



Tenure Completion Report of **Postharvest Management Expert** (11 January 2018 to 10 December 2022)

Submitted to
Managing Director
Hortex Foundation, Dhaka

Prepared and submitted by
Md. Atiqur Rahman, Ph.D.
Postharvest Management Expert

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National Agricultural Technology Program-Phase II Project (NATP-2)
Hortex Foundation
As Strategic Partner of the Department of Agricultural Extension

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Executive Summary

In Bangladesh, the average postharvest loss of fresh fruits and vegetables was estimated at about 30%, which negatively impact on the economic benefit derived from crop production. Thus, it is important to integrate postharvest technologies and best management practices for improving the existing value chain system, which will be helpful to add value, minimize postharvest losses, maintain product quality and safety, and finally to ensure better price for the marginal farmers. The main objective of National Agricultural Technology Program-Phase II Project (NATP-2) is to increase agricultural productivity of smallholder farms and improve smallholder farmer's access to markets in selected districts. In this project, Hortex Foundation is working as strategic partner of DAE to assist the Common Interest Groups (CIG's), Producer organizations (POs) and private entrepreneurs through various measures. The major activities of Hortex Foundation are to (i) horizontally expansion of postharvest technologies and best practices in selected 30 Upazilas; (ii) vertical expansion of six high value crops i.e, brinjal, sweet gourd, bitter gourd, tomato, banana and aromatic rice; (iii) conduct survey to assess the existing postharvest management practices in the horticultural chains; (iv) capacity building for CIGs, POs, DAE and Hortex officials on postharvest management technology and value chain improvement; (v) assist POs in establishing the commodity collection and marketing centre (CCMC) and collection points (CP), and (vi) develop market linkages and contractual agreements between CIGs/POs with traders, supermarkets, processors and exporters. As strategic partner, Hortex Foundation in association with DAE is doing work in organizing contract farming, production planning, and establish or renovate of CCMC and collection points along with improved postharvest management practices. To implement the improved postharvest management practices (IPHMP) 30 CCMC and 30 CP were established based on information and field visit. Field surveys were done in 30-selected upazilas for assessing the knowledge gap of growers and traders in postharvest management of horticultural crops and reported accordingly. Improved postharvest technology packages for tomato, bitter gourd, sweet gourd, brinjal, banana and aromatic rice were prepared, printed and distributed. One training module entitled "Improvement of Value Chain and Marketing System of High Value Crops through Postharvest Management Practices" and two other booklets related to IPHMP of fresh produces were published in Bengali. In addition, three posters and three fact sheets IPHM and food safety issues were published during my tenure. During the development of all training courses under NATP-2 project, I contributed to select topics on "Improved postharvest management system for fresh fruits and vegetables". As a resource speaker I participated in six ToT program for providing training to 147 DAE officers, 300 SAAO/AAEO, 30 Local Business Facilitators (LBF), 6000 CIG and PO members from different upazilas under selected districts for enhancing their capacity on improved postharvest management of fruits and vegetables. Moreover, out of 10 national workshops conducted during the project period, I presented five keynote papers on different topics. Beside the above activities, I frequently visited all CCMCs and CPs to provide necessary suggestion and guidelines to PO-MMC members and other value chain actotors on improved PHM practices and marketing of fruits and vegetables. As a consequence, a total of 38,620 MT of quality fruits and vegetables was marketed through the CCMCs up to November 2022 following improved PHM practices out of which, 2,475 MT fresh vegetables was exported to overseas countries including Dubai, Kuwait, Saudi Arabia, Qatar, Malaysia, Italy and UK.

1. Background of the Project

National Agricultural Technology Program-Phase II Project (NATP-2) has been initiated by the MoA, Government of the People's Republic of Bangladesh (GoB) with the financial support from the World Bank, IFAD and the USAID. The main objective of the project is to increase the agricultural productivity of smallholder farms and improving smallholder farmers' access to markets in selected districts. Horticulture Export Development Foundation (Hortex Foundation) has been assigned as a strategic partner of Department of Agricultural Extension (DAE) for providing technical services on value chain development in horticulture and field crop. Strategic partnership between DAE and Hortex Foundation is mainly focused on mobilizing 15,000 Common Interest Group (CIG) farmers (300 new CIGs and 300 old CIGs) in 30 upazilas under 22 districts with a view to undertake larger amount of production of targeted value chains of horticulture/crop and the improvement of their quality standard, and marketing as their key activities. With a view to increasing the marketing capacity of these small producers, the technical assistance team of the NATP-2, Hortex Foundation would assist DAE to build the capacity of CIGs farmers and Producer Organizations (POs) and private entrepreneurs through value chain development of High Value Crops (HVCs). The existing value chains will be improved by establishing or renovating of Collection Points (CP) and Commodity Collection and Marketing Center (CCMC) at accessible area of value chain cluster of each upazila. Using the CCMC facilities standard postharvest management technologies like sorting, grading, packaging, washing etc. will be intervened for proper management of horticultural crops. Food safety issues will also be campaigned for raising awareness among the value chain actors.

The rationale of the value chains development in horticulture/crop is to address constraints that hinder the development proper marketing of high value agriculture produces. It is anticipated that the result of the inputs from strategic partnership between DAE and Hortex Foundation will be to enhance productivity of high value agriculture produces maintaining better quality standard, implementation of improved postharvest management practices in the value chain system, develop market linkages, formal and informal contracts, and to increase farm income and employment opportunities in the rural sector.

2. Major Project Activities

To achieve the goal of the project, seven major activities will be done by Hortex Foundation as a strategic partner of DAE which are as follows:

1. Validate and finalize value chain selection. Undertaking value chain analysis, market studies and surveys;
2. Mapping and organizing the vertical expansion of selected six crops, brinjal, bitter gourd, sweet gourd, tomato (summer and winter), banana and aromatic rice;
3. Organizing programs for horizontal expansion of best practices in selected 30 old and new generation upazilas;
4. Undertake marketing capacity building for CIGs, POs and DAE staff/officials on value chain management, organize and assist POs in establishing the CCMC and renovation of existing markets with good post-harvest management and short term storing facilities where producers (CIGs and non-CIG farmers), processors and traders come together and are doing business;
5. Develop market linkages and contractual arrangements between CIGs/POs with traders, supermarkets, processor and exporter;
6. Provide financial advisory services to CIG/POs and entrepreneurs to apply for matching grants for Agricultural Innovation Funds (AIF-2, technology adoption, and AIF-3 for market and enterprise development; and
7. Organize communication campaign on food safety, SPS, etc.

3. Project Area and Selected High Value Crops

According to DPP of NATP-2 Project, Hortex Foundation is providing services in value chain improvement through improved postharvest management practices and better market linkage in 30 upazilas out of 270 covering 22 districts, focusing on one particular HVC in each upazila for vertical production. A total of six HVCs, namely, Brinjal, Bitter gourd, Sweet gourd, Tomato (summer & winter), Banana, and Aromatic rice are selected for vertical production as mentioned. The selected upazilas are to be investigated during the NATP-2 period to priorities the selected crop wise upazilas in clusters based on existing cropping area, market linkages, and growth potentiality in terms of production area expansion, unmet market demand, income and employment generation, and preference of farmer's communication.

4. Key Issues in Improving the Value Chain System of Horticultural Crops

An important element of the value chain improvement in horticulture/crop is to assess the knowledge gap of stakeholders in postharvest management of horticultural crops and identify constraints and develop an action plan in resolving the constraints and reduce postharvest losses. Training modules and resource materials on postharvest management, and quality and safety assurance of horticultural commodities are needed to be developed. In addition, postharvest technology packages for selected horticultural crops is to be prepared and also provide technical assistance in agro-product processing, value addition, food safety etc. to the stakeholders. Training, seminar, workshop and exposure visit on effective postharvest management of horticultural crops are necessary to be arranged for different level of value chain actors including growers, collectors, packers, truck driver, wholesalers and retailers in reducing postharvest losses and maintaining produce quality in the whole value chain. Besides, regular checking of the produce qualities both in the CCMC and the developed markets will be needed to ensure produce quality.

4.1. Intervention of Postharvest Technologies and Good Practices in the Value Chain System

The primary aims of improving the existing value chain are to integrate smallholder farmers into the mainstream markets of agricultural commodities through interventions of improved and effective postharvest technology and good practices. Based on the survey data and information the appropriate postharvest management technologies and good practices will be intervened at each stage of value chain system including harvesting, sorting, grading, washing, packaging, and market linkages including market information system (product quality, availability, price etc). At this stage, it is needed to identify relevant and suitable partners and according to consensus define their roles and responsibilities for the implementation of selected commodities value chains upgrading plan. For improving the value chain system different facilities and supports are needed to from multidisciplinary team members from pertinent agencies. The focus is on to engage farmers in the production of high value crops (HVCs) (i.e., aromatic rice, fruits and vegetables), adoption of postharvest management practices and finally produces are to be healthy and safe to attract potential buyers.

4.2. Contract Farming

Contract farming involves an agreement between the farmers and traders of domestic and export markets and processors for the production and supply of HVCs. The agreement also invariably involves the provision of a degree of production support by the purchasing company, through, for example, the supply of seed, fertilizer, credit and the provision of technical advice to the farmers. The basis of such agreements is a commitment on the part of the farmers to provide a specific agriculture commodity in quantities and at quality standards determined by the company and a commitment on the part of the company to support the farmer's production and to purchase the commodity.

These agreements can be formal or informal. In case of perishable horticulture produces, informal contract farming may be worked as because still it is a main challenge for the farmers of Bangladesh

to operating a production and supply chain that delivers the right products with quality standard and quantity at the right time. However, NATP-2 might have an opportunity to support and strengthen contract farming of the existing agro-processing company, for example, the PRAN, Square, Bombay Sweets, etc. Private agro-processing companies involve in aromatic rice procurement from lead farmer's group and then processing and distributing in domestic and export markets.

5. Responsibilities and Focus of Main Activities

The focus of main activities until the final report is presented is as follows:

- Assess the knowledge gap of stakeholders in postharvest management of horticultural/agricultural crops and identify constraints and develop an action plan in resolving the constraints and reduce postharvest losses;
- Assist in supervising all aspects of production, harvesting and postharvest management activities in project sites, farmer fields, collection points, commodity collection & marketing centers (CCMCs);
- Prepare detailed work plan on the basis of the project activities for interventions in postharvest management and quality assurance areas;
- Prepare postharvest technology packages of horticultural/agricultural crops including maturity indices of specific crops;
- Check regularly the produces both in the collection points, CCMCs and the developed markets to ensure produce quality;
- Supervise harvest practices and postharvest handling, grading, sorting, washing, packaging, storage and transportation;
- Develop training modules and resources materials on postharvest management and organize training for stakeholders;
- Collaborate in establishing collection points, CCMCs and market infrastructure/renovation;
- Provide technical assistance in agro-product processing, value addition, food safety, packaging, storage, cool chain transport, etc;
- Organize training, workshop, seminar and field days relating to postharvest management of horticultural produce;
- Prepare periodical and annual reports including PCR in time;
- Work independently and maintain all related files and documents; and
- Develop Postharvest Management Manual;
- Develop Agribusiness Policy;
- Any others tasks as assigned by the Authority.

6. Accomplishment of different project activities and major achievement at a glance

Sl. No.	Major technical & developmental activities during last six months	Outputs		Major achievements
		Target (%)	Actual (%)	
1.	Preparation of inception and quarterly report	02	02 (100%)	Both inception and quarterly reports had prepared in time and submitted to the Managing Director of Hortex Foundation on 08 February and 01 April 2018, respectively.
2.	Preparation of detailed work plan for improving value chain and postharvest management practices	01	01 (100%)	Detailed work plan was prepared and submitted with the inception report

Sl. No.	Major technical & developmental activities during last six months	Outputs		Major achievements
		Target (%)	Actual (%)	
3.	Assessment of the knowledge gap of stakeholders in postharvest management and marketing of horticultural crops (Baseline survey)	01	10 (100%)	Detailed data were collected from the growers and traders of each selected upazila through two types of structural questionnaires. The collected data were analyzed using statistical software. A comprehensive report was prepared based on the collected data from selected upazilas of Bangladesh (Annexure-1 & 2).
4.	Publication			
4.1	Preparation of postharvest technology packages of selected horticultural crops and	06	06 (100%)	Postharvest technology packages for tomato, bitter gourd, sweet gourd, brinjal, banana and aromatic rice were prepared and printed. Finally, they were distributed among different level of stakeholders of the value chains of fresh fruits and vegetables.
4.2	Development of training module	01	01 (100%)	A training module entitled “Improvement of Value Chain and Marketing System of High Value Crops through Postharvest Management Practices” was prepared in Begali language and distributed among the training participants came from DAE, Hortex, business and farmers.
4.3	Writing book and manual on postharvest management of high value crops	03	03 (100%)	Two books entitled 1. Packhouse based improved postharvest management of fruits and vegetables, 2. Exportable mango production and improved postharvest management and 3. a manual entitled “Improved postharvest management of high value crops” were written in Begali and distributed to farmers, traders, different CCMC, PO members, selected UAO office and also libraries of BARC, BARI etc.
4.4	Poster and packaging material development preparation	04	04 (100%)	Three posters entitled 1. Ensure nutrition by saving postharvest losses of vegetables, 2. Ensure quality and safety of mango by using improved technologies during production and marketing chains and 3. Ensuring quality and safety of Banana through value chain improvement were prepared showing improved value chains and marketing system of safe fruits and vegetables. A CFB carton for packaging of fresh fruits & vegetables has also been designed, printed and distributed among the respective value chain actors.
4.5	Prepare & printing of three fact sheets on food safety and	03	03 (100%)	Three fact sheets namely 1) Easy ways to disinfect of fresh fruits & vegetables from

Sl. No.	Major technical & developmental activities during last six months	Outputs		Major achievements
		Target (%)	Actual (%)	
	hygiene issues of fresh fruits and vegetables			pesticide residues at home; 2) Techniques to reduce microbial hazards to make fruits and vegetables safe and healthy and 3) Harvesting safe and healthy fruits & vegetables following standard pre-harvest interval of pesticide spray were prepared, printed and distributed among different level of stakeholders of the value chains.
5.	Collaboration in establishing CCMC, CP and market renovation	58	58 (100%)	A total of 28 CCMC and 30 CP were established on rental basis having one CCMC and one CP in each selected upazila based on extensive visit and information. I actively participated in establishing those facilities.
6.	Supervising all aspects of harvest and postharvest management of fruits and vegetables in project sites, collection points and CCMC.	30	30	Almost all of the CCMCs and CPs located at different upazilas namely Delduar, Madhupur, Muktagacha, Kishoregonj sadar, Islampur, Shibpur, Belabo, Raipura, Bogura sadar, Shibgonj, Polashbari, Mithapukur, Parbotipur, Birgonj, Chirirbandar, Jashore sadar, Bagharpara, Jikorgacha, Kaligonj, Savar, Kapasia and others were visited frequently during my working period at Hortex Foundation in NATP-2 project. I visited the CCMCs mainly to participate in training program, PO-MMC meeting and guided the PO and MMC for implementing improved postharvest management practices including sorting, grading, washing, packaging, storage and transportation of fruits & vegetables in improving the value chain. However, the number of visit was limited due to due to Covid-19 situations.
7.	Capacity Building Program			
7.1	TOT for DAE and Hortex Staffs	06 batches	06 batches	Six batches of ToT courses were organized participating 147 Officers from DAE and Hortex Foundation. The programmes were completed during January to December 2018. I actively participated in all ToT courses as resource speaker.
7.2	Capacity building for AAEO/SAAO of DAE	10 batches	10 batches	A total of 300 AAEO/SAAOs were trained up in 10 batches between 14-15 Mar and 09-10 April 2018. The trainings were organized at 10 different venues across the country. I myself physically envolved to organized in 04 training programs. I emphasized on IPHM practices of fresh fruits and vegetables to

Sl. No.	Major technical & developmental activities during last six months	Outputs		Major achievements
		Target (%)	Actual (%)	
				improve the existing value chains.
7.3	Foundation and refreshment training for Local Business Facilitators (LBFs)	04 Prog.	04 Prog.	A total of four training program were organized for the 30 LBFs during 2017-18 and 2018-19 fiscal years. In those training program I participated as a resource speaker for delivering lectures on improved postharvest management and food safety aspects.
7.4	Capacity building for CIG farmers	467 batches	467 batches	A total of 14000 CIG farmers were trained up in 467 batches in 30 selected upazilas across the country during 2018 to 2021. Among the programs, I directly involved in 140 batches including 4200 farmers on improved PHM of fruits and vegetables.
7.5	Capacity building for PO members	134 batches	134 batches	A total of 6028 PO members working in different CCMCs were trained up in 134 batches on improved PHM of fruits and vegetables, financial management, documentation etc. during 2018 to 2021. Among the trainings, at least 50 batches were conducted under my direct supervision.
7.6	Capacity building for traders of fresh produces	30 batches	30 batches	Total 900 agricultural traders were trained up on “improved PHM of fruits and vegetables based on CCMC” during January to 2018-19 and 2019-2020. I myself participated in eight training programs involving 240 participants held at Kishoregonj, Mymensingh, Muktagacha, Jashore sadar, Bagharpura, Jhikorgacha, Shibgonj and Bogura sadar upazilas.
7.7	Organizing 10 training program on value addition through processing of fruits and vegetables	10 batches	10 batches	Ten batches of training program on “Small scale food processing for small holders” were organized for women CIG in 10 selected upazilas. Among them I actively organized the hands-on training in four upazilas including Delduar, Belabo, Kapasia and Kishoregonj. In those training program the participants came to know how to prepare and store of processed products like jam, jelly, pickels etc. in aseptic conditions.
8.	Workshop/seminar			
8.1	Organizing 10 national workshops under NATP-2 project.21-22	10	10	Ten national workshops were organized during 2018 to 2022. Among them I myself presented four keynote papers in four different workshops. The titles of one workshop were 1) “Postharvest

Sl. No.	Major technical & developmental activities during last six months	Outputs		Major achievements
		Target (%)	Actual (%)	
				Management of Fruits & Vegetables for Food Safety and Quality Assurance" that was held on 06 February 2019 2) "Postharvest loss reduction of banana assuring quality and safety through improved postharvest management during marketing" held on 30 October 2019, 3) "Increasing Farmer's Income Through Postharvest Loss Reduction of Fruits and Vegetables" which was held on 11 May 2022 and 4) "Improved Management of Mango to Enhance Export Assuring Quality and Safety" that was held on 23 August 2021.
8.2	Organizing 60 business planning and related workshops for the PO-MMC members and LBFs 21-22	60	60	Thirty business planning workshops and another 30 business related workshops were organized for the PO-MMCs members and LBFs of 30 selected upazilas during February to June 2022. Personnaly, I directly participaed at least in 25 program to conduct the workshops.
9.	Development of short video documentaries on improved postharvest management and value chain development (VCD) of fresh fruits and vegetavles	05	07 (140%)	Seven video documentaries on postharvest management and improved value chains of fresh fruits and vegetables were developed and broadcasted through different TV chennels. The titles of those videos were i) Improved production and postharvest practices of vegetables that was made in Shibpur upazila, Norsingdi ii) CCMC based improved postharvest management of fruits and vegetables that was made in Jashore sadar upazila iii) Implementation of IPHM practices to ensure quality and food safety of fruits and vegetables to enhance export-Belabo, Norsingdi iv) Improved value chain of banana in reducing postharvest loss maintaining fruit quality and safety-Bogura and Madhupur, Tangail v) Improved postharvest management of fruits and vegetables and strengthening of market linkage that was made in Mithapukur upazila, Rangpur, vi) Food processing and value addition to fruits and vegetables for family nutrition and income and vii) improved pre- and postharvest management of mango for enhancing export were developed in Chapainawabganj.
10.	Analysis of market samples to determine nutrient quality and	32	32	A total of 32 samples of tomato, brinjal, bitter gourd and banana had collected

