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ASSESSMENT OF POSTHARVEST LOSSES AND FOOD QUALITY BY EVALUATING POSTHARVEST PRACTICES AND MARKETING PERFORMANCE IN SELECTED VEGETABLE SUPPLY CHAINS IN BANGLADESH

COLD CHAIN BANGLADESH ALLIANCE (CCBA) REPORT

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Assessment of Postharvest Losses and Food Quality by Evaluating Postharvest Practices and Marketing Performance in Selected Vegetables Supply Chain in Bangladesh

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ABSTRACT

Different studies assessed quantitative postharvest losses of vegetables based on field surveys, but loss assessment through physical monitoring of vegetable lots is rare in Bangladesh. Therefore, the study was carried out at Jessore, Kishoregonj and Mymensingh districts to estimate quantitative and qualitative postharvest losses of vegetables at various stages of supply chain using conventional, improved and cool chain packaging and transportation, and the financial impact of improved packaging over conventional method during January-April, 2016. Nine lots of vegetables namely, brinjal, country bean, tomato and bitter gourd were monitored using conventional, improved and refrigerated transportation system, and recorded data on postharvest losses and related financial costs for estimating cost-benefit analysis. The study revealed that the postharvest losses of vegetables were much higher for conventional method of packaging compared to improved and cool chain method. In conventional method, the percent of postharvest losses of brinjal, country bean, tomato, and bittergourd at traders' level were 27.2%, 29.5%, 22% and 9.9% respectively. The corresponding losses were 16.4%, 23.1%, 17.7% and 9.2% under improved method, respectively. In cool chain method, the total loss of brinjal was 13.6% which was much lower than other two methods, but the system is not cost effective to the traders. In monetary term, the losses in conventional method ranged from Tk. 924-Tk.1482 per ton for selected vegetables which were 48-312% higher than improved method. In improved method, Bepari and retailers received net margins ranged from Tk.1219-Tk.4632 and Tk.2345-Tk.8866 per ton which were 10.4-42.6% and 3.4-6.0% higher than conventional method respectively. In cool chain method, Bepari received negative net margin (Tk.-2067) in brinjal marketing. The stakeholders gave emphasis on packaging high value vegetables using plastic crates which effectively minimize losses during distant transportation.

1. INTRODUCTION

1.1 Background

A variety of vegetables are grown in Bangladesh. Currently, it produces around 10923 thousand metric tons of vegetables (including potato) per year (BBS 2012). Vegetables are very important for human diet, especially for vitamins and minerals since it is the major sources of vitamins and minerals without which the human body cannot maintain proper health and develop resistance to diseases. They also contain pectin, cellulose and various energy giving substances (www.choosemyplate.gov/vegetables-nutrients-health). The per capita per day consumption of vegetables in Bangladesh is only 211g against a minimum requirement of 400g (FAO/WHO 2003; BBS 2010), which manifests a poor dietary status of the people of Bangladesh. However, there is a wide gap between availability and per capita requirement of vegetables.

High postharvest losses due to higher perishability, poor transportation, improper storage and low processing facility are the major reasons for lower availability of quality vegetables to the consumers. Besides, due to seasonal oversupply and the absence of proper marketing system, bulk quantity of the harvested vegetables gets wasted every year. The technologies developed in the fields of harvest, postharvest and cold chain management of vegetables and agricultural products are not fully utilized throughout Bangladesh. Therefore, it is necessary to develop appropriate technologies and promote them throughout the supply chain in order to reduce postharvest loss and retain quality for vegetables. Again, appropriate marketing infrastructure is crucial for efficient marketing of perishable agricultural commodities. Efficient transportation and product handling are needed for the trade of agricultural product and is an important factor in assuring good prices and poverty alleviation in rural areas (Khandaker *et al.* 2009).

The Postharvest Technology Division of BARI estimated postharvest losses of some vegetables (i.e. tomato, country bean, cauliflower, brinjal, cabbage, and cucumber) in Bangladesh. The estimated losses for vegetables ranged from 3.5 to 9.03% at farmers' level and 20.5 to 27.64% at traders' level. Hasan (2010) reported that postharvest loss of fruits and vegetables in Bangladesh ranged from 23.6 to 43.5%, which accounts for an annual loss of Tk. 34420 Million. Khatun et al. (2014) reported total postharvest loss of tomato was 25. 37% and total national loss was about Tk.52.31 crore during 2009-10. Kayser et al. (2014) reported that postharvest losses were maximum in brinjal (23.38%), followed by bitter gourd (17.97%) and potato (16. 73%).The postharvest losses were reported mainly at harvesting (8.0%), handling from orchard to selling point by the growers and *Beparis* involved in harvesting (4.61%) and after buying to consumption by the consumers (7.5%).

1.2 Justification of the Study

All kinds of vegetables can't be grown in a particular area. Different areas are suitable for producing particular crop, but the consuming areas are spread all over the country. Therefore, vegetables need to be moved a long distance to reach the ultimate consumers under the prevailing marketing system. These vegetables will be fully realized only when they reach the consumers in good condition and at a reasonable price. But in reality, a plenty of harvested vegetables are damaged due to inefficient market. Appropriate marketing channels and market functionaries are very much important in the movement of vegetables from one place to another place and to reduce postharvest losses, risk and uncertainty in timely delivery of quality and safe vegetables at reasonable prices to the consumers.

The postharvest losses could be considerably reduced by adopting improved handling, packaging, storing, and efficient transport system. Again, the maintenance of low temperatures at different stages of handling helps in reducing losses and in retaining the original colour, flavor, and taste of

vegetables. High cost in storing and the lack of abundant uninterrupted power supplies make it difficult to develop cold chain systems for vegetables in Bangladesh. But little is known about the current knowledge and practices of the key stakeholders in the vegetable supply chain in relation to postharvest handling and food quality. Nevertheless, there have been very few systems and attempts in the current vegetable marketing system to estimate the postharvest losses at each stage of handling and its causal factors. The aforesaid information is very much important to develop and promote cost effective and appropriate harvest and postharvest technologies of selected vegetables. Therefore, the present study was conducted with the following specific objectives.

1.3 Objectives

i. To estimate the quantitative and qualitative postharvest losses at different segments of the USAID-funded Cold Chain Bangladesh Alliance (CCBA) mandated vegetables supply chain using traditional and improved packaging.

ii. To estimate the financial impact of improved packaging of vegetables over traditional packaging.

iii. To assess stakeholder's perceptions towards postharvest loss reducing practices and measures for promoting cost effective technologies.

2. REVIEW OF LITERATURE

Proper knowledge and reliable information regarding postharvest management of vegetables are very much important for producers and stakeholders in reducing postharvest losses and ensuring food quality for the consumers. But, there have been very few systematic attempts to assess the knowledge, attitudes and practices towards food quality, postharvest handling, and postharvest losses in vegetable supply chains. Different studies were conducted on vegetables marketing based on small-scale survey and experiments, but it did not reflect the real situation. Some of the related studies conducted at home and abroad have been reviewed in the sub-sequent paragraphs.

The total value of vegetables produced in Bangladesh is around Tk. 19400 million, calculated at average retail price. About 70% of the vegetables pass through the marketing channels. If the spoilage is 10%, the loss comes to Tk. 1,462 millions. These losses are due to inadequate knowledge on harvesting, carrying, packaging, transport and storage techniques. In the vegetable marketing channels, traders suffer maximum losses, because they handle and transport more quantities from one place to another than any other intermediaries (Rashid, 1998).

Hossain et al., (2001) assessed the price of vegetables in four districts, namely Gazipur, Dhaka, Comilla and Jessore. The study revealed that the prices of vegetables were affected by improper handling and transportation. There were other causes like delay selling, more ripen and rotten that influenced the price of vegetable. It was observed that the prices of blemish vegetables were always found less than the blemish-free vegetables and both farmers and traders incurred some losses due to this reason. This loss varied from 12 to 35% for different vegetables.

Utama and Kitinoja (2015) estimated postharvest losses of vegetables in small-scale agribusiness chains of Bali, Indonesia. They opined that the level of product loss depends on the agribusiness chain system or distribution channel. In general, the loss of production on farm as rejected or non-harvested vegetables is about 5-10% due to the production size not being in accordance with market demand, and defects due to pest attack or diseases. The percentage of loss at the production stage can be greater depending on the level of pests and disease attack during the production process. The loss in the local traditional retail market located close to the production area occurs due to mechanical, physiological, and micro-biological damages during marketing. The farm level damage

is lower than the damage that occurs in case of city for institutional customers it is set at no later than 9 a.m. However, the study identified five major agribusiness chains in vegetable marketing. The highest loss (23-42%) incurred in the longest channel *Farmer-sub-district wholesale traditional Market-City Collectors-City traditional retail market*. The lowest loss (9.5-18%) incurred in the chain *Farmers-Suppliers of institutional Consumers-Institutional consumers.*

Addol et al., (2015) analyzed the determinants of postharvest losses within the tomato value chain, key players, their roles in the pre-harvest, harvest and postharvest handling of tomato at farmer's level. The study indicated that quantitative losses during harvest across regions ranged between 4.6% and 10.85%, with the highest in Upper East region. Between 3.6% and 13.75% of tomato were lost during grading and parking time; 2.3% to 7.4%; and 2.6% to 3.3% during transporting and marketing respectively. Postharvest loss in the tomato value chain is very alarming. It demands that policy makers and other stakeholders redirect their focus towards reducing or eradicating these losses by offering training on postharvest handling of perishable products. It must be conducted with follow ups, feedback and adoption measurement to ensure sustainability.

Khatun et al., (2014) identified and estimated postharvest practices and losses of tomato at farmers and intermediaries' level. The major postharvest activities practiced by the farmers and intermediaries were harvesting, grading, cleaning, storing, packaging and transporting. The average postharvest losses were estimated to be 15.37% and 10% at the farmers' and intermediaries level, respectively. The harvesting loss was found to be the highest (6%) as compared to grading, packaging, storing and transporting. Besides, the losses of tomato were found to be the highest for *Beparis* (6.3%) followed by *Paikers* (2%) and retailers (1.5%) due to transportation and selling. Monetary loss at farmers' level was Tk.78,540 per hectare and it was Tk.1,28,258 at traders' level. At national level monetary loss was estimated at Tk.52.31 crore during 2009-10. Important factors leading harvesting losses were due to early and delayed harvesting and insect infestation. Product price, farming experience and suitable packaging materials had negative and total production and rainfall had positive and significant relationship with total postharvest losses.

Buntong et al., (2013) assessed and introduced possible handling improvements in traditional and modern supply chains for tomato. Traditional chain involved farmers and collectors in Kandal Province and wholesalers and retailers in wet markets in the capital of Phnom Penh, Cambodia. In the modern chain, only one intermediary between farmers and supermarkets was involved. Postharvest losses in the traditional and modern chains were 23% and 22.5%, respectively. The losses of farmer were mainly due to pre-harvest damage by insect-pests and diseases, and immaturity while losses during subsequent handling were due to physical damage, rotting, weight loss and/or over-ripening. Improved packaging, pre-cooling and sanitizing treatments as individual handling improvements were tried in the traditional chain. It was found that the use of 20kg capacity plastic crate with 50µm-thick low density polyethylene bagging and 20kg capacity bamboo basket lined with newsprint reduced tomato damage at the wholesale and retail stages relative to the conventional packaging of using 20kg capacity 50µm-thick high density polyethylene.

In Nigeria, Ayandiji et al., (2011) estimated postharvest losses of tomato in their study. It reveals that about 72% farmers used van/pick up to transport their produce from farm to the market. No storage facilities were used in the study areas to preserve the tomato from rotten after harvesting. The average gross margin with postharvest losses was less than the average gross margin when no damage occurred in tomatoes thus showing that postharvest losses reduce the mine of farmers in the study area.

In Nigeria, Ayandiji et al., (2011) mentioned his study *determinants of postharvest losses among tomato farmers in Imeko-afon local government area of Ogun state* that about 72% farmers use van/pick up in transporting their produce from the farm to the market. No storage facilities were used in the study area to preserve the fruits from rotten after harvesting as at the time of study. The average gross margin with postharvest losses is less than the average gross margin when no damage occurred in the fruits. The effect of all the independent variables (pre harvest working days, harvest working days, distance from the farm to the market (km), days fruit spent on the farm (days), age of fruit at harvest (months), area of land cultivated (ha), days fruit spent in the market before getting to the consumer (days), and no. of basket that was harvested) on the dependent variable (quantity of fruit loss) tested were significant at 5% probability level. The effects of postharvest losses lead to wastage of the products and tend to frustrate the efforts put into production and their income on the produce.

Saeed and Khan (2010) reported that the quality of tomatoes mainly depends on proper handling during postharvest processes like harvest, grading, packing and transportation. The study also focused on shelf life of tomato based on the systematic survey of the distribution of tomato crop. The deterioration of the produce due to packing material was 25%, transportation system was 10%, means of distribution was 5%, exceeding postharvest losses up to 30%, and sometimes the whole lot is lost. Time lag in transportation, bulky packing in the traditional wooden crates wrapped with papers cause high humidity making the microclimate favorable for mycoflora.

