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COST-BENEFIT AND EFFECTIVENESS OF REFRIGERATED TRUCKS FOR TRANSPORTATION AND MARKETING OF FRESH PRODUCE

COLD CHAIN BANGLADESH ALLIANCE (CCBA) REPORT

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COST-BENEFIT AND EFFECTIVENESS OF REFRIGERATED TRUCKS FOR TRANSPORTATION AND MARKETING OF FRESH PRODUCE

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Introduction

This study has been conducted combining a quantitative and qualitative approach. Real-time data on harvesting and post-harvest handling were collected directly from the farmers' fields, collection points, refrigerated vans and local transport, and wholesale markets. The data was used to assess the comparative costs and returns of using refrigerated logistics and plastic crates in comparison with the existing conventional logistical arrangements for moving produce from field to market.

Three shipments of produce were followed through the marketing channels on May 16, 18, and 21, 2015. The consignments included three commodities: eggplant, bitter gourd, and pointed gourd. The produce was collected from two community level collection centers established by the USAID-funded Cold Chain Bangladesh Alliance (CCBA) located in Hurgati and Birnarayanpur, both in Jessore, and transported to a wholesale market in Khulna (Shonadanga) and a wholesale market (Karwan Bazaar) in Dhaka. The Shonadanga Market in Khulna is the largest divisional wholesale vegetable market in Bangladesh, while the Karwan Bazaar is the largest vegetable wholesale market in Dhaka, Bangladesh's largest city. The Karwan Bazaar is located about 345km from the collection centers and the Shonadanga Market is about 75km from the collection centers.

Two types of transportation and handlings systems were used for comparison. A refrigerated truck with the capacity of roughly 3 metric tons was loaded with produce packed in plastic crates. The refrigerated truck can carry 240 crates per load. Each crate holds a slightly different weight of the varied types of produce, on average 13.5kg. Alternatively, the typical local open transportation option, known as a *nosimon*, carries produce in 200kg capacity baskets and has a rough total capacity of 1 metric ton. The *nosimon* is used for conventional shipments to Khulna and a large open back truck was used for the shipments to Dhaka.

While the number of samples was extremely limited, it appears that the use of refrigerated trucks may offer benefit when transporting fresh produce to the more distant markets, with fewer opportunities in the geographically proximate markets. The current analysis does not offer any significant opportunities between the different crops. That said, there are still losses occurring due to breakdowns in the cold chain. In fact, the losses could be higher during periods of significant market volumes because the product shelf-life is shortened due to high temperature and relative humidity, and delays in selling the products result in lower quality product.

Background

One third of all food produced globally is lost or wasted. According to Food and Agriculture Organization (FAO), 1.3 billion tons of food is lost or wasted every year (Gustavsson et al., 2011). Although available data on food loss and waste for developing countries has been estimated in the range of 20-50 % (Kader), in South Asia the range is 8-40% and in Bangladesh, the loss is 8-25%, which is slightly less than the post-harvest losses in India (30%) and Sri Lanka (40%) (Acedo and Easdown, 2012). In the United States, in 2010, an estimated 31% of the 430 billion pounds of food produced was not available for human consumption at the retail and consumer levels. The top three food groups in terms of share of total value of food loss were meat, poultry, and fish (30 percent, \$48 billion); vegetables (19 percent, \$30 billion); and dairy products (17 percent, \$27 billion). (Buzby et al, 2014). Understandably, products having the attributes of high perishability would lose their life of usability without proper transportation and storage. The lack of access to cold chain system, starting from farm gate, all the way to processing and retail outlets of the goods until is being used by the consumers is one of the major reason of high losses in Bangladesh and elsewhere.

