modern infrastructure with facilities for conveyer belt system for sorting, grading, washing, drying, weighing, packaging, pre-cooling and staging. Modern pack-houses are the first step in organised post-harvest management for horticulture, and are in effect the first mile sourcing points for this sector. A modern integrated pack-house unit enables small lot sourcing of horticulture produce, and should be built close to farm-gate.

3. **Refrigerated Transport:** The refrigerated transport system, with an insulated carrier and equipped with active refrigeration, designed for temperature controlled carriage of perishable products. This can include refrigerated trucks (reefer trucks), vans, rail, containers and ships for transporting perishable products.

4. **Storage:** Static infrastructure designed with insulated and refrigerated chambers for long term or transient storage of whole fresh, ready-to-retail, or processed forms of perishable products.

5. **Pre-Cooling Unit:** A specialized cooling system designed to rapidly remove field heat from freshly harvested produce and thereby prepares the cargo for subsequent travel in the cold-chain. A Precooling unit can be in the form of forced-air cooling, hydro cooling, vacuum cooling, room cooling, icing, etc. Precooling or post-harvest cooling is the heart of a modern pack-house and is one of the key steps in preparing fruits and vegetables for the extended cold-chain.

6. **Sorting:** The activity at source when produce is assorted into target lots basis qualitative criteria viz. as non-edible, as reject or dump, by quality, by shelf-life, by market value, etc. It is the first stage categorisation of received produce and separates them into differentiated value-based flow towards an ascertained and useful end-use. Thus, the process of sorting is key to direct the flow of collected produce into existing and multiple value-based productive use.

7. **Grading:** The activity at source for physical segregation of goods into optimal packing lots, after undergoing initial sorting. It is a pre-cursor to effective packaging, performed such that the space in a unit package can be maximised for safe carriage, and leads to efficient shelf space utilisation and graded shelf presentation.

8. **Cold Room (Staging):** An insulated and refrigerated chamber which serves as a transient staging space, and is a necessary attachment to a Pre-Cooling Unit. Appended to pre-coolers, a staging cold room frees the pre-cooler space for the sequential batch of incoming freshly harvested produce. This component is typically installed at farm-gate as part of a modern pack house, and temporarily stores preconditioned fresh produce, awaiting transport link to a distribution point (a cold store close to market).

9. **Cold Storage (Bulk):** Environment controlled warehousing space with multiple chambers intended for the bulk storage of perishable produce. It is designed for long duration storage of produce so as to build an inventory buffer which will serve to smoothen the episodic production by stabilising & sustaining the supply lines. These are normally constructed in areas close to producing areas (farm-gate) to facilitate quick access to producers for a selective set of crops only.

10. **Cold Storage (Hubs):** Environment controlled warehousing space with multiple temperature zones for functioning as a distribution hub. It is designed for short term handling of products so as to serve as a distribution logistics platform for market ready packaged produce and ready to retail products. Cold storage (Hubs) are key to effective distribution of perishable foods and essentially at the front end of the cold-chain, constructed close to consuming centres.

11. **Reefer Vehicles:** Road transport vehicles with a fixed insulated body equipped with active refrigeration designed for environment controlled carriage of products. These are effectively cold rooms on wheels – or mobile cold stores. The refrigeration on long haul trucks is powered through integrated diesel driven motors, independent of the main truck engine. In case of small vehicles, the use of direct drive systems linked to the vehicle engine or battery powered refrigeration is the norm. Normally Reefer trucks incorporate GPS based location tracking system and are installed with data logging temperature and humidity sensors.

12. **Batch-Load:** A capacity measurement utilised when the infrastructure is used to sequentially throughput goods after a time based activity or procedure. Usually used for pack-houses where the pre-coolers operate to cool a few tons of produce at a time, in multiple runs or batches per day. For example, a pre-cooler with holding volume of 5 tons can output 15 tons of conditioned vegetables if operated every 6 hours for three times in a day. The batch load in this case would compute to 5 tons/batch in 3 batches/day, or 15 tons per day. Similarly, in case of sorting and grading lines, the batch load is assessed in the volumetric throughput – or tons per hour or per day.

13. **Holding Life:** Also called Product Life, refers to the Saleable Life Span of a product. In case of Fresh produce, this commences at harvest and extends until the produce perishes. In case of processed food products, this is initiated after the manufacturing process and extends up to the predetermined expiry date. Holding life is divided into time spent in each activity in the supply chain, with Shelf Life being the time spent in the front end, on shelf.

### Holding Life (saleable Life span of produce)



| Harvest | Preconditioning at Pack House | Transport Cold House | Retail Store / Kitchen Shelf |
|---|---|---|---|
| Preparation | Transit | | Shelf Life |

The holding life of produce is extended with cold-chain, creating more opportunity for producers by expanding the range and accessibility to markets.

# A kinnow supply chain study
## 2016