Sl. No.	Major technical & developmental activities during last six months	Outputs		Major achievements
		Target (%)	Actual (%)	
	food safety of fresh fruits and vegetables 19 and 21-22			from different fields and were analyzed in the Postharvest lab, Pathology lab and pesticide analytical lab of BARI to determine the food quality and nutrient status, microbial contamination and also pesticide residues level left over the commodities. A brief report was also prepared and submitted to the office.
11.	Assisting PO-MMCs in starting CCMC-based agri business and operating mini-truck.21-22	30	30	During my visit to different CCMCs/CPs, I talked to PO-MMC members on different issues like fund raising to start agri-business using the mini-truck and CCMC facilities. I guided them to implement IPMP of fruits and vegetables before marketing them.
12.	Institutional linkage development for supplying fresh vegetables 21-22			CCMCs located at Godagari, Rajshahi, Mithapukur of Rangpur, Palashbari of Gaibandha, Muktagacha of Mymensingh, Norsingdi and sadar upazila, Jashore were linked with different with big traders and exporter for regular suppling of vegetables from the CCMC/CP.
13.	Assisting PO-MMC to prepare and submit sub-project for awarding AIF-3 matching grant 21-22	30	30	From Hortex Foundation we assisted all 30 PO-MMC for raising savings, preparation and submission of sub-projects for getting AIF-3 matching grant from NATP-2 project. Finally, all of the PO-MMC submitted the sub-project in time with required fund and documents and awarded the matching grant.
14.	Measures taken to mobilize CIG farmers and traders for fruits & vegetables marketing and operate the CCMCs during lockdown period of Covid-19 pandemic - 2020			<ul style="list-style-type: none"> ✓ Hortex Foundation took necessary measures for keeping the CCMCs functional for marketing fruits and vegetables regularly by following WHO guidelines and maiantaining social distancing. ✓ The CIG farmers and traders around the CCMCs were mobilized to join the temporary open field markets, which organized by the upazila administrations for maintaining social distancing as regular markets and shops were kept closed.
15.	Linkage of CCMCs with online marketing of fresh fruits & vegetables-2020			Out of the 30, 19 CCMCs have been linked with Hortex Online Marketing system , and the respective PO-MMCs send their produces to the Hortex Foundation for selling through online marketing system. Up to December 2020 a total of 37 tons of different agri-commodities were sold at a value over BDT 21 lakh (BDT 2.1 Million)

7. Major project activities undertaken and accomplishment during 2018-2022

7.1. Collaboration in establishing CCMC, CP and market renovation

Twenty-eight (28) CCMCs and 30 collection points (CP) located in 30 different upazilas namely Delduar, Madhupur, Muktagacha, Kishoregonj sadar, Islampur, Shibpur, Belabo, Raipura, Bogura sadar, Shibgonj, Polashbari, Mithapukur, Parbotipur, Birgonj, Godagari, Boraigram, Chandina, Khagrasori, Chirirbandar, Jashore sadar, Bagharpura, Jikorgacha, Kaligonj, Savar and Kapasia. Almost all of the CCMCs are equipped with necessary hardware facilities including sorting/grading table and mat, washing facilities, plastic crates and other small instrument to utilize them for improved PHM practices.

Further, I visited several locations in Polasbari, Mithapukur, Shibgonj, Bogura sadar, Shibpur, Raipura, Belabo, Jashore sadar, Jhikorgacha, bagharpura, Kaligonj, Delduar, Madhupur, Muktacha and Kishoregonj upazilas for establishing collection points for those CIG farmers who live far away from the existing CCMC. In the mean time all 30 CPs have been established across the country. CIG farmers around the CPs are happy for getting these facilities near to the field. Now, immediately after harvest farmers bring their produces to the CP from the field for primay sorting, grading and packaging. After that they shifted their produces to the nearby assemble market for sale. In some upazilas, the trades go to the CP for directly purchasing the fruits and vegetables. All of these CCMC and CP are now using as rural packhouse and local business centres. The market management committee in each PO is operating these CCMC and CP involving 400-500 CIG and non-CIG farmers around the CCMC.



Fig 1. Established CCMC (left) and CP (right)

7.2 Field visit to monitoring the implementation status of improved postharvest management practices (IPMP) in different CCMCs of selected upazilas

Almost all of the CCMCs and CPs were frequently visited during my working period in NATP-2 project to parcipate in various CCMC-based training program, observe postharvest management activities, and to provide necessary suggestion and guidelines to the MMC, MLC and traders. During my visit the MMCs were suggested and guided for properly function of the CCMCs. I especially emphasized on implementing of improved postharvest management technologies and good practices in reducing postharvest lossess maintaining quality and food safety of fresh produces. However, field visit and training program were restricted from July to December 2021 due to Covid-19 pandemic situations.

7.3 Supervising of CCMC and CP activities and meeting with PO-MMC

CCMCs located at different upazilas were frequently visited during project period to supervise them and guidance the PO and MMC for implementing improved postharvest management practices including sorting, grading, washing, packaging, storage and transportation of fruits & vegetables before marketing. However, we had to limited or stopped visit from April to June 2020 due to Covid-19 situations.



Fig 2. Washing lemon with clean water at CCMC Delduar before packaging and sending them to the wholesale markets

Fig 3. packaging of green chilli and bitter gourd in plastic crates for marketing through CCMC (right)



Fig 4. Meeting with MMC in the CCMC of Bogura Sadar



Fig 5. CCMC activities of Jashore sadar and meeting with PO-MMC members

7.4 Functioning of CCMCs during lock down period due to Covid-19 pandemic

The Government of Bangladesh took drastic measures to lock down of different areas of the the country from 26 March 2020 due to Covid-19 pandemic. Under such situation, most of the CCMCs across the country faced serious challenges to operate. These were as follows:

- Traders, usually coming from outside to buy produces from the CCMCs, could not come due to shut-down of public transport
- Transports were not available for the same reason to enable transporting fresh produces to different wholesale markets or related destinations
- Movement restrictions prevented farmers from bringing their products to the CCMCs and even to the local assembled market
- Forced closure of some of the CCMCs by police and local administrative authorities applied as a blanket rule to keep all market closed, despite government directive to allow uninterrupted flow of food and related agricultural commodities

As a result, prices of fruits and vegetables went down, farmers were discouraged from harvesting their produces to bring for sale, and even in some places farmers destroyed their crops and planted a next season crop. In the first few weeks following the lockdown, almost all the CCMCs faced some level of disruption or closure. There were lots of confusion to organizing and keeping chain of essential supplies open as concerns of catching the infection-troubled people. In some cases, the whole areas remained under lockdown and so nobody could move. In some places, the LBFs could not come as they were obstructed on their way and the CCMCs could not be opened. Three of the LBFs were forced to leave station for their homes as their co-habitants left and food became unavailable, but they left arrangements with MMC functionaries to keep the CCMCs operational. Despite all odds, all the CCMCs managed to operate once or twice every week during the first few weeks of the lockdown. However, as mentioned earlier, few farmers brought produces for sale while few local traders bought those as demands and prices were low.

We from the Hortex Foundation were ahead of the crisis and had already prepared and sent leaflets recommending practices like hand-washing, social distancing, etc. for the staff and farmers for safety measures against possible infection. In order to avoid crowding by farmers at the CCMC, Hortex worked with the CIGs along with DAE officers and staff to organize group marketing. One member of a CIG would thus bring produce from other fellow farmers of the group to the CCMC, whilst sharing transport and other costs between them. Hortex kept contact with the UAOs, LBFs and the MMCs for keeping the CCMCs functional. MMC members were requested and LBFs were instructed to approach the UAO for supporting CCMC operations, so that Police would not arbitrarily close a CCMC. Gradually, the business improved.

7.5. Mobilization of CIG farmers and traders for fruits & vegetables marketing during Covid-19 lockdown

The CIG farmers and local traders around the CCMCs were mobilized to join the temporary open field markets, where upazila administrations organized such system for maintaining social distancing as regular markets and shops were kept closed. In a number of places, the PO-MMC with the help of UAO and upazila administration organized vegetable sale for the local consumers using the rickshaw vans. Moreover, the LBF tried to strengthen the linkage between local traders and farmers, which made possible to sell fresh produces directly from the farmer's field.

7.6 Assessment of knowledge gap of stakeholders in postharvest management and marketing of horticultural crops

Two types of questionnaires were developed for growers and traders (Annexure-1) to assess the knowledge gap of stakeholders in postharvest management of high value crops particularly in horticultural crops. Data on present production, postharvest practices and marketing trends of selected HVCs have been reflected through the assessment. The collected data had been analyzed using statistical software and executive summary of the report is as follow:

Executive summary of baseline survey report: A survey was carried out on existing postharvest management practices followed by the grower and traders in fresh producer's value chains in Bangladesh during August to October 2018. This study assessed the knowledge, attitude and practices

of value chain's key actors and the status of market opportunities in the country. A total of 515 farmers and 295 traders were interviewed from 30 selected upazilas of Bangladesh under NATP-2 project. Pre-tested structured questionnaires were used to collect data from the field and markets. Data were analyzed using Merlin Statistical Software. Findings of this study revealed that most of the growers (50-70%) showed positive attitude towards GAP, maturity indices, and role of good packaging for keeping the produces safe for the consumers. About 32% farmers aggregate their harvested commodities beside the field on direct soil contact under open sun, which may cause weight loss and microbial contamination of the produces. Washing and grading practice did not follow by most of farmers (58%) and traders (52.2%) during marketing of fruits & vegetables. Nevertheless, 91% farmers and 78% traders sorted their produce before marketing to get better price. More than 56% farmers and traders used jute or nylon sac for packaging fresh fruit & vegetables. Only 20% farmers and 24% traders used plastic crates as a packaging material of fresh produces. Generally, farmer used different local vehicles including three-wheeler van, rickshaw, bi-cycle, tempo etc., whereas the traders transported their produces to the wholesale market using truck and pickup. The average postharvest losses were estimated 8% and 15% at farmer and trader's level, respectively. At firm level, these losses occurred mainly due to knowledge gap in maturity indices, faulty harvesting method, insect-pest and disease infection. On the other hand, the maximum loss (15%) occurred at trader's level was due to inappropriate bulk packaging, overloading and rough handling during marketing of the produces. Both the farmers and traders suggested various measures to reduce postharvest losses and to keep them safe for the consumers. A detailed report is attached herewith in annexure 2.

7.7 Publication of Booklet/Brochure, Fact sheets, Posters

7.7.1 Development of training module, PO manual and brochures on improved postharvest management of fruits and vegetables

Postharvest technology packages for tomato, bitter gourd, sweet gourd, brinjal, banana and aromatic rice had been prepared, printed as a brochure entitled "Improved Postharvest Technologies of Fruits and Vegetables".



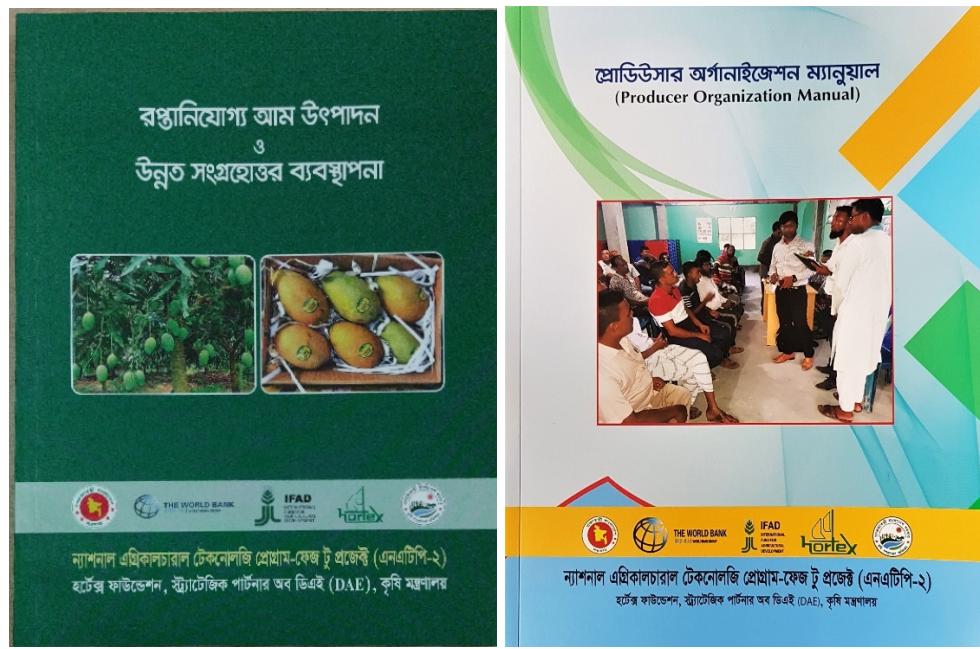


Fig 6. Training module, PO manuals and brochures on improved postharvest management of high value crops

Moreover, One manual entitled “Improved Postharvest Management of High Value Chain Crops”, and two brochures related to postharvest management of horticultural crops entitled i) Packhouse based improved postharvest management of fruits and vegetables, and ii) Exportable mango production and improved postharvest management, and iii) PO manual had been prepared and published in Begali. The printed materials were distributed among the farmers, DAE officers, BARI scientists, PO members, Farmers, CCMC and different value chain stakeholders.

সংগ্রহোত্তর ব্যবস্থাপনার মাধ্যমে উচ্চ-মূল্য ফসলের ভ্যালু চেইন উন্নয়ন ও বাজারজাতকরণ
বিষয়ক প্রশিক্ষণ মডেল

Training Module on
Improvement of Value Chain and Marketing System of High Value Crops
through Postharvest Management Practices

রচনার্য (Written by)

দেবা: আতিকুর রহমান
মেবা: বজ্জনুর রহমান
মো: কুন্দত-ই-গনী
মোফারেক সাতার
মিটুন কুমার সাহা

সম্পাদনার্য (Edited by)
মো: মনজুরুল হায়ান

জুন, ২০১৮



ন্যাশনাল একালচারাল টেকনোলজি প্রোগ্রাম-ফেজ ২ প্রজেক্ট (এনএটিপি-২)
হটেক ফাউন্ডেশন, স্ট্রাটেজিক পার্টনার অব ডিএই (DAE), কৃষি মন্ত্রণালয়

7.7.2 Food Safety Campaign through fact sheet and posters

I had prepared three fact sheets on different food safety issues including i) decontamination of pesticide residues from fresh fruits and vegetables, ii) Ways in making fresh produce safe and healthy through reducing biological risks, iii) Pesticide use following pre-harvest interval for safe produce harvesting etc.

Fig 7. Fact sheets prepared on food safety issues of fruits and vegetables

In addition, three posters entitled i) Ensuring quality and safety of Banana through value chain improvement, ii) Implementing improved technologies assuring quality and safety of mango and iii) Ensuring nutritional security though reducing postharvest losses of vegetables showing improved value chains and marketing system of fresh mango, banana and vegetables had been prepared and printed. These fact sheets and posters were printed and distributed among different level of stakeholders including all PO members, farmers and traders for raising awareness on food safety.



Fig 8. Three posters on improved value chain of mango, banana and vegetables to assure quality and food safety

7.7.3 Design and development of corrugated fiberboard carton (CFB) for packaging fresh fruits and vegetables

An ideal corrugated fibreboard carton (CFB) had been designed and printed for packaging of fresh fruits & vegetables during marketing.

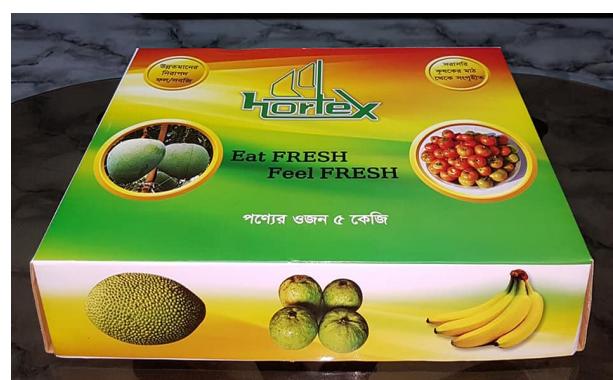


Fig. 9. CFB carton was designed for improved packaging of fresh fruits and vegetables

7.8 Training and Capacity Building Program

7.8.1 ToT for capacity building of Hortex and DAE staff

Six batches of ToT program consisting of 25 participants in each batch were arranged at the conference room of Hortex Foundation during January to October 2018 for capacity building of DAE and Hortex Staff.

Before starting the training program we prepared the training module taking into consideration the existing postharvest handling situations in the country. Very selective and relevant topics such as contract farming system, improved production technology of HVCs, postharvest management, producer organization, collection point, CCMC, marketing system of HVCs etc. At the same time the draft programme of activities during the training as well as the questionnaire for the pre-and post-tests to assess the level of knowledge of the participants were prepared prior to the mission. Power point presentations of all topics assigned to the each resource speaker were also prepared.

The first batch training was conducted on 23-24 January 2018. Twenty five participants from different upazilas participated in that program (Attachment- 2). Md. Abdul Aziz, Director General, DAE, attended in the inaugural session of the training program as chief guest.