The Bangladesh Agriculture Development Corporation, a government subsidiary, bought refrigerated trucks and established cold storages for perishables products, but is not profitably operated. The Hortex Foundation, an export promoting body established by the Government of Bangladesh, has also procured several refrigerated trucks to support vegetables exporters without much success due to lack of commercial viability. However, why the cold chain is not being used or adopted extensively, in spite of availability and establishment of certain cold chain infrastructures both in the private and in public sectors, remained a big question. Moreover, no study has yet been undertaken to find out the real cause of non-use or non-utilization of the existing facilities in the context of high level of post-harvest losses. Considering the situation, the present study was undertaken to find out the real cause of non-use of refrigerated trucks for transporting fresh vegetables to super-shops and wholesale market.

The Cold Chain Bangladesh Alliance (CCBA) is a project funded by the United States Agency for International Development (USAID), aiming to reduce post-harvest losses at the field and further throughout the whole value chain until the perishables reaches to consumers.

Cost-Benefit

Over the three shipment days, there were eight product samples sent to Khulna between two days, and six product samples sent to Dhaka on one day.¹ Four of the product samples destined for Khulna were shipped by refrigerated trucks and packed in crates, while the other four were sent using the existing conventional means of *nosimon*, using 200kg baskets. Eggplant samples

¹ The full cost-benefit data for each sample is provided in Appendix 2.

were shipped on two different days; only one sample each of bitter gourd and pointed gourd were shipped and moved to market on the same day, along with one of the eggplant samples.

One refrigerated truck using crates, and one conventional open back truck using traditional baskets, each took samples of eggplant, bitter gourd, and pointed gourd to Dhaka.

Table 1: List of shipments by date, type of logistics system, product, and destination market

Date	Logistics System	Product	Destination
5/16/15	Refrigerated Truck	Eggplant	Khulna
5/16/15	Conventional Transport	Eggplant	Khulna
5/18/15	Refrigerated Truck	Eggplant	Khulna
5/18/15	Refrigerated Truck	Bitter Gourd	Khulna
5/18/15	Refrigerated Truck	Pointed Gourd	Khulna
5/18/15	Conventional Transport	Eggplant	Khulna
5/18/15	Conventional Transport	Bitter Gourd	Khulna
5/18/15	Conventional Transport	Pointed Gourd	Khulna
5/21/15	Refrigerated Truck	Eggplant	Dhaka
5/21/15	Refrigerated Truck	Bitter Gourd	Dhaka
5/21/15	Refrigerated Truck	Pointed Gourd	Dhaka
5/21/15	Conventional Transport	Eggplant	Dhaka
5/21/15	Conventional Transport	Bitter Gourd	Dhaka
5/21/15	Conventional Transport	Pointed Gourd	Dhaka

Key data points collected for the cost/benefit analysis included quantity shipped, total shipping cost (transportation cost), cost of unloading at destination market (the farmers assisted in loading the trucks), average price obtained for the crop, and unsold quantity (unsold due to damage/loss). Using this information, the cost/benefit of using refrigerated transport with plastic crates can be assessed versus the conventional open transport and traditional basket packing.

Table 2: Cost-benefit by crop²

	Eggplant	Bitter Gourd	Pointed Gourd
Average net margin - conventional	14.50	16.40	11.41
Average net margin - refrigerated	14.89	16.61	11.47
Net difference	0.39	0.20	0.06
% difference	3%	1%	1%
Average loss - total	7%	6%	10%
Average loss - conventional	10%	9%	17%
Average loss - refrigerated	4%	1%	2%

² In Bangladesh Taka (BDT)

Considering the average net revenue³, while eggplant had the highest average return of the refrigerated truck over conventional with a 3% increase in revenue compared to the 1% increase of bitter melon and pointed melon, the difference was insignificant and likely not worth the increased cash cost of the transport. This average includes all samples of each crop, regardless of destination market. The average cost per kilogram of conventional, open back transport using the bamboo baskets was 2.25 BDT/kg while the refrigerated truck, packed in plastic crates was 4.92 BDT/kg, 119% more.

