

A BASELINE SURVEY ON THE WINTER TOMATO SUPPLY CHAIN IN SELECTED AREAS OF BANGLADESH

TCP/RAS/3502

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A BASELINE SURVEY ON THE WINTER TOMATO SUPPLY CHAINS IN SELECTED AREAS OF BANGLADESH

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Abstract

Tomato is a popular and nutritious vegetable in Bangladesh. Due to the lack of appropriate pre- and post-harvest measures and inefficient supply chain, a lot of tomatoes are spoiled every year. Adequate data and information regarding these issues are lacking in Bangladesh. Therefore, the study assessed the knowledge, attitude and practices (KAP) of key actors in winter tomato supply chains regarding pre- and post-harvest handling, food safety, food quality, and post-harvest losses, and the status of tomato market opportunities in Bangladesh. Sixty farmers and 91 traders in the tomato supply chain were interviewed from Rajshahