Estimation of Overall Food Losses and Waste at all Levels of the Food Chain

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Dr Md Kamrul Hassan
(The Principal Investigator of the Project)

Contents

Abbreviations and Acronyms

AAS	**A**tomic Absorption Spectrophotometer
AOAC	**A**ssociation of Official Analytical Chemist
BAU	**B**angladesh Agricultural University
BBS	**B**angladesh Bureau of Statistics
BARC	**B**angladesh Agricultural Research Council
BFSA	**B**angladesh Food Safety Authority
BSTI	**B**angladesh Standard and Testing Institution
CA	**C**ontrolled Atmosphere
CARS	**C**entre for Advanced Research in Sciences
CODEX	**C**odex Alimentarius Commission
CFB	**C**orrugated Fibreboard Boxes
DAE	**D**epartment of Agricultural Extension
DAM	**D**epartment of Agricultural Marketing
DM	**D**ry matter
DU	**D**haka University
EU	**E**uropean Union
FAO	**F**ood and Agriculture Organization of the United Nations
FBO	**F**ood Business Operator
FLW	**F**ood Loss and Waste
FLI	**F**ood Loss Index
FWI	Food Waste Index
FPMU	**F**ood Planning and Monitoring Unit
GAP	**G**ood Agricultural Practices
GMP	**G**ood Manufacturing Practices
GHP	**G**ood Hygiene Practices/Good Husbandry Practices
HIES	**H**ousehold Income and Expenditure Survey
HACCP	**H**azard Analysis and Critical Control Points
HPLC	**H**igh Performance Liquid Chromatography
HWT	**H**ot Water Treatment
IFPRI	**I**nternational Food Policy Research Institute
IIFS	**I**nterdisciplinary Institute of Food Security
HVCs	**H**igh Value Crops
MA	**M**odified Atmosphere
MAP	**M**odified Atmosphere Packaging
MoA	**M**inistry of Agriculture
MoF	**M**inistry of Food
MUCH	**M**eeting the Undernutrition Challenge
$NaHCO_3$	**B**aking Soda
MRL	**M**aximum Residue Limit
PHL	**P**ostharvest Loss
PHI	**P**re-harvest Interval
PHT	**P**ostharvest Technology
QA	**Q**uality Assurance
QC	**Q**uality Control
SDG	**S**ustainable Development Goals
SOFA	**S**tate of Food and Agriculture
USAID	**U**nited States Agency for International Development
WFP	**W**orld Food Programme
WHO	**W**orld Health Organization
WRAP	**W**aste & Resources Action Programme
3R	**R**educe, Reuse and Recycle Policy in Bangladesh

Estimation of Overall Food Losses and Waste at all Levels of the Food Chain

EXECUTIVE SUMMARY

Rationale

Recognising the significance of reducing food loss and waste (FLW), SDG target 12.3 calls for halving per capita FLW by 2030. Food shortage may have serious consequences on national, regional and global stability as experienced during the Covid 19 pandemic. A strategy to handle FLW is therefore needed. The causes of FLW are manifold. Food loss occurs throughout the value chain- from production, processing, distribution to retail and consumption. Global FLW amounts to roughly one-third of total production. FLW have negative impacts on agriculture, environment, human nutrition, food security and natural resources. Recent global average postharvest to distribution estimates of losses in terms of food groups are 8%, 12%, 22% and 25% for cereals and pulses, meat and animal products, fruits and vegetables, and roots and tubers, respectively (FAO 2019). While there is no precise and recent data on the magnitude of FLW in Bangladesh, FAO (2019) found an average estimate of FLW of 7.4% irrespective of food groups with a range 0.2-35.0% based on grey literature and national and sectoral reports published during 2000-2017. In addition to the above, some previous studies in Bangladesh shown that postharvest losses of fruits and vegetables, potatoes, and paddy were 24-44% (Hassan et al. 2010), 23-28% (Hossain and Mia 2009) and 11-12% (Bala et al. 2010), respectively. There is no data on postharvest losses for animal products in Bangladesh. Information on food waste in Bangladesh is also limited. The present study aims to fill these gaps by generating recent data on commodity-specific food losses across selected food chains and on the magnitude of food waste; identifying key factors influencing FLW; and giving recommendations to reduce FLW.

Methodology

Quantitative and micronutrient losses of 14 commonly-consumed food commodities selected from the FAO-recommended 5 food groups, namely cereals and pulses (paddy and wheat); fruits and vegetables (mango, banana, tomato and red amaranth); roots and tubers and oil-bearing crops (potato and carrot); animal products (milk, egg, chicken meat and red meat); and fish and fish products (small fish and carp fish), were assessed. The quantitative food losses of the above-mentioned selected food value chains (producers to retailers) were assessed as per the suggested method (‘Category method’ and ‘Self-reported method’) described by Delgado et al. (2017). The magnitudes of food waste were assessed through questionnaire survey at the households of various socio-economic status, restaurant outlets, and community centres. The survey was carried out using structured and pre-tested questionnaires through face-to-face interview by trained data enumerators. Furthermore, data and information on possible reasons for FLW and the ways to reduce FLW were recorded and analysed. Micronutrients were analysed using AAS (Atomic Absorption Spectrophotometer), HPLC (High Performance Liquid Chromatography) and UV Spectrophotometer. The collected data were processed and analysed using SPPS (Version 20), and descriptive statistics were mainly used to describe the variables. Four MS theses and 8 scientific papers were drafted using data of the present research.

Results

Average postharvest paddy loss along the selected value chains (farmers to processors) was estimated as 17.80% in which the losses at the farmers, middlemen and millers' levels were 14.02% (transportation loss- 1.4%; threshing loss- 1.7%; winnowing loss- 1.5%; drying loss- 2.6%, and storage loss 6.8%), 1.62% and 2.12%, respectively. However, the total paddy loss including the pre-harvest loss was 23-28%. Lack of proper storage was the main reason for postharvest loss at the producers' level, while the damage due to rodent pests was identified as the main cause of pre-harvest loss. Average postharvest wheat loss was estimated as 17.59%. There were wide-ranging postharvest losses for the selected horticultural produce, which ranged from 17% to 32%, wherein the losses of mango, banana, potato, carrot, tomato and red amaranth were 31.7, 19.9, 21.8, 26.1, 27.9 and 16.6%, respectively. There also exists considerable field loss. For example, substantial field loss (≈10%) was observed in tomato, which is not harvested by the growers owing mainly to low price at the end of the growing season. Across the selected horticultural value chains, wholesale and retail levels were identified as critical loss points. This is due mainly to the advanced ripening and senescence of the perishables, and lack of storage and food processing facilities. Loss also occurs at the processors' levels. For example, in large-scale mango processing, 13 to 17% of the raw materials received were lost during sorting, grading, de-sapping, washing and crushing, while 2 to 4% loss occurred during internal transportation and storage of the transformed mangoes. Loss was also observed in large-scale processing of tomatoes. There were also losses during cold storage as found for potatoes (5.7%) and carrots (11.0%). Results also revealed that 2-5% loss occurred for the selected horticultural produce in Dhaka's super shops. Losses of animal products including milk (cow and buffalo), eggs, poultry meat, and red meat at different levels of value chains (producers and middlemen including Bepari, wholesalers and retailer) were assessed. Total postharvest losses of cow milk and buffalo milk were estimated as 8.07 and 15.67%, respectively. The postharvest losses of eggs, poultry meat and red meat were 12.9, 16.9 and 21.4%, respectively. The processing losses of meat and meat products and milk and milk products were observed to be 5-9 and 8-12%, respectively. Total quantitative losses of small fish and carp fish were assessed along the value chains, and were estimated as 25.45 and 18.13%, respectively.

There is paucity of data and information on micronutrient loss in food commodities. The current research suggests that levels of vitamin C in fruits and vegetables decline sharply after harvest. Vitamin C content declines by 62% and 79% four and eight days after harvest, respectively, for mangoes (cv. BARI Am 4). Similarly, vitamin C content in tomatoes (cv. Hybrid 1217) declined by 29 and 40% within 3 and 7 days after harvest, respectively. Potatoes showed comparable results. Vitamin C content in potatoes also greatly varies when sampled at different levels of marketing channel. The highest vitamin C content was found in potatoes harvested at the right stage of maturity and prior to cold storage followed by those harvested in the previous season and held in cold storage, which suggests the importance of appropriate storage to retain micronutrients. The immature potatoes harvested early to fetch higher prices had the lowest level of vitamin C content. This is important to note that although the above-mentioned commodities are not really promoted as main sources of vitamin C but are popular and commonly-consumed food items, and there is a need to conserve the nutrient and mitigate losses. Folate contents also tended to decline over time after harvest as found in mango, milk and beef. This was also the case for zinc for certain crops, meat and milk. Conversely, vitamin A (β-carotene) levels in mango increased as ripening ocurred. Vitamin and mineral contents vary widely among varieties, and their patterns of change or losses also vary. For example, the potato variety Diamant contained higher iron and zinc (25.78 and 6.26 ppm, respectively) as compared to the variety Cardinal (only 6.26 and 5.42 ppm, respectively). Micronutrient contents of various animal products were also assessed. Calcium content was the highest in buffalo milk followed by cow milk and egg. Iron content was found to be the highest in red meat followed by egg and chicken meat. Zinc content was found the highest in red meat followed by egg. There is also a need to generate breed-specific data on micronutrient levels of animal products.

Assessment of food waste is another important component of the present research. There is lack of data on the magnitude of food waste in Bangladesh- which mainly occurs at retail and consumption levels of the food chain. This study reveals that food waste is the highest for richer families and lowest for poorer ones. Strikingly, more than 2 kilograms of food is thrown away per week by high-income households. For restaurants, among those categorized as A+ and A by BFSA (Bangladesh Food Safety Authority), one quarter recorded between 21 to 40% food waste, and another quarter between 11 to 20%. In contrast, the B and C category restaurants recorded only 6 to 10% and 3 to 5% food waste, respectively. Excess food order and tendency to taste all foods are critical factors for food waste in restaurants. In community centres, food waste as leftovers ranged from 5 to 30%.

Policy implications and recommendations

- Reduction FLW is a global concern and linked with SDGs. By this time, a number of countries like Australia, China, Japan, Singapore and Thailand developed national strategy to reduce FLW. The Government of Bangladesh needs to develop and implement a national strategy to reduce FLW towards achieving SDG target 12.3.
- Irrespective of types of food, substantial losses (12-32%) occur along food value chains. In the case of cereals, adoption of improved pre-harvest practices at the producers' level and modern storage technology (hermetic storage) at the producers, middlemen and millers' levels would have substantial impact on reducing loss of paddy, the staple food of the nation.
- Fruits and vegetables play a vital role in human nutrition, given their contribution of vitamins, minerals, dietary fibre, antioxidants and phytonutrients, that have marked nutritional significance. The present consumption of vegetables and fruits (212 g day^{-1} $capita^{-1}$) in Bangladesh is well below the FAO/WHO recommended minimum requirement (400 g day^{-1} $capita^{-1}$), and the situation is further compounded by huge pre- and postharvest losses. Traders' levels have been identified as critical loss points in horticultural value chains. Substantial losses are also evident across the value chains of the animal and fish products. Significant improvements may occur by creating modern harvesting (mechanical harvesting) and postharvest facilities (sorting, grading, storage, packaging, cooling, refrigeration, transportation, slaughterhouses and abattoirs), encouraging civil society dialogues, and promoting public-private partnership.
- Adoption of improved pre- and postharvest practices, namely Good Agricultural Practices (GAP), Good Aquaculture Practices (GAqP), Good Hygiene Practices (GHP), GMP (Good Manufacturing Practices) and Hazard Analysis and Crticical Control Points (HACCP) across food value chains is needed to improve food quality and safety and to reduce loss.
- Food waste occurs at the tail end of the food value chain. Significant waste of food is observed in the middle and high income households, as well as in restaurants and community centres. Like food loss, food waste also has an impact on the national economy, food security and the environment.

- ❖ To deal with food waste, a number of actions need to be taken: create mass awareness; capacity building in related food use education, research and human resource development; improvement of cooking and consumption habits of consumers through enhanced food and nutrition literacy; creation of guidelines and code of practices (CoPs) for value chain actors including consumers; promulgation of legislation especially to stop food waste; increase in capacity of waste recycling; promotion of public and private sector food rescue and food banking services; and the engagement of civil society.
- ❖ Furthermore, strengthening mass awareness and promoting country-wide small, medium and large-scale agro-processing initiatives are key to reducing FLW.

Chapter 1
INTRODUCTION

Roughly one-third of all food produced for human consumption is lost or wasted which is equivalent to 1.3 billion tons (FAO 2015, 2017). Postharvest food loss is a leading cause of food insecurity for millions of families across the globe. Achieving zero hunger by the year 2030 requires that no more food is lost or wasted. In 2019, 690 million peoples suffered from hunger, and the situation has worsened due to the COVID-19 pandemic. A range of actors, including farmers, handlers, traders and governments, are part of the solution to prevent and reduce harvest and postharvest losses and produce enough food for a growing population (FAO 2021). With food production being challenged by limited land and water resources, as well as weather variability due to climate change, reduction of food losses, in particular at the harvest and postharvest stages are among the keys towards achieving the goals of food security in a sustainable way. Food loss and waste (FLW) have emerged as global concerns for the past few years. With accelerated economic growth and increased production, FLW are now grave concern in Bangladesh as well. FLW refer to the "decrease of food in subsequent stages of the food supply chain intended for human consumption". Food is lost or wasted throughout the supply chain, from initial production down to final household consumption" (FAO 2017). An important part of food loss is food waste, which relates to the discarding or alternative (non-food) use of food that was fit for human consumption (FAO 2015). Food loss occurs at the various stages of supply chain including production (due to mechanical damage during harvesting, crops sorted out postharvest, etc.); postharvest handling and storage (due to spillage and degradation during handling, storage, transportation and distribution); processing (during milling, sorting, washing, peeling, slicing, boiling, process interruptions, accidental spillage, etc.); distribution (wholesale markets, super market, retailers and wet markets); and consumption (at households, restaurants, community centres, etc.). Food loss can be quantitative as measured by decreased weight or volume, or can be qualitative, such as reduced nutrient value and undesirable changes to taste, color, texture, or cosmetic features of food. A typical postharvest value chain comprises a number of stages for the movement of harvested output from the field to the final retail market (Hassan et al., 2010; Hassan et al., 2013). The losses incurred at each step vary depending upon the types of commodity, organization and technologies used in the food supply chain. For example, in less developed countries where the supply chain is less mechanized, larger losses are incurred during drying, storage, processing and in transportation. At regional level food loss estimates ranges from 5-6% in Australia and New Zealand to 20-21% in Central and Southern Asia (FAO (2019), which means that there remains scopes for other countries to reduce loss to a level close Australia and New Zealand through appropriate measures.

In Bangladesh, there is paucity of reliable recent data to indicate the magnitude of food loss. Hence, the present study was undertaken to estimate food loss (quantitative, qualitative and micronutrient) of 14 commonly-consumed food commodities selected from the FAO-recommended 5 food groups, namely cereals and pulses (paddy and wheat); fruits and vegetables (mango, banana, tomato and red amaranth); roots and tubers and oil-bearing crops (potato and carrot); animal products (milk, egg, chicken meat and red meat); and fish and fish products (small fish and carp fish). The quantitative losses of the above-mentioned food commodities were assessed across the value chains from producers to retailers. For food loss assessment, the suggested 'Category method' and 'Self-reported method' were used (Delgado et al. 2017). Food waste assessment was conducted at the selected households, restaurant outlets and community centres. Micronutrient was analysed using AAS (Atomic Absorption Spectrophotometer), HPLC (High Performance Liquid Chromatography) and UV

Spectrophotometer. The survey was carried out using structured and pre-tested questionnaires through face-to-face interview by the trained data enumerators. Data were analysed using SPPS (Version 20), and descriptive statistics were used to describe the variables. Four MS theses and 8 research papers were drafted. The research outputs in relation to the magnitude of FLW and micronutrient loss will be of enormous importance in devising ways and means to reduce FLW based on scientific evidence and data. Finally, the research outputs will be used to underpin the reasons for food loss and waste and provide recommendations for informed policy making to reduce FLW and contribute to achieving SDG target 12.3.

Chapter 2

PLANNED OUTPUTS

The research objectives are those outlined in the FAO-MUCH Terms of References (ToR 3). The pre-set objectives, and the corresponding expected outputs are summarized the Table 2.1.

Table 2.1 Objectives and expected outputs of the present study

Sl. No.	Objectives	Expected outputs
1.	Measure food losses and associated micronutrient losses for key commodities of the Bangladesh diet (in terms of quantity and/or nutritional importance) by assessing losses along the different types and levels of value chains that exist (traditional, modern, etc.).	**1.1** Reliable data on quantitative and qualitative losses of commonly consumed foods of plant and animal origin at different levels of selected supply chains (traditional and modern) generated using validated methodology. **1.2** Nutrient loss (change) of vitamins (β-carotene, vitamin C and folic acid) and minerals including Zn, Fe (and sugars, namely lactose in milk) in selected animal and plant food commodities documented. **1.3** Four MS theses on food loss assessment (cereal; horticulture; livestock; and fisheries) prepared. **1.4** Drafting of 4 national and 4 international research articles finalized for publication using research data.
2.	Identify the predominant sources of food and nutrient losses and provide recommendations for changes in practices along the value chain in order to reduce these losses, notably through use of appropriate processing and preservation technologies.	**2.1** Information on underlying causes of quantitative and qualitative food losses of plant and animal origin generated, and recommendations prepared on reducing losses. **2.2** Cause of losses of nutrients in the selected foods of plant and animal origin during postproduction stages identified, and recommendations related to proper postharvest handling and preservation techniques prepared on reducing nutrient losses in the selected food items. **2.3** Policy Brief prepared to facilitate adopting appropriate measures to significantly reduce food loss and food waste to contribute achieving SDG (12.3.1).

3.	Measure food waste considering geographic and socio-economic characteristics of consumers and the different types of retailers.	**3.1** Magnitude of food wastes in selected restaurant outlets, households of different socio-economic status and community centres (catering houses) assessed.
4.	Identify the main sources of food waste and make recommendations on how to reduce food waste at all levels and on appropriate mitigation measures.	**4.1** Causes of food wastes at the restaurant outlets, households and community centres (catering house) identified, and appropriate recommendations prepared on reducing food waste.

Chapter 3
REVIEW OF LITERATURE

Secondary data and information related to food loss and waste (FLW) collected and reviewed in this section. FLW have emerged as global concerns for the past few years. With accelerated economic growth and increased production, FLW are now grave concern in Bangladesh as well. FLW refer to the "decrease of food in subsequent stages of the food supply chain intended for human consumption". Food is lost or wasted throughout the supply chain, from initial production down to final household consumption" (FAO 2017). An important part of food loss is food waste, which relates to the discarding or alternative (nonfood) use of food that was fit for human consumption (FAO 2015). Roughly one third (approximately 1.3 billion tons) of the food produced in the world for human consumption is lost every year. FLW amount to roughly 680 billion US$ in industrialized countries and 310 billion US$ in developing countries (FAO 2015, 2017). Food losses occur at the various stages of supply chain including production, postharvest handling and storage, processing, distribution and consumption. Food losses can be quantitative as measured by decreased weight or volume, or can be qualitative, such as reduced nutrient value and undesirable changes to taste, color, texture, or cosmetic features of food. A typical postharvest value chain comprises a number of steps for the movement of harvested produce from the farm to the final retail market (Hassan et al., 2010; Hassan et al., 2013). The losses incurred at each steps depend on types of commodity, organization and technologies used in the food supply chain. For example, in less developed countries where the supply chain is less mechanized, larger losses occurred during drying, storage, processing and in transit. In this chapter, an attempt has been made to review available literatures in relation to postharvest losses in major areas of concern including crops (cereals, fruits and vegetables), livestock and poultry, fishery and industry, in order to find out the information gaps and conduct a study to assess food FLW in Bangladesh.

3.1 FOOD LOSS

3.1.1 Postharvest loss- horticultural produce

As per FAO (2015, 2017), horticultural produce like fruits and vegetables and roots and tubers, have the highest rates of loss of any food. Global quantitative FLW per year are roughly 45% for fruits and vegetables, and root and tubers. In Bangladesh, postharvest losses of important fruits and vegetables were assessed through primary survey, and were reported as 24-44% (Hassan et al. 2010). In China, the postharvest losses of fruits and vegetables were 15-35% (Feng 2001). Extents of postharvest losses of important horticultural produce, especially in developing countries including Bangladesh, are summarized in Tables 3.1. Comparative reasons for postharvest losses in the developing and developed countries are also summarized in Table 3.2. It was noticed that most of the data on postharvest losses were of more than 10 years old, and there are paucity of recent data on magnitude of postharvest losses which are required for monitoring of progress of SDG 12.3.1.

Table 3.1 Extent of postharvest losses of fruits and vegetables in developing countries including Bangladesh

Produce	Postharvest loss (%)	Country	Sources of information
Mango	27.4	Bangladesh	Hassan et al. (2010)
	39.4	Bangladesh	HRC Annual Report (2008-2013)
	26.0	India	Roy (1993)
	31.1	Pakistan	Mushtaq et al. (2005)
	26.3	Ethiopia	Tadesse (1991)
Banana	24.6	Bangladesh	Hassan et al. (2010)
	26.6	Bangladesh	HRC Annual Report (2008-2013)
	20.0	Sri Lanka	Wasala et al. (2014)
	18.2-45.8	Kenya	George and Mwangangi (1994)
	49.2	Ethiopia	Tadesse (1991)
Tomato	32.9	Bangladesh	Hassan et al. (2010)
	42.4	Bangladesh	HRC Annual Report (2008-13)
	40.2	India	Kitinoja and Cantwell (2010)
	35.0	India	Gajbhiye et al. 2008
	20.0	Pakistan	Mujib et al. (2007)
	54.0	Sri Lanka	Rupasinge et al. (1991)
	24.6	Cambodia	Weinberger et al. (2008)
	19.1	Vietnam	Weinberger et al. (2008)
Potato	27.7 (conventional)	Bangladesh	Hossain and Mia (2009)
	23.1 (cold storage)	Bangladesh	Hossain and Mia (2009)
	18.0	India	Roy (1993)
	29.4	India	Kumar et al. (2004)
	34.7	India	Pandey et al. (2003)
Red amaranth	28.6	Bangladesh	Hassan et al. (2010)

Table 3.2 Extent and reasons of food loss and waste in the industrialized and developing countries (FAO 2015)

Indicators	Industrialized countries	Developing countries
Stages of value chain where loss occur	• Later stages of the food chain (retail and consumption). • 40% loss occurs at retail and consumer level.	• Early part of the food chain (during harvesting, transport and storage). • 40% at postharvest and processing levels.
Main reasons of loss	• Mainly related to consumer behaviour and the policies and regulations. For example, agricultural subsidies contribute to the production of surplus of which at least a proportion is lost or wasted. • The applied food safety and quality standards that remove food that is still safe for consumption from the supply chain. • At the consumer level, improper purchase planning and failure to use food before its expiry, also lead to avoidable food waste.	• Mainly related to wide-ranging managerial and technical limitations in harvesting techniques, storage, transportation, processing, cooling facilities, infrastructure, packaging and marketing systems.

3.1.2 Postharvest loss- cereals

Global quantitative loss of cereals is roughly 30% as reported by FAO (2015, 2017). The dominant food crop of Bangladesh is rice, which accounts for about 75% of agricultural land use, and more than 50% households are involved in rice production. The main steps of rice value chain in Bangladesh are: production, harvesting, threshing, cleaning, drying, bagging, paddy rice storing, parboiling and drying, packaging, milled rice storing, and marketing. At each step of the value chain, there is scope of loss. The total average cumulative postharvest loss from harvesting to milling was reported to be 13.52% (FAO/BARI 1986). The drying loss varied from 1.63 to 2.84%, and parboiling loss from 1.93 to 2.75%. The highest loss occurred during milling operation which varied from 3.28 to 4.54% (FAO/BARI 1986). Bala et al. (2010) reported that the postharvest losses of rice at national level from producer to retailer were 10.74% for Aman 11.71% for Boro and 11.59% for Aus. The estimated total postharvest losses of rice at the farm level in Bangladesh were 9.16, 10.10 and 10.17% for Aman, Boro and Aus, respectively. The storage loss of rice was 3.45-4.14% followed by drying (2.19-2.37%), harvesting (1.60-1.91%), threshing (1.10-1.79%) and transportation (0.87-1.13%). The estimated total postharvest losses of rice at the processors' level in Bangladesh were quite low and were reported as 1.30, 1.30 and 1.13% for Aman, Boro and Aus, respectively. In this study, the loss during winnowing at growers' level was not included. There are paucity of data and information on postharvest losses of other cereals like wheat. In a study conducted by Bala et al. (2010) reported that the storage losses of wheat and maize were relatively lower in Bangladesh as compared to that of rice because of the fact that these crops are stored for very short period. They estimated the storage losses of wheat and maize as 1.54 and 2.50%, respectively, while the total postharvest losses of wheat and maize were 3.62 and 4.07%, respectively. Postharvest loss of wheat, at farm level was 8-10% as reported by Amiruzzaman (2001).

3.1.3 Postharvest loss- Animal products

Postharvest loss of animal products may occur along the supply chain including production, transport, slaughtering, cutting, packing and distribution. At primary production, losses are considered from the moment when the animals are ready to be slaughtered. Reports related to postharvest losses of livestock and poultry products scanty in Bangladesh. Nonetheless, some pertinent reports from abroad on losses of animal products are reviewed below:

3.1.3.1 Meat loss

Meat is defined as the edible parts of animal, i.e. the carcass and the giblets (heart, liver and gizzard). Co-products are defined as anatomical elements derived from carcass which can be considered as edible but needs special processing before consumption, e.g. mechanically separated meat. By-products are defined as all parts that are excluded from human food: dead broilers (died during transport or euthanized), blood and non-edible parts of the animal (feathers, intestinal tract, feet and head) separated at slaughtering or at processing, and the carcasses or part of the carcass which have been withdrawn from the production line because of safety or technical reasons (Malher 2014). Meat losses may be categorized as agricultural loss, postharvest loss and consumer loss. Agricultural losses occur already at the initial stage of farm gate. Agricultural losses of animal commodities and products refer mainly due to death and sickness before postharvest handling. The calculated losses for beef, lamb and poultry ranged from 7-14, 2-7 and 5-10%, respectively (Liu 2013). There are fewer studies for postharvest losses of meats. The losses at postharvest handling, storage, processing, and distribution stages of meats were estimated about 1.4-2.1%, 2.5- 3.7%, 1.1%, and 3%, respectively (Xu 2007).

3.1.3.2 Milk loss

The losses in milk include both pre and post production losses. Pre-production losses mean mortality or inability of animal to produce due to various reasons, whereas post-production losses occur usually during handling and transportation and are highest in milk value chain due to spillage and spoilage (PRLA Activity 2012). In developing countries, about 20% losses occur in milk value chain (Jaspreet and Regmi 2013). A study was conducted on losses in milk production in terms of quantity and value in N-E States, India. Mineral deficiency causes maximum economic losses, i.e., Rs. 55.28 crores followed by repeat breeding (Rs. 36.62 crores) and worms infestation (Rs. 12.91 crores). All these three constraints accounted for 94% of the value of milk loss where mineral deficiency alone accounts for approximately 50% losses. The value of milk loss from Foot and Mouth Disease, Mastitis, Hemorrhagic Septicemia, Black Quarter and milk fever were Rs. 4.19, 2.25, 0.16, 0.12 and 0.08 crores, respectively accounting for 6% of the total value of losses (Rs. 112.08 crores) (Paul 2013).

3.1.3.3 Egg loss

The magnitude of losses of table eggs at layer farms, wholesalers, retailers, cold store, egg processing unit and household level were found to be 0.98, 1.39, 3.26, 2.11, 1.24 and 3.24%, respectively which together constituted an overall annual loss of 12.22%. However, the overall loss of table eggs from poultry farms to household consumers via wholesale-retail channel was found to be 8.87% in the survey area of India. Losses of eggs were found to be more in small layer farms (1.94%) than in medium (1.11%) or large farms (0.95%). The losses were comparatively more in summer (1.31%) than in rainy (0.88%) or winter (0.75%) season at the same farms. Similar trends of seasonal variation in losses of table eggs were also observed at market (wholesale/retail) and consumer (household) levels. The bulk of egg damage at farm level was in the form of straight crack (35.2%) followed by star crack (16.4%), smashed/leakers (15.2%), soft-shell (14.3%), holes (9.8%), shell-less eggs (8.9%) and spoiled (rotten) eggs (0.1%). Majority of egg damage occurred at poultry farms during collection stage, whereas the same was maximum during packing and transport at market and household consumer level, and during mechanical washing operation at egg processing plants. Poor feed quality, summer stress, defective cage design and mishandling were main reasons for loss, while defective packaging and transport hazard were the major causes of loss in the marketing channels (Singh et al. 2005).

3.1.4 Postharvest losses- fish and fishery products

Fish is an important source of protein, and it provides livelihood for millions. Fish is a highly perishable food, requiring proper handling, processing and distribution. The demand for fish is growing in the country, and reduction in postharvest losses can contribute to satisfy this demand, improve quality and increase income for fishermen. In Bangladesh, fisheries sector suffers from serious postharvest loss every year due to ignorance and negligence in handling and processing at different stages of supply chain from catch to retail distribution. There are generally two types of postharvest losses, namely quantitative and qualitative losses (Alam 2010). Quantitative loss can occur due to massive kill during harvest, physical injury caused by netting, fish killed by disease, discard by-catch fishery, glut catches, etc. Huge losses are encountered during processing, transportation, storage and marketing of fishery items. These are mainly weight loss due to dehydration, fragmentation, loss of parts, damage due to reabsorption of moisture (mold attack), etc. On the other hand, qualitative loss consists of losses in commercial value, but not in physical biomass, through losses of quality. Quality loss of major cultured and captured fish in different stages of distribution channel was directly assessed using a sensory based Fish Loss Assessment Tool (Alam 2010). In case of quantitative loss, the highest loss was found during storage of the products in all fishes with the highest in ribbon fish (20.2%) and lowest in mackerel (10.6%). Losses during packaging and transportation were quite less (0.7 to 2.5%). Losses during marketing varied from 3.4 to 6.6%, and was attributed to weight loss in retail sale for fractional weighing for small-scale buyers and continuous drying out of products. A research by the FAO project for coastal people in Cox's Bazar (Empowerment of Coastal Fishing Communities for Livelihood Security (ECFC) Project: BGD/97/017) found that about 20% of the marine fish landed in Cox's Bazar was deteriorated up to 80% of its original quality before it was loaded on the truck for distance transport. About 28% fish lost 60-70% of freshness quality before it reached the consumer in local retail wet fish traders' shop. It has been assumed that the trend of postharvest loss of wet fish is almost similar throughout the country, although the actual loss might be very high (BICAS 2003; Alam 2004).

3.1.5 Postharvest losses- during processing

Food loss also occurs during processing to produce different food products. The reasons for food losses during processing include: removal of inedible portions, discarding of substandard products, visual based rejection, shrinkage, poor handling, package failures, transportation losses, etc. Processing loss of cereals and fruits and vegetables in India were 3.9-6.0 and 5.8-18.0% (CIPHET 2010). For meat and poultry, processing losses were 2.3 and 3.7% as reported by FUSION (2016). In addition to the food loss in quantity, losses of micronutrients during food processing are also an important considerable factor. However, there is lack of data on levels of micronutrient losses of food commodities during processing.

Grain processing results in variable degrees of macro- and micronutrient contents, stability and retention, depending on rice variety and original nutritional quality. Rice drying mainly affects rice milling quality as rice kernel fissuring that may occur during drying leads to rice yield reduction. Rice grain aging during storage is inevitable and responsible for the changes in rice appearance, and milling, eating, cooking and nutritional qualities. As milling significantly changes the chemical composition of rice by removing protein and lipid-rich bran layers, milling can alter the aging process of rice and also affect rice appearance, eating and sensory qualities, but mainly affects the nutritional quality (Atungulu et al. 2014). Therefore, drying methods, storage conditions and milling methods need to be further researched to achieve and maintain the desired rice grain quality.

In the above, available literature, research data and information were reviewed in relation to the magnitude of postharvest losses in agricultural value chain including crops (cereal, fruits and vegetables), livestock and poultry, fisheries and food processing industries which constitute the major portion of our daily food. Data on the extent of postharvest losses of agricultural produces were mostly outdated. However, estimates of postharvest losses of agricultural produce in Bangladesh are still not conclusive, and dates back. It is also worth to mention that some published reports on postharvest losses are available for crops and fisheries in Bangladesh but no such published reports were found available for livestock and poultry sectors and the food processing sector.

3.2 FOOD WASTE

Food waste is slightly different from food loss, which relates to the discarding or alternative (nonfood) use of food that was fit for human consumption (FAO 2015). Food waste at the consumers' level occurs both at the household level and during meals away from home. Food waste at consumers' level is less in low-income countries than in middle- and high-income countries (Gustavsson et al. 2011). A major portion (68 to 81%) of the urban wastes in Bangladesh is composed of food wastes (Shams et al. 2017). However, magnitudes of wastes of various categories of foods have not yet been documented in Bangladesh, and the outputs of the present study may fill up the gaps. Aschemann-Witzel et al. (2015) studied the factors behind the generation of food waste by consumers in households and along supply chains and demonstrated that motivation to avoid food waste, management skills in providing and handling food, and food priorities had extensive influence on the food waste behaviour of the consumers. Schanes et al. (2018) reported that food waste is a complex and multi-faceted issue that cannot be attributed to a single variable. Given the complex nature of food waste, a growing body of literature sheds light on food-related practices and routines, ranging from planning and shopping, to storing, cooking, eating, and managing leftovers, within the context of food waste generation by adopting practice, theories and other conceptual approaches Schanes et al. (2018).

In Vietnam, in order to reduce food loss and facilitate the transformation and restructuring of agriculture, a number of policies have been put into place to reduce loss in agriculture, and to increase value-add in processed agricultural, forestry and fishery products, and setting 2020 as the target year for reducing food loss. In 2018, the Law on Crop Production (Law No. 31/2018/QH14) was issued with regulations on harvest activities to limit food loss and ensure quality and cost efficiency. The government has also introduced a number of policies to attract the private sector, including investments in technological innovation, strengthening food processing, ensuring food safety, setting competitive prices and meeting market requirements, as well as investments in agricultural waste recycling technologies. There are also a number of initiatives and good practices by local governments, the private sector, civil society, and other stakeholders on reducing food waste. For example, volunteer-based Hanoi Food Rescue was established in 2013 operating in the field of training and job support for students in Vietnam who find themselves in difficult circumstances. The Tet Donation is an annual event organised to collect quality leftover food after the Lunar New Year for the poor and homeless. Furthermore, many private enterprises have also invested in the processing and recycling of food waste and organic waste, such as the Vietnam Food Joint Stock Company (VNF), which has produced animal feed from shrimp shell by-products using enzymatic hydrolysis technology (Liu and Nguyen 2020).

3.3 MICRONUTRIENT LOSS

The above reviews mainly related to quantitative losses. There are, however, other forms of losses, such as a reduction in nutritive values. It is critical to estimate nutritional losses for informed policy making on reducing food losses. Unfortunately, reports on nutritional losses are scanty both in home and abroad. Nevertheless, Hassan et al. (2010) studied changes in nutritional quality and reported that significant losses of vitamins (e.g. vitamin C) occurred in a number of fruits and vegetables examined during postharvest stages. Therefore, attempts has been made in the present study to properly document nutritional losses of the commonly-consumed food commodities to fill knowledge gaps and facilitate policy decision.

Chapter 4
METHODOLOGY

4.1 Food loss assessment

Food losses of cereals, horticultural produce, animal products and fish products were assessed across the selected value chains. The detaiuled methodology followed for the assessment is brifed in this chapter.

4.1.1 Selected food commodities

Fourteen commonly-consumed food commodities were selected from the FAO-recommended 5 food groups (cereals and pulses; fruits and vegetables; roots, tubers and oil-bearing crops; animal products; fish and fish products) to assess the magnitude of losses across the value chains (Table 4.1).

Table 4.1 Selected food commodities from 5 FAO food groups for food loss assessment

FAO Food Groups	Name of selected commodities
Cereals and pulses	Paddy, wheat
Fruits and vegetables	Mango, banana, tomato, red amaranth
Roots, tubers and oil bearing crops	Potato, carrot
Animal products	Poultry meat, red meat, milk (cow and buffalo), eggs
Fish and fish products	Carp fish, small fish

4.1.2 Method of assessment

The 'Category method' as described by Delgado et al. (2017) was mainly used to estimate the quantitative losses of the selected food commodities along the value chains. The methodology was applied to the producer and middlemen (Bepari, wholesalers and retailers) levels of the value chain to determine the magnitude of the postharvest loss in terms of weight and value. Loss was also estimated using 'Self-reported method' (Delgado et al. 2017), especially at the processors and cold storage levels (i.e. later stage of value chain) due to the heterogeneity of the crop transformation processes. All methodologies estimated both the total produce that is lost (quantitative loss) and the product that, albeit not being completely lost, is affected by quality deterioration (qualitative loss). Qualitative loss refers to the decrease in food attributes that reduces the value of foods in terms of its intended use. It may result in reduced nutritional value and/or economic value because of non-compliance with certain standards (FAO 2019). The reference period was the last cropping season at the producer, the middlemen and the processors level.

The 'Category method' is based on evaluation of a commodity and classification of that commodity into quality categories. It classifies each commodity into end use (e.g. suitable for export, formal market, informal market or animal feed). Each category is associated with crop damage coefficient, indicating the percentage of crop that is damaged within each category.

These categories were established prior to data collection for all the selected foods in consultation with relevant experts. Generally, the number of category varies from 4 to 6 (Delgado et al. 2017). At the producer level, the quantitative and qualitative losses were determined using following equations.

Quantitative loss ($WeightLoss_P$) $= \sum_{i=1}^{I} C_i * QC_{iPH} + (Q_{Prod} - Q_{PH})$

Qualitative loss ($ValueLoss_P$) $= \sum_{i=1}^{I} (\bar{P}_{ideal} - \bar{P}_{Ci}) * QC_{iPH} + (V_{Prod} - V_{PH})$

C_i is the damage co-efficient for category I (where total number of categories is I); $\bar{P}_{ideal}$ is the average sale price for an ideal product; $\bar{P}_{Ci}$ is the samples average sales price for a product in category I; Q_{iPH} is the quantity in each category at postharvest level; and Q_{PH} and V_{PH} are the quantity and value of produce after production.

At the middleman level, the quantitative and qualitative losses are obtained from the following equations:

Quantitative loss ($WeightLoss_M$) $= \sum_{i=1}^{I} C_i * (QC_{iSale} - QC_{iPurchase}) + WeightTotLost$

Qualitative loss ($ValueLoss_M$) $= \sum_{i=1}^{I} (\bar{P}_{ideal} - \bar{P}_{Ci}) * (QC_{iSale} - QC_{iPurchase}) + ValueTotLost$

C_i is the same damage coefficient as in the producers' survey; $\bar{P}_{ideal}$ and $\bar{P}_{Ci}$ are the average sale price for an ideal product and sale price for a product in category i at the middlemen level; and QC_{iSale} and $QC_{iPurchase}$ are the quantities in each category at purchase and sale. To obtain total quantitative and qualitative losses, the weight (or value) of the quantity that was totally lost was added.

4.1.2 Selection of study area

The study areas were selected in order to collect the required data to estimate the postharvest losses of all the 14 selected commodities across the value chains (producers to retailers). For selection of producer, a multistage sampling procedure was followed. For each of the commodities, two districts were first selected on the basis of production volume. From each district, one Upazila was selected after discussion with the Upazila Agriculture Officer (AEO) or Upazila Livestock Officer (ULO) or Upazila Fisheries Officer (UFO), and then a particular agricultural block was selected on the basis of production volume of the respective commodity for conducting the survey. From each of the selected Upazila, one large-scale assembly market was purposively selected for interviewing the Bepari. For the wholesalers and retailers, two wholesale and retail markets of Dhaka city were purposively selected. The details of the study areas for the selected commodities are furnished in Appendix 1.

4.1.3 Data collection

Data collection is a methodical process of gathering and analysing specific information to offer solutions to relevant questions and evaluate the results. For each of the commodity, data were collected from the randomly selected each of 50 growers/fishermen, 50 Bepari, 50 wholesalers and 50 retailers through trained data enumerators. Details of study areas and sampling plan are furnished in Appendix 1. A multistage random sampling was followed to collect data at the producers' level, while purposive random sampling was followed for data collection at the Bepari, wholesalers', retailers' and processors' levels. Data of last cropping season was recorded from the respondents. Sixty-five types of questionnaires (excluding food waste) for all 14 commodities for all the respondents (growers/fishermen, Bepari, wholesalers, retailer and processors) were developed (Plate 4.1; Appendix 2) in the light of the method reported by Delgado et al. (2017), where emphasis was given on the following four aspects:

a) Socio-demographic parameters- Age, sex, income and education.
b) Production/traded volume, and magnitude, cause and remedies of losses- Key questions were related to the production practices and postharvest practices; pre-harvest field loss; total and category-wise (Premium, Grade A, Grade B and Grade C) production/traded volume; levels of losses, and their causes and remedies.
c) Postharvest activities- Key questions were related to the postharvest activities conducted by the growers and middlemen (e.g. sorting, washing, grading, transportation, storage, packaging, etc.).
d) Market access- Key questions were related to product destinations (i.e. for consumption, for sale, for donation, etc.); prices of the products (average and category-wise) in normal and Covid-19 affected year under the high and low seasons.

A total of 2327 questionnaires (producer- 650; 'Bepari'-650; wholesalers- 500; retailers- 500; rice mills- 10; flour mills- 02; fruit processing plant- 01; milk processing plant- 01; meat processing plant- 1; super shop- 5; cold store- 07) were used to collect data (Appendix 1). Data were collected through trained data enumerators (Plate 4.2). Data obtained on the above-mentioned parameters were used to assess food losses across the selected food value chains following the method ('Category method' and 'Self-reported' method where required) suggested by Delgado et al. (2017). The research progress was time to time shared with TAT members, relevant FAO and FPMU officials and other stakeholders to receive feedback and suggestions towards improving methodology and implementing the study (Plate 4.3).

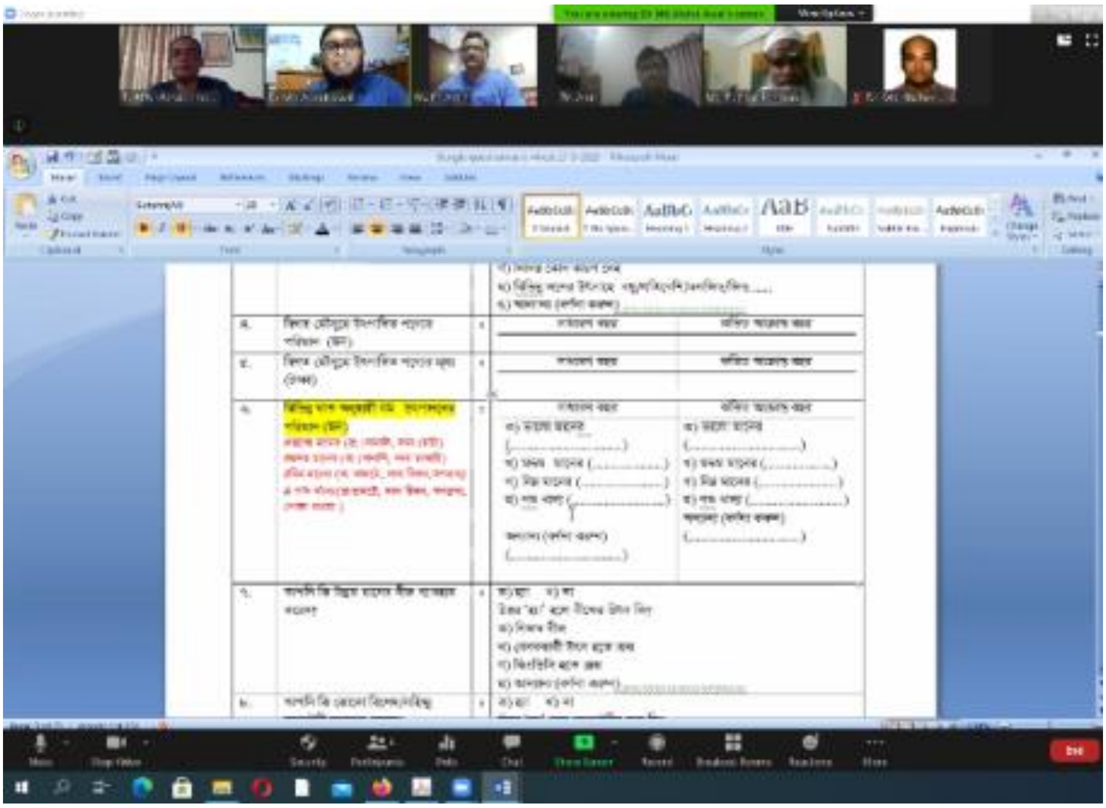


Plate 4.1 Internal project meeting related to finalization of questionnaires.

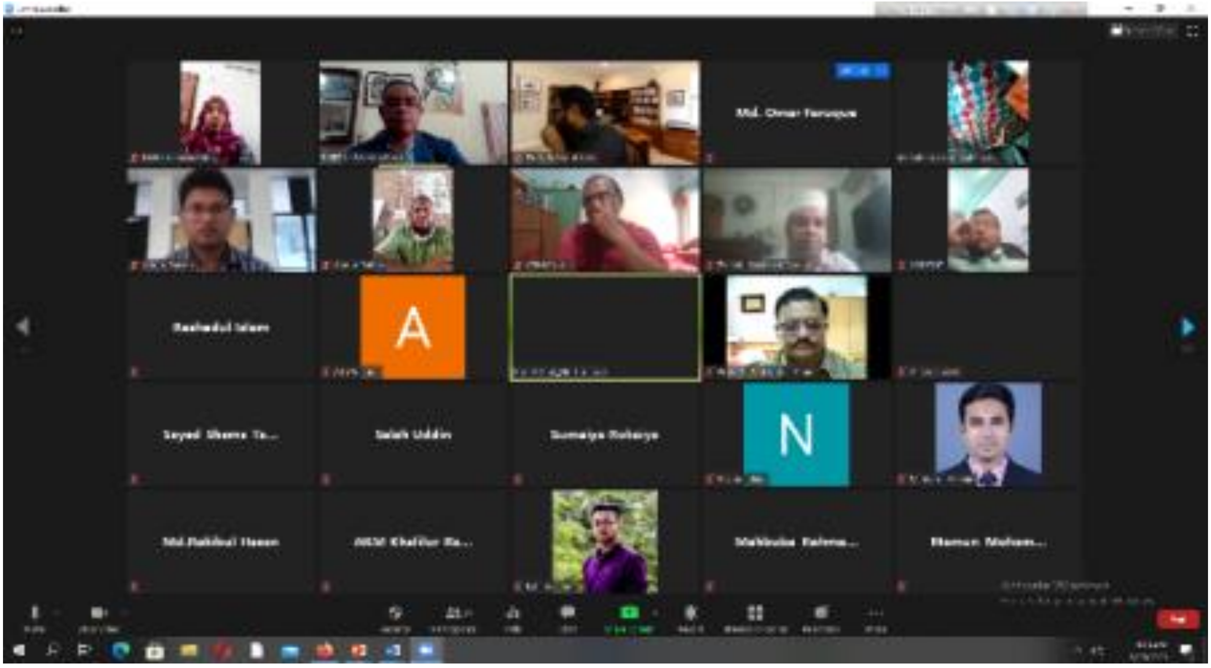


Plate 4.2 Training of data enumerators.

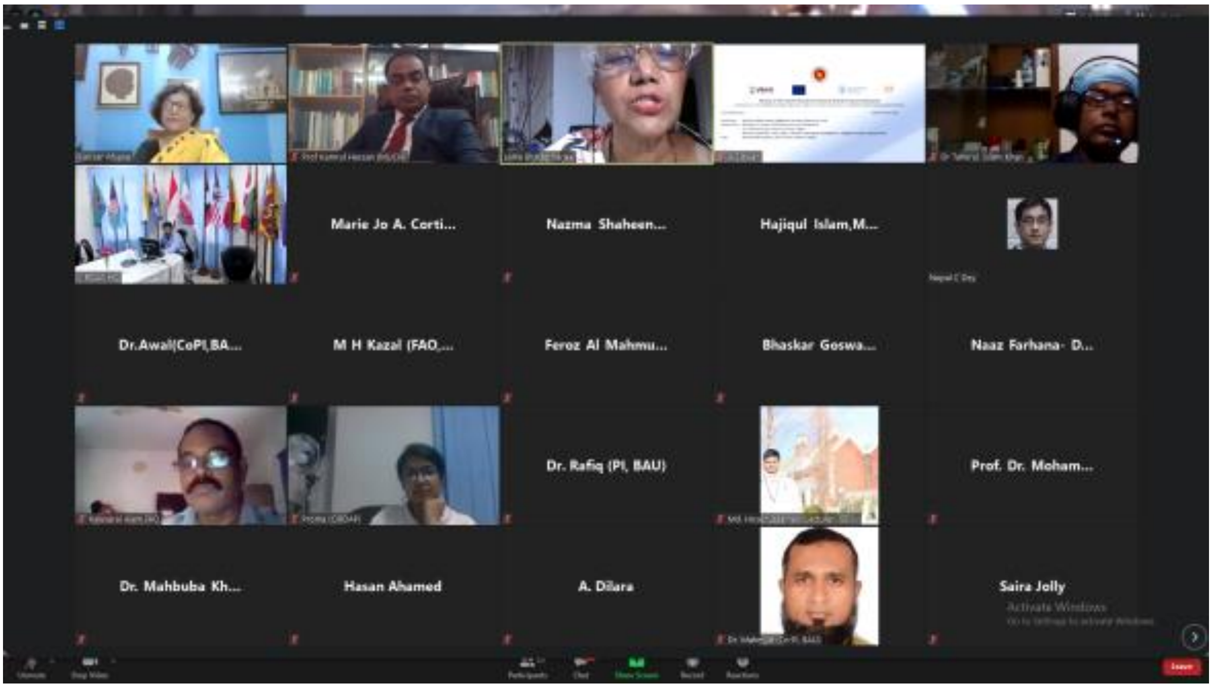


Plate 4.3 Mid-term review on research methods, outputs and implemenation.