National Agricultural Technology Program- Phase II Project (NATP-2) Hortex Foundation As Strategic Partner of DAE

Training course: Production, Postharvest Management & Marketing of High Value Crops

Venue: Conference Room, Hortex Foundation, Sech Bhaban, Dhaka-1207

Course Coordinator: Mr. Mitul Kumar Saha, AGM, Hortex Foundation

Day 1			Date: 23/01/2018
Time	Topic	Trainer/Guest Speaker	
9.00 – 9.30	Registration	Hortex Foundation Staff	
9.30 – 10.00	Inaugural Session	Chief Guest: Kbd. Md. Abdul Aziz Director General, DAE Special Guest: Kbd. Md. Abdul Hannan Director, Field Service Wing, DAE Session Chair: Kbd. Md. Manzurul Hannan Managing Director, Hortex Foundation	
10.00 – 10.30	Refreshment & Photo Session		
10.30 – 11.00	Pre training evaluation	Course Coordinator/Training Management Expert	
11.00 – 12.00	Production planning	Kbd. Md. Abdul Aziz, DG, DAE/Dr. Mofa Sattar, M & E Expert, NATP-2, Hortex Foundation	
12.00 – 13.00	Objectives, formation and functions of Producer Organization (PO)	Kbd. Md. Manzurul Hannan, MD, Hortex Foundation/Mr. Mitul Kumar Saha, AGM (Marketing), Hortex Foundation/Md. Bazlur Rahman, Marketing Expert, NATP-2	
13.00 – 14.00	Break for Lunch & Prayer		
14.00 – 15.00	Appropriate time and harvesting methods of fruits and vegetables	Dr. Nazrul Islam PSO, HRC, BARI, Joydebpur	

Time	Topic	Trainer/Guest Speaker
15.00 – 16.00	Setup and Operation of Commodity Collection and Marketing Center (CCMC) and Collection Point (CP)	Kbd. Md. Manzurul Hannan, MD, Hortex Foundation/Mr. Mitul Kumar Saha, AGM (Marketing), Hortex Foundation/Md. Bazlur Rahman, Marketing Expert, NATP-2, Hortex Foundation
16.00 – 17.00	Contract farming system	Kbd. Masud Ahmed Joint Director(CG), BADC

Day – 2

Date: 24/01/2018

Time	Topic	Trainer/Guest Speaker
9.00 – 10.00	Improving quality and safety of fruits and vegetables in Bangladesh	Prof. Dr. Md. Kamrul Hassan Department of Horticulture, BAU, Mymensingh
10.00 – 10.30	Tea Break	
10.30 – 11.30	Value addition of high value horticultural crops	Dr. Miaruddin, CSO, BARI, Joydebpur, Gazipur
11.30 – 12.30	Packaging and transportation of fresh fruits and vegetables	Kbd. Md. Abdul Hannan, Director, FSW, DAE/Dr. Md. Atiqur Rahman, Post Harvest Management Expert, NATP-2, Hortex Foundation
12.00 – 13.00	Marketing concept of agro-commodities	Prof. Dr. Shankar Kumar Raha Professor(Rtd.), Department of Agribusiness and Marketing, BAU
13.00 – 14.00	Break for Prayer & Lunch	Course Coordinator
14.00 – 15.00	Business plan development of high value horticultural crops	Prof. Dr. Shankar Kumar Raha Professor (Rtd.), Department of Agribusiness and Marketing, BAU
15.00 – 16.30	Group works and presentation Group 1: Appropriate time and harvesting methods of fruits & vegetables Group 2: Criteria for safe fruits and vegetable production Group 3: Measures to be considered for CCMC and CP functioning Group 4: Functions of PO	Facilitators: 1. Course Coordinator 2. Experts of NATP-2, Hortex Foundation
16.30 – 17.00	Post Training Evaluation	Course Coordinator/ Training Management Expert



Fig. 10: Inaugural session of first batch ToT for Capacity Building of DAE & Hortex Staff. Mr. Md. Abdul Aziz, Director General, DAE (middle) formally Inaugurated the training programme as chief guest.

The second batch training was conducted on 29-30 January 2018. Twenty five participants from different upazilas also participated in that program (Attachment-2). Former secretary of MoA Mr. Anwar Faruque and Md. Mohsin, Director, PQW, DAE joined to the program as chief and special guests, respectively.



Fig. 11: Inaugural session of second batch ToT for Capacity Building of DAE & Hortex Staff. (Left to right) Dr. Mofarahus Sattar (M&E Expert), Md. Mohsin (Director, PQW, DAE), Mr. Anwar Faruque (Former Secretary, MoA), Md. Mazurul Hannan (MD, Hortex) and Md. Qudrat-E-Ghani (Training Management Expert) presented in the inaugural session

The third batch ToT was conducted on 12-13 February 2018. Twenty five participants from different upazilas also participated in that program (Attachment-4). Md. Abdul Hannan, Director, Field Services Wing, DAE joined to the program as chief guest in the inaugural session.



Fig 12. Inaugural session of 3rd batch ToT for Capacity Building of DAE & Hortex Staff. Md. Abdul Hannan, Director, Field Services Wing, DAE (2nd from left) inaugurated the training program.

The 4th batch ToT was conducted on 18-19 February 2018. Twenty five participants from different upazilas also participated in that program (Attachment-5). Md. Manzurul Hannan, Managing Director, Hortex Foundation joined to the program as chief guest.



Fig. 13. Inaugural session of 4th batch ToT Training for Capacity Building of DAE & Hortex Staff. Md. Manzurul Hannan, Managing Director, Hortex Foundation (2nd from left) inaugurated the programme

7.8.2 Training for capacity building of AAEOs/SAAOs, DAE

According to DPP there is provision for 10 batches of two days long capacity building training of field level workers specially for AAEOS and SAAOs of DAE under selected upazilas. Accordingly, the training program was designed and scheduled at different location of the country during 14 to 29 March 2018. The Hortex Experts under NATP-2 Project were divided into two groups for efficiently conducted the training programs in time. In our group I myself and Dr. Mofarahu Sattar jointly conducted three training programs during the scheduled time frame.

The first batch training was arranged at DDAE office, Jeshore on 14-15 March 2018. The objective was to awareness and capacity building for AAEO/SAAOs of four upazilas including Bagharpura, Jhikorgacha, and sadar upazila of Jashore district, and Kaligonj upazila of Jinedha district on postharvest management, marketing, food safety and quality assurance of HVCs.



Fig.14. Guest participants in the training program at DDAE Office, Jashore: left to right- Md. Zahidul Alam, UAO, Bagharpura, Jashore; Kazi Habibur Rahman (DD, DAE, Jahore); Chandi Das Kundu (AD, Jashore Region); Dr. Mofarahu Sattar (M & E Expert) and Subrata Kumar Chakrabarty (ADD, DAE, Jashore).



Fig.15. Participants in the training program on postharvest management, marketing, safety and quality control of HVCs at DDAE Office, Jashore. A total of 40 participants including SAAO and AAEO participated in the program out of which four were woman.

The program was organized in collaboration between Hortex Foundation and DAE under NATP-2 project. A total of 40 participants participated in the program out of which 04 were women (*Attachment-6*). Ten trainees from each upazila of Bagharpura, Jhikorgacha, and sadar upazila of Jashore district, and Kaligonj upazila of Jinedha districts were participated in the training program. The inaugural session of the program was started at 9:50 am chaired by Kazi Habibur Rahman, DDAE, Jashore. Dr. Mofarahus Sattar (M & E expert, Hortex foundation) and Dr. Md. Atiqur Rahman (Postharvest Management expert) joined to the program as chief guest and special guest, respectively and Subrata Kumar Chakrabarty (ADD, DAE, Jashore) acted as announcer of the session.

The 2nd batch training was conducted at RDA, Bogura on 20-21 March 2018 for capacity building of AAEOS/SAAOs of four upazilas including Bogura sadar, Shibgonj, Palashbari and Mithapukur on postharvest management, marketing, food safety and quality assurance of HVCs. The training was done with same objectives as mentioned earlier. A total of 40 participants were participated in the program out of which 03 were women (*Attachment-7*). Ten trainees from each upazila of Mithapukur, Palashbari, Shibgonj and Bogura Sadar of Rangpur, Gaibandha and Bogura districts, respectively participated in the program. The inaugural session of the program was chaired by Mr. Pratul Chandra Sarker, DD, DAE, Bogura and AD, DAE, Bogura region joined there as chief guest. The session was conducted by Md. Obaidur Rahman Mondal, ADD, Bogura.



Fig. 16. Guest participants in the inaugural session of the training program at RDA, Bogura: left to right- Md. Obaidur Rahman Mondal (ADD, Bogura); Md. Kamal Uddin Talukdar (DD, Regional Office, Bogura); Dr. Mofarahus Sattar (M & E Expert); Md. Motiar Rahman (AD, DAE, Bogura Region) and Mr. Pratul Chandra Sarker (DD, DAE, Bogura)



Fig. 17. Participants in training on postharvest management, marketing, safety and quality control of HVCs at RDA, Bogura

The 3rd batch training was conducted at Kewatkhali Horticulture Centre Mymensingh on 28-29 March 2018 for capacity building of AAEOS/SAAOs of three upazilas including Muktagachha, Mymensingh; Delduar, Tangail and sadar upazila, Kishorgonj. A total of 30 participants were participated in the program out of which 04 were women (*Attachment-8*). Ten trainees from each upazila of Muktagachha, Delduar and sadar upazila of Mymensingh, Tangail and Kishoregonj districts were participated in the training program. The inaugural session of the program was started at 10:21 am chaired by Mr. Abdul Mazed, DDAE, Mymensingh. Md. Asadullah, AD, Mymensingh region joined to the program as chief guest. Dr. Mofarahus Sattar (Hortex Foundation) and Mr. Nitai Chandra Banik, DD, Horticulture Centre, Mymensingh presented in the program as special guests. Mr. Md. Saiful Islam, ADD, DAE, Mymensingh conducted the inaugural session.



Fig. 18. Guest participants in the inaugural session of the training program at Horticulture Centre, Kawatkhal, Mymensingh: left to right- DR. Md. Atiqur Rahman (PHM Expert, Hortex Foundation), Mr. Nitai Chandra Banik (DD, Horticulture Centre, Mymensingh); Md. Habibur Rahman (DTO, DAE, Mymensingh); Md. Asadullah (AD, DAE, Mymensingh Region); Mr. Abdul Mazed (DDAE, Mymensingh) and Dr. Mofarahus Sattar (M & E Expert).



Fig. 19. Participants in the training program on postharvest management, marketing, safety and quality control of HVCs at Horticulture Centre, Kawatkhal, Mymensingh. A total of 30 participants including SAAO and AAEO participated in the program out of which four were women.

7.8.3 Training for capacity building of CIG farmers

According to the workplan of Hortex Foundation, a total of 100 batches training of CIG farmers of selected upazila under NATP-2 project were successfully conducted in 2018. The training program was designed and scheduled at different upazilas across the country. The experts of Hortex Foundation under NATP-2 Project were assigned individually for efficiently conducting the training programs during 21 May to 26 June 2018. I myself visited six upazilas including Savar, Kapasia, Shibpur, Mirsarai, Polashbari and Jhikorgacha under Dhaka, Gazipur, Narsingdi, Chattogram, Gaibandha and Jashore districts, respectively to facilitate the training program on postharvest management, marketing and food safety assurance of HVCs.

Training at Savar Upazila, Dhaka: The training program was organized in collaboration between Hortex Foundation and DAE under NATP-2 project at Horticulture Centre, DAE, Rajalakh, Savar. A total of 4 batches training were conducted on 21 and 22 May. On first day two batches training containing 30 CIG farmers in each batch were participated. Similarly, another 60 CIG farmers participated on 22 May 2018. Among the participants about 40% were women. On day 1, the training program was formally started at 9:30 am with registration of the participants. The training component was delivered by a team of nine resource persons including Mr. Md. Shahidullah (UAO, Savar), Mr. Md. Rassel (AEO, Savar), Nazia Akter (AEO, Savar), Mr. Md. Salam (ADD, Crop, DAE, Dhaka), Mr. Md. Mojibar (ADD, DAE, Dhaka), Sheikh Iffat Ara Islam (Horticulturist, Savar) Dr. Md. Atiqur Rahman (Postharvest Management expert) and Mr. Md. Bazlur Rahman (Supply Chain Intégration & Marketing Expert, Hortex Foundation).

After completing the PPT oral presentation a practical session was conducted each day. In that session the resource speakers demonstrated all postharvest activities including sorting, grading, washing and packaging of HVC with special emphasis on vegetable (bitter gourd). She practically showed all activities step by step and explained its benefit and necessities. Dr. Md. Atiqur Rahman, Postharvest Management Expert, NATP-2, Hortex Foundation helped Mrs. Nazia by providing technical assistance in postharvest management aspect. All participants actively participated in the practical session. The practical exercise was performed by the participants to actualize those read, heard, and seen in the lectures and training manual. This experiential learning when matched with theoretical knowledge is undoubtedly an effective way to build capability and self-security or confidence in people who will later echo those learned to their clients. After that the training program was formally closed at 4:15 pm.

Training Schedule for Capacity Building of CIG farmers on Postharvest Management, Marketing and Food Safety of HVCs

Venue: Training Hall, DAE Horticulture Centre, Rajalakh, Savar

Date: 21-22 May 2018

Time	Topic	Trainer/Guest Speaker
9:30-10:00	Registration	Mr. Chandan, LBF, Savar & Dr. Rahman
10:00 – 11:00	Appropriate time and harvesting methods of fruits and vegetables	Mr. Md. Rasel, AEO, DAE, Savar
11:00-12:00	Postharvest management of fruits and vegetables.	Mr. Md. Shahidullah, UAO, Savar
12:00 – 13:00	Safety and quality assurance of fruits & vegetables	Mr. M.A. Salam, ADD, DAE, Dhaka
11:50 – 13:00	Market management of fresh fruits & vegetables	Mrs. Iffat Ara Islam, Horticulturist, Horticulture Centre, Rajalakh, Savar
13:00 – 14:00	Break for Prayer & Lunch	
14:00-16:00	Postharvest management practices of fruits and vegetables (Practical session)	Mrs. Nazia Akhter, AEO, DAE, Savar, Dhaka.



Fig 20. Nazia Akter, AEO, Savar Upazila is conducting a session on food safety issues of horticultural crops.



Fig 21. Hand's on session is going on by sorting, grading, washing and packaging of bitter gourd.

Training at Kapasia Upazila, Gazipur: The training program was organized in collaboration between Hortex Foundation and DAE under NATP-2 project on 24 May 2018 at CCMC and high school, Chandpur Bazar, Kapasia, Gazipur on **Postharvest Management, Marketing and Food Safety of HVCs**. A total of 3 batches training were conducted on that day. Two batches of training containing 60 CIG farmers were participated at CCMC venue and another batch had 30 participants participated at the local high school venue. Among the participants about 30% were women. The training program was formally started at 9:30 am with registration of the participants. The training component was delivered by a team of nine resource persons including Mr. Asish Kumar Kor (UAO, Kapasia), Mr. Md. Jashim Uddin (DTO, DAE, Gazipur), Banani Karmokar (AEO, DAE, Gazipur), Mr. Md. Shah Alam (ADD, Crop, DAE, Gazipur), Dr. Md. Atiqur Rahman (Postharvest Management expert) and Mr. Md. Bazlur Rahman (Supply Chain Intégration & Marketing Expert, Hortex Foundation).



Fig 22. Female and male CIG farmers participated in the training class arranged at the CCMC, Chandpur Bazar, Kapasia.



Fig 23. Hands on session is going on by dahanding, sorting, grading, washing and packaging of banana.

After completing the PPT oral presentation, a practical session was conducted by Dr. Atiqur Rahman demonstrating all postharvest activities including sorting, grading, washing and packaging of HVC with special emphasis on banana. He practically showed all activities step by step and explained it's benefit and necessities. All participants actively participated in the practical session. The practical exercise was performed by the participants to actualize those read, heard, and seen in the lectures and training manual. After that the training program was formally closed at 4:15 pm.



Fig 24. Female and male CIG farmers participated in the training class at Shibpur Upazila, Narsingdi District.



Fig 25. Hand's on session is going on by sorting, grading, washing and packaging of brinjal.



Fig 26. Group photo with a part of the CIG trainees participated in the training program at Mirsarai Upazila, Chattogram.



Fig 27. A view of the training class room at the Upazila Parishad Auditorium, Mirsarai, Chattogram.



Fig 28. Female CIG farmers participated in the training class at Polashbari Upazila, Gaibanda District.



Fig 29. Hands on session is going on by sorting, grading, washing and packaging of banana.



Fig 30. CIG farmers participated in the training class at DAE office, Jhikorgacha of Jashore District



Fig 31. Hand's on session is going on by sorting, grading, washing and packaging of brinjal. Mr. Susanta and Mr. Diponkar led the practical session

7.8.4 Organizing training for the PO-MMC members

A total of 6028 PO members working in different CCMCs were trained up in 134 batches on improved PHM of fruits and vegetables, financial management, documentation etc. during 2018 to 2021. Among the trainings, at least 50 batches were conducted under my direct supervision. All of the training were arranged at the training hall of Upazila Agriculture Office of the selected upazila. DAE officials including UEO, UAO, ADD and DDAE delivered lectures on different pre-selected topics including sub-project submission to get AIF-3 matching grant from the NATP-2 project. In most of the training program I also participated as a resource speaker.

7.8.5 Capacity building program for LBF and traders of fresh produces

Hortex Foundation organized refresher course for LBF and some capacity building programme on “Improved PHM and value chain development” for agri-traders. Before starting the training program, we had prepared the lecture note and provided to all participants during the training program. At the same time, the draft programme of activities during the training was prepared prior to the mission. Power point presentations of all topics assigned to each resource speaker were also prepared for devering lectures. Four hundred fifty (450) traders were trained up on “improved PHM of fruits and vegetables based on CCMC” during January to June 2019. I myself participated in two training program at Kishoregonj.

7.8.6. Organizing 10 batches training program on value addition through processing of fruits and vegetables

Ten batches of training program on value addition through processing of fruits and vegetables were organized for women CIG in 10 selected upazilas. Among them I actively organized the hands-on training in three upazilas including Delduar, Belabo and Kishoregonj. In those training the participants came to know how to prepare and store of processed products like jam, jelly, pickels etc. in aseptic conditions.

7.9 Organizing 10 national workshops

Ten national workshops were organized during 2018 to 2022. Among them I myself presented four keynote papers in four different workshops. The titles of those workshop were 1) “Postharvest Management of Fruits & Vegetables for Food Safety and Quality Assurance” that was held on 06 February 2019 2) “Postharvest loss reduction of banana assuring quality and safety through improved postharvest management during marketing” held on 30 October 2019, 3) “Increasing Farmer’s Income Through Postharvest Loss Reduction of Fruits and Vegetables” which was held on 11 May 2022 and 4) “Improved Management of Mango to Enhance Export Assuring Quality and Safety” that was held on 23 August 2021.



Fig.32. National workshop on “Postharvest Management of Fruits & Vegetables for Food Safety and Quality Assurance” held on 06 February 2019

7.10 Organizing 60 business planning and related workshops for the PO-MMC members

Thirty business planning workshops and another 30 business related workshops were organized for the PO-MMCs members and LBFs in 30 selected upazilas during February to June 2022. Personnally, I directly participaed in 25 program to conduct the workshops.

7.11 Development of short video documentaries on improved postharvest management and value chain development of fresh fruits and vegetables

Seven video documentaries on postharvest management and improved value chains of fresh fruits and vegetables were developed and broadcasted through different TV chennels. The titles of those videos were i) Improved production and postharvest practices of vegetables that was made in Shibpur upazila, Norsingdi ii) CCMC based improved postharvest management of fruits and vegetables that was made in Jashore sadar upazila iii) Implementation of IPHM practices to ensure quality and food safety of fruits and vegetables to enhance export-Belabo, Norsingdi iv) Improved value chain of banana in reducing postharvest loss maintaining fruit quality and safety-Bogura and Madhupur, Tangail v) Improved postharvest management of fruits and vegetables and strengthening of market linkage that was made in Mithapukur upazila, Rangpur, vi) Food processing and value addition to fruits and vegetables for family nutrition and income and vii) improved pre- and postharvest management of mango for enhancing export were developed in Chapainawabganj.