Matin et al., (2008) carried out a study on tomato marketing system in Bangladesh to identify the most efficient and suitable marketing channels of tomato in selected areas of Bangladesh. According to the volume of tomato handled and longevity or participation of the intermediaries in the channel, four major channels were identified as dominant in the study area. The channel *Farmer-Bepari-Arathdar (Dhaka)-Retailer (Dhaka)-Consumer* was ranked first. The results showed that *Farmer-Arathdar (Local) – Bepari Arathdar (Dhaka)-Retailer (Dhaka)-Consumer* possesses the highest marketing efficiency. Establishment of tomato processing plant in the intensive growing areas may be the remedy of the problem which will ensure fair prices for the farmer.

In Pakistan, Rahman et al., (2007) estimated the postharvest losses of tomato in Peshawar valley to be 20% of the total production. The losses mainly occurred during picking of the crop, during handling and transportation to the markets. In order to reduce these losses, farmers need to be trained about the latest techniques of packaging, processing of tomato crops, advanced techniques and methods of postharvest handling.

It was found in two different studies conducted in Ayes and Mallihar districts of Ankara that the losses in tomato during the harvest period varied from 5.15% to 9.83%. It was pointed out that precautions taken by producers until the harvest maturity are not sufficient and necessary measures should also be taken during harvest and after harvest period, in order to decrease or eliminate the losses (Tatlidil et al., 2003; Demirci et al., 2005).

Detachment of fruit from the stalk was found to be the major cause of postharvest damage of brinjal and about 48-60% of the growers reported this as one of the causes of damage. Nearly 56% retailers also opined that maximum damage in brinjal occurred due to fruit separation from the stalk. However, huge amount of losses were faced by *Bepari* every year due to lack of proper transport system. *Beparis* (52-64%) opined that maximum damage occurred due to bruises and vibrations in brinjal transport. They estimated 29.4% actual postharvest losses of brinjal which was due to the sub-standard postharvest handling, practices, inadequate transport, lack of storage facility, and ignorance of the stakeholders (Hassan et al, 2010).

In India, per quintal postharvest losses in brinjal crop were estimated in three major supply chains. The chains were (1) Farmer-Commission agent1-Commission agent 2- Retailer-Consumer; (2) Farmer-Wholesaler-Retailer-Consumer; (3) Farmer-Retailers-Consumer. The per quintal losses in different supply chains were 21.62 kg in supply chain-I, 19.36 kg in supply chain-II and 16.24 kg in supply chain-III. In supply chain-I, losses were maximum at farm level (8.84 kg/q) followed by commission agent's level (5.29 kg/q) and at wholesaler's level (4.82 kg/q). In supply chain-II, the losses were found to be maximum at farm level (7.88 kg/q) followed by wholesaler's level (7.87 kg/q). In supply chain-III, the highest loss was found at farm level (8.76 kg/q). Among all agencies, it was found that postharvest losses at farm level were highest in all supply chains of brinjal (Sagar et al. 2010).

Sharma and Singh (2011) estimated the total postharvest loss of brinjal in Bhabhan farms was 16.81% of which growers' level loss was 11% and retailer's level loss was 5.81%. At grower's level, the highest postharvest loss was found during grading and packing (6%) followed by harvesting (4.50%).

In Jordan, Kitinoja and Kader (2015) estimated the total postharvest losses of brinjal as 19.4%. In Ghana through sampling method, they found physical losses of brinjal were 13.9% in farmer's level, 11.3% in wholesale market, and 16.2% in retail market.

Sagar et al. (2010) estimated the total postharvest losses of beans in three major supply chains. The chains were (1) Farmer-Commission agent1-Commission agent 2- Retailer-Consumer; (2) Farmer-Wholesaler-Retailer-Consumer; and (3) Farmer-Retailers-Consumer. The total estimated losses were 16.32 kg/q, 12.36 kg/q and 9.61 kg/q in supply chain I, II and III respectively. It was also observed that in supply chain-I, maximum losses were found to be 4.75 kg/q at farm level followed by commission agent's level (6.02 kg/q) and at wholesaler's level (3.6 kg/q). In supply chain-II, the losses were found to be more at farm level (4.95 kg/q) and at wholesaler's level (4.58 kg/q). In supply chain-III, maximum losses were at retailer's level (4.79 kg/q) followed by farm level (4.82 kg/q).

Hoq et al. (2012) estimated the per hectare production cost and value addition by farmers for bitter gourd were Tk.1,04,644 and Tk.2,37,356 respectively. The average estimated marketing cost and value addition by suppliers were Tk.2906 and Tk.3094 per ton. The value addition by different exporters for UK, Saudi Arabia, Kuwait, and Qatar were Tk.55,778, Tk.16,661, Tk.16,902, and Tk. 23,754 per ton respectively. The study revealed that bitter gourd cultivation was more profitable compared to other vegetables and UK market was more profitable for vegetables export.

It is clear from the aforesaid literature that a number of studies regarding quantitative loss of different vegetables have been carried out in Bangladesh and elsewhere in the world based on field survey. But the assessment of quantitative and qualitative losses through physical monitoring of vegetable lots is rare in Bangladesh. Therefore, a systematic approach to estimate postharvest losses in quantitative, qualitative and economic terms is the need of the time in Bangladesh.

3. APPROACH AND METHODOLOGY

3.1 Approach

The Agricultural Economics Division of Bangladesh Agricultural Research Institute (BARI) implemented the present study at the CCBA's selected locations of Bangladesh. Principal Investigator (PI) was responsible for implementing the project activities.

The present study was implemented between January-April, 2016. Study areas, plan of activities, and implementation strategies of the project were worked out through consultation with the relevant stakeholders prior to launching the project.

Four CCBA mandated vegetables were selected with the consultation of CCBA personnel for the study. Both primary and secondary data and information were collected and used in this study. Primary data and information were collected from vegetable growers, traders such as *Bepari, Paiker, Arathdar* and retailer (*for definitions, please see Glossary*) through monitoring different four CCBA mandated vegetable lots. Necessary steps were also taken to assess both quantitative and qualitative postharvest losses at different segments of vegetable supply chain using traditional, improved packaging (plastic crates) and improved packaging with refrigerated transportation (cool chain) systems. An in-depth literature review was conducted from secondary sources which supplemented primary data and information.

Eight selected vegetable lots using traditional and improved packaging systems and one improved packaging with refrigerated transportation (cool chain) were monitored and recorded data on postharvest losses and related financial costs for estimating cost-benefit analysis.

A completion workshop was held in Gazipur at the end of the project (April 28, 2016), where the results of the study were presented and discussed among concerned stakeholders, scientists, and experts. Finally, the researchers always discussed critical issues with CCBA's personnel prior to implement any activity relevant to the project.

3.2 Methodology

Selection of vegetables: The CCBA mandated vegetables which are mostly associated with postharvest losses, food safety and retention of its shelf life issues were taken into consideration in this study. Accordingly, four important vegetables, namely brinjal, country bean, tomato, and bitter gourd were selected for the project.

Selection of study area and market: At the initial stage of the project, Jessore district was selected for the study, because a variety of vegetables grow in this district mostly on commercial basis. Besides, both domestic and international trade on vegetables occurs in this location. The selected location is also a pocket area for growing aforesaid selected vegetables. But it was experienced during conducting this study that all the selected vegetables were not adequately available in Jessore for study. Therefore, another two districts namely Kishoregonj for studying tomato and Mymensingh for bitter gourd were selected in consultation with CCBA personnel for this study.

After consultation with CCBA personnel in Jessore, we visited three vegetable assembling markets namely Satmile bazar, Vatara bazaar and Khajura bazar at Sadar upazila of Jessore district. Finally, Satmile bazar (Fig 1) and Khajura bazar under Sadar Upazila of Jessore district for brinjal and country bean, Jhaowtola bazar (Fig 2) under Karimgonj Upazila of Kishoregonj district for tomato, and Baktali Bazar (Fig 3) under Fulbaria Upazila of Mymensingh district for bittergourd transaction were selected for the study. We followed both conventional and improved methods of packaging for the aforesaid vegetables. The above markets were selected on the basis of following criteria.

i. Availability of the selected vegetables
ii. Presence of large number of buyers and sellers
iii. Daily market, and
iv. Most farmers practiced traditional method to transport vegetables to the end users.

Fig-1: Brinjal packaging using gunny bags, Satmile bazar, Jessore

Fig-2: Tomato packaging using plastic crates, Jhaowtola bazaar, Kishoregonj

Fig-3: Bitter gourd heap waiting for truck loading, Baktali bazaar, Mymensingh

Selection of producers and traders: Both vegetable producers and traders were selected for the study. The producers of the selected vegetables who come to the market for selling their produces were randomly selected for interview. A number of traders (i.e. *Bepari* and retailer) were selected for each vegetable through establishing a congenial relationship with them.

***Selection of transport with loading capacity*:** In the study areas, *Beparis* generally use truck with 8-12-ton capacity for transporting brinjal, country bean and bitter gourd from assemble market to destination wholesale markets under conventional system. Generally, they do not use plastic crates in transporting aforesaid vegetables, but in case of tomato transportation, they use plastic crates.

For the present study, 10 ton loading capacity trucks for transporting brinjal and country bean and 5 ton loading capacity truck for bitter gourd were used (Figs 4, 6, & 10) in case of conventional transportation with gunny bags. On the other hand, 2-ton capacity pickups were used for carrying brinjal, country bean, and bitter gourd in case of improved transportation (Figs 5, 7 & 11) with plastic crates. Two tons' capacity pickup was used to transport tomato using conventional packaging system with gunny bags (Fig 8).

Selection of refrigerated van for cool chain management: Generally, no modern refrigerated vehicle is found commercially operating in vegetables supply chain in the study areas. Therefore, a three and half ton capacity refrigerated covered van was hired from Bangladesh Agricultural Development Corporation (BADC) for carrying brinjal using improved packaging system (Fig 12). The temperature and relative humidity maintained in the refrigerated van were 12°C and 95% respectively. Ventilation setting was 15 CMH and dehumidification switch was kept off. The findings of this cool chain management have been discussed in the respective sections (i.e. 4.6.1, 4.7.1, 4.7.2, 4.9.2.1 and 4.11.1).

Fig 4. Brinjal loaded truck under conventional packaging waiting for going destination market, Satmail bazar, Jessore

Fig 5. Brinjal loaded pickup under improved packaging waiting for going destination market, Satmail bazar, Jessore

Fig 6. Countrybean loaded truck under conventional packaging waiting for going destination market, Satmail bazar, Jessore

Fig 7. Countrybean loaded pickup under improved packaging waiting for going destination market, Satmail bazar, Jessore

Fig 8. Tomato loaded pickup under conventional packaging waiting for going destination market, Jhawtola bazar, Kishoregonj

Fig 9. Tomato loaded truck under conventional packaging waiting for going destination market, Jhawtola bazar, Kishoregonj

Fig 10. Bitter gourd loaded truck under conventional packaging, Baktali bazar, Mymensingh

Fig 11. Bitter gourd loaded pickup under improved packaging, Baktali bazar, Mymensingh

Fig 12. Brinjal loaded refrigerator van under improved packaging, Khajura bazar, Jessore

Table 1. Fleet operational plan (collection point and destination)

Vegetable name	Collection point	Destination market	Distance (km)
Brinjal	Satmail Bazar, Sadar Upazila, Jessore	Gazipur Chowrasta wholesale market, Gazipur	293
Brinjal	Khajura Bazar, Sadar Upazila, Jessore	Kawran Bazar wholesale market, Dhaka	327
Country bean	Satmail Bazar, Sarar Upazila, Jessore	Shafipur wholesale market, Gazipur	283
Tomato	Jhaowtola bazaar, Karimgonj Upazila, Kishoregonj	Gazipur Chowrasta wholesale market, Gazipur	93
Bitter gourd	Baktali bazaar, Fulbaria Upazila, Mymensingh	Gazipur Chowrasta wholesale market, Gazipur	94

Table 2. Packing type, weight, time (loading &unloading) and distance

Vegetable name	Packing type	Loading weight (kg)	Un-loading weight (kg)	Loading period	Unloading period	Distance (km)	Total time (hours)
Brinjal	Gunny bags	10000	9729	3:00-6:00 pm	1:30-2:30 am	293	7.5
	Plastic crates	2000	1976	2:00-5:00 pm	12:30-1:30 am	293	7.5
	Cool chain	2046	1961	2:00-5:00 pm	2:00-3:00 am	327	9.0
Country bean	Gunny bags	10000	9410	3:00-6:00 pm	1:00-2:00 am	283	7.0
	Plastic crates	2000	1944	2:30-5:30 pm	12:30-1:30 am	283	7.0
Tomato	Gunny bags	8000	7928	3:00-6:00 pm	11:0pm -1:30am	93	5.0
	Plastic crates	3500	3500	3:00-6:00 pm	11:0pm -1:30am	93	5.0
Bitter gourd	Open truck covering with gunny bags	4800	4572	1:00-4:00 pm	7:00-9:00 pm	94	3.0
	Plastic crates	2000	1951	1:00-2:00 pm	5:00-6:00 pm	94	3.0

***Quality assurance measurement before loading and after unloading*:** We considered quality assurance in terms of quantity of vegetables shapeless, over matured, spotted, cracked, etc. in conventional, improved and refrigerated transportation system. The shapeless, spotted, and cracked vegetables were identified through observation, whereas over matured vegetables were identified and ensured through breakage.