While the difference between crops is insignificant and does not show interesting benefit over the costs, the difference between markets shows some marked differences.

Table 3: Cost-benefit by destination market⁴

	Khulna	Dhaka
Average net margin - conventional	19.44	7.12
Average net margin - refrigerated	19.10	8.15
Net difference	-0.35	1.03
% difference	-2%	14%
Average loss - total	3%	12%
Average loss - conventional	6%	19%
Average loss - refrigerated	0%	6%

Across all of the crops, the average net margin of refrigeration (with plastic crates) over the conventional logistical method, was actually a -2% margin difference into the Khulna market over the 14% margin improvement into the Dhaka market. The Khulna market is only about 75km from the collection center, while the Dhaka market is about 345km. While there was no loss from the use of the refrigerated truck with plastic crates into the Khulna market, there was an average of 6% loss using the refrigerated truck with crates into the Dhaka market; and there was 19% loss average into the same Dhaka market using the conventional logistical methods. Transport cost differences between the refrigerated truck with crates and the existing practice of *nosimon* with baskets, for the Khulna market, and the open back truck with baskets, for the Dhaka market were also different between the destinations. Using the refrigerated truck to transport to Khulna cost 114% more than the cost of the *nosimon*, while the refrigerated truck cost 122% more than the open back truck into the Dhaka market.

³ The net margin is calculated by the quantity sold multiplied by the average price minus the cost of transport plus the unloading cost. An average across all the samples of each crop was used for this crop by crop comparison.

⁴ In Bangladesh Taka (BDT)

Table 4: Losses from the samples destined for Dhaka

Date	Logistics System	Product	Destination	% loss
5/21/15	Conventional Transport	Bitter Gourd	Dhaka	10%
5/21/15	Conventional Transport	Eggplant	Dhaka	16%
5/21/15	Conventional Transport	Pointed Gourd	Dhaka	30%
5/21/15	Refrigerated Truck	Bitter Gourd	Dhaka	1%
5/21/15	Refrigerated Truck	Eggplant	Dhaka	13%
5/21/15	Refrigerated Truck	Pointed Gourd	Dhaka	4%

The day that the samples went into the market in Dhaka was a period with substantial product supply and large unsold volumes. The quantities unsold were either sorted out from transport damage, as in the case of the conventional transport, or were product which experienced significant deterioration over the course of sitting in the open air throughout the night market. The product from both trucks arrived at the market at 1am and was sold slowly until what remained in very poor condition and was considered a loss at 7am, as the market closed.

In the conventional system destined for Dhaka, the product is packed in jute bags with a rigid bamboo basket making up the base and the lower sides. These baskets/sacks are loaded into an open backed truck and may be moistened, if the heat is significant. The roads are uneven and the product is packed tightly to avoid significant jostling. Often the traders or owners of the product will travel with their product in the back of the vehicle or riding on top of their product. This accounts for the physical damage and loss of product in the conventional system.

In the refrigerated truck, the product damage and loss came from changes in temperature and the breaking of the cold chain upon arrival at the open air market. The specific temperature changes are noted in the subsequent section documenting the post-harvest handling and temperatures, but resulted in soggy and unsalable product by the closing of the market the following morning.