7.12 Analysis of market and field samples to determine nutrient quality and food safety of fresh fruits and vegetables

Food safety is a major concern in Bangladesh. Indiscriminate uses of synthetic pesticides and chemical fertilizers in fruits and vegetables are the prime causes of food safety hazards in the country. In most of the cases farmers do not follow the safe pre-harvest interval period for pesticide application in the crops resulting left over higher amount of pesticide residues in harvested crop. A total of 32 samples of tomato, brinjal, bitter gourd and banana had been collected from different fields and were analyzed in the Postharvest lab and Plant Pathology lab of BARI to determine the food quality and nutrient status, and microbial contamination (Table 1). A brief report was also prepared and submitted to the office.

Table 1. Identification of food borne bacteria and quantification of the microbial load in some fresh samples

Crop	Location	Total CFU/g	Salmonella sp.	<i>E.coli</i>
Bitter gourd	Tangail	$>10^8$	56×10^6	3×10^7
Bitter gourd	Norshingdi	$>10^8$	10^7	10^8
Bitter gourd	Jashore	$>10^8$	6×10^7	10×10^5
Bitter gourd	Jamalpur	$>10^8$	6×10^3	10×10^2
Banana	Modhupur,	$>10^8$	10^8	10^8
Banana	Bogra	$>10^8$	2×10^8	10^8
Banana	Norshingdi	$>10^8$	8×10^7	2×10^8
Banana	Gazipur	$>10^8$	8×10^2	2×10^3
Tomato	Cumilla	$>10^8$	4×10^4	10^7
Tomato	Jashore	$>10^8$	4×10^1	10^3
Tomato	Jamalpur	$>10^8$	3×10^7	7×10^4
Tomato	Dinajpur	$>10^8$	31×10^4	10^8
Brinjal	Savar	TFTC	TFTC	0
Brinjal	Norshingdi	TFTC	TFTC	0
Brinjal	Rangpur	TFTC	0	0
Brinjal	Cumilla	36	0	TFTC

Table 2. Guidelines for the interpretation of results for hygiene indicator organism in ready-to-cut food in general

Hygiene indicator organism	Result (colony forming unit, CFU/g)		
	Satisfactory	Borderline	Unsatisfactory
<i>Salmonella</i> spp.	Not detected	Not applicable	Detected
<i>Escherichia coli</i>	<20	20-<100	>100

Source: Microbiological Guideline for Food, August 2014 (Revised). Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods Placed on the Market, November 2009, ©Health Protection Agency.

In this study, all the fresh crop samples except brinjal were detected with the presence of *Salmonella* spp. and *Escherichia coli* (Table 1). The samples of bitter gourd, banana and tomato from all the seven districts, were severely contaminated with *Salmonella* spp. and *Escherichia. coli* ($>10^3$ CFU/g), which is belong to unsatisfactory level of hygiene indicator (Table 2). The presence of such amount of inoculum in the fresh vegetables may cause serious diseases of human such as diarrhea and vomiting. It is necessary to immediate investigation of the causes of food contamination in the market through investigating the food origin, production process, marketing and also consider environmental monitoring.

I also collected eight brinjal and eight bitter gourd samples directly from farmer's field from three neighbouring upazilas like Shibpur, Belabo and Raipura of Narsingdi district. After harvest, the samples were brought to the pesticide analytical laboratory of BARI to determine the amount of pesticide residues left over the produce. The samples were analyzed using GCMSMS following standard procedures and protocols. Results of the analysis showed that almost all of the brinjal and bitter gourd samples were highly contaminated by pesticides in particular chloropyrifos group of insecticides. The residues found in the crops were much higher than that of maximum residue level (MRL), which are not safe for consumption. Therefore, it is suggested that our farmers should be more cautious regarding the judicial application of appropriate pesticides and have to be confined in maintaining the pre-harvest interval before marketing the produce. A detailed report is attached in annexure 3.

7.13 Assisting PO-MMC members to operate mini truck for transporting fruits and vegetables at high-end markets

To assist PO-MMC, a operational guideline on proper management of mini-truck was developed and sent to the PO-MMC who purchased the truck by the using the matching grant of AIF-3 under NATP-2 project. We also advised them to maintain a log-book and a separate cash book for truck to keep daily income and expenditure record clearly.

7.14 Institutional linkage development for supplying fresh fruits and vegetables

In Mithapukur of Rangpur and Palashbari of Gaibandha, the MMC supplied vegetables to the upazila administrations & local political leaders for distribution as relief material to the poor and needy. The LBF in Muktagachha of Mymensingh organized vegetable sales to the Border Gourd of Bangladesh (BGB) over there. Fresh vegetables with bulk volume were also supplied to the Dhaka cantonment from the Belabo and Raipura CCMC during Covid-19 pandemic situation. With the help of UAO, the MMC of Jashore sadar organized door-to-door vegetable sale collecting on a truck from the CCMC as all other markets were closed. They also contacted with 'Ad-Din' medical centre, Jashore to lift vegetables regularly from the CCMC. I also communicated with several exporters to collect good quality fruits and vegetables from some of the potential CCMCs including Delduar, Chandina and Dakkhin Surma. Consequently, the Deputy Director of Shampur packhouse Mr. Abul Kalam Azad visited the Delduar CCMC and discussed the PO-MMC for exporting seedless lemon to the middle-east countries. Similarly, another exporter Mr. Rajib visited the Dakkhin Surma CCMC and held meeting with PO-MMC to get high quality vegetables through CCMC for export purpose.

7.15 Mobilization of CIG farmers and traders for fruits & vegetables marketing during Covid-19 lockdown

The CIG farmers and local traders around the CCMCs were mobilized to join the temporary open field markets, where upazila administrations organized such system for maintaining social distancing as regular markets and shops were kept closed. In a number of places, the PO-MMC with the help of UAO and upazila administration organized vegetable sale for the local consumers using the rickshaw vans. Moreover, the LBF tried to strengthen the linkage between local traders and farmers, which made possible to sell fresh produce directly from the farmer's field.

7.16 Measures taken to operate the CCMCs during lockdown period due to Covid-19 pandemic

The Government of Bangladesh took drastic measures to lock down at different areas of the country during Covid-19 pandemic situations. Under such circumstances, most of the CCMCs across the country faced serious challenges to operate. These were as follows:

- Traders, usually coming from outside to buy produce from the CCMCs, could not come due to shut-down of public transport

- Transports were not available for the same reason to enable transporting fresh produces to different wholesale markets or related destinations
- Movement restrictions prevented farmers from bringing their products to the CCMCs and even to the local assembled market
- Forced closure of some of the CCMCs by police and local administrative authorities applied as a blanket rule to keep all market closed, despite government directive to allow uninterrupted flow of food and related agricultural commodities

As a result, prices of fruits and vegetables went down, farmers were discouraged from harvesting their produces to bring for sale, and even in some places farmers destroyed their crops and planted a next season crop. In the first few weeks following the lockdown, almost all the CCMCs faced some level of disruption or closure. There were lots of confusion to organizing and keeping chain of essential supplies open as concerns of catching the infection-troubled people. In some cases, the whole areas remained under lockdown and so nobody could move. In some places, the LBFs could not come as they were obstructed on their way and the CCMCs could not be opened. Three of the LBFs were forced to leave station for their homes as their co-habitants left and food became unavailable, but they left arrangements with MMC functionaries to keep the CCMCs operational. Despite all odds, all the CCMCs managed to operate once or twice every week during the first few weeks of the lockdown. However, as mentioned earlier, few farmers brought produces for sale while few local traders bought those as demands and prices were low.

We from the Hortex Foundation were ahead of the crisis and had already prepared and sent leaflets recommending practices like hand-washing, social distancing, etc. for the staff and farmers for safety measures against possible infection. In order to avoid crowding by farmers at the CCMC, Hortex worked with the CIGs along with DAE officers and staff to organize group marketing. One member of a CIG would thus bring produce from other fellow farmers of the group to the CCMC, whilst sharing transport and other costs between them. Hortex kept contact with the UAOs, LBFs and the MMCs for keeping the CCMCs functional. MMC members were requested and LBFs were instructed to approach the UAO for supporting CCMC operations, so that Police would not arbitrarily close a CCMC. Gradually, the business improved.

7.17 Linkage development of CCMCs with online marketing of fresh fruits & vegetables

Hon'ble Agriculture Minister Dr. Muhammad Abdur Razzaque MP officially inaugurated the Hortex's online marketing site www.hortexbazarbd.com on 24 June 2020 to home delivery of fresh fruit and vegetables in Dhaka city to address the Covid-19 problem. Out of the 30, 19 CCMCs have been linked with Hortex Online Marketing system, and the respective PO-MMCs sent their produces to the Hortex Foundation for selling through online marketing system. I personally communicated with different PO-MMC working in Shibpur, Belabo, Kapasia, Khagrasori, Madhupur, Godagari to connect with the online marketing system of Hortex Foundation www.hortexbazarbd.com for supplying fresh fruits & vegetables from the CCMC. Up to December 2020 a total of 37 tons of different agri-commodities were sold at a value over BDT 21 lakh (BDT 2.1 Million).

7.18 Marketing volume of fresh fruits and vegetables through CCMC and CP following improved postharvest management practices

All CCMC and CP are using as business centres of different agri-commodities. Both farmers and traders are get togethers in the CCMC for selling and purchasing of fresh fruits and vegetables with better process. As a consequence, 38, 620 MT of quality fruits and vegetables were marketed through the CCMCs following improved PHM practices upto November 2022, out of which 2475 MT fresh vegetables were exported to overseas countries including Dubai, Kuwait, Saudi Arabia, Qatar, Malaysia, Italy and UK during that period.

8. Major Outputs

- i. The inception report, quarterly and half-yearly progress reports were submitted on time to the Managing Director of Hortex Foundation in each year during 2018 to 2022.
- ii. This Final Report constitutes another output from the PHM Expert as per the ToR.
- iii. Baseline information on knowledge gap of the stakeholder on postharvest management practices in the existing value chains has been generated.
- iv. Postharvest technology packages for six selected crops was developed, printed and distributed among the value chain actors, that helped to use improved postharvest management practices for fresh fresh fruits and vegetables
- v. One training module, three booklets, three fact sheets and four posters were prepared, printed and distributed to different levels of value chain actors. As a result, improved postharvest technologies and relevant information on fresh fruits and vegetables are readily available to the trainers and all levels of stakeholders including growers, traders, packers, retailers of the value chain. These are helpful in improving performance, wider coverage and awareness building on PHM, value chain and food safety activities
- vi. Data on food safety issues particularly on the presence of *Salmonella* and *E. coli* in fresh fruits and vegetables marketed through the existing value chains were collected and analysed using statistical tools. A detailed report based on the laboratory data was prepared and included in this report. Findings of hat study are very helpful for implementing appropriate technologies in the value chains to assuring safe food for the consumers.
- vii. Trained DAE officers had organized training programme for SAAOs, CIG farmers and members of the producer organization as resource speakers and getting involved in proper PHM promotion
- viii. Trained SAAO/AAEO understood and realized the importance of PHM practices and interacting with CIGs and PO's members accordingly
- ix. The LBFs are now capable to organize farmers, raising fund for the cooperatives, data collection, CCMC functioning, CP selection and hiring, organizing farmer's training and other meeting with traders etc.
- x. The trained CIG farmers and other value chain actors across the country showed their interest to use improved postharvest technologies including sorting, grading, washing and packaging of fresh produces using plastic crate as packaging container for marketing the produces. The increased usage of IPHT is helping to reduce the postharvest losses of fresh produces managing quality.
- xi. The CCMCs are becoming popular as market places displaying the validated technologies of PHM practices (sorting, grading, washing, drying and packaging), which is helpful for the farmers, traders, and entrepreneurs to watch the practical handling system of fruits and vegetables.
- xii. Very good marketing linkages were developed with some institutional buyers, big traders and exporters, which is very much helpful for marketing the fresh fruits and vegetables with better prices. Smallholder's farmers are getting economic benefits from this marketing system.
- xiii. A total of 38, 620 MT of quality fruits and vegetables were marketed through the CCMCs following improved PHM practices upto November 2022, out of which 2475 MT fresh vegetables were exported to overseas countries including Dubai, Kuwait, Saudi Arabia, Qatar, Malaysia, Italy and UK during that period.

National Agricultural Technology Program-Phase II Project (NATP-2)
Hortex Foundation as Strategic Partner of DAE

কৃষক পর্যায়ে ফল ও সবজির সংগ্রহোত্তর ব্যবস্থাপনার প্রচলিত প্র্যাকটিস সংক্রান্ত জরীপ

সাক্ষাৎকার সূচী

উপজেলাঃ ----- ইউনিয়নঃ ----- জেলাঃ -----

প্রশ্ন পত্র নং:

তারিখ:

১। উত্তরদাতার নামঃ----- বয়সঃ----- শিক্ষাঃ-----

গ্রামঃ----- ইউনিয়ন/পৌরসভা মোবাইল নং-----

২। মোট আবাদী জমি ও অন্যান্য জমির পরিমাণ (শতক)

বসত ভিটা	মোট আবাদী জমি	ফল/ সবজির জমি	মাঠ ফসলের জমি

৩। ২০১৭-১৮ (গত) বছরে ফল/সবজি চাষের বিবরণ

ফল/সবজির নাম	জমির পরিমাণ (শতক)	মোট উৎপাদন (কেজি)	মন্তব্য
কলা			
করলা			
টমেটো			
বেগুন			
মিষ্টি কুমড়া			
অন্যান্য সবজি			

৪। আপনি কত বছর ধরে ফল/সবজি চাষ করছেন? বছর

৫। আপনি ফলমূল ও শাকসবজি মাঠ থেকে সংগ্রহ করা ও বাজারজাত করার উপর কোন প্রশিক্ষণ নিয়েছেন কি? হ্যাঁ না

উত্তর হ্যাঁ হলে কতবার?

৬। নিরাপদ ও স্বাস্থ্যসম্মত ফল ও সবজি উৎপাদনের জন্য আপনি কি উত্তম কৃষি চর্চা (GAP) অনুসরণ করেন? হ্যাঁ না

উত্তর হ্যাঁ হলে ফসল উৎপাদনে কি কি পদ্ধতি অবলম্বন করে থাকেন?

পরিমিত সার দেই অনুমোদিত কীটনাশক সংস্থিক পরিমাণে ব্যবহার আইপিএম আইসিএম অন্যান্য

৭। ২০১৭-১৮ (গত) বছরে ফলমূল ও সবজি বাজারজাতকরণ সম্পর্কিক তথ্য

ফল/সবজির নাম	বিক্রয়ের স্থান	ক্রেতার বিবরণ	বিক্রয়ের পরিমাণ (কেজি)	একক দাম (টাকা/কেজি)
কলা	-জমি থেকে	-খুচরা বিক্রেতা		
করলা	-বাড়ি থেকে	-ফরিয়া		
টমেটো	-স্থানীয় বাজার	-পাইকার		
বেগুন	-পাইকারী বাজার	-বড় বেপারি		
মিষ্টি কুমড়া	-উপজেলা বাজার	-ভোক্তা		
অন্যান্য সবজি	-জেলা বাজার			

৮। ফল ও সবজি কোন অবস্থায় মাঠ থেকে সংগ্রহ করেন?

অপরিপক্ষ উপযুক্ত পরিপক্ষ বেশী পরিপক্ষ বাজারের চাহিদা অনুযায়ী

৯। দিনের কোন সময় সংগ্রহ করেন?

ভোর বেলা রোদ উঠলে বিকালে যে কোন সময়

১০। কিভাবে ফল/সবজি সংগ্রহ করেন?

হাত দিয়ে টেনে কাঁচি/চাকু দিয়ে বেঁটাসহ কেটে অন্য পদ্ধতিতে

১১। ফল/সবজি তোলার সময় মোট কি পরিমাণ নষ্ট হয়?

ক্রমিক নং	নষ্টের কারণ	নষ্টের পরিমাণ (১০০ কেজিতে কত কেজি?)
১.	পোকায় খাওয়া	
২.	রোগাক্রান্ত বা পাঁচে যাওয়া	
৩.	কাটা, ফাটা বা খেতলে যাওয়া	
৪.	জমিতে বরে পড়া	
৫.	অন্যান্য	

১২। জমি থেকে তোলার পর ফল/সবজি কোথায় জড়ে করেন?

জমির একপার্শে খোলা রোদে গাছের ছায়ায় অন্য কোন ছায়াযুক্ত স্থানে

১৩। জমি থেকে উঠানের পর ফল/সবজি কি ধূয়ে পরিষ্কার করেন? হাঁ না

উত্তর হাঁ হলে কিভাবে করেন ?

ক) নালা বা ডোবার পানি দিয়ে ধুই।

খ) বালতিতে টিউবয়েলের পানি দিয়ে ধুই।

গ) নদীর পানিতে ধুই।

১৪। ফল/শাকসবজি তোলার পরে রোগ-পোকাক্রান্ত, নষ্ট, পচা গুলো বাছাই করেন কি? হাঁ না

বাছাই করলে, কি পরিমাণ শাকসবজি নষ্ট পান? %

১৫। ফল/সবজি বিক্রয়ের জন্য প্রেডিং বা ভাগ করেন কি? হাঁ না

কিভাবে প্রেডিং করেন? ছোট-বড় সাইজ দেখে পরিপন্থতা দেখে রং দেখে অন্যান্য

১৬। কিভাবে সবজি প্যাকেজিং করেন ?

চট বা প্লাষ্টিকের ব্যাগে বাঁশের বৃত্তিতে প্লাষ্টিকের ক্রেটে অন্যান্য

১৭। পরিবহনের সময় ফল/সবজি নষ্টের হিসাব

পরিবহনের স্থান	পরিবহনের ধরন	দূরত (কি.মি)	ফল/সবজির মোট পরিমাণ (কেজি)	নষ্টের পরিমাণ (১০০ কেজিতে কত কেজি?)
মাঠ বা বাড়ি থেকে স্থানীয় বাজার	মাথায়/সাইকেল/রিক্ষা/ ভ্যান/টেম্পু/অন্যান্য			

১৮। বাজারজাতকরনের উদ্দেশ্যে টমেটো বা কলা পাকানোর জন্য কোন কেমিক্যাল ব্যবহার করেন কিনা?

হাঁ না।

ব্যবহার করলে কোন কেমিক্যাল কিভাবে ব্যবহার করে থাকেন?

ইথিলিন দ্রবনে ডুবিয়ে ইথিলিন দ্রবন স্প্রে করে খোয়া দিয়ে কার্বাইড দিয়ে অন্য পদ্ধতিতে

১৯। ফল ও শাকসবজি সংগ্রহের অপচয় কিভাবে হাস করা সম্ভব বলে আগন্তি মনে করেন?