***Sampling design for postharvest loss assessment**:* The postharvest practices and losses practiced and incurred in various stages of vegetable marketing were assessed through close monitoring of different vegetable lots that moved from assembling market (i.e. it refers to the market where producers are gathered for selling their produces) to consuming markets (treated as retail market). Major supply or marketing chains involved in vegetable marketing are (i) *Farmer-Faria-Bepari-Arathdar-Retailer-Consumer*; (ii) *Farmer-Bepari-Arathdar-Retailer-Consumer*; (iii) *Farmer-Bepari-Retailer-Consumer*; and (iv) *Farmer-Retailer-Consumer* (Matin et al. 2008). The traders involved in the *Farmer-Bepari-Arathdar-Retailer-Consumer* supply chain were taken as sample for interview. However, Channel-II was monitored in this study because the highest proportion of vegetables moves through this channel. The intended vegetable traders were *Bepari, Paiker, Arathdar* and retailer.

For each vegetable, two truck lots taking one lot for traditional and another lot for improve packaging and transportation system were considered for close monitoring. Thus, 8 truck lots were monitored for this study. Again, 10 producers, one Bepari, and 5 retailers were selected for each vegetable for the study. Thus, the total number of producers, Bepari and retailers were 40, 4, and 20 respectively.

Assessment of quantitative and qualitative postharvest loss: A number of studies regarding quantitative loss of different vegetables have been done in our country based on field survey (Amiruzzaman, 1990; Kader, 1992; Khatun et al., 2014; Kayser el al., 2014; Hasan et al., 2010). But the assessment of quantitative and qualitative losses through physical monitoring of vegetable lots is rare in Bangladesh. Therefore, the main concern of this study was to estimate the quantitative and qualitative loss assessment of selected vegetables through monitoring basis. Quantitative loss was measured in terms of physical and monetary value considering spoilage, damage, and weight loss (dehydration) which make unsold of the selected vegetables. Information on postharvest losses was obtained from traders during various operations, such as sorting & grading, packaging, loading & unloading, transportation, and selling to the consumers. This physical loss at different stages was estimated by using following formula:

1. *Physical loss of **Bepari** (kg/truck) = Quantity loss during loading period (kg/truck) + {Quantity during loading (kg/truck) – Quantity during unloading (kg/truck)} + Quantity loss during unloading period (kg/truck)*
2. *Physical loss of **Retailer** (kg) = Quantity loss during selling period (kg) + {Quantity purchased (kg) – Quantity sold (kg)}*
3. *Monitory loss (Tk) = Total quantity loss (kg) × Unit price (Tk/kg)*

Besides, some basic parameters of quality losses which are responsible for lower price such as odd shape, color change, spots, cut, and crake were considered for measuring qualitative postharvest losses of selected vegetables. For this, a loaded lot of each vegetable from assemble market to wholesale or retailing point was considered and monitored by the project personnel. Blemish vegetables were categorized and measured into three scales (i.e. high, moderate and low). Project personnel supervised and recorded the quantitative and qualitative losses of selected vegetables at each and every stage of marketing among the stakeholders. This task was done with the

collaboration of different stakeholders of vegetables chain and vehicle driver through paying actual remuneration.

1. *Quantity of blemish vegetables of **Bepari** (kg/truck) = Quantity blemished during loading period (kg/truck) {Quantity blemished during loading (kg/truck) – Quantity blemished during unloading period (kg/truck)}*
2. *Quantity of blemish vegetables of **Retailer** (kg)= Quantity blemished during selling period (kg)*
3. *Monitory loss (Tk) = Total quantitative loss (kg) × purchase price of fresh vegetables (Tk/kg) + {Quantity of blemish vegetables (kg) × sale price of fresh vegetables (Tk/kg) - Quantity of blemish vegetables (kg) × sale price of blemish vegetables (Tk/kg)}*

Data and information: The data and information regarding vegetables marketing at traders' level were collected on traded volume, marketing costs (e.g. transport cost, commission, market tolls, wastages, miscellaneous costs, etc.), mode of sales, purchase and sale prices, price formation, gross & net margins, return on investment, and marketing constraints. Data relating to supply/value chain development, marketing chain, marketing margins, postharvest losses, marketing constraints, food quality, food safety measures etc. were also gathered from various stakeholders.

Comparative economic assessment of vegetable supply chain: At first, a number of supply chains for each vegetable were identified during study. Then vegetable loaded trucks were monitored and aforementioned data were recorded for assessing quantitative and qualitative postharvest losses at different segments of supply chain using conventional, improved and improved packaging with refrigerated transportation systems. Plastic crate packaging using truck transportation to distant market was considered as improved packaging system. A number of selected commodity lots using conventional and improved packaging systems were monitored and record data and information on postharvest losses and related financial aspects in order to estimate cost-benefit of the transaction.

3.3 Analytical Techniques

Marketing margin analysis: Marketing margin of the traders was calculated by the following equation

$GM_{ij} = PR_{ij} - Pp_{ij}$

Where,
GM_{ij}= Gross margin (Tk/unit) for i^{th} intermediary of jth vegetables
PR_{ij} = Price received (Tk/unit) for i^{th}intermediary of jth vegetables
PP_{ij} = Price paid (Tk/unit) by i^{th} intermediary of jth vegetables
$NM_{ij} = GM_{ij} - Mc_{ij}$

Where,

NM_{ij} = Net margin (Tk/unit) for i^{th} intermediary ofj^{th} vegetables
MC_{ij} = Marketing cost incurred (Tk/unit) by i^{th} intermediary of jth vegetables

Estimation of marketing performances: The marketing performance was investigated by examining price spread, producer's share to the consumer's price, and marketing efficiency. The methods (equations 1-3) for studying these estimates are given in the following.

***Measuring price spread*:** The price spread refers to the difference between the price paid by the consumer and price received by the producer for an equivalent quantity of farm product. Total price spread is another measure of the marketing margin. Farmers' share is widely regarded as a measure

of fairness of the farm price and the efficiency of the marketing system (Kohls and Uhl, 1980). Middlemen's investment was involved in the marketing system and their share was also important. Different factors were found to be responsible for variations in the shares of income going to different groups of participants in the marketing of vegetables in Bangladesh. An attempt was made to study the price spread of vegetables through the following equation (1).

$$Ps = Cp - Pp \quad \text{----------} \quad (1)$$

Where,

Ps = Price spread,
Cp= Price paid by Consumers,
Pp = Price received by producers

Producers' share to consumers' price: The producers' share was derived by the ratio of net average price received by the producer to the weighted average price of selected vegetables. It was calculated with the following formula (2):

$$\text{Producer's share (\%)} = \frac{\text{Price received by the producer}}{\text{Price paid by the consumer}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Measurement of marketing efficiency: There are several types of measures that have some values and limitations in measuring marketing efficiency, but no single one can tell the whole story. However, the following formula (equ-3) was used for measuring marketing efficiency (Acharya and Agarwal, 2004). The higher value of marketing efficiency denotes higher level of efficiency and vice versa.

$$\text{Marketing efficiency (ME)} = \frac{FP}{MC+MM} \quad \text{----------} \quad (3)$$

Where,

FP = Net price received by farmer (Tk/ton)
MC= Total marketing cost (Tk/ton)
MM = Total net marketing margin of intermediaries

Project premises and logistic support: A total of 1800cft office space at the Agricultural Economics Division (AED) of BARI was used as project premises. The AED permanently provided two computers including one desktop and one laptop for the project activities. One secretariat table, two computers, one file cabinet, one almirah and six chairs were also provided for project purpose.

4. Results and Discussion

4.1 Mode of Transport Used by the Farmers

Farmers in the study areas used different means of transportation to carry their product in the market. It was revealed from Table 3 that the majority of brinjal farmers (60%) used auto-van for transporting their products in the market. Similarly, the highest percentage of country bean (55%) and bitter gourd (70%) farmers used auto-van to carry their products. About 30% farmers used van and 8% used bicycle when they marketed brinjal. Only 2% brinjal farmers used their head or shoulder for this purpose. In the case of bitter gourd, 20% farmers used van and 10% used bicycle when they marketed their products. In the study areas, Van, head load and bicycle were also important mode of transports for country bean farmers. However, 100% tomato farmers used head load for carrying their tomato in the market. In most cases, tomato farmers sell their produce at farmyard.

Table 3. Mode of transport used by the farmers

Mode of transportation	Percentage of respondent			
	Brinjal *(n=10)*	Country bean *(n=10)*	Tomato *(n=10)*	Bitter gourd *(n=10)*
Head load	2	10	100	--
Van	30	25	-	20
Auto-van	60	55	-	70
Bicycle	8	10	-	10
Total	100	100	100	100

4.2 Place of Selling

Farmers in the study areas sold their produces in farm yard, primary market and secondary market. One hundred percent brinjal and country bean farmers reported that they sold their product in the secondary market. On the other hand, 100% tomato farmers used farm yard for selling their tomatoes. In the study areas, 75% bitter gourd farmers used primary market and another 25% farmers used farm yard for selling their products (Table 4).

Table 4. Place of selling of selected vegetables

Buying and selling place	Percentage of respondent			
	Brinjal *(n=10)*	Country bean *(n=10)*	Tomato *(n=10)*	Bitter gourd *(n=10)*
Farm yard	-	-	100	25
Primary market	-	-	-	75
Secondary market	100	100	-	-

4.3 Marketing Costs Incurred by Farmers

Table 5 shows that the average marketing cost of farmer was highest for brinjal which was Tk. 772/ton. The average marketing cost of country bean, bitter gourd and tomato were Tk. 663, Tk. 604 and Tk. 420 per ton, respectively. Among the cost items, transportation cost was the major cost item for brinjal, country bean and bitter gourd farmers which were more than 80% of total marketing cost. However, the major cost item for tomato farmers was weighing charge (Tk. 195/ton) which was little bit higher than cost of transportation. Weighing charge for brinjal, country bean and bitter gourd were Tk.80, Tk. 70 and Tk. 75 per ton, respectively. Personal expenses of tomato farmers shared 9% of the total marketing cost which was higher than brinjal (7%), country bean (7%) and bitter gourd (5%) farmers.

Table 5. Marketing costs (Tk/ton) incurred by farmer for selected vegetables

Cost item	Jessore		Kishoregonj	Mymensingh
	Brinjal *(n=10)*	Country bean *(n=10)*	Tomato *(n=10)*	Bitter gourd *(n=10)*
Transportation	640 (83)	545 (82)	188 (45)	500 (83)
Weighing charge	80 (10)	70 (11)	195 (46)	75 (12)
Personal expenses	52 (7)	48 (7)	37 (9)	32 (5)
Total	772 (100)	663 (100)	420 (100)	604 (100)

Note: Figures in the parentheses are the percentages of total cost

4.4 Producer's Share to Consumer's Price

Producer's share to the consumer's price is one of the efficiency measures of commodity marketing. Higher producer's share indicates the market is functioning well to some extent. However, the estimated producers' shares to the consumers' prices for different vegetables ranged from 25.8 to 48.5% for conventional method and 23.7 to 47.3% for improved method of packaging (Table 6). The highest producer's share was found in tomato marketing and the lowest in country bean marketing. The overall producer's shares revealed that there are imperfections in different vegetables marketing system that need to be identified for protecting farmers' interest.

Table 6. Producer's share to consumer's price for selected vegetables

Vegetables	Farmer price (Tk/ton)		Consumer price (Tk./ton)		Producer's share (%)	
	Conventional	Improved	Conventional	Improved	Conventional	Improved
Brinjal	3200	3200	12300	12800	26.0	25.0
Country bean	2800	2800	11300	11800	25.8	23.7
Tomato	8000	8000	16500	16900	48.5	47.3
Bitter gourd	12000	12000	27500	30000	43.6	40.0

4.5 Marketing Channel

Two major marketing channels were identified in the study areas based on the transected volume of products and participations of intermediaries. Channel 1 was the major marketing channel for selected vegetables. About 90% product ran through this channel (Table 7).

Table 7. Studied vegetables run through the major channels in the study areas

Channel	Marketing Channels	Percent of product run	Rank (I)
1.	Farmer –Bepari –Aratdar (Gazipur) – Retailer (Gazipur) -Consumer	90%	1
2.	Farmer –Bepari –Arathdar (Gazipur) – Paiker (Gazipur)- Retailer (Gazipur) - Consumer	10%	2

4.6 Marketing Costs Incurred by Different Intermediaries

Different intermediaries such as *Bepari, Arathdar, Paiker*, and retailer have to spend a big amount of money on different purposes during marketing of vegetables. All these marketing costs for selected vegetables are discussed in the following sub-sequent sections.

4.6.1 Marketing cost of brinjal

Different marketing costs of brinjal for different intermediaries are shown in Table 8. Among the intermediaries, the highest marketing cost was estimated for Bepari in the case of improved method of packaging with refrigerated transportation which was Tk.7467/ton followed by improved method (Tk.3804/ton) and conventional method (Tk.3704/ton). Transportation cost was the foremost cost item for Bepari for each of the method because it shared 32.4-68.9% of total marketing cost. The transportation cost of vegetables through refrigerated covered van (Tk. 5143/ton) was found much higher compared to improved and conventional method since no refrigerated transportation system for vegetables was available in the study areas. The second important cost item for Bepari in conventional and improved method were commission to Arathdar which occupied more than 26% of total marketing cost. Loading, unloading, labour for crates/dhoop (big bundle of brinjal) making, market tolls, entertainment & personal expenses, water supply, tips, and donation were also

important cost items for Bepari. Cost of packaging materials such as gunny bags and rope were necessary cost items for Bepari in conventional method whereas for improved method it was plastic crates hiring. Salary to the employees was the most important cost item for Arathdar which occupied 58% of total marketing cost. Weighing charge, rent of shop, and entertainment & personal expense were also important cost items for Arathdar of Gazipur. Retailer of Gazipur incurred Tk. 700/ton for transportation which was 58% of total marketing cost. Cost of shop rent and gunny bag shared 8% and 7% of the total marketing cost of retailer. The average marketing cost of retailer and Arathdar were Tk. 1217 and Tk. 601 per ton, respectively.