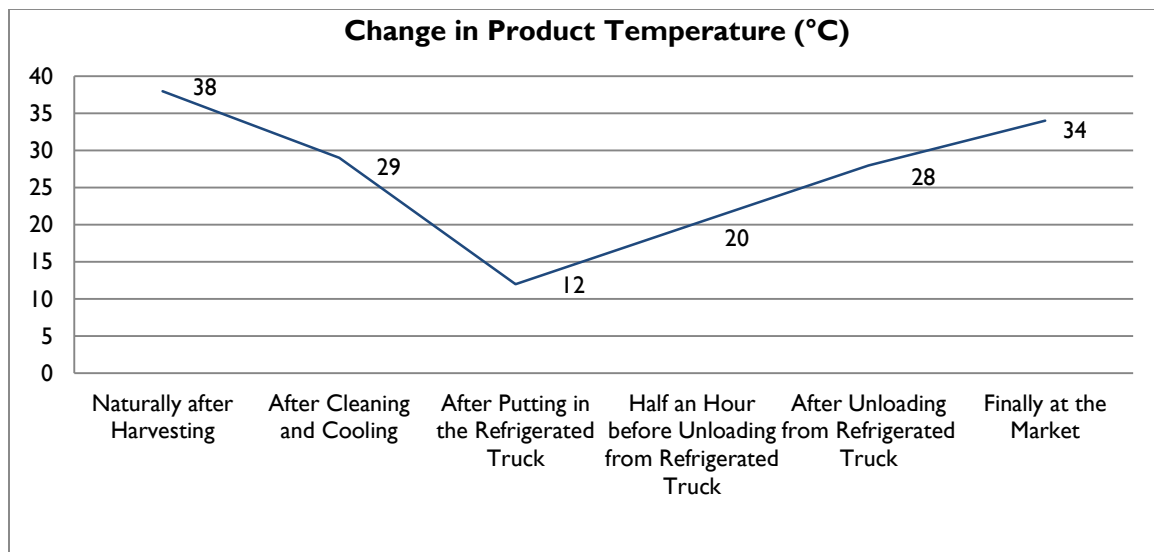
In summary, the number of samples is extremely limited, but it appears that the use of refrigerated trucks may offer benefit into the more distant markets. The current analysis doesn't seem to offer any significant opportunities between the crops though. That said, there is still loss occurring due to the breaking of the cold chain, and in fact the loss may be higher during periods of significant market volumes because the product shelf-life may actually be reduced and delays in marketing may result in lower quality product.

Post-Harvest Handling and Temperature

The produce was harvested, packed into crates, and transported to the collection centers, where the commodities of all producers went through postharvest handling process. The produce was sorted, cleaned, and graded based on size, quality, and maturity, weighed, pre-cooled, and

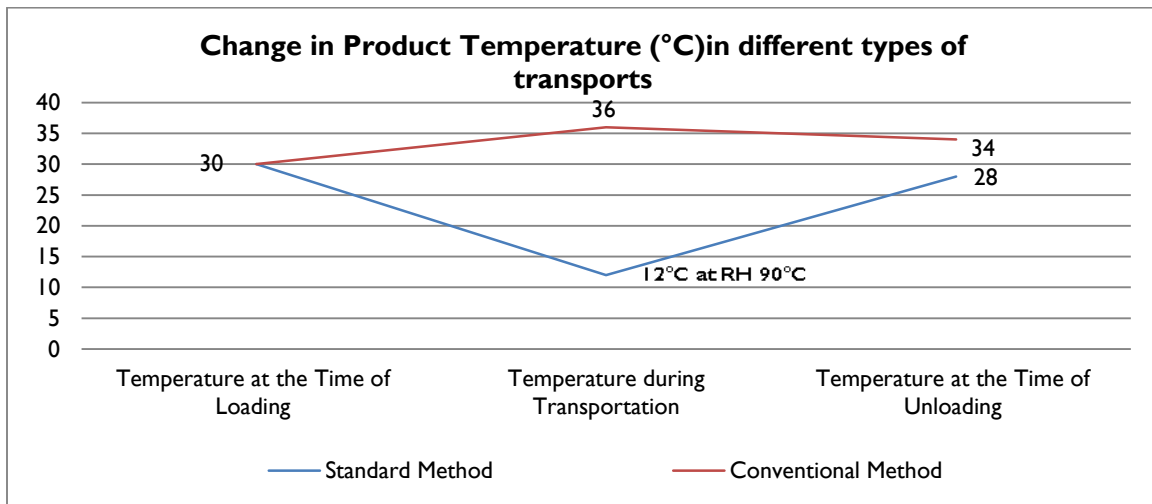
stacked in crates. Field heat of the produce was removed initially by keeping the harvested produce under shade followed by water-cooling, in the case of eggplant and pointed gourd. In general, the ambient temperature at collection centers during the time of packing ranged from 34°C to 38°C; the product internal temperatures were brought down to about 29°C through pre-cooling. The temperature was measured accurately with a temperature probe, inserted into a produce sample. Immediately after loading the crates into the refrigerated truck, the cooling system was turned on and the temperature of the cooling chamber came down slowly to 12°C. A half an hour before unloading the commodity from the refrigerated truck, the temperature of the truck interior was slowly raised to 20°C. After unloading from the refrigerated truck, the product temperature was 28°C and finally at the market place, the temperature was 34°C.