.....
তথ্য সংগ্রহকারীর স্বাক্ষর

নামঃ

National Agricultural Technology Program-Phase II Project (NATP-2)

Hortex Foundation

as Strategic Partner of the Department of Agricultural Extension

ব্যবসায়ী পর্যায়ে ফল ও সবজির সংগ্রহোত্তর ব্যবস্থাপনার প্রচলিত প্র্যাকটিস সংক্রান্ত জরীপ

সাক্ষাৎকার সূচী

উপজেলাঃ ----- ইউনিয়নঃ----- জেলাঃ -----

পাইকার/বেপোরী

প্রশ্ন পত্র নং:

তারিখ:

১। উত্তরদাতার নামঃ----- বয়সঃ----- শিক্ষাঃ-----

গ্রামঃ----- মোবাইল নং-----

২। ক্রয়কৃত ফল/সবজি কোন ধরণের বাজারে নিয়ে যান? (টিক চিহ্ন দিন)

■ দূরবর্তী পাইকারী বাজারে ■ খুচরা বাজারে

৩। পাইকারী বাজারের দূরত্ব কত এবং যেতে কত সময় লাগে? -----কি.মি.-----ঘণ্টা

৪। প্রতি সপ্তাহে ফল/সবজি ক্রয়ের পরিমাণ ও দাম

ফল/সবজি সংগ্রহের মৌসুম	ফসলের নাম	মোট ক্রয়ের পরিমাণ (কেজি)	ক্রয়মূল্য (টাকা/মন)
প্রধান মৌসুম			
অমৌসুম			

৫। কত দিন পর পর কেনেন? (টিক চিহ্ন দিন)

■ প্রতিদিন ■ সপ্তাহে ১ বার ■ সপ্তাহে ২ বার ■ মাসে একবার

৬। কেনার পর ফল/সবজি ধুয়ে পরিষ্কার করেন কি? ■ হ্যাঁ ■ না

উত্তর হ্যাঁ হলে কোন পানিতে ধুয়ে থাকেন ?

ক) নালা বা ডোবার পানি দিয়ে ধুই।

খ) বালতিতে টিউবয়েলের পানি দিয়ে ধুই।

গ) নদীর পানিতে ধুই।

৭। ফল/শাকসবজি সংরক্ষণ কিংবা বিক্রয়ের পূর্বে বাছাই করেন কি? ■ হ্যাঁ ■ না

বাছাই করলে, কি পরিমাণ শাকসবজি নষ্ট পান? %

৮। ফল/সবজি বিক্রয়ের জন্য প্রেতিং করেন কি? ■ হ্যাঁ ■ না

কিভাবে প্রেতিং করেন? ■ ছোট-বড় সাইজ দেখে ■ পরিপক্ষতা দেখে ■ রং দেখে ■ অন্যান্য

৯। পরিবহনের জন্য কিভাবে ফল বা সবজি প্যাকেজিং করেন ?

■ চট বা প্লাস্টিকের ব্যাগে ■ বাঁশের ঝুড়িতে ■ প্লাস্টিকের ক্রেট ■ অন্যান্য

১০। কত কেজি ওজনের প্যাকেট করেন? -----কেজি

১১। পরিবহনের সময় ফল/সবজি নষ্টের উপাত্ত

পরিবহনের স্থান	পরিবহনের ধরন	দূরত্ব (কি.মি)	প্রতি ট্রাকে/পরিবহনে ফল/সবজির পরিমাণ (কেজি)	পাইকারী বাজারে ফল/সবজির নষ্টের পরিমাণ (%)
স্থানীয় বাজার থেকে দূরবর্তী পাইকারী বাজার	ট্রাক/বাসের ছাদে/ রিক্লা/ভ্যান/টেম্পু			

১২। পরিবহনের সময় কি কি কারণে ফল/সবজি নষ্ট হয় বলে আপনি মনে করেন?

■ অনুপযুক্ত এবং বড় প্যাকেজিং ■ পরিবহনে অতিরিক্ত লোড দেওয়া ■ ট্রাকে উঠানে ও নামানোর সময় রাফ হ্যান্ডিলিং ■ রোগ ও পোকা ■ অন্যান্য

১৩। বাজারজাতকরনের উদ্দেশ্যে টমেটো বা কলা পাকানোর জন্য কোন কেমিক্যাল ব্যবহার করেন কিনা?

■ হ্যাঁ ■ না।

ব্যবহার করলে কোন কেমিক্যাল কিভাবে ব্যবহার করে থাকেন?

■ ইথিলিন দ্রবনে ডুবিয়ে ■ ইথিলিন দ্রবন স্প্রে করে ■ ধৌঁয়া দিয়ে ■ অন্য পদ্ধতিতে

১৪। নিরাপদ ফল ও সবজি সম্পর্কে আপনার কোন ধারণা আছে কী? ■ হ্যাঁ ■ না

উত্তর হ্যাঁ হলে, কী কী বিষয় ফল ও সবজি নিরাপদ রাখার সাথে জড়িত বলে আপনি মনে করেন?

■ বিষমুক্ত ■ রোগ-পোকামুক্ত ■ পরিষ্কার-পরিচ্ছন্নতা ■ বিশুদ্ধ পানি দ্বারা ধোতকরণ ■ অন্যান্য

১৫। কোন কারণগুলোর জন্য ফল ও সবজি স্বাস্থের পক্ষে ক্ষতিকর হয় বলে আপনি মনে করেন?

■ মাত্রাতিরিক্ত কীটনাশক/ছত্রাকনাশক দেয়ায় কারণে ■ কেমিক্যাল দিয়ে ফল পাকানোর কারণে

■ রাসায়নিক সার ব্যবহারের কারণে ■ অপরিষ্কার পানি দ্বারা ধোতকরণ ■ পোকা-মাকড়ের কারণে ■ অন্যান্য কারণ

১৬। ফল ও সবজি নিরাপদ রাখার জন্য কি কি ব্যবস্থা নেয়া দরকার বলে আপনি মনে করেন?

ক)

খ)

গ)

১৭। পণ্যের গুণাগুন ঠিক রেখে এগুলোর সংগ্রহোত্তর ক্ষতি হাসের ক্ষেত্রে কি ধরনের শিক্ষামূলক কার্যক্রমকে উপযুক্ত বলে মনে হয়?

■ হাতে-কলমে শিক্ষা ■ শিক্ষা ভ্রমন ■ কৃষক ও অন্যান্য ব্যবসায়ীদেও সাথে আলাপ-আলোচনা

■ কৃষি সম্প্রসারণ ও কৃষি গবেষকদের সাথে নিয়মিত যোগাযোগ। ■ অন্যান্য

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তথ্য সংগ্রহকারীর স্বাক্ষর

নামঃ

**BASELINE SURVEY ON EXISTING VALUE CHAINS OF FRUITS AND VEGETABLES IN
SELECTED UPAZILAS OF BANGLADESH**

Executive summary

A survey was carried out on existing postharvest management practices followed by the grower and traders in fresh producer's value chains in Bangladesh during April to October 2018. This study assessed the knowledge, attitude and practices of value chain's key actors and the status of market opportunities in the country. A total of 515 farmers and 295 traders were interviewed from 30 selected upazilas of Bangladesh under NATP-2 project. Pre-tested structured questionnaires were used to collect data from the field and markets. Data were analyzed using Merlin Statistical Software. Findings of this study revealed that most of the growers (50-70%) showed positive attitude towards good agriculture practices (GAP), maturity indices, and role of good packaging for keeping the produces safe for the consumers. More than 41% farmers aggregated their harvested commodities beside the field on direct soil contact under open sun, which might cause of weight loss and microbial contamination of the produces. Washing practice did not follow by most of farmers (79.6%) and traders (61%) during marketing of fruits and vegetables. Only 27% farmers and traders washed their produces out of which, 32% used unsafe water found from the canal, ditch or river. Similarly, grading was performed only by 25.3% farmers and 23.1% traders. Nevertheless, on an average 86.9% farmers and traders sorted out their produces before marketing to get better price. More than 56% farmers and traders used jute or nylon sac for packaging fresh fruit and vegetables. Only 20.1% farmers and 24.4% traders used plastic crates as a packaging material of fresh produces. Generally, farmer used different local vehicles including three-wheeler van, rickshaw, bi-cycle, tempo etc., whereas the traders transported their produces to the wholesale market by using truck and pick up van. *Most growers and traders (92.8% and 96.2%, respectively) did not use any ripening agent for force ripening of fruits; however, about 6% of farmers and traders used ethephon solution following spray or dipping method for uniform and quick ripening of banana and tomato for early market and good price.* The average postharvest losses were estimated 13.2% at farm level, whereas it was 11% at trader's level up to wholesale market. At firm level, these losses occurred mainly due to knowledge gap on maturity indices, faulty harvesting method, insect-pest and disease infection. On the other hand, the maximum loss occurred at trader's level was due to inappropriate bulk packaging, overloading and rough handling during marketing the produces. Both the farmers and traders suggested various measures to reduce postharvest losses and to keep them safe for the consumers.

1. Introduction

Fruits and vegetables play a significant role in human nutrition, especially as sources of vitamins, minerals, dietary fiber and antioxidants. The present consumption of fruits and vegetables in Bangladesh is about 346 g day⁻¹capita⁻¹, which is still lower than the minimum requirement of 400 g day⁻¹capita⁻¹ (WHO, 2018). Increased consumption of a variety of fruits and vegetables on a daily basis is highly recommended to improve nutrition and for other associated health benefits, which include reduced risk of some forms of cancer, heart disease, stroke, and other chronic diseases.

Postharvest losses of fresh fruits and vegetables in Bangladesh are estimated to range from 22 to 40% based on crops and postharvest management practices, with an overall average of 31% between production and consumption sites. Therefore, strategies should be taken to reduce postharvest losses in order to increase food availability to the growing population, decrease the area needed for production, and conserve natural resources. Under such situation, reduction of postharvest losses has become the prime issue to increase the availability of fruits and vegetables at household level. Thus, the existing status of postharvest handles including sorting, grading, wrapping, packaging, transportation, storage, processing and preservation of harvested commodity are needed to be identified, and at the same time the loss reduction strategies are needed to intervened in the existing value chain.

Fresh fruits and vegetables remain the leading cause of foodborne illness outbreaks implicating virulent pathogens such as *Escherichia coli*, *Salmonella* etc. (Callejon *et al.*, 2015). The current global philosophy related to ensuring the food safety of fresh produce is to prevent contamination in the field and to minimize cross-contamination during postharvest handling. In Bangladesh, the value chains of fresh produce are open in nature meaning that contamination can be introduced at various points in production, harvesting and processing, and then passed to the consumer (Nuesch-Inderbinen and Stephan, 2016). Generally, fresh fruits and vegetables are not properly cleaning or washing in our country before marketing them. Therefore, interventions of effective measures like washing with potable water, use of sanitizer with washing water etc. are needed to apply for postharvest decontamination of harmful microbes from the fresh produce. Therefore, the knowledge of postharvest management for fruits and vegetables is very much important at growers' and various stakeholders' levels in reducing postharvest losses and ensuring food safety for the consumers.

Efficient marketing system plays a crucial role not only in stimulating production, but also in accelerating the pace of economic development. Efficient marketing system usually ensures higher producer's share, reducing the number of intermediaries in the value chain, and restricting the marketing charges and mal-practices during marketing of farm products (Matin *et al.*, 2008). It is, therefore, essential to study the existing value chain of fresh produce in order to suggest suitable channel for the producers, appropriate postharvest technologies and proper food safety measures for the key stakeholders of the value chain to ensure food quality and safety of the produce.

Baseline data and information regarding the knowledge, attitude, and practices (KAP) of key stakeholders including growers and traders toward improved postharvest handling, postharvest losses, and quality and food safety in the value chain of fresh fruits and vegetables are very much important for successful implementation of the NATP-2 project in particularly value chain development part as well as for assessing the impact of the adapted technological packages at project sites of 30 upazilas across the country. With these views in mind, an attempt was made to generate some baseline indicators regarding the present status of the use of postharvest technologies at field and market channel for selected crops, which will provide guidelines for implementation and impact assessment of the project. Baseline data can be used to evaluate the performance of the on-going project in future. These data and information will also be helpful for the scientists, extension personnel, and policy makers of the country to formulate optimal plan for reducing postharvest losses and ensuring quality and safety of fresh fruits and vegetables in Bangladesh. Therefore, the study was conducted with the following objectives:

1. *To assess the knowledge, attitude and practices (KAP) of growers and traders toward existing postharvest handling practices, postharvest losses, quality and food safety of fruits and vegetables in the existing value chains.*
2. *To assess the status of market opportunities through analyzing the value chain for fresh fruits and vegetables in Bangladesh.*

2. Methodology

2.1. Study Area Selection

Hortex Foundation has been working with DAE as strategic partner under NATP-2 project to develop value chain and marketing of selected high value crops including tomato, brinjal, bitter gourd, pumpkin, banana and aromatic rice in 30 upazilas under 22 districts across the country. Among the 30 upazilas, 28 were selected for fruits and vegetables and two for aromatic rice. However, surveys were conducted in all 30 upazilas namely Savar, Kapasia, Shibpur, Belabo, Raipura, Chandina, Mirsarai, Khagrasori, Sreemongal, Dakkhin surma, Delduar, Madhupur, Muktagacha, Islampur, Nokhla, Kishoregonj sadar, Boraigram, Godagari, Naogaon, Shibgonj, Bogura sadar, Polashbari, Mithapukur, Parbotipur, Birgonj, Jashore sadar, Bagarpura, Jhikorgacha and Kaligonj. The postharvest management expert of NATP-2, Hortex Foundation prepared the questionnaire by consulting with

respective scientists of Economic Division of BARI. All LBFs were trained up on data collection procedures at field and market levels.

2.2. Sampling procedure

For conducting baseline survey at field and market level, a complete list of farmers and traders of fruits and vegetables was prepared by local business facilitator (LBF) of each upazila with the help of DAE personnel (DAE). It was planned to take interview of 600 farmers and 300 local traders in the fruit and vegetable value chains (i.e. 20 farmers and 10 traders from each of the 30 upazilas), but due to the unavailability of some key actors the actual number of farmer's sample size was 515 and traders was 295. All of the value chain actors were randomly selected and interviewed from different CIGs, local assembled market and retail markets. Trained enumerators (LBF) along with SAO collected data and information for this study.

2.3. Study period

Data were collected by interviewing growers and traders of fruits and vegetables using structured and pre-tested questionnaires scheduled during April to October 2018.

2.4. Analytical techniques

Mostly tabular method of analysis was followed to provide a comprehensive picture of the existing value chains of fruits and vegetables in Bangladesh. Collected data were summarized, processed and analyzed using computer software's like M.S Excel and Merlin Statistical Software.

3. Results and discussion

3.1. Socio-economic characteristics of the farmers and traders of fruits and vegetables

Socio-economic and demographic profile of the sampled farmers are required to have an idea about the present farm activities, possible development opportunities and potentials for more efficient fruit farming. Therefore, information regarding respondent's age, education and farm size were recorded for the study. Table1 shows the socio-economic profile of fruit and vegetables growers at selected areas of Bangladesh.

The selected farmers were grouped into five categories based on the age distribution. Among the 515 respondents, the maximum farmers (34.76%) belonged to the age group of 31-40 years and minimum (0.58%) belonged to the age group of ≤ 20 years (Table 1). The average age of farmers who grew fruits and vegetables in the country was found 42.3 years in the selected upazilas. On the other hand, the maximum number (38%) traders belonged to the age group of 41-50 years, which was followed by the age group of 31-40 years old (Table 1). However, the average age of the traders was 41.2 years old.

Table 1. Age of farmers and traders of fresh fruits and vegetables' value chains in Bangladesh

Age group of farmers and traders	Farmers		Traders	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses
Up to 20 years	3	0.58	3	1.02
21-30 years	79	15.34	42	14.24
31-40 years	179	34.76	104	35.25
41-50 years	134	26.02	112	38.00
50+ years	120	23.30	34	11.53
Mean score	42.3		41.2	

According to educational level, 29.7% and 28.3% farmers completed primary and high school (class 6-10) levels of education, respectively. However, a significant portion of farmers accounted of 11.4% had no education (Table 2). Among the respondent traders, the maximum number (41.3%) completed

their education at high school level (class 6-10) and 30.5% were completed their primary education. On the other hand, 5.7% traders found illiterate (Table 2).

Table 2. Education level of farmers and traders of fresh fruits and vegetables' value chains in Bangladesh

Education levels of farmers and traders	Farmers		Traders	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses
Up to class 5	153	29.71	90	30.51
Class 6 - 10	146	28.35	122	41.36
SSC	97	18.83	53	17.97
HSC	40	7.77	7	2.37
Degree	13	2.52	2	0.68
Masters	7	1.36	4	1.36
No Education	59	11.46	17	5.76

Among the farmers interviewed under this study, the maximum number of farmers (28.7%) had the cultivated land area of 50-100 decimals and 24.2% farmers had the cultivated land area of up to 50 decimals (Table 3). On the other hand, only 7% farmer owned the cultivated land size of 250 decimals. About 56.5% of the marginal farmers who had 50 decimals land grew fruits and vegetables for commercial purpose.

In this study, it was found that most of the farmer grew different kinds of fruits and vegetables round the year. Among the respondents, the maximum number of farmers (313) cultivated brinjal, which was followed by bitter gourd (219), tomato (175), pumpkin (165) and banana (101) during the year of 2017-18 (Table 4).

Table 3. Cultivated land area of farmers for growing fruits, vegetables and field crops

Land area	Total cultivated Land		Land under fruits and vegetables		Land under field crops	
	No. of respondent (n=515)	% of responses	No. of respondent (n=515)	% of responses	No. of respondent (n=515)	% of responses
Up to 50 Decimal	125	24.22	291	56.5	175	33.98
51-100 Decimal	147	28.75	129	25.05	120	23.3
101-150 Decimal	89	17.34	40	7.77	56	10.87
151-200 Decimal	76	14.76	24	4.66	54	10.49
201-250 Decimal	42	8.00	4	0.78	6	1.17
250+ Decimal	36	7.00	25	4.85	42	8.16
Mean Score	187.6		78.0		99.1	

The maximum number of farmers (60.5%) mentioned that each of them produced about 11.5 tons brinjal in the year of 2017-18. Whereas, 42.5% and 33.2% respondents told that each of them produced about 2.5 tons bitter gourd and 4.0 tons tomato, respectively in that year. On the other hand, about 20% respondents mentioned that they produced 8.5 tons banana in the year of 2017-18 (Table 4).

3.2. Knowledge, attitudes and practices of farmers on postharvest management of fruits and vegetables in the existing value chains

In the value chains of fruits and vegetables, farmer is one of the of key stakeholder involved in growing fresh produces. They were asked questions related to their knowledge, attitudes and practices (KAP) usually done in production and marketing of fruits and vegetables. The questions were related to postharvest handling practices of fruits and vegetables at farmers' level, and quality and food safety issues.