4.1.4 Data analysis

Collected data were entered and analysed using IBM SPSS Statistics Software (Version 20). In some cases, the Microsoft Office Excel software was also used. Descriptive statistics were followed to describe the variables.

4.2 Micronutrient loss assessment

Samples of freshly-harvested commodities, and those at different stages of supply chains, were analysed for nutrients. Samples were collected and transported to the analytical laboratory in cool box so that sample quality and levels of micronutrients in the samples are not affected. For each of the selected commodity, samples were collected at 4-5 stages/sampling points (depending on the nature of commodity) in triplicate to analyze the levels/loss in micronutrients. Furthermore, timing of sample collection, sample storage and analysis were planned properly so that losses of micronutrients may not affect the results. The names of micronutrients that were analysed in the selected food commodities under 5 food groups are summarized in Table 4.2.

Table 4.2 Name of food and micronutrients tested

Food group	Commodity	Name of nutrients to be tested
Cereals and pulses	Paddy	Minerals (incl. Zn, Fe); Folate
	Wheat	Minerals (incl. Zn, Fe); Folate
Fruits and vegetables	Mango	Minerals (incl. Zn, Fe); Vit C; β- Carotene, Folate
	Banana	Minerals (including Zn, Fe); Vit C
	Tomato	Minerals (including Zn, Fe); Vit C, Folate
	Red amaranth	Minerals (including Zn, Fe); β- Carotene
Roots, tubers and oil-bearing crops	Potato	Minerals (including Zn, Fe); Vit C
	Carrot	Minerals (including Zn, Fe); Vit C; β-Carotene
Animal products	Red meat	Minerals (incl. Zn, Fe); Folate
	Poultry meat	Minerals (incl. Zn, Fe); Folate
	Milk	Mineral (incl. Zn, Fe); Folate
	Egg	Minerals (incl. Zn, Fe); Folate
Fish and fish products	Carp fish	Minerals (incl. Zn and Fe); vitamin A (retinol equivalent); Folate
	Small fish	Minerals (incl. Zn and Fe); vitamin A (retinol equivalent); Folate

The nutrient analysis was mainly performed at the Food Safety Laboratory (IIFS- Plate 4.4) and Humboldt Soil Teasting Laboratory of BAU and the Laboratory of CARS (Centre for Advanced Research in Sciences) of DU. The brief methodology for assessment of the above nutrients is given below:

Plate 4.4 Micronutrient analysis is in progress (Food Safety Lab, IIFS, BAU).

4.2.1 Assessment of vitamin C

Vitamin C contents in the selected food samples were determined using HPLC. For HPLC analysis, fruit samples were extracted as per the flow chart shown in Fig 4.1. A RP CD18 (Acclaim TM 120, 5µm, 150×4.6 mm) column (column temperature- ambient) was used for the detection. An isocratic elution of 0.3 mM potassium dihydrogen phosphate in 0.35% (v/v) ortho-phosphoric acid was used as the mobile phase with flow rate 0.5 ml min^{-1}. UV detection was achieved at 248 nm. Injection volume of the extract was 20 µl and run time was 15 min. HPLC chromatograms of vitamin C standard and mango sample are shown in Fig 4.2.

Step 1
- 2.5 g of sample was weighted and homogenized/blended.

Step 2
- Transferred to a 100 ml volumetric flask with a suitable volume of 3% metaphosphoric acid.

Step 3
- Shaken vigorously for 2 min and sonicated in ultrasonic bath for 5 min.

Step 4
- The sample extract was made up to the mark with 3% metaphosphoric acid.

Step 5
- Filter through filter paper Whatman 42 and further pass through membrane filter 0.45 µm.

Step 6
- 1 ml of the filtrate was taken in a 1.5 ml glass vial and 20 µl was injected into the system.

Fig 4.1 Flow chart showing the preparation of sample for the analysis of vitamin C.

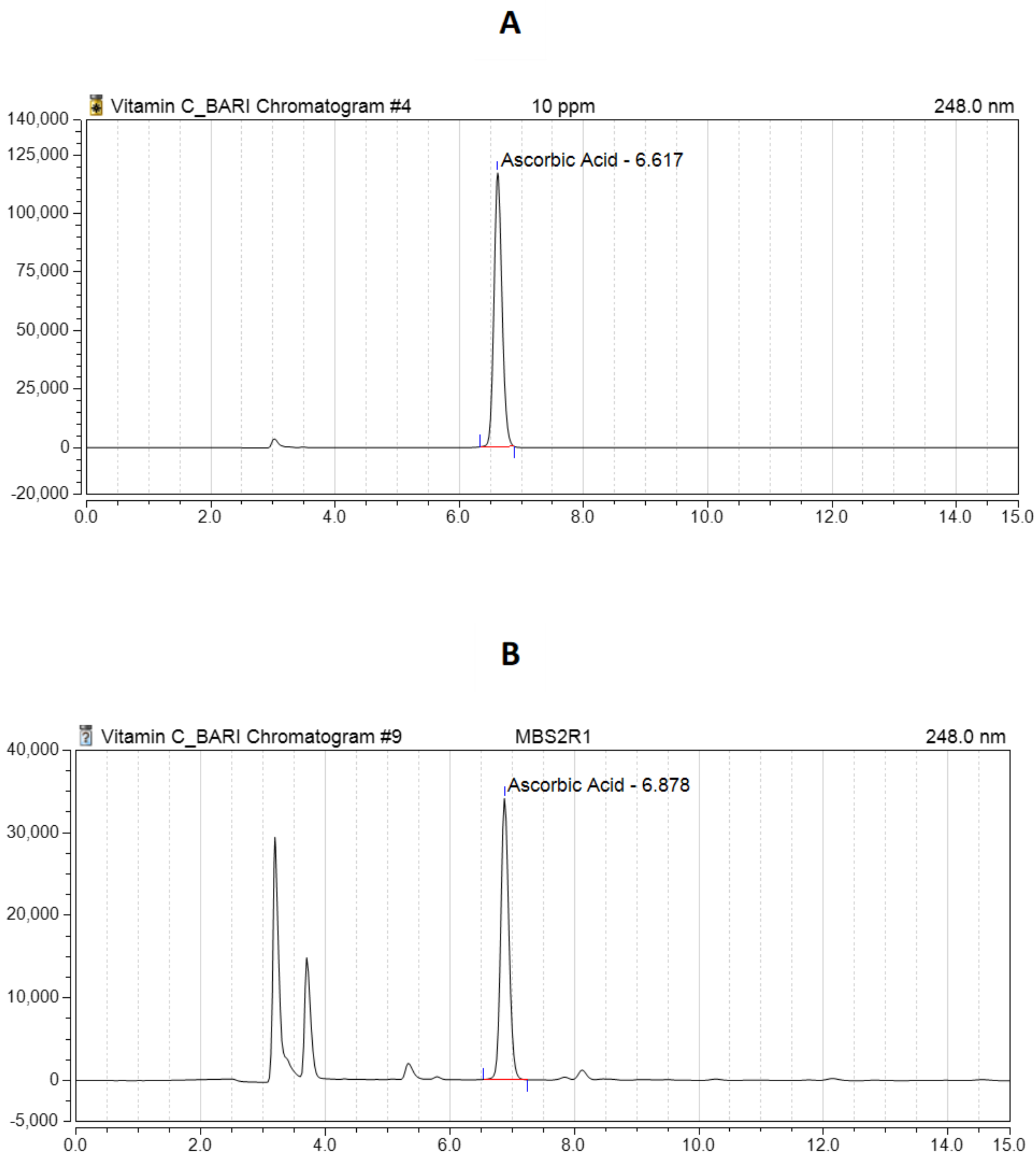


Fig 4.2 HPLC chromatograms of vitamic C standard (A) and mango sample (B).

4.2.2 Assessment of folate

Folate content in the selected food samples was determined using HPLC. A C18 (Acclaim TM 120, 5µm, 150×4.6 mm) column was used for the purpose of detection of the compound. For HPLC analysis, food samples were extracted as per the flow chart shown in Fig 4.3. A gradient elution program of aqueous solution of trifluroaceticacid (0.025%, v/v) (Solvent A), and acetonitrile (solvent B), was used as the mobile phase with flow rate 0.800 ml min^{-1}. UV detection was achieved at 210 nm. The run time was 26 min. HPLC chromatograms for the folate standard and the mango sample extract are shown in Fig 4.4.

- Step 1 — •Mango sample (pulp) was homogenized in a laboratory blender.
- Step 2 — •2 g was taken in 100 ml volumetric flask.
- Step 3 — •40 ml of deionized water was poured into the flask.
- Step 4 — •4 ml of 2M NaOH was added to the flask for dissolving the sample.
- Step 5 — •Vortexed for 2 min.
- Step 6 — •Next, 50 ml of pH 5.5 phosphate buffer was added to the flask.
- Step 7 — •Ultrasonicated for 30 min and made up to the volume with DI water.
- Step 8 — •The flask was kept in dark overnight for complete extraction of vitamins.
- Step 9 — •Centrifuged at 4000 RPM for 10 minutes.
- Step 10 — •Supernatant was filtered using 0.22 µm syringe filter.
- Step 12 — •20 µl was injected into the HPLC system.

Fig 4.3 Flow chart showing the preparation of sample for analysis of folate.

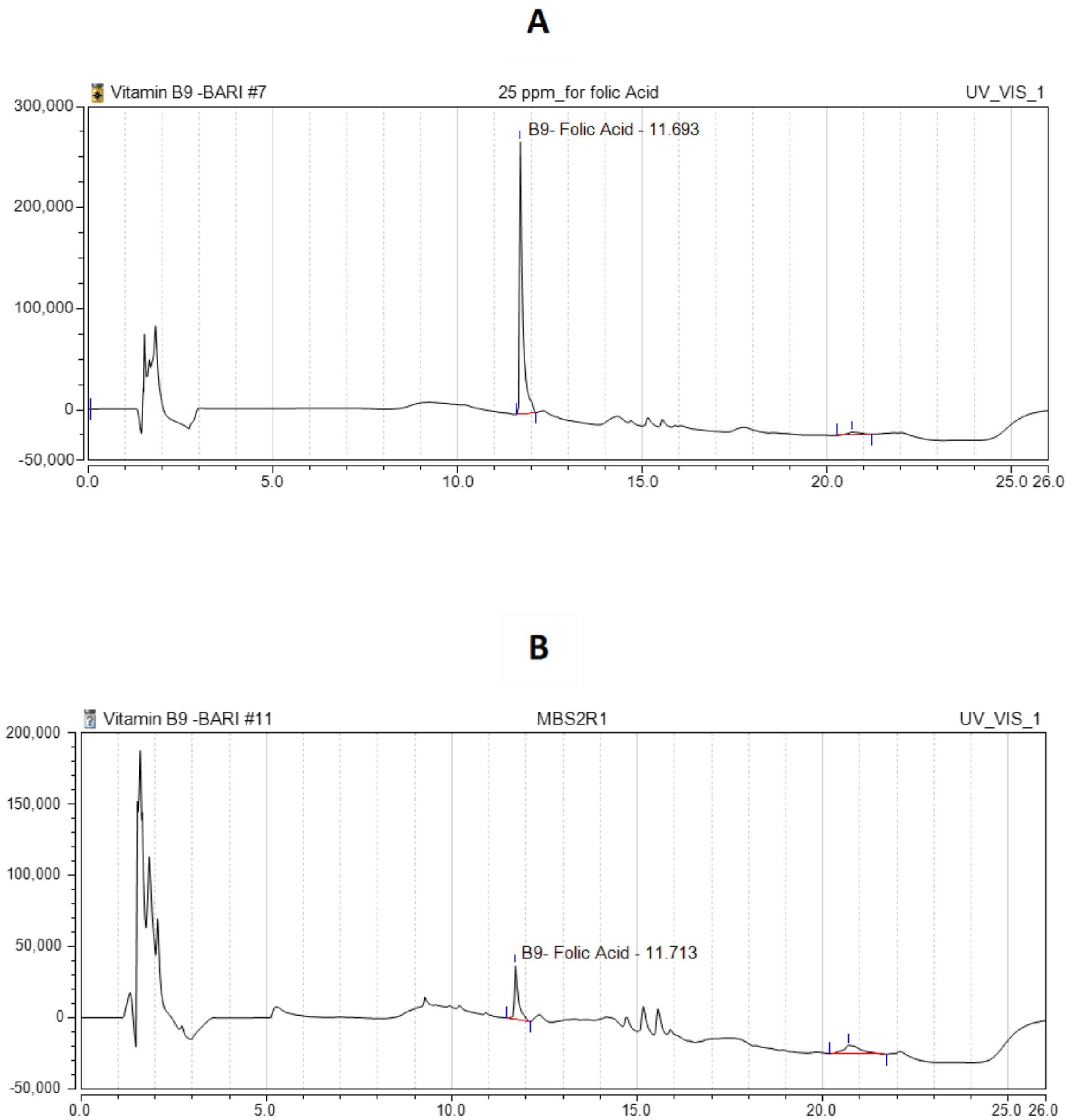


Fig 4.4 HPLC chromatograms of folate standard (A) and mango sample (B).

4.2.3 Assessment of β-carotene

β-carotene in the selected food samples were analysed using UV spectrophometry method.

4.2.4 Assessment of minerals

Ca, Fe and Zn were analysed using Atomic Absorption Spectrophotometer (AOAC 2000; Kumar 2015). Na and K contents were determined following Flame Photometry (Kumar 2015).

4.3 Assessment of food waste

Food waste assessment was caried out at the households of different socio-economic status, restaurant outlets and community centres. For households, waste data were collected from 150 purposively selected households of low, medium and high income from Dhaka and Mymensingh. The income groups were determined based on Gross National Income (GNI-

Annual capita^{-1} income) as suggested by World Bank (Low Income < 1026$; Middle Income 1026-12375$; High Income- >12375$) (World Bank Data Team 2020). Apart from households, 30 purposively selected restaurants were selected for food waste assessment in Dhaka and Mymensing. For selection of the restaurants in Dhaka, the restaurants were selected from those of A+, A, B and C categories designataded by Bangladesh Food Safety Authority (BFSA). Since in Mymensingh there is no such categorization exists, waste data were collected from 15 restaurants (5 each of small, medium and large). In addition, 10 purposively selected community centres (5 from each of Dhaka and Mymensingh) were also included in the present investigation to assess food waste. Food waste assessment was carried out through primary survey by trained data enumerators using structured and pre-tested questionnaires. Three (3) different sets of questionnaires (Apendix 2) were prepared for food waste data collection. During preparation of questinnaires, several reports, namely Waste & Resources Action Programme-WRAP (2012); Guam Environmental Protection Agency (2020); Herpen *et al*. (2019) and Bhandari (2017), were consulted.

Chapter 5

FOOD LOSSES- CEREALS

5.1 PADDY

Rice is the staple food for about 164 million people of the country in Bangladesh. According to an earlier report of the World Bank on Bangladesh, the population growth rate is 1.01% per year, and if the population increases at this rate, the total population will reach 238 million by 2050 (Mejia 2004). At the same time, the total cultivable land is decreasing at a rate of more than 1% per year owing to the construction of industries, factories, houses, roads, and highways (Basavaraja et al. 2007). Feeding this huge population is a great challenge. It is estimated that by 2025, 10 billion people will depend on rice as a main food and demand will reach about 880 metric tons (Nath et al. 2016). To feed this continuously increasing population, an increase in total rice production and decrease in postharvest loss are required. Therefore, attempts should be made to decrease the postharvest loss and increase the yield per unit area of rice. Pre- and postharvest losses of paddy were assessed in the selected value chains. Some activities related to field data collection have been captured in the following pictures (Plates 5.1-5.8).

Plate 5.1 Pre-testing of questionnaires in a semi-automatic rice mill (Phulpur, Mymensingh).

Plate 5.2 Data collection from an automatic rice mill.

Plate 5.3 Data collection from producer (Mahadebpur, Naogaon)

Plate 5.4 Data collection from producer (Mahadebpur, Naogaon)

Plate 5.5 Data collection from middleman (Bepari) (Mahadebpur, Naogaon).

Plate 5.6 Data collection from miller (Mahadebpur, Naogaon).

Plate 5.7 Data collection from miller (Mahadebpur, Naogaon).

Plate 5.8 Use of modern storage (IRRI Cocoon) and Moisture Meter for safe and long-term storage of paddy by a producer (Phulpur, Mymensingh).

5.1.1 Pre- and postharvest loss of paddy- At farmers' levels

Total paddy loss includes both field loss and postharvest loss. Field loss occurs before and during harvesting of paddy in the field. Damage by rats, insect pests and diseases, uncut paddy, damage by storm and heavy rainfall, drought, and cutting loss due to unskilled labors, were considered as field loss. The field loss was found to be 6.15 and 6.06% in Phulpur, Mymensingh and Mahadebpur, Naogaon, respectively (Fig 5.1). Postharvest loss comprises transportation loss, threshing loss, winnowing loss, drying loss and storage loss. Amount of moisture removal is not considered as postharvest loss. Results revealed that transportation loss was found greater in Naogaon (1.79%) than in Mymensingh (1.09%), and this was attributed to the fact that in Naogaon the growers usually transport paddy from field to house by head load. In both the study areas, farmers were found to use mechanical closed drum thresher and winnower. In Mymensingh and Naogaon, the threshing and winnowing losses were 1.53 & 1.88% and 1.58% & 1.49%, respectively (Fig 5.1). In both of the study areas, only sun-drying method was used to dry the harvested paddy. In Mymensingh and Naogaon, drying losses were found to be 2.52 and 2.59%, respectively. In a nutshell, the Fig 5.2 shows the field loss and postharvest losses of paddy in the study areas.

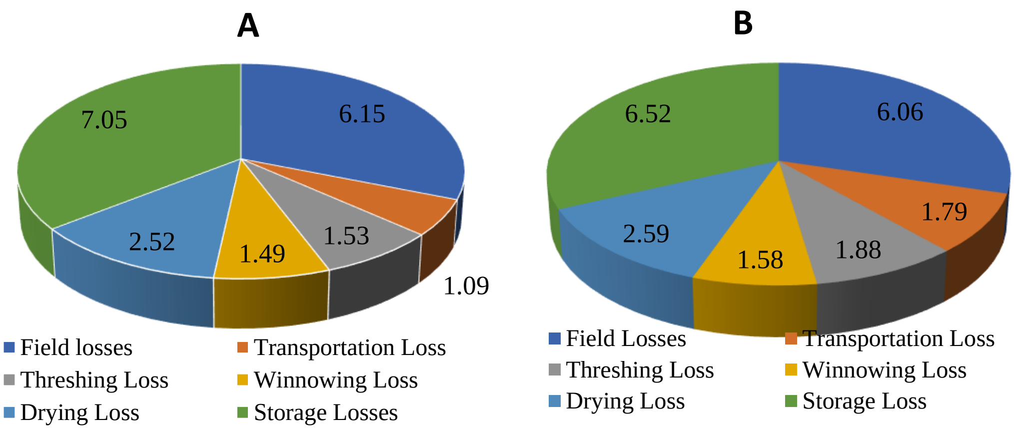


Fig 5.1 Pie chart showing overall paddy losses (%) at the farmers' levels in two selected study areas (Phulpur, Mymensingh-A; Mahadebpur, Naogaon-B; N=25 for each of the study areas).

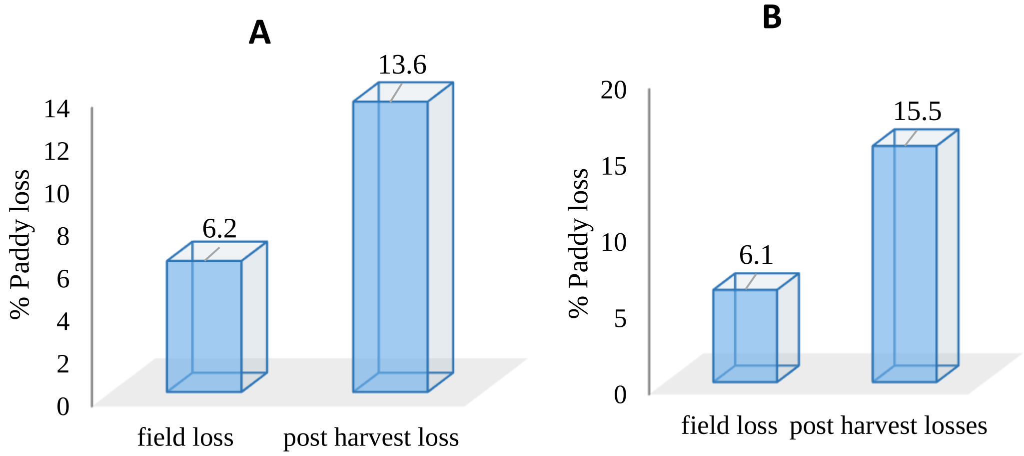


Fig 5.2 Pre-harvest field loss and postharvest loss of paddy at the farmers' levels in the selected sites (Phulpur, Mymensingh- A and at Mahadebpur, Naogaon- B; N=25 for each of the study areas).

5.1.2 Postharvest paddy losses- Middlemen level

Generally, middlemen (Bepari) buy paddy from farmers and sell to the nearest automatic rice mills. Some of them store a significant amount of paddy for a few months. Un-stored paddy loss occurs for those paddy which were not stored for long duration (months). Normally, the middlemen buy and sell their paddy at the same day, but some time they keep it in their 'Arat' (business house) for one to three weeks, due to market fluctuation. The loss for lotting, re-lotting, handling and transportation for this short duration storage is considered as un-stored loss. Un-stored paddy loss occurs due to handling and transportation of paddy. In Mymensingh and Naogaon, the storage losses at the middlemen level were found to be 2.5 and 3.11% and for un-stored paddies, the losses were 1.48 and 1.76%, respectively. The following Fig 5.3 shows un-stored paddy loss and storage loss at the middlemen level in the study areas. Details of the sampling for loss assessment at the middlemen levels are summarized in Tables 5.1, 5.2.

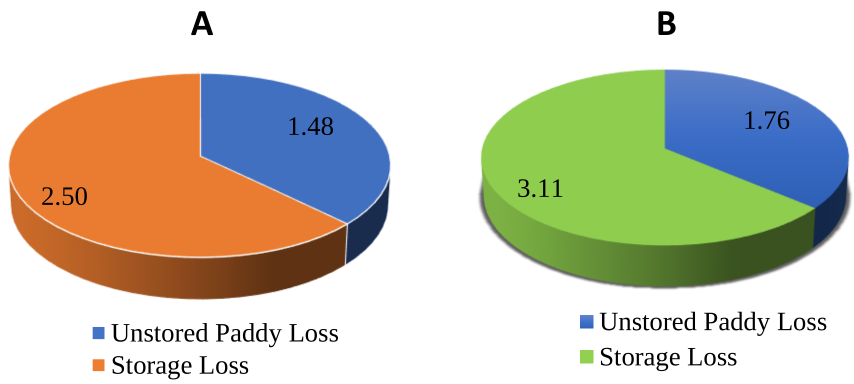


Fig 5.3 Graph showing average paddy loss (%) at the middlemen (Bepari) level (Phulpur, Mymensingh-A; Mahadebpur, Naogaon- B).

Table 5.1 Types and magnitudes of losses of paddy at middlemen level (Phulpur, Mymensingh)

Type of losses	N	Minimum	Maximum	Mean	Stdev
Un-stored paddy loss	18	0.25	5.00	1.48	1.28
Stored paddy loss	01	2.50	2.50	2.50	-

Table 5.2 Types and magnitudes of paddy loss at the middlemen level (Mahadebpur, Naogaon.

Type of losses	N	Minimum	Maximum	Mean	Stdev
Un-stored paddy loss	28	0.50	4.50	1.76	0.97
Stored paddy loss	11	3.00	6.00	3.11	0.90

5.1.3 Postharvest paddy losses- Millers

In automatic rice mills, paddy loss occurs before processing, during processing and after the processing of paddy (Fig 5.4; Plate 5.9). The loss after processing is very low and negligible. Some mills store paddy for a few months and in those cases storing losses occurs. The storage loss at the millers' level was 5.5% in Mymensingh. At Naogaon, the millers did not respond on paddy storage activity at their facility.

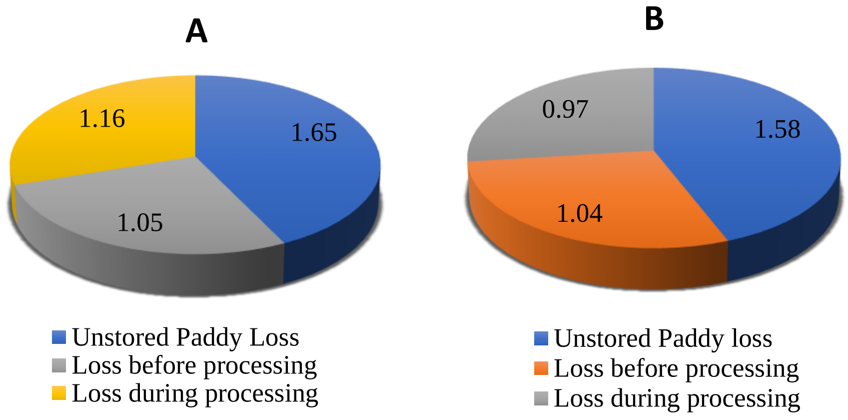


Fig 5.4 Paddy loss (%) at the millers' level (Phulpur, Mymensingh- A; Mahadebpur, Naogaon-B; N=10).

Plate 5.9 Nature of paddy damage at the millers' levels.

5.1.5 Total postharvest paddy loss (excluding pre-harvest field loss)

The average total postharvest loss (farmers-processors) of paddy in the two selected value chains (Phulpur, Mymensingh and Mahadebpur, Naogaon) was 17.8% wherein, the losses at the producer, middlemen and millers' levels were 14.02% (transportation loss- 1.4%; threshing loss- 1.7%; winnowing loss- 1.5%; drying loss- 2.6%, and storage loss- 6.8%), 1.62% and 2.12%, respectively (Fig 5.5). Appiah et al. (2011) conducted a study on postharvest loss of rice (*Oriza sativa*) from harvesting to milling in Ghana. They found harvesting losses ranged between 4.07 and 12.05% at farmers' fields. Storage and drying losses were 7.02 and 1.66% respectively. Finally, they reported that harvesting loss was 3.03% to 12.05%; threshing loss was 0.53% to 4.07%; drying loss was 1.57% to 1.76%; total postharvest loss was 4.60% to 17.88%. International Rice Research Institute IRRI (2007) in the Philippines reported that between 5 and 16 % of rice is lost in the postharvest process, which includes harvesting, handling, threshing and cleaning. During the postharvest period, another 5 to 21 % disappears during drying, storage, milling and processing. Total estimated losses not counting later losses by retailers and consumers ranged from 10 to 37 % of all rice grown (De Padua 1978, as cited by Chukwunta 2014). On the other hand, the losses at threshing operation were 19 and 17%, drying 9.3 and 7.0%, storage 4.2 and 6.0%, milling 1.3 and 1.0% and transportation 1.33 and 0.8% for Cameroon and Gambia, respectively (Majumder et al. 2016). According to a FAO and APO study (2006), postharvest losses of food grains in Bangladesh are about 15% of the total production and for south Asia is 10-37% (FAO 2007). In India, 25% cereal loss was reported by Goyal et al. (2017). The results found in the present study are closely agreed with many of the previous studies. In the present research, the critical loss point was identified as the producer level, where substantial pre-harvest field loss and postharvest loss occurred. In particular, storage loss was substantial (6.79%), and which result was in support of Awal et al. (2017).

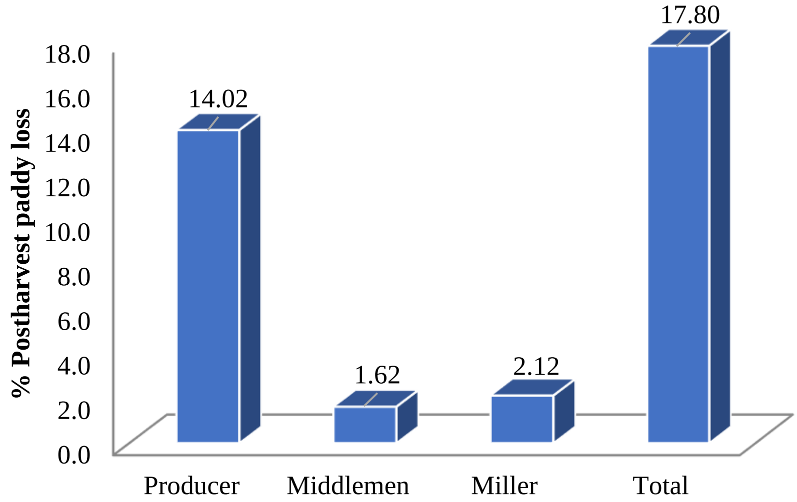


Fig 5.5 Total postharvest paddy loss (excluding pre-harvest field loss).

5.1.5 Comparison of paddy losses- 'Self-reported method' vs. 'Category method'

In Phulpur, Mymensingh, the estimated average postharvest paddy losses at the producers' level (excluding storage loss) of 6.6 and 7.5% were found when calculated through the 'Self-reported method' and 'Category method', respectively. The slightly higher estimates in the 'Category method' may be due to the categorization of the products and the use of category-wise damage co-efficient. The value loss as per 'Category method' was also estimated as 6.66% (Fig 5.6). The comparative postharvest paddy losses in Mahadebpur, Naogaon due to difference in methods of calculation are also shown in Fig 5.7.

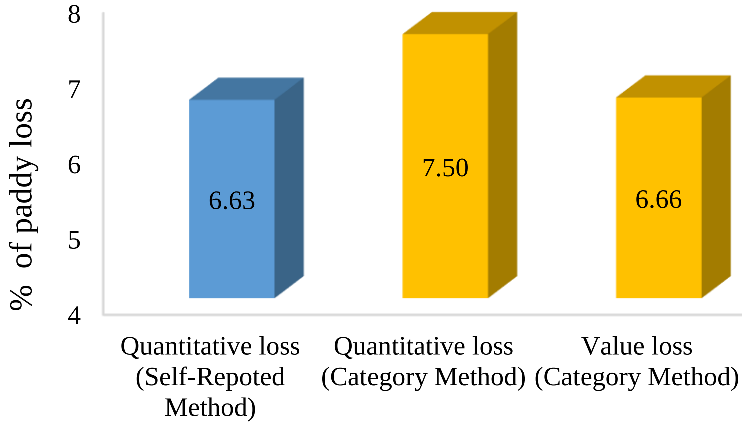


Fig 5.6 Comparative postharvest paddy loss estimates at the producers' levels (Phulpur, Mymensingh; N=25).

Table 5.3 Postharvest quantitative and value losses of paddy (Category Method, Delgado et al. 2017) in Phulpur, Mymensingh

Postharvest activities	Quantitative loss (%)				Value loss (%)			
Transportation, threshing, winnowing and drying	Mean	Max	Min	Std dev.	Mean	Max	Min	Std dev.
	7.50	14.84	2.90	3.01	6.66	13.38	1.92	3.03

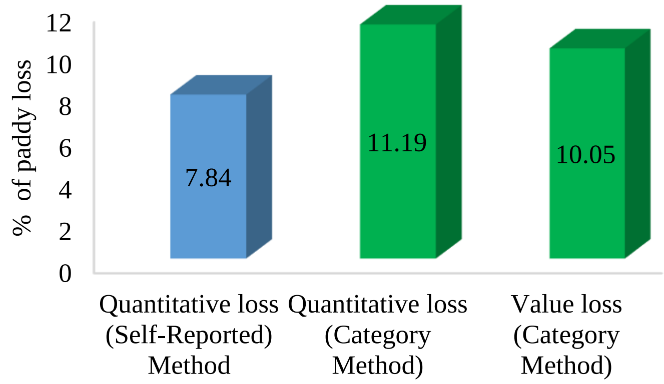


Fig 5.7 Comparative postharvest paddy loss estimates at the producers' levels (Mahadebpur, Naogaon; N=25).

Table 5.4 Postharvest quantitative and value losses of paddy ('Category method'; Delgado et al. 2017) in Mahadebpur, Naogaon

Postharvest activities	Quantitative loss (%)				Value loss (%)			
Transportation, threshing, winnowing and drying	Mean	Max	Min	Stdev.	Mean	Max	Min	Stdev.
	11.19	12.89	5.04	2.06	10.05	11.89	4.08	1.93

5.1.6 Underlying reasons and remedies for paddy losses at the producers' levels

The underlying reasons for substantial paddy losses at the producers' levels have been illustrated in Fig 5.8. Rodent (rat) damage has been identified as the critical factor followed by insect and pest damage and improper harvest techniques. To minimize losses, harvesting at proper maturity, employ efficient/trained labours and proper field management have been suggested.

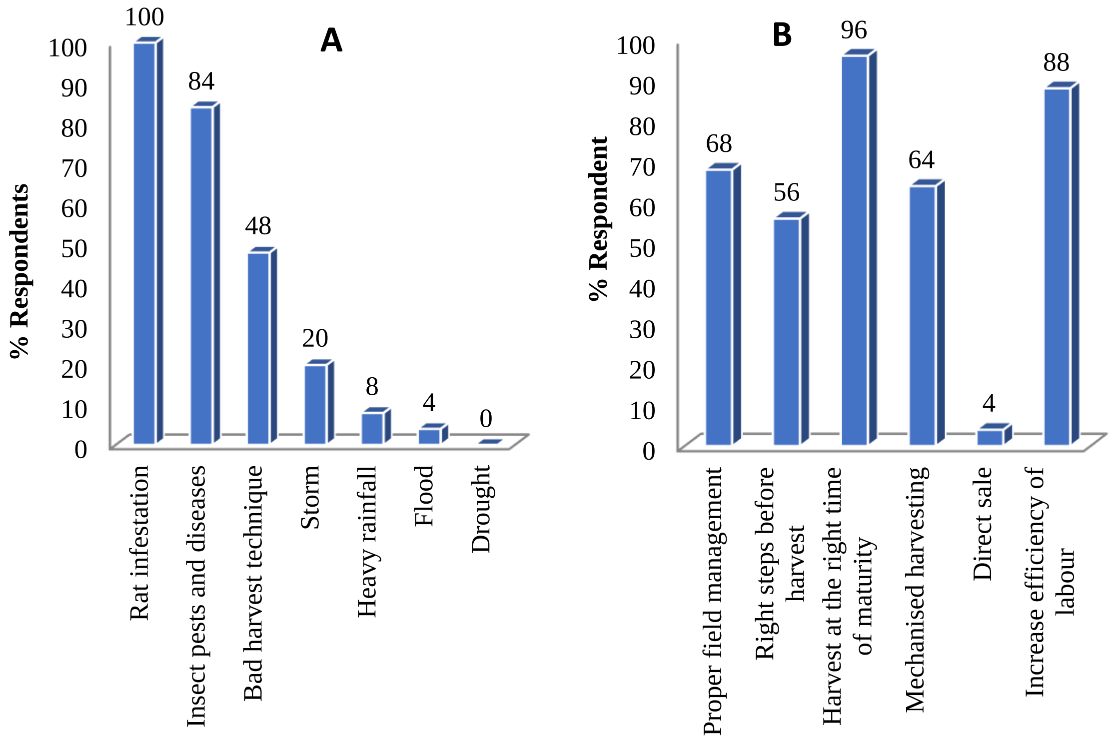


Fig 5.8 Underlying reasons for loss (A) and possible measures to reduce loss (B) at producers' levels (N=25).

5.2 WHEAT

Major food crops in Bangladesh are paddy, wheat and maize, where, wheat is the second most important staple food crop after rice. Over the last decades, wheat sector in Bangladesh has gone through many significant changes in terms of production. Extreme weather conditions and natural disasters in recent years affected the productivity of the crop. In recent times, farmers are opting for producing other food crops (such as 'boro' cultivation) over wheat. With the continuous fall of wheat production in Bangladesh, the country's dependency on wheat imports is increasing over time. The top four countries ahead of Bangladesh in importing wheat are Egypt, Indonesia, Algeria and Brazil. In 2020, wheat production in Bangladesh was 1250 thousand tons. Over the last 22 years, wheat production in Bangladesh decreased on an average by 0.18% each year, although it grew from 111 thousand tons in 1973 to 1988 thousand tons in 1999 (World Data Atlas 2020). On the other hand, wheat consumption in Bangladesh has more than doubled in the past six years for changing food habits, increasing demand and exports of bakery products. There was 116% rise in wheat import as its local cultivation failed to meet the demand. Being an essential commodity, wheat bears no import tariff. As per NBR, during 2019-20, 67 lakh tons of wheat (BDT 14114 crore) were brought into the country, whereas it was just 31 lakh tons during 2014-15 (The Daily Star 2020; 27 Sep 2020). Wheat comes to Bangladesh from 16 countries, including Russia, Canada, Ukraine, India, the US, Cyprus, Italy, Australia, Argentina, Estonia and Belgium. When it comes to its own production, Bangladesh averaged in the range of 10 to 12 lakh tons in the past six years. About 12 lakh tones were harvested from 3.5 lakh ha of land last fiscal year, whereas 11.5 lakh tons from 3.3 lakh ha of land in 2018-19 as per DAE (The Daily Star 2020; 27 Sep 2020).

Postharvest loss can occur at any stage along the wheat postharvest value chain. Understanding the circumstances around harvest and postharvest operations for a given crop will help reduce postharvest losses and improve the income of farm households. Reduction in wheat postharvest losses will also help to offset the costs of importing wheat. Improvements in postharvest management practices will help avoid both quantitative and qualitative losses and maintain the quality of the grain for various end uses. It is necessary to develop effective strategies for the postharvest value chain (farm to market) that avoid deterioration in wheat grain quantity and quality, satisfy market demands and improve income and food security of smallholder farmers (Dessalegn et al. 2017). Reduction in postharvest losses therefore is crucial to increase food availability and contribute to alleviation of food shortage problems. Managing the effect of postharvest losses has the potential tendency to reduce the effect of the efforts put into production and increase marketing efficiency (Addo et al. 2015). The current study was therefore designed to quantify the types and magnitudes of postharvest losses of wheat from producer to processor, identify underlying factors that contribute to the massive postharvest losses and recommend possible measures for reducing loss, and thereby increase income of wheat farmers, middlemen and millers in Bangladesh.

The present study was conducted in two leading wheat growing districts of Bangladesh, namely Pabna and Dinajpur. Study area was selected in order to collect the required data to estimate postharvest losses of wheat. The sites were selected on the basis of production volume of wheat and availability of automatic flour mills. Pabna and Dinajpur were selected as wheat cultivation is a common practice in these districts, where large amounts of wheat are produced every year. Dinajpur produces the largest amount of wheat in Bangladesh. Again, the largest number of automatic flour mills is also situated in Pabna. Transportation availability and other favourable conditions were also considered. From each of the districts, a particular Upazila was purposively selected to collect data from farmers, middlemen (Bepari) and millers. Upazila was selected after consulting with Upazila Agricultural Officer (AEO). Dinajpur Sadar Upazila from Dinajpur district and Ishwardi Upazila from Pabna district were selected to conduct the survey.

After randomly selecting 25 farmers and 25 middlemen (Bepari), apposite information was collected from them with the help of trained data enumerator along with SAAO (Sub-assistant Agriculture Officer). Data of last cropping season was recorded from the interviewees. Questions were asked to the farmers on information related to the harvesting methods, land area and production, storage facility, market facility, postharvest losses, etc. Similar information were also collected from middlemen (Bepari) including places of purchase and sale, storage facility, storage loss, transportation loss and other losses. Twelve automatic flour mills were visited, and a face-to-face interview was conducted with each of the owner/manager of the mills. Information about milling process, produced products and by-products, wastes, milling efficiency, other losses, price of different products and by-products, etc. were recorded. From the two mentioned study areas data were collected from total 50 farmers, 50 middlemen (Bepari) and 12 automatic flour mills. Field data collection activities are shown in the following (Plates 5.10-5.19).

Plate 5.10 Wheat data collection from producer (Ishwardi, Pabna).

Plate 5.11 Data collection on wheat from middleman, Bepari (Ishwardi, Pabna).

Plate 5.12 Data collection from automatic flour mill (Ishwardi, Pabna).

Plate 5.13 Data collection activities (Flour mill, Ishwardi, Pabna).

Plate 5.14 Data collection activities from producer (Dinajpur).

Plate 5.15 Data collection activities from producer (Dinajpur).

Plate 5.16 Data collection activities from producer (Dinajpur).

Plate 5.17 Data collection activities from middleman, Bepari (Dinajpur).

Plate 5.18 Data collection activities from miller (Dinajpur).

Plate 5.19 Data collection from flour mill (Dinajpur).

5.2.1 Wheat losses- Producers' level

5.2.1.1 Producer- Ishwardi, Pabna

Field loss is the loss, which occurs in the field due to rats, insects, shattering, mechanical faults, uncut amount of wheat damaged by storm, heavy rainfall, drought, and cutting loss due to unskilled labours etc. In the study area, the total field loss was found to be 8.76% (Table 5.5). Natural weight loss for traditionally un-stored wheat was found 6.45%, which occurred due to removal of moisture from wheat for drying, and removal of moisture is not actually food loos. Paddy loss due to transportation, threshing, winnowing, drying and storage were 0.32, 2.74, 0.60, 1.05 and 5.86%, respectively (Table 5.5; Fig 5.11A).

Table 5.5 Wheat losses at producer level (Ishwardi, Pabna)

Types of losses	N	Minimum	Maximum	Mean	Stdev.
Loss of harvest due to transportation	24	0.15	0.70	0.33	0.14
Loss due to threshing	25	0.75	4.50	2.73	0.92
Loss due to winnowing	25	0.20	2.50	0.60	0.50
Loss due to drying	25	0.20	2.80	1.05	0.96
Loss during storage	10	2.50	7.75	5.86	1.69
Natural weight loss for traditionally un-stored wheat	24	2.25	15.00	6.45	3.11
Percent loss during harvest in a normal year	25	3.00	16.00	8.76	3.69

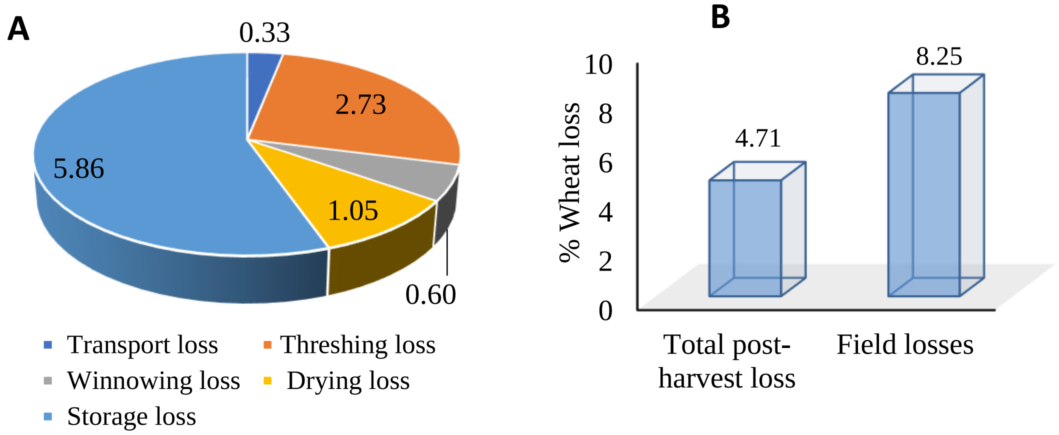


Fig 5.11 Postharvest loss (A) and pre-harvest field loss and postharvest loss (B) of wheat at producers' level (Ishwardi, Pabna).

5.2.1.2 Producer- Dinajpur

The pre-harvest field loss and postharvest losses of wheat at the producers' level in Dinajpur are summarized in Table 5.6 and Fig 5.12.

Table 5.6 Wheat losses at the producers' level in Dinajpur

Types of losses	N	Minimum	Maximum	Mean	Stdev
Percent loss during harvest in a normal year	25	1.25	11.25	6.39	2.51
Loss of harvest due to transportation	25	0.20	5.00	1.49	1.40
Loss due to threshing	25	0.75	3.35	1.84	0.83
Loss due to winnowing	25	0.25	2.25	1.09	0.56
Loss due to drying	25	0.15	2.25	0.89	0.68
Loss during storage	12	2.25	10.50	6.04	2.41
Natural weight loss for traditionally un-stored wheat	24	0.25	7.25	3.25	1.93

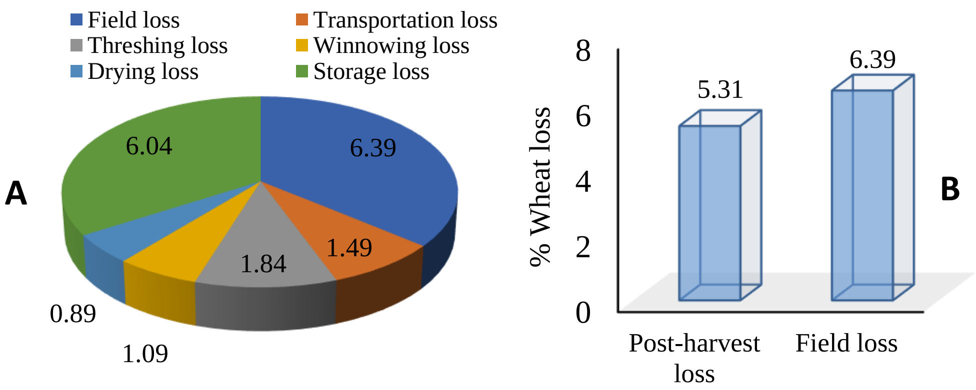


Fig 5.12 Postharvest loss (A) and pre-harvest field loss and postharvest loss (B) of wheat at producers' level (Dinajpur, N=25).

5.2.2 Wheat losses- Middlemen (Bepari) level

5.2.2.1 Middlmen- Ishwardi, Pabna

Middlemen (wholesaler and Aratdar) buy wheat from the producers from market and they directly bring to the 'Arat' (sell center) and sell those to the wheat millers. Significant amount of wheat is stored by the middlemen for around 1-3 months. Un-stored wheat loss occurs from the products which are not stored for a long time. It mainly occurs due to improper handling and transportation of wheat. From the study areas, natural weight loss for the stored wheat was found 1.09%, and natural weight loss for handling of un-stored wheat was found 0.97% (Fig 5.13). The following Tables 5.7 shows the percentage loss of the stored and un-stored wheat:

Table 5.7 Wheat losses at the middlemen level (Ishwardi, Pabna)

Types of losses	N	Minimum	Maximum	Mean	Stdev
Natural weight loss for stored goods	24	0.50	5.00	1.22	1.11
Natural weight loss for un-stored goods	24	0.00	5.00	0.97	1.94
Loss in a normal year	24	0.00	7.50	2.47	2.19

5.2.2.2 Middlemen- Dinajpur

Table 5.8 Wheat losses at the middlemen level (Dinajpur)

Types of losses	N	Minimum	Maximum	Mean	Stdev.
Natural weight loss for stored wheat	25	0.00	1.50	1.09	0.42
Natural weight loss for un-stored wheat	25	0.00	4.00	2.83	0.86

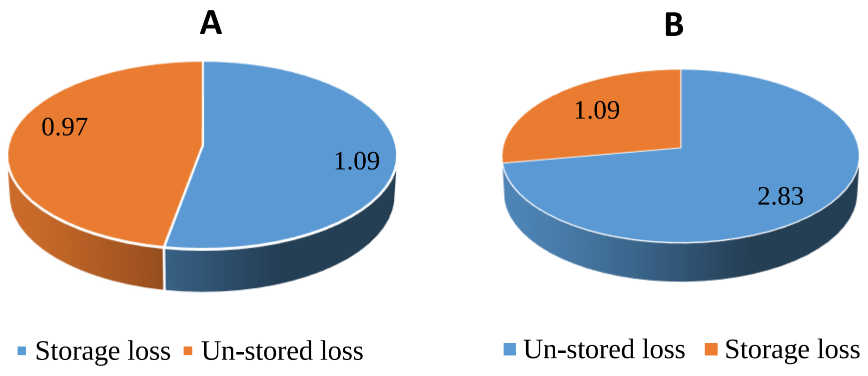


Fig 5.13 Wheat losses at middleman level (A- Ishwardi, Pabna; B- Dinajpur Sadar, Dinajpur; N=25).

5.2.3 Wheat losses at millers' level

5.2.3.1 Miller level (Ishwardi)

At miller level wheat loss is occurred in three stages (before processing, during processing and after processing). Some loss occurs during storage of some wheat by millers before processing which is called storage loss. From Ishwardi, Pabna it is found 0.75%. At miller level some losses occurred during handling, packaging, transporting which is called un-stored loss. At miller level it is found as 1.65%. At miller level, processing loss was found to be 1.03%, loss before processing was 0.95%. The following Fig 5.14 shows the levels of loss in the study area.