Table 8. Marketing cost (Tk/ton) of brinjal for different intermediaries

Items	Bepari			Arathdar (Gazipur)	Retailer (Gazipur)
	Conventional	Improved	Cool chain		
Transportation	1200 (32.4)	1480 (38.9)	5143(68.9)	-	700 (57.5)
Loading	156 (4.2)	156 (4.1)	156 (2.1)	-	72 (5.9)
Unloading (to Arathdar)	375 (10.1)	375(9.9)	375 (5.0)	-	80 (6.6)
Wage labour	156 (4.2)	162 (4.3)	162 (2.2)	-	-
Employee's salary	--	--	--	350 (58.2)	-
Weighing charge	--	--	--	85 (14.1)	-
Packaging materials:	--	--	--	-	
Plastic crates hiring	--	144 (3.8)	144 (1.9)	-	-
Gunny bag	270 (7.3)	--	--	-	90 (7.4)
Rope	62 (1.7)	--	--	-	-
Broker charge	32 (0.98)	32 (0.8)	32 (0.4)	-	-
Arathdar commission	1000 (27.0)	1000 (26.3)	1000(13.4)	-	-
Shop rent	-	--	--	75 (12.5)	94 (7.7)
Market tolls	188 (5.1)	188(4.9)	188 (2.5)	-	-
Entertainment & personal expenses	80 (2.2)	80(2.1)	80 (1.1)	71.10 (11.8)	60 (4.9)
Electricity bill	-	--	--	11.00 (1.8)	26 (2.1)
Mobile bill	30 (0.8)	30 (0.8)	30 (0.4)	7.50 (1.2)	25 (2.1)
Water supply	62 (1.7)	62 (1.6)	62 (0.8)	-	70 (5.8)
Sweeper	-	-		1.60 (0.3)	--
Tips and donation	93 (2.5)	95 (2.5)	95 (1.3)	-	-
Total	**3704 (100)**	**3804 (100)**	**7467(100)**	**601 (100)**	**1217 (100)**

Note: Figures within parentheses are percentages of total cost

4.6.2 Marketing cost of country bean

It was found from Table 9 that the average marketing cost of country bean was found to be the highest for Bepari in the case of using improved method of packaging (Tk. 3939/ton) followed by Bepari using conventional method (Tk. 3813/ton). The cost of transportation was the major cost item for retailer and Bepari for both conventional and improved method because it shared 57.4%, 39.3% and 46% of total marketing cost, respectively. Commission to Arathdar was the second important cost item for Bepari in both conventional and improved method which occupied more than 25% of total marketing cost for country bean. However, wages and salaries to the employees was the most important cost item for Arathdar which occupied about 56% of total marketing cost.

Weighing charge, shop rent, and entertainment & personal expense were occupied 15%, 12% and 13% of total marketing cost of Arathdar of Gazipur respectively. The cost of loading, unloading, gunny bags, entertainment & personal expense were also important cost items for retailer and Bepari. The average marketing cost of country bean for retailer was Tk.1255/ton which was two times higher than the Arathdar (Tk. 511/ton).

Table 9. Marketing cost (Tk/ton) of country bean for different intermediaries

Items	Bepari		Arathdar (Gazipur)	Retailer (Gazipur)
	Conventional	Improved		
Transportation	1500 (39.3)	1800 (45.7)	-	720 (57.4)
Loading	142 (3.7)	142 (3.6)	-	75 (6.0)
Unloading (to Arathdar)	357 (9.4)	350 (8.9)	-	82 (6.5)
Labour for crates/Net bag binding	71 (1.9)	75 (1.9)	-	
Wages and salaries	-		285 (55.8)	-
Weighing charge	-		78 (15.3)	-
Packaging Materials:			-	
Plastic crates hiring	-	125 (3.2)	-	-
Gunny bag	286 (7.5)	-	-	95 (7.6)
Rope	15 (0.4)	-	-	15 (1.2)
Broker charge	32 (0.8)	32 (0.8)	-	-
Arathdar commission	1000 (26.2)	1000 (25.4)	-	-
Shop rent	-	-	65 (12.7)	94 (7.5)
Market toll	188 (4.9)	188 (4.8)	-	-
Entertainment & personal expense	60 (1.6)	65 (1.7)	66.20 (13.0)	65 (5.2)
Electricity			9.10 (1.8)	22 (1.8)
Telephone	30 (0.8)	30 (0.8)	6.20 (1.2)	25 (2.0)
Water supply	62 (1.6)	62 (1.6)	-	62 (4.9)
Sweeper	-	-	1.60 (0.3)	-
Tips and donation	70 (1.8)	70 (1.8)	-	-
Total	**3813 (100)**	**3939 (100)**	**511 (100)**	**1255 (100)**

Note: Figures within parentheses are percentages of total cost

4.6.3 Marketing cost of tomato

Table 10 revealed the cost of tomato marketing for different intermediaries. Among the intermediaries, the average cost of tomato marketing was found to be the highest (Tk. 3581/ton) for Bepari who used improved method of packaging followed by other Beparis who used conventional method of packaging. The average cost of tomato marketing for retailer (Tk. 1165/ton) was much higher compared to Arathdar (Tk. 552/ton). The cost of transportation was the major cost item for retailer and Bepari for both conventional and improved method of packaging. However, the second important cost item for Bepari was Arathdar's commission in both conventional and improved method which occupied 29.4 and 27.9% of total marketing cost respectively. Loading, unloading, labour for making and binding crates/dhoop, market tolls, entertainment & personal expense, water supply, and tips & donation were necessary cost items for Bepari. The cost of packaging materials such as gunny bags was important cost item for Bepari of conventional method, whereas for improved method it was for hiring plastic crates. For Arathdar, wages and salaries to the employees was the most important cost item followed by weighing charge, entertainment & personal expenses,

and shop rent. Again, the cost of loading, unloading, hiring cost of crates, rent of shop, and entertainment & personal expense were also important cost items for tomato retailer.

Table 10. Marketing cost (Tk./ton) of tomato for different intermediaries

Items	Bepari		Arathdar (Gazipur)	Retailer (Gazipur)
	Conventional	Improved		
Transportation	1050 (30.9)	1481 (41.4)	-	750 (64.4)
Loading	185 (5.4)	185 (5.2)	-	74 (6.4)
Unloading (to Arathdar)	185 (5.4)	185 (5.2)	-	82 (7.0)
Labour for Crates/gunny bag binding	278 (8.2)	250 (7.0)	-	
Wages and salaries	-	-	310 (56.2)	-
Weighing	-	-	82 (14.9)	-
Packaging materials:				
Plastic crates hiring	-	94 (2.6)	-	74 (6.4)
Gunny bag	280 (8.2)	-	-	-
Paper lining	32 (0.9)	-	-	-
Arathdars' commission	1000 (29.4)	1000 (27.9)	-	-
Shop rent			68 (12.3)	95 (8.2)
Entertainment & personal expense	250 (7.4)	250 (7.0)	76.00 (13.8)	55 (4.7)
Electricity	-	-	9.10 (1.6)	20 (1.7)
Telephone	64 (1.9)	64 (1.8)	5.20 (0.9)	15 (1.3)
Sweeper	-	-	1.60 (0.3)	-
Tips and donation	72 (2.1)	72 (2.0)	-	-
Total	**3396 (100)**	**3581 (100)**	**552 (100)**	**1165 (100)**

Note: Figures within parentheses are percentages of total cost

4.6.4 Marketing cost of bitter gourd

Table 11 depicted that the average cost of bitter gourd marketing was found highest for Bepari using improved method of packaging which was Tk.3368/ton followed by Bepari using conventional method (Tk.3252/ton). Transportation cost was the main cost item for Beparis who used conventional and improved method of packaging. The percentage shares were estimated to be 34.6% and 38.2% of the total cost for conventional and improved method of packaging respectively. The second important cost item for both the systems was Arathdar's commission which occupied about 30% of total cost of bitter gourd marketing. Loading, unloading, labour wage, and entertainment & personal expense were also important cost items for Bepari. For Arathdar, wages and salaries to the employees was the most important cost item which occupied 56% of total marketing cost. Weighing charge, entertainment and personal expense and rent of shop were important cost item for Arathdar of Gazipur which occupied 15%, 14% and 12% of total marketing cost of Arathdar. Retailer of Gazipur incurred Tk.742/ton for transportation which was about 65% of total marketing cost. The cost of shop rent and entertainment & personal expenses shared 8% and 5% of the total marketing cost of retailer respectively. Similarly, the cost of loading and unloading was Tk. 80/ton which shared 7% of the total marketing. Retailer of Gazipur incurred on an average Tk.1134/ton as marketing cost.

Table 11. Marketing cost (Tk./ton) of bitter gourd for different intermediaries

Items	Bepari		Arathdar (Gazipur)	Retailer (Gazipur)
	Conventional	Improved		
Transportation	1125 (34.6)	1285 (38.2)	-	742 (65.4)
Loading	184 (5.7)	184 (5.7)	-	80 (7.1)
Unloading (to Arathdar)	184 (5.7)	184 (5.7)	-	80 (7.1)
Labour for crates/gunny bag binding	275 (8.5)	245 (7.3)	-	-
Wages and salaries	-	-	310 (55.6)	-
Weighing charge	-	-	82 (14.7)	-
Packaging Materials:	-	-	-	-
Plastic crates hiring	-	95 (2.5)	-	-
Gunny bag	109 (3.4)	-	-	55
Arathdar commission	1000 (30.8)	1000 (29.7)	-	-
Shop rent	-	-	68 (12.2)	90 (7.9)
Entertainment & personal expenses	240 (7.4)	240 (7.1)	80 (14.3)	56 (4.9)
Electricity	-	-	9.50 (1.7)	15 (1.3)
Telephone	65 (2.0)	65 (1.9)	6.5 (1.2)	16 (1.4)
Sweeper	-	-	1.60 (0.3)	-
Tips and donation	70 (2.2)	70 (2.1)	-	-
Total	**3252 (100)**	**3368 (100)**	**558 (100)**	**1134 (100)**

Note: Figures within parentheses are percentages of total cost

4.7 Marketing Margins for Intermediaries

Marketing margin is the difference between selling and buying prices of the commodities. The average marketing margins received by different intermediaries are discussed in the following sub-sequent sections.

4.7.1 Marketing margin of brinjal

At Bepari level, the sale prices of brinjal in conventional, improved and cool chain method were Tk. 8100, Tk. 8500 and Tk. 8600 per ton, respectively. Similarly, the sale price of brinjal at retailer level was little bit higher in improved cool chain method. Due to better quality, the price of brinjal under improved packaging with refrigerated transportation system was found to be higher at both levels than the brinjal under conventional and improved method.

Table 12. Marketing margin (Tk/ton) of brinjal for different intermediaries

Particulars	Name of Intermediaries						
	Bepari			Arathdar	Retailer		
	Conventional	Improved	Cool chain	C&I	Conventional	Improved	Cool chain
Sale price	8100	8500	8600	-	12300	12800	13000
Purchase price	3200	3200	3200	-	8100	8500	8600
Gross margin	4900	5300	5400	-	4200	4300	4400
Commission	-	-	-	1000	-	-	-
Marketing cost	3704	3804	7467	601	1217	1217	1217
Net margin	1196	1496 (25.1)	-2067 (-72.8)	399	2983	3083 (3.4)	3183 (6.7)

Note: Figures in the parentheses are percent higher/lower than conventional method

The highest gross margin of brinjal marketing was found for Bepari. Among the intermediaries, the retailer of cool chain method received the highest net margin (Tk. 3183/ton) due to better price followed by the retailer of improved and conventional method. The net margin of Arathdar was Tk. 399 /ton which was much lower than Bepari. In the case of improved method of packaging with refrigerated transportation, Bepari received negative net margin (Tk.-2067/ton) which was only because of higher transportation cost (Table 12).

4.7.2 Price spread of brinjal

The price spread refers to the difference between the price paid by the consumer and price received by the producer of a commodity. Farmers' share is widely regarded as a measure of fairness of the farm price and the efficiency of marketing system (Kohls and Uhl, 1980). Table 13 shows the price spread and producer's share in retail price of brinjal. The total price spreads of brinjal were Tk.9100, Tk.9600 and Tk.9800 per ton for conventional, improved and cool chain method respectively. The percent shares of price spread received by Bepari and retailer in conventional method were 53.8% and 46.2% respectively which were little bit higher than that of improved and cool chain method. Again, the producers' share to consumers' or retail price was found lowest (24.6%) in the cool chain method and the highest in conventional method (26%). Similarly, the share of Beparis to the consumer's price was estimated to be 41.5% in the cool chain method which was higher than improved and conventional method. In the case of retailer, this share was found highest in conventional method and the lowest in cool chain method.