Table 4. Fruits and vegetables grown by the respondent farmers during 2017-18

Name of the crops	Land area (Decimal)		Total Production (ton)		
	No. of respondent (n=515)	Mean Score	No. of respondent (n=515)	% of responses	Mean Score
Banana	101	63.0	103	20	8.5
Bitter Gourd	219	21.5	219	42.5	2.5
Tomato	175	26.4	171	33.2	4.0
Brinjal	313	36.3	312	60.5	11.5
Pumpkin	165	21.5	155	30.0	1.3
Potato	66	51.5	63	12.2	6.2
Yard long bean	28	10.5	28	5.4	1.0
Pointed gourd	27	22.8	26	5.0	3.2
Teasel gourd	31	29.2	30	5.8	3.6

3.2.1. Status of pre-and postharvest management practices of fruits and vegetables at farm level:

The quality and safety of fruits and vegetables are largely determined by pre-harvest production factors including soil type, weather conditions and good agriculture practices (GAP), and postharvest management practices (PMP) which are discussed below:

Table 5. Measures taken to make fruits and vegetables safe for the consumers

Type of measures	Farmers	
	No. of respondent (n=515)	% of responses
A. Do you follow GAP to produce safe and hygienic fruits and vegetables?		
Positive response	290	56.31
Negative response	225	43.69
B. What methods do you follow?		
Apply balanced fertilizer	174	60.00
Apply recommended pesticide in proper dose	179	61.72
IPM	123	42.41
ICM	25	8.62
Other methods	13	4.48

3.2.2. Crop production status following GAP for quality and safety assurance: Among the respondent farmers, 56.3% told that they follow GAP in producing fruits and vegetables out of which, 60-61% applied balanced fertilizer with recommended dosage and judiciously used pesticides for prevent their crops from insect pest and diseases (Table 5). On the other hand, 42.4% and 8.6% of the respondent farmers got awareness about IPM and ICM practices, respectively in crop production.

3.2.3. Training received on postharvest management of fruits and vegetables: Postharvest management is a very important part for managing quality and safety of fresh fruits and vegetables during marketing. Findings of this shows that about 11% farmers received training on PMP of fresh produce only one time. Whereas, about 89% farmers did not receive any training on this important area of the value chain (Table 6).

Table 6. Capacity building program on postharvest management of fruits and vegetables

Particulars	Farmers	
	No. of respondent (n=515)	% of responses
A. Did you receive any training of postharvest management of fruits and vegetables?		
Positive response	57	11.07
Negative response	458	88.93
B. How many times?		
One time	57	100
Mean Score		1.0

3.2.4. Perception of farmers on crop maturity: Harvesting of crops at proper maturity stage is of great importance for attaining desirable quality and shelf life. The level of maturity actually helps in selecting storage methods, estimating postharvest shelf life, selecting processing operations for value addition (Dhatt and Mahajan, 2007). Proper knowledge on crop maturity is very much important to reduce postharvest losses as well. Therefore, farmers were asked to response on crop maturity and its perceived characteristics. Fruits and vegetable growers generally identify fruit maturity through observing physical outlook and acquired experience. All of the respondents know the maturity symptoms of fresh produces. Table 7 shows that about 70% respondents harvest well matured fruits and vegetables from the field. On the other hand, 32% farmers harvest their produces based on the market demand for getting better price. In that case they usually did not consider the proper maturity stages of the crop.

Table 7. Perception of the farmers on maturity indices of fruits and vegetables at harvest

Maturity stages of crop at harvest	Farmer	
	No. of respondent (n=515)	% of responses
Immature	5	0.97
Well matured	358	69.51
Over matured	20	3.88
Based on the market demand	165	32.04

3.2.5. Harvesting time and method of fruits and vegetables: Harvesting of fruits and vegetables at the right time of the day and in the right way maximizes crop yield, and minimizes crop losses and quality deterioration. Growers in most of the study areas were cautious about harvesting their fruit and vegetables. They know well that produce quality mostly depends on the proper harvesting time and method. Table 8 shows that more than 60% farmers harvest their produces early in the morning, whereas 28.3% farmers harvest in the afternoon. On the other hand, most of the farmers (88.3%) harvest their crop by hand pulling, which might cause partial damage of the crops and mother plant as well (Table 9). Nevertheless, 11.2% farmers used scissors or knife for detach the crop from the plant.

Table 8. Farmer's perception on harvesting time of the day

Harvesting time	Farmer	
	No. of respondent (n=515)	% of responses
Early morning	311	60.39
After Sun rise	47	9.13
Afternoon	146	28.35
Any time of the day	40	7.77

Table 9. Harvesting method of fruits and vegetables from the mother plant

Harvesting method	Farmer	
	No. of respondent (n=515)	% of responses
Hand pulling	455	88.35
Harvesting with scissor/knife	58	11.26
Other method	2	0.39

3.2.6. Aggregation place of harvested fruits and vegetables: Harvested produces should be aggregated in such a place so that this should reduce transpiration loss as well as microbial contamination of the produce. Different places near the field were reported to use to aggregate the harvested commodities. Irrespective of fruits and vegetable crops, majority of the farmers (42%) accumulated their harvested commodities on the ground under the open sun beside the field (Table 10). Keeping produce on direct contact of the soil might cause microbial contamination. On the other hand, harvested produces kept under sunlight enhanced the rate of transpiration and respiration losses, which finally deteriorated the produce quality and shelf life. Nevertheless, about 31.8% farmers aggregated the harvested fruits and vegetables under tree shade near the field, and more than 26% farmers gathered the harvested produces under a shady place like hut or open house near the field (Table 10).

Table 10. Aggregation places of harvested fruits and vegetables near the field

Aggregation site after harvest	Farmer	
	No. of respondent (n=515)	% of responses
Beside the field	164	31.84
Under a tree shade	214	41.55
Other shady places	137	26.60

3.2.7. Postharvest losses of fruits and vegetables at farm levels and their causes: On an average, the total postharvest loss of fruits and vegetables at harvest was 13.2% of the total production (Table 11). At the farmers' level, damaged produces caused by insect and disease infection, cracked and rotten fruits were usually discarded from good ones through sorting. The rate of damage for different causes can be seen in Table 11. Different factors were responsible for postharvest losses of fruits and vegetables at harvest at the farm level. The highest percentage of growers (82-83%) mentioned that most of the losses occurred due to disease and insect infestation accounting of 4.5 and 4.2%, respectively. On the other hand, more than 70% farmers mentioned that a significant portion (3.2%) of the harvested produce was lost due to cracking and abrasion damage.

Table 11. Factors contributing to the postharvest losses of fruits and vegetables at farm levels

Causes of postharvest losses	Farmers		
	No. of respondent (n=515)	% of responses	Postharvest loss (%)
Insect infestation	421	81.7	6.2
Diseases infection and rotting	429	83.3	4.5
Cracking, abrasion or bruising damage	362	70.3	3.2
Damaged due careless harvesting	292	56.7	3.3
Total	-	-	13.2

3.2.8. Mode of transportation and distance of local assemble market from the farm: Farmers are the key actors in the fresh produce's value chain. They used different types of local vehicles to transport fruits and vegetables from the production areas to the nearby local assemble markets (LAM). The use of vehicles varied from farmers to farmers and the distances of destination markets. Farmers transported their produces by using different local carriers like bicycle, rickshaw, three-wheeler van and tempoo, auto rickshaw (Table 12). Sometimes they carry their small amount of produces by head also. Table shows that most of the farmers (70%) used three-wheeler van and the rest of them used tempoo, auto rickshaw, manually pulled rickshaw to carry fruits and vegetables from the field to the assemble markets (Table 12). The average distance of LAM was 3.2 km from the field. The packaging volume of fruits or vegetables prepared by a farmer ranged from 10 to 200 kg, which averaged 85 kg (Table 12). Farmers usually used bamboo basket lined with or without newspaper, jute or plastic sacks and reusable plastic crates as packaging containers of fruits and vegetables. About 51% farmers opined that the postharvest loss accounting of 5% occurred due to wrong packaging and transportation of the produces to the LAM. However, the average postharvest loss of fruit and vegetables found 4.3% during marketing at the LAM (Table 12).

Table 12. Mode of transport and distance of local assemble market (LAM) for selling fruits and vegetables by the farmers

Type of transport vehicles	Farmers		Avg. distance of LAM (km)	Avg. unit packaging volume (kg)	Loss due to packaging and transportation (%)
	No. of respondent (n=456)	% of responses	No. of respondent (n=492)	No. of respondent (n=456)	No. of respondent (n=437)
By head	25	5.48			
Auto rickshaw	15	3.29			
Rickshaw	12	2.63			
Van	319	70.0	3.2	85.0	4.3
Tempoo	70	15.3			
Bi-cycle	68	14.9			

3.2.9. Perception of farmers on safe fruits and vegetables: Safe food refers to handling, preparing and storing food in a way that best reduces the risk of individuals becoming sick from foodborne illnesses. In another word, “Food safety is the assurance that food will not cause harm to the consumer when it is prepared or eaten according to its intended use”. The respondent farmers in the value chains of fruits and vegetables were asked about the perceptions of food safety and its related factors. Most of the respondents (84%) provided positive response on it (Table 13). Majority of them (78%) considered those fruits or vegetables safe for human consumption, which was free from chemical or pesticides (Table 13). On the other hand, more than 40% farmers thought that the safe produce must be free from disease and insect. However, 16.8% respondents opined that safe produces must be physically neat and clean, whereas a good percentage of respondents (14%) thought that safe fruits or vegetables must be washed with clean and safe water (Table 13).

Table 13. Perception of farmers about production and marketing safe fruits and vegetables

Reasons	Farmers	
	No. of respondent (n=515)	% of responses
A. Do you have any idea about safe fruit and vegetable?		
Positive response	433	84.00
Negative response	82	16.02
B. What are the things related to safe produces?		
Free from chemicals and pesticides	402	78.00
Disease-insect free	210	40.78
Neat and clean	87	16.80
Wash with safe water	73	14.10

The major contributing factors, which make fruits and vegetables unsafe for human consumption were reported to be the indiscriminate use of pesticides (74.7%), use of ripening chemicals (30%), washing with dirty water (19.2%) and use of more chemical fertilizers (10.8%) for growing crops (Table 14).

Table 14. Perception of farmers on different factors making fruits and vegetables unsafe to consumer's health

Hazardous Factors	Farmers	
	No. of respondent (n=515)	% of responses
Indiscriminate use of pesticide	385	74.7
Fruit ripening with chemicals	196	30.0
Use of chemical fertilizer to grow crops	56	10.8
Washing of fruit and vegetable with dirty water	99	19.2
Insect and diseases	33	6.4

3.3. Status of postharvest management practices and marketing of fruits and vegetables at trader's level

3.3.1. Marketing channels of fruits and vegetables: The process of fresh produce marketing started with the growers and continued through certain channels until the produce reached to the final consumers. Direct and indirect transactions between the growers and consumers found in the marketing system of fruits and vegetables. The indirect transaction was found to be more prominent than the direct one. A number of intermediaries such as local small traders, large traders, wholesaler and retailer were involved in the transaction. It was found that the small and large traders in the LAM played important role in the value chain during marketing of fresh fruits and vegetables in the study area. They traded different volume of fresh produces from the farmers based on the seasonal variation. Usually they did not store the purchased produces for even one night. On the other hand, wholesalers in the big cities simply play their role as a commission agent.

3.3.2. Volumes traded and seasonal variations: Local small traders play vital role in the fruit and vegetable's value chain. Among the respondents, the maximum number (57.6%) of local traders traded fresh produces daily in a week, whereas 31.2% traders operated their business twice in a week (Table 15).

Table 15. Purchasing habit of small traders of fruits and vegetables at the local assemble market

Frequency of business operation	Traders	
	No. of respondent (n=295)	% of responses
Daily in a week	170	57.63
Once a week	32	10.85
Twice a week	92	31.20
Once a month	01	0.34

The local small traders purchased entire volume of produces in particularly vegetables from farmers and sold them to the large traders. On an average, a local small trader purchased about 8,834 kg of vegetables in the main harvesting season, whereas it was about 3,945 kg in the off-season (Table 16). The price of fresh produces also varied due to seasonal variation. Usually the price was higher in the off-season compared to main season because of gap between market demand and supply. In the main season, the average unit price of fresh produce (mainly vegetables) was BDT 18.00 kg⁻¹, whereas it was BDT 26.00 kg⁻¹ in the off-season (Table 16).

Table 16. Seasonal variation in purchasing habit of small traders and unit price of fruits and vegetables at the local assemble market

Marketing season	Local small traders			
	Total Purchase (kg)		Unit Price (BDT kg ⁻¹)	
	No. of respondent (n=295)	Mean Score	No. of respondent (n=295)	Mean Score
Main Season	295	8,834	295	18.00
Off-Season	216	3,945	215	26.00

3.3.3. Packaging volume and container used for fruits and vegetables by the farmers and traders: Good packaging clearly communicates its product's features and allows the product to be displayed in the best possible way to highlight those features. Therefore, appropriate packaging of fresh produces keeping optimum volume is very much important for maintaining product quality, easy handling and reducing postharvest losses. Majority of the respondent traders agreed that good packaging has crucial role in maintaining product quality and attracting consumers. Most of the traders (54%) under this study used 50-100 kg package to transport the produce to the wholesale markets and 21.3% traders mentioned that they used 26-50 kg packages (Table 17).

Table 17. Packaging volume fruits and vegetables for transporting to the wholesale market

Unit packaging volume	Traders	
	No. of respondent (n=252)	% of responses
Up to 25 kg	51	17.29
26 kg - 50 kg	159	53.90
51-kg - 100 kg	63	21.36
100+ kg	22	7.46
Mean Score (kg)	60.4	

Table 18 shows the types of packaging containers used by the farmers and traders during marketing of fresh fruits and vegetables. About 54% farmer and 60% traders usually used jute or nylon sacks as packaging container for marketing the produces (Table). Due to the lower cost and locally available, a significant number of farmer and small traders (36.5 and 23%, respectively) used bamboo basket with paper lining as packaging container for fruits and vegetables (Table 18). On the other hand, more than 20-24% farmer and traders used reusable plastic crates as packaging container. However, most of the farmers and traders opined that plastic crate was the best packaging container that could maintain product quality to a great extent during transportation and handling of fresh produces (Table 18).

Table 18. Perception of farmers and traders on packaging containers of fruits and vegetables

Type of packaging containers	Farmers		Traders		Total	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses	No. of respondent (n=810)	% of responses
Jute or plastic sacks	278	54.0	177	60	455	56.17
Bamboo basket	188	36.5	68	23.05	256	31.60
Plastic crate	104	20.2	72	24.41	176	21.73
Others	18	3.5	22	7.46	40	4.94

3.3.4. Mode of transport at trader's level: The low-cost vehicles like rickshaw, three wheelers van, tempoo etc. were very common in the study areas, which were used mainly by the small traders for carrying produces from garden to the assemble markets (Table 19). However, the large traders (Bepari) usually used truck for transporting fruits and vegetables to the wholesale markets. Data of the present study revealed that more than 58.3 % traders used truck to transport the fresh produces from local assemblies market to the distant wholesale markets (Table 19). In contrast, 31.5% small traders used three wheelers van to carry fresh produces mainly from the field to the LAM. The average distance of the destination wholesale market from the LAM was about 135km and the average volume of fruits and vegetables of 5,481Kg loaded in a truck of five-ton capacity (Table 19).

Table 19. Mode of transport for sending fruits and vegetables to the wholesale markets

Types of transport vehicles	Traders		Avg. distance of wholesale markets (km)	Produce vol. loaded in a truck (kg)	Produce loss at reaching to the wholesale market (%)
	No. of respondent (n=257)	% of responses			
Truck	150	58.37			
Bus roof	21	8.17			
Rickshaw	9	3.50	135.1	5481.0	6.7
Van	81	31.52			
Tempo	30	11.67			

3.3.5. Postharvest losses of fruits and vegetables at wholesale level: The postharvest losses of fresh fruits and vegetables at wholesale level in the value chain is presented in Table 20. Among the respondents, the maximum number (62%) told that the postharvest loss at wholesale level was estimated at 6-10%. However, about 26% traders informed that it was up to 5%. On the other hand, a

significant portion of the produces got partial damage in the form of compression, bruising or abrasion during transporting to the wholesale market, which could be sold at reduced price (data not shown).

Table 20. Postharvest loss of fruits and vegetable at reaching to the wholesale market

Postharvest loss (%)	Traders	
	No. of respondent (n=271)	% of responses
Up to 5	167	61.62
6-10	71	26.2
11-15	17	6.27
16-20	10	3.69
≤ 20	6	2.21
Mean Score		6.7

The postharvest losses fruits and vegetables largely dependent on various factors such as distance of the wholesale market, type packaging container and packaging volume, mode of transportation used and handling operations. In this study, 52-57% traders told that rough handling and overloading were the major causes of postharvest loss (Table 21). On the other hand, about 47% of the respondent opined that inappropriate bulk packaging was the main reason for huge postharvest loss during transportation of fruits and vegetables to the wholesale market.

Table 21. Factors contributing to postharvest losses of fresh produces during transportation to the wholesale markets

Factors of postharvest losses	Traders	
	No. of respondent (n=295)	% of responses
Inappropriate bulk packaging	139	47.12
Overloading	154	52.20
Rough handling during loading and unloading	168	56.95
Insect and disease problem	24	8.14
Others	2	0.68

3.4. Perception of farmers and traders on improved postharvest management practices of fruits and vegetables for quality and safety assurance

Quality is the degree of excellence or superiority, which is a combination of attributes, properties, or characteristics that give each commodity value, in terms of its intended use. The quality and safety of horticultural produces reaching to the consumer depend upon pre-harvest factors as well as proper postharvest management practices throughout the value chain, from the field to the consumer. Each actor along the value chain who involved in harvesting, handling and marketing of fresh produce has a role to play in assuring the food safety and quality of fresh produce. In this regard, the growers and traders in the study areas were asked about the significance of improved postharvest management practices like sorting, grading, washing and ripening of fruits and vegetables for maintaining produces' quality and safety for the consumers.

3.4.1. Sorting and grading of fruits and vegetables: Sorting and grading are very important postharvest operations before marketing or storing of fresh fruits and vegetables. Sorting is done by hand to remove the fruits and vegetables, which are unsuitable to market or storage due to damage by mechanical injuries, insects, diseases, immature, over-mature, misshapen etc. This is usually carried out manually and done before washing. On the hand, classifying of fruit and vegetables into different groups by separating from a fruit lot is called grading. Grading depends on shape, size, colour, maturity and external appearance of the products. In this study, more than 91% farmers and 78.3% traders usually sorted their produces before marketing (Table 22). Among the respondents, the maximum number (36.5%) of farmers mentioned that about 6-10% of the harvested produce

were sorted out due to different kinds of damages like mechanical injuries, insect-pest and diseases infection, immature or over maturity etc. At trader's level, it was about 5% as mentioned by 50.6% traders (Table 22). However, the average amount of sorted fruits and vegetables was 8.55% as mentioned by most of the farmers and traders.