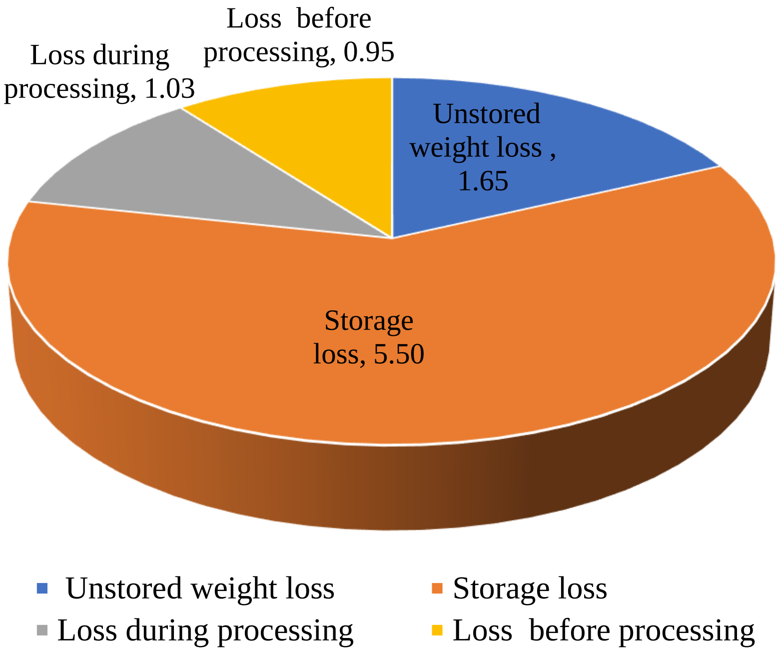


Fig 5.14 Wheat losses at miller level (Ishwardi, Pabna; N=10).

5.2.3.2 Miller level (Dinajpur)

Wheat loss at the millers' level in Dinajpur are shown in Table 5.9 and Fig 5.15.

Table 5.9 Wheat losses at the millers' level (Dinajpur)

Types of losses	N	Minimum	Maximum	Mean	Stdrv
Natural weight loss for un-stored wheat	2	0.00	0.25	0.13	0.18
Total loss during processing	2	1.05	5.75	3.40	3.32
Storage loss	2	0.25	5.00	2.63	3.36
Loss during processing	2	0.75	0.80	0.78	0.04

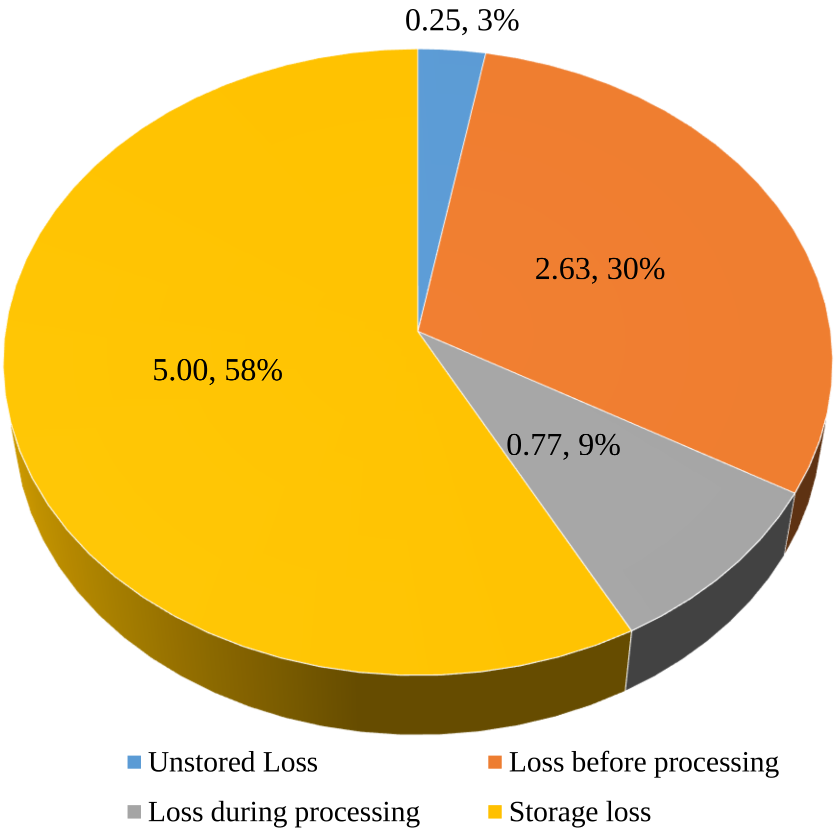


Fig 5.15 Wheat losses (%) at miller level (Dinajpur Sadar, Dinajpur; N=2).

Plate 5.20 Loss scenario at a surveyed flour mill.

5.2.5 Average total postharvest wheat losses in the selected value chains

The total postharvest loss of wheat in the study areas was 17.59%, where the losses at the producers, middlemen and millers' levels were 10.96%, 2.99% and 3.64%, respectively (Fig 5.16). Tadesse et al. conducted a study on "Assessment of Wheat Post-Harvest Losses in

Ethiopia" and estimated 17.1% wheat loss from harvesting to milling. But they could not consider loss in retailers' level.

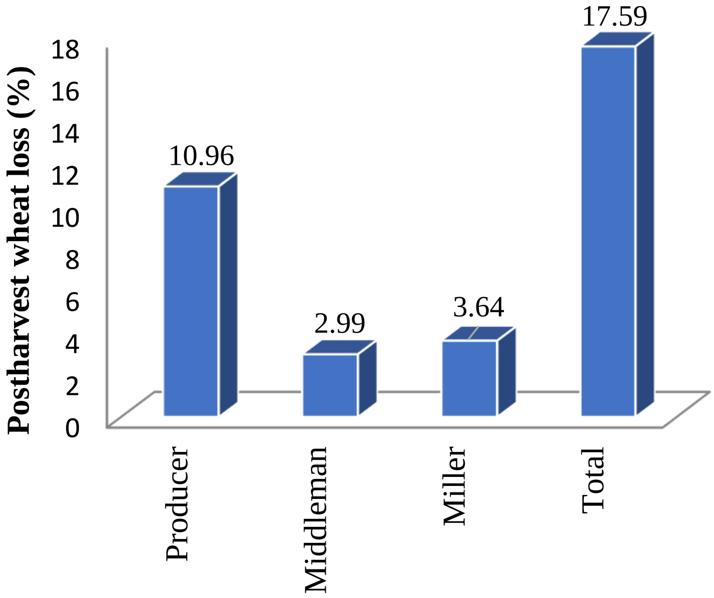


Fig 5.16 Average total postharvest wheat losses in the selected value chains.

5.2.6 Underlying reasons and remedies of wheat losses

The underlying reasons for substantial wheat losses at the producers' levels have been illustrated in Fig 5.17. Uncut, falling grains at farm, rodent (rat) damage and unskilled labourers have been identified as the critical factors for loss at the producers' levels. At the millers' level, losses were mainly occurred during transportation and cleaning (Fig 5.17).

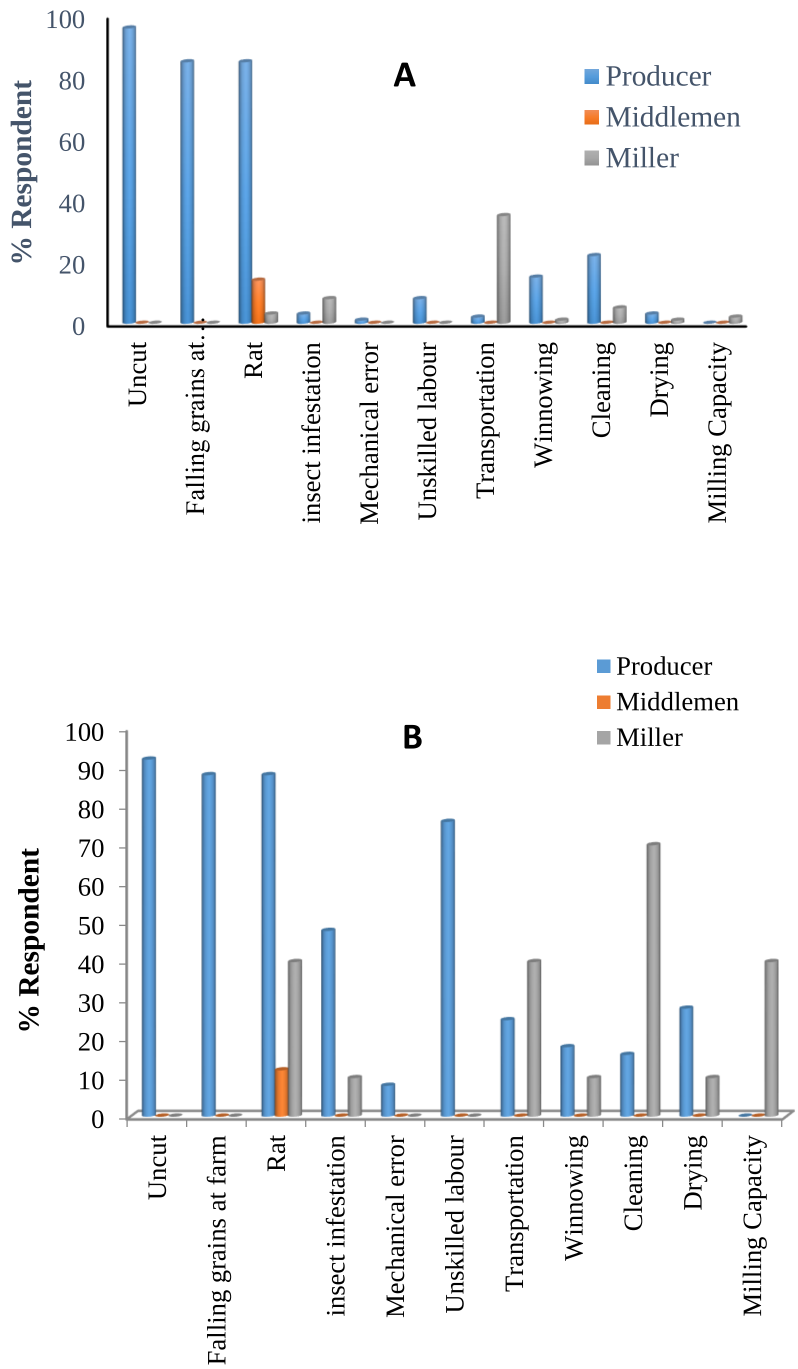


Fig 5.17 Underlying reasons for wheat losses in Dinajpur (A) and Pabna (B).

5.2.7 Ways to reduce wheat losses

To minimize losses, harvesting at proper maturity, employ efficient/trained labours, proper field management and mechanized harvesting have been suggested (Fig 5.18).

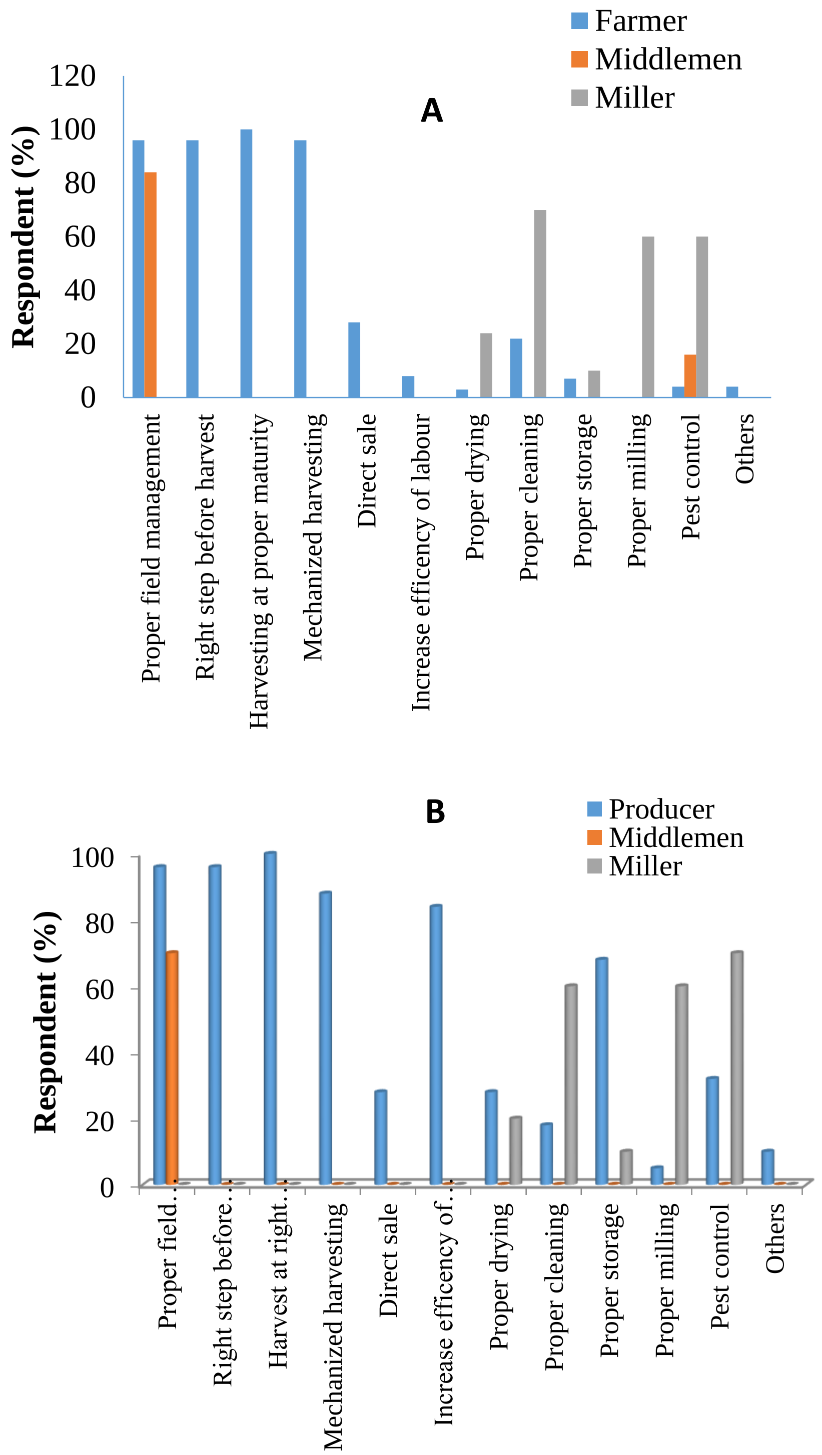


Fig 5.18 Ways to reduce of postharvest loss at Dinajpur (Top) and Pabna (Bottom).

5.2.8 Comparative estimates of wheat losses by 'Self-Reported' and 'Category Method'

The comparative estimates of postharvest losses at the producers' levels excluding storage losses are furnished in Tables 5.10 and 5.11. Slightly higher estimates were observed in case of 'Category method' as compared to that of the 'Self-reported method'.

Table 5.10 Wheat loss calculated by different methods (Dinajpur, N=25)

Descriptive statistics	% Quantitative loss (Self-reported method)	%Quantitative loss (Category method)	%Value loss (Category method)
Average	5.31	6.56	5.67
Stdev.	1.50	1.67	1.74

Table 5.11 Wheat loss calculated by different methods (Pabna, N=25)

Descriptive statistics	% Quantitative loss (Self-reported method)	%Quantitative loss (Category method)	%Value loss (Category method)
Average	4.70	8.02	12.20
Stdev.	1.45	2.73	3.94

5.2.9 Micronutrient analysis

Micronutrients, especially calcium iron, zinc and folate in paddy and wheat were determined. Levels of the nutrients vary with variety (Table 5.12). Wheat was found to contain very high amounts of folate as compared paddy (Fig 5.19). In case of rice, storage conditions and cooking methods influence the final folate concentrations available for nutrition. Dong et al. (2011) reported that folate contents of brown rice varied substantially from 13.3 to 111.4 µg 100 g^{-1}, whereas milled rice varied from 10.3 to 77.7 µg 100 g^{-1}. The average folate losses caused by storage and cooking were 23% and 48.3%, respectively. These results warrant developing new processing methods for maintaining higher folate contents in cooked rice.

Table 5.12 Micronutrient contents of different paddy varieties

Micronutrient	Paddy Variety				Unit
	BR-28		BR-49		
	Mean	Stdev	Mean	Std dev	
Ca	125.27	8.09	118.52	11.31	ppm
Fe	29.15	20.53	49.14	1.80	ppm
Zn	16.90	3.72	15.38	0.66	ppm

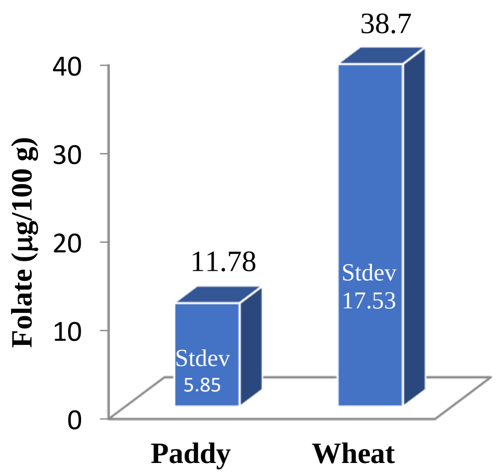


Fig 5.19 Folate contents in freshly-harvested paddy and wheat samples (N=3).

Chapter 6

FOOD LOSS- HORTICULTURAL PRODUCE

Assessment of quantitative and micronutrient losses of the selected horticultural products (mango, banana, potato, carrot, tomato and red amaranth) were assessed across the selected value chains. The results obtained are presented and discussed in this chapter.

6.1 MANGO

6.1.1 Present status of postharvest handling in mango value chain

Mango fruits reach the hands of the consumers after passing through a number of postharvest handling steps including sorting, grading, washing, packaging, transportation and storage. In the case of mango growers in the surveyed locations, sorting, grading, packaging and transportation are followed by most of the respondents (Table 6.1), while the practice of washing and storage are rarely followed by growers, although the latter practices are very common in the developed and some of the developing countries. So, there are scopes for improving postharvest handling practices, which would greatly contribute to reduce postharvest loss of mango.

Table 6.1 Postharvest activities performed during harvesting and postharvest handling of mango by the growers

Name of postharvest activity	% Respondents	
	Chapai Nowabganj (N=25)	Satkhira (N=25)
Washing	0.0	16.0
Sorting	84.0	100.0
Grading	100.0	100.0
Drying	0.0	12.0
Packaging	80.0	16.0
Storing	0.0	4.0
Transportation	84.0	84.0

6.1.2 Postharvest quantitative and qualitative losses

Postharvest losses of mangoes were estimated along the selected value chains. Mango losses were estimated at the growers and the intermediary (Bepari, wholesalers and retailers) levels following ‘Self-reported method’ and ‘Category method’ (Delgado et al. 2017). The postharvest quantitative losses of mangoes were estimated as 1.3, 7.2, 6.7 and 7.1% at the growers, Bepari, wholesalers’ and retailers’ levels with a total loss of 22.3% (Fig 2; ‘Self-reported method’). However, the loss with ‘Category method’ was 31.7% (Appendix 3). These results were at per with the results reported by Delgado et al. (2017), where ‘Category method’ generally shows slightly higher estimates as compared to ‘Self-reported method’. However, this estimated total loss in the current study excludes the field loss, and which cannot be harvested due to insect pest and disease attacks, disasters, and natural calamities, for instance AMPHAN during the period of data collection (2020). Rahman et al. (2017, 2019) reported that postharvest loss of mango ranged from 28-37%, which result also supports the present findings of 31.7% loss as estimated through ‘Category-method’ (Delgado et al. 2017). This is also important to note that the total postharvest loss of mango was slightly lower than that reported in 2010 (Hassan et al.

2010). In India, the postharvest loss of mango across the value chain i.e. during farm and post-farm operations was reported as 23.4% (IIHR 2014). Recently, Goyal et al. (2017) from India reported that fruits and vegetables loss in India is very high and was 37%. Recently Kamda Silapeux (2021) reported that 40-50% of fruits produced in Cameroon did not reach the consumers because of loss.

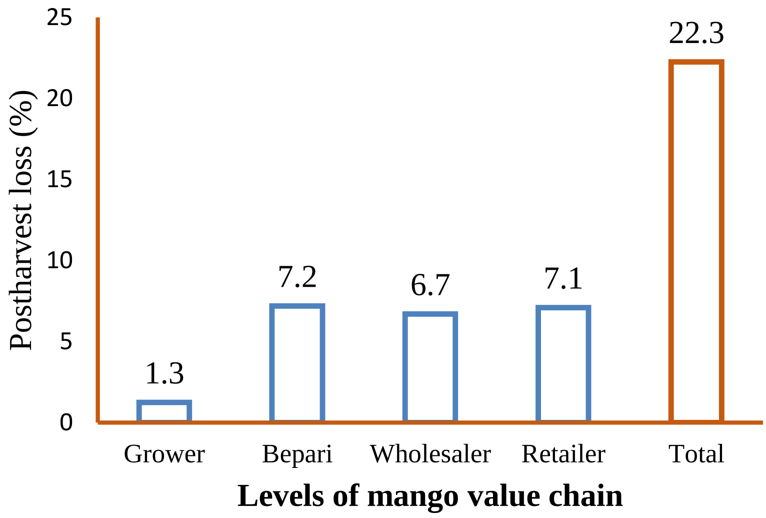


Fig 6.1 Postharvest loss of mango at the different levels of supply chain-'Self-reported method' (N = 200: 50 growers, 50 Bepari, 50 wholesalers and 50 retailers).

Postharvest loss of mangoes also varies with locations, especially at the Bepari level. As per the respondents, these results were attributed to the frequent natural calamities, high levels of pest and disease attacks due to high temperature, and the pre-dominantly cultivated Himsagar variety, which is prone to damage. Moreover, longer distance (Satkhira-Dhaka) and prevailing high temperature may also contribute to higher loss in Satkhira.

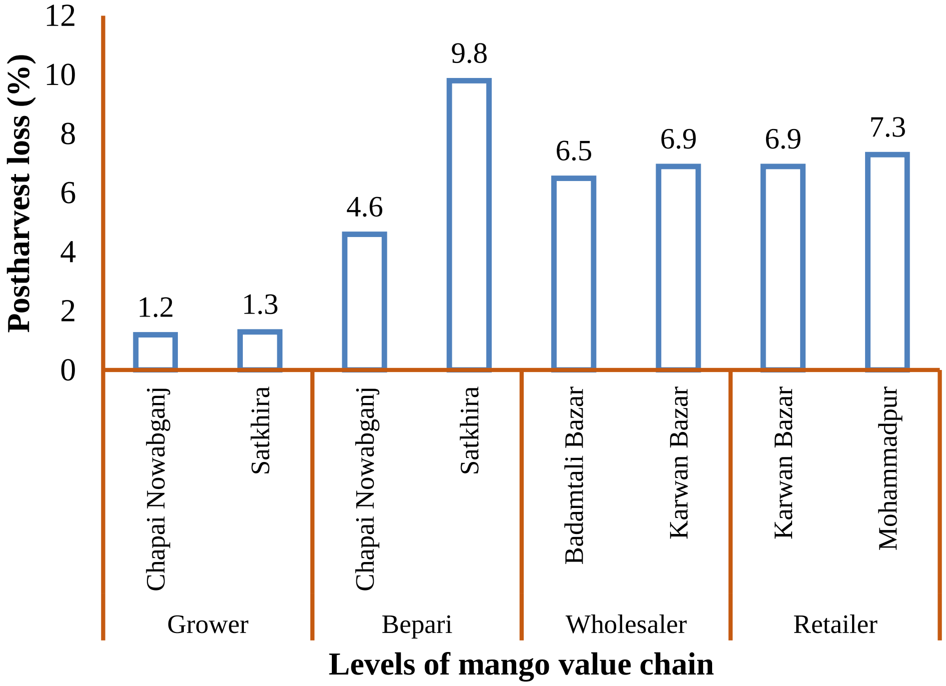


Fig 6.2 Location-wise estimates of postharvest loss of mango at different levels of supply chain-'Self-reported method' (N = 200: 50 growers, 50 Bepari, 50 wholesalers, 50 retailers).

6.1.3 Causes and remedies for loss of mango

Apart from assessing the magnitudes of quantitative losses, data and information on the possible reasons for losses and the ways and means to reduce losses were also collected from the respondents as summarized in Tables 6.2-6.5.

6.1.3.1 Growers

The reasons for postharvest losses at the growers' levels were mainly due to cuts, bruises, rots and insect damage. The levels of loss again differ with location. However, the main reasons for losses at the growers' levels were due to rots and bruises (Table 6.2). Interestingly, insect damage was found to be higher in Satkhira than Chapai Nowabganj.

Table 6.2 Reasons for incurring postharvest losses of mango at the growers' levels

Reasons for postharvest loss	% Respondent			
	Chapai Nowabganj (N=25)	Chapai Nowabganj (N=25)	Satkhira (N=25)	Satkhira (N=25)
	Number	%	Number	%
Cuts	15.0	60.0	11.0	44.0
Bruisea	24.0	96.0	19.0	76.0
Rots	25.0	100.0	18.0	72.0
Insect damage	7.0	28.0	21.0	84.0

Various opinions were suggested by the growers in order to minimize postharvest loss and field loss. In Chapai Nowabganj, harvesting by trained labourers, proper precautions during harvesting, perform proper field activities and immediate poastharvest sales have been suggested for minimizing postharvest loss of mango. In the case of the growers of Satkhira, opinions were in the favour of trained labourers, harvesting at proper stage of maturity and taking proper precautions during harvesting.

Table 6.3 Possible ways to reduce postharvest losses of mango at the growers' levels

Category	% Respondents			
	Chapai Nowabganj N=25)	Chapai Nowabganj (N=25)	Satkhira (N=25)	Satkhira (N=25)
	Number	%	Number	%
Perform proper field activities	24.0	96.0	13.0	52.0
Harvest at proper stage of maturity	19.0	76.0	18.0	72.0
Harvest by trained labours	25.0	100.0	22.0	88.0
Precautions during harvesting	25.0	100.0	16.0	64.0
Mechanical harvesting	6.0	24.0	4.0	16.0
Use of proper harvesting container (plastic crate)	3.0	12.0	15.0	60.0
Proper storage	1.0	4.0	4.0	16.0
Immediate sale after harvest	23.0	92.0	12.0	48.0

6.1.3.2 Middlemen

At the intermediary levels, bruise, rots, lack of storage and Covid-19 were found to be the major reasons for loss (Table 6.4). The postharvest losses of mangoes at the wholesalers' and retailers' levels were very high as compared to those of Bepari and growers levels due mainly to advanced levels of ripening and lack of options for storage and processing.

Table 6.4 Main reasons for incurring postharvest losses of mango at the wholesale and retail levels

Reasons for postharvest loss	**% Respondents**	
	Wholesaler (Dhaka, N=25)	Retailers (Dhaka, N=25)
Cuts	40.0	71.0
Bruise	92.0	94.0
Rots	76.0	77.0
Lack of storage	68.0	88.0
Low market demand	56.0	41.0
Insect infestation	28.0	29.0
Lack of electricity	0.0	6.0
Low market price	8.0	35.0
Effect of COVID-19	80.0	82.0

At the wholesale level, the possible options of reducing losses, as suggested by the respondents, included proper grading, processing, packaging and storage. The retailers also opined that proper sorting and grading, packaging, processing and proper storage facilities may contribute to reduce postharvest losses of mangoes during marketing.

Table 6.5 Possible options for reducing postharvest losses of mango at the wholesale and retail levels

Reasons for postharvest loss	**% Respondents**	
	Wholesaler (Dhaka, N=25)	Retailers (Dhaka, N=25)
Practice proper sorting	0.0	77.0
Practice proper grading	92.0	100.0
Pre-cooling	4.0	41.0
Proper storage	36.0	100.0
Proper packaging	44.0	100.0
Value addition (processing)	76.0	86.0
Others	16.0	6.0

6.2 BANANA

6.2.1 Status of important postharvest activities in banana value chain

Bananas reach the consumers through a number of supply chain actors. Unlike mango, hardly any improved postharvest handling practices are followed by the supply chain actors involved in banana production and marketing. For example, grading, packaging and storage are not practiced by the growers of the surveyed locations. By contrast, the wholesalers and retailers were found to practice sorting and grading during post-farm operations (Table 6.6). So, there are scopes for adopting improving postharvest handling practices, especially improved packaging and storage and also adopting sorting and grading practices at the growers' levels in order to minimize losses. The pre-dominant modes of transportation of bananas by the value chain actors are summarized in Table 6.8. Growers mostly use van; Bepari and wholesalers mostly use auto rickshaw, mini truck and truck; and retailers use van and rickshaw. Growers do not use low temperature storage.

Table 6.6 Status of postharvest activities performed by the banana value chain actors

Postharvest activities	**% Respondent**			
	Grower (Sadar, Bogura; N=25)	**Bepari (Mokamtala, Bogura; N=25)**	**Wholesaler (Dhaka; N=25)**	**Retailer (Dhaka; N=25)**
Washing	0.0	0.0	4.0	0.0
Sorting	0.0	0.0	92.0	25.0
Grading	0.0	5.0	92.0	25.0
Packaging	0.0	0.0	0.0	0.0
Storing	0.0	0.0	0.0	0.0
Transportation	100.0	25.0	100.0	25.0
Others	100.0	0.0	96.0	24.0

Table 6.7 Cultivated varieties of bananas in Bogura

Names of cultivated varieties	**% of growers**
Champa	60.0
Champa, Anagi (Plantain)	4.0
Anupam	8.0
Anupam, Champa	12.0
Sabri	16.0

Table 6.8 Mode of transportation of bananas by the value chain actors

Level of education	**% Respondent**			
	Grower (Sadar, Bogura; N=25)	**Bepari (Mokamtala, Bazar, Bogura; N=25)**	**Wholesaler (Dhaka; N=25)**	**Retailer (Dhaka; N=25)**
Head load	24.0	0.0	0.0	0.0
Bicycle	24.0	0.0	0.0	0.0
Van	92.0	88.0	92.0	100.0
Rickshaw	0.0	0.0	56.0	100.0
Animal cart	0.0	0.0	0.0	0.0
Auto rickshaw	20.0	64.0	0.0	0.0
Mini truck	0.0	88.0	100.0	0.0
Truck	0.0	84.0	100.0	0.0
Bus	0.0	0.0	4.0	0.0
Boat	0.0	0.0	0.0	0.0
Rail	0.0	0.0	0.0	0.0
Others	0.0	0.0	16.0	0.0

Table 6.9 Status of storage practice of banana by growers

Use of cold storage	% Respondent (Growers, Bogura Sadar, N=25)
Yes	4.0
No	96.0

In terms of place of sales of bananas, the growers mostly sell their produce to the Faria, Bepari and wholesalers (Table 6.10).

Table 6.10 Place of sale of banana by growers

Place of sales of banana	% Respondent (Growers, Bogura Sadar, N=25)
Rural assembly market	4.0
Wholesale market	92.0
Faria	100.0
Bepari	100.0

6.2.2 Levels of postharvest loss of banana

Harvest and postharvest losses of bananas were estimated along the selected value chains. Banana losses were estimated at the growers and the intermediary (Bepari, wholesalers and retailers) levels as per 'Self-reported method' and 'Category method' (Delgado et al. 2017). The postharvest quantitative losses of bananas were estimated as 0.4, 4.0, 8.4 and 7.5% at the growers, Bepari, wholesalers and retailers' levels, respectively with a total loss of 20.3% (Fig 6.3). The total loss with 'Category method' was 19.9% (Appendix 3). The total postharvest loss was significantly lower than that (24.6%) reported in 2010 (Hassan et al. 2010). In India, the postharvest loss of banana across the value chain i.e. during farm and post-farm operations was reported to be 10.56% (IIHR 2014).

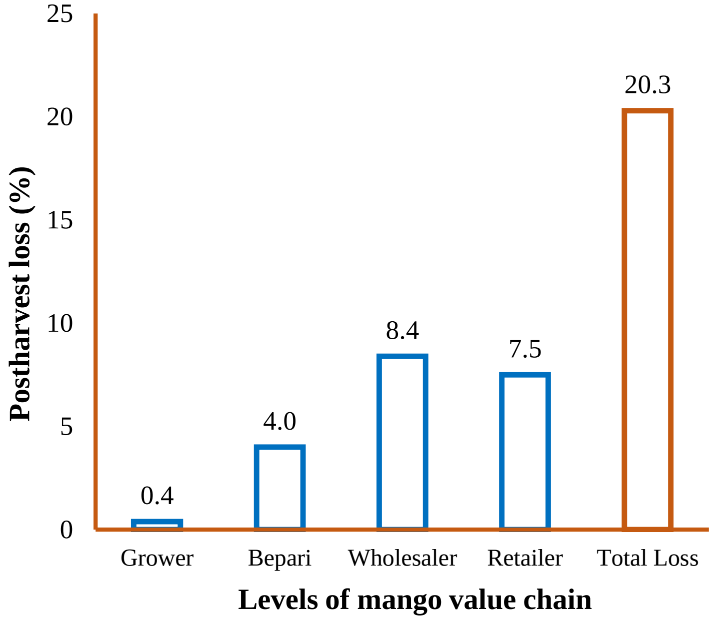


Fig 6.3 Total postharvest loss of banana at the different levels of supply chain- 'Self-reported method' (N = 200: 50 growers, 50 Bepari, 50 wholesalers and 50 retailers).

Postharvest loss of bananas also varies with locations, especially at the Bepari level, where loss in Madhupur, Tangail was higher than those of Mokamtala, Bogura, which might be due to cultivation and marketing of relatively tolerant varieties (Sabri and Champa) as compared to less tolerant Amritsagar and Mehersagar (Fig 6.4). Results also showed that the loss was the highest at the wholesalers' level followed by retailers and Bepari. The present results would have policy implications, and more emphasis should be given at the wholesale and retail level in minimizing loss. The growers level loss was minimal since, they just sell their bananas to the intermediary (Faria or Bepari), who actually perform the harvesting and postharvest operations.

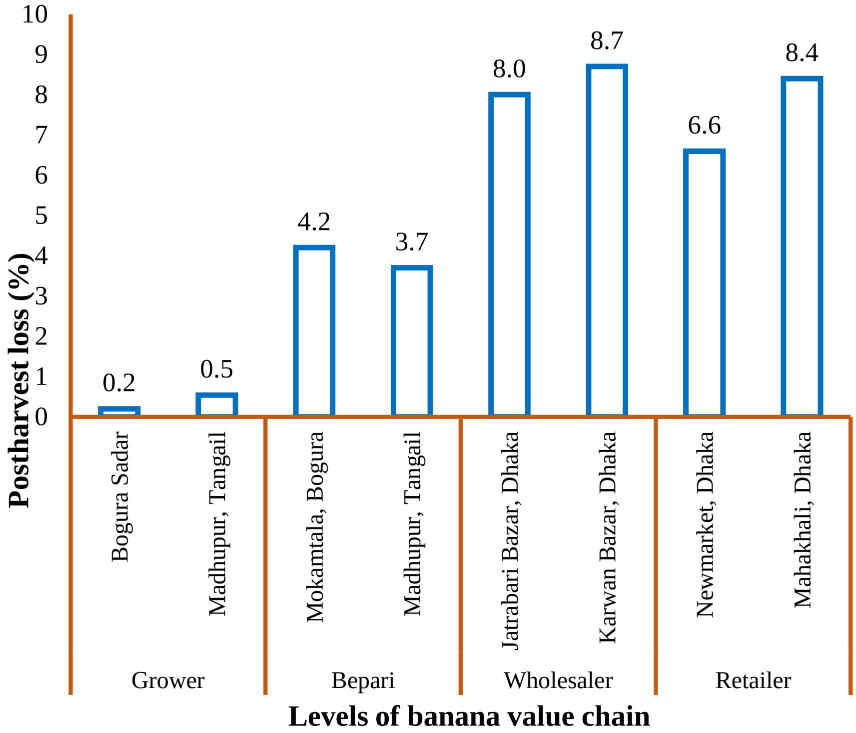


Fig 6.4 Location-wise estimates of postharvest loss of banana at different levels of supply chain-Self-reported method (N = 200: 50 growers, 50 Bepari, 50 wholesalers, 50 retailers).

6.2.3 Underlying causes of loss and possible remedies

Apart from assessing the magnitudes of quantitative losses, data and information on the possible reasons for losses and the ways and means to reduce losses were also collected from the respondents as summarized below.

6.2.3. At growers and Bepari level

The reasons for postharvest losses of bananas at the growers' levels of Madhupur, Tangail were mainly due to bruises and cuts (Table 6.11; Plate 6.1, Plate 6.2). However, the main reasons for the losses in Bogura as suggested by the respondents were due to bruises, low market price, low market demand and lack of storage.

Table 6.11 Reasons for incurring postharvest losses of banana at the grower and Bepari levels

Reasons for postharvest loss	% Respondents	
	Growers (Sadar, Bogura, N=25)	Bepari (Mokamtala Bazar, Bogura; N=25)
Cuts	28.0	0.0
Bruises	96.0	100.0
Rots	4.0	68.0
Insect damage	4.0	8.0
Lack of storage	0.0	60.0
Electricity problem	0.0	0.0
Low market demand	0.0	76.0
Low market price	0.0	76.0
COVID-19	0.0	52.0
Others	8.0	4.0

Various opinions were suggested by the growers in order to minimize postharvest loss and field loss of bananas. In Bogura, harvesting at proper stage of maturity by trained labourers and taking precautions during harvesting were suggested for minimizing postharvest loss of mango. At the Bepari level, practice of proper grading and creation of storage facilities have been suggested to improve the situation.

Table 6.12 Possible options for reducing postharvest losses of banana at growers and Bepari levels

Growers (Bogura Sadar, N=25)		Bepari (Mokamtala Bazar, N=25)	
Options to reduce loss	% Respondent	Options to reduce loss	% Respondent
Perform proper field activities	4.0	Sorting	0.0
Harvest at proper stage of maturity	100.0	Grading	68.0
Harvest by trained labourer	84.0	Storage	4.0
Taking precautions during harvesting	100.0	Pre-cooling	0.0
Mechanical harvesting	0.0	Packaging	0.0
Use of proper harvesting container	0.0	Value addition/processing	0.0
Proper preservation/storage	4.0	Others	52.0
Immediate postharvest sale	40.0	-	-
Others	0.0	-	-

6.2.3. At wholesalers and retailers level

At the wholesale and retail levels, bruises, rots and low market demand were found common to contribute to losses (Table 6.13; Plate 6.3, 6.4). Interestingly, Covid-19 impacted mainly at the wholesale level, possibly due to restrictions on movement.

Table 6.13 Reasons for incurring postharvest losses of banana at the wholesale and retail levels

Reasons for postharvest loss	**% Respondents**	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Cuts	24.0	64.0
Bruises	100.0	100.0
Rots	100.0	100.0
Insect infestation	12.0	12.0
Lack of storage	32.0	24.0
Electricity problem	0.0	8.0
Low market demand	96.0	84.0
Low market price	28.0	44.0
COVID-19 impact	96.0	20.0

At the wholesale and retail levels, the possible options of reducing losses, as suggested by the respondents, included practicing proper sorting and grading and facilitate processing or value addition activities and packaging (Table 6.14).

Table 6.14 Possible options for reducing postharvest losses of banana at the wholesale and retail levels

Reasons for postharvest loss	**% Respondents**	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Practice of proper sorting	80.0	96.0
Practice of proper grading	96.0	96.0
Pre-cooling	4.0	28.0
Proper packaging	0.0	0.0
Value addition (processing)	36.0	32.0

Plate 6.1 Field and postharvest damage of banana at growers' level (Madhupur, Tangail).

Plate 6.2 Pictures showing nature of damage of bananas due to rough handling during harvesting and transportation.

Plate 6.3 Pictures showing nature of postharvest damage of bananas at the wholesale level (Karwan Bazar, Dhaka).

Plate 6.4 Pictures showing postharvest loss of banana fruits at the retail levels due to over ripening and lack of options for processing and storage.

6.3 POTATO

Potatoes reach the consumers through a number of supply chain actors. Results showed that all growers grade their produce. Jute bags are mostly used as harvesting container by the growers in Bogura (Table 6.15). Packaging and sorting practices are also practiced by most of the growers. Most importantly, 80% of the growers store their produce and 40% of them wash their produce for early marketing (Table 6.16). Most-cultivated variety in Bogura is Lalpakhri followed by Granola and Romano (Table 6.17). Sorting, grading and packaging are also practiced by most Bepari. However, only 56% of the Bepari store potatoes. The pre-dominant modes of transportation of potatoes by the value chain actors are summarized in Table 6.18. Growers mostly use van and auto rickshaw; Bepari and wholesalers mostly use mini truck and truck; retailers use van, rickshaw and auto rickshaw.

6.3.1 Status of postharvest activities performed by the potato value chain actors

Table 6.15 Different types of harvesting containers used by potato growers

Names of harvesting containers	% of growers
Bamboo basket	4.0
Plastic bag	20.0
Jute bag	88.0
Plastic crate	16.0

Table 6.16 Status of postharvest activities performed by the potato value chain actors

Postharvest activities	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mahasthan Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Washing	40.0	56.0	20.0	0.00
Sorting	84.0	100.0	100.0	92.00
Grading	100.0	100.0	60.0	100.00
Drying	56.0	8.0	44.0	0.00
Packaging	92.0	100.0	100.0	100.00
Storing	80.0	56.0	100.0	4.00
Transportation	92.0	100.0	96.0	88.00

Table 6.17 Cultivated varieties of potato in Bogura

Names of cultivated varieties	% of growers
Asterix	12.0
Cardinal	8.0
Granola	16.0
Lalpakhri	32.0
Romano	16.0

Table 6.18 Mode of transportation of potato by the value chain actors

Mode of transportation	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mokamtala, Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Head load	4.0	0.0	36.0	0.0
Bicycle	0.0	0.0	28.0	0.0
Van	100.0	4.0	44.0	96.0
Rickshaw	8.0	0.0	0.0	48.0
Animal cart car	0.0	0.0	0.0	8.0
Auto rickshaw	88.0	0.0	4.0	44.0
Mini truck	0.0	36.0	88.0	36.0
Truck	0.0	100.0	84.0	4.0
Bus	0.0	0.0	4.0	0.0
Boat	0.0	0.0	16.0	0.0
Rail	0.0	0.0	0.0	0.0
Others	0.0	0.0	0.0	4.0

Table 6.19 Methods of storage of potatoes by the growers

Reasons for not practicing storage	% Respondent (Growers, Bogura Sadar, N=25)
Traditional storage	56.0
Cold storage	100.0

Table 6.20 Cost of storage cost for potato

Cost (Tk. 80 kg $sack^{-1}$)	% Respondent (Growers, Bogura Sadar, N=25)
220	36.0
230	12.0
250	32.0
260	12.0
300	8.0

Table 6.21 Duration of storage of potato in traditional storage

Duration of storage	% Respondent (Growers, Bogura Sadar, N=25)
Traditional (month)	
1	4.0
3	4.0
4	40.0
6	4.0
Cold storage (month)	
4	16.0
5	16.0
6	24.0
7	20.0
8	24.0

Table 6.22 Place of sale of potato by the growers

Place of sales of potato	% Respondent (Growers, Bogura Sadar, N=25)
Farm	4.0
Village market	64.0
Wholesale market	88.0
Retailer	52.0
Super market	8.0

Table 6.23 Buyers of potato from the growers

Types of buyers	% Respondent (Growers, Bogura Sadar, N=25)
Faria	8.0
Bepari	28.0
Aratdar (commission agent)	36.0
Wholesalers	88.0
Consumers	44.0

6.3.2 Levels of postharvest loss

Postharvest losses of potatoes were estimated along the selected value chains. Potato losses were estimated at the growers and the intermediary (Bepari, wholesalers and retailers) levels. The postharvest quantitative losses of potatoes as estimated through 'Self-reported method' were estimated as 2.1, 3.1, 3.7 and 5.9% at the growers, Bepari, wholesalers and retailers' levels, respectively with a total loss of 14.8% (Fig 6.5). The loss with 'Category-method' was 21.8% (Appendix 3). The present result was in agreement with Delgado et al. (2017), where 12.87 and 19.86% losses of potatoes were reported with 'Self-reported method' and 'Category-method', respectively. In India, the postharvest loss of potatoes across the value chain i.e. during farm and post-farm operations was reported to be 15.72% (IIHR 2014). Earlier in Bangladesh, the postharvest losses of the conventionally-stored and cold-stored potatoes were 27.7 and 23.1%, respectively (Hossain and Mia 2009) indicating a significant reduction of losses in the last decade.

Postharvest loss of potatoes varies with locations only at the growers levels, where loss in Munshiganj was found to be higher than those of Bogura, which might be due to cultivation and marketing of relatively tolerant varieties (only Diamant) as compared to various tolerant and non-tolerant varieties (e.g. granola, cardinal, etc.). Results also showed that the loss was the highest at the wholesalers' level followed by retailers and Bepari levels. The present results would have policy implications, and more emphasis should be given at the intermediary levels in minimizing postharvest loss of potatoes.

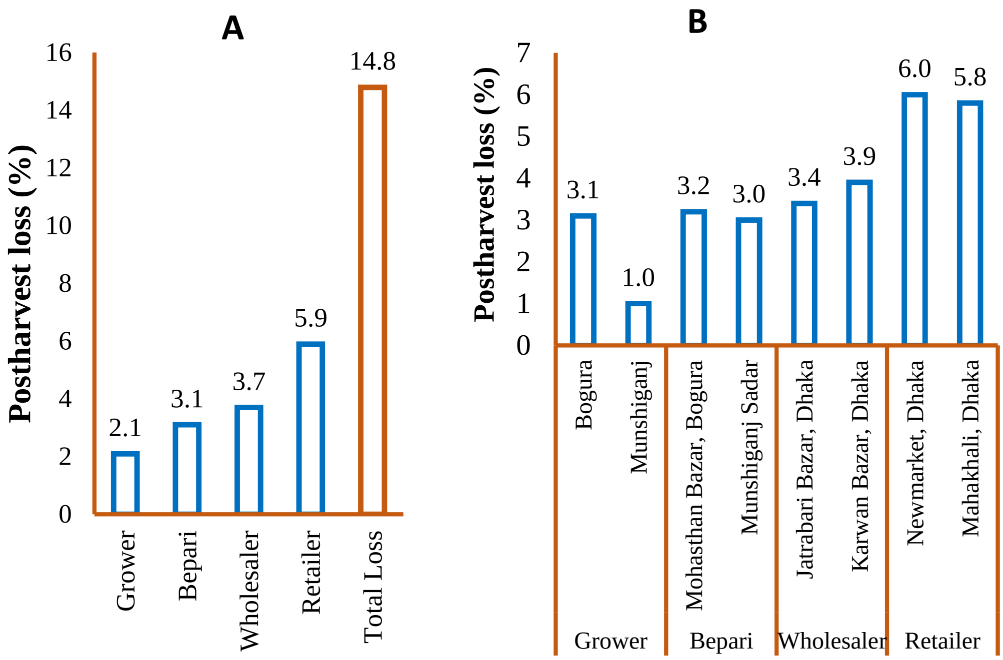


Fig 6.5 Total (A) and location-specific postharvest losses (B) of potato across value chains- ‘Self-reported method’ (N = 200: 50 each of growers, Bepari, wholesalers and retailers).

6.3.3 Causes and remedies for loss of potatoes

Apart from assessing the magnitudes of quantitative losses, data and information on the possible reasons for losses and the ways and means to reduce losses were also collected from the respondents and summarized below.

6.3.3.1 Grower and middlemen (Bepari)

The reasons for postharvest losses of potatoes at the growers’ levels of Bogura were mainly due to cuts, bruises, insect damage and rots (Table 6.24). Reasons were more or less same at the Bepari level (Table 6.24; Plates 6.5, 6.6). Various opinions were suggested by the growers in order to minimize postharvest loss and field loss of potatoes. In Bogura, conduct proper field activities, harvesting at proper stage of maturity by trained labourers, taking precautions during harvesting, proper storage, etc. were suggested for minimizing postharvest loss of potatoes. At the Bepari level, practice of proper sorting, grading, packaging, storage, and value addition were suggested to improve the situation (Table 6.25).

Table 6.24 Reasons for incurring postharvest losses of potato at the grower and Bepari levels

Reasons for postharvest loss	% Respondents	
	Growers (Sadar, Bogura, N=25)	Bepari (Mohasthan Bazar, Bogura; N=25)
Cuts	100.0	36.0
Bruises	100.0	36.0
Rots	84.0	52.0
Insect damage	100.0	24.0
Lack of storage	0.0	8.0
Electricity problem	0.0	8.0
Low market demand	0.0	12.0
Low market price	0.0	36.0

Table 6.25 Options for reducing postharvest losses of potato at the growers and Bepari levels

Growers (Bogura Sadar, N=25)		**Bepari (Mokamtala Bazar, N=25)**	
Options to reduce loss	% Respondent	Options to reduce loss	% Respondent
Proper field activities	100.0	Proper sorting	44.0
Harvest at proper stage of maturity	96.0	Proper grading	40.0
Harvest by trained labour	96.0	Proper storage	28.0
Taking precautions during harvesting	80.0	Pre-cooling	20.0
Mechanical harvesting	92.0	Proper packaging	32.0
Use of plastic crates	84.0	Value addition	32.0
Proper preservation/storage	84.0	Others	0.0
Immediate postharvest sale	68.0	-	-
Others	4.0		

At the wholesale level, cuts, lack of storage and Covid-19 pandemic were found common to contribute to losses (Table 6.26). At the retail level, rots, insect damage, bruises, cuts and Covid-19 were the important reasons for loss.

Table 6.26 Reasons for incurring postharvest losses of potatoes at the wholesalers and retailers levels

Reasons for postharvest loss	**% Respondents**	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Cuts	28.0	60.0
Bruises	4.0	88.0
Rots	4.0	100.0
Insect damage	4.0	92.0
Lack of storage	24.0	36.0
Lack of electricity	4.0	4.0
Low market demand	0.0	16.0
Low market price	0.0	16.0
COVID-19	36.0	56.0
Others	0.0	8.0

At the wholesale and retail levels, the possible options of reducing losses, as suggested by the respondents, included practicing proper sorting and grading, proper packaging and storage, facilitate processing or value addition activities (Table 6.27).