Table 13. Price spread (Tk/ton) of brinjal in the supply chain

Particulars	Conventional method		Improved method		Cool chain method	
	Tk./ton	%	Tk./ton	%	Tk./ton	%
A. Gross price received by producers	**3200**	**26.0**	**3200**	**25.0**	**3200**	**24.6**
a. Marketing cost incurred by producers	772	6.3	772	6.0	772	5.9
b. Net price received by producers	2428	19.7	2428	19.0	2428	18.7
B. Gross margin received by the Bepari	**4900 (53.8)**	**39.8**	**5300 (55.2)**	**41.4**	**5400(55.1)**	**41.5**
a. Marketing cost incurred by Bepari	3704	30.1	3804	29.7	7467	57.4
b. Net margin received by Bepari	1196	9.7	1496	11.7	-2067	15.9
C. Gross margin received by retailer	**4200 (46.2)**	**34.1**	**4300 (44.8)**	**33.6**	**4400(44.9)**	**33.8**
a. Marketing cost incurred by retailer	1217	9.9	1217	9.5	1217	9.4
b. Net margin received by retailer	2983	24.3	3083	24.1	3183	24.5
D. Price paid by the consumers (A+B+C)	**12300**	**100**	**12800**	**100**	**13000**	**100**
E. Price spread (D-A)	9100 (100)		9600 (100)		9800 (100)	

Note: Figures in the parentheses are the percentages of total price spread

4.7.3 Marketing margin of country bean

It was revealed from Table 14 that the net margin of country bean was found to be the highest for retailer using of improved method which was Tk. 2345/ton followed by retailer of conventional method (Tk. 2245 /ton). The improved method using Bepari received the highest gross margin (Tk.5400 /ton) from country bean marketing followed by the Bepari of conventional method (Tk.5000/ton). Again, the net margin received from country bean marketing was found to be Tk. 1461/ton for Bepari of improved method, whereas it was Tk. 1187/ton for conventional method. The net margin of Arathdar was Tk.489/ton which was much lower than Bepari. In improved method of packaging, the purchase and sale price of country bean for retailer were Tk. 8200 and

Tk. 11800 per ton, respectively. The sale price was higher in the case of improved packaging compared to conventional packaging only because of good quality product.

Table 14. Marketing margin (kg/ton) of country bean for different intermediaries

Particulars	Name of Intermediaries				
	Bepari		Arathdar	Retailer	
	Conventional	Improved	C&I	Conventional	Improved
Sale price	7800	8200	-	11300	11800
Purchase price	2800	2800	-	7800	8200
Gross margin	5000	5400	-	3500	3600
Commission	-	-	1000	-	-
Marketing cost	3813	3939	511	1255	1255
Net margin	1187	1461 (23.1)	489	2245	2345 (4.5)

Note: Figures in the parentheses are percent higher than conventional method

4.7.4 Price spread of country bean

The price spread and producer's share in retail price of country bean are presented in Table 15. The total price spreads of country bean were Tk.8500 and Tk.9000 for conventional and improved method respectively. Bepari received 58.8% of the price spread, whereas it was 41.2% for retailer in conventional method. In improved method, the respective shares for Bepari and retailer were 1% higher and 1% lower than that of conventional method respectively which was due to higher consumer's price. Again, the producers' share to consumers' price was 24.8% in conventional method and 23.7% in improved method. Similarly, the Beparis and retailers shares to the consumer's price were estimated to be 44.2% and 31.0% in the conventional method respectively. In improved method, Beparis share to the consumer's price was little bit higher than conventional method.

Table 15. Price spread (Tk/ton) of country bean in the supply chain

Particulars	Conventional method		Improved method	
	Tk./ton	%	Tk./ton	%
A. Gross price received by producers	**2800**	**24.8**	**2800**	**23.7**
a. Marketing cost incurred by producers	663	5.9	663	5.6
b. Net price received by producers	2137	18.9	2137	18.1
B. Gross margin received by the Bepari	**5000 (58.8)**	**44.2**	**5400 (60)**	**45.8**
a. Marketing cost incurred by Bepari	3813	33.7	3939	33.4
b. Net margin received by Bepari	1187	10.5	1461	12.4
C. Gross margin received by retailer	**3500 (41.2)**	**31.0**	**3600 (40)**	**30.5**
a. Marketing cost incurred by retailer	1255	11.1	1255	10.6
b. Net margin received by retailer	2245	19.9	2345	19.9
D. Price paid by the consumers (A+B+C)	**11300**	**100**	**11800**	**100**
E. Price spread (D-A)	8500 (100)		9000 (100)	

Note: Figures in the parentheses are the percentages of total price spread

4.7.5 Marketing margin of tomato

Among the intermediaries, the retailer using improved method received the highest net margin (Tk. 2935/ton) from tomato marketing followed by the retailer of conventional method (Tk. 2835/ton). Again, the Bepari using improved method of packaging received the highest gross margin and net margin followed by the Bepari using conventional method. For Arathdar, the net margin from tomato marketing was estimated to be Tk. 448/ton which was much lower than Bepari and retailer.

Due to better quality product, the retailers who used improved method of packaging received the higher sale price of tomato compared to the retailers who used conventional method (Table 16).

Table 16. Marketing margin (Tk/ton) of tomato for different intermediaries

Particulars	Name of Intermediaries				
	Bepari		Arathdar	Retailer	
	Conventional	Improved	C&I	Conventional	Improved
Sale price	12500	12800	-	16500	16900
Purchase price	8000	8000	-	12500	12800
Gross margin	4500	4800	-	4000	4100
Commission	-	-	1000	-	-
Marketing cost	3396	3581	552	1165	1165
Net margin	1104	1219 (10.4)	448	2835	2935 (3.5)

Note: Figures in the parentheses are percent higher than conventional method

4.7.6 Price spread of tomato

The total price spreads of tomato were Tk.8500 and Tk.8900 for conventional and improved method respectively. Bepari received 53% of the price spread, whereas it was 47% for retailer in conventional method. In improved method, the respective shares for Bepari and retailer were 1% higher and 1% lower than that of conventional method respectively which was due to higher consumer's price. Again, the producers' share to consumers' price was 48.5% in conventional method and 47.3% in improved method implying that producers did not received any benefit from improved method of packaging. However, tomato producers received comparatively big share of the retail price in the study areas. Similarly, the Beparis and retailers shares to the consumer's price were estimated to be 27.3% and 24.4% in the conventional method respectively. In improved method, Beparis share to the consumer's price was little bit higher than conventional method (Table 17).

Table 17. Price spread (Tk/ton) of tomato in the supply chain

Particulars	Conventional method		Improved method	
	Tk./ton	%	Tk./ton	%
A. Gross price received by producers	**8000**	**48.5**	**8000**	**47.3**
a. Marketing cost incurred by producers	420	2.5	420	2.5
b. Net price received by producers	7580	45.9	7580	44.9
B. Gross margin received by the Bepari	**4500 (53)**	**27.3**	**4800 (54)**	**28.4**
a. Marketing cost incurred by Bepari	3396	20.6	3581	21.2
b. Net margin received by Bepari	1104	6.7	1219	7.2
C. Gross margin received by retailer	**4000 (47)**	**24.2**	**4100 (46)**	**24.3**
a. Marketing cost incurred by retailer	1165	7.1	1165	6.9
b. Net margin received by retailer	2835	17.2	2935	17.4
D. Price paid by the consumers (A+B+C)	**16500**	**100**	**16900**	**100**
E. Price spread (D-A)	8500 (100)		8900 (100)	

Note: Figures in the parentheses are the percentages of total price spread

4.7.7 Marketing margin of bitter gourd

Among the intermediaries, the net margin of bitter gourd marketing was found to be the highest for retailer followed by Bepari and Arathdar. However, the highest net margin (Tk.8866/ton) was received by the retailers using improved method of packaging followed by the retailers of conventional method (Tk.7866/ton). The net margin of Arathdar was Tk.442/ton which was much

lower than retailer and Bepari. Again, the Bepari using improved method received the higher net margin (Tk.4632/ton) compared to the Bepari using conventional method (Tk.3248/ton). Similar to other vegetables, the average retail sale price of bitter gourd was higher in the case of improved packaging compared to conventional packaging (Table 18).

Table 18. Marketing margin (Tk/ton) of bitter gourd for different intermediaries

Particulars	Name of Intermediaries				
	Bepari		Arathdar	Retailer	
	Conventional	Improved	C&I	Conventional	Improved
Sale price	18500	20000	-	27500	30000
Purchase price	12000	12000	-	18500	20000
Gross margin	6500	8000	-	9000	10000
Commission	-	-	1000	-	-
Marketing cost	3252	3368	558	1134	1134
Net margin	3248	4632 (42.6)	442	7866	8866 (12.7)

Note: Figures in the parentheses are percent higher than conventional method

4.7.8 Price spread of bitter gourd

The total price spreads of bitter gourd were Tk.15500 and Tk.18000 for conventional and improved method respectively. In both conventional and improved method of packaging, retailers received the highest shares (56-58%) of the price spread compared to Bepari. In improved method, the percent shares for Bepari and retailer were 2% higher and 2% lower than that of conventional method respectively which was due to higher consumer's price. Again, the producers' share to consumers' price was 43.6% in conventional method and 40.0% in improved method implying that producers did not received any benefit from improved method of packaging. However, bitter gourd producers received bigger share of the retail price in the study areas. The percent shares of Beparis and retailers to the consumer's price were estimated to be 23.6% and 32.7% in the conventional method respectively. In improved method, Beparis share to the consumer's price was higher than conventional method (Table 19).

Table 19. Price spread (Tk/ton) of bitter gourd in the supply chain

Particulars	Conventional method		Improved method	
	Tk./ton	%	Tk./ton	%
A. Gross price received by producers	**12000**	**43.6**	**12000**	**40.0**
a. Marketing cost incurred by producers	604	2.2	604	2.0
b. Net price received by producers	11396	41.4	11396	38.0
B. Gross margin received by the Bepari	**6500 (42)**	**23.6**	**8000 (44)**	**26.7**
a. Marketing cost incurred by Bepari	3252	11.8	3368	11.2
b. Net margin received by Bepari	3248	11.8	4632	15.4
C. Gross margin received by retailer	**9000 (58)**	**32.7**	**10000 (56)**	**33.3**
a. Marketing cost incurred by retailer	1134	4.1	1134	3.8
b. Net margin received by retailer	8366	30.4	8866	29.6
D. Price paid by the consumers (A+B+C)	**27500**	**100**	**30000**	**100**
E. Price spread (D-A)	15500 (100)		18000 (100)	

Note: Figures in the parentheses are the percentages of total price spread

4.8 Marketing Efficiency of Vegetables

The higher value of marketing efficiency denotes higher level of efficiency and vice versa. It is reveled from Table 20 that the conventional marketing system of vegetables is more efficient than

improved system for all the studied vegetables except brinjal. It was because of higher transport cost in the case of improved method leading to higher marketing cost than conventional marketing system. Again, the total marketing margin in the cool chain of brinjal was low compared to other two methods. Therefore, the marketing efficiency of brinjal in cool chain method is similar to conventional method. Traders carry large amount of vegetable by traditional packaging like gunny bag or locally called "dhoop" which make low transportation cost as well as lower marketing cost than improved method. Therefore, traditional methods are popular and efficient marketing system in the study areas. Traders only used improved methods like plastic crates in the case of tomato due to its highly perishability.

Table 20. Marketing efficiency of selected vegetables

Particulars	Brinjal			Country bean		Tomato		Bitter gourd	
	Conventional	Improved	Cool chain	Conventional	Improved	Conventional	Improved	Conventional	Improved
Price received by the farmers	3200	3200	3200	2800	2800	8000	8000	12000	12000
Total marketing cost in the chain	4921	5021	8684	5068	5194	4561	4746	4386	4502
Total net marketing margin in the chain	4971	4579	1116	3432	3806	3939	4154	11614	13498
Marketing efficiency	0.32	0.33	0.32	0.33	0.31	0.94	0.90	0.75	0.67

4.9 Postharvest Losses of Vegetables

Postharvest loss is the loss that occurs from the point of harvest of vegetables in the field till it reaches to the ultimate users. A bulk quantity of the harvested vegetables gets wasted every year both at farmers and traders level due to their perishability nature, seasonal oversupply, lack of storage facility, lack of processing facility, poor transportation system, and absence of proper marketing system. Two types of losses such as quantitative losses and qualitative losses were estimated on the basis of some parameters in the present study. The involvement of different marketing actors such as farmers, intermediaries, and consumers, four stages were identified to estimate the postharvest losses during marketing. These were at field level loss, loss during local trading, at wholesale market, and retail level. However, the postharvest losses of vegetables at farmers and traders level are discussed in the following sections.

4.9.1 Postharvest losses of vegetables at farm level

The estimated postharvest losses at farm level are presented in Table 16. In the study areas, the total postharvest losses of brinjal, country bean, tomato and bitter gourd were estimated at 10.5%, 16.8%, 10.1% and 2.6% at producers' level respectively (Table 20). In the total postharvest loss of vegetable, the percent share of qualitative postharvest loss was much higher compared to quantitative loss (Fig 13). In the case of brinjal, the share of postharvest qualitative loss was estimated at 76.2% and the rest was quantitative loss. Similarly, the share of qualitative loss of bitter gourd was 68.2% and the rest was for quantitative loss. In the case of tomato, no qualitative loss was reported by the respondent farmers at all. However, the percent share of quantitative loss was higher for country bean compared to qualitative loss.