Table 22. Sorting of fruits and vegetables by growers and traders before marketing

Particulars	Farmers		Traders		Total	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses	No. of respondent (n=810)	% of responses
A. Do you sort out rotten, insect-infested and diseased ones from the produces lot?						
Positive response	473	91.84	231	78.31	704	86.91
Negative response	42	8.16	64	21.69	106	13.09
B. How much of the fruits or vegetables sorted out?						
Up to 5%	277	58.5	181	78.35	458	65.05
6% - 10%	171	36.1	43	18.61	214	30.4
11% - 15%	20	4.2	7	3.0	27	3.83
16% -20%	5	1.0	0	0	5	0.71
20% +	0	0	0	0	0	0

In case of grading, most of the farmers (74.7%) and traders (76.9%) told that they marketed their produces without graded them into different groups (Table 23). Nevertheless, among the respondents under this study, only 25.2% farmers and 23% traders graded their produces most of whom (91.9 and 95.6%, respectively) practiced it mainly based on the shape and size of fruits and vegetables. However, about 17.1% farmers and 13.7% traders graded the produces based on the maturity stages of the crops (Table 23).

Table 23. Grading of fruits and vegetables by growers and traders before marketing

Grading criteria	Farmers		Traders		Total	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses	No. of respondent (n=810)	% of responses
A. Do you perform grading of fruits and vegetables?						
Positive response	385	74.76	227	76.95	612	75.56
Negative response	130	25.24	68	23.05	198	24.44
B. What is the basis of grading?						
Size and shape	354	91.95	217	95.59	571	93.30
Maturity stages	66	17.14	31	13.66	97	15.85
External Colour	39	10.13	16	7.05	55	8.99
Others	3	0.78	0	0	3	0.49

3.4.2. Perception of farmers and traders on washing of fruits and vegetables before marketing: Washing of fresh fruits and vegetables is very much important to remove external soil, debris, and microbes including *E. coli* and *Salmonella* from the surface of the produces. Thus, it is always advisable to wash most of the fruits and vegetables before marketing them to ensure clean and safe products for the consumers. Among the respondents under this study, about 80% farmers and 61% traders stated that they marketed their produces without washing or cleaning with water or other means (Table 24). Only 20.3% farmers and about 38.9% traders practiced to wash fresh produces before packaging and subsequent marketing. Among the positively stated respondents, the maximum number of farmers (48.5%) and traders (85.2%) mentioned that they usually used water from tube-well or tap for washing the produces. However, 32.3% farmers and 8.7% traders used water from ditches or canal for washing purposes (Table 24).

Table 24: Washing of fruit and vegetable before packing and sources of water

Water sources	Farmers		Traders		Total	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses	No. of respondent (n=810)	% of responses
A. Do you wash fruits and vegetables before packing?						
Positive response	105	20.3	115	38.98	220	27.17
Negative response	410	79.6	180	61.02	590	72.83
B. What source of water do you use to wash them?						
Canal or ditch water	34	32.3	10	8.72	44	20.0
Tube-well/tap water	51	48.5	98	85.2	149	67.2
River water	20	19.0	7	6.67	27	12.2

It is very much important to know that open sources of water like rive, canal, pond, ditch are not safe for washing fruits and vegetables because of high probability to contaminate the produces by hazardous microorganisms like *E. coli* and *Salmonella*. Therefore, it is advisable to use clean potable water for washing fresh fruits and vegetables before marketing and also before eating or cooking.

3.4.3. Perception of farmers and traders on artificial ripening of banana and tomato: Uniformity in external colour, taste, and flavour is very important to assure of fruits and vegetables' quality. Therefore, the use of ripening chemicals is required for quick, uniform and bulk ripening of some fruits and vegetables like banana and tomato during marketing for commercial purposes. A number of chemicals including ethyphon, calcium carbide etc. are available in the market, which are using by different stakeholder in the value chains for enhancing the ripening process of fruits and vegetables in particularly banana, mango and tomato. So, the farmers and traders under this study were asked about the use ripening agents for artificial ripening of fruits and vegetables. Most of the respondent farmers (92.8%) and traders (96.2%) strongly argued that they did not use any chemicals for force ripening of fruits and vegetables (Table 25). Nonetheless, on an average 5.9% farmers and traders used some chemicals for uniform ripening of banana and tomatoes for better marketing of these produces. Among them, most of the farmers and traders (59.4% and 81.8%, respectively) mentioned that they sprayed ethyphon solution over the produces for ripening purpose. Other farmers and traders used ethyphon dip, heat & smoke treatment and calcium carbide for ripening purpose (Table 25).

Table 25: Perception of farmers and traders on artificial ripening of banana and tomato

Name of ripening chemicals	Farmers		Traders		Total	
	No. of respondent (n=515)	% of responses	No. of respondent (n=295)	% of responses	No. of respondent (n=810)	% of responses
A. Do you use any chemical for artificial ripening of tomato & banana?						
Positive response	37	7.18	11	3.73	48	5.93
Negative response	478	92.82	284	96.27	762	94.07
B. What chemical and how do you use?						
Ethepron solution dip	10	27.03	1	9.09	11	22.92
Ethepron solution spray	22	59.46	9	81.82	31	64.58
Smoke & heat	5	5.41	1	9.09	3	6.25
Calcium carbide	3	8.11	0	0	3	6.25

4. Conclusion and Recommendations

4.1 Conclusion

Assuring quality and safe fruits and vegetables for the consumers is pivotal nowadays. Due to perishable in nature, fruits and vegetables have more risks from harmful microbial contamination if not handled with extra care. Findings of this study revealed that most of the farmers expressed positive attitudes towards safe crop production following GAP, maturity indices, harvesting and

improved postharvest management practices for assuring quality and safety of fruits and vegetables. However, many of them did not practice these improved postharvest management techniques due to faulty marketing system prevailed in the country. Although most of the farmers and traders sorted out the produces before marketing, few of the respondents graded the produces. Similarly, most of the respondent farmers and traders did not wash the produce before marketing. Only 27% respondents washed the produces; however, many of them used unsafe water found from the canal, river or ditches. On an average, more than 56% farmers and traders used jute or nylon sacks as packaging material for fruits and vegetables, whereas 21.7% used plastic crates. Most growers and traders did not use ripening agent for force ripening of fruits; however, about 6% of farmers and traders sprayed ethephon solution for uniform and quick ripening of banana and tomato for early market and good price.

The average postharvest losses were 13.2% and 11.0% at grower and traders' level up to wholesale market, respectively. Major marketing problems in the value chains were lower price of fruits and vegetables at farm level, lack of facilities at LAM for applying improved PHM practices, unavailability and higher price of plastic crates, delayed sale and lack of buyers. However, to meet the challenges on global quality and safety requirements, necessary steps should be taken throughout the value chain from 'farm to plate' for maintaining quality and safety of fruits and vegetables in order to stay healthy, and to be competitive both in the domestic and export markets.

4.2. Recommendations

Based on the findings of the study, a number of measures are needed to reduce postharvest losses, and supply safe and quality produces for the consumers.

- Emphasis must be given in producing good-quality fruits & vegetables following improved techniques based on the code of GAP
- Pre-harvest interval should strictly be followed during pesticide application, and harvesting should be done at proper maturity stages of the crop
- Green belt should be identified across the country for production of quality and safe fruits & vegetable
- Instead of bulk packaging in nylon net or jute sack, the use of Plastic Crates should be encouraged for packaging of most of the fruits & vegetables during transportation & marketing, which can reduce PH loss by 18-20%
- Continuous research is essential to mitigate diverse problems prevailing in the fresh produce's value chains in Bangladesh. Therefore, BARI and agricultural universities should strengthen their existing capacity in terms of postharvest research needs to be taken into consideration.
- Well facilitated packhouse or CCMC must be established in all production hub across the country for application of improved PHT
- Capacity building of actual value chain actors including fruit & vegetable traders, packers, handlers, truck driver, wholesalers and retailers on "Improved Postharvest Management and Food Safety" should be undertaken
- Part of the Agricultural Incentive provided by the government should be shared in the postharvest sector particularly in packaging and transportation of fresh produces
- National food control and regulatory systems should be strengthened in harmonization with Codex, HACCP & Food Hygiene standards to ensure quality and safe products for both domestic and overseas consumers
- Pesticide residue analysis laboratory should be established in major production areas as well as city wholesale markets to meet requirements of international standards
- Provision for grant of Certification System for "Quality Produce" is to be developed through the institutional arrangement.

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References

Callejon, R. M., Rodriguez-Naranjo, M. I., Ubeda, C., Hornedo-Ortega, R., Garcia-Parrilla, M. C., Troncoso, A. M. 2015. Reported foodborne outbreaks due to fresh produce in the United States and European Union: trends and causes. *Foodborne Pathogens and Disease*, 12: 32–38.

Matin, M. A., M. A. Baset, Q.M. Alam, M. R. Karim and M. R. Hasan. 2008. Mango marketing system in selected areas of Bangladesh, *Bangladesh Journal of Agricultural Research*, 33(3): 427-438.

Nuesch-Inderbinen, M., Stephan, R. 2016. Fresh fruit and vegetables as vehicles of bacterial foodborne disease: A review and analysis of outbreaks registered by proMED-mail associated with fresh produce. *Journal of Food Safety and Food Quality-Archiv Fur Lebensmittelhygiene*, 67: 32–39.

WHO. 2019. Increasing fruit and vegetable consumption to reduce the risk of non-communicable diseases. http://www.who.int/elena/titles/fruit_vegetables_ncds/en/

Traditional Postharvest Management Practices Affecting the Quality, Food Safety and Postharvest Loss of Fruits and Vegetables in Bangladesh

Md. Atiqur Rahman, *Ph.D.*
 PHM Expert, NATP-2
 Hortex Foundation, Dhaka

Abstract

A study was carried out during May to December 2019 to determine the effect of traditional postharvest management practices on decline the quality, food safety and postharvest losses of fresh fruits and vegetables in Bangladesh. Four selected commercially grown horticultural crops namely, tomato, brinjal, bitter gourd and banana were used in this study, which were marketed from Jashore, Narsingdi, Cumilla, Tangail, Jamalpur, Gazipur and Bogura districts following traditional postharvest management practices in the existing value chain. The data were taken at the wholesale level only. The recovery of good quality produces ranged from 41 to 55%, and slide mechanically damaged produces was 36.4%. The postharvest losses were 16.4, 13.5, 11.7 and 9.8% for tomato, brinjal, bitter gourd and banana, respectively. The higher postharvest loss and quality deterioration of horticultural crops mainly occurred due to inappropriate bulk packaging, overloading and rough handling. Firmness and other nutritional quality of the selected crops varied significantly due to agro-ecological zones, crop varieties and distances of the wholesale market from the production areas. However, among the selected fruits and vegetables, bitter gourd was found the richest sources of vitamin-C ($102.9 \text{ mg g}^{-100\text{g}}$) and β -carotene ($53.66 \mu\text{g g}^{-1}$). All of the crops except brinjal under this study were severely contaminated with *Salmonella* and *Escherichia coli* ($>10^3 \text{ CFU/g}$), which belonged to unsatisfactory level of hygiene indicator. Nonetheless, the presence of *Salmonella* and *E. coli* was far below the critical level (TFTC, $<20 \text{ CFU/g}$) in brinjal indicating safe for consumption.

Keywords: Traditional value chain, postharvest loss, food safety, nutritional quality, fruits and vegetables, Bangladesh.

1. Introduction

Postharvest handling consists of harvesting, sorting, grading, cleaning, packaging, storage, transportation and distribution of the fresh produce. The important objectives of postharvest handling are keeping the product fresh, reduce moisture loss, avoiding physical damage such as cracking and bruising and slow down undesirable chemical changes. In Bangladesh, generally, farmers and traders do not carry out the improved postharvest management practices (IPMP) including sorting, grading and washing before marketing of fresh fruits and vegetables (i.e. banana, tomato, brinjal, bitter gourd and pumpkin) in the existing value chains. At local assembling market, the traders purchase the produces from farmers, and directly pack into jute sacks having 100 to 800 kg capacity for sending them to the distant wholesale markets. These heavy packages are roughly handled during loading, unloading and subsequent handling, which resulted bruising, cracking and compression damage of the produces. The postharvest losses of fresh fruits and vegetables in Bangladesh was estimated as 22-42 % depending on the nature of the crop (Hasan *et al.*, 2010; Sirivatanapa, 2006). Moreover, the produces become more susceptible to microorganisms due to getting mechanical damage during transportation and marketing causing decay and suffer from nutritional loss at the retail outlets. At the end, the consumers get poor quality and unsafe fruits and vegetables from the retailers.

Fresh fruits and vegetables remain the leading cause of foodborne illness outbreaks implicating virulent pathogens such as Shiga Toxin producing *Escherichia coli*, *Salmonella* etc. (Callejon *et al.*, 2015). The current global philosophy related to ensuring the food safety of fresh produce is to prevent contamination in the field and to minimize cross-contamination during postharvest handling. In Bangladesh, the value chains of fresh produces are open in nature meaning that contamination can be introduced at various points in production, harvesting and processing, and then passed to the consumer (Nuesch-Inderbinen and Stephan, 2016). Generally, fresh fruits and vegetables are not

properly cleaning or washing in our country before them marketing. On the other hand, it became evident that postharvest washing under commercial conditions has limited decontamination efficacy and, if anything, can potentially lead to cross-contamination events (Barrera *et al.*, 2012; Gombas *et al.*, 2017). Therefore, interventions of more effective means of control are needed to apply for postharvest decontamination that can replace or supplement postharvest washing (Meireles *et al.*, 2016).

The present study was undertaken to determine the effect of traditional postharvest management practices on quantitative and qualitative losses, food safety measures of selected fruits and vegetables in the existing value chain of Bangladesh. The findings of this study will provide valuable information on the impact of postharvest management of fresh produces, which will serve as the basis in the formulation of interventions in the value chain towards quality and food safety maintenance and loss reduction.

2. Materials and Methods

2.1. Materials and procedures of the study

The study was carried out with four crops including banana, brinjal, tomato and bitter gourd. The produces were collected directly from the Kawranbazar wholesale market, which had come from different parts of the country namely Jashore, Narsingdi, Cumilla, Tangail, Jamalpur, Gazipur and Bogura districts following traditional postharvest management (TPM) and handling practices by the traders in a simulated marketing chain. In the TPM, sorting, grading and washing were not done. Both the brinjal and bitter gourd were directly packed into jute sacks of 100-150 kg capacity, and sealed with nylon string. However, tomatoes were packed in 20 kg capacity stackable plastic creates during transportation to the wholesale markets. Banana on the other hand, transported to the market in unpackaged condition using open truck. The produces loaded in truck together with other vegetables and started to transport in the evening (4:00 to 6:00 pm) of a day and reached to the Kawranbazar wholesale market, Dhaka about 4:00 p.m. of the following day.

Ten kilograms of each selected vegetables came from each district was purchased from the Kawranbazar wholesale market. Therefore, a total of 50 kg brinjal, 40 kg tomato and 40 kg bitter gourd were purchased for this study. In case of banana, a total of 12 bunches were purchased having three from each district. After purchasing from the wholesale market, the fruits and vegetables were brought to the postharvest laboratory of BARI, Gazipur using a pick up van. The produces were then assessed by separating of good quality (sound) fruit, mechanically-damaged (abrasion, bruising etc.) fruit and unmarketable fruit from each container of each produce. After physical evaluation, five fruit samples replicated three were randomly taken from each of the selected crops for nutrition analysis. Standard procedures and methods were used to determine the content of ascorbic acid, total acid, β -carotene etc.

2.2. Microbial counts: A total of 12 fresh samples of bitter gourd, banana and tomato (four of each) were collected from Kawranbazar wholesale market, Dhaka, which were supplied from different districts namely Tangail, Norshingdi, Jashore, Bogura, Cumilla, Jamalpur, Gazipur and Dinajpur through traditional value chain during 12-16 May, 2019 (Table 1). On the other hand, four brinjal samples were collected on 23 December 2019. The samples were transported to the laboratory of the Department of Plant Pathology, Bangladesh Agricultural Research Institute (BARI) and culturing was initiated within one day of collection. For the isolation of *Salmonella* species, approximately 10gm fresh samples of individual were placed in 50 mL Buffered Peptone Water (BPW) (HIMedia lab, Mumbai, India) at 37 °C for 18hrs. BPW is a pre-enrichment medium for increasing the recovery of injured *Salmonella* species from foods prior to selective media for isolation. After the incubation of the samples, 100 μ L suspension of each samples were plated in Bismuth Sulphite Agar (BSA) medium with 10-fold dilution (10^{-8}) and were incubated at 37 °C for 24hrs. After the incubation of the sample, typical black colonies (30-300) of *Salmonella* spp. were grown in the medium. For the isolation of *Escherichia coli*, 10g fresh ground samples of individual were also placed in 50 mL sterilized distilled water. after 10 min of incubation, 100 μ L suspension were plated in CT-

MacConKey medium with 10-fold dilution (10^{-8}) at 37 °C for 24 h. Violet and Pink typical colonies (30-300) were observed in the medium. In addition, for the counting of total colony forming unit (CFU)/g, after making suspensions of bacteria (10g samples/50 mL sterilized distilled water), 100 μ L suspensions were plated in Luria-Bertani agar (LBA) medium with 10-fold dilution (10^{-8}) at 28°C for 24h. Different colored bacteria (presumably different genera) were grown in the medium.

2.3. Data recording: Data were collected on mechanical damage and decay caused by pathogens. All purchased fruits and vegetables were evaluated individually as to the severity of mechanical damage as follows: 1-sound (no damage), 2-slight, 3-moderate, and 4-severe. Fruits with evident compression damage in the form of bruising or abrasion were classified as moderately damaged, which considered as marketable with lower price, and those with cracks as severely damaged were considered unmarketable. The collected data were analyzed to calculate the loss up to wholesale market in the existing value chain.

For the counting of colony forming unit (CFU/g) of *Salmonella* and *E. coli*, the following formula was used:

$$\text{CFU/g} = \text{no. colonies} \times \text{dilution factor} / \text{volume of plated bacteria}$$

2.4. Experimental design and statistical analysis: The study on physic-chemical traits and postharvest losses of fruits and vegetables was carried out in a randomized complete design (RCD) with three replications. Whereas, the experiment on microbial count was done following Completely Randomized Design (CRD) with five replications. The collected data were subjected to analysis of variance (ANOVA) using 'R' Statistical Software version 3.1.2. The results showing significant differences were then subjected to mean separation using LSD test at $P < 0.05$.

3. Results and Discussion

3.1. Recovery of good quality and mechanically damaged produces at wholesale level

Tomato: Table 1 shows the recovery of sound (no damage) and mechanically damaged tomato upon arrival to the wholesale market. Tomatoes marketed from Jashore had the highest (60.12%) recovery of good quality fruits followed by the fruits from Dinajpur having the recovery of 41.6% (Table 1). The average recovery of good quality tomato found 41.16% up to wholesale level. The presence of mechanically damaged fruits in the form of compression and bruising found higher in tomatoes, which had travelled from Cumilla and Jamalpur districts showing the values of 51.8 and 49.0%, respectively. On the other hand, the tomatoes marketed from Jashore had significantly ($P \leq 0.05$) the lowest amount (27.2%) of fruits showing compression or abrasion damage at wholesale level. Similarly, the highest postharvest loss of 18.13% was recorded in tomatoes marketed from Jamalpur, which was statistically similar with the tomatoes travelled from Dinajpur (17.54%) and Cumilla (17.25%) districts. However, the lowest postharvest loss of 12.6% was recorded in tomatoes travelled from Jashore. The average postharvest loss of tomato was recorded 16.4% up to wholesale market in the existing value chain.