Table 6.27 Options for reducing postharvest losses of potatoes at wholesale and retail levels

Reasons for postharvest loss	**% Respondents**	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Practice of proper sorting	100.0	100.0
Practice of proper grading	72.0	88.0
Proper storage	96.0	12.0
Pre-cooling	84.0	12.0
Proper packaging	4.0	96.0
Value addition (processing)	80.0	56.0
Others	0.0	16.0

Plate 6.5 Pictures showing data collection on postharvest loss assessment of potato.

Plate 6.6 Pictures showing nature of damage of the early-harvested and non-cured potatoes (Lal Pakhri- top) and Diamanat (bottom).

Plate 6.7 Pictures showing general scenario of stacking pattern of potato sacks in cold store and the practice of sorting of the cold-stored potatoes.

Plate 6.8 Pictures showing nature of postharvest damage to the cold-stored potato tubers.

6.4 CARROT

6.4.1 Status of postharvest activities performed by the carrot value chain actors

A number of postharvest activities are performed by the carrot growers of Bogura as summarized in Table 6.28. The important activities performed by the growers of Bogura include washing, sorting, grading, packaging and storage. It was observed that 12% of the growers follow some sort of traditional storage but 96% of the growers mentioned that they have experience with cold storage of carrots (Table 6.29).

Table 6.28 Status of postharvest activities performed by the carrot value chain actors

Postharvest activities	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mahasthan Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Washing	100.0	100.0	28.0	0.0
Sorting	68.0	100.0	100.0	100.0
Grading	100.0	100.0	88.0	100.0
Drying	4.0	0.0	40.0	0.0
Packaging	100.0	100.0	100.0	92.0
Storage	100.0	40.0	100.0	16.0
Transportation	100.0	0.0	0.0	100.0
Curing	48.0	96.0	-	-

Table 6.29 Methods of storage of carrot by growers

Methods of storage	% Respondent
Traditional storage	12.0
Cold storage	96.0

5.1.3.5.2 Levels of postharvest losses of carrot

Postharvest losses of carrots were estimated across the selected value chains. Potato losses were estimated at the growers and the intermediary (Bepari, wholesalers and retailers) levels. The postharvest quantitative losses of carrots were estimated as 2.6, 8.3, 4.6 and 5.1% at the growers, Bepari, wholesalers and retailers' levels, respectively with a total loss of 20.6% (Fig 6.6A; 'Self-reported method'). The loss, however, following 'Category-method' was 26.1% (Appendix 3). Similar report was not found available in Bangladesh. Postharvest loss of carrots greatly vary with locations, especially at the growers and Bepari levels, where losses in Bogura were significantly higher than those observed on Ishwardi, which might be due to the fact that the growers of Ishwardi do not do anything but cultivation, and all the harvesting and postharvest activities are performed by the Bepari (Fig 6.6B; Plate 6.9). Moreover, growers and traders of Ishwardi are very skilled and experienced in carrot production and marketing, which may also contribute to less loss in Ishwardi.

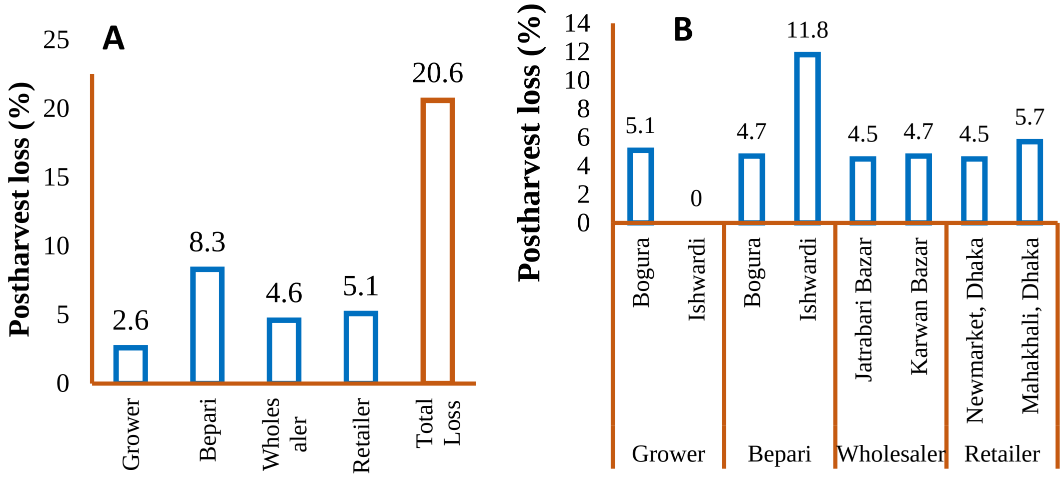


Fig 6.6 Total postharvest loss (A) and location-specific loss (B) of carrot at the different levels of supply chain- Self-reported method (N = 200: 50 growers, 50 Bepari, 50 wholesalers, 50 retailers).

Plate 6.9 Data collection activities on postharvest loss assessment of carrot.

6.4.3 Underlying causes of loss and remedial measures

6.4.3.1 Growers and Bepari

The reasons for postharvest losses of carrots at the growers' levels were mainly due to cuts, bruises, insect damage and rots (Table 6.30; Plate 6.10). Reasons of losses were more or less the same at the Bepari level as those of the growers along with low market demand (Table 6.30). Various opinions were suggested by the growers in order to minimize postharvest loss and field loss of carrots, which include conduct proper field activities, harvesting at proper stage of maturity and facilities for proper storage (Table 6.31). At the Bepari level, practice of proper sorting, grading and value addition were suggested to improve the situation (Table 6.32).

Table 6.30 Reasons for incurring postharvest losses of carrot at the grower and Bepari levels

Reasons for postharvest loss	**% Respondents**	
	Growers (Sadar, Bogura, N=25)	Bepari (Mahasthan, Bogura; N=25)
Cuts	100.0	92.0
Bruises	100.0	80.0
Rots	40.0	60.0
Insect infestation	76.0	28.0
Lack of storage	0.0	12.0
Electricity problem	0.0	0.0
Low market demand	0.0	0.0
Low market price	0.0	72.0


Plate 6.10 Pictures showing nature of damage on harvested carrot roots.

Table 6.31 Options for reducing postharvest losses of carrot at growers and Bepari levels

Options for reducing postharvest loss	**% Respondent**
	Growers (Sadar, Bogura, N=25)
Proper field activities	100.0
Harvest at proper stage of maturity	92.0
Harvest by trained labour	44.0
Taking precaution during harvest	68.0
Mechanical harvesting	52.0
Use of plastic crates as harvest containers	68.0
Proper preservation/storage	84.0
Immediate postharvest sale	24.0

Table 6.32 Possible options for reducing postharvest losses of carrot at the Bepari level

Options for reducing postharvest loss	% Respondent
	Bepari (Mahasthan, Bogura; N=25)
Sorting	92.0
Grading	92.0
Proper storage	20.0
Cool condition	20.0
Proper packaging	32.0
Value addition	84.0

6.4.3.2 Wholesale and retail levels

At the wholesale level, bruises, rots, insect damage and lack of storage were found to be the main causes of losses. At the retail level, cuts, bruises, rots and lack of market demand were the important reasons for loss (Table 3.33). At the wholesale level, the possible options of reducing losses, as suggested by the respondents, included practicing proper sorting and grading, proper packaging and storage (Table 3.34). At the retail level, proper sorting and grading may improve the situation.

Table 6.33 Main reasons for incurring postharvest losses of tomato at the wholesalers and retailers levels

Reasons for postharvest loss	% Respondents	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Cuts	44.0	80.0
Bruises	100.0	96.0
Rots	96.0	80.0
Insect infestation	96.0	12.0
Lack of storage	92.0	20.0
Electricity problem	0.0	0.0
Low market demand	0.0	32.0
Low market price	4.0	64.0
COVID-19 impact	32.0	36.0

Table 6.34 Possible options for reducing postharvest losses of tomato at the wholesalers and retailers' levels

Reasons for postharvest loss	% Respondents	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Practice of proper sorting	100.0	96.0
Practice of proper grading	96.0	80.0
Proper storage	100.0	16.0
Pre-cooling	48.0	36.0
Proper packaging	92.0	48.0
Value addition (processing)	44.0	24.0

6.5 TOMATO

6.5.1 Status of postharvest activities performed by the tomato value chain actors

There was wide variation in respect of cultivated varieties (Table 6.35). Tomatoes are highly perishable and reach the consumers through a number of supply chain actors. Results showed that all the value chain actors grade their produce, while the middlemen mainly perform sorting. Packaging is also practiced by most of the value chain actors, while practice of storage is very rare at the growers' level. Plastic crates, plastic net bags and jute bags of varying capacities are used for packaging by the middlemen (Table 6.36). Results also showed that 25-30 kg plastic crates and 2 kg plastic bet bags are mostly used by the middlemen. Use of plastic crates and plastic net sacks by both the retailers and wholesalers is a sign of improvement in packaging sector of Bangladesh.

Table 6.35 Cultivated varieties of tomato in Bogura

Names of cultivated varieties	% of growers
Hybrid 1217	28.0
Bahubali	4.0
Beautiful/Bijli/Hybrid 1217/Bahubali	4.0
Lovely	16.0
Lovely/Bahubali	4.0
Safal	12.0
Safal/Hybrid 1217/Bahubali	4.0
Safal/Hybrid 1217	14.0
Others	14.0

Table 6.36 Status of postharvest activities performed by the tomato value chain actors

Level of education	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mahasthan Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Washing/cleaning	4.0	8.0	100.0	100.0
Sorting	8.0	96.0	100.0	100.0
Grading	100.0	100.0	100.0	100.0
Drying	4.0	12.0	96.0	100.0
Packaging	76.0	92.0	100.0	100.0
Transportation	68.0	96.0	100.0	100.0

Table 6.37 Use of plastic crates and other packaging materials at the middlemen level

Types of packaging	% Respondent		
	Retailers	Wholesalers	Bepari
Plastic crates (20 kg)	8.0	0.0	64
Plastic crates (25 kg)	68.0	0.0	36
Plastic crates (30 kg)	24.0	65.0	-
Plastic crates (40 kg)	0.0	24.0	-
Bamboo basket (60 kg)	0.0	6.0	-
Plastic net bag (25 kg)	48.0	77.0	-
Plastic net bag (30 kg)	4.0	24.0	-
Jute bag (30 kg)	8.0	30.0	-
Jute bag (40 kg)	0.0	71.0	-

Plate 6.10 Pictures showing practice of improved harvesting contains (rigid plastic crates) during harvesting and transportation of tomatoes.

Table 6.38 Mode of transportation of tomato by the value chain actors

Level of education	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mahasthan Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Head load	4.0	0.0	4.0	0.0
Van	36.0	32.0	36.0	53.0
Rickshaw	0.0	8.0	0.0	0.0
Auto rickshaw	92.0	48.0	92.0	11.9
Mini truck	0.0	84.0	0.0	94.0
Truck	0.0	44.0	0.0	100.0
Other	-	-	0.0	5.9

Use of low temperature storage by the stakeholders is very unnoticeable. Results showed that only 8% of the Bepari responded that they have used cold storage to store tomatoes. So, there is great need to create facilities for low temperature storage of tomatoes. Most of the respondents had no idea/knowledge about the use of cold storage for tomatoes. They also mentioned that there is lack of storage facilities and also, they have no knowledge or experience on storage (Tables 6.39, 6.40).

Table 6.39 Status of storage of tomatoes by the value chain actors

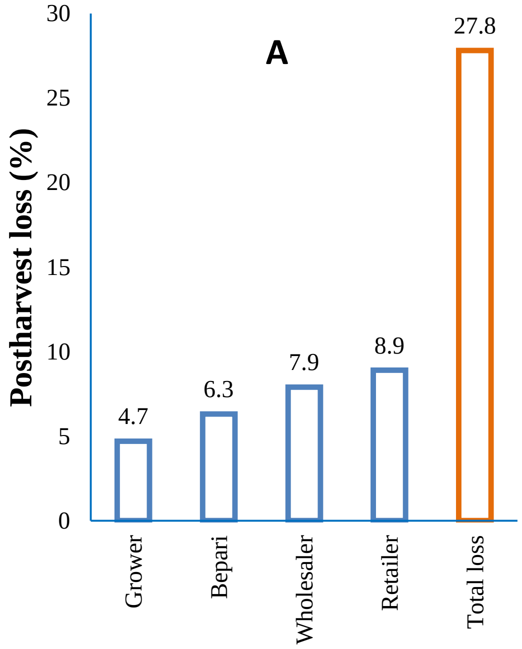
Level of education	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mahasthan Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Yes	0.0	8.0	0.0	0.0
No	100.0	92.0	100.0	100.0

Table 6.40 Reasons for not storing highly perishable tomatoes by the value chain actors

Level of education	% Respondent			
	Grower (Sadar, Bogura; N=25)	Bepari (Mahasthan Bazar, Bogura; N=25)	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Perishable	12.0	60.0	76.0	100.0
No experience	92.0	100.0	100.0	100.0
No cold storage	0.0	68.0	88.0	100.0

6.5.2 Levels of postharvest loss

The average total postharvest losses of tomatoes (growers to retailers) were 4.7, 6.3, 7.9 and 8.4% at the growers, Bepari, wholesalers and retailers' levels, respectively with a total loss of 27.8% (Fig 6.7; 'Self-reported method'). The loss with 'Category-method' was 27.9% (Appendix 3). The loss was comparatively lower than those (32.9%) reported by Hassan et al. (2010). However, the estimated total loss in the current study excludes the field loss, which has been observed as around 10%. Like other produce, postharvest loss of tomatoes also varies with locations for all the value chain actors. Results showed that loss was the highest at the retailers' levels followed by wholesalers and Bepari. The present results would have policy implications, and more emphasis should be given at the intermediary levels in minimizing loss.



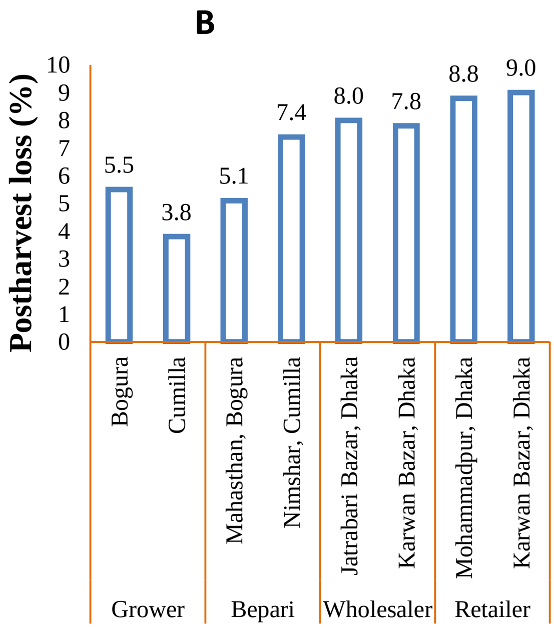


Fig 6.7 Total (A) and location-specific (B) postharvest losses of tomatoes at different levels of supply chain- 'Self-reported method' (N = 200; 50 for each of growers, Bepari, wholesalers and retailers).

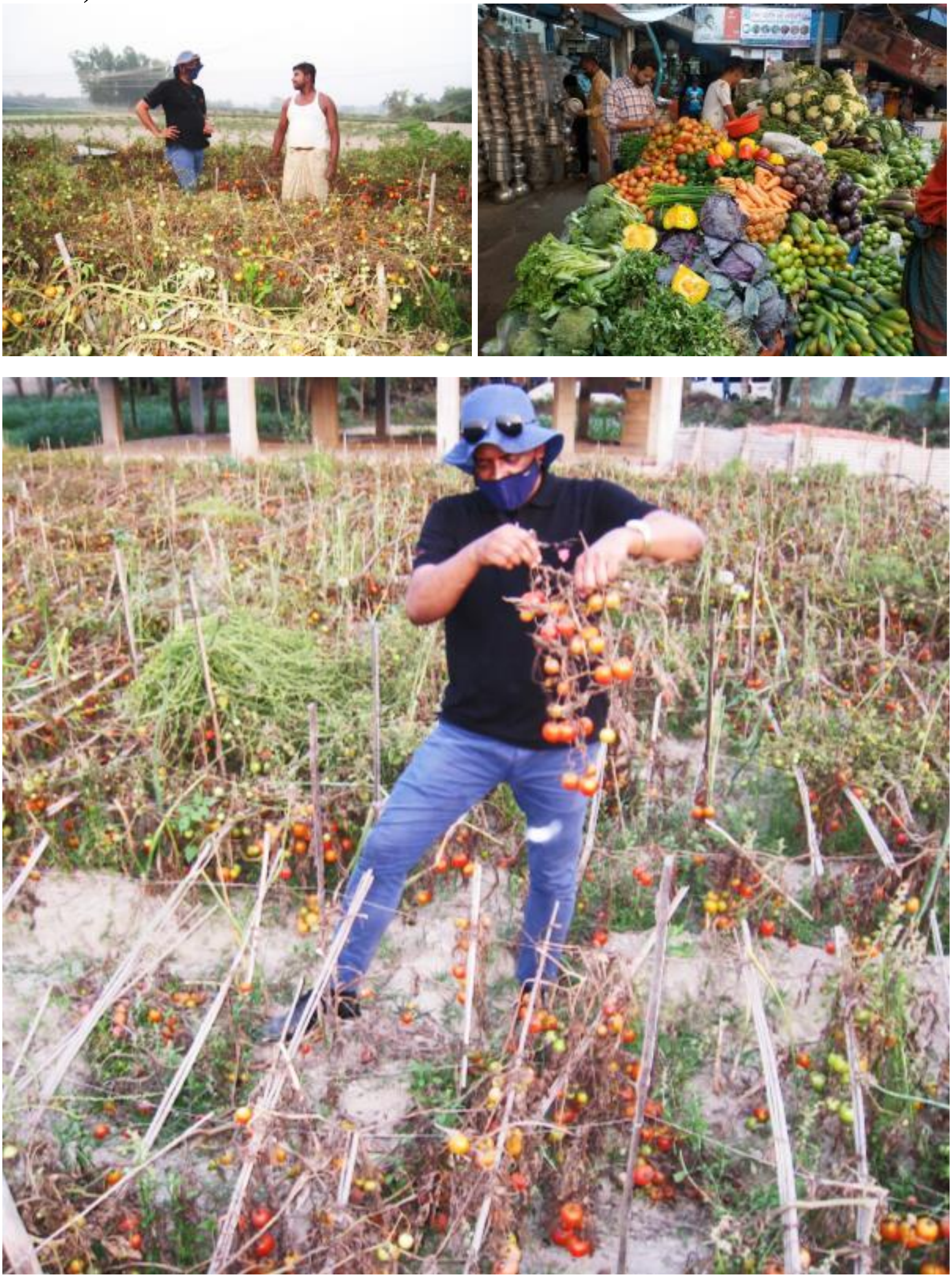


Plate 6.11 Pictures showing field data collection for postharvest loss assessment of potato.

6.5.3 Underlying reasons for loss and remedial measures

Apart from assessing the magnitudes of quantitative losses, data and information on the possible reasons for losses and the ways and means to reduce losses were also collected from the respondents as summarized below.

6.5.3.1 Growers and middlemen (Bepari)

The reasons for postharvest losses of tomatoes at the growers' levels were mainly due to bruises, rots, insect damage and lack of storage (Table 6.41; Plate 6.11). Similar observations were also provided by the Bepari with the addition of other factors including low market demand and low market price. Adoption of improved practices like grading and packaging, and creation of facilities for storage and value addition, were suggested by the growers in order to minimize postharvest loss and field loss of tomatoes (Table 6.42). At the Bepari level, practice of proper sorting, grading, packaging, storage and value addition (food processing) were suggested to improve the situation (Table 6.42). These results would be useful in policy formulation to reduce enormous loss of tomatoes both at the farm and off-farm levels.

Table 6.41 Main reasons for postharvest losses of tomato at the growers and Bepari levels

Reasons for postharvest loss	**% Respondents**	
	Growers (Sadar, Bogura, N=25)	Bepari (Mahasthan, Bogura; N=25)
Cuts	4.0	4.0
Bruises	100.0	96.0
Rots	100.0	100.0
Insect infestation	100.0	68.0
Lack of storage	100.0	64.0
Electricity problem	0.0	12.0
Low market demand	0.0	92.0
Low market price	0.0	80.0

Table 6.42 Options for reducing postharvest losses of tomato at the growers and Bepari levels

Options for postharvest loss	**% Respondents**	
	Growers (Sadar, Bogura, N=25)	Bepari (Mahasthan, Bogura; N=25)
Proper practice of sorting	0.0	77.0
Proper practice of grading	92.0	100.0
Proper storage	36.0	100.0
Cool condition	4.0	41.0
Proper packaging	44.0	100.0
Value addition (processing)	76.0	86.0
Trained labour	16.0	6.0

6.5.3.1 Wholesale and retail level

At the wholesale level, bruises, rots and low market demand were found to contribute to losses (Table 6.43; Plate 6.12). At the retail level, cuts, rots, insect damage, bruises, lack of storage, low market demand and Covid-19 impact were the important reasons for loss (Table 6.43; Plate 6.13). At the wholesale and retail levels, the possible options for reducing losses, as suggested by the respondents, included practicing improved postharvest handling like sorting, grading and packaging. Create facilities of storage and food processing activities are also strongly suggested by the middlemen to reduce loss (Table 6.44). These results are particularly important for policy formulation since majority of losses occur at the middlemen i.e. wholesale and retail levels.

Table 6.43 Main reasons for incurring postharvest losses of tomato at the wholesalers and retailers' levels**.**

Reasons for postharvest loss	% Respondents	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Cuts	28.0	100.0
Bruises	100.0	100.0
Rots	100.0	100.0
Insect infestation	96.0	94.0
Lack of storage	0.0	71.0
Electricity problem	0.0	18.0
Low market demand	72.0	88.0
Low market price	4.0	6.0
COVID-19 impact	0.0	94.0

Table 6.44 Options for reducing postharvest losses of tomato at wholesale and retail levels

Options for postharvest loss	% Respondents	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Practice of proper sorting	100.0	100.0
Practice of proper grading	100.0	100.0
Proper storage	100.0	88.0
Proper packaging	80.0	100.0
Value addition (processing)	100.0	100.0

Plate 6.12 Pictures showing losses of tomatoes at the growers' level (Bogura).

Plate 6.13 Pictures showing quality deterioration and postharvest loss of tomatoes during retail sales (Karwan Bazar, Dhaka).

6.6 RED AMARANTH

6.6.1 Levels of postharvest loss

Postharvest loss of red amaranth, a popular and year-round available leafy vegetable, was estimated along the selected value chains through questionnaire interview (Plate 6.14). The postharvest quantitative losses of red amaranth were estimated as 3.1, 1.1, 2.2 and 6.3% at the growers, Bepari, wholesalers and retailers' levels, respectively with a total loss of 12.7% (Fig 6.8; 'Self-reported method'). The loss with 'Category-method' was 16.6% (Appendix 3). Similar report was not found available in Bangladesh. The loss varies with locations particularly at the growers and Bepari levels. For instance, in Bogura, growers do not have any loss because they sell their produce directly from farm, whereas the growers of Jashore had considerable loss at the levels of harvesting. Postharvest loss of red amaranth was found to be the highest at the retail level in the value chain. Overall, loss of red amaranth was found to be lower than those of other commodities possibly due to shorter chain as these leafy vegetables are generally locally grown and marketed.

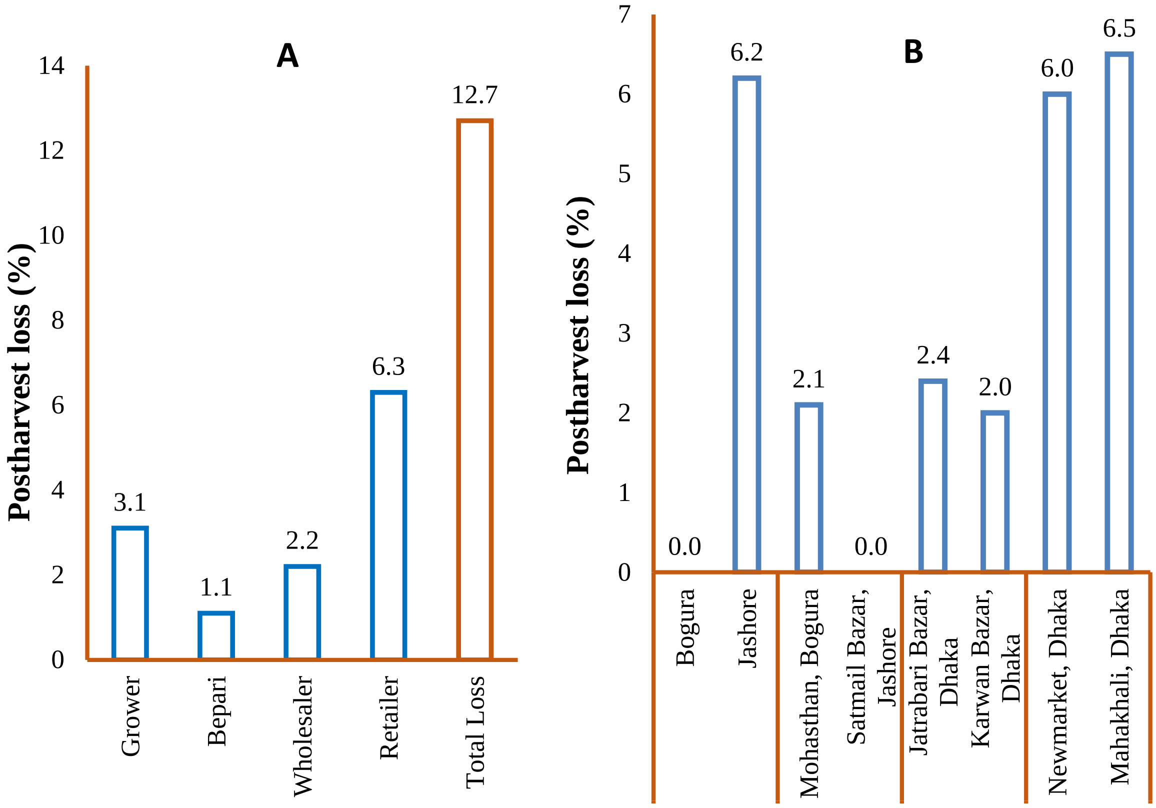


Fig 6.8 Total (A) and location-specific (B) postharvest losses of red amaranth at different levels of supply chain- 'Self-reported method' (N = 200; 50 growers, 50 Bepari, 50 wholesalers, 50 retailers).

Plate 6.14 Field data collection activities on postharvest loss assessment of red amaranth.

Plate 6.15 Pictures showing quality deterioration of red amaranth at the wholesale level.

6.6.2 Causes and remedies for loss of red amaranth

Apart from assessing the magnitudes of quantitative losses, data and information on the possible reasons for losses and the ways and means to reduce losses were also collected from the respondents and summarized below.

6.6.2.1 Middlemen (Bepari)

The reasons for postharvest losses of red amaranth at the Bepari level were mainly due to bruises, rots, lack of storage, low market demand and price (Table 6.45). Proper packaging may reduce loss at the Bepari level.

Table 6.45 Main reasons for postharvest losses of red amaranth at Bepari level

Reasons for postharvest loss	Bepari (Mahasthan, Bogura; N=25)
Cuts	0.0
Bruises	96.0
Rots	92.0
Insect infestation	4.0
Lack of storage	64.0
Electricity problem	0.0
Low market demand	72.0
Low market price	92.0
COVID-19 impact	40.0

Table 6.46 Options for reducing postharvest losses of red amaranth at the Bepari level

Reasons for postharvest loss	% Respondents
	Bepari (Mahasthan, Bogura; N=25)
Sorting	8.0
Grading	8.0
Proper storage	4.0
Cool condition	0.0
Proper packaging	92.0
Value Addition	0.0

6.6.2.2 Wholesalers and retailers’ levels

At the wholesale level, cuts, lack of storage and Covid-19 pandemic were found common to contribute to losses (Table 6.47). At the retail level, bruises, rots, lack of storage, low market demand and price were the important reasons for loss. At the wholesale and retail levels, the possible options of reducing losses, as suggested by the respondents, included practicing proper sorting, grading and storage (Table 6.48).

Table 6.47 Reasons for postharvest loss of red amaranth at wholesale and retail levels

Reasons for loss	% Respondents	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Cuts	4.0	4.0
Bruises	92.0	52.0
Rots	52.0	92.0
Insect infestation	4.0	36.0
Lack of storage	100.0	48.0
Low market demand	0.0	88.0
Low market price	0.0	76.0
COVID-19 impact	0.0	0.0

Table 6.48 Options for reducing loss of red amaranth at wholesale and retail levels

Reasons for loss	% Respondents	
	Wholesaler (Dhaka; N=25)	Retailer (Dhaka; N=25)
Practice of proper sorting	100.0	100.0
Practice of proper grading	92.0	100.0
Proper storage	100.0	100.0
Pre-cooling	0.0	0.0
Proper packaging	0.0	0.0
Value addition (processing)	0.0	0.0

6.7 PROCESSING LOSS

Processing loss refers to the loss that occurs at the processing plant immediately after receiving the raw materials. Generally, processing loss occurs during sorting, grading, crushing, mixing, in-factory transportation and storage. Data were collected from large-scale food processing industry of Bangladesh (Plate 6.16). Production statistics of tomato and mango products from PRAN are furnished in Table 6.49.

Table 6.49 Type and quantity of processed products from tomato and mango (PRAN, 2020).

Commodity	Products	Quantity produced (mt)
Tomato	Sauce	3000
	Ketchup	1500
	Total Quantity	**4500**
Mango	Mango juice	2100
	Mango bar	450
	Pickles	300
	Others	150
	Total Quantity	**3000**

Food losses at the processors level were observed to be 12-15% and 13-17% for the tomato and mango (raw materials), respectively (Table 6.50). There are also losses of the transformed products (Table 6.50).

Table 6.50 Postharvest loss of tomato and mango at the processors' level

Commodity	Steps of processing	Loss (%)
Tomato	Before processing (sorting and grading)	5-6
	During processing (crushing- fibre, seed, skin)	7-9
	Loss of raw materials received	**12-15**
	Transportation (within factory)	1-2
	Storage	1-2
	Loss of transformed tomatoes	**2-4**
Mango	Before processing (sorting and grading)	6-7
	Manual desapping	0.5-0.8
	Washing	1
	During processing (crushing- fibre, seed, skin)	5-8
	During mixing in tank	0.2-0.5
	Loss of raw materials received	**13-17**
	Transportation (within factory)	1-2
	Storage	1-2
	Loss of transformed mangoes	**2-4**

Plate 6.16 Data collection in the fruit processing plant (PRAN, Natore).

6.8 COLD STORAGE LOSS

Around 70% of the potatoes are stored principally in the commercial cold stores throughout the country. However, there is lack of data and information on the magnitude of loss during cold storage period and prior to delivery to the clients. Results suggested that the total losses of potato and carrots at the cold storage levels were 5.65 and 11.00%, respectively (Fig 6.9).

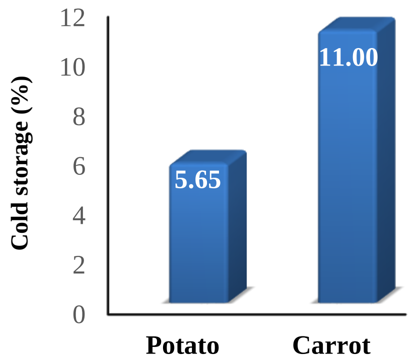


Fig 6.9 Loss of potato and carrot held in commercial cold storage in Bogura (N=5 for potato, and N=2 for carrot).

6.9 LOSS IN SUPER SHOP

Losses were also assessed in selected super shops in Dhaka. Nowadays, commodity purchase from super shops shows an increasing trend in urban settings of the country. Results revealed that duration of supershop business duration in Dhaka ranged from 8-21 years. The daily purchase and sales of the selected horticultural produce as recorded in the selected super shops are summarized in Table 6.51. There exists considerable losses (2-5%) of the selected perishables in super shops, wherein banana had the highest level of loss followed by mango (Fig 6.10).

Table 6.51 Daily purchase and sale of selected fruits and vegetables by super shops (N=5)

Commodity	Purchase day^{-1} (N=5)	Sale day^{-1} (N=5)
Mango	88 kg (stdev 22.8)	78 kg (stdev 17.2)
Banana	116 Piece (stdev 35.8)	103 Piece (stdev 29.4)
Potato	158 kg (stdev 42.7)	143 kg (stdev 43.2)
Carrot	68 kg (Stdev 35.6)	58 kg (Stdev 29.1)
Tomato	34 kg (stdev 13.4)	29.4 kg (stdev 11.9)
Red amaranth	22 kg (stdev12.1)	20 kg (stdev10.1)

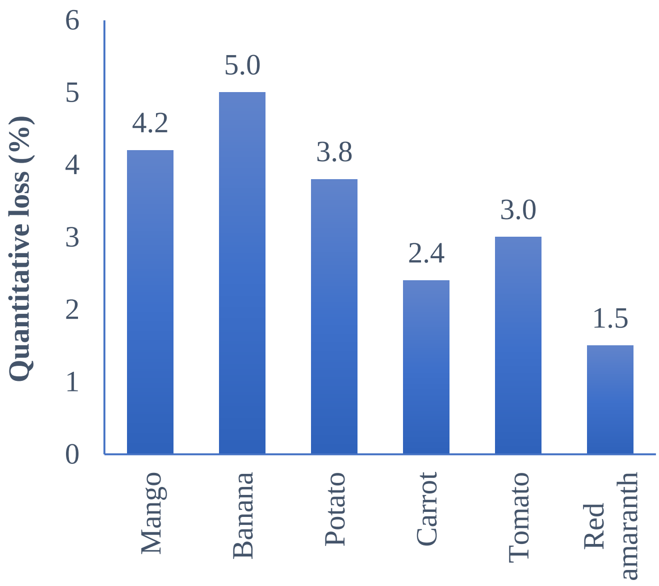


Fig 6.10 Postharvest loss of fresh horticultural produce in super shops of Dhaka City (N=5).

Apart from loss, some relevant information were also collected. Temperature and relative humidity (RH) of the surveyed super shops were mostly 20 ºC and 50%. Horticultural produces are physiologically different from each other and require specific temperature and RH for longer shelf life (Hassan 2010). In particular, very low level of RH greatly deteriorates fresh product quality and results in loss. In the super shops, the reasons for loss were rots, bruises, products remained unsold, lack of technical knowledge on product handling, lack of technology for shelf life extension, lack of food processing options and rough handling by the customers.

6.10 MICRONUTRIENT LOSS

6.10.1 Vitamin C

There is paucity of data and information on micronutrient loss in food commodities. The current research suggests that levels of vitamin C in fruits and vegetables decline sharply after harvest. Vitamin C as estimated by HPLC in potato samples collected at different stages of the value chain are shown in Fig 6.11. Vitamin C content was the highest in those potato tubers harvested at the right stage of maturity (well-developed and ready to harvest) and properly cured (to form outer protective periderm layer) and marketed without cold storage (2021-harvest; approximately 1 month after harvest) followed by those tubers harvested in the last season and held in cold storage (2020-harvest; approximately 12-month after harvest) suggesting the importance of appropriate storage to retain micronutrients. Significant decline in vitamin C content was noted in those potatoes harvested in last season, held in cold store, and then marketed (2020-harvest; approximately 12-month after harvest). The early-harvested (to fetch high early price) potatoes (immature, non-cured and non-stored) potatoes (2021-harvest; approximately 2-3 days after harvest) had the lowest level of vitamin C content. Vitamin C is susceptible to destruction by heat, light and water, and is especially unstable.

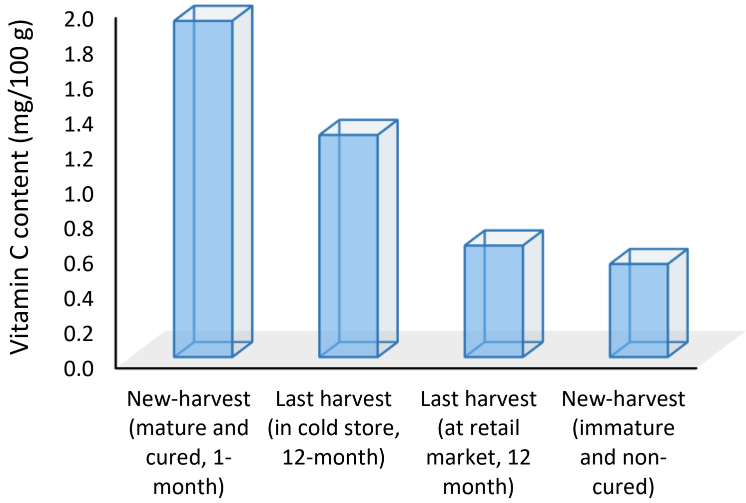


Fig 6.11 Vitamin C level in potatoes sampled at various stages of marketing (cv. Diamant).

In the case of mango (cv. BARI Am 4), vitamin C content sharply declined after harvest and as the ripening process advanced. It was also observed that vitamin C content declined by 62% and 79% at 4 and 8 days after harvest, respectively, for mangoes (cv. BARI Am 4) (Fig 6.12). Similarly, vitamin C content in tomatoes (cv. Hybrid 1217) declined by 29 and 40% within 3 and 7 days after harvest, respectively. Potatoes showed comparable results, but contained comparatively lower amounts as compared to mangoes and tomatoes (Fig 6.12). Similar result was also reported by Islam et al. (2012) who reported 8.8 mg 100 g^{-1} vitamin C in potato without mentioning name of variety and stage of sampling. Vitamin C content also differs with stage of ripening and type of commodities. For example, vitamin C content in green mangoes was only 3 mg 100 g^{-1}, and much higher amounts, 31 and 40 mg 100 g^{-1}, in ripe mangoes as reported by Gopalan et al. (1981) and Islam et al. (2012), respectively. In contrast, green tomatoes contained slightly higher level of vitamin C (31 mg 100 g^{-1}) as compared to ripe tomatoes (27 mg 100 g^{-1}) (Gopalan et al. 1981). Although the above-mentioned commodities are not really promoted as predominant sources of vitamin C but are popular and commonly-consumed food items, so there is a need to conserve nutrients and take measures to mitigate their losses.

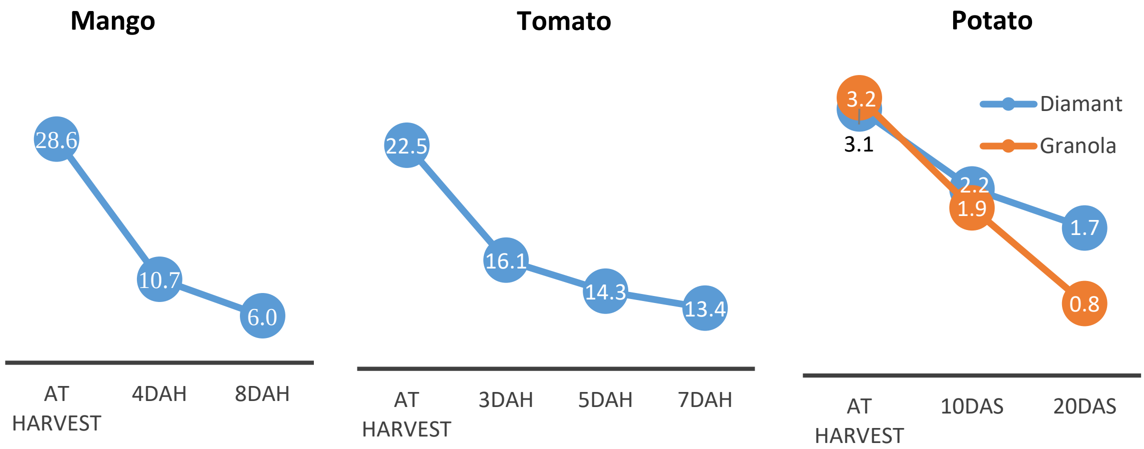


Fig 6.12 Decline in vitamin C level (mg 100 g^{-1}) in mango (cv. BARI Am 4), tomato (Hybrid 1217) and potato (Diamant and Granola) at different times after harvest (DAH- Day after harvest; DAS- Days after storage at ambient condition).

6.10.2 Folate

Folate contents in mango and tomato are shown in Fig 6.13. Patterns of loss/changes in folate content vary with commodity. In case of mango, a slight decline in folate was found at the 4th day after harvest, and after that the level remained almost stable until the 8 day after after harvest (Fig 6.13A). In contrast, folate contents showed an increasing trend in tomatoes with the progress of duration after harvest (Fig 6.13B). Dolores Iniesta et al. (2009) studied the effects of cultivar, on-vine ripening and year of harvest on the folate content of raw tomatoes. Folate content in hot-break tomato puree (HTP) subjected to pasteurization at different temperatures and its evolution during storage of tomato juice were investigated. The 5-methyltetrahydrofolate (5-CH_3-H_4-folate) was the only folate compound identified in raw tomatoes and HTP. The content of folates in raw tomatoes ranged from 4.1 to 35.3 µg 100 g^{-1} of fresh weight and was found to be highly influenced by all of the factors studied. No clear trend of folate content with ripening stage was observed. Importantly, tomato juice showed folate losses during storage independent of the storage temperature. Folate losses were higher when tomato juice was packed in glass bottles than in tetra pack (Dolores Iniesta et al. 2009).

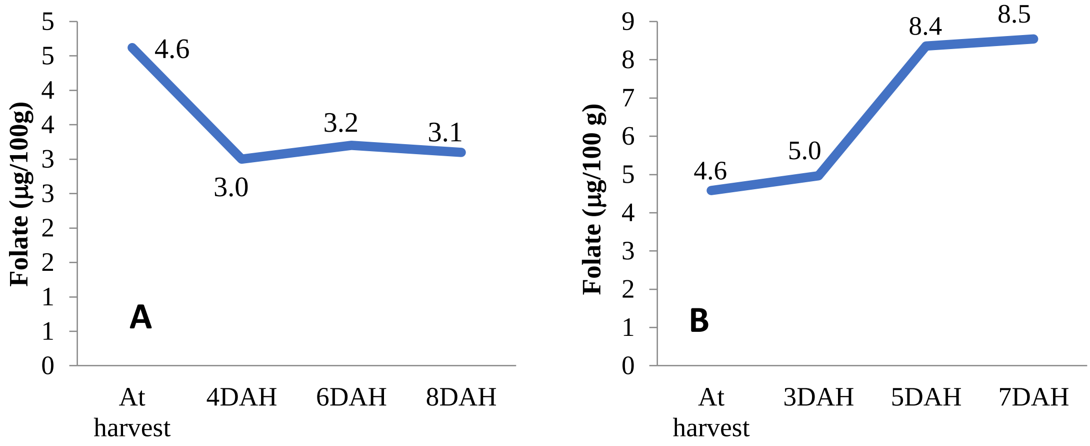


Fig 6.13 Folate contents in mango (cv. BARI Am 4) and tomato (cv. Hybrid 1217) at different times after harvest.

6.10.3 β-carotene

β-carotene level in carrot showed an increasing trend as time after harvest progressed. Level of β-carotene increased to 2825 µg 100 g^{-1} at the 12th day after harvest as compared to 2231 µg 100 g^{-1} as recorded immediately after harvesting at ambient condition indicating that there is less chance of loss of β-carotene rather may increase with time at ambient conditions (Fig 6.14). This result may be attributed to the synthesis of β-carotene as physiological processes progressed with time after harvest. Carrot was reported to contain 1890.00 and 1689.43 µg 100 g^{-1} β-carotene (Gopalan et al. 1981) and Islam et al. (2012), respectively. However, none of the reports provided adequate details on time of sampling after harvest. Reports on changes on levels of β-carotene after harvest prior to marketing are also scarce in the scientific literature. Nonetheless, carrot root dry matter was found to contain 13.57-14.28% less β-carotene as compared to those of un-stored carrot roots (Fikselova et al. 2010).

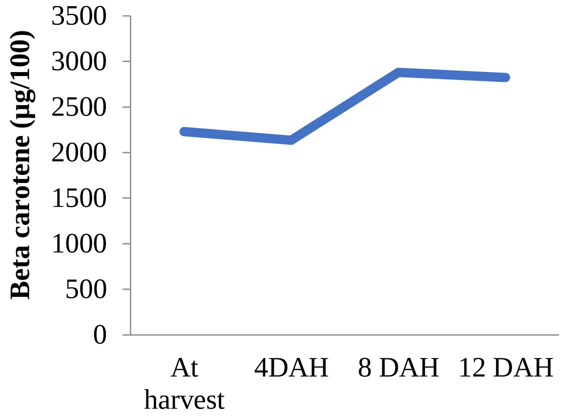


Fig 6.14 Increase in β-carotene content (µg 100 g^{-1}) in carrot roots after harvest.

6.10.4 Minerals

Levels of calcium, iron and zinc in bananas (cvs. Amritasagar and Sabri) are furnished in Table 6.52 and Fig 6.15. In case of Sabri, iron level fall until the 8th day after harvest. For zinc, significant decline was evident as time progressed after harvest (Fig 6.15). Mineral contents in potatoes of different varieties and of different stages of marketing are summarized in Table 6.53. Calcium content in carrot was also found to decline with time (Fig 6.16).

Table 6.52 Mineral contents (mean and Stdev) in edible portion of bananas at different levels of ripening

Time after harvest	Mineral contents in banana (cv. Amritasagar) (ppm) at different days after harvest (DAH)					
	Calcium (N=3)		Iron (N=3)		Zinc (N=3)	
	Mean	Stdev	Mean	Stdev	Mean	Stdev
At harvest	43.24	0.92	13.72	0.49	6.03	0.22
4DAH	62.79	22.67	14.92	1.33	2.85	0.31
8DAH	32.44	24.72	25.57	8.43	5.83	3.17
10 DAH	19.57	1.75	27.38	13.99	6.16	2.33
12DAH	40.70	21.27	12.78	3.20	4.25	1.16

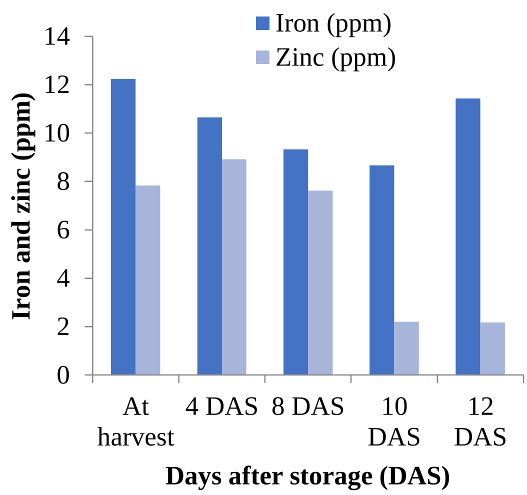


Fig 6.15 Iron and zinc contents in banana (cv. Sabri) at different days after storage (DAS).

Table 6.53 Mineral contents in potatoes as influenced by variety and time after harvest (values in the parentheses are stdev)

Stage of marketing	Micronutrient content in potato			
	Iron (ppm)	Zinc (ppm)	Sodium (%)	Potassium (%)
Diamant (current season Early- Mechua Bazar, Mymensingh) November 2020)	26.50 (24.26)	25.48 (22.83)	0.19 (0.05)	0.22 (0.06)
Diamant (last season Old-Mechua Bazar, Mymensingh) November 2020	25.78 (12.23)	35.77 (25.52)	0.25 (0.05)	0.27 (0.04)
Granola (current season Early- Mechua Bazar, Mymensingh) November 2020	7.55 (4.81)	33.42 (20.07)	0.23 (0.05)	0.24 (0.05)
Cardinal (last season Old- KR Market) November 2020	5.42 (3.70)	6.26 (0.61)	0.32 (0.18)	0.24 (0.02)

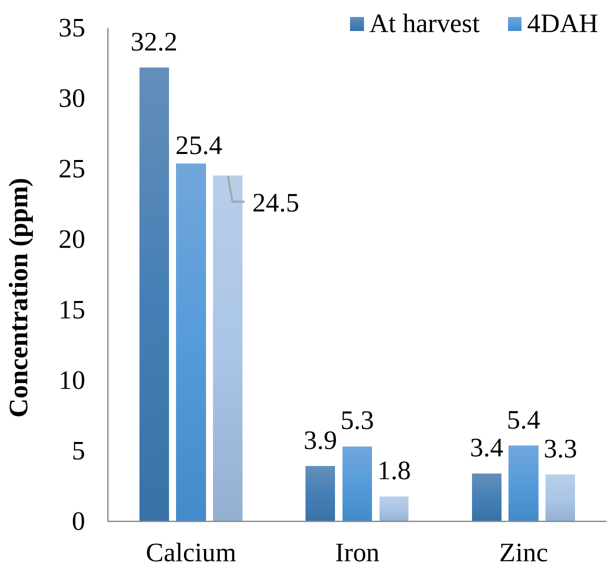


Fig 6.16 Mineral contents in edible portion of carrot roots at different days after harvesting (DAH).

Chapter 7

FOOD LOSS- ANIMAL PRODUCTS

Assessment of quantitative and micronutrient losses/changes of selected animal products (poultry meat, red meat, egg, cow milk and buffalo milk) across value chains (producers to retailers) were carried out. Results on magnitudes of losses and postharvest activities for the selected animal products are presented and discussed in this chapter. Some activities on field data collection are shown in Plates 7.1-7.4.

Plate 7.1 Field data collection on loss assessment of eggs.