Table 5: Ambient and product temperatures of the refrigerated truck from collection center to wholesale market



In the shipment on May 16th, eggplants were harvested and packed at the Hurgati collection center and shipped to the Shonadanga Market in Khulna. The eggplants arrived at the collection center from the field at 9am. The ambient temperature was 30°C and the eggplants were pre-cooled to 26°C using water. Both the refrigerated truck and the conventional *nosimon* departed the collection center at 12:30pm after being packed. The refrigerated truck arrived at Shonadanga at 2:00pm and the *nosimon* arrived at 2:40pm, taking an additional 40 minutes in transit. The product in the *nosimon* rose to 36°C, having traveled in direct sun. The refrigerated truck product reached 12°C in transit; the temperature was slowly raised to 28°C prior to unloading, and ultimately acclimated to the ambient temperature of the open air market at 34°C.

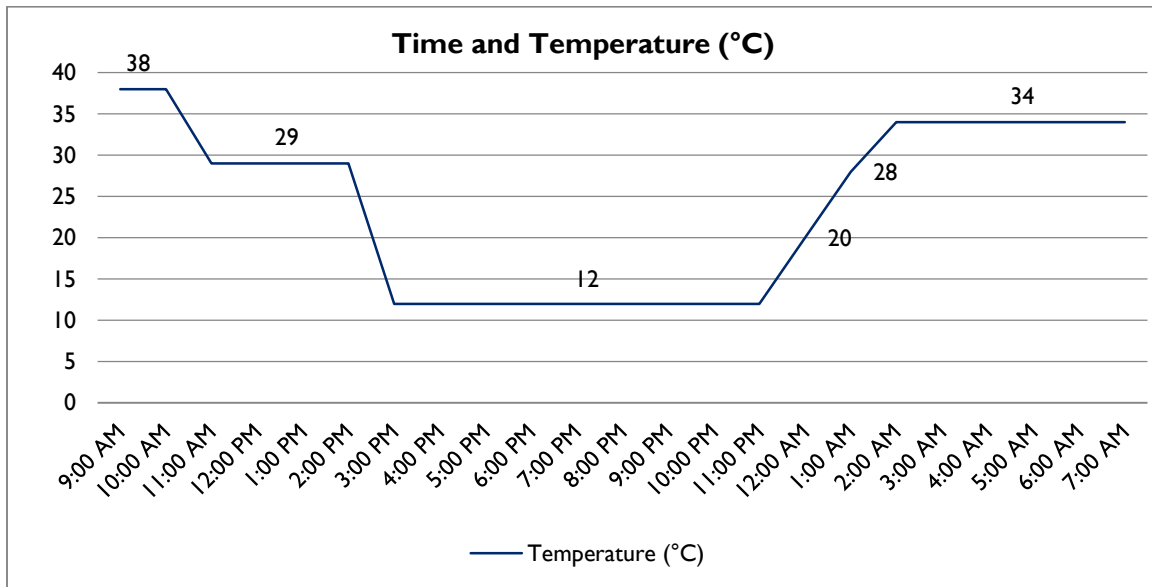
Table 6: Change in product temperature in different models of transport systems



The refrigerated truck does not allow individuals to travel inside the closed truck and thus farmers and/or traders must pay for separate transport if they are to accompany their produce. Alternatively, the owners of the produce (farmers and/or traders) usually accompany their produce on the *nosimon* and travel for free; but cause physical damage through their weight and jostling of the product.