Table 1. Effect of postharvest handling on physical damage and postharvest losses of tomato in the existing value chain

Location	Good quality fruit (%)	Abrasion & compression damage (%)	Postharvest Loss (%)
Jamalpur	31.94c	49.0a	18.13a
Cumilla	30.95c	51.8a	17.25a
Dinajpur	41.66b	40.8a	17.54a
Jashore	60.12a	27.2b	12.61b
Average	41.16	42.2	16.4
Level of significance (%)	0.05	0.05	0.05

Values in each column followed by the same letter (s) are not significantly different

Brinjal: Table 2 shows the recovery of sound (no damage) and mechanically damaged brinjal upon arrival to the wholesale market. Eggplants marketed from Gazipur district had significantly ($P \leq 0.05$) the highest recovery of sound fruits (60%), which was followed by brinjals marketed from Cumilla and Norsingdi districts showed the recovery of good quality fruits 42.3 and 43.3%, respectively. On the other hand, the lowest recovery of good quality fruit was recorded 30.23% in brinjal marketed from Rangpur.

Table 2. Effect of postharvest handling on physical damage and postharvest losses of brinjal (eggplant) in the existing value chain

Location	Good quality fruit (%)	Abrasion & compression damage (%)	Postharvest Loss (%)
Rangpur	30.23d	48.0a	21.8b
Cumilla	42.34b	39.5b	18.1c
Norsindi	43.30b	48.6a	8.10d
Jashore	36.60c	40.2b	23.2a
Gazipur	60.00a	34.4c	6.00d
Average	41	42.1	13.5
Level of significance (%)	0.05	0.05	0.05

Values in each column followed by the same letter (s) are not significantly different

At wholesale level, the highest incidence of mechanical damage in the form of abrasion, bruising and compression was found 48.6 and 48.0% in brinjals marketed from Norsingdi and Rangpur district, respectively. It was lowest (34.4%) in brinjal travelled from Gazipur district. The highest postharvest loss of 23.2% in brinjal was recorded when they were marketed from the Jashore district, which was followed by Rangpur brinjals. The lowest postharvest loss of 6.0% was recorded in brinjals marketed from Gazipur district (Table 2). Results of this study revealed that the longer the distance of the destination market the higher the postharvest losses of brinjal.

Bitter gourd (BG): Table 3 shows the recovery of sound (no damage) and mechanically damaged BG upon arrival to the wholesale market. Results of this study showed that the highest percentage (58.2%) of good quality fruit was recorded found in BG marketed from Tangail, which was statistically similar with BG marketed from Norsingdi and Jamalpur districts.

Table 3. Effect of postharvest handling on physical damage and postharvest losses of bitter gourd in the existing value chain

Location	Good quality fruit (%)	Yellowing (%)	Abrasion & compression damage (%)	Postharvest Loss (%)
Jashore	50.38b	11.17d	26.14a	12.31a
Norsingdi	56.57ab	17.42b	15.51b	10.52b
Tangail	58.24a	19.65a	10.44c	11.67b
Jamalpur	55.45ab	15.56c	16.50b	12.50a
Average	55.1	15.9	17.1	11.75
Level of significance (%)	0.05	0.05	0.05	0.05

Values in each column followed by the same letter (s) are not significantly different

Conversely, BG marketed from Jashore showed the highest mechanically damaged fruits of 26.1% in the form of compression, abrasion and bruising effect, which was considered marketable but with lower price. Besides the mechanical damaged fruit, the skin colour of a significant portion of BG changed from green to yellowish showing the highest value of 19.6% in BG travelled from Tangail. The postharvest losses found highest of 12.5% in BG, which travelled from Jamalpur district followed by Jashore district (12.3%). However, significantly lower postharvest losses were recorded in BG marketed from Norsingdi and Tangail districts.

Banana: Table 4 shows the recovery of good quality and mechanically damaged banana finger upon arrival to the Tejgaon wholesale market, Dhaka. Bananas marketed from Gazipur district showed

Table 4. Effect of postharvest handling on physical damage and postharvest losses of banana in the existing value chain

Location	Good quality finger (%)	Black spotted finger (%)	Postharvest Loss (%) (cracked and stem broken)
Madhupur	45.00c	45.81b	9.26b
Narsingdi	52.50b	38.51c	9.00b
Bogura	27.62d	60.88a	11.5a
Gazipur	59.61a	30.56d	9.75b
Average	46.17	44.0	9.87
Level of significance (%)	0.05	0.05	0.05

Values in each column followed by the same letter (s) are not significantly different

significantly ($P \leq 0.05$) highest recovery of 59.6% of spotless good quality fingers, which followed by bananas marketed from Narsingdi district showing 52.5% recovery of good quality fingers. On the other hand, the lowest recovery of 27.6% of good quality fruit was found in bananas marketed from Bogura. At wholesale level, the highest number (60.8%) of black spotted fingers was recorded in banana marketed from Bogura, which was caused due to rough handling, overloading and transportation in unpackaged condition into open truck. It was lowest (30.5%) in banana fingers, which was marketed from Gazipur district. Similarly, the highest postharvest loss of 11.5% was recorded in banana marketed from Bogura district, and the lowest postharvest loss of 9.0% was found in bananas from Narsingdi district. The average postharvest loss of banana was recorded 9.87% at wholesale level, which marketed from selected four districts. Results of this study revealed that rough handling during loading and unloading, overloading and transportation of whole bunches in unpackaged condition were the major causes of higher postharvest loss and quality deterioration of bananas during marketing.

3.2. Effect of traditional postharvest handling practices on fruit firmness and nutritional quality of fresh produces

Tomato: Firmness is an important quality trait that determines the freshness and shelf life of fresh fruits and vegetables. At wholesale level, the average firmness of tomatoes marketed from Jamalpur, Cumilla, Dinajpur and Jashore districts was recorded by 6.9 Newton showing the higher firmness of 7.15N in tomato of Jamalpur (Table 5). The highest content of vit-C ($17.1 \text{ mg g}^{-100\text{g}}$) was found in tomatoes marketed from Dinajpur district, which was followed by 15.03 and $14.5 \text{ mg g}^{-100\text{g}}$ found in tomatoes travelled from Jamalpur and Jashore districts, respectively. The average acid in tomato was found 0.35%, which was more or less similar in all tomatoes marketed from selected districts. The highest content of β -carotene of $21.87 \mu\text{g g}^{-1}$ was recorded in tomato found from Cumilla district, which was followed by $20.32 \mu\text{g g}^{-1}$ in tomatoes from Jamalpur. However, the average content of β -carotene was recorded $20.3 \mu\text{g g}^{-1}$.

Table 5. Effect of postharvest handling on firmness and nutritional quality of tomato in the existing value chain

Location	Fruit firmness (Newton)	Nutritional quality		
		Vit-C ($\text{mg g}^{-100\text{g}}$)	Total acid (%)	β -carotene ($\mu\text{g g}^{-1}$)
Jamalpur	7.15	15.03b	0.41a	20.32b
Cumilla	7.06	12.91c	0.32b	21.87a
Dinajpur	6.7	17.11a	0.32b	19.18c
Jashore	6.8	14.52b	0.35b	19.85c
Average	6.9	14.9	0.35	20.3
Level of significance (%)	NS	0.05	0.05	0.05

Values in each column followed by the same letter (s) are not significantly different

Brinjal: Table 6 shows the firmness and quality parameters of brinjals marketed from Rangpur, Cumilla, Norsingdi, Jashore and Gazipur districts. At wholesale level, the firmness of brinjal ranged from 11.3 to 15.1 N showing highest firmness in brinjal marketed from Rangpur. However, the average firmness of 12.7 N was recorded in brinjals marketed from Rangpur, Cumilla, Norsingdi, Jashore and Gazipur districts. The highest vit-C content of $8.23 \text{ mg g}^{-100\text{g}}$ was found in brinjal marketed from Gazipur district, which was followed by 7.05 and $7.05 \text{ mg g}^{-100\text{g}}$ found in brinjals travelled from Cumilla and Jashore districts, respectively.

Table 5. Effect of postharvest handling on firmness and nutritional quality of brinjal (eggplant) in the existing value chain

Location	Fruit firmness (Newton)	Nutritional quality		
		Vit-C ($\text{mg g}^{-100\text{g}}$)	Total acid (%)	β -carotene ($\mu\text{g g}^{-1}$)
Rangpur	15.1a	5.88c	0.20a	26.0c
Cumilla	12.0c	7.05b	0.13b	28.6b
Norsindi	13.3b	6.00c	0.20a	24.0c
Jashore	12.1c	7.06b	0.14b	32.0a
Gazipur	11.3d	8.23a	0.15b	31.2a
Average	12.7	6.84	0.16	28.3
Level of significance (%)	0.05	0.05	0.05	0.05

Values in each column followed by the same letter (s) are not significantly different

The average titratable acidity (TA) in brinjal was found 0.16%, which was more or less similar in all brinjals marketed from selected districts. The highest content of β -carotene of $32.0 \mu\text{g g}^{-1}$ was recorded in brinjal marketed from Jashore district, which was followed by $31.2 \mu\text{g g}^{-1}$ in brinjal from Gazipur. However, the average content of β -carotene of brinjal was recorded $28.3 \mu\text{g g}^{-1}$.

Bitter gourd: Firmness of bitter gourd marketed from Jashore, Norsinngdi, Tangail and Jamalpur districts found slide variation, which ranged from 13.0 to 15.7 N showing the highest firmness in BG came from Norsingdi district (Table 6).

Table 6. Effect of postharvest handling on firmness and nutritional quality of bitter gourd in the existing value chain

Location	Fruit firmness (Newton)	Nutritional quality		
		Vit-C ($\text{mg g}^{-100\text{g}}$)	Total acid (%)	β -carotene ($\mu\text{g g}^{-1}$)
Jashore	14.7b	99.56b	0.23	58.41a
Norsingdi	15.7a	106.2a	0.23	55.05b
Tangail	13.4c	100.6b	0.21	48.62b
Jamalpur	13.0c	105.2a	0.22	52.56c
Average	14.2	102.9	0.22	53.66
Level of significance (%)	0.05	0.05	NS	0.05

Values in each column followed by the same letter (s) are not significantly different

The average firmness of BG was recorded by 14.2 N. The highest content of vit-C ($106.2 \text{ mg g}^{-100\text{g}}$) was recorded in BG marketed from Tangail district, which was statistically similar with BG marketed from Jamalpur district found the content of $105.2 \text{ mg g}^{-100\text{g}}$. The average contents of TA in BG was recorded by 22.2% and there was no statistical differences in the content of TA in BG marketed from different selected districts. The contents of β -carotene in BG marketed from four selected districts showed significant differences (Table 6). The highest content of β -carotene of $58.41 \mu\text{g g}^{-1}$ was recorded in BG marketed from Jashore district, which was followed by $55.05 \mu\text{g g}^{-1}$ in BG from Norsingdi district. However, the average content of β -carotene was recorded $52.66 \mu\text{g g}^{-1}$.

Banana: Table 8 shows the firmness and quality parameters of banana marketed from Madhupur, Norsingdi, Bogura and Gazipur districts. At wholesale level, the firmness of banana ranged from 19.0

to 24.5 N showing highest firmness in produces marketed from Madhupur. However, the average firmness of banana marketed from four selected districts was recorded by 21.0 N (Table 8). The highest content of vit-C of $11.23 \text{ mg g}^{-100\text{g}}$ was found in unripe fresh banana marketed from Madhupur, which was followed by 10.5 and $10.2 \text{ mg g}^{-100\text{g}}$ found in bananas marketed from Norsingdi and Gazipur districts, respectively. No statistical differences were observed in TA contents of bananas from selected districts. The average titratable acidity (TA) in was found 0.56%. Among the four crops used in this study, banana showed the lowest contents of β -carotene, which ranged from 5.0 to $5.8 \mu\text{g g}^{-1}$. The average content of β -carotene of banana was recorded by $5.58 \mu\text{g g}^{-1}$.

Table 8. Effect of postharvest handling on firmness and nutritional quality of banana in the existing value chain

Location	Fruit firmness (Newton)	Nutritional quality		
		Vit-C ($\text{mg g}^{-100\text{g}}$)	Total acid (%)	β -carotene ($\mu\text{g g}^{-1}$)
Madhupur	24.5a	11.2a	0.58	5.80a
Norsingdi	21.3b	10.5b	0.61	5.00b
Bogura	19.0c	9.51c	0.55	6.00a
Gazipur	19.6c	10.2bc	0.51	5.54ab
Average	21.0	10.3	0.56	5.58
Level of significance (%)	0.05	0.05	NS	0.05

Values in each column followed by the same letter (s) are not significantly different

3.3. Effect of traditional postharvest handling practices on the presence of *Salmonella* and *E. coli* on the fresh produce's surfaces

In this study, all the fresh crop samples except brinjal were detected with the presence of *Salmonella* spp. and *Escherichia coli* (Table 9).

Table 9. Identification and quantification of *Salmonella* and *Escherichia. coli* in some fresh produces marketed through traditional postharvest management practices

Crop	Location	Total CFU/g	<i>Salmonella</i> sp.	<i>E. coli</i>
Bitter gourd	Tangail	$>10^8$	56×10^6	3×10^7
Bitter gourd	Norshingdi	$>10^8$	10^7	10^8
Bitter gourd	Jashore	$>10^8$	6×10^7	10×10^5
Bitter gourd	Jamalpur	$>10^8$	6×10^3	10×10^2
Banana	Madhupur	$>10^8$	10^8	10^8
Banana	Bogra	$>10^8$	2×10^8	10^8
Banana	Norshingdi	$>10^8$	8×10^7	2×10^8
Banana	Gazipur	$>10^8$	8×10^2	2×10^3
Tomato	Cumilla	$>10^8$	4×10^4	10^7
Tomato	Jashore	$>10^8$	4×10^1	10^3
Tomato	Jamalpur	$>10^8$	3×10^7	7×10^4
Tomato	Dinajpur	$>10^8$	31×10^4	10^8
Brinjal	Savar	TFTC	TFTC	0
Brinjal	Norshingdi	TFTC	TFTC	0
Brinjal	Rangpur	TFTC	0	0
Brinjal	Cumilla	36	0	TFTC

The samples of bitter gourd, banana and tomato from all the seven districts, were severely contaminated with *Salmonella* and *Escherichia. coli* ($>10^3 \text{ CFU/g}$), which is belong to unsatisfactory level of hygiene indicator (Table 10). The presence of such amount of inoculum in the fresh vegetables may cause serious diseases of human such as diarrhea and vomiting. It is necessary to immediate investigation of the causes of food contamination in the market through investigating the food origin, production process, marketing and also consider environmental monitoring.

On the other hand, in case of brinjal, *Salmonella* spp. was present in the samples collected from Norshingdi and Savar, Dhaka districts. However, the colony number were too few to count (TFTC, <10 CFU/g) (Table 1). *Escherichia coli* colony was absent in all the fresh samples except the samples collected from Cumilla (TFTC, <20 CFU/g) district. The presence of lower number (safe level) of *Salmonella* and *E. coli* in brinjal samples might be due to the seasonal advantage of growing and harvesting the crop. The optimum temperature range for better growth and spread of *Salmonella* and *E. coli* is 35-37°C. Nevertheless, the average temperature of the last week of December 2019 prevailed 15°C in Bangladesh, which might be the main reason for getting lower number of those pathogens in the brinjal samples. Moreover, there was no rainfall during the growing and harvesting time of brinjal in the month of December, which also prevented the spreading of the pathogens. The presence of lower number of CFU in brinjal samples indicated that such small amount of *Escherichia coli* inoculum in the fresh brinjal may not cause diseases of human such as diarrhea and vomiting.

Table 10. Guidelines for the interpretation of results for hygiene indicator organism in ready-to-cut food in general

Hygiene indicator organism	Result (colony forming unit, CFU/g)		
	Satisfactory	Borderline	Unsatisfactory
<i>Salmonella</i> spp.	Not detected	Not applicable	Detected
<i>Escherichia coli</i>	<20	$20-100$	>100

Source: Microbiological Guideline for Food, August 2014 (Revised). Guidelines for Assessing the Microbiological Safety of Ready-to-Eat Foods Placed on the Market, November 2009, © Health Protection Agency.

4. Conclusion

Findings of the present study revealed that the main causes of lower recovery of good quality fruits ranging 41 to 55%, and higher postharvest loss amounting to 13% at wholesale level were due to inappropriate bulk packaging, overloading and rough handling, which resulted fruit cracking, abrasion and compression damages of the produces. A significant portion of the produces amounting to 36.4% had lost their quality due to partial mechanical damage, which were marketable but with lower price compared to good quality produces. Firmness and other nutritional quality of the selected crops varied significantly due to agro-ecological zones, crop varieties and distances of the wholesale market from the production areas. However, it is very clear from the study that the longer the distance of the wholesale market the higher the quality deterioration and postharvest losses of the fresh produces. The samples of bitter gourd, banana and tomato marketed from all of the seven districts severely contaminated with *Salmonella* and *Escherichia coli* ($>10^3$ CFU/g), which belonged to unsatisfactory level of hygiene indicator. Nonetheless, the presence of *Salmonella* and *E. coli* was few (TFTC, <20 CFU/g) in the brinjal samples indicating safe for consumption.

References

Barrera, M. J., Blenkinsop, R., Warriner, K. (2012). The effect of different processing parameters on the efficacy of commercial post-harvest washing of minimally processed spinach and shredded lettuce. *Food Control*, 25: 745-751.

Callejon, R. M., Rodriguez-Naranjo, M. I., Ubeda, C., Hornedo-Ortega, R., Garcia-Parrilla, M. C., Troncoso, A. M. (2015). Reported foodborne outbreaks due to fresh produce in the United States and European Union: trends and causes. *Foodborne Pathogens and Disease*, 12: 32-38.

Gombas, D., et al. (2017). Guidelines to validate control of cross-contamination during washing of fresh-cut leafy vegetables. *Journal of Food Protection*, 80: 312-330.

Hassan, M. K. (2010). Final report-postharvest loss assessment: a study to formulate policy for loss reduction of fruits and brinjal and socio-economic uplift of the stake holders (Funded by USAID and EC and Jointly Implemented by FAO and FPMU of MoFDM). p.189.

Meireles, A., Giaouris, E., Simoes, M. (2016). Alternative disinfection methods to chlorine for use in the fresh-cut industry. *Food Research International*, 82: 71–85.

Nuesch-Inderbinen, M., Stephan, R. (2016). Fresh fruit and vegetables as vehicles of bacterial foodborne disease: A review and analysis of outbreaks registered by proMED-mail associated with fresh produce. *Journal of Food Safety and Food Quality-Archiv Fur Lebensmittelhygiene*, 67: 32–39.

Sirivatanapa, S. 2006. Packaging and transportation of fruits and vegetables for better marketing: Postharvest Management of Fruits and Vegetables in Asia-Pacific Region. Food and Agricultural Organization and Asian Productivity Organization. pp. 43-48.