Plate 7.2 Field data collection on loss assessment of chicken meat.

Plate 7.3 Field data collection on loss assessment of red meat.

Plate 7.4 Field data collection on loss assessment of milk.

7.1 MILK

7.1.1 Levels of loss

7.1.1.1 Loss at producer level

The quantitative and value losses of milk were calculated following 'Category method' of Delgado et al. (2017) and are shown in Fig 7.1. The average quantitative loss of cow and buffalo cow's milk at producer level was 4.83%, where buffalo cow milk loss was found higher as compared with cow milk. On the other hand, the value loss (Tk.) was found higher in cow milk than buffalo cow's milk even though the percent weight loss (quantitative loss) was higher in buffalo cow milk. This is because of the amount of cow milk production was higher in Bangladesh than buffalo cow's milk but if value loss is converted to percent loss then buffalo cow's milk loss was found higher than cow milk. In developing countries about 20% losses occur in milk value chain (Jaspreet and Regmi 2013). In N-E States of India, the milk loss from disease accounting for 6% of the total value of losses (Rs. 112.08 crores) (Paul 2013). In South East Asia (Gustavsson et al. 2011), Norway (Franke et al. 2016) and Turkey (Tatlıdil et al. 2013) the total postharvest losses of milk were 17.0, 0.3 and 10.0%, respectively. The estimated total fluid milk loss at retailers' level in USA was 12.0% (Buzby et al. 2014).

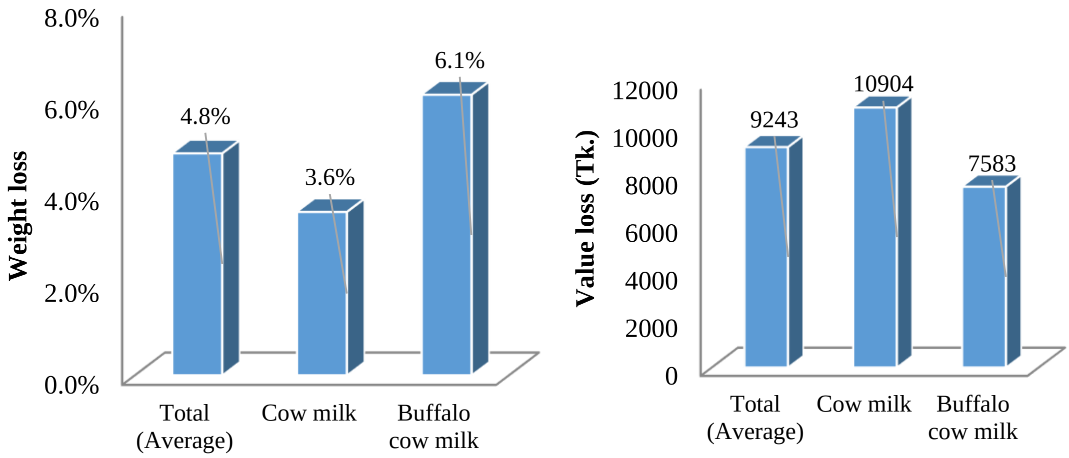
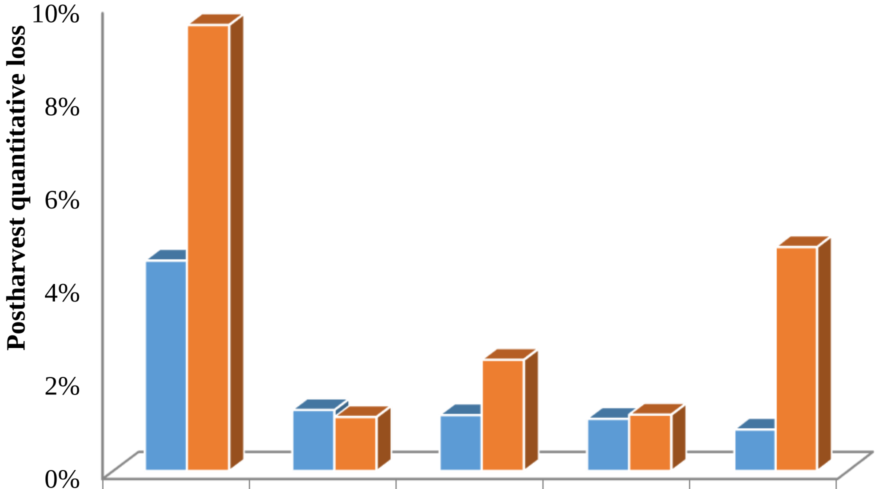


Fig 7.1 Quantitative and value losses of cow and buffalo cow milk at producer level (N=25 for each of cow's milk and buffalo cow's milk).

7.1.1.2 Loss at middleman (Bepari) level

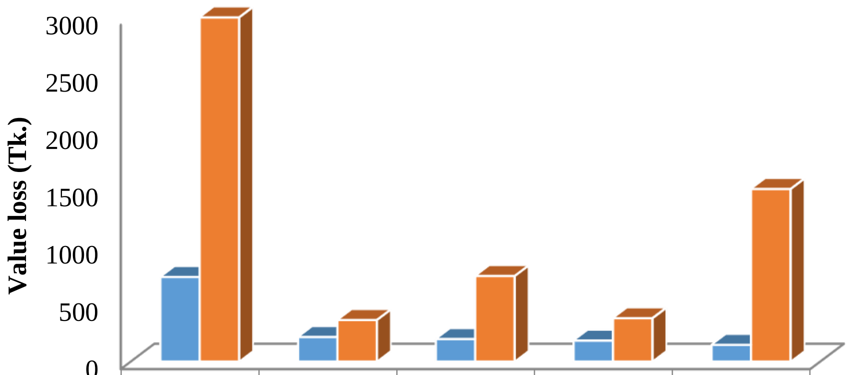
The weight (%) and value (Tk.) losses of cow and buffalo cow milk at the middleman level were estimated and shown in Fig 7.2 and 7.3, respectively. The weight and value losses mainly occurred during collection, storing, loading and unloading, and transportation. The total weight loss (%) was found more than double in buffalo cow milk of Subornochar than that of cow milk in Sirajganj. The weight loss for cow milk in Sirajganj was found the highest during milk collection followed by storing, loading and unloading and transportation stage.



	Total	Collection	Storing	Loading/Unloading	Transportation
Cow	4.52%	1.31%	1.20%	1.12%	0.89%
Buffalo cow	9.57%	1.16%	2.39%	1.21%	4.81%

Fig 7.2 Quantitative loss of cow and buffalo cow milk at middlemen level (N=25 for each of cow's milk and buffalo cow's milk).

On the other hand, the weight loss (quantitative loss) for buffalo cow milk in Subornochar Upazila was found the highest during milk transportation followed by storing, loading and unloading and collection stage. In Subornochar Upazila, buffalo cow milk producers reared buffaloes mainly in seashore or different island of Noakhali district. The time needed to reach mainland or marketplaces with milk need prolonged time. Especially during summer and high humid condition, it was difficult to keep milk safe and prevent milk protein and fat degradation. Moreover, higher levels of total solids and fat in buffalo cow milk are one of the major reasons for its quicker spoilage compared to cow's milk. This may also be the reason for maximum losses of buffalo cow milk during transportation and storage compared to cow's milk. On the contrary, the total value loss (Tk.) was found to be more than four times higher in buffalo cow milk in Subornochar than that of cow milk in Sirajganj, but when calculated as percentage, the value loss would be similar corresponding to weight loss (quantitative loss).



	Total	Collection	Storing	Loading/Unloading	Transportation
Cow	739.91	214.41	196.40	183.31	145.66
Buffalo cow	2997.55	363.36	748.65	379.03	1506.70

Fig 7.3 Postharvest value loss (Tk.) of cow and buffalo cow milk at middleman (Bepari) level (N=25 for each of cow's milk and buffalo cow's milk).

The value loss for cow milk in Sirajganaj district was found the highest during milk collection followed by storing, loading and unloading, and transportation stage. On the other hand, the value loss for buffalo cow milk in Subornochar Upazila was found the highest during milk transportation followed by storing, loading and unloading, and collection stage. The value loss for buffalo cow milk showed four times higher because of the buffalo cow milk prize in Subornochar was almost double than that of cow milk. The reason for higher value losses of buffalo cow milk was similar as of weight loss (quantitative loss) for the same.

7.1.2 Possible reasons for loss of milk during postharvest operation

The possible reasons for the losses of cow and buffalo cow milk during postharvest operation are shown in Fig 7.4. In this section, mainly experiences of the producer and middleman are assessed with some selected questionnaires and tried to get some of their inbuilt ideas they practiced during their long involvement. Majority of the cow milk producers and middlemen thought that sickness of animals, transportation, loading/unloading, high temperature and humidity, broken container and marketing were the main causes of the postharvest losses of cow milk. On the other hand, buffalo cow milk producers and middleman prioritized high temperature and humidity, transportation, lack of cooling facility and marketing as the major causes of the post-harvest losses of buffalo cow milk. Some of these causes are commonly known, and some of the causes are related to the inherent perishable nature and its short shelf life properties that exacerbate the spoilage of milk and deterioration of its quality (Azeze et al., 2016), while some are location specific with variations in temperature and environmental factors. All these valuable suggestions should be considered by the proper authorities in time.

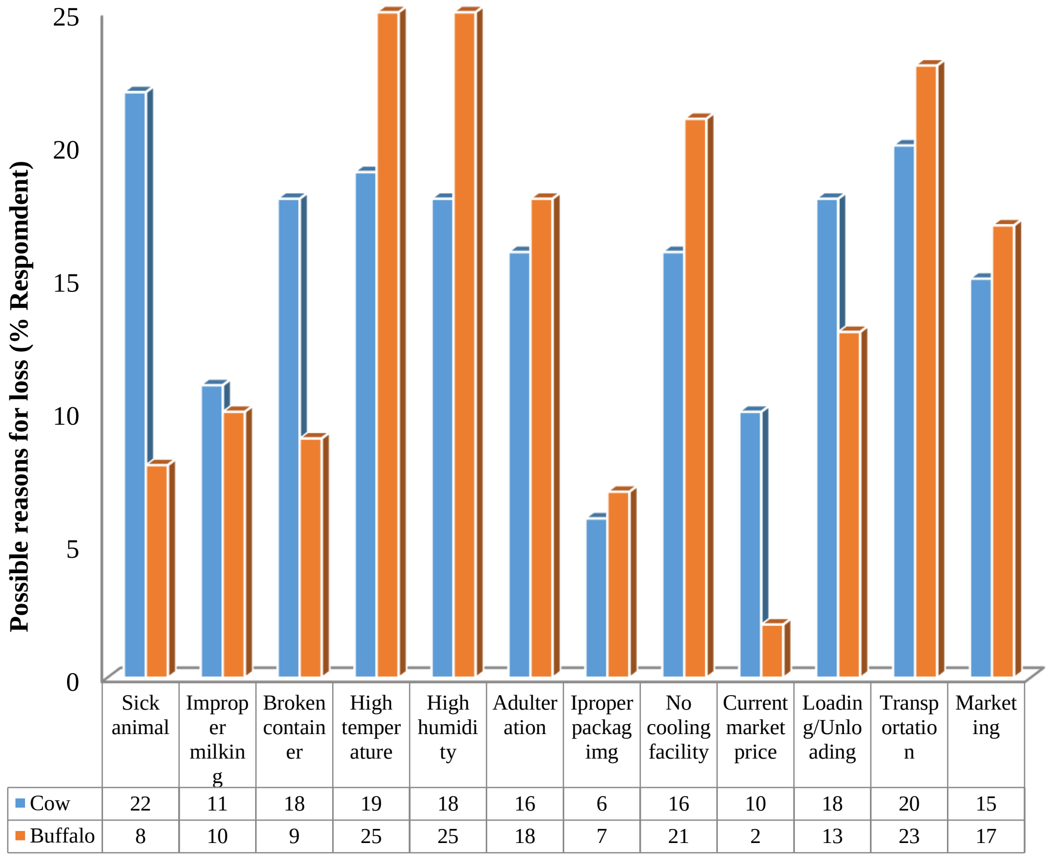


Fig 7.4 Possible reasons for the loss of cow and buffalo cow milk during postharvest operations (N=25).

7.1.3 Possible solutions to reduce losses of milk during postharvest operation

The possible solutions to reduce the losses of cow and buffalo cow milk during postharvest operation are shown in Fig 7.5. In the last section, possible reasons for the losses of cow and buffalo cow milk during postharvest operations are identified. In this section, 100% of the respondents wanted to ensure cooling facility to reduce postharvest losses of cow milk followed by avoid sick animals, careful collection, avoid adulteration, proper transportation and so on. On the other hand, buffalo cow milk producers and middlemen prioritized transportation followed by proper storage and collection of buffalo cow milk as key factors.

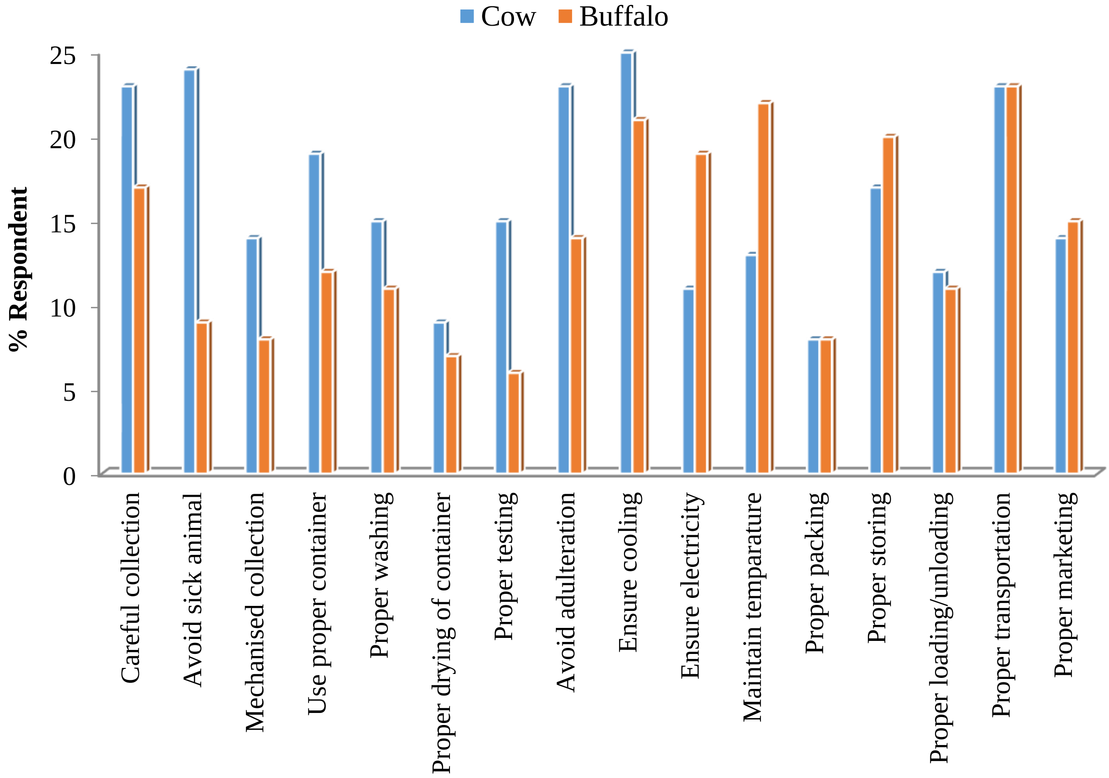


Fig 7.5 Possible solutions to reduce losses of cow and buffalo cow milk during postharvest operation (N=25).

7.2 POULTRY (HEN) EGG

7.2.1 Postharvest loss of eggs

7.2.1.1 At producer level

The quantitative loss or weight loss (%) and value losses (Tk.) of egg at producer level calculated according to the 'Category method' of Delgado et al. (2017) and are shown in Fig 7.6. The average number of loss of eggs was more than 3% where in Mymensingh Sadar the loss was higher than Gazipur Sadar. On the other hand, the value loss (Tk.) in Gazipur Sadar was found higher than Mymensingh Sadar even though the percent egg loss was higher in Mymensingh than Gazipur Sadar. This was because of the number of egg production was higher in Gazipur Sadar than Mymensingh Sadar. But if value loss is converted to percentage then loss in Mymensingh was found higher than Gazipur Sadar. The losses of table eggs at producer level were found 0.98% in India. Losses of eggs were found to be more in small layer farms (1.94%) than in medium (1.11%) or large farms (0.95%) and comparatively more in summer (1.31%) than in rainy (0.88%) or winter (0.75%) season. The bulk of egg damage at farm level was in the form of egg cracks, spoiled (rotten) eggs and during collection stage. They estimated egg losses at layer farms, wholesalers, retailers, cold store, egg processing unit and household level as 0.98, 1.39, 3.26, 2.11, 1.24 and 3.24%, respectively with a total postharvest loss of 12.22 and 8.87%, respectively (Singh et al. 2005). The postharvest losses of egg in Norway (Calculation-Fusion method) (Franke et al. 2016) and Turkey (Tatlıdil et al. 2013) were 3.6 and 4%, respectively.

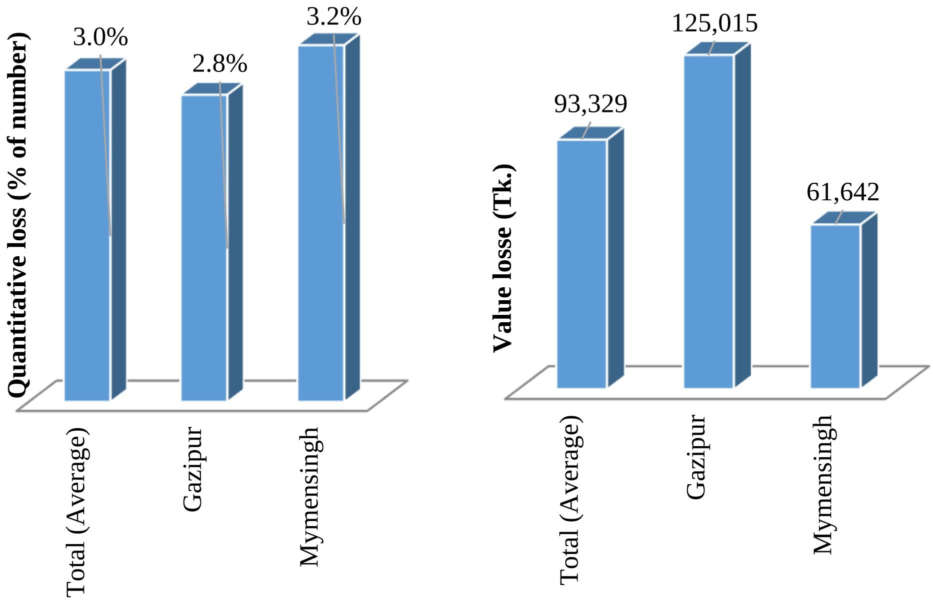
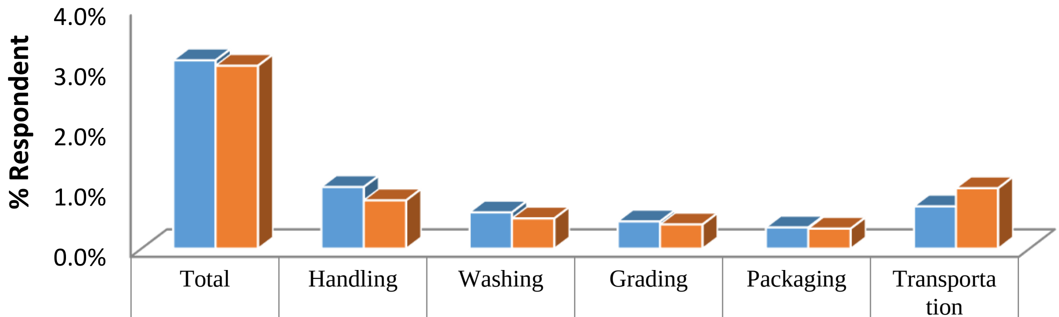


Fig 7.6 Postharvest loss (% in terms of number) and value loss (Tk) of egg at producer level of Gazipur Sadar and Mymensingh Sadar (N=25 for each of Mymensingh and Gazipur).

7.2.1.2 At middlemen level- Bepari

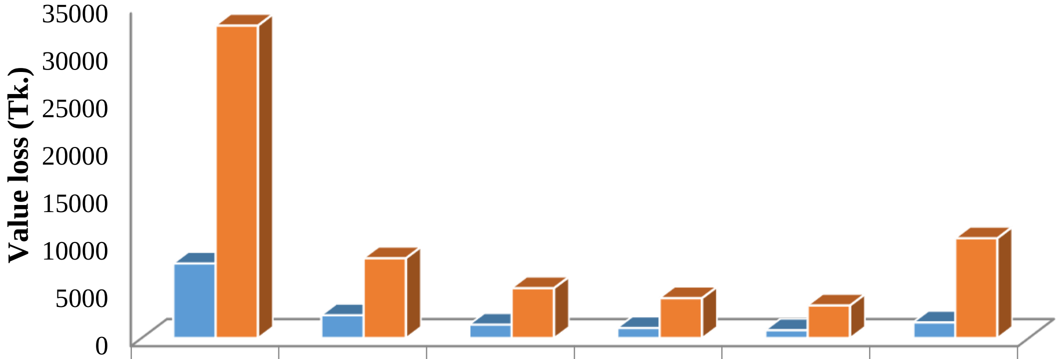
The quantitative (% in terms of number) and value (Tk.) losses of egg at middleman (Bepari) level in Gazipur and Mymensingh Sadar were calculated according to 'Category method' of Delgado et al. (2017) and are shown in Fig 7.8 and 7.9, respectively. The number and value loss of egg at the middleman (Bepari) level mainly occurred during handling, washing, grading, packaging and transportation. The total number of egg loss (%) at Bepari level was found almost similar in Gazipur and Mymensingh Sadar. The number of egg loss (%) in Gazipur city was found the highest during egg handling followed by transportation, washing, grading and packaging. On the other hand, the number of egg losses (%) in Mymensingh city was found highest during egg transportation followed by handling, washing, grading and packaging.



	Total	Handling	Washing	Grading	Packaging	Transporta tion
Gazipur	3.12%	1.02%	0.60%	0.45%	0.35%	0.70%
Mymensingh	3.03%	0.80%	0.50%	0.40%	0.33%	1.00%

Fig 7.8 Postharvest loss of egg (%) at middleman level in Gazipur and Mymensingh Sadar (N=25 for each of Mymensingh Sadar and Gazipur Sadar).

The total value (Tk.) loss of egg in Mymensingh Sadar was more than 4 times higher than that of Gazipur Sadar. This big difference of value losses may be due to the huge number of eggs produced and its corresponding losses were more in Mymensingh than in Gazipur. The value losses (Tk.) of egg in Mymensingh city was found the highest during egg transportation followed by handling, washing, grading and packaging. On the other hand, the value losses (Tk.) of egg in Gazipur Sadar was found the highest during egg handling followed by transportation, washing, grading and packaging.

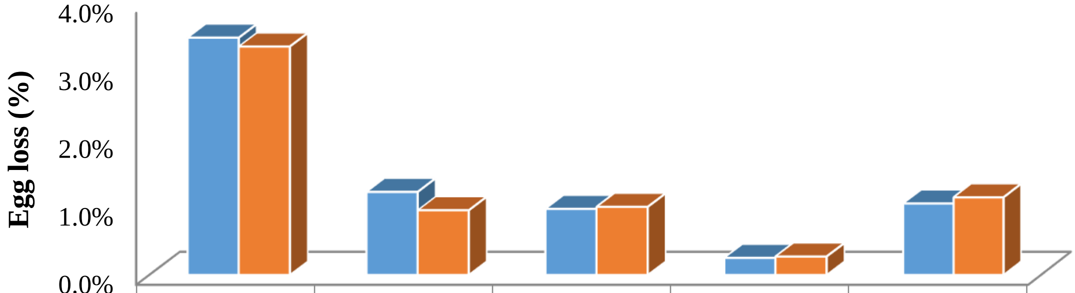


	Total	Handling	Washing	Grading	Packaging	Transportation
Gazipur	7920.00	2418.68	1422.75	1067.07	829.94	1659.88
Mymensingh	32849.03	8477.16	5298.23	4238.58	3458.51	10596.45

Fig 7.9 Postharvest value loss (Tk.) of egg at middlemen level (Bepari) in Gazipur and Mymensingh Sadar (N=25).

7.2.1.3 At middlemen level- Wholesaler

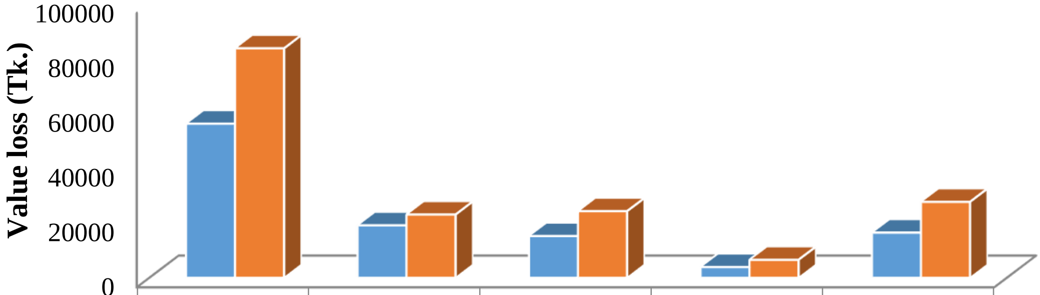
The number (%) and value (Tk.) losses of egg at the wholesalers' level in Rayer Bazar and Kaptan Bazar, Dhaka were calculated according to 'Category method' of Delgado et al. (2017) and are shown in Fig 7.10 and 7.11, respectively. The number and value losses of eggs at the wholesalers' level mainly occurred during handling, storing, transportation and marketing.



	Total	Handling	Transportation	Storing	Marketing
Rayer bazar	3.49%	1.22%	0.97%	0.25%	1.05%
Kaptan bazar	3.36%	0.95%	1.00%	0.27%	1.14%

Fig 7.10 Postharvest egg loss (%) of wholesaler in Rayer Bazar and Kaptan Bazar (N=25 for each of Rayer Bazar and Captan Bazar).

The total value loss (%) at the wholesalers' level was found almost similar in both the study locations. The value loss (%) in Rayer Bazar was found the highest during egg handling followed by marketing, transportation and storing. On the other hand, the value loss (%) in Kaptan Bazar was found the highest during egg marketing followed by transportation, handling and storing.

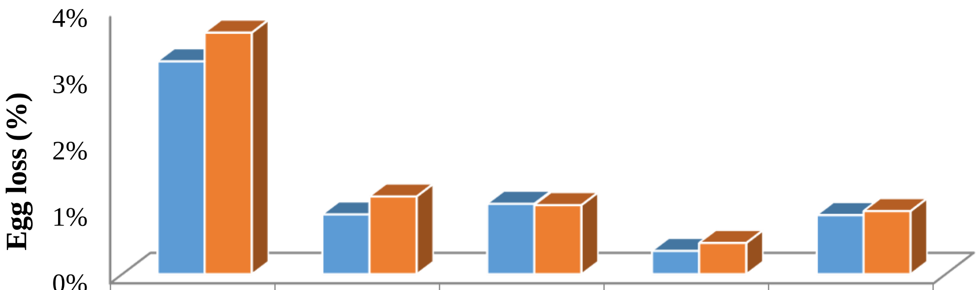


	Total	Handling	Transportation	Storing	Marketing
Rayer bazar	56231.14	19162.57	15235.81	3926.76	16492.37
Kaptan bazar	83630.00	23095.49	24311.05	6563.98	27714.59

Fig 7.11 Postharvest value (Tk.) loss of egg at the wholesalers levels in Rayer Bazar and Kaptan Bazar (N=25 for each of Rayer Bazar and Captan Bazar).

7.2.1.4 At middlemen level- Retailer

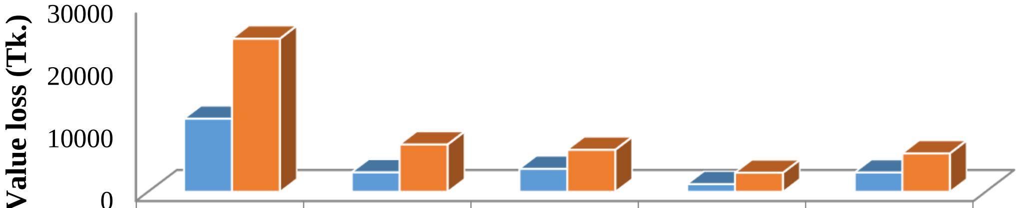
The number (%) and value (Tk.) losses of egg at retailers' level in Notun Bazar, Mymensingh and Mirpur Bazar, Dhaka were calculated according to 'Category method' of Delgado et al. (2017) and are shown in Fig 7.12 and 7.13, respectively. The number and value losses of egg at the retailers' level mainly occurred during handling, storing, transportation and marketing.



	Total	Handling	Transportation	Storing	Marketing
Notun bazar	3.20%	0.90%	1.06%	0.35%	0.89%
Mirpur bazar	3.63%	1.17%	1.04%	0.47%	0.95%

Fig 7.12 Postharvest egg loss (%) of retailer in Notun Bazar, Mymensingh and Mirpur Bazar, Dhaka (N=25 for each of Notun Bazar and Mirpur Bazar).

The total number of egg loss (%) at retailers' level was found higher in Mirpur Bazar, Dhaka than Notun Bazar, Mymensingh. The number of egg loss (%) in Mirpur Bazar was found the highest during egg handling followed by transportation, marketing and storing. On the other hand, the number of egg loss (%) in Notun Bazar, Mymensingh was found the highest during egg transportation. Storing losses are found the lowest in Notun Bazar, Mymensingh. The total value loss (Tk.) of egg in Mirpur Bazar, Dhaka was higher than that of Notun Bazar, Mymensingh. The value loss (Tk.) of egg in Mirpur Bazar, Dhaka was found the highest during egg handling followed by egg transportation, marketing and storing. On the other hand, the value loss (Tk.) of egg in Notun Bazar, Mymensingh was found the highest during egg transportation followed by handling, marketing and storage.



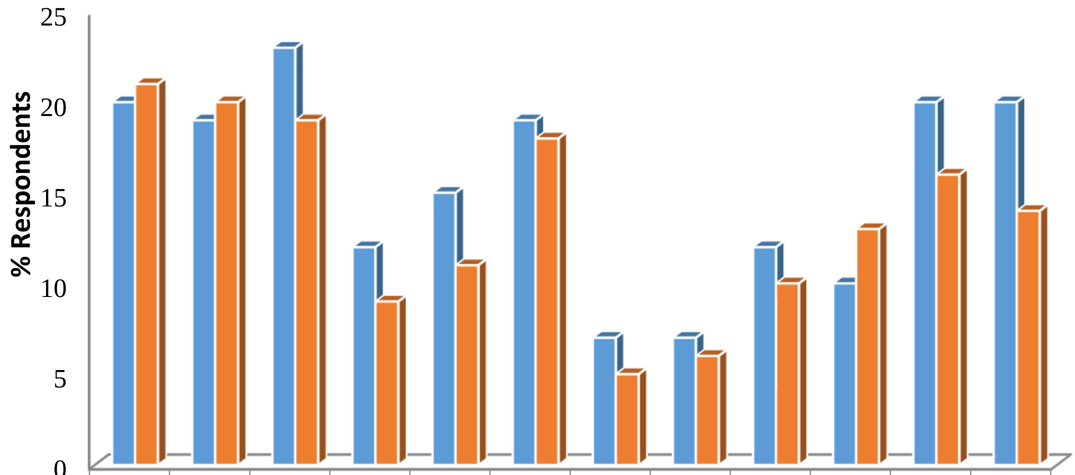
	Total	Handling	Transportation	Storing	Marketing
Notun bazar	11707.87	3117.49	3671.71	1212.36	3082.85
Mirpur bazar	24476.61	7576.09	6734.30	3043.39	6151.53

Fig 7.13 Postharvest value (Tk.) loss of egg of retailers in Notun Bazar and Mirpur Bazar (N=25 for each of Notun Bazar and Mirpur Bazar).

The magnitude of losses of table eggs at the wholesalers and retailers' levels were found to be 1.39 and 3.26%, respectively. In India, an overall loss of table eggs from poultry farms to household consumers via wholesale-retail channel was found to be 8.87% in the surveyed area. Majority of egg damage occurred during packaging and transport at the market and household consumer level. Opinion on possible causes of losses of eggs obtained from the respondents revealed that defective packaging and transport hazard were the major causes of loss in the marketing channels (Singh et al. 2005). The estimated total egg loss at retailers' level in the USA was 7% (Buzby et al. 2014).

7.2.2 Possible reasons for the loss of egg during postharvest operation

The possible reasons for the losses of eggs during postharvest operation are shown in Fig 7.14. In this section, mainly experiences of producer, middleman (Bepari), wholesaler and retailer were assessed with some selected questionnaires based on their inbuilt ideas and practice during their long involvement in egg production and marketing. Majority of the egg producer, middleman (Bepari), wholesaler and retailer thought that broken egg, improper collection, improper handling, during storage, during transportation, during marketing, during packaging and during loading/unloading were the main causes of postharvest losses of egg.

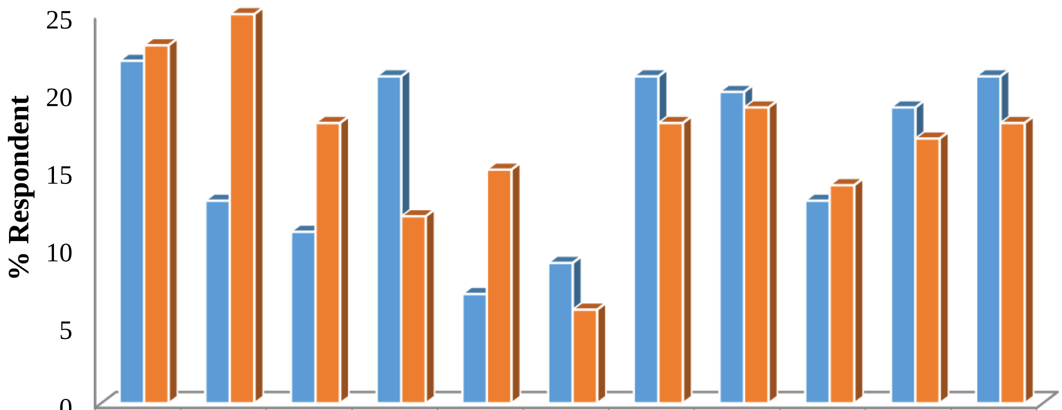


	Improper collection	Improper handling	Broken egg	Improper cleaning	Improper washing	During storage	During checking	During grading	During packaging	During loading /unloading	During transportation	During marketing
Mymensingh	20	19	23	12	15	19	7	7	12	10	20	20
Gazipur	21	20	19	9	11	18	5	6	10	13	16	14

Fig 7.14 Possible reasons for the loss of eggs during postharvest operations (N=25).

7.2.3 Possible solutions to reduce losses of egg during postharvest operation

The possible solutions to reduce the losses of egg during postharvest operations are shown in Fig 7.15. In the last section, possible reasons for the losses of egg during postharvest operation are identified. In this section like before, producer, middleman (Bepari), wholesaler and retailer suggested that proper overall preparation is very important to reduce postharvest losses of egg. They also addressed on proper collection, use of proper container, proper packaging, proper storage and proper transportation and marketing could significantly reduce postharvest losses of egg.



	Proper collection	Proper preparation	Mechanised collection	Use proper container	Proper washing	Proper drying	Proper packaging	Proper storing	Proper loading/ unloading	Proper transportation	Proper marketing
Mymensingh	22	13	11	21	7	9	21	20	13	19	21
Gazipur	23	25	18	12	15	6	18	19	14	17	18

Fig 7.15 Possible solutions to reduce losses of egg during postharvest operation (N=25).

Plate 7.5 Picture showing loss of eggs due to breakage during marketing.

7.3 CHICKEN MEAT

7.3.1 Postharvest losses

7.3.1.1 At producer level

The quantitative loss (%weight loss) and value loss (Tk.) of chicken meat in the study areas, Gazipur Sadar and Mymensingh Sadar at the producer level were calculated according to the 'Category method' of Delgado et al. (2017) and shown in Fig 7.16. The average loss of chicken meat was found near to 4% where in Gazipur Sadar, and the loss was higher than in Mymensingh Sadar. On the other hand, the value loss (Tk.) in Mymensingh Sadar was found higher than Gazipur Sadar even though the percent meat loss was higher in Gazipur than Mymensingh Sadar. This might be because of higher amounts of chicken meat production in Mymensingh Sadar than Gazipur Sadar but if the value loss is converted to percentage then loss in Gazipur was found higher than Mymensingh Sadar. The calculated loss for poultry meat ranged from 5-10% (Liu 2013). The losses at postharvest handling, storage, processing and distribution stages of meats were estimated as 1.4-2.1%, 2.5- 3.7%, 1.1% and 3%, respectively (Xu 2007). In India, poultry loss was estimated to be 6.74% (ICAR 2015). The postharvest losses of poultry meat in Norway (Calculation-Fusion method) (Franke et al. 2016) and Thailand (Preechajarn et al. 2016) were 1.7 and 10%, respectively. On the contrary, the postharvest loss of all type of meat in South East Asia (Gustavsson et al. 2011), Turkey (Tatlıdil et al. 2013), China (Liu et al. 2013) and Pakistan (pre- and post) (PRLA Activity 2012) were 15, 6.7, 12, and 6.5%, respectively.

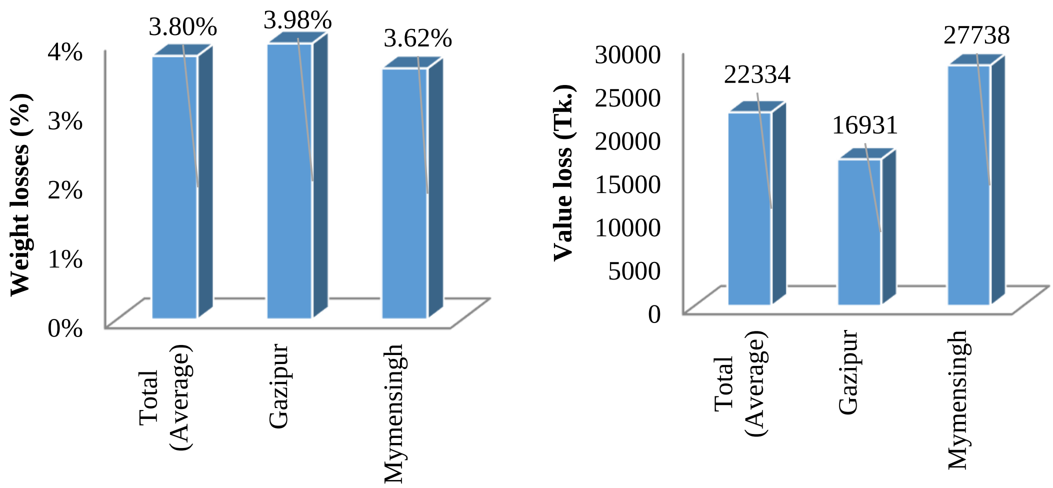
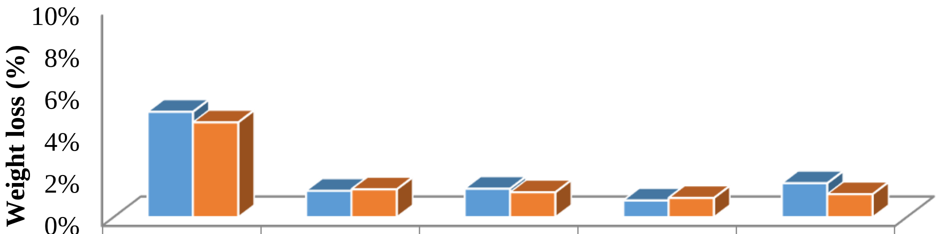


Fig 7.16 Postharvest quantitative loss (%) and value loss (Tk.) of chicken meat at producer level in Gazipur Sadar and Mymensingh Sadar (N=25 for each of Gazipur Sadar and Mymensingh Sadar).

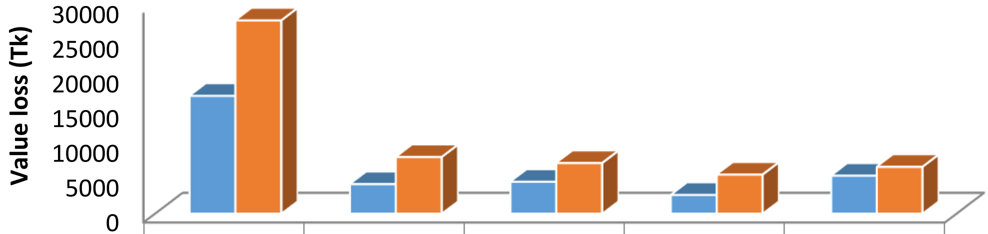
7.3.1.2 At middlemen level- Bepari

The weight (%) and value (Tk.) losses of chicken meat at the middleman (Bepari) level in Gazipur Sadar and Mymensingh Sadar were calculated and are shown in Fig 7.17 and 7.18, respectively. The weight and value loss of chicken meat at Bepari level mainly occurred during handling, storing, loading/unloading and transportation. The total quantitative or weight loss (%) of chicken meat at Bepari level was found higher in Gazipur Sadar than Mymensingh Sadar. The weight loss (%) of chicken meat in Gazipur Sadar was found the highest during chicken meat transportation followed by storing, handling and loading/unloading. On the other hand, the weight loss (%) of chicken meat in Mymensingh Sadar was found the highest during chicken meat handling followed by storing, transportation and loading/unloading.



	Total	Handling	Storing	Loading/Un loading	Transportati on
Gazipur	5.00%	1.25%	1.35%	0.79%	1.61%
Mymensingh	4.50%	1.32%	1.18%	0.91%	1.09%

Fig 7.17 Postharvest quantitative loss (%) of chicken meat at Bepari level in Gazipur Sadar and Mymensingh Sadar (N=25).



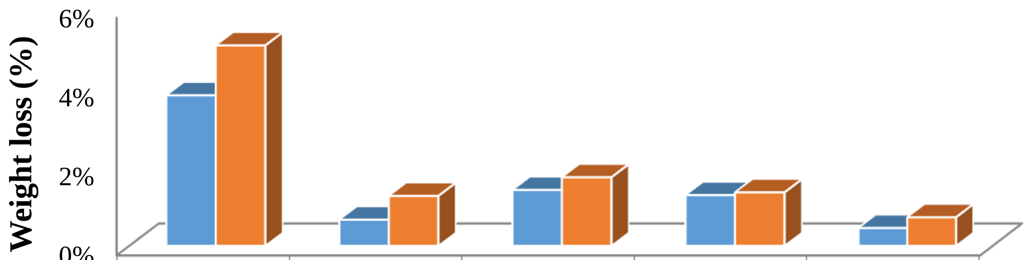
	Total	Handling	Storing	Loading/Unloading	Transportation
Gazipur	16930.65	4232.66	4571.28	2675.04	5451.66
Mymensingh	27737.99	8135.66	7272.79	5608.68	6718.09

Fig 7.18 Postharvest value loss (Tk.) of chicken meat at Bepari level in Gazipur and Mymensingh Sadar (N=25 for each of Gazipur Sadar and Mymensingh Sadar).

The total value loss (Tk.) of chicken meat at Bepari level in Mymensingh Sadar was higher than that of Gazipur Sadar. These differences of value losses may be due to higher number of chicken meat produced and its corresponding loss was more in Mymensingh Sadar than Gazipur Sadar. The value losses (Tk.) of chicken meat in Mymensingh Sadar was found the highest during chicken meat handling followed by storing, transportation and loading/unloading. On the other hand, the value loss (Tk.) of chicken meat in Gazipur Sadar was found the highest during chicken meat transportation followed by storing, handling and loading/unloading.

7.3.1.3 At middlemen level- Wholesaler

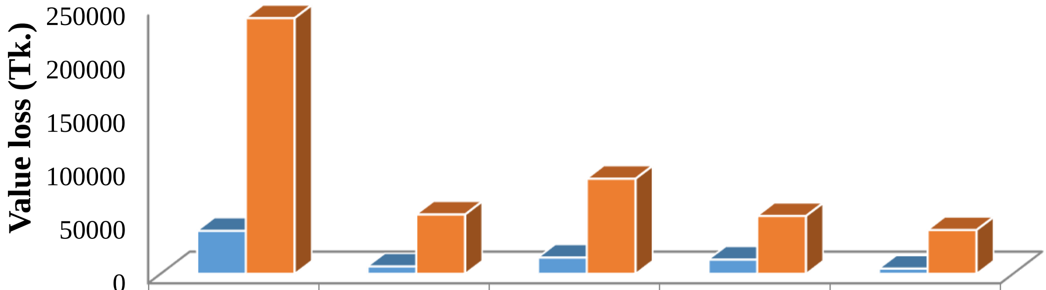
The weight (%) and value (Tk.) losses of chicken meat at the wholesalers' level in Karwan Bazar and Jatrabari Bazar, Dhaka were calculated and the results are shown in Fig 7.19 and 7.20, respectively. The weight and value losses of chicken meat at wholesales' level mainly occurred during handling, transportation, storage and marketing. The quantitative loss of chicken meat (%) at wholesalers' level was found higher in Jatrabari Bazar than Karwan Bazar, Dhaka. The quantitative loss (%) of chicken meat in Karwan Bazar was found the highest during transportation followed by storing, handling and marketing. The quantitative chicken meat loss (%) in Jatrabari Bazar, Dhaka was also found the highest during transportation followed by storing, handling and marketing. The trend of losses in two different wholesale markets in Dhaka is similar although the magnitudes of losses are different.



	Total	Handling	Transportation	Storing	Marketing
Karwan Bazar	3.80%	0.66%	1.41%	1.28%	0.45%
Jatrabari Bazar	5.06%	1.26%	1.73%	1.35%	0.72%

Fig 7.19 Postharvest quantitative loss (%) of chicken meat at wholesalers' level in Karwan Bazar and Jatrabari Bazar, Dhaka (N=25 for each of Karwan Bazar and Jatrabari Bazar).

The total value (Tk.) loss of chicken meat in Jatrabari Bazar was almost six times higher than that of Karwan Bazar. The value losses (Tk.) of chicken meat in Karwan Bazar was found highest during transportation followed by storing, handling and marketing. On the other hand, the value losses (Tk.) of chicken meat in Jatrabari Bazar was found highest during transportation followed by handling, storage, and marketing.

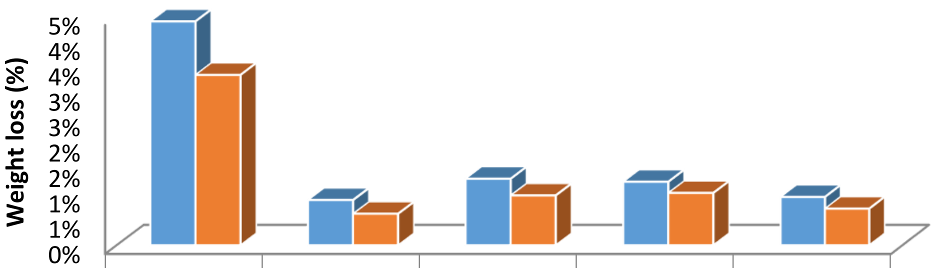


	Total	Handling	Transportation	Storing	Marketing
Karwan bazar	40056.8	6846.44	15123.49	13284.14	4802.73
Jatrabari bazar	238748	55348.26	88651.03	53941.1	40807.61

Fig 7.20 Postharvest value loss (Tk.) loss of chicken meat at wholesalers' level in Karwan Bazar and Jatrabari Bazar, Dhaka (N=25 for each of Karwan Bazar and Jatrabari Bazar, Dhaka).

7.3.1.4 At middlemen- Retailer

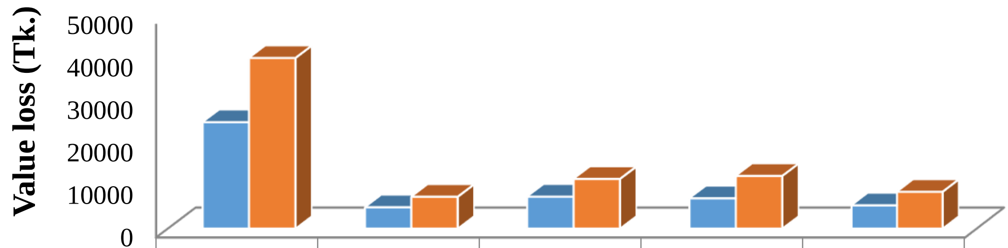
The quantitative loss (%) and value loss (Tk.) of chicken meat at the retailers' level in Rayer Bazar, Dhaka and Townhall Bazar, Mymensingh were calculated, and results are shown in Fig 7.21 and 7.22, respectively. The weight and value losses of chicken meat mainly occurred during handling, transportation, storage and marketing. The total quantitative chicken meat loss (%) at the retailers' level was found higher in Rayer Bazar, Dhaka than Townhall Bazar, Dhaka (Fig 7.21). The chicken meat loss in Rayer Bazar was found the highest during transportation followed by storing, marketing and handling. On the other hand, the loss in Townhall Bazar was found the highest during storage but transportation loss was also very close with storage loss followed by marketing and handling loss.



	Total	Handling	Transportation	Storing	Marketing
Rayer Bazar	4.40%	0.89%	1.31%	1.25%	0.95%
Townhall Bazar	3.35%	0.62%	0.98%	1.03%	0.72%

Fig 7.21 Postharvest weight loss (%) of chicken meat of retailer in Rayer Bazar and Townhall Bazar, Dhaka (N=25 for each of Rayer Bazar and Townhall Bazar, Dhaka).

The total value (Tk.) loss of chicken meat in Townhall Bazar was almost close to double than that of Rayer Bazar. The value losses (Tk.) of chicken meat in Rayer bazar was found highest during transportation followed by storing, marketing and handling. On the other hand, the value loss (Tk.) of chicken meat in Townhall Bazar was found higher both during storage and transportation followed by marketing and handling. The estimated total chicken meat loss at retailers' level in USA was reported as 4% (Buzby et al. 2014).



	Total	Handling	Transportation	Storing	Marketing
Rayer Bazar	24975.2	4983.96	7470.56	7088.31	5426.98
Townhall Bazar	40056.8	7452.43	11644.42	12343.08	8616.87

Fig 7.21 Postharvest value (Tk.) loss (%) of chicken meat of retailer in Rayer Bazar and Townhall Bazar (N=25 for each of Rayer Bazar and Townhall Bazar, Dhaka).

7.3.2 Possible reasons for loss of chicken meat during production and marketing

The possible reasons for the losses of chicken meat during production and marketing are shown in Fig 7.22. In this section, mainly experiences of the farmers, Bepari, wholesalers and retailers were assessed with some selected questionnaires to get their inbuilt ideas and practices throughout their long involvement in poultry rearing and marketing.

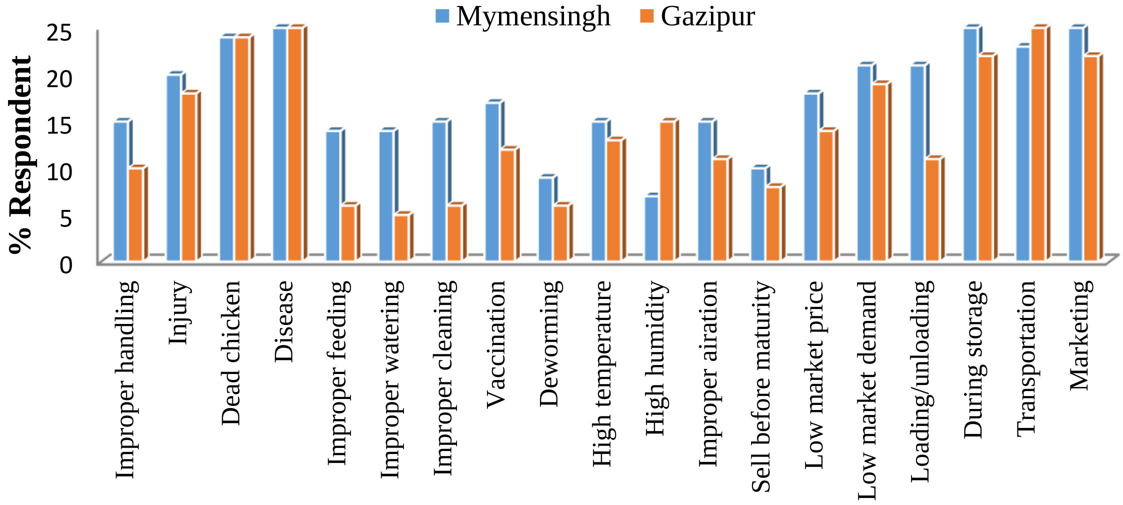


Fig 7.22 Possible reasons for the loss of chicken meat during postharvest operation (N=25).

Majority of the chicken meat producer, Bepari, wholesalers and retailers thought that disease, dead chicken, injury, low market demand and price, and during storage, transportation, marketing and during loading/unloading were the main causes of loss during production and marketing of chicken meat. In Mymensingh Sadar, higher number of respondents thought that improper handling, feeding, watering, cleaning, vaccination, high temperature and aeration were also responsible for the losses of chicken meat than Gazipur Sadar. Some of their ideas are common and some are location specific. All these valuable suggestions should be considered during policy formulation to reduce huge postharvest losses of chicken meat across value chain.

7.3.3 Possible solutions to reduce losses of chicken meat production and marketing

The possible solutions to reduce losses of chicken meat during production and marketing are shown in Figure 7.23. In last section, possible reasons for the losses of chicken meat during production and marketing are identified. In this section like before, producer, Bepari, wholesalers and retailers suggested that proper rearing of broiler is very important to reduce postharvest losses of chicken meat. They also gave emphasis on proper feeding, proper vaccination, prevention of disease, temperature control, market demand and price, proper transportation and marketing to reduce the postharvest losses of chicken meat across the value chains. Some of them also opined that proper storage and proper loading and unloading need to be addressed.

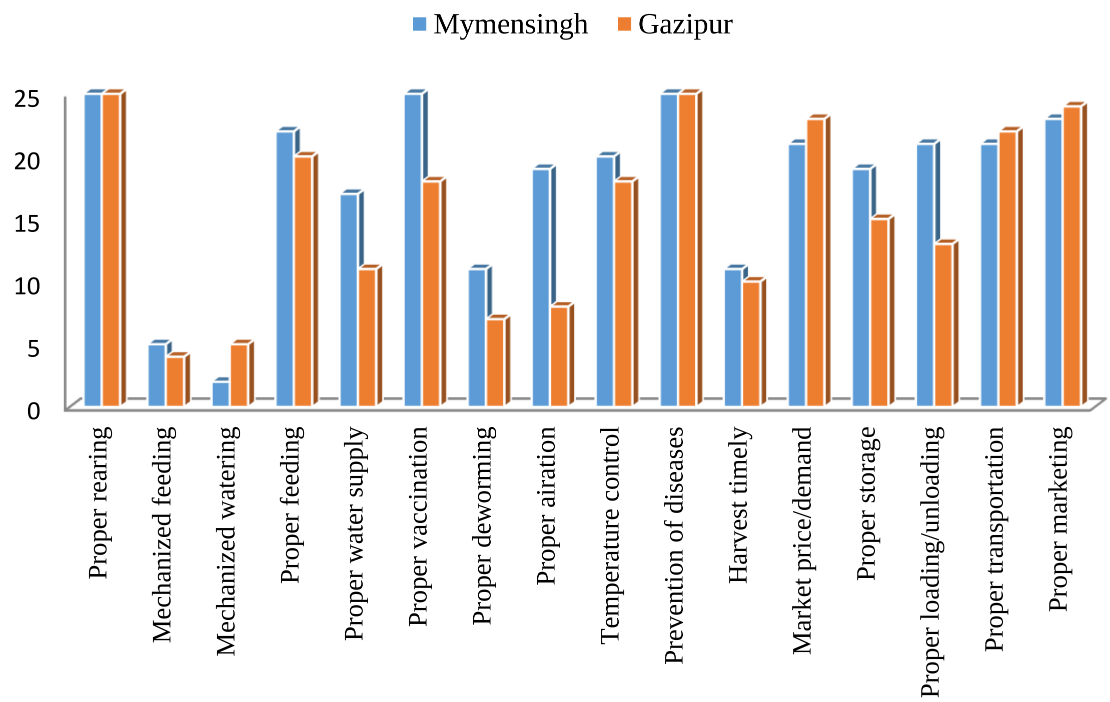


Fig 7.23 Possible solutions to reduce loss of chicken meat during production and marketing (N=25).

Plate 7.6 Photographs showing loss of chicken.

7.4 RED MEAT (CATTLE)

7.4.1 Levels of loss

7.4.1.1 At producer level

The quantitative loss (%) and value loss (Tk.) of red meat (cattle) at the producers' level in Sirajganj and Chuadanga were calculated and the results are shown in Fig 7.24. The average loss of red meat was found nearly 13.0%, where in Sirajganj the loss was higher than Chuadanga. On the other hand, the value loss (Tk.) in Chuadanga was found higher than Sirajganj even though the red meat loss is higher in Sirajganj than Chuadanga. This might be because of the amount of red meat production was higher in Chuadanga than Sirajganj but if value loss is converted to percentage then loss in Sirajganj was found higher than Chuadanga. The calculated losses for beef ranged from 7-14% according to Liu (2013). There are fewer studies for postharvest losses of meats. The losses at postharvest handling, storage, processing, and distribution stages of meat were estimated as 1.4-2.1%, 2.5-3.7%, 1.1%, and 3%, respectively (Xu 2007).

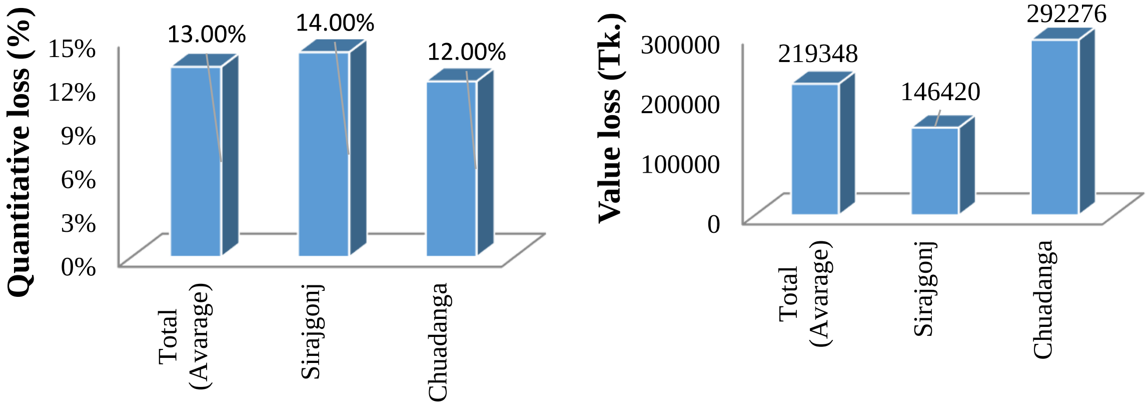


Fig 7.24 Postharvest weight (%) and value (Tk.) loss of red meat at producer level of Sirajganj and Chuadanga (N=25 for each of Sirajganj and Chuadanga).

7.4.1.2 At middlemen level- Bepari

The quantitative loss (%) and value loss (Tk.) of red meat at middleman (Bepari) level in Sirajganj and Chuadanga were calculated and shown in Fig 7.25 and 7.26, respectively. The quantitative and value losses of red meat at Bepari level mainly occurred during handling, storing, loading/unloading and marketing. The quantitative loss (%) of red meat at Bepari level was found higher in Sirajganj than Chuadanga. The loss of red meat in Sirajganj was found the highest during red meat storing followed by loading/unloading and handling. On the other hand, the weight loss (%) of red meat in Chuadanga was found the highest as of Sirajganj during red meat storing followed by handling and loading/unloading.

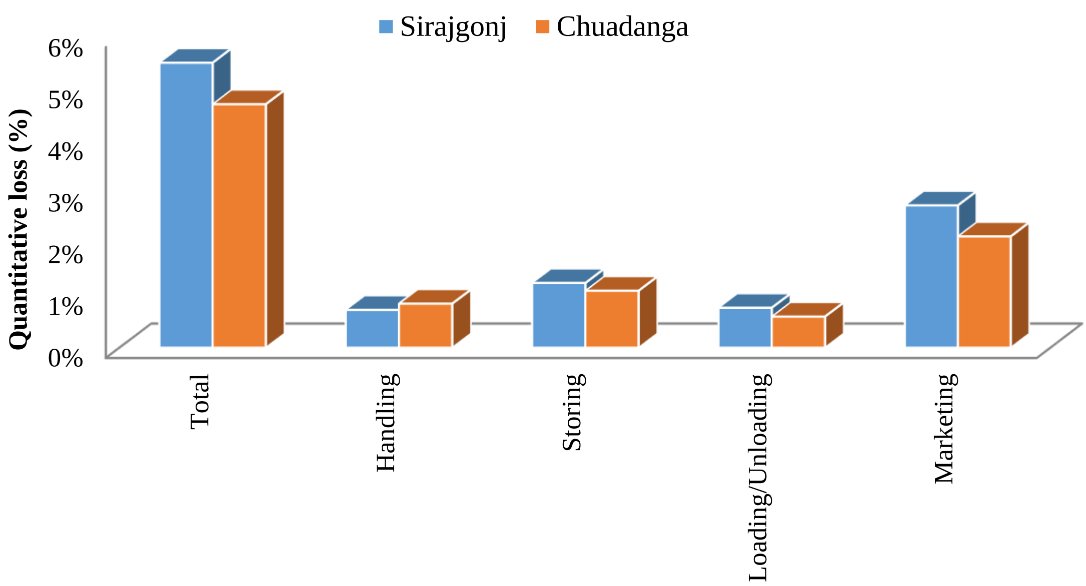
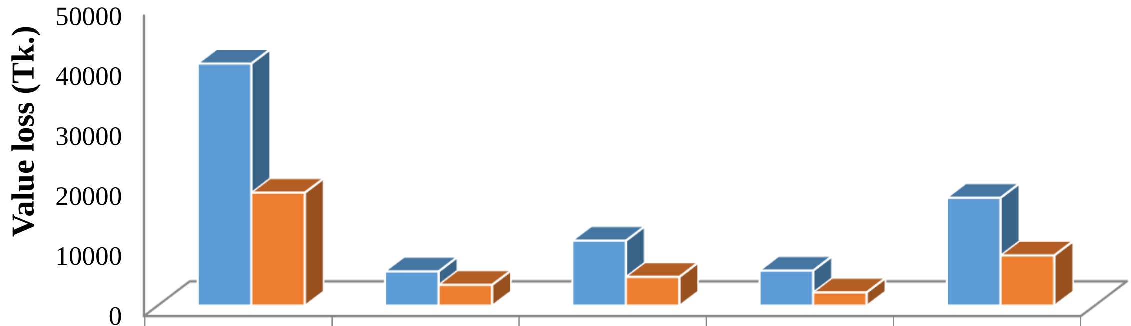


Fig 7.25 Postharvest quantitative loss (%) of red meat at middleman (Bepari) in Sirajganj and Chuadanga (N=25 for each of Sirajganj and Chuadanga).

The total value loss (Tk.) of red meat in Sirajganj was more than double than as compared to that of Chuadanga. These differences of value losses may be due to higher amounts of red meat produced and its corresponding loss was more in Sirajganj than in Chuadanga. The value loss of red meat in Sirajganj was found the highest during red meat marketing followed by storing, loading/unloading and handling. On the other hand, the loss in Chuadanga was found the highest during red meat marketing followed by storing, handling and loading/unloading.

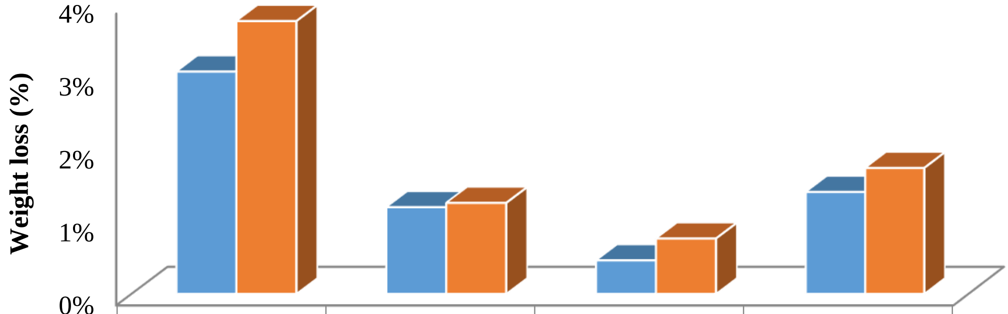


	Total	Handling	Storing	Loading/Un loading	Marketing
Sirajgonj	40265.45	5696.1	10802.94	5827.04	17939.43
Chuadanga	18790	3454.32	4782.91	2201.66	8351.11

Fig 7.26 Postharvest value loss (Tk.) of red meat at middleman (Bepari) in Sirajganj and Chuadanga (N=25 for each of Sirajganj and Chuadanga).

7.4.1.3 At middlemen level- Retailers

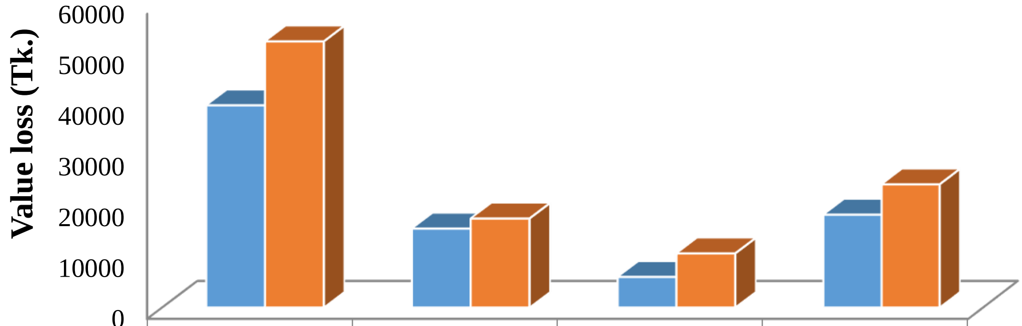
The quantitative or weight loss (%) and value loss (Tk.) of red meat at retailers' level in Notun Bazar and Mirpur Bazar, Dhaka were calculated and shown in Fig 7.27 and 7.28, respectively. The weight and value losses of red meat at the retailers' level mainly occurred during handling, storing and marketing. The total weight loss (%) of red meat at the retailers' level was found higher in Mirpur Bazar, Dhaka than Notun Bazar. The weight loss (%) of red meat in Notun Bazar was found the highest during marketing followed by handling and storing. On the other hand, the weight loss (%) of red meat in Mirpur Bazar, Dhaka was found also the highest during marketing followed by handling and storing.



	Total	Handling	Storing	Marketing
Notun bazar	3.05%	1.19%	0.46%	1.40%
Mirpur bazar	3.74%	1.25%	0.76%	1.73%

Fig 7.27 Postharvest quantitative or weight loss (%) of red meat at the retailers level in Notun Bazar and Mirpur Bazar, Dhaka (N=25 for each of Notun Baza and Mirpur Bazar, Dhaka).

The total value loss (Tk.) of red meat in Mirpur Bazar, Dhaka was higher than that of Notun Bazar. The value losses of red meat in Notun Bazar was found the highest during marketing followed by handling and storing. The value loss (Tk.) of red meat in Mirpur Bazar, Dhaka followed a similar trend as of Notun Bazar.



	Total	Handling	Storing	Marketing
Notun bazar	39762.9	15514.05	5997.03	18251.82
Mirpur bazar	52349	17496.32	10637.76	24214.91

Fig 7.28 Postharvest value (Tk.) loss (%) of red meat of retailer in Notun Bazar and Mirpur Bazar (N=25 for each of Notun Baza and Mirpur Bazar, Dhaka).

7.4.1.4 Possible reasons for the loss of red meat production and marketing

The possible reasons for the loss of red meat during production and marketing are shown in Fig 7.29. In this section, mainly experiences of producer, middleman (Bepari) and retailers were assessed with some selected questionnaire to get some of their inbuilt ideas and practice they followed during their long involvement in cattle farming and marketing.

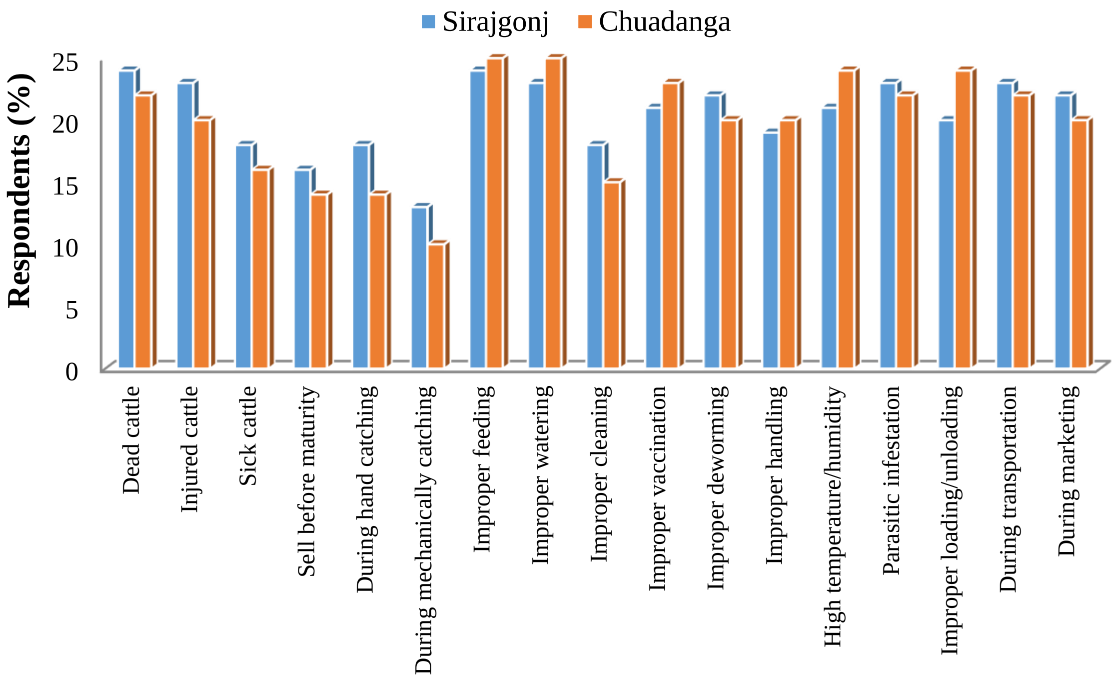


Fig 7.29 Possible reasons for the loss of red meat during post-harvest operation (N=25).

Majority of the red meat producer, middleman (Bepari) and retailers both in Sirajganj and Chuadanga thought that improper feeding and watering, disease, dead animal, injury, high temperature and humidity, and during transportation, during marketing, proper vaccination and deworming and during loading/unloading were the main causes for the loss of red meat during production and marketing. All these valuable suggestions should be considered to reduce huge postharvest losses of red meat.

7.4.1.5 Possible solutions to reduce loss of red meat during production and marketing

The possible solutions to reduce the loss of red meat during production and marketing are shown in Fig 7.30. In last section, possible reasons for the loss of red meat during production and marketing are identified through survey. In this section like before, producer, middleman (Bepari) and retailers suggested that proper rearing, proper feeding and water supply, timely vaccination and deworming and disease control could reduce postharvest loss of red meat. They also emphasized on proper maturity, proper preparation, proper loading/unloading, proper transportation and marketing to reduce the postharvest loss of red meat across marketing channel. Some of them also mentioned that mechanized feeding, watering, and control of temperature and humidity, are needed.

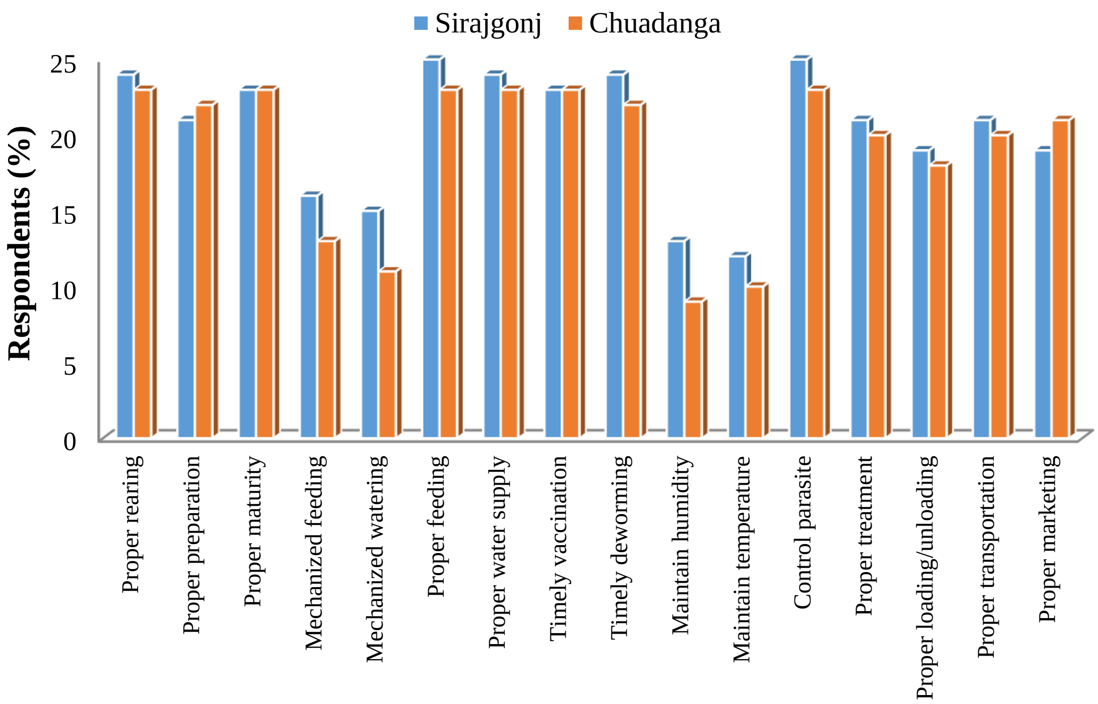


Fig 7.30 Solutions to reduce loss of red meat during production and marketing (N=25).

Plate 7.7 Field data collection on red meat loss.

7.5 PROCESSING LOSS

7.5.1 Meat and meat products

Processing loss refers to the loss that occurs at the processing plant immediately after receiving the animals/raw materials. Generally, processing loss occurs during handling, sorting, grading, packaging, in-factory transportation and storage. The results obtained from the largest meat processing industry of Bangladesh, Bengal Meat, Tejgaon, Dhaka are summarized in Table 7.1, 7.2. A variety of meat products are prepared by the company (Table 7.1). The losses at different levels of processing are shown in Table 7.2. Meat loss at the processors' level was observed to be 5-9% for meat and meat products (Table 7.2). Similar results were nor found available in Bangladesh. However, processing loss of all type of meat and poultry meat in India were reported as 2.3 and 3.7%, respectively (CIPHET 2010).

Table 7.1 Type and quantity of processed products (Bengal Meat, Tejgaon, Dhaka)

Commodity	Name of products	Quantity produced yr^{-1} (metric tons)
Meat and meat products	Meat curry	18
	Meat kebab	16
	Meat steak	60
	Meat ball	36
	Meat sausage	18
	Meat cuts	150
	Others	60
	Total quantity	**358**

Table 7.2 Postharvest loss of meat and meat products at the processors' level

Commodity	Steps of processing	Loss (%)
Meat and meat products	Before processing (sorting and grading)	1-2
	During processing (slaughtering, skinning, storing, handling, etc.)	2-3
	After processing (packaging and transportation)	1-2
	Storage	1-2
	Total loss (%)	**5-9**

7.5.2 Milk and milk products

The results obtained from the largest milk processing industry of Bangladesh, Milk Vita, are furnished in Tables 7.3, 7.4. Variety of milk products are prepared by the company (Table 7.3). The loss at the processor's level was assessed as 8-12% for milk and milk products (Table 7.4).

Table 7.3 Type and quantity of processed milk products (Milk Vita)

Commodity	Name of products	Quantity produced yr^{-1} (metric tons)
Milk and milk products	Liquid milk	20750
	Powder milk	983
	Sweet meat	635
	Ice cream	540
	Yogurt	250
	Ghee	160
	Butter	110
	Labang	90
	Condensed milk	100
	Others	60
	Total quantity	**23678**

Table 7.4 Postharvest loss of milk and milk products at the processors' level

Commodity	Steps of processing	Loss (%)
Milk and milk products	Before processing (handling, collection, loading/unloading, grading, cooling, storing)	3-4
	During processing (pasteurization, operation, preparation)	2-3
	After processing (packaging, transportation, marketing)	2-3
	Storage	1-2
	Total loss (%)	**8-12**

7.6 MICRONUTRIENT CONTENT

Mineral contents, namely calcium, iron and zinc in the selected animal products (cow milk, buffalo cow milk, chicken meat, red meat and egg) were assessed at different times after milking or slaughtering or laying using AAS (Atomic Absorption Spectrophotometer). Apart from that folate, an important B-complex vitamin, was also assessed in the above-mentioned animal products using HPLC Estimates were taken from triplicate samples (Plate 7.8). The results obtained are presented and discussed in the following:

7.6.1 Calcium content

Calcium is required in our body to maintain strong bones and to carry out important functions. Almost all calcium is stored in bones and teeth, where it supports their structure and hardness. Our body also requires calcium for muscles to move and for nerves to carry messages between the brain and other body parts. The micronutrient calcium content in cow milk, buffalo cow milk, red meat, chicken meat and egg at different times after sampling are furnished in Fig 7.31. Among the livestock products examined, calcium content was found the highest in buffalo cow milk followed by cow milk and egg. The calcium content of red meat and chicken meat was almost similar. As per USDA (2019), the concentrations of calcium in beef, chicken meat, cow milk, buffalo cow milk and egg were 18, 15, 120, 195 and 50 mg $100g^{-1}$, respectively.

In the present study, in the case of cow's milk, calcium content showed a decreasing trend up to 9^{th} h of milking but again increased at the 12^{th} h of milking. In buffalo cow milk, calcium content was found quite stable up to the 18^{th} h but slightly increased at the 24^{th} h of milking. Milk being one of the most important sources of readily available calcium, the calcium concentration in milk generally remains stable from the second month post-partum, and it remains so until the end of lactation (Nogalska et al. 2017). In red meat, the values of calcium content were stable up to 12 h of sampling and the trend was found similar for chicken meat as of red meat up to 12 h. In case of egg, calcium content showed slightly decreasing trend with the increase of sampling days.

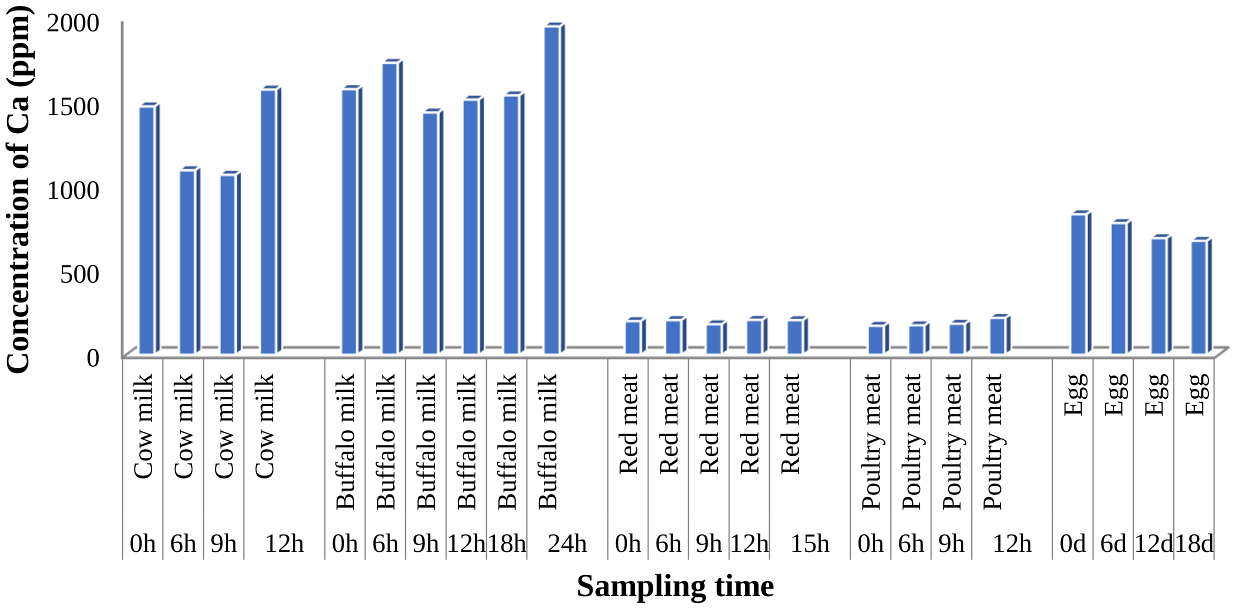


Fig 7.31 Calcium content in cow milk, buffalo cow milk, red meat, chicken meat and egg at different times (h=hours; d=days) after sampling.

7.6.2 Iron content

Iron contents in cow milk, buffalo cow milk, red meat, chicken meat and egg at different times (h=hours; d=days) after sampling are shown in Fig 7.32. Among the livestock products examined, iron content was found the highest in red meat followed by egg and chicken meat. The iron contents of cow milk and buffalo cow milk were almost similar. In case of cow milk, iron content steadily increased with increase of sampling hours. In contrast, iron content in buffalo cow milk did not show any regular patter of changes as time progressed after milking. However, it must be noted that milk is an insignificant source of iron. In case of red meat, iron contents were found to decrease with time but did not follow any regular pattern. In chicken meat, iron contents decreased up to 9 h of sampling but again increased to its original concentration at the 12th h of sampling. In case of egg, iron content trended to increase with the progress in time after sampling. Human body needs iron for growth and development. Iron contributes to produce haemoglobin, a protein in red blood cells that carries oxygen from the lungs to all parts of the body, and myoglobin, a protein that provides oxygen to muscles. It is also required to produce certain hormones. Iron concentrations in beef, chicken meat, cow milk, buffalo cow milk and egg were 2.6, 1.16, 0.05, 0.12 and 1.2 mg 100 g^{-1}, respectively (USDA 2019).

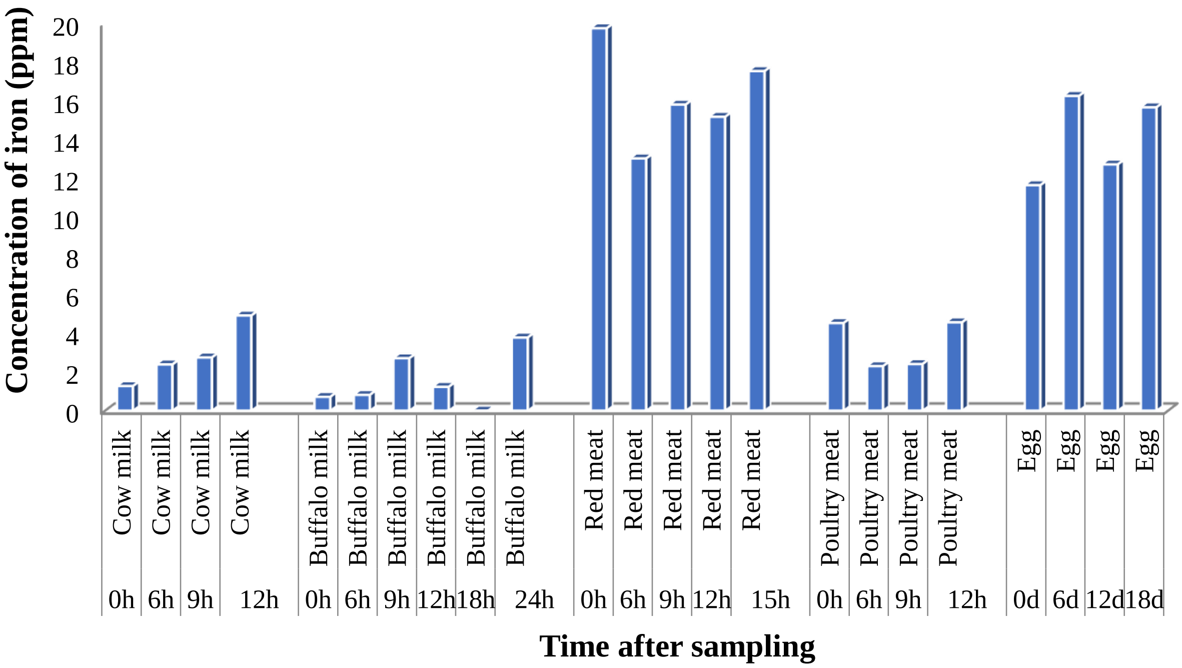


Fig 7.32 Iron contents in cow milk, buffalo cow milk, red meat, chicken meat and egg at different times (h=hours; d=days) after sampling.

7.6.3 Zinc content

Zinc contents in cow milk, buffalo cow milk, red meat, chicken meat and egg at different times after sampling are shown in Fig 7.33. Among the livestock commodities examined, zinc content was found the highest in red meat followed by egg. The zinc content in buffalo cow milk was slightly higher than cow milk. In case of cow milk, zinc content slightly decreased up to 9 h but suddenly increased almost 3 times at 12 h after milking. In buffalo cow milk, there was a tendency to decrease zinc content. In red meat, zinc content was found to decrease from 6 to 15 h of sampling. In case of chicken meat, zinc content slightly decreased up to 9 h but again increased to its original concentration at 12 h of sampling. In case of egg, zinc content slightly increased but decreased from 12 days onwards. Zinc is an important mineral that people need to stay healthy. Zinc is found in cells throughout the body. It helps the immune system to fight off invading bacteria and viruses. The body also needs zinc to make proteins and DNA, the genetic material in all cells. The zinc concentrations in beef, chicken, cow milk, buffalo cow milk and egg were 6.31, 1.0, 0.4, 0.22 and 1.0 mg 100 g^{-1}, respectively (USDA 2019).

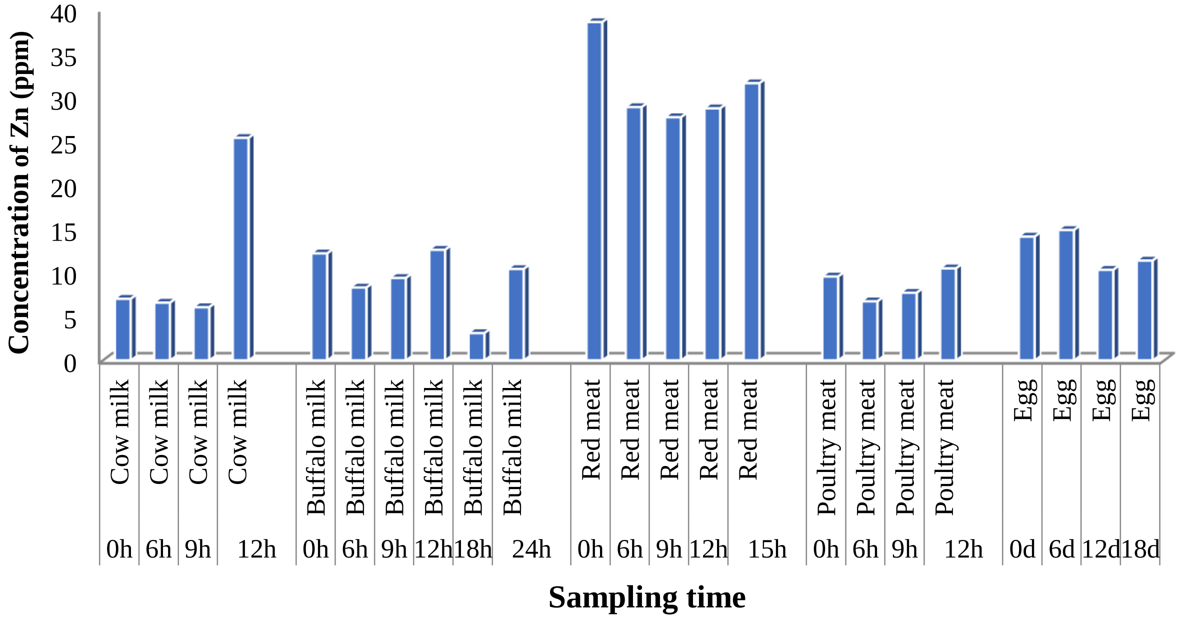


Fig 7.33 Zinc contents in cow milk, buffalo cow milk, red meat, chicken meat and egg at different times (h=hours; d=days) after sampling.

7.6.4 Folate content

Folate contents vary with the type of animal products. Chicken meat was found to contain the highest folate content followed by beef. The pattern of changes/loss of folate greatly varies with product types. For example, folate contents in beef and egg initially increased until 6 h and declined thereafter (Fig 7.34A, B). In the case of cow milk, folate content sharply declined with time progressed after milking. There was 28% decline in folate at 12 h after milking (Fig 7.34C). However, contrasting patters of folate change in chicken meat and buffalo milk were evident (Fig 35A, B). The causes of such contrasting patterns were not immediately understood. These results warrant more in-depth study on micronutrient changes in commonly consumed food items in Bangladesh. In recent years, folates have come into focus due to their protective role against childbirth defects, for example, neural tube defects. In addition, folates may have a protective role to play against coronary heart disease and certain forms of cancer. During the last few years many countries have established increased recommended intakes of folates, for example, between 300-400 µg day^{-1} for adults. In animals, the liver is the main storage organ for folate, and it is abundant in leafy vegetables and many plant foods. The folate concentrations in beef, chicken, cow milk, buffalo cow milk and egg were 9-11, 76, 7-10, 5-7 and 44 µg 100 g^{-1}, respectively (USDA 2019).

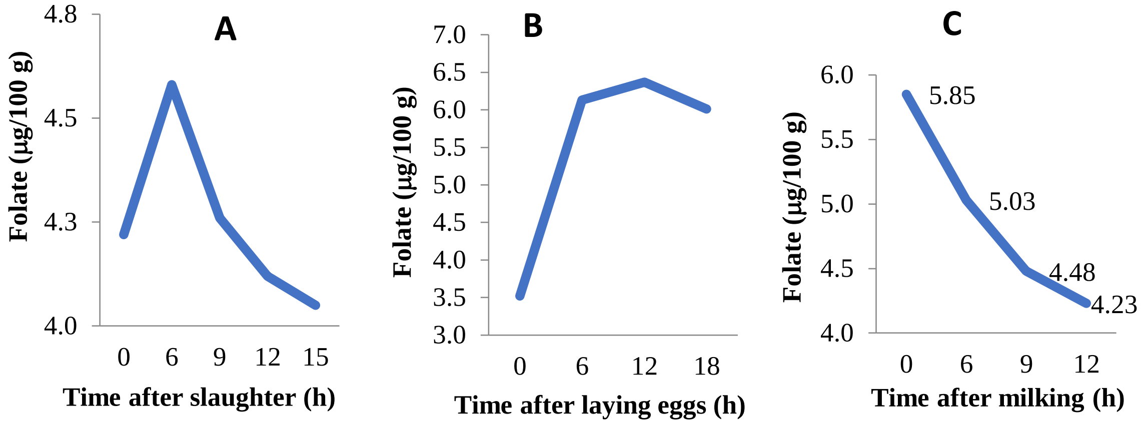


Fig 7.34 Folate content in beef (A), egg (B) and cow milk (C) at different times after sampling, respectively at ambient condition (N=3).

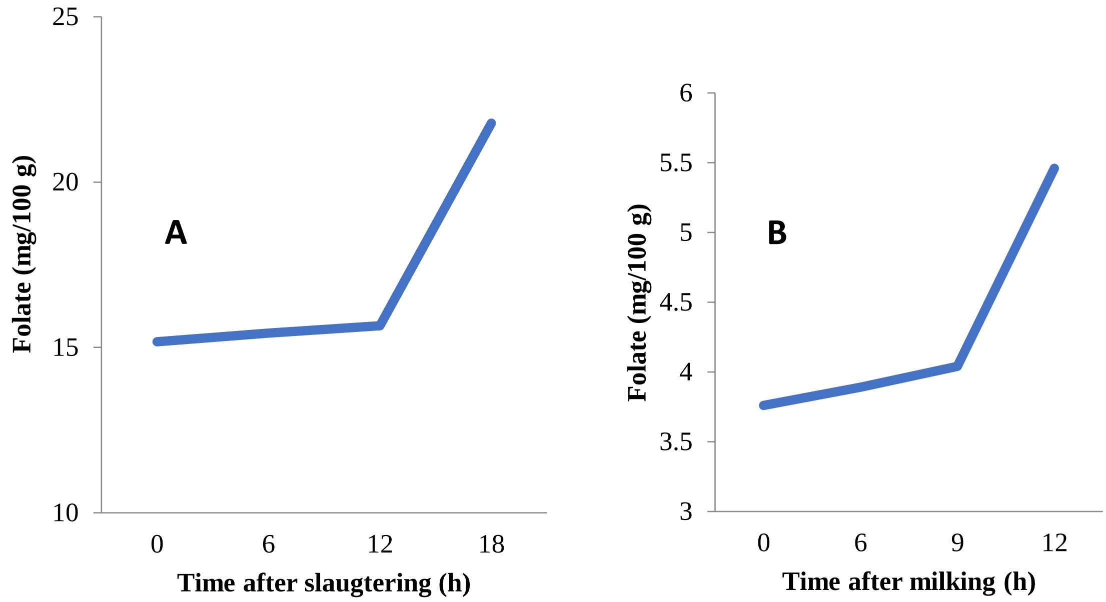


Fig 7.35 Folate content in chicken meat (A) and buffalo cow milk (B) at different times after slaughter and milking, respectively at ambient condition (N=3).

Plate 7.8 Pictures showing sample preparation for micronutrient analysis in animal products.

Chapter 8
FOOD LOSS- FISH PRODUCTS

Postharvest quantitative losses in the selected value chains (fishermen to retailers) for carp and small fishes were assessed following 'Category method' of Delgado et al. (2017). Detailed sampling plan has been furnished in Appendix 1. Some important field activities are shown in Plates 8.1-8.12.

Plate 8.1 Field data collection for small fish from a fisherman (A) and a woman retailer (B).

Plate 8.2 Storage (A) and display (B) of small fish at wholesale market (no ice is used).

Plate 8.3 Auction (A) and primary packaging (B) of small fish (no ice is used in fishes).

Plate 8.4 Crushing of ice manually (A) and collection of dirty ice (B) for preservation.

Plate 8.5 Packaging of small fish (A) and closing the package under heavy pressure (B).

Plate 8.6 Use of partially crushed ice in Mymensingh (A) and retailing in Dhaka City (B).

Plate 8.7 Drain clogging (A) and unhygienic condition of fish market (B) in Dhaka City.

Plate 8.8 Drip loss of small fish (A) and fish waste (B) at retail market in Dhaka City.

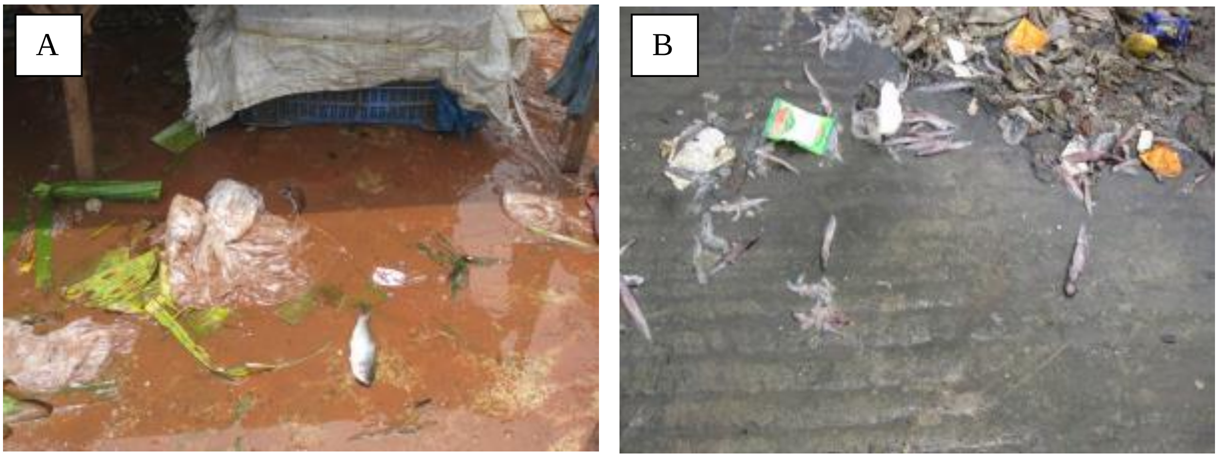


Plate 8.9 Fish wasted in wholesale (A) and retail market (B) in Dhaka.

Plate 8.10 Fish air bladder wasted in wholesale market (A) and low tempered ice in use (B).

Plate 8.11 Use of unclean balance for weighing fish in wholesale market (A) and live carp fish being taken care of at a retail market (B).

Plate 8.12 Fish quality assessment in the laboratory (A) and at the field (B).

8.1 SMALL FISH

8.1.1 Status of postharvest handling of small fish in the value chain

Postharvest activities in fisheries involve a number of activities such as sorting, washing, weighing, preservation, packaging, storage and distribution. In case of small fish that are harvested from floodplains of Tarail Upazila of Kishoregonj district, different value chain actors performed different postharvest activities that are depicted in Fig 8.1.

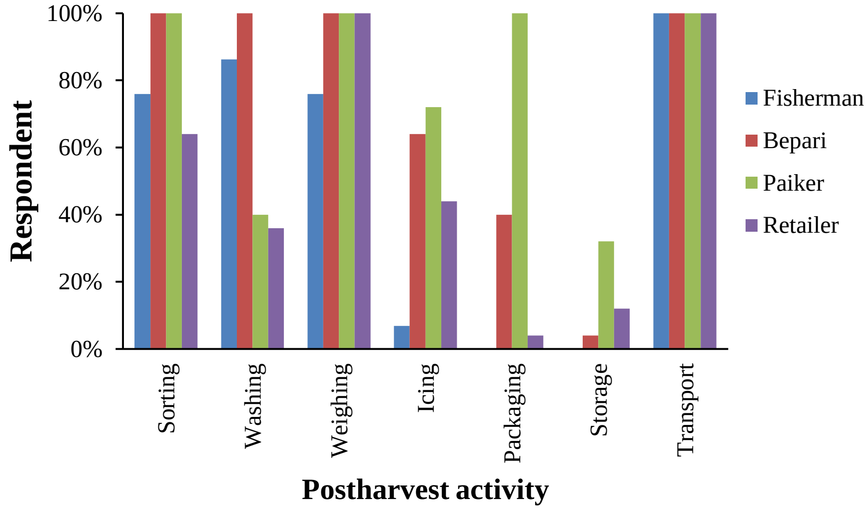


Fig 8.1 Status of postharvest activities performed by different value chain actors of small fish (N = 25 for Fisherman; 25 for Bepari, middleman; 25 for Paiker, wholesaler; and 25 for retailers).