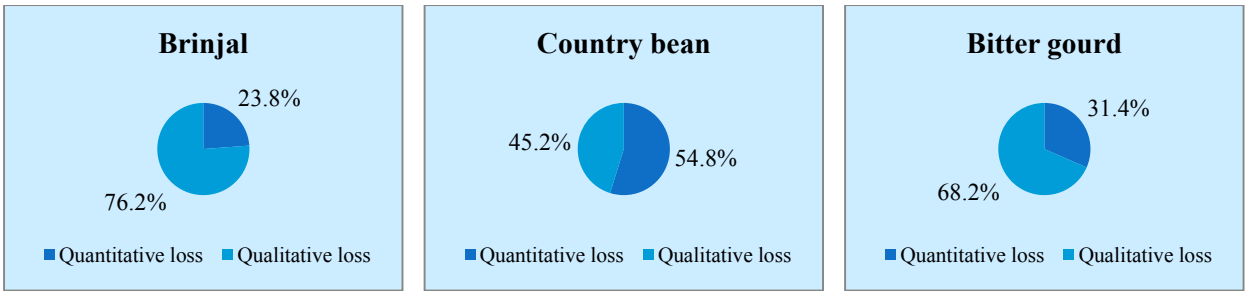

Fig 13. Percent shares of quantitative and qualitative loss of vegetables in the total loss

The major reasons of quantitative losses were reported to be spoilage, infested by insects, infected by diseases, and over maturity. The highest quantitative postharvest loss was recorded in tomato (101 kg/ton) and the lowest (8kg/ton) was for bitter gourd. The quantitative postharvest losses of brinjal and country bean were 25 kg/ton and 92 kg/ton respectively. Infestation of different insects was the main cause of this quantitative loss. Again, the highest qualitative loss was found in brinjal (80 kg/ton) and the lowest (17.5 kg/ton) was for bitter gourd. The qualitative postharvest loss of country bean was 76 kg/ton and no qualitative loss was reported for tomato at farm level. The causes of qualitative losses were insect infestation, infection by diseases, spotted, shapeless, and over maturity (Table 21).

Table 21. Postharvest loss (kg/ton) of selected vegetables at farm level

Postharvest losses	Brinjal	Country bean	Tomato	Bittergourd
A. Quantitative loss (kg/ton)	25 (23.8)	92 (54.8)	101 (100.0)	8 (31.4)
Rotten and spoiled	-	-	31 (30.7)	-
Insect infestation	20 (19.0)	92 (54.8)	-	5 (19.6)
Infected by diseases	5 (4.8)	-	70 (69.3)	-
Over matured	-	-	-	3 (11.8)
B. Qualitative loss (kg/ton)	80 (76.2)	76 (45.2)	-	17.5 (68.2)
Shapeless/over mature	20 (19.0)	-	-	15 (58.8)
Spotted	5 (4.8)	76 (45.2)	-	-
Insect infestation	45 (42.9)	-	-	-
Infected by diseases	10 (9.5)	-	-	2.5 (9.8)
C. Grand total (A+B)	105 (100)	168 (100)	101 (100)	25.5 (100)

Note: Figures within parentheses are percentages of total loss

4.9.2 Postharvest losses of vegetables at trader's level

The trader's level postharvest losses were estimated at each transaction point on the basis of transporting selected vegetables under both conventional and improved methods. The materials used in conventional packaging system were gunny bag, plastic bag (locally called 'jail') and open space on truck depending on the nature of vegetables. The improved packaging system considered only plastic crates for carrying vegetables through truck or pickup van. In the case of cool chain, plastic crates were used for brinjal packaging and then transported them through refrigerated van.

4.9.2.1 Postharvest losses of brinjal

The total postharvest loss of brinjal in conventional method was 72 kg/ton in which quantitative and qualitative postharvest losses were 62 kg/ton and 10 kg/ton respectively for Bepari. The causes of quantitative loss under conventional system were crack (48.6%) and weight loss (37.5%), whereas only cracked & spotted (10.9%) was reported to be the main cause of qualitative postharvest loss

of brinjal for Bepari. In the case of improved method, the total postharvest loss of brinjal was 39kg/ton which was due to weight loss (61.5%) and qualitative postharvest loss (21.5%) occurred in improved method for Bepari. In the case of cool chain, the total postharvest loss of Bepari was 23kg/ton which was lowest among different packaging methods. The above scenario implying that Bepari could save 84.6% postharvest loss of brinjal through transportation with improved packaging, whereas it was 213% for refrigerated transportation (Table 22).

In retail level, the total postharvest loss of brinjal under conventional methods was 95 kg/ton in which the amounts of quantitative and qualitative postharvest losses were 35 kg/ton and 60 kg/ton respectively. Among total postharvest losses, retailer found 26.3% rotten & spoiled and 10.0% weight loss which was under quantitative postharvest loss and 63.2% cracked & spotted which was under qualitative postharvest loss in conventional method packaging of brinjal. In improved method, the total postharvest loss of brinjal at retail level was 20 kg/ton in which quantitative and qualitative postharvest losses were 15 kg/ton and 5 kg/ton respectively. Among the total losses the retailer found 60% rotten & spoiled and 15% weight losses which were under quantitative postharvest losses, and 25% cracked & spotted which was under qualitative postharvest losses in improved methods of brinjal marketing. In cool chain method, this loss was only 8 kg/ton of which the shares of quantitative and qualitative losses were 62.5% and 37.5% respectively (Table 22). Like wholesale level, the postharvest loss was also lowest in cool chain method of transportation.

Table 22. Postharvest losses of brinjal at trader's level

Postharvest losses	Bepari			Retailer			Total		
	Conventional	Improved	Cool chain	Conventional	Improved	Cool chain	Conventional	Improved	Cool chain
A. Quantitative loss (kg/ton)	62 (86.1)	32 (82.1)	18 (78.3)	35 (36.8)	15 (75.0)	5 (62.5)	97 (58.1)	47(79.7)	23(74.2)
Weight loss	27 (37.5)	24 (61.5)	18 (78.3)	10 (10.5)	3 (15.0)	2 (25.0)	37 (22.2)	27 (45.7)	20(64.5)
Rotten and spoiled	-	-	-	25 (26.3)	12 (60.0)	3 (37.5)	25 (14.9)	12 (20.4)	3 (9.7)
Cracked	35 (48.6)	8 (20.5)	-	-	-	-	35 (20.9)	8 (13.6)	-
B. Qualitative loss (kg/ton)	10 (13.9)	7 (17.9)	5 (21.7)	60 (63.2)	5 (25.0)	3 (37.5)	70 (41.9)	12 (20.3)	8 (25.8)
Cracked and spotted	10 (13.9)	7 (17.9)	5 (21.7)	60 (63.2)	5 (25.0)	3 (37.5)	70 (41.9)	12 (20.3)	8 (25.8)
C. Grand total (A+B)	72 (100)	39 (100)	23 (100)	95 (100)	20 (100)	8 (100)	167 (100)	59 (100)	31 (100)

Note: Figures within parentheses are percentages of total loss

Irrespective of traders, the total postharvest losses of brinjal were estimated to be 167 kg, 59 kg and 31 kg per ton under conventional, improved and cool chain method of packaging and transportation. In conventional method, the shares of quantitative and qualitative losses were 58.1% and 41.9% respectively. On the other hand, these shares were 79.7% and 20.3% respectively for quantitative and qualitative losses under improved method. In cool chain method, the share of quantitative loss (74.2%) was much higher than qualitative loss (25.8%). However, the analysis clearly shows that transportation with improved packaging and refrigerated van could save a huge amount of postharvest losses (108-136 kg/ton) of brinjal for the traders in the study areas.

***Total postharvest loss (%) in the supply chain*:** The total postharvest loss of brinjal in the supply chain was estimated to be 27.2%, 16.4% and 13.6% for conventional, improved and cool chain method of packaging respectively. In conventional method, the total quantitative and qualitative losses were 12.2% and 15% respectively, which were higher than improved and cool chain method (Fig 14). The total postharvest loss of brinjal would be lower if the study is conducted in the peak season. It was opined that the qualitative loss of brinjal is much lower in the peak season because of less quantity over matured brinjal in the harvest. However, the total postharvest loss of brinjal

was highest for farmer followed by Bepari and retailer. Hassan et al. (2010) estimated 29.4% total postharvest loss of brinjal through survey method. In India, this loss was 16.81% (Sharma and Singh, 2011). Postharvest loss of brinjal in Jordan (19.4%) was higher than India as well as the present study (Kitinoja and Kader, 2015).

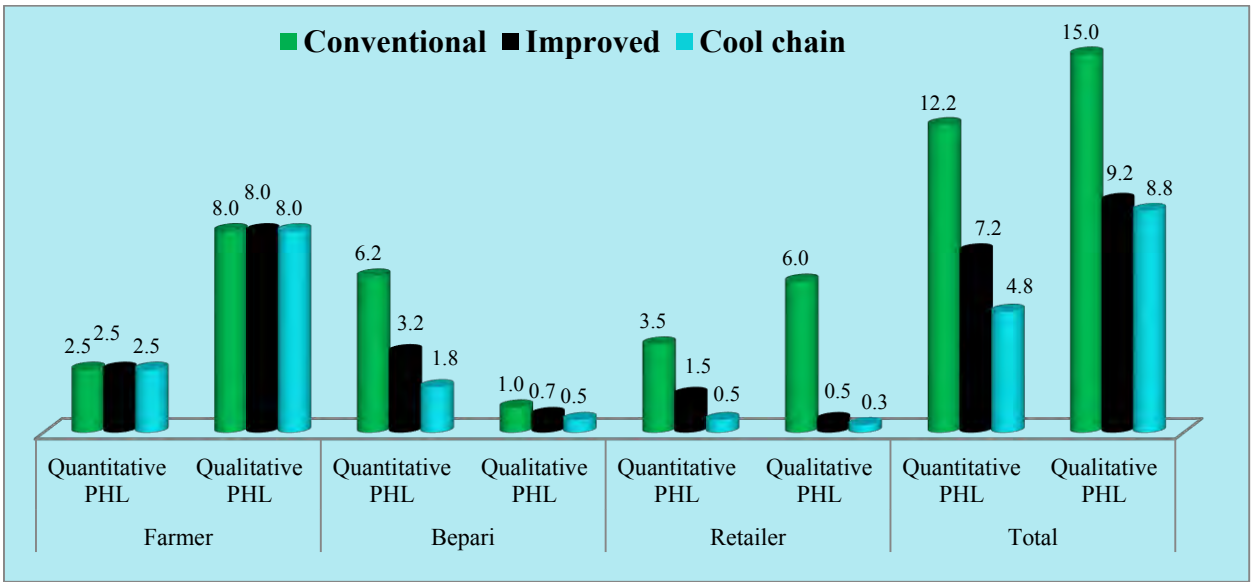

Fig 14. Total postharvest loss of brinjal in the supply chain

4.9.2.2 Postharvest loss of country bean

In conventional transportation with plastic bag packaging, the total postharvest loss of country bean was 72 kg/ton in which the amounts of quantitative and qualitative postharvest losses were 59 kg/ton and 13 kg/ton respectively for Bepari. Among the total losses 81.9% weight loss was found under quantitative losses and only 13.1% cracked & spotted country beans were found under qualitative postharvest losses. In improved method of packaging, the total postharvest loss of country bean was much lower (61.1%) compared to conventional method and this loss was only because of weight loss. In this case, no qualitative postharvest loss was found by Bepari (Table 23).

In retail level, the total postharvest loss of country bean under conventional methods was 55 kg/ton in which the amounts of quantitative and qualitative postharvest losses were 15 kg/ton and 40 kg/ton respectively. The causes of quantitative losses under conventional method were rotten & spoiled (18.2%) and weight loss (9.1%), and cracked & spotted (72.7%) was for qualitative postharvest losses. In improved packaging method, the total postharvest loss was 35 kg/ton in which the amounts of quantitative and qualitative postharvest losses were 10 kg/ton and 25 kg/ton respectively. The causes of quantitative loss under improved method were rotten & spoiled (22.9%) and weight loss (5.7%), whereas only cracked & spotted (71.4%) was responsible for qualitative loss (Table 23).

Finally, the total postharvest losses of country bean were estimated to be 127 kg/ton and 63 kg/ton under conventional and improved method of packaging and transportation. The shares of quantitative and qualitative losses were 58.3% and 41.7% respectively under conventional method. Again, these shares for quantitative and qualitative losses were 60.3% and 39.7% respectively under improved method. The analysis revealed that transportation with improved packaging could save 50.4% of postharvest losses of country bean for the traders in the study areas.

Table 23. Postharvest losses of country bean at trader's level

Postharvest losses	Bepari		Retailer		Total	
	Conventional	Improved	Conventional	Improved	Conventional	Improved
A. Quantitative loss (kg/ton)	59 (81.9)	28 (100)	15 (27.3)	10 (28.6)	74 (58.3)	38 (60.3)
Weight loss	59 (81.9)	28 (100)	5 (9.1)	2 (5.7)	64 (50.4)	30 (47.6)
Rotten and spoiled	-	-	10 (18.2)	8 (22.9)	10 (7.9)	8 (12.7)
B. Qualitative loss (kg/ton)	13 (18.1)	-	40 (72.7)	25 (71.4)	53 (41.7)	25 (39.7)
Cracked & spotted	13 (18.1)	-	40 (72.7)	25 (71.4)	53 (41.7)	25 (39.7)
C. Grand total (A+B)	72 (100)	28 (100)	55 (100)	35 (100)	127 (100)	63 (100)

Note: Figures within parentheses are percentages of total loss

***Total postharvest loss (%) in the supply chain*:** The total postharvest loss of country bean in the supply chain was estimated to be 29.5% and 23.1% for conventional and improved method of packaging. In conventional method, the total quantitative and qualitative losses were 16.6% and 12.9% respectively, which were higher than improved method (Fig 15). Among the stakeholders of the supply chain, the total postharvest loss was highest for farmer followed by Bepari and retailer. In India, Sagar et al. (2010) estimated 16.32% total postharvest losses of beans in the supply chain *Farmer-Commission agent1-Commission agent 2- Retailer-Consumer.* The quantitative loss estimated in the present study is more or less same as the loss found in India.

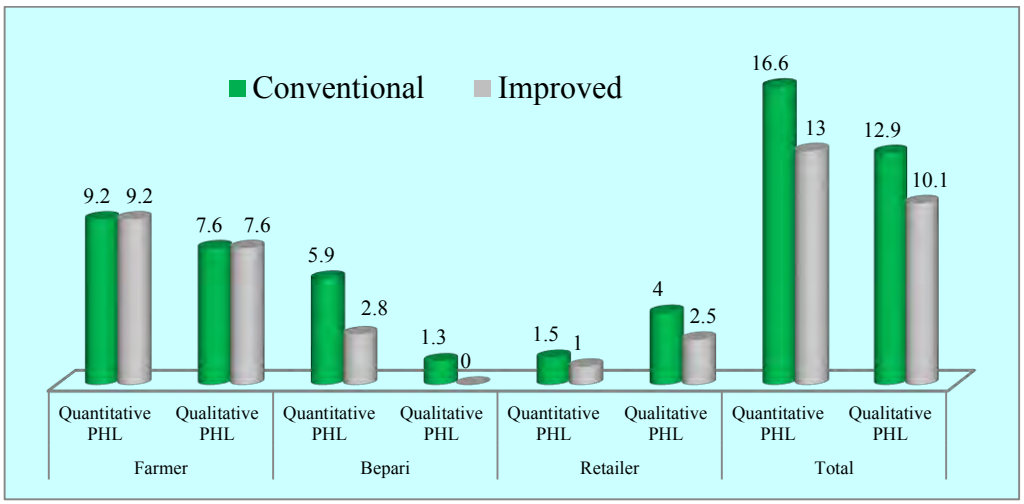

Fig 15. Total postharvest loss of country bean in the supply chain

4.9.2.3 Postharvest loss of tomato

The total postharvest quantitative loss of tomato in conventional method of packaging was 29 kg/ton and no qualitative loss was found at all by Bepari. The loss was occurred due to cracks (82.8%) and rotten & spoiled (17.8%). Again, no loss was found by Bepari in improved method of packaging and transportation (Table 24).

In retail level, the total postharvest loss of tomato was 90 kg/ton under conventional method and 76 kg/ton under improved method indicating that retailer could save about 16% tomato from postharvest losses by practicing improved packaging. In conventional method, the percent share of quantitative and qualitative loss was 40% and 60% respectively. Again, the total postharvest loss of tomato in improved method was 76kg/ton in which the amounts of quantitative and qualitative postharvest losses were 31kg/ton and 45 kg/ton respectively. The cause of this quantitative loss was

rotten & spoiled (40.8%). Besides, cracked & spotted (59.2%) was identified as the main cause for qualitative loss in improved methods of tomato retailing (Table 24).

Table 24. Postharvest loss of tomato at traders' level

Postharvest losses	Bepari		Retailer		Total	
	Conventional	Improved	Conventional	Improved	Conventional	Improved
A. Quantitative loss (kg/ton)	29 (100)	-	36 (40.0)	31 (40.8)	65 (54.6)	31 (40.8)
Crakes	24 (82.8)	-	-	-	24 (20.2)	-
Rotten and spoiled	5 (17.2)	-	36 (40.0)	31 (40.8)	41 (34.5)	31 (40.8)
B. Qualitative loss (kg/ton)	-	-	54 (60.0)	45 (59.2)	54 (45.4)	45 (59.2)
Cracked & spotted	-	-	54 (60.0)	45 (59.2)	54 (45.4)	45 (59.2)
C. Grand total (A+B)	**29 (100)**	**-**	**90 (100)**	**76 (100)**	**119 (100)**	**76 (100)**

Note: Figures within parentheses are percentages of total loss

The total postharvest loss of tomato was found to be 119 kg/ton for conventional method and 76 kg/ton for improved method of packaging and transportation. In conventional method, the percent shares of quantitative and qualitative losses were 54.6% and 45.4% respectively. Again, these shares were 40.8% and 59.2% respectively for quantitative and qualitative losses under improved method. However, it is clear that transportation with improved packaging could save a huge amount of postharvest losses (36.1%) of tomato for the traders as well as for the country.

***Total postharvest loss (%) in the supply chain*:** The total postharvest loss of tomato in the supply chain was estimated to be 22.0 % and 17.7% for conventional and improved method of packaging. In conventional method, the total quantitative and qualitative losses were 16.6% and 5.4% respectively, which were higher than improved method (Fig 16). Among the stakeholders of the supply chain, the total postharvest loss was highest for farmer followed by Bepari and retailer. Khatun et al., (2014) estimated quantitative postharvest losses of tomato to be 15.37% and 10% at the farmers' and intermediaries level respectively. In Pakistan, Rahman et al., (2007) estimated the postharvest loss of tomato in Peshawar valley to be 20% of the total production. These losses were little bit higher in Cambodia which were 23% and 22.5% in the traditional and modern chains respectively (Buntong et al., 2013).

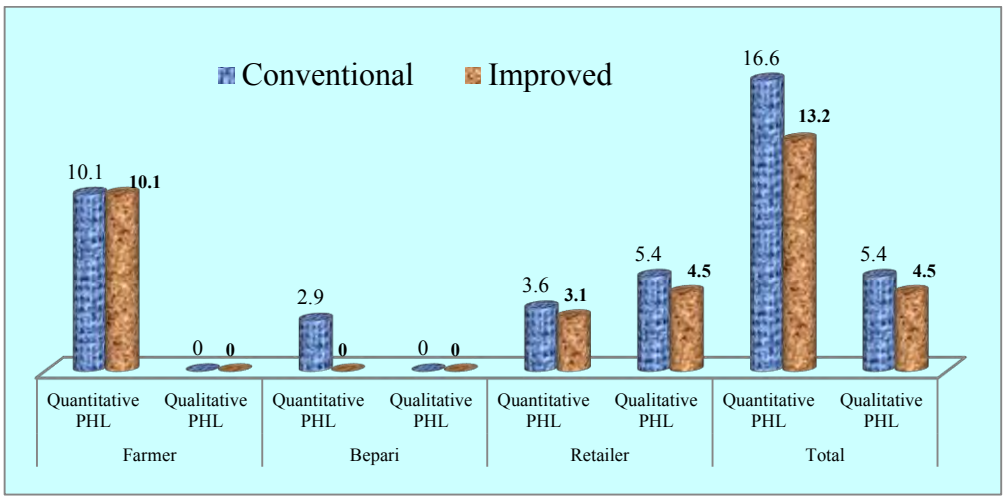

Fig 16. Total postharvest loss of tomato in the supply chain

4.9.2.4 Postharvest loss of bitter gourd

Table 25 shows that the total postharvest loss in conventional method was about 49% higher than that of improved method for Bepari, whereas it was about 18% higher for retailer. In conventional method, the total postharvest loss of bitter gourd was 47.6 kg/ton in which the amounts of

quantitative and qualitative postharvest losses were 32.6 kg/ton and 15 kg/ton respectively for Bepari. Among the total losses, the highest weight loss (56.7%) was found in quantitative postharvest losses and 31.6% shapeless & spotted were found in qualitative postharvest losses in conventional methods. Again, the total postharvest loss of bitter gourd under improved method was 24.7 kg/ton in which the amounts of quantitative and qualitative losses were 16.7 kg/ton and 8 kg/ton respectively for Bepari. In improved method, the highest 48.6% weight loss was found in quantitative postharvest losses and 32.4% shapeless & spotted was found in qualitative postharvest losses.

The total postharvest loss of bitter gourd at retail level was 25.5 kg/ton in which the amounts of quantitative and qualitative losses were 22.5 kg/ton and 3.0 kg/ton respectively. In conventional method, retailer found 35.3% weight loss and 27.5% rotten & spoiled bitter gourd under quantitative postharvest loss and 11.8% shapeless & spotted under qualitative postharvest loss. In improved method, the total postharvest loss of bitter gourd was 21 kg/ton in which the amounts of quantitative and qualitative losses were 19 kg/ton and 2 kg/ton respectively. Among the total losses, the quantitative loss was 33.3% due to weight loss and 31.0% for rotten & spoiled. Only 9.5% shapeless and spotted bitter gourd was found in qualitative postharvest losses under improved methods of bitter gourd retailing (Table 25).

Table 25. Postharvest loss of bitter gourd at traders' level

Postharvest losses	Bepari		Retailer		Total	
	Conventional	Improved	Conventional	Improved	Conventional	Improved
A. Quantitative loss (kg/ton)	32.6 (68.4)	16.7 (67.6)	22.5 (88.2)	19 (90.5)	55.1 (75.4)	35.7(78.1)
Weight loss	27 (56.7)	12 (48.6)	9 (35.3)	7 (33.3)	36 (49.2)	19 (41.6)
Rotten and spoiled	-	-	7 (27.5)	6.5 (31.0)	7 (9.6)	6.5 (14.2)
Disease infected	1.4 (2.9)	1.0 (4.0)	-	-	1.4 (1.9)	1 (2.2)
Over matured	4.2 (8.8)	3.7 (15.0)	6.5 (25.5)	5.5 (26.2)	10.7 (14.6)	9.2 (20.1)
B. Qualitative loss (kg/ton)	15 (31.6)	8 (32.4)	3 (11.8)	2 (9.5)	18 (24.6)	10 (21.9)
Spotted/ shapeless	15 (31.6)	8 (32.4)	3 (11.8)	2 (9.5)	18 (24.6)	10 (21.9)
C. Grand total (A+B)	**47.6 (100)**	**24.7 (100)**	**25.5 (100)**	**21.0 (100)**	**73.1 (100)**	**45.7 (100)**

Note: Figures within parentheses are percentages of total loss

Irrespective of traders, the total postharvest loss of bitter gourd under conventional method was found to be 73.1 kg/ton, whereas this loss was 45.7 kg/ton under improved method of packaging and transportation. The shares of quantitative and qualitative losses were 75.4% and 24.6% respectively under conventional method. In improved method, these shares were estimated at 78.1% and 21.9% respectively for quantitative and qualitative losses. Finally, the study revealed that transportation with improved packaging could save about 38% postharvest losses of bitter gourd for the traders as well as for the country.

***Total postharvest loss (%) in the supply chain*:** The total postharvest loss of bitter gourd in the supply chain was estimated to be 9.9% and 7.2% for conventional and improved method of packaging. In conventional method, the total quantitative and qualitative losses were 6.3% and 3.6% respectively, which were higher than improved method (Fig 17). Among stakeholders in the supply chain, the total postharvest loss was highest for Bepari followed by retailer.

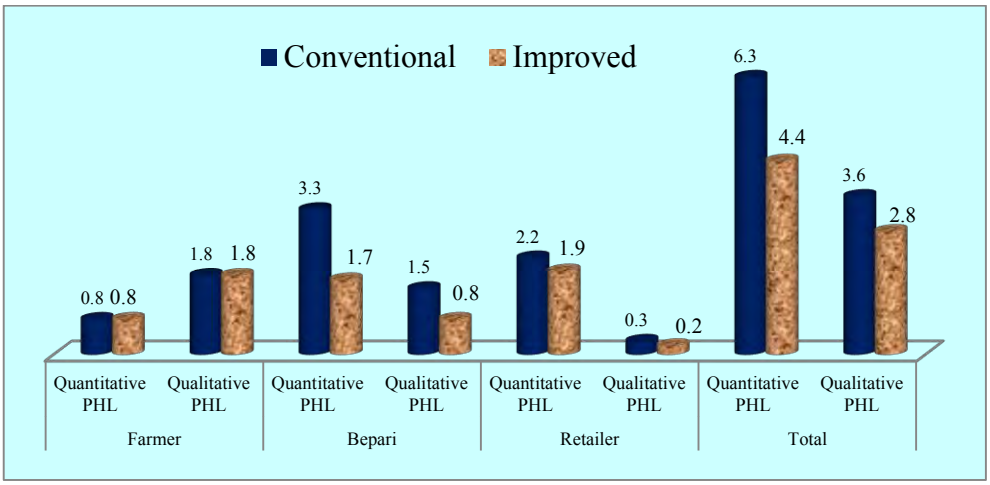

Fig 17. Total postharvest loss of bitter gourd in the supply chain

4.10 Monetary Loss of Vegetables at Farm Levels

An attempt was made to estimate the monetary loss of vegetables that lost during postharvest handling at farm level. Table 26 reveals that the estimated monetary loss per ton ranged from Tk.192 to Tk. 808 for different selected vegetables. However, the highest loss was found for tomato (Tk.808/ton) followed by country bean (Tk. 375/ton), brinjal (Tk. 208/ton) and bitter gourd (Tk.192/ton).