In the shipment to Dhaka on May 21st, the produce was harvested and packed at two separate collection centers, eggplant in Hurgati and bitter gourd and pointed gourd at Birnarayanpur. The crops arrived from the field at the collection centers respectively at 10:30am and 9:00am. The ambient temperature in Jessore was 38°C. The temperature of the product was reduced to 29°C through pre-cooling. The product was packed by 12:00pm and trucks started for Dhaka at 2:00pm. The distance from the collection centers to Karwan Market in Dhaka was 345km. The transit included the ferry crossing of the River Padma. The complete transit time was 11 hours, which included the 25-minute wait for the ferry, the one-hour ferry ride, and the time spent waiting on the outskirts of Dhaka for permission to enter the city and reach the market (specific to trucks entering the city for night markets.) The market ambient temperature was 34°C overnight.

Table 7: Time and ambient temperature for product moved in a refrigerated truck from collection center to Dhaka



Conclusion

The study included three consignments that provided some initial analysis of cost-benefit of different transport and packing methodologies, comparison of shipping to different markets, and the effect of breaks or gaps in temperature control. The study shows that when produce is shipped to geographically near markets, including Khulna, the net revenue increase from the use of refrigerated trucks and crates was insignificant while the overall transport cost increased significantly, requiring a large upfront cash outlay.

In case of selling the produce at the capital city, the overall loss between the refrigerated truck and crates, and the conventional transport system was less, although not eliminated; and the net margin increase was 14%, even with the significantly higher transport costs. However, as the produce, which had been transported under refrigeration, sat in the open air overnight, during the marketing period, the quality deteriorated as time progressed due to an increased loss of internal water. The commodities were offloaded from the controlled temperature environment at a wholesale market temperature of 34-35°C and then sat for up to six hours waiting for sale. The produce was visibly soggy as a result, and ultimately some quantity remained unsold and was a loss. This signifies the importance of implementing complete cold chain management throughout the supply chain to ensure its viability.

In all three consignments, the refrigerated truck returned to its original point with empty crates and no load due to the unavailability of suitable backhaul to Jessore. If suitable commodities can be sourced for a backhaul to the origin, the cost will be significantly reduced and this could facilitate establishment of efficient distribution channel using cold supply chain.

The study reiterates the importance of establishment of cold supply chain with proper storage facility, harvesting high value products at right time, proper precooling to remove field heat, a fleet of refrigerated vans with standard capacity that will run back and forth with fully loaded products, use of standard crates and retail outlets with proper display refrigerators. However, since retail outlets having refrigerated storage is limited; only a very small fraction of fresh commodities are sold through these super shops, the whole sale market are not temperature controlled and there is no cold storage facility at the whole sale markets. The conventional system will win over the cold chain. This also calls for central temperature controlled warehouse at Dhaka and other locations.

Appendix I: Materials used for the study

Materials	Purpose
Crates	For bringing the produce from the field to Collection Center, packaging and transporting to the market which helps prevent the commodity from being damaged
Bamboo basket	For transporting the produce from the Collection Center to markets in conventional system for comparative analysis
Potable water from 100 ft. deep tube well	For fresh water supply to clean the produce as well as to apply pre-cooling method
Temperature probe	Measure the temperature of the produce to calculate
Grading table	For grading and sorting the produce according to its size and quality to facilitate customized packaging
Refrigerated trucks	For transportation of freshly harvested vegetables from the market to keep the produce fresh during transportation period
Local transport <i>nosimon</i> (open small trucks)	For transporting the produce in the conventional method from the field to Shonadanga wholesale market for comparative analysis.