It was observed that sorting of small fish according to different criteria such as species, size, sex and quality, and weighing of fish were performed by majority of the value chain actors. These activities are needed for ease of exchange/sale. Washing of small fish to remove dirt, mud and various foreign materials was largely done by the fishermen and Bepari (middleman), whereas 40% of the Paiker (wholesaler) and 36% of the retailers performed the tasks before selling. This is largely due to lack of awareness and lack of supply of potable water required for washing. Interestingly, it was observed that fishermen tend not to use ice to preserve their catch during storage and transportation. They argued that buyers do not prefer to buy iced fish as they bear a misconception that iced fish are of low quality. Also they told that icing reduces the shiny appearance of small fish, hence making it unattractive to buyers/consumers. Generally, crushed ice prepared from large ice blocks is used to preserve fish in different parts of Bangladesh. It was observed that only 6.9% of the fishermen carried ice on their boats to keep the quality of small fish. Packaging of small fish was another important postharvest activity that was lacking in the case of fishermen and retailers. It was revealed that fishermen kept the fish on the hull of their boats and sprinkled water on the fish to preserve its freshness. Similar tendency of not packaging was reported by the Bepari and retailers. The Bepari and Paiker (wholesalers), on the other hand, used traditional packaging method of using bamboo made baskets to pack and transport small fish to distant places via luggage compartment of city bound bus service and/or mini trucks.

8.1.2 Levels of loss

Loss of small fish was estimated along the selected value chain according to 'Category method' described by Delgado et al. (2017). Fig. 8.2 shows the loss estimated at fishermen and the intermediary (Bepari, wholesalers and retailers) levels.

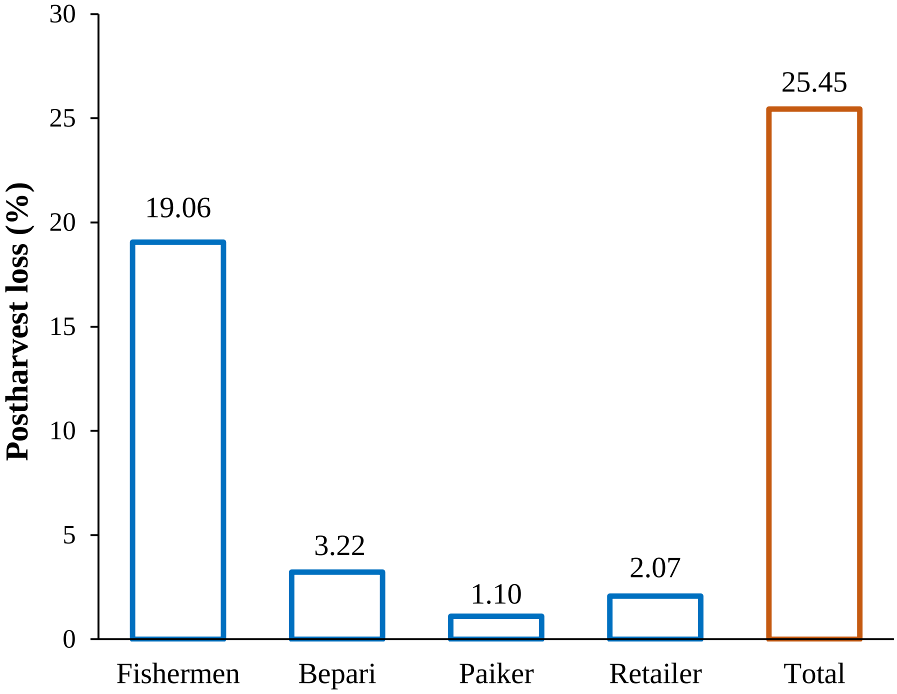


Fig 8.2 Postharvest losses of small fish at different levels in the supply chain. N=25 for each of fishermen, Bepari, Paiker (wholesaler) and retailers.

As shown in Fig. 8.2, total loss for small fish was 25.45%. Of this loss, fishermen reported the highest level of postharvest loss of 19.06 ± 3.56% followed by 3.22 ± 2.71% for Bepari, 1.10 ± 0.06% for Paiker and 2.07 ± 2.11% for retailer. In developing countries, the degree of postharvest fish losses ranges between 10-59% of their total catch (Ibengwe and Kristófersson 2012; Maulu et al. 2020). Study conducted by the Central Institute of Fisheries Technology (CIFT) of India found that 10-30% of fish landed were of poor quality that fetched price loss between 45-75% (Papadopulos 1997). Since there is a scarcity of data of postharvest loss for small fish in the region, it becomes difficult to compare our result with other studies. The levels of loss for individual value chain actors are separately described below:

8.1.2.1 Loss at fishermen level

Fishermen reported the highest level of loss as obtained by 'Self-reported' method (Fig. 8.3). This indicates that economic loss is also the highest for the fishermen (Torell et al. 2020). In the present study, a number of factors were responsible for the loss at the fishermen level, which included loss due to pollution/poisoning of water body (pre-harvest loss of 8.15%), loss due to delay in lifting of gear (1.73%), loss due to fish holding on-board the craft (3.02%), loss during other postharvest activities like sorting (2.11%), loss during unloading (4.05%).

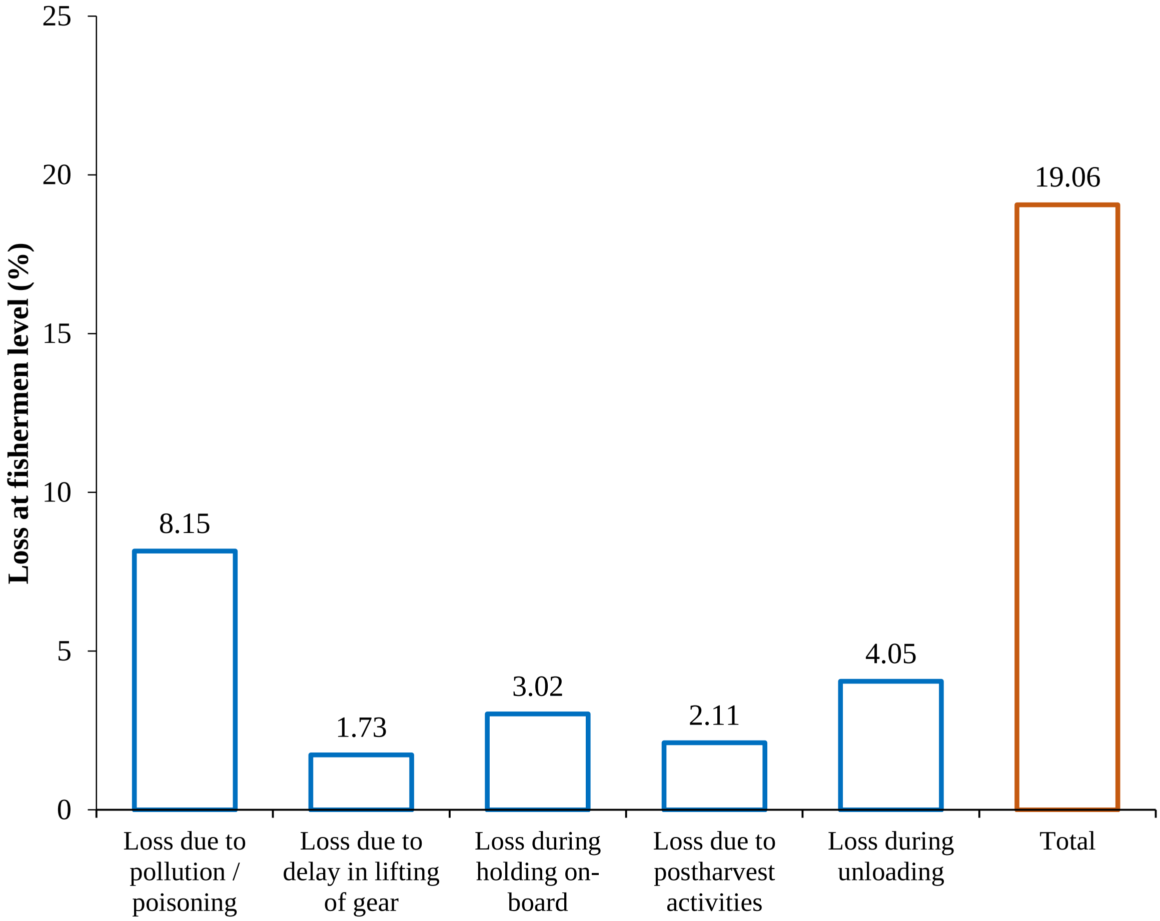


Fig 8.3 Postharvest losses of small fish at fishermen level (N=25).

When comparing this level of loss at fishermen level, the value seems slightly higher than those reported by others. As for example, Adelaja et al. (2018) reported that the fishermen in Nigeria incurred average postharvest fish losses of 8.15% for croaker, 7.76% for catfish and 7.57% for shrimp. This is because the present study used 'Category method' of Delgado et al. (2017) method that considers pre-harvest loss as an important component of total loss. Other minor causes of loss by fishermen were stealing of their caught fish, contamination, unhygienic condition, storage, etc.

A key feature of loss estimation by the 'Category method' of Delgado et al. (2017) is that it considers losses from pre-harvest stage. In this study, an estimated 8.15% loss was reported by fishermen as pre-harvest loss due to water pollution/poisoning. This is a substantial amount because pollution of aquatic environment has become prevalent in different areas of Bangladesh and, this situation is aggravating for open water fisheries of the country. Various harmful substances are said to pollute water bodies that include insecticide, pesticides, heavy metals, industrial wastes, etc. (Malik et al. 2021) that possibly end up through run-off into the aquatic ecosystem. So, steps are necessary to prevent water pollution/poisoning so that the loss from this side can be minimized.

8.1.2.2 Loss at Bepari level

In case of Bepari, the estimated loss was 3.22 ± 2.65% that was mainly caused by sorting (76%), packaging under heavy pressure (12%) and leaching/drip loss of fish (8%).

8.1.2.3 Loss at Paiker/wholesaler level

Paiker reported 1.10 ± 0.06% loss that was due to washing (4%), packaging (4%), transport (12%), storage (8%) and marketing (72%).

8.1.2.4 Loss at retailers' level

Finally, retailers reported loss of 2.07 ± 2.11% that was due to more or less similar causes as those of the Paiker (wholesalers). In addition, softening of fish and lack of buyers were other important causes of fish loss reported by the retailers. This situation has become much pronounced during the Covid-19 pandemic.

8.1.3 Causes of incurring postharvest losses in the small fish value chain

When data was collected on the major causes of post-harvest loss in the value chain of small fish, it was revealed that causes reported by fishermen were slightly different from other value chain actors. Table 2 shows the causes of incurring of post-harvest loss for small fish. Majority of the fishermen (84%) reported that a number of post-harvest activities caused loss in their catch. Some causes of pre-harvest loss of small fish reported by fishermen were pollutants of the water (23%), poisoning of water body by chemical substances (21%). Others reported that use of synthetic monofilament gillnet (locally called *Current Jal*) as well as capsizing of their fishing craft due to bad weather. Loss incurred due to unloading of catch was reported by 52% of the fishermen while loss due to holding longer duration on board the fishing craft was reported by 28% of the fishermen (Table 8.1).

Table 8.1 Causes of postharvest loss in the value chain of small fish (N=25 for each of fisherman, Bepari, wholesaler and retailers).

Reasons of postharvest loss	**Respondent (number)**			
	Fishermen	**Bepari**	**Paiker (Wholesaler)**	**Retailer**
Loss due to harvesting method	11 (44)	-	-	-
Loss due to holding on-board	7 (28)	-	-	-
Loss during unloading	13 (52)	-	-	-
Loss due to postharvest activities	21 (84)	-	-	1 (4)
During handling	-	-	0	0
During washing	-	-	1 (4)	0
During sorting	-	19 (76)	0	0
During packaging	-	3 (12)	1 (4)	3 (12)
During storage	-	0	2 (8)	3 (12)
During transportation	-	0	3 (12)	4 (16)
During marketing	-	0	18 (72)	16 (64)
Others	-	8 (32)	7 (28)	4 (16)

Values in the parentheses indicate percentage (%)

In case of Bepari, 76% reported that their loss was caused due to sorting. This is probably related to discarding of spoiled/low-valued fishes. On the other hand, 12% respondents said that packaging caused some loss to their product. This may be related to packing of fish under heavy pressure and use to traditional bamboo made baskets as icebox for transport. Interestingly, 32% of the Bepari reported that they had to give extra weight for selling their fish. Paiker reported that their loss incurred due to different postharvest activities. Among those, 72% respondents said that marketing was their major cause of loss since market price of these perishable commodities fluctuated much, while 12% reported lack of transport facilities was the cause of loss. Interestingly, drip loss and softening of fish was reported as another important cause reported by 28% of the Paiker (wholesalers). Retailers reported that marketing (64%) to be the major cause of their loss followed by transportation (16%), packaging (12%), storage (12%) and handling (4%). Among these sellers, 16% reported that they had to give 5-10 g of extra weight per kg of small fish to the consumers.

8.1.4 Possible ways to reduce postharvest losses in the small fish value chain

When data were collected on the possible ways to reduce postharvest loss in the value chain of small fish, it was revealed that fishermen gave emphasis on adopting good fishing practices (84%) followed by 72% for adoption of modern fishing method/gear, 44% for immediate sale of their catch and 20% for use of modern icebox (Table 8.2).

Table 8.2 Possible ways to reduce postharvest loss in the value chain of small fish (N=25 for each of fisherman, Bepari, wholesalers and retailers)

Reasons of postharvest loss	**Respondent**			
	Fishermen	**Bepari**	**Paiker (Wholesaler)**	**Retailer**
Adopt modern fishing gears/method	18 (72)	-	-	-
Adopt good practices during fishing	20 (80)		-	-
Use of modern icebox	5 (20)	-	-	-
Immediate sell of the catch	11 (44)	-	-	-
Proper handling of fish	-	12 (48)	7 (28)	3 (12)
Icing	-	14 (56)	17 (68)	10 (40)
Protect from sunlight	-	5 (20)	8 (32)	7 (28)
Use of clean water	-	9 (36)	9 (36)	5 (20)
Use of clean utensils	-	11 (44)	15 (60)	11 (44)
Immediate sale of fish	-	17 (68)	9 (36)	1 (4)
Others	-	-		1 (4)

Values in the parentheses indicate percentage (%)

8.2 CARP FISH

8.2.1 Status of postharvest handling of carp fish value chain

In Mymensingh region, carp fish cultured in earthen ponds are harvested and passed through a marketing channel to finally reach the consumers at different areas including Dhaka, Gazipur, Chattogram and other parts of the country. Fig. 8.4 shows various postharvest activities performed by different value chain actors of carp fish.

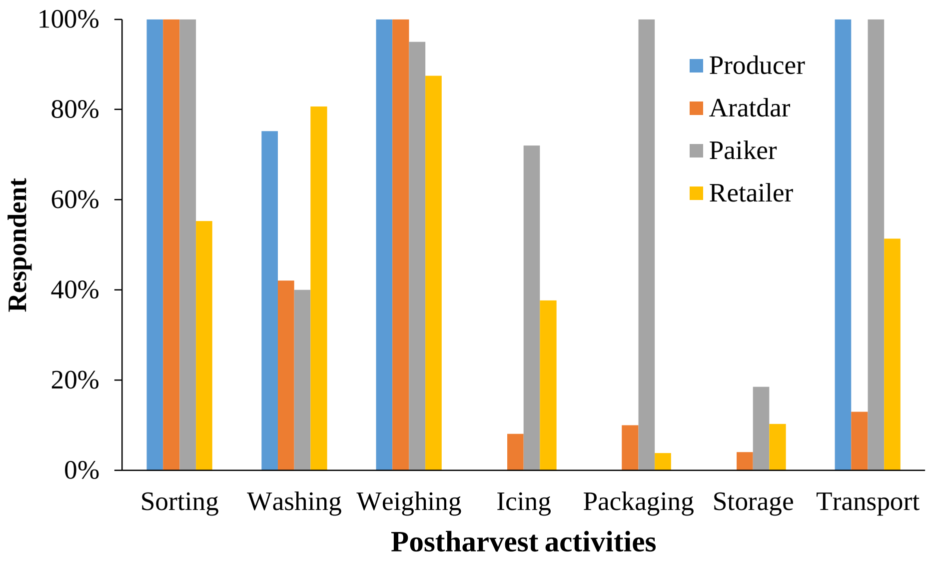


Fig 8.4 Status of postharvest activities of carp fish for different actors along the value chain. N = 25 for fishermen, 25 for Aratdar (commission agent/middleman), 25 for Paiker (wholesaler), and 25 for retailers.

Similar to small fish, carp fish are sorted according to different criteria such as size, sex and quality. Washing of carp fish to remove dirt, mud and various foreign materials were largely performed by the fishermen and retailer, whereas 42% of the Aratdar (commission agent) and 40% of the Paiker (wholesalers) performed the tasks before selling. Weighing was a common practice performed by majority of the stakeholders so that they can ensure their profit. Icing was not practiced by fishermen as well as Aratdar (commission agent). They argued that transportation of their farmed (cultured) fish from the farms to the auction center took about 10-30 minutes, and they did not require to use ice. Other value chain actors such as Paiker (wholesalers) and retailers used ice in majority of the cases. The Paiker (wholesalers) used traditional packaging method of using bamboo baskets to pack and transport carp fish to distant places usually by mini trucks. Sometimes, they used plastic water drums to transport the carp fishes to Dhaka and Gazipur cities. It is assumed that loss during transportation of these fishes is high due to improper icing, rough handling, lack of personal hygiene and awareness about fish quality.

8.2.2 Levels of loss

Quantitative loss of carp fish across the value chain was assessed. Fig 8.5 shows the estimated postharvest loss at producer, Aratdar (commission agent/middlemen), Paiker (wholesaler) and retailer levels. As expected, producers' level had the the highest level of postharvest loss of 12.72 ± 5.43% followed by 1.26 ± 0.67% for Aratdar, 1.10 ± 0.26% for Paiker and 3.05 ± 0.05% for retailers.

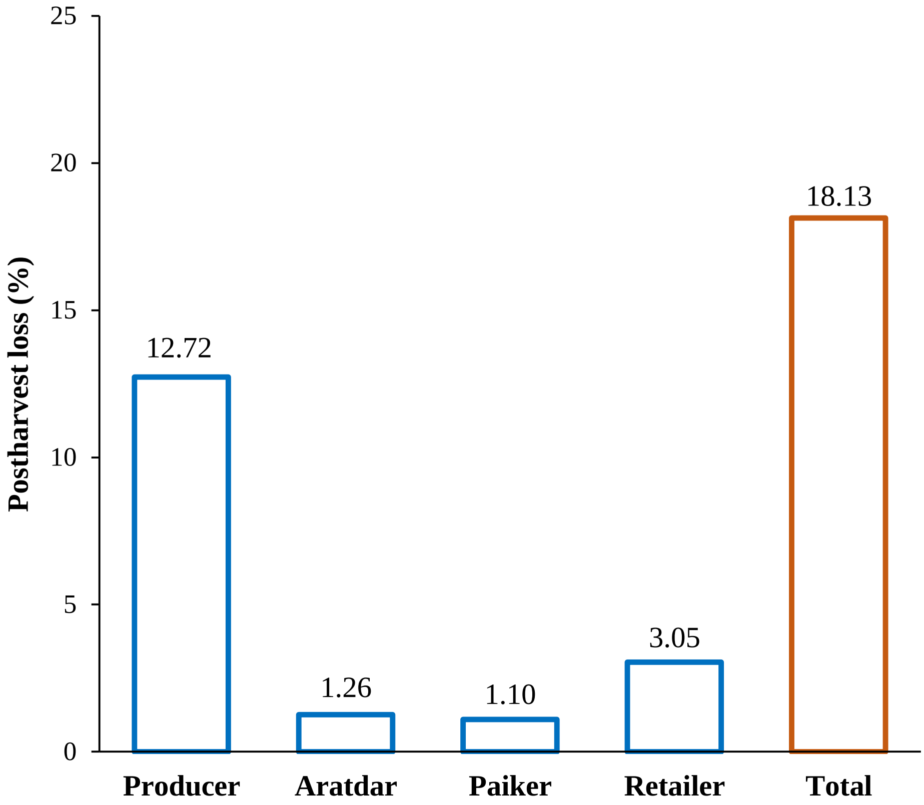


Fig 8.5 Postharvest loss of carp fish at different levels in carp fish supply chain (N=25 for each of fisherman, Bepari, wholesaler and retailers).

The magnitude of postharvest loss of carp fish estimated in the present study is slightly lower that that reported by previous study conducted back in 1983 (Ahmed 1983), who reported quantitative loss of about 19-26% for carp fish. A recent study conducted by Alam (2010) reported that wet fish in Bangladesh incurred 7-19% loss with an average loss of 12.4% across the value chain. These values are in agreement with the findings of the present study. Postharvest losses at each of the value chain actors are briefly described below:

8.2.2.1 Loss at producer level

Producers reported the highest level of loss (12.72%) (Fig. 8.6). The factors responsible for loss at the fishermen level were loss due to fish uncaught from pond, loss due to extended feeding of fish, loss immediately at harvest, loss due to lower demand and loss due to improper postharvest activities. In the present study, 0.95% preharvest loss was found due to fish that remained uncaught during harvest. This uncaught fish was, however, got harvested at the start of the next farming cycle. Among other loss factors, the highest loss was incurred due to extended feeding of fish (6.54%) followed by 2.41% loss due to lower demand, 1.77% loss at harvesting and 1.05% loss during various postharvest activities (e.g. weight reduction etc.).

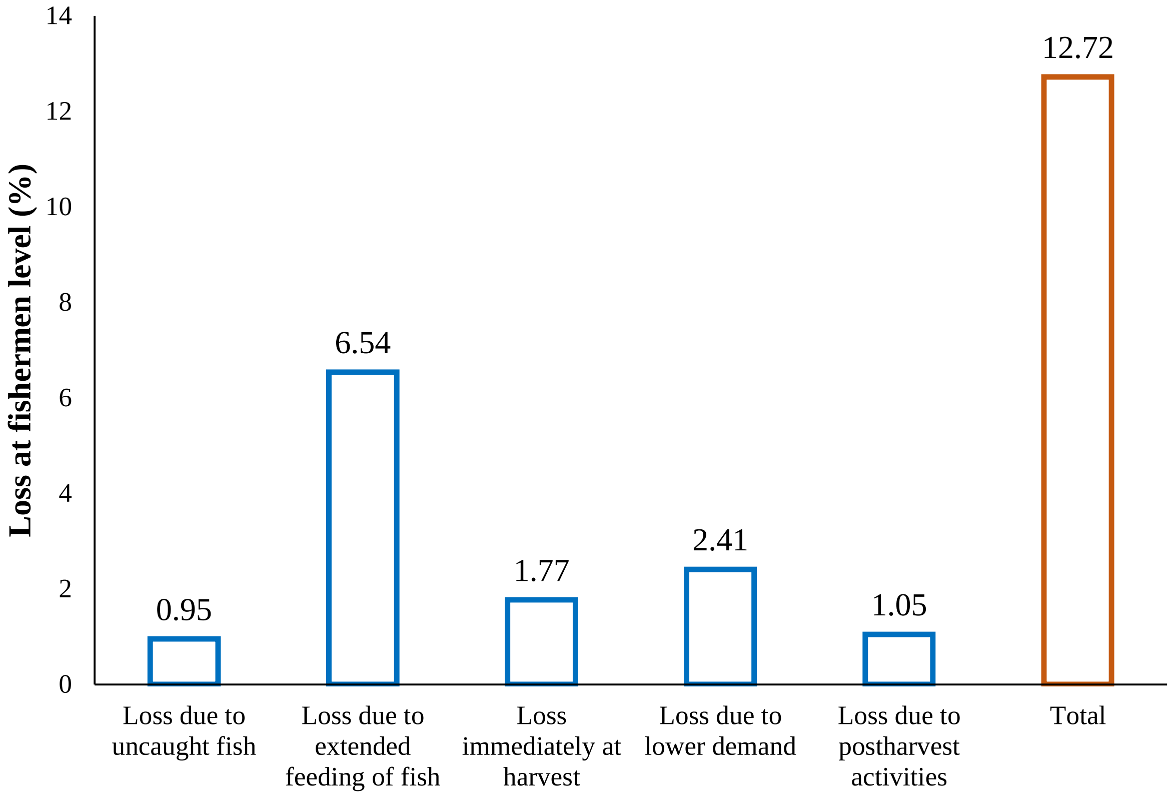


Fig 8.6 Losses of carp fish at fishermen level (N=25).

8.2.2 Causes of incurring postharvest losses in the carp fish value chain

Data were collected to identify the major causes of postharvest loss in the car fish value chain. The findings are shown in the table below. Producers of carp fish in Trishal Upazila, Mymensingh District reported reasons for loss as: loss due to uncaught fish from pond (84%), loss due to extended feeding of fish (52%), loss immediately at harvest (32%), loss due to lower demand (20%) and loss during postharvest activities (80%) were the main reasons (Table 8.3). On the other hand, rough handling, and leaching due to washing, sorting, packaging, storage, transport and marketing were reported to be causes of loss at the traders' level of carp fish. Marketing of carp fish has been observed as a major constraint of carp fish production, and this was reflected by Aratdar (Bepari), Paiker (wholesalers) and retailer.

With the gradual increase of carp fish production in Bangladesh, the country has reached self-sufficiency in fish in 2016. However, due to lack of marketing facilities, lack of product diversification, lack of value addition and some other technical limitations, the carp fish production sector is facing challenges, and consequently many of the carp fish producers are suspending culture activities. So, there is an urgent need to minimize the problems identified in the study to ensure productivity and sustainability.

Table 8.3 Causes of incurring postharvest loss in the value chain of carp fish (N=25 for each of fisherman, Bepari, wholesaler and retailers)

Reasons of post-harvest loss	Respondent (Number)			
	Producer	Bepari (Aratdar)	Paiker (Wholesaler)	Retailer
Loss due to fish uncaught from pond	21 (84)	-	-	-
Loss due to extended feeding of fish	13 (52)	-	-	-
Loss immediately at harvest	8 (32)			
Loss due to lower demand	5 (20)	-	-	-
Loss due to post-harvest activities	20 (80)	-	-	-
During handling	-	2 (8)	0	1 (4)
During washing	-	3 (12)	0	0
During sorting	-	2 (8)	0	0
During packaging	-	0	2 (8)	3 (12)
During storage	-	3 (12)	7 (28)	11 (44)
During transport	-	4 (16)	8 (32)	10 (40)
During marketing	-	16 (64)	15 (60)	13 (52)
Others	-	3 (12)	7 (28)	3 (12)

Values in the parentheses indicate percentage (%)

8.2.3 Possible way to reduce postharvest losses in the carp fish value chain

The survey results revealed that the carp fish producers are facing economic loss due to inequalities within the supply chain. So appropriate measures are needed to reduce the current loss incurred in the value chain of carp fish and protect all the stakeholders. The results are shown in Table 8.4. Among the suggested ways to reduce postharvest loss of carp fish, producers suggested adoption of good aquaculture practice (72%), mechanization of aquaculture (80%), adoption of modern harvesting practice (20%) and expansion of domestic market through product diversification (44%). The carp fish traders suggested that improvements are needed in marketing network, handling, icing of fish, protection from sunlight, use of clean water during fish washing, use of clean utensils, improved preservation facilities.

Table 8.4 Possible ways to reduce post-harvest loss in the value chain of small (N=25 for each of fisherman, Bepari, wholesaler and retailers)

Reasons of postharvest loss	Respondent (number)			
	Producer	Bepari (Aratdar)	Paiker (Wholesalers)	Retailer
Adopt good aquaculture practice	18 (72)	-	-	-
Mechanization of aquaculture	20 (80)		-	-
Adopt modern harvesting practice	5 (20)	-	-	-
Expansion of domestic market through product diversification	11 (44)	-	-	-
Proper handling of fish	-	2 (8)	17 (68)	5 (20)
Proper Icing	-	2 (8)	7 (28)	4 (16)
Protect from sunlight	-	5 (20)	9 (36)	10 (40)
Use of clean water	-	12 (48)	10 (40)	5 (20)
Use of clean utensils	-	8 (32)	10 (40)	15 (60)
Improved preservation facilities	-	10 (40)	18 (72)	10 (40)
Improved marketing infrastructure	-	15 (60)	20 (80)	-
Immediate sale of fish	-	20 (80)	12 (48)	12 (48)
Others	-	-	-	1 (4)

Values in the parentheses indicate percentage (%)

8.2.4 Impacts of COVID-19 on the fish value chain of Bangladesh

The recent pandemic has greatly affected fisheries sector throughout the world let alone Bangladesh. A survey was, therefore, conducted among the value chain actors of small and carp fish in the study areas. The results of the survey are furnished in Table 8.5. All the respondents agreed that Covid-19 had an impact on fisheries sector that was different from a normal year. All the activities including fish demand, fish price, production, marketing and transport facilities were affected. So they suggested that appropriate measures are needed to improve the situation.

Table 8.5 Impact of Covid-19 on the value chain of carp fish (N=25 for each of fishermen, Bepari, wholesaler and retailers).

Impact of Covid-19	Respondent (number)			
	Producer	Bepari (Aratdar)	Paiker (Wholesaler)	Retailer
Covid-19 year was different from normal year	25 (100)	25 (100)	25 (100)	25 (100)
Covid-19 impacted fishery activities	12 (48)	-	-	-
Covid-19 impacted production	18 (72)	5 (20)	10 (40)	10 (40)
Covid-19 impacted fish demand	21 (84)	15 (60)	20 (80)	22 (88)
Covid-19 impacted sale price	25 (100)	17 (68)	25 (100)	25 (100)
Covid-19 impacted marketing	15 (60)	15 (60)	10 (40)	25 (100)
Covid-19 impacted transport	10 (40)	11 (44)	20 (80)	16 (64)
Steps are needed to improve post Covid-19 effect	25 (100)	25 (100)	25 (100)	25 (100)

Values in the parentheses indicate percentage (%)

8.3 MICRONUTRIENT LOSS

Micronutrient losses/changes in selected small fish across the value chain were estimated. Mineral contents in the fish sample were analysed at the Food Safety Laboratory of IIFS (Interdisciplinary Institute of Food Security) and Humboldt Soil Testing Laboratory (Department of Soil Science) of Bangladesh Agricultural University. The results related to minerals in small fish are shown in Fig 8.7. Very high concentration of calcium (2616-2753 ppm) was found in small fish. Zinc and Fe contents ranged from 16-18 and 7-9 ppm, respectively (Fig 8.7). Similar to that of other commodities, zinc level trended to decrease as the product moves from fishermen to retailers. Reduced Ca, Fe and Zn contents were noticed at the Bepari level, and reasons for such drip at regular pattern were not immediately understood.

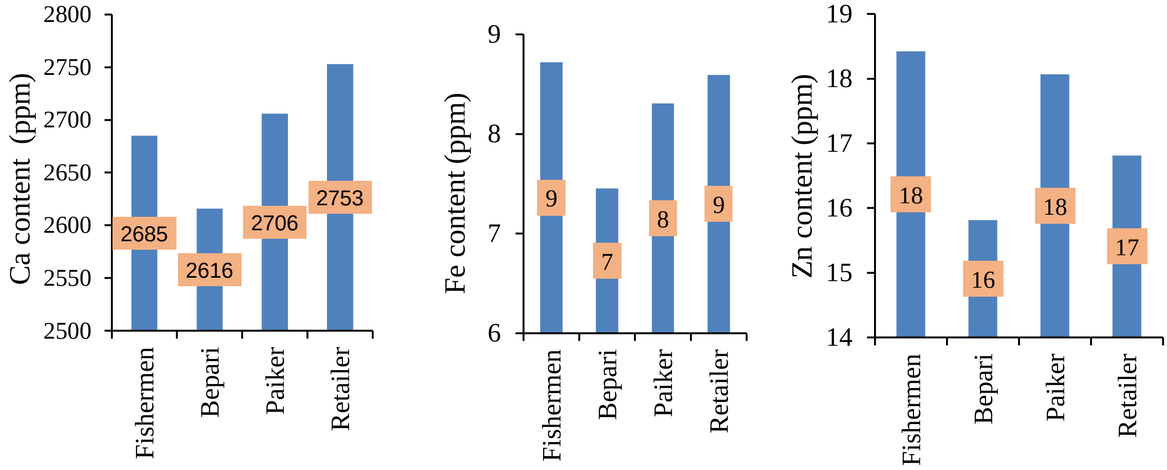


Fig 8.7 Status of minerals (Ca, Fe and Zn) in small fish (*Puntius* sp.) samples collected at different levels in the supply chain.

Chapter 9
FOOD WASTE ASSESSMENT

Food waste is a global crisis that is linked with greenhouse gas emission, food insecurity, loss in biodiversity and environmental pollution. Therefore, like food loss, the SDG 12.3 also aims to halve food waste by 2030. The global estimates of food waste from households, retail establishments and the food service industry totals 931 million tons each year. Nearly 570 million tons of food waste occurs at the household level. It was also estimated that yearly global average of food waste is 74 kg capita^{-1} (UNEP 2021). A major portion (68 to 81%) of the urban wastes in Bangladesh is composed of food wastes (Shams et al. 2017). A recent study in Sri Lanka also reported that the total daily solid waste generated in Colombo Municipal Council is 706 tons of which 50% (approximately 353 tons), is food waste. In Sri Lanka, FAO contributed to prepare a national roadmap to tackle food waste, and a 'food use-not-waste' approach has been in place to significantly reduce the impacts of food waste on climate change, support raising incomes for food supply chain actors (from wholesale to households), and ensure food and nutrition security for all (FAO 2021). Similar roadmap or national strategy is also required in Bangladesh to tackle food waste. However, there is lack of updated data and information on the magnitudes of food waste in Bangladesh, and therefore, the present study attempted to assess food waste in the selected households, restaurants and community centres in Dhaka and Mymensingh. Due to paucity of similar study in Bangladesh, the outputs of the present study will be useful in terms of generating waste data and methodology to track progress towards achieving SDG target 12.3. The results obtained from the present study on magnitudes of waste, underlying reasons for waste and mitigation measures are presented and discussed in the following.

9.1 Households

As mentioned earlier, there is lack of data on the magnitude of food waste- which occurs at retail and consumption levels- in Bangladesh. Food waste varies with food groups and income levels (Table 9.1). This present study reveals that food waste is the highest for richer families and the lowest for poorer ones. Results suggested that the food waste is higher in the households of high and middle-income groups as compared to those of the lower income groups. It was found that food waste was lower in the low-income group as compared to those of middle income and high-income group, wherein per capita income that is higher in the middle income households is likely to play a key role in the evolution of food waste (Barrera and Hertel 2021). For instance, around 60% of households of the low-income do not throw any food if it remains edible and only 45% of the households throw food in amounts less than 250 g. Strikingly, more than 2 kilograms of food is thrown away per week by high-income households. It was also observed that 67% of the household of high-income group thrown >1000-2000 g food and the values were 33 and nil for the middle and low income group, respectively (Table 9.2). As an example in the present study, 100% of the households of the high-income group was found to waste 0.5 to 2.0 kg food per week, which accounts for approximately 26-104 kg food waste per year per high-income household (≈6.5-26 kg capita^{-1}; average household size is 4.0 person; HIES 2016). This estimate is smaller than that reported by UNEP (2019) wherein a global yearly average food waste of 74 kg capita^{-1} was reported. This comparison actually indicates that food waste in Bangladesh is lower as compared to that of the global average. This statement is supported by FAO (2015, 2017) where it has been clearly mentioned that food waste is less in developing countries as compared those of the developed countries (FAO 2015, 2017).

Table 9.1 Levels of household food waste (%) in various food groups according to income

CODEX Food Groups	%Household (Dhaka)								
	Low-income[a] (N=25)			Medium-income[b] (N=25)			High-income[c] (N=15)		
	<2 kg week^{-1}	3-5	6-10	<2	3-5	6-10	<2	3-5	6-10
1	78.90	21.10	-	100.00	-	-	85.70	14.30	-
2	100.00	-	-	100.00	-	-	100.00	-	-
3	69.20	30.80	-	100.00	-	-	100.00	-	-
4	88.00	12.00	-	60.00	40.00	-	14.30	85.70	-
5	11.10	88.90	-	100.00	-	-	77.80	11.10	11.10
6	84.00	16.00	-	52.00	48.00	-	7.10	85.70	7.10
7	83.30	16.70	-	100.00	-	-	92.30	-	7.70
8	100.00	-	-	100.00	-	-	92.90	7.10	-
9	100.00	-	-	96.00	4.00	-	78.60	21.40	-
10	100.00	-	-	100.00	-	-	100.00	-	-
11	100.00	-	-	100.00	-	-	92.90	-	7.10
12	100.00	-	-	100.00	-	-	100.00	-	-
13	-	43,80	-	83.30	16.70	-	87.50	12.50	-
14	86.70	13,30	-	100.00	-	-	92.90	7.10	-
15	-	100.00	-	-	-	-	-	-	-
16	100.00	-	-	100.00	-	-	64.30	35.70	-

CODEX Food Groups

1. Dairy products and analogues; 2. Fats and oils; 3. Edible ices, including sherbet and sorbet; 4. Fruits and vegetables; 5. Confectionery; 6. Cereals and cereal products; 7. Bakery wares; 8. Meat and meat products; 9. Fish and fish products; 10. Eggs and egg products; 11. Sweeteners, including honey; 12. Salts, spices, soups, sauces, salads, protein products; 13. Foodstuffs intended for particular nutritional uses; 14. Beverages, excluding dairy products; 15. Ready-to-eat savouries; 16. Prepared foods.

Table 9.2 Levels of household food waste according to income group

Waste category	%Households					
	Low-income[a]		Middle-income[b]		High-income[c]	
	Dhaka	Mymen-singh	Dhaka	Mymen-singh	Dhaka	Mymen-singh
Do not throw if it is possible to eat	40.0	57.9	35.0	10.5	25.0	31.6
<250 g week^{-1}	-	44.8	100.0	44.8	-	10.3
>250- 500 g week-1	16.7	-	50.0	85.7	33.3	14.3
>500 -1000 g week^{-1}	-	16.7	-	50.0	100.0	33.3
>1000-2000 g week^{-1}	-	-	-	33.3	100.0	66.7
>2000 g week^{-1}	-	-	-	-	100.0	100.0

[a]<BDT 7182 head^{-1} month^{-1}; [b]BDT 7182-87000 head^{-1} month^{-1}; [c]>BDT 87000 head^{-1} month^{-1})

The reasons for food waste also differ with income levels of the households. In the case of low-income households, the main reason of food waste was poor smell and taste followed by lack of preservation, whereas improper packaging, mold growth on food, excess food purchase, disliking of food or ingredients and suspicious labeling were the main reasons for food waste in the high-income households. Lastly, poor cooking, long-time holding of food in fridge/freezer and taking excess food in plate were found to be the main reasons for food waste in the middle-income families (Table 9.3). Factors that can influence food waste also vary with income levels of the households (Table 9.4).

Table 9.3 Reasons for household food waste by income group

Reasons	% Household (Mymensingh)		
	Low-income[a]	Middle-income[b]	High-income[c]
Date expired food	10.0	50.0	40.0
Excess food purchase	-	22.2	77.8
Excess food cooking	23.5	41.2	35.3
Poor looking/appearance	-	-	100
Poor smell and taste	52.8	33.3	13.9
Freezing food for a long time	7.7	61.5	30.8
Improper packaging	-	-	100.0
Grow mold on food	-	16.7	83.3
Preservation in a wrong way	28.6	42.9	28.6
Excess food in plate	21.4	57.1	21.4
Suspicious labeling	-	42.9	57.1
Dislike food/food ingredient	-	25.0	75.0
Poor cooking	20.0	60.0	20.0

[a]<BDT 7182 head^{-1} month^{-1}; [b]BDT 7182-87000 head^{-1} month^{-1}; [c]>BDT 87000 head^{-1} month^{-1})

Table 9.4 Factors that may contribute to reduced food waste

Factors	% Household (Mymensingh)		
	Low-income[a]	Middle-income[b]	High-income[c]
Knowledge on impacts of food waste on environmental pollution	50.0	43.2	6.8
Knowledge on impact of food waste on economy	42.6	44.7	12.8
If tax imposed for food waste	25.0	41.7	33.3
Clear (corrigible) labeling	-	75.0	25.0
Proper packaging	-	66.7	33.3

[a]<BDT 7182 head^{-1} month^{-1}; [b]BDT 7182-87000 head^{-1} month^{-1}; [c]>BDT 87000 head^{-1} month^{-1})

Results of the present study suggest that there exists different types of waste management options, which vary with the household types (Table 9.5). For instance, donating leftovers was found to be the pre-dominant option in the high-income household both in Dhaka and Mymensingh. On the other hand, making compost with the leftovers was the pre-dominant option in the case of middle-income households followed by animal feed and donation (Table 9.5).

Table 9.5 Management of leftovers by the households

Types of management	%Household					
	Low-income[a]		Middle-income[b]		High-income[c]	
	Dhaka	Mymen -singh	Dhaka	Mymen-singh	Dhaka	Mymen-singh
Throw into bin	31.9	38.2	33.3	41.2	34.8	20.6
Donation	-	4.3	38.5	34.8	61.5	60.9
Compost making	-	-	100.0	60.0	-	40.0
Animal feed	42.9	46.2	50.0	30.8	7.1	23.1

[a]<BDT 7182 head^{-1} month^{-1}; [b]BDT 7182-87000 head^{-1} month^{-1}; [c]>BDT 87000 head^{-1} month^{-1})

Covid-19 caused behavioral change of the consumers in terms of food waste, and the nature of changes was found to be influenced by the level of income of the households. For instance, 38.9% of the low income households experienced no change in food waste, whereas, 23.5-36.4% of the households experienced decreased food waste, and remarkably, no households neither in Dhaka nor Mymensingh experienced increased level of food waste during Covd-19 pandemic (Table 9.6). In the case of high income households, especially in Dhaka, the level of food waste increased as responded by 75% of the households, and this was also the fact for the middle income households (Table 9.6). These results were due to the fact that over purchase of food triggered by the perceived uncertainty of food crisis due to Covid-19. High and middle income (especially the upper middle class) households generally donate food to the poor, beggar, house keeper, underprivileged, etc., and the imposed restrictions on peoples' movement during the first wave of Covid-19 also contributed to the increased level of food waste. In contrast, the decreased food waste as observed in the cases of middle and high income households was due mainly to the cautions purchase of food.

Table 9.6 Impacts of Covid-19 on behavioral change in terms of food waste by the households according to income level

Behavioral changes on food waste due to Covid-19	%Household					
	Low-income[a]		Middle-income[b]		High-income[c]	
	Dhaka	Mymen -singh	Dhaka	Mymen-singh	Dhaka	Mymen-singh
Increase food waste	-	-	25.0	66.7	75.0	33.3
Decrease food waste	23.5	36.4	35.3	54.5	41.2	9.1
Unchanged	38.9	38.9	33.3	31.5	27.8	29.6

[a]<BDT 7182 $head^{-1}$ $month^{-1}$; [b]BDT 7182-87000 $head^{-1}$ $month^{-1}$; [c]>BDT 87000 $head^{-1}$ $month^{-1}$)

9.2 Restaurants

The restaurant food waste was assessed in the selected BFSA-categorized restaurants in Dhaka and selected large, medium and small restaurants in Mymensingh using pre-tested and structured questionnaires through trained data enumerators. Some activities of field data collection from restaurants are shown in Plates 9.1-9.5.


Plate 9.1 Data collection for food waste assessment (Sorgorom Restaurant, Mymensingh).


Plate 9.2 Data collection for food loss assessment (Presidency Kitchen, Mymensingh).

Plate 9.3 Data collection for food loss assessment (Sarinda, Mymensingh).

Plate 9.4 Data collection for food loss assessment at Hotel Amir International (Mymensingh).

Plate 9.5 Data collection on food waste assessment at restaurant (Dhaka).

In terms of area, the A+ restaurants were the largest followed by A, B and C (Fig. 9.1). And all the restaurants experienced food wastes (Fig 9.2A), except the C-category restaurant where 60% of the restaurants experienced no waste. It was found that 50% of the B-category restaurants experienced regular food waste followed by the A+ and A-category restaurants. The C-category restaurants either experienced occasional food waste or none (Fig 9.2B).

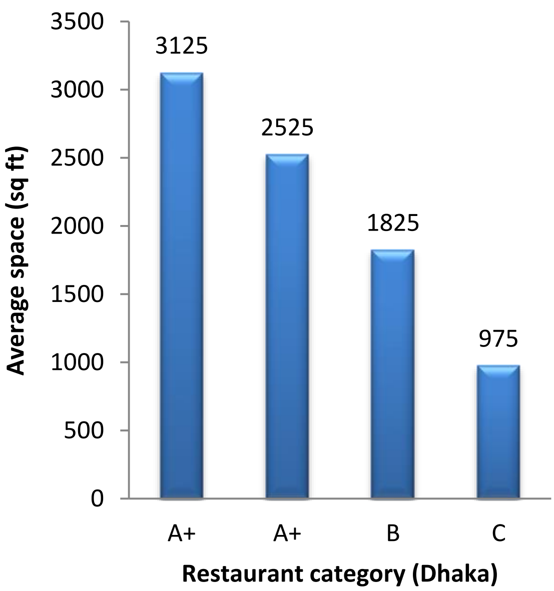


Fig 9.1 Average space of restaurants of different categories (Dhaka, N=4).

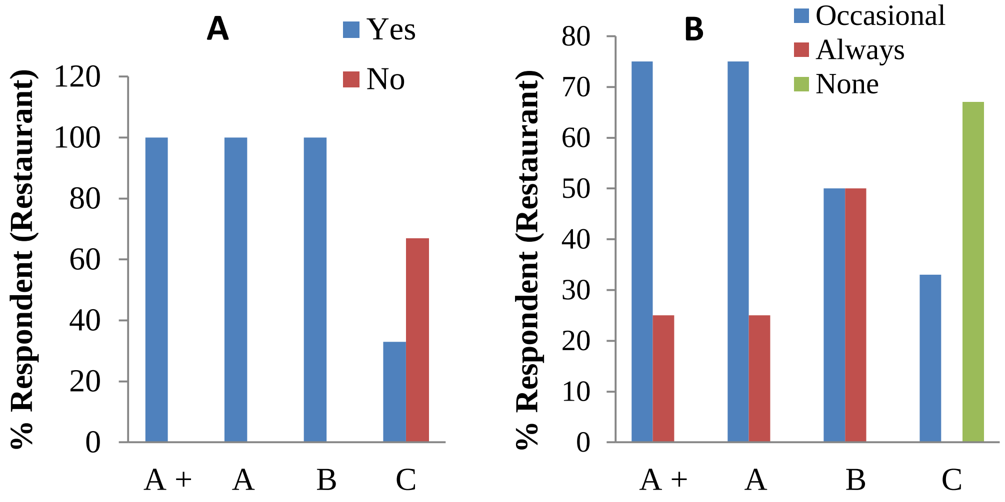


Fig 9.2 Ourrence of food waste by restaurants (A) and frequency of wasting of food by customers (B) in the selected BFSA-categorized restaurants (Dhaka, N=4 for each category).

For restaurants, among those categorized as A+ and A by BFSA, one quarter recorded between 21 to 40% food waste, and another quarter between 11 to 20%. In contrast, the B and C category restaurants recorded only 6 to 10% and 3 to 5%, respectively (Fig 9.3). Excess food order and tendency to taste all foods are critical factors for food waste in restaurant. It was also found that high level of food waste was observed in the case of female customers in both the A+ and B category restaurants followed by children in the A+ and A category restaurants (Fig 9.4).

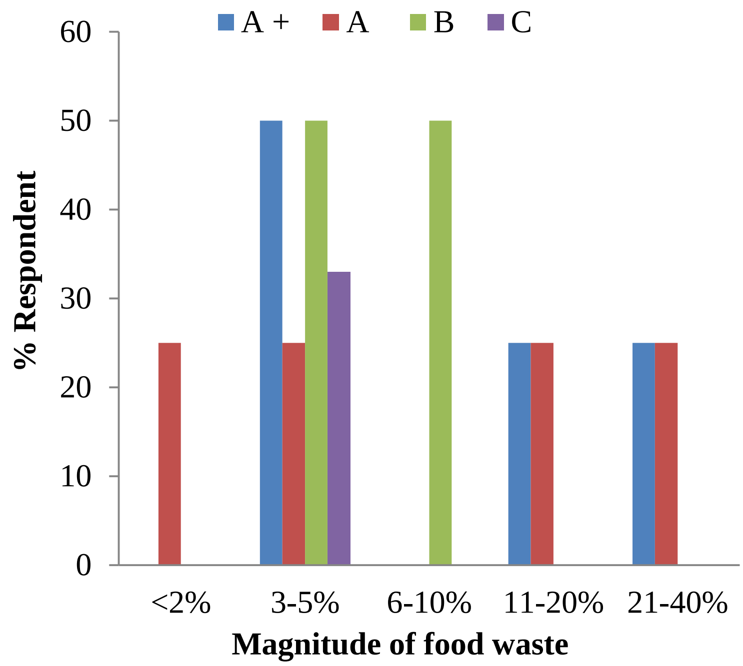


Fig 9.3 Magnitude of food waste in BFSA-categorized restaurants (Dhaka, N=4).