Table 26. Monetary loss due to postharvest loss of vegetables at farm level

Name of Stakeholders	Postharvest loss (kg/ton)		Price (Tk./kg)		Monetary loss (Tk./ton)
	Quantitative loss (Full damaged)	Qualitative loss (Partial damaged)	Fresh price	Reduced price	
Brinjal	25	80	3.20	1.60	208
Country bean	92	76	2.80	1.25	375
Tomato	101	-	8.00	4.55	808
Bitter gourd	8	17.5	12.00	6.50	192

4.11 Monetary Loss of Vegetables at Traders' Level

An attempt was also made to estimate the monetary loss of vegetables that lost during postharvest handling at traders' level. The amounts of monetary loss incurred for different vegetables are briefly discussed in the following sections.

4.11.1 Monetary loss of brinjal

The total monetary losses of brinjal were estimated at Tk.1325, Tk.524 and Tk.259 per ton for conventional, improved and cool chain method respectively. The estimated loss under conventional method was 153% and 412% higher than that of improved and cool chain method. The monetary loss of brinjal was higher for retailer than Bepari in conventional method, but lower in improved method. In conventional method, the monetary loss of retailer was Tk. 779/ton, whereas it was Tk. 546/ton for Bepari. Similarly, the monetary losses of retailer and Bepari in improved method were Tk. 220 and Tk. 304 per ton respectively (Table 27).

Table 27. Monetary loss of brinjal at traders' level

Particulars	Methods	Unit	Bepari	Retailer	Total
Quantitative loss (Full damaged)	Conventional	kg/ton	62	35	97
	Improved	kg/ton	32	15	27
	Cool chain	kg/ton	18	5	23
Qualitative loss (Partial damaged)	Conventional	kg/ton	10	60	70
	Improved	kg/ton	7	5	12
	Cool chain	kg/ton	5	3	8
Fresh price	Conventional	Tk./kg	8.10	12.30	20.4
	Improved	Tk./kg	8.50	12.80	21.3
	Cool chain	Tk./kg	8.60	13.00	21.60
Reduce price	Conventional	Tk./kg	3.70	6.50	10.2
	Improved	Tk./kg	4.00	7.20	11.2
	Cool chain	Tk./kg	4.20	7.40	11.60
Total monetary loss	Conventional	Tk./ton	546	779	1325
	Improved	Tk./ton	304	220	524
	Cool chain	Tk./ton	177	82	259

Note: Figures in the parentheses are percent higher than improved method

4.11.2 Monetary loss of country bean

The monetary loss of country bean was higher for Bepari than retailer in conventional method, but opposite scenario was found in improved method. In conventional method, the monetary loss of Bepari was Tk. 512/ton, whereas it was Tk. 230/ton for retailer. Similarly, the monetary losses of retailer and Bepari in improved method were Tk. 268 and Tk. 230 per ton respectively. Both at Bepari and retailer level, the qualitative and quantitative loss of country bean were higher in conventional method than improved method. The total monetary losses of country bean were estimated at Tk.925 and Tk.498 per ton for conventional and improved method respectively. The estimated loss under conventional method was 86% higher compared to improved method (Table 28).

Table 28. Monetary loss of country bean at traders' level

Particulars	Methods	Unit	Bepari	Retailer	Total
Quantitative loss (Full damaged)	Conventional	kg/ton	59	15	74
	Improved	kg/ton	28	10	38
Qualitative loss (Partial damaged)	Conventional	kg/ton	13	40	53
	Improved	kg/ton	0	25	25
Fresh price	Conventional	Tk./kg	7.80	11.30	19
	Improved	Tk./kg	8.20	11.80	20
Reduce price	Conventional	Tk./kg	3.80	5.20	9
	Improved	Tk./kg	4.30	5.80	10
Total monetary loss	Conventional	Tk./ton	512 (123)	414 (54)	925 (86)
	Improved	Tk./ton	230	268	498

Note: Figures in the parentheses are percent higher than improved method

4.11.3 Monetary loss of tomato

The estimated monetary loss of tomato was much higher for retailer compared to Bepari at both conventional and improved method. The monetary loss of Bepari in conventional method was Tk. 362.5/ton, whereas it was Tk. 1053/ton for retailer. The estimated monetary loss of retailer in

improved method was Tk. 915 per ton, whereas no monetary loss was found for Bepari. The total monetary losses of tomato were estimated at Tk.1416 and Tk.915 per ton for conventional and improved method respectively. The estimated loss under conventional method was 55% higher compared to improved method (Table 29).

Table 29. Monetary loss of tomato at traders' level

Particulars	Methods	Unit	Bepari	Retailer	Total
Quantitative loss (Full damaged)	Conventional	kg/ton	29	36	65
	Improved	kg/ton	-	31	31
Qualitative loss (Partial damaged)	Conventional	kg/ton	-	54	54
	Improved	kg/ton	-	45	45
Fresh price	Conventional	Tk./kg	12.50	16.50	29
	Improved	Tk./kg	12.80	16.90	29.7
Reduced price	Conventional	Tk./kg	5.90	8.00	13.9
	Improved	Tk./kg	6.00	8.20	14.2
Total monetary loss	Conventional	Tk./ton	362.5	1053 (15)	1416 (55)
	Improved	Tk./ton	0	915	915

Note: Figures in the parentheses are percent higher than improved method

4.11.4 Monetary loss of bitter gourd

Table 30 shows that the estimated monetary loss of bittergourd was much higher for Bepari than retailer in conventional method, but opposite scenario was found in improved method. The monetary loss of Bepari in conventional method was Tk. 835/ton, whereas it was Tk. 649/ton for retailer. Similarly, the monetary losses of retailer and Bepari in improved method were Tk. 594 and Tk. 406 per ton respectively. The total monetary losses of bitter gourd were estimated at Tk.1483 and Tk.1000 per ton for conventional and improved method respectively. The estimated loss under conventional method was 48% higher compared to improved method.

Table 30. Monetary loss of bitter gourd at traders' level

Particulars	Methods	Unit	Bepari	Retailer	Total
Quantitative loss (Full damaged)	Conventional	kg/ton	36.6	22.5	59
	Improved	kg/ton	16.7	19.0	36
Qualitative loss (Partial damaged)	Conventional	kg/ton	15.0	3.0	18
	Improved	kg/ton	8.0	2.0	10
Fresh price	Conventional	Tk./kg	18.50	27.50	46
	Improved	Tk./kg	20.00	30.00	50
Reduced price	Conventional	Tk./kg	8.00	17.50	25.5
	Improved	Tk./kg	11.00	18.00	29.0
Total monetary loss	Conventional	Tk./ton	835 (106)	649 (9)	1483 (48)
	Improved	Tk./ton	406	594	1000

Note: Figures in the parentheses are percent higher than improved method

4.12 Stakeholders Perceptions towards Postharvest Loss

The stakeholders in the vegetable supply chain were asked to response about the required measures that will minimize damages to vegetables during postharvest handling and transportation. In this respect, they suggested some probable measures that should maintain during transportation and request to provide them necessary information to minimize postharvest losses to vegetables. All their perceptions are discussed in the following sections.

4.12.1 Steps for minimizing transportation damages

Vegetable traders suggested different steps for reducing damage to vegetables during transportation. Majority of the traders suggested using plastic crates with paper lining for minimizing damage of vegetables. About 67% traders recommended that good vegetables should be separated from rotten, bad quality, damaged, and contaminated vegetables during transportation. A good percentage of *Bepari* and retailer suggested avoiding transport large volume of vegetables at a time. The use of clean container can also minimize damages and contamination of vegetables to some extent. That's why 58% traders suggested using clean container to minimize transportation loss. About 38% traders thought that transportation loss could be minimized through buying vegetables from nearby markets (Table 31).

Table 31. Probable steps needed during transportation to minimize damage to vegetables

Type of information needed	% of responses		
	Bepari *(n=4)*	Retailer *(n=20)*	All *(n=24)*
1. Use plastic crates or bamboo cage for packaging	75	85	83
2. Separate rotten, bad quality, damaged and contaminated tomatoes from good ones	75	65	67
3. Avoid large volume transport at a time	75	60	63
4. Use clean container	50	60	58
5. Purchase from nearby markets	25	40	38

4.12.2 Type of information needed

The stakeholders in the vegetable supply chain felt the necessity of information regarding food quality and reducing postharvest losses to vegetables. They needed different types of information such as political program like *Hartal*, transport strike, technique of quality maintenance, low-cost storage, good quality packaging, daily market price, and exact dose of ripening chemicals for tomato (Table 32).

Table 32. Need of information pertinent to food quality and reducing postharvest losses

Type of information needed	% of responses		
	Bepari *(n=4)*	Retailer *(n=20)*	All *(n=24)*
1. Quality maintenance information	50	60	58
2. Political program (i.e. Hartal, strike)	50	45	46
3. Good quality packaging	50	40	42
4. Low cost storage	75	25	33
5. Daily market price	25	15	17
6. Exact dose of ripening chemicals	25	20	21

4.12.3 Type of preferred broadcast media

Respondent vegetable traders were asked about their preferred broadcast media though which they like to get their required information. In this regard, they mentioned various broadcast media. The highest percentage of traders (92%) preferred television as the broadcast media because they enjoy it on a regular basis. The second most preferred broadcast media was reported to be mobile massage (79%). The next important preferred broadcast media was billboard. It will easily be visible to most of the traders in the market. The other favorite broadcast medias were distributing brochure or pamphlets and conducting training for vegetable traders (Table 33).

Table 33. Percent responses on preferred broadcast media

Preferred broadcast media	% of responses		
	Bepari *(n=4)*	Retailer *(n=20)*	All *(n=24)*
1. Television	100	90	92
2. Mobile massage	100	75	79
3. Billboard	50	60	58
4. Leaflet or pamphlets	25	25	25
5. Conducting training	50	20	25

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study has estimated the quantitative and qualitative postharvest losses of vegetables at various stages of supply chain using conventional, improved and cool chain packaging and transportation, and analyzed the financial impact of improved packaging over conventional method. In the study areas, vegetables are mostly transported long distances with open truck using conventional packaging and no modern refrigerated vehicle is found operating in vegetables supply chain. The postharvest losses of vegetables are much higher for long distance transportation with conventional packaging compared to improved and cool chain packaging using plastic crates. Traditional transportation with improved packaging can efficiently minimize both quantitative and qualitative losses of selected vegetables and ensure better margins for the traders. Again, the lowest postharvest loss is occurred in the cool chain method, but the system is not cost effective to the traders. Finally, the stakeholders of the supply chain put emphasis on using plastic crates for packaging high value vegetables for distant transportation and suggest providing information regarding the techniques of maintaining good quality and minimizing loss to vegetables.

5.2 Recommendations

- Cool chain method of transportation ensures lowest level of postharvest loss of vegetables, but the system is not cost effective to the traders. Therefore, traders involved in high value vegetable marketing should be encouraged for using plastic crates so that they can minimize postharvest losses of vegetables and ensure better margin for them.
- Using plastic crates not only minimize transportation losses to vegetables, but also increase the cost of transportation. Because empty crates had to be taken back by the traders after unloading the vegetables in wholesale market. To minimize this cost, plastic crates should be made in such a way so that it can be folded during taking back. Government or development agency can come forward in this issue.
- Traders should be motivated to avoid transport large volume of vegetables at a time. This will only possible when the truck fare will be reasonable. So that government should take necessary initiatives (e.g. reduce fuel price, reduce ferryboat charge, control bribing, etc.) in this regards.
- Most of the farmers generally harvest vegetables in the afternoon and sell them in the next day that increases the possibility of losses to vegetables. Therefore, farmers may be motivated to harvest vegetables just prior to sell (in the morning) instead of harvesting previous day.
- All the stakeholders in the vegetable supply chain should be given adequate training on postharvest management practices. Bangladesh Agricultural Research Institute (BARI) may play a leading role in collaboration with BARC, DAE, and BAU to perform the task.

- Loss reduction strategies should be strengthened right from the beginning. Continuous research is crucial to mitigate diverse problems prevailing in vegetable supply chain in Bangladesh. Capacity strengthening in terms of postharvest research of BARI needs to be taken into consideration.
- To minimize postharvest loss of tomato, small-scale processing facilities should be established in the tomato growing areas. This initiative will enhance employment generation and women's involvement.
- To create awareness among vegetable producers and traders, postharvest management related information should be disseminated through TV, mobile phone, setting billboard in the market premises, and distributing leaflets.

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GLOSSARY

***Bepari*:** *Bepari* is a professional wholesale trader who makes his purchase from producer or *Faria* at the local assemble market, bring their consignment to the urban wholesale market and sell them to *Paiker* and retailer through *Arathdar*. Their volume of purchase is generally high and use large vehicle for transporting produces from assemble market to distant wholesale markets.

***Arathdar*:** *Arathdar* is a commission agent who has a fixed establishment and operates between *Bepari* and retailer, or between *Bepari* and *Paiker*, or between *Faria* and *Bepari*. They take commission from both the parties, but generally they do not follow any standard rule to take commission. The rate of commission was 100 taka per quintal in the study areas.

Paiker: Wholesaler in the wholesale market is known as *Paiker*, who purchase from *Bepari* through *Arathdar* and sell those to the retailer.

Retailer: The retailer, the last link in the marketing channel, buys produces from *Arathdar* or wholesaler/*Paiker* and sells these to the consumers.

ANNEX A. Photos of vegetable marketing

RRM

ISSAN

শীতাতপ নিয়ন্ত্রিত রপ্তানীযো
শাক সজী, ফল ফুল ও হিমায়িত পণ্য
(Freezing Van)
বাংলাদেশ কৃষি উন্নয়ন