Appendix 2: Cost-benefit data

Cost per kilogram shipped

Date	Logistics System	Product	Destination	Kilograms shipped	Total Transport Cost	Total Unloading Cost	Total Cost	Cost/kg shipped
5/16/15	Refrigerated Truck	Eggplant	Khulna	2,760	6,603	1,200	7,803	2.83
5/16/15	Conventional Transport	Eggplant	Khulna	2,760	4,200	840	5,040	1.83
5/18/15	Refrigerated Truck	Eggplant	Khulna	2185	5,522.60	2,336.78	7,859	3.60
5/18/15	Refrigerated Truck	Bitter Gourd	Khulna	624	1,577.16	667.35	2,245	3.60
5/18/15	Refrigerated Truck	Pointed Gourd	Khulna	27	68.24	28.88	97	3.60
5/18/15	Conventional Transport	Eggplant	Khulna	1800	2100	630	2,730	1.52
5/18/15	Conventional Transport	Bitter Gourd	Khulna	450	525	157.5	683	1.52
5/18/15	Conventional Transport	Pointed Gourd	Khulna	150	175	52.5	228	1.52
5/21/15	Refrigerated Truck	Eggplant	Dhaka	1461	9,200	954	10,154	6.95
5/21/15	Refrigerated Truck	Bitter Gourd	Dhaka	1209	7,613	790	8,403	6.95
5/21/15	Refrigerated Truck	Pointed Gourd	Dhaka	270	1,700	176	1,877	6.95
5/21/15	Conventional Transport	Eggplant	Dhaka	1460	3,638	933	4,570	3.13
5/21/15	Conventional Transport	Bitter Gourd	Dhaka	1200	2,990	767	3,756	3.13
5/21/15	Conventional Transport	Pointed Gourd	Dhaka	270	673	173	845	3.13

Revenue and percentage loss

Date	Logistics System	Product	Destination	Quantity Sold	Unsold Quantity	Average Sales Price	Total Revenue	Total Net Revenue	Net Revenue / kg shipped	% loss
5/16/15	Refrigerated Truck	Eggplant	Khulna	2,760	0	23	63,480	55,677	20.17	0%
5/16/15	Conventional Transport	Eggplant	Khulna	2,574	186	23	59,202	54,162	19.62	7%
5/18/15	Refrigerated Truck	Eggplant	Khulna	2,185	0	22	48,070	40,211	18.40	0%
5/18/15	Refrigerated Truck	Bitter Gourd	Khulna	624	0	25	15,600	13,355	21.40	0%

5/18/15	Refrigerated Truck	Pointed Gourd	Khulna	27	0	20	540	443	16.40	0%
5/18/15	Conventional Transport	Eggplant	Khulna	1,683	117	22	37,026	34,296	19.05	7%
5/18/15	Conventional Transport	Bitter Gourd	Khulna	415	35	25	10,375	9,693	21.54	8%
5/18/15	Conventional Transport	Pointed Gourd	Khulna	143	7	20	2,860	2,633	17.55	5%
5/21/15	Refrigerated Truck	Eggplant	Dhaka	1,271	190	15	19,065	8,911	6.10	13%
5/21/15	Refrigerated Truck	Bitter Gourd	Dhaka	1,194	15	19	22,686	14,283	11.81	1%
5/21/15	Refrigerated Truck	Pointed Gourd	Dhaka	260	10	14	3,640	1,763	6.53	4%
5/21/15	Conventional Transport	Eggplant	Dhaka	1,221	239	9.5	11,600	7,029	4.81	16%
5/21/15	Conventional Transport	Bitter Gourd	Dhaka	1,080	120	16	17,280	13,524	11.27	10%
5/21/15	Conventional Transport	Pointed Gourd	Dhaka	189	81	12	2,268	1,423	5.27	30%

Appendix 3: References

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