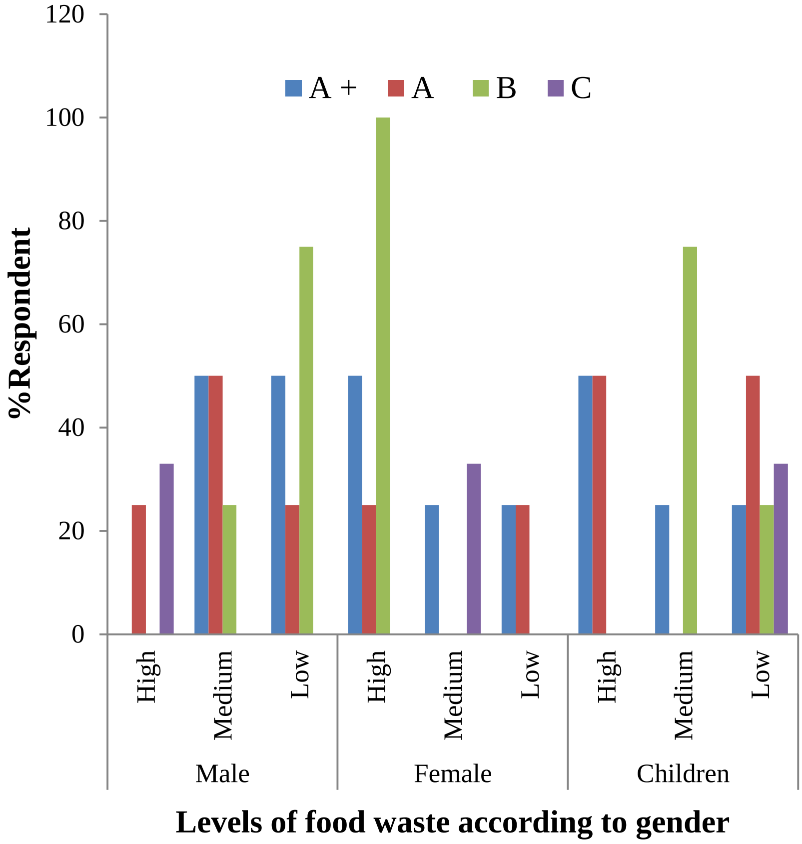


Fig 9.4 Levels of food waste according to gender in the selected BFSA-categorized restaurants in Dhaka (N=4).

The reasons for food waste at the restaurants have been shown in Fig 9.5A, where excess food order has been found as the key factor of food waste followed by buffet system of food serving and tendency to taste as many food as possible. Types of food waste have been shown in Fig 9.5B. It was also found that there exists the practice of donation of food, especially at the A+ category restaurant (Fig 9.6), and also there remains strong willingness to donate various types of food wastes by the A+, A and B category restaurants. These results indicate possibility of establishing food banking or food rescue services in Bangladesh.

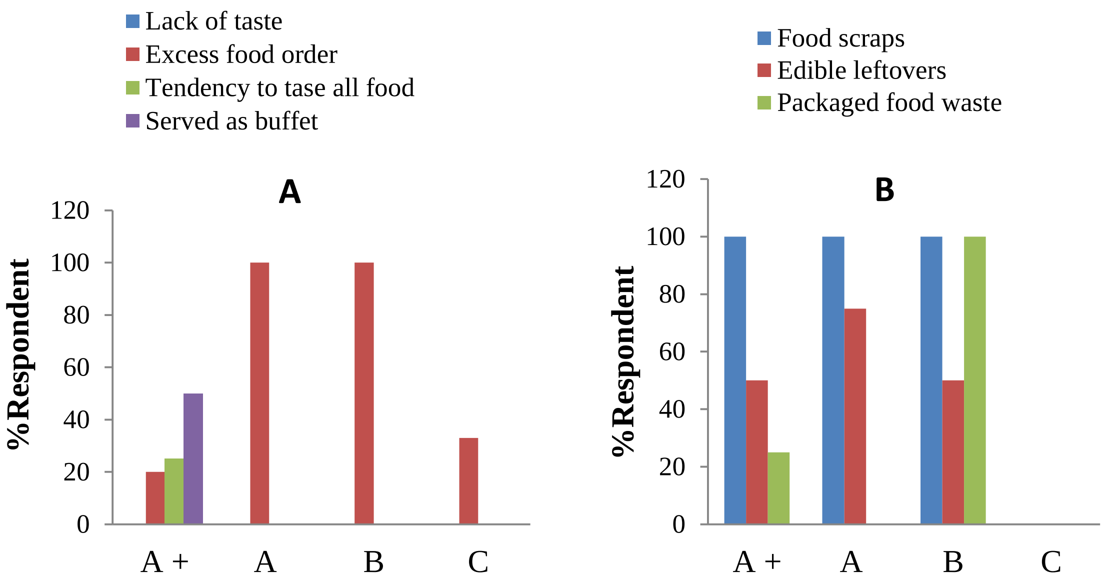


Fig 9.5 Reasons for wasting food by customers (A) and types of food waste (B) in BFSA-categorized restaurants (Dhaka, N=4).

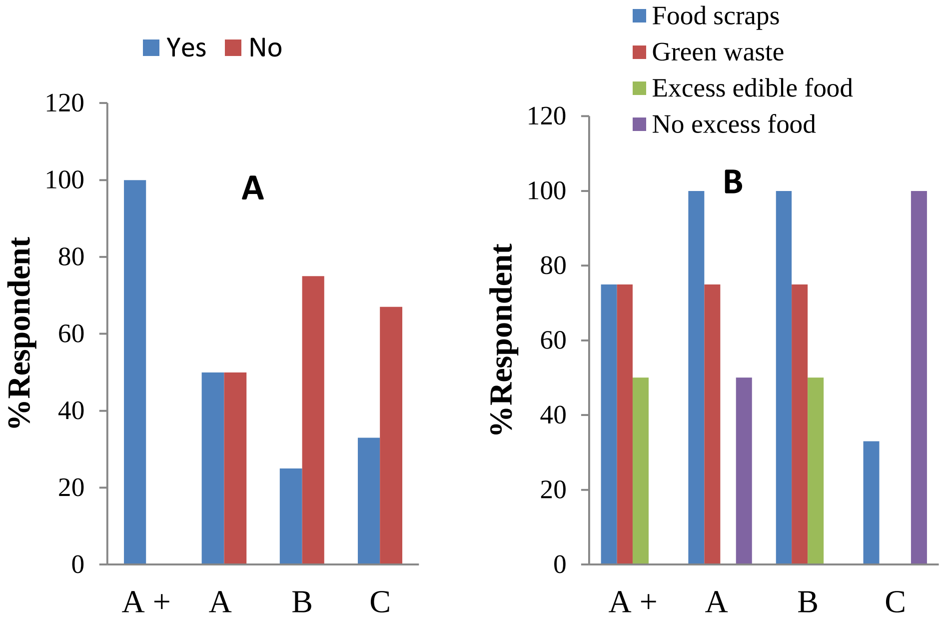


Fig 9.6 Status of donation of edible food waste (A) and willingness to donate (B) by different BFSA-categorized restaurants (N=4).

The present practice of diposing food wsates include mainly donation (giving to poor peoples), dump into bins and comspot making (Fig 9.7A). Create much awareness and redesign of food menue were suggested as important ways of reducing food waste at the restaurant levels. Moreover, restricting the number of dishes, charge penalty for wsate and promulgate legislation were also sggested by some of the respondents (Fig 9.7B).

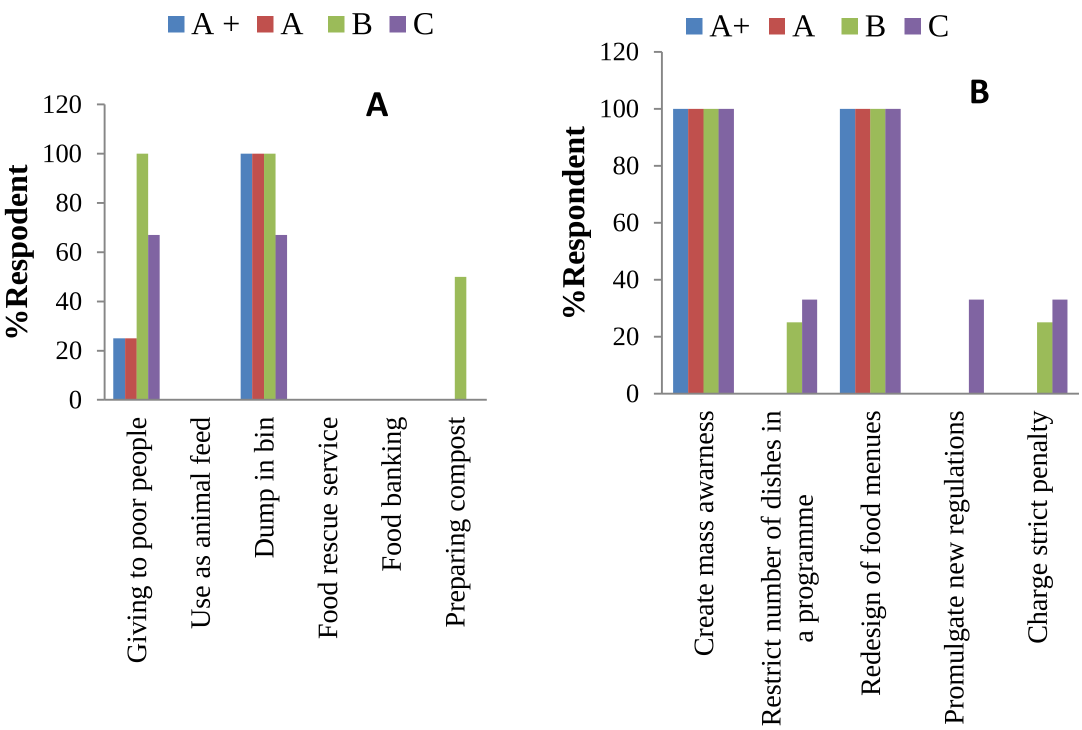


Fig 9.7 Options for disporal of food wsate (A) and measures for reduction of food waste (B) as opined by the BFSA-categorized restaurants.

9.3 Community centre

An attempt was made to assess food waste at the selected community centres in Dhaka and Mymensingh (Plate 9.6). Results suggest that food waste as % leftovers in the community centre under different food items were found substantial and ranged from 5-30% (Fig 9.8).

Plate 9.6 Data collection on food waste assessment at community centre (Mymensingh).

Community centre provides facilities for arranging various events. They prepare wide range of foods as per the desires of the organizers. Levels of food waste vary with types of foods (Fig 9.8) and events (9.9). The highest level of food is wasted in marriage ceremony (Fig 9.9).

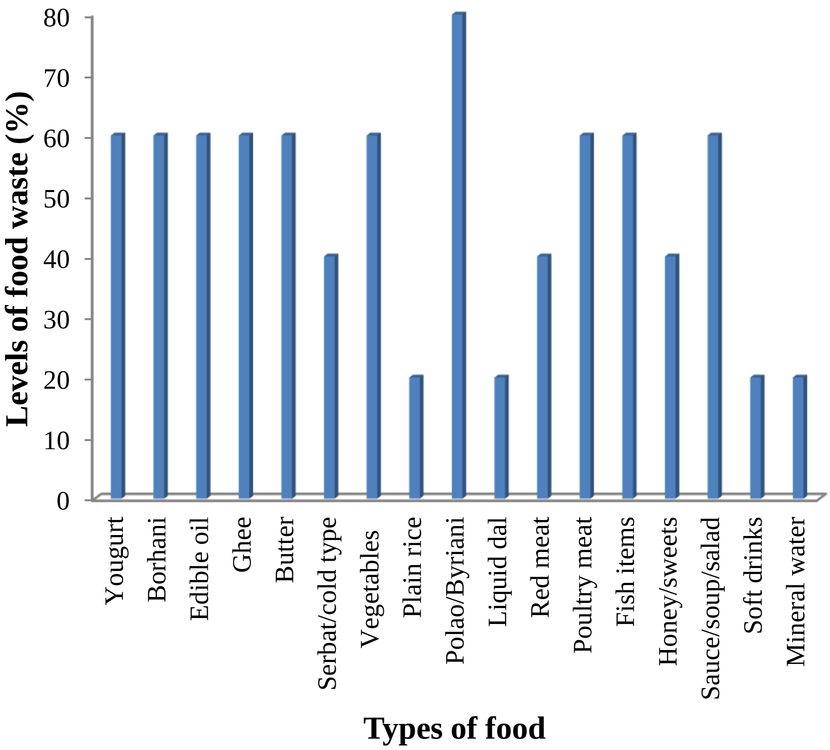


Fig 9.8 Variation in food waste in community centre according to types of food (Mymensingh; N=5).

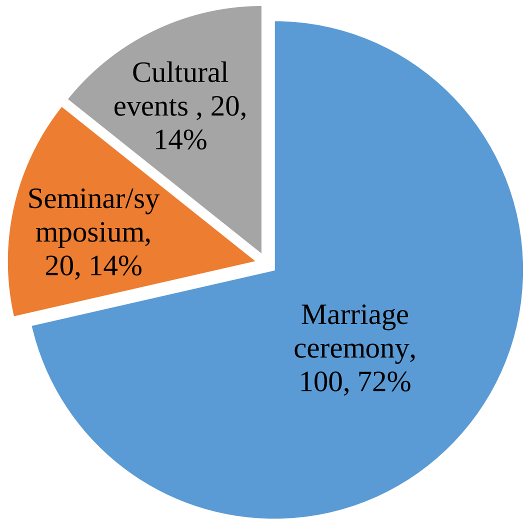


Fig 9.9 Variation in food waste as per types of events (Mymensingh; N=5).

Community centre food waste ranged from 5-30% (Fig 9.10A). Results revealed that 20% of the community centres recorded 21-30% food waste, followed by 20% recorded 11-20% food waste and 40% recorded 5-10% food waste (Fig 9.10A). Reasons for food waste included ordering excess food, lack of taste, food served as buffet and tendency to taste as many food items as possible. The present study reveals that, merely any measures taken by the community centre to reduce food waste. Only 20% of the community centre requests the customer to pack and take home (Fig 9.11). The levels of impacts of food waste as suggested by the respondents are shown in Fig 9.12.

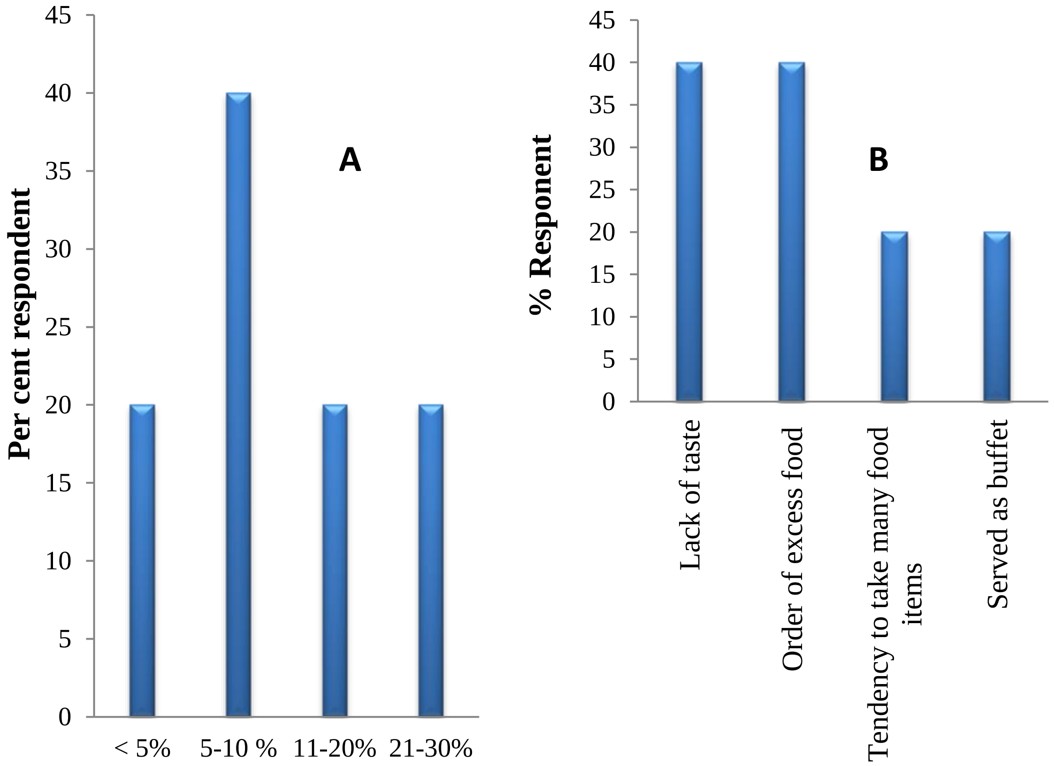


Fig 9.10 Magnitude of food waste (A) and reasons for food waste in community centre (Mymensingh; N=5).

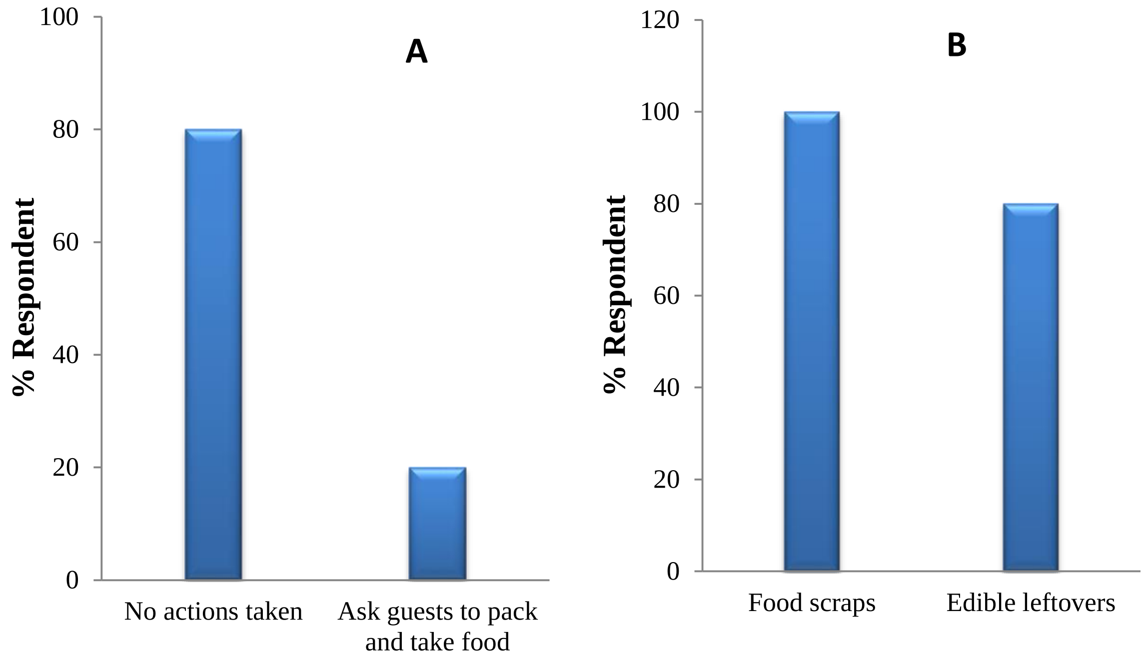
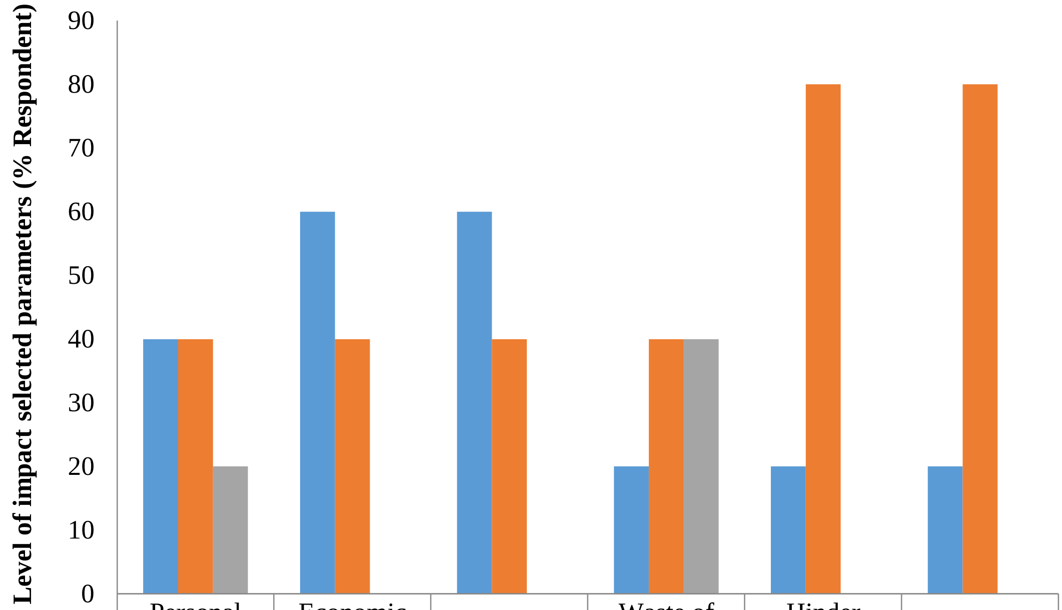


Fig 9.11 Present practice in the case of food waste (A), and types of food waste (B) (Mymensingh; N=5).



	Personal economic loss	Economic loss to the organizers	Enviromental pollution	Waste of natural resources	Hinder development of a country	Affect food security
High	40	60	60	20	20	20
Medium	40	40	40	40	80	80
Low	20	0	0	40	0	0

Fig 9.12 Levels of impacts of food waste on economic, environmental, national development and food security (Mymensingh; N=5).

During data collection, it was also observed that the community center authority rents the space and manages offices. The food item selection, cooking and food item management are not their duty and they have no access to it. It mainly depends on the organizer to take decision on excess food. In most of the cases, the organizers take away the excess food home. If in any cases, the community center authority controls the programme, most of the time the waiters take away the excess food, and in some cases, they provide food to orphan people. Nonetheless, there are some charity organizations, namely "Momenshahi Orphan Home" and "Aftabdia Orphan House", who collect excess food from various community center.

The options for waste disposal and ways to minimize food waste have been furnished in Fig 9.13 and 9.14. To deal with this problem a number of actions can be taken: create mass awareness, creation of guidelines and code of practices (CoPs) for value chain actors including consumers, promulgation of legislations, especially to stop food waste, increase in capacity of waste recycling, and promotion of public and private sector food rescue and food banking services. In 2016, France became the world's first country to ban supermarket waste and compel large retailers to donate unsold food, and breaching the law may face up to 75000 Euro fine (Perchard 2016).

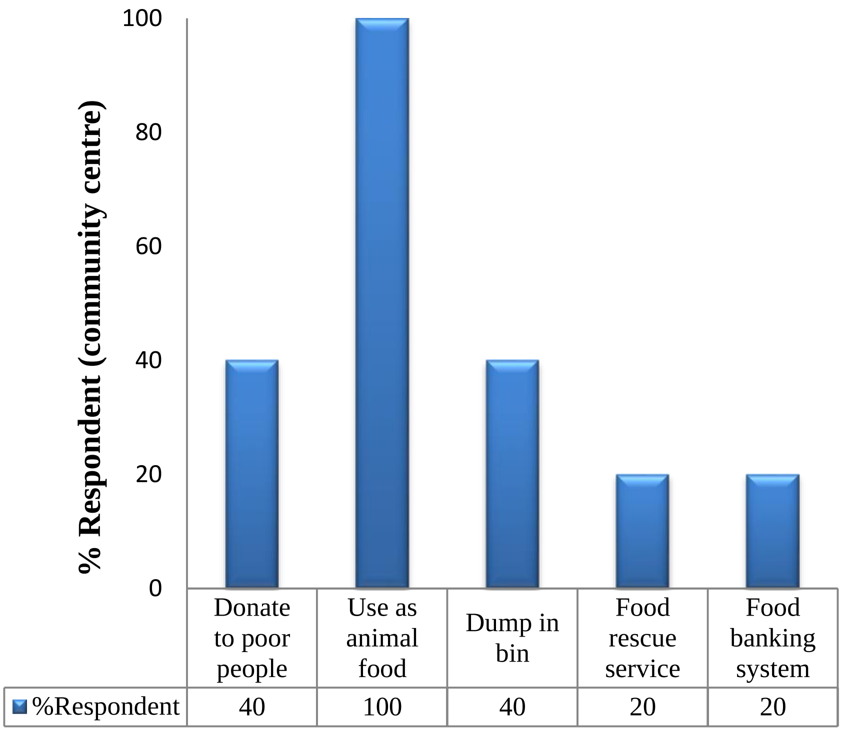


Fig 9.13 Options to dispose food waste from community centre (Mymensingh; N=5).

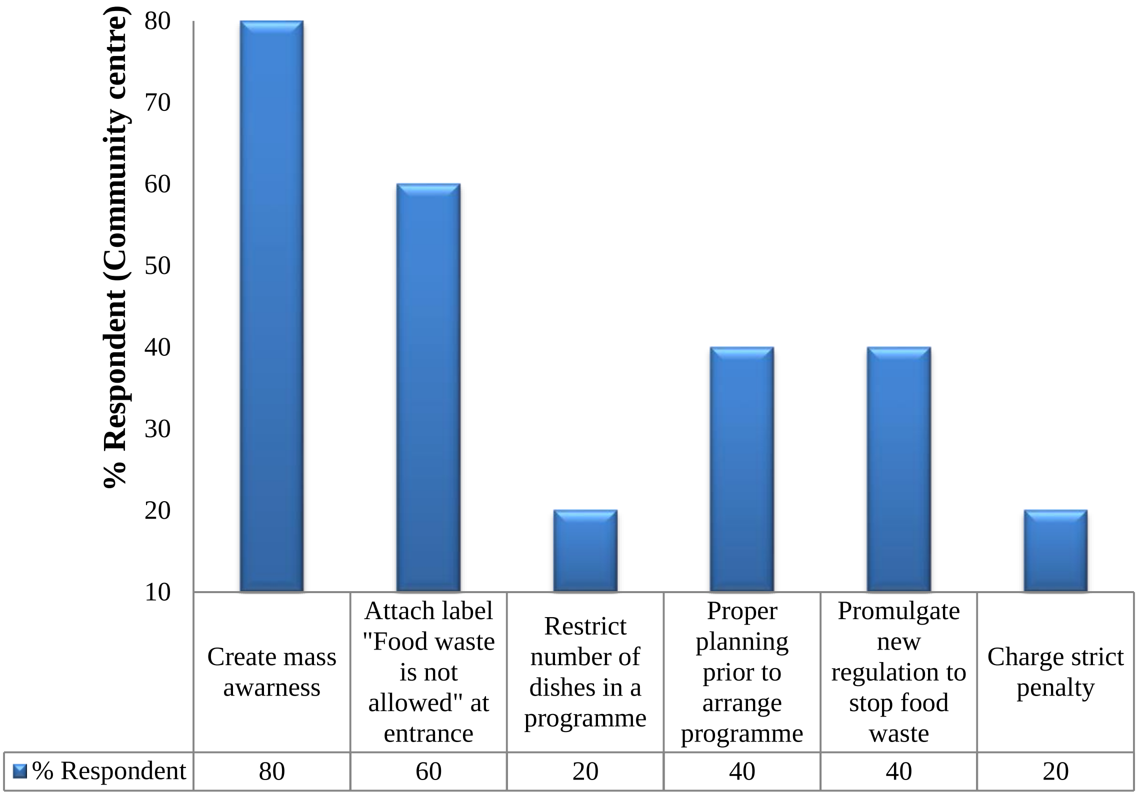


Fig 9.14 Options to reduce food waste in community centre (Mymensingh; N=5).

Chapter 10
Challenges encountered

- Start of survey was delayed due to Covid-19 pandemic (March 2020) and the resulted closure of university and restrictions of movement and health risks. However, in consultation FAO-MUCH and FPMU, Data Enumerators were recruited and trained and survey completed in the selected locations of Bangladesh. The Data Enumerators were provided with sanitizers, face masks, hand gloves and health guidelines.
- Challenges were also faced in terms of limited access to households and restaurants while collecting data, especially in Dhaka City. However, proper clarification, motivation and proper use of health and safety guidelines eased the situation, and data collection completed.
- To adjust the delay due to the Covid-19 (1^{st} wave) related fears, confusions, restrictions and obstacles, an extension up to 14 May 2021 was granted and LoA (Phase II) was signed. Covid-19 (2^{nd} wave) further struck and affected project activities.
- The main lessons learned were related to coping strategies with the Covid-19 pandemic situation and move forward with alternative options (e.g. virtual meeting, consultation workshop; use of telephone, email and other digital options for data collection and other activities).

Chapter 11
Drafting of MS theses

Four MS theses have will be drafted from the research project as summarized in the following:

SL No.	Thesis Title	Department
1	Estimation of quantitative and qualitative losses of tomato along supply chain	MS in Horticulture, BAU, Mymensingh
2	Estimation of quantitative and qualitative postharvest losses of paddy supply chain	MS in FPM, BAU, Mymensingh
3	Estimation of quantitative and qualitative postharvest losses of poultry meat through supply chain in two different cities of Bangladesh	MS in Animal Science, BAU, Mymensingh
4	Postharvest and nutritional loss assessment of freshwater fishes along the supply chain	MS in Fisheries Technology, BAU, Mymensingh

Chapter 12
Drafting research articles

Eight (8) manuscripts have been drafted from the research project as summarized in the following:

SL No.	Title of scientific article	Department
1	Assessment of quantitative and qualitative losses of mango along supply chain- National	Department of Horticulture, BAU
2	Assessment of quantitative and qualitative losses of root and tuber crops in Bangladesh-International	Department of Horticulture, BAU
3	Assessment of quantitative and qualitative losses of paddy supply chain-International	Department of Farm Power and Machinery, BAU
4	Assessment of quantitative and qualitative losses of wheat supply chain in Bangladesh-National	Department of Farm Power and Machinery, BAU
5	Assessment of quantitative and qualitative post-harvest losses of poultry egg through supply chain in two different cities (National).	Department of Animal Science, BAU
6	Assessment of quantitative and qualitative post-harvest losses of milk along supply chain in Bangladesh (International).	Department of Animal Science, BAU
7	An assessment of postharvest fish losses in the Haor floodplain in Bangladesh-National	Department of Fisheries Technology, BAU
8	Quantitative and qualitative losses of freshwater fishes along the supply chain in Bangladesh- International	Department of Fisheries Technology, BAU

Chapter 13
Policy Implication and Recommendations

The present study was undertaken to estimate the magnitudes of food loss and waste (FLW) across food value chains and identify the underlying reasons for FLW and suggest recommendations to reduce FLW towards achieving SDG target 12.3, which calls for halving the per capita food FLW by 2030. Food shortages may have serious consequences on national, regional, and global stability as experienced during the COVID-19 pandemic. A strategy to handle FLW is imminently needed. The causes of FLW are also manifold. Food loss occurs throughout the value chain- from production, processing, distribution to retail and consumption. Global FLW amounts to roughly one-third of total production with negative impacts on agriculture, the environment, human nutrition, food security and natural resources. Recent global average postharvest to distribution estimates of losses are 8%, 12%, 22% and 25% for cereals and pulses, meat and animal products, fruits and vegetables, and roots and tubers, respectively (FAO 2019).

While there is no precise and recent data on the magnitude of FLW in Bangladesh, FAO (2019) found an average estimate of FLW of 7.4% irrespective of food groups with a range 0.2-35.0% based on grey literature and national and sectoral reports published during 2000-2017. In addition to the above, some previous studies in Bangladesh shown that postharvest losses of fruits and vegetables, potatoes, and paddy were 24-44%, 23-28% and 11-12%, respectively. There is also no data on postharvest losses for animal products. Likewise, data on food waste are also scanty in Bangladesh. As per the recent report of UNEP (2021), the global estimates of food waste from households, retail establishments and the food service industry totals 931 million tons each year, and nearly 570 million tons of this waste occurs at the household level. The report also reveals that annual global average of food waste is 74 kg capita^{-1} year^{-1}. Recognising the paucity of updated data and information on FLW in Bangladesh, the present study aims to fill these gaps by generating data on commodity-specific food losses across selected food chains and on the magnitude of food waste, identifying key factors influencing FLW and proposing recommendations to reduce FLW towards achieving SDG target 12.3.

Results of the present study suggest that postharvest loss of agricultural produce was substantial across the selected value chains and ranged from 12-32% irrespective of food groups. In case of cereals, average postharvest paddy loss (farmers to processors) was 17.80% in which the losses at the producers, middlemen (Bepari) and millers were 14.02% (transportation loss- 1.4%; threshing loss- 1.7%; winnowing loss- 1.5%; drying loss- 2.6%, and storage loss 6.8%), 1.62% and 2.12%, respectively. However, the total paddy loss including the pre-harvest loss was 23-28%, which result signifies the importance of undertaking appropriate steps at the producers' level to reduce paddy loss. Lack of proper storage was the main reason for postharvest loss at the producers' level, while the damage due to rodent pests was identified as the main cause of pre-harvest loss. Average postharvest wheat loss was estimated as 17.59%.

There were wide-ranging postharvest losses for the selected horticultural produce. Results revealed that postharvest losses of fruits and vegetables and roots and tubers ranged from 17% to 32%, where the losses of mango, banana, potato, carrot, tomato, and red amaranth were 31.7, 19.9, 21.8, 26.1, 27.9 and 16.6%, respectively. There also exists considerable field losses, and very substantial field loss was found in tomato, which is not harvested by the growers owing mainly to low price at the end of the growing season. Across the selected horticultural value chains, wholesale and retail levels are identified as critical loss points. This is due to ripening and senescence of the perishable commodities, and lack of storage and agro-processing facilities. Loss also occurs at processors' levels. For example, in large-scale mango processing plants, 13 to 17% of raw materials are lost during sorting, grading, de-sapping, washing and crushing, while 2 to 4% loss occurs during internal transportation and storage of the transformed mangoes. Similar loss is also observed in large-scale processing of tomatoes. Losses also happen during cold storage as found for potatoes (5.7%) and carrots (11.0%). Levels of loss of selected selected horticultural produce in selected super shops ranged from 2-5%.

This is important to note that there is no early study in Bangladesh to indicate the magnitude of loss of animal products. This is possibly the first study where losses of animal products including milk (cow and buffalo), eggs, poultry (chicken) meat and red meat at different levels of value chains (producers and middlemen including Bepari, wholesalers and retailer) have been assessed. Total postharvest losses of cow and buffalo cow milk were estimated as 8.07 and 15.67% (average milk loss 11.87%), respectively. The postharvest losses of eggs, poultry meat and red meat were 12.9, 16.9 and 21.4%, respectively. The processing losses of meat and meat products and milk and milk products were in the range of 5-9 and 8-12%, respectively. Total quantitative losses of small fish and carp fish were also assessed along the selected value chains, and were 25.45 and 18.13%, respectively.

There is another type of loss, which is often termed as micronutrient loss, and it is possibly one of the least-studied subjects globally. Results of the present study suggest that levels of vitamin C, a powerful antioxidant with scores of health functions, declines sharply as time progressed after harvesting of fruits and vegetables. For example, in mango (cv. BARI Am 4) it declines by 62% and 79% at 4 and 8 days after harvest, respectively. Similarly, in tomatoes (cv. Hybrid 1217), the rates of decline were 29% and 40% within 3 and 7 days after harvest, respectively. Both ripe mangoes and tomatoes are rich sources of vitamin C. It was also observed that vitamin C content greatly varies with postharvest handling during marketing and distribution. For instance, the highest vitamin C content was found in potatoes harvested at the right stage of maturity and prior to cold storage followed by those harvested in the previous season and held in cold storage, which results suggest the importance of appropriate storage of produce to retain micronutrients. The immature potatoes harvested early to fetch higher prices had the lowest level of vitamin C content. Hence, it is important to conserve micronutrients in food through proper food handing, preparation, cooking, and consumption practices.

Folate is an important B complex vitamin, responsible for producing blood cells, and is considered an important micronutrient for pregnant women. Folate contents vary widely among the food groups examined. In the present study, the folate levels were in the order of wheat (38.70 μg 100 g^{-1}) > chicken meat (15.17-21.78 μg 100 g^{-1}) > rice (11.78 μg 100 g^{-1}) and > tomato (4.60-8.50 μg 100 g^{-1}). Folate shows significant variation in pattern of changes or loss with type of food. Its level declines in cow milk, beef and mango and increases in tomato, chicken meat, buffalo milk and tomato, and these contrasting behaviours warrant in-depth investigation in relation to diet planning and nutrition messages. β-carotene (precursor of vitamin A) levels increased as ripening occurred (mangoes) or time after harvesting progressed (carrots).

Like vitamins, mineral contents also vary widely among crop varieties, and their patterns of change or losses also vary. For example, the potato variety Diamant contained higher iron and zinc (25.78 and 6.26 ppm, respectively) as compared to the variety Cardinal (only 6.26 and 5.42 ppm, respectively). Mineral contents of various animal products were also assessed. Calcium content was the highest in buffalo milk followed by cow milk and egg. Iron content was found to be the highest in red meat followed by egg and chicken meats. Zinc content was found the highest in red meat followed by egg. Amongst the minerals studied, zinc contents in certain crops, meat and milk trended to slightly decrease as time progressed after harvesting or milking or slaughtering. In addition to the currently available food composition tables, there is an imminent need to generate variety and breed-specific data on micronutrient levels of various food products to facilitate preparation of guidelines, policies, code of practices related to nutrition.

Finally, the food waste, a global crisis, and linked with greenhouse gas emission, food insecurity, loss in biodiversity and environmental pollution. There is lack of data on the magnitude of food waste- which occurs at retail and consumption levels- in Bangladesh. This study reveals that food waste is the highest for richer families and lowest for poorer ones. Strikingly, more than 2 kilograms of food is thrown away per week by high-income households. For restaurants, among those categorized as A+ and A by BFSA (Bangladesh Food Safety Authority), one quarter record between 21 to 40% food waste, and another quarter between 11 to 20%. In contrast, the B and C category restaurants record only 6 to 10% and 3 to 5%, respectively. Excess food order and tendency to taste all foods are critical factors for food waste in restaurant. In community centres, food waste as leftover ranges from 5 to 30%.

Policy implications and recommendations

- Like many countries (e.g. Australia, China, Japan, Singapore and Thailand), the Government of Bangladesh needs to develop and implement a national strategy to reduce FLW towards achieving SDG target 12.3.
- Irrespective of the types of food, substantial losses occur along food value chains. In the case of cereals, adoption of improved pre-harvest practices at the producers' level and modern storage technology (hermetic storage) at the producers, middlemen and millers' levels would have substantial impact on reducing loss of paddy, the staple food of the nation.
- Fruits and vegetables play a vital role in human nutrition, especially for vitamins, minerals dietary fibre, antioxidants and phytonutrients that have marked nutritional significance. The present consumption of vegetables and fruits (212 g day^{-1} $capita^{-1}$) in Bangladesh is well below the FAO/WHO recommended minimum requirement (400 g day^{-1} $capita^{-1}$) and the situation is further compounded by huge pre- and postharvest losses. Traders' levels have been identified as critical loss points in horticultural value chains. Substantial losses are also evident across the value chains of the animal and fish products. Significant improvements may occur by creating modern harvesting (mechanical harvesting) and postharvest facilities (sorting, grading, storage, packaging, cooling, refrigeration, transportation, slaughterhouses and abattoirs), encouraging civil society dialogues, and promoting public-private partnership.
- Adoption of improved pre- and postharvest practices, namely Good Agricultural Practices (GAP), Good Aquaculture Practices (GAqP), Good Hygiene Practices (GHP), Good Manufacturing Practices (GMP) and Hazard Analysis and Crticical Control Points (HACCP)) across the food value chains is needed to improve food quality and safety and to reduce food losses.
- Food waste occurs at the tail end of the food value chain. Significant waste of food is observed at the middle and high income households, as well as in restaurants and community centres. Like food loss, food waste also has great impact on the national economy, food security and the environment.
- To deal with food waste, a number of actions can be taken: create mass awareness; capacity building in education, research and human resource development; improvement of cooking and consumption habits of consumers through enhanced food and nutrition literacy; creation of guidelines and code of practices (CoPs) for value chain actors including consumers; promulgation of legislations, especially to stop food waste; increase in capacity of waste recycling; promotion of public and private sector food rescue and food banking services; and engagement of civil society.
- Furthermore, strengthening mass awareness and promoting country-wide small, medium and large-scale agro-processing initiatives are key to reducing FLW.

Suggested further studies

- Conduct national survey on assessment of food loss and waste through coordinated effors of BBS, DAE, DLS, DoF and BAU.
- Conduct research on recycling of food wsate.
- Establish food banking on pilot basis.
- Assessment of micronutrients of the commonly-consumed food of plant and animal origin in terms of variety, breeds and stage of harvesting/marketing.
- Development and optimization of postharvest technology to reduce FLW.
- Appropriate coking practice to minimize micronutrient loss.
- Value-added product development including fresh-cut, minimal processing and secondary and tertiary processing.
- Assessing processing loss (quantitative and micronutrient) during procesing and milling.

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LIST OF APPENDICES

Appendix 1
Survey location and sampling plan

Name of food	Producer (District/Upazilla)	Middlemen		
		'Bepari' (Local assembly markets)	Wholesales/millers	Retail markets & super shops
Potato	**Bogura** Shibganj (25 producers, 5 cold stores) **Munshiganj** Sadar (25 producers, 5 cold stores)	**Bogura** Mohasthan (25) **Munshiganj** Sadar (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50) Super shop (5)
Carrot	**Bogura** Shibgonj (25 producers, 2 cold stores) **Pabna** Sadar (25 producers)	**Bogura** Mohasthan (25) **Pabna** Sadar (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50) Super shop (5)
Tomato	**Cumilla** Chandina (25) **Bogra** (25 producers)	**Cumilla** Chandina (25) **Bogra** Mohasthan (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50) Super shop (5)
Red amaranth	**Jashore** Sadar (25) **Bogura** Sadar (25)	**Jessore** Barinagar (25) **Bogura** Mohasthan (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50) Super shop (5)
Banana	**Tangail** Madhupur (25) **Bogura** Mokamtola (25)	**Tangail** Madhupur (25) **Bogura** Mokamtola (25)	Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50) Super shop (5)
Mango	**C. Nowabgonj** Shibgonj (25) **Satkhira** Sadar (25) **Natore** Processing plant (PRAN)	**Chapai Nowabganj** Shibgonj (25) **Sathkhira** Sadar (25)	**Dhaka** Karwan Bazar (25) Badamtoli (25)	**Dhaka** 2 Retail markets (50) Super shop (5)
Paddy	**Mymensingh** Phulpur (25) **Noagaon** Sadar (25)	**Mymeningh** Phulpur (25) **Noagaon** Sadar (25)	**Mymensingh** Phulpur **Noagaon** Sadar 10 semi-automatic and automatic rice mills (from both Upazila)	Not applicable
Wheat	**Dinajpur** Sadar (25) **Pabna** Sadar (25)	**Dinajpur** Sadar (25) **Pabna** Sadar (25)	**Dinajpur** Sadar (25) **Pabna** Sadar (25) 2 flour mills (from both Upazila)	Not applicable
Poultry meat (Chicken meat)	**Gazipur** Sadar (25) **Mymensingh** Sadar (25)	**Gazipur** Sadar (25) **Mymensingh** Sadar (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50)

Red meat (cattle)	**Pabna** Shathia (25) **Kushtia** Alamdanga (25)	**Pabna** Shajadpur (25) **Kushtia** Alamdanga (25)	Not applicable	**Dhaka** 2 Retail markets (50 retailers) 1 processing unit
Eggs	**Gazipur** Sadar (25) **Mymensingh** Sadar (25)	**Gazipur** Sadar (25) **Mymensingh** Sadar (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50)
Milk (cow and buffalo)	**Shirajganj** Baghabari (25) **Noakhali** (Buffalo) Subarnachar (25)	**Pabna** Shajadpur (25) **Noakhali** Subarnachar (25) Processing plant (1)	Not applicable	Not applicable
Fish	**Mymensingh** Trishal (25) **Kishorganj** Tarail (25)	**Mymensingh** Trishal (25) **Kishorganj** Tarail (25)	**Dhaka** Karwan Bazar (25) Jatrabari Bazar (25)	**Dhaka** 2 Retail markets (50)
Total questionnaires	**2327** (Producer- 650; 'Bepari'-650; Wholesalers- 500; Retailers- 500; Cold stores- 07; Super shop- 05 for each of the selected horticultural crops; Semi-automatic and automatic rice mills- 10; Flour mills- 02; Fruit processing plant- 01; Milk processing plant- 01; Meat processing plant- 01).			

Appendix 2

Types of questionnaires prepared for assessment of food loss and waste of selected 14 food commodities under 5 food groups

COMMODITY	TYPES OF QUESTIONNAIRES PREPARED FOR VARIOUS RESPONDENTS												Total
	Growers	'Bepari'	Wholesalers	Retailers	Rice mills	Flour mills	Fruit/milk/meat processing plant	Household	Restaurant	Community centre	Super shop	Cold store	
Cereals[A]	02	02	-	-	01	01	-	-	-	-	-		06
Horticulture[B]	06	06	06	06	-		01	-	-	-	01	01	27
Animal products[C]	04	04	03	03	-		02	-	-	-	-		16
Fish and fish products[D]	04	04	04	04	-		- -				-		16
Food waste (All food)	-	-	-	-	-			01	01	01	-		03
Grand Total													**68**

[A]Cereals (Paddy and wheat)
[B]Horticulture (Potato, carrot, tomato, red amaranth, banana, mango)
[C]Animal products (poultry meat, red meat, egg, cow milk and buffalo milk)
[D]Fish and fish products (carp fish and small fish)

Appendix 3

Postharvest quantitative loss of selected horticultural crops at different levels of the value chains (Category Method)

Crops	Postharvest quantitative loss at different levels of value chain								Total loss (%)
	Growers		Bepari		Wholesalers		Retailers		
	Location	Loss (%)	Location	Loss (%)	Location	Loss (%)	Location	Loss (%)	
Mango	Chapai Nowabganj (N=25)	3.9 (1.7)	Kansat, Chapai Nowabganj (N=25)	9.2 (7.1)	Karwan Bazar, Dhaka (N=25)	7.4 (2.9)	Karwan Bazar, Dhaka (N=25)	9.5 (2.2)	**31.7**
	Satkhira (N=25)	9.3 (2.4)	Satkhira Sadar (N=25)	10.1 (1.8)	Badamtali Bazar, Dhaka (N=25)	7.5 (2.5)	Mohammadpur, Dhaka (N=25)	6.3 (2.0)	
	Mean	**6.6**	**Mean**	**9.7**	**Mean**	**7.5**	**Mean**	**7.9**	
Banana	Bogura (N=25)	6.6 (3.0)	Mokamtala, Bogura (N=25)	1.1 (0.1)	Karwan Bazar, Dhaka (N=25)	7.2 (2.3)	Newmarket, Dhaka (N=25)	4.2 (1.9)	**20.3**
	Madhupur, Tangail (N-25)	4.6 (2.5)	Madhupur (N=25)	1.4 (1.0)	Jatrabari Bazar, Dhaka (N=25)	7.8 (1.9)	Mahakhali, Dhaka (N=25)	6.5 (1.9)	
	Mean	**5.7**	**Mean**	**1.3**	**Mean**	**7.5**	**Mean**	**5.4**	
Potato	Bogura (N=25)	10.7 (5.0)	Mahasthan, Bogura (N=25)	0.0 (0.0)	Karwan Bazar, Dhaka (N=25)	3.9 (1.0)	Newmarket, Dhaka (N=25)	9.8 (3.7)	**21.8**
	Munshiganj (N=25)	6.8 (0.3)	Munshiganj Sadar (N=25)	3.1 (0.6)	Jatrabari Bazar, Dhaka (N=25)	7.4 (3.5)	Mahakhali, Dhaka (N=25)	9.7 (3.5)	
	Mean	**8.8**	**Mean**	**1.6**	**Mean**	**5.7**	**Mean**	**9.8**	
Carrot	Bogura (N=25)	10.2 (4.5)	Mahasthan, Bogura (N=25)	0.1 (0.0)	Karwan Bazar, Dhaka (N=25)	7.8 (2.6)	Newmarket, Dhaka (N=25)	4.5 (1.2)	**26.1**
	Ishwardi, Pabna (N=25)	0.0 (0.0)	Ishwardi, Pabna (N=25)	11.8 (2.8)	Jatrabari Bazar, Dhaka (N=25)	8.1 (2.6)	Mahakhali, Dhaka (N=25)	9.6 (4.0)	
	Mean	**5.1**	**Mean**	**5.9**	**Mean**	**8.0**	**Mean**	**7.1**	
Tomato	Bogura (N=25)	11.1 (3.6)	Mahasthan, Bogura (N=25)	1.4 (1.3)	Karwan Bazar, Dhaka (N=25)	6.4 (1.7)	Karwan Bazar, Dhaka (N=25)	5.8 (2.4)	**27.9**
	Cumilla (N=25)	12.0 (5.2)	Nimshar, Cumilla (N=25)	7.5 (2.4)	Jatrabari Bazar, Dhaka (N=25)	6.1 (1.9)	Mohammadpur, Dhaka (N=25)	5.1 (1.8)	
	Mean	**11.6**	**Mean**	**4.5**	**Mean**	**6.3**	**Mean**	**5.5**	
Red amaranth	Bogura (N=25)	1.5 (1.2)	Mahasthan, Bogura (N=25)	0.0 (0.0)	Karwan Bazar, Dhaka (N=25)	1.7 (0.6)	Newmarket, Dhaka (N=25)	4.8 (1.7)	**16.6**
	Jashore (N=25)	13.2 (3.5)	Satmail Bazar, Jashore (N=25)	5.0 (1.9)	Jatrabari Bazar, Dhaka (N=25)	1.1 (0.7)	Mahakhali, Dhaka (N=25)	5.8 (2.5)	
	Mean	**7.4**	**Mean**	**2.5**	**Mean**	**1.4**	**Mean**	**5.3**	

NB- The values in the parentheses are the standard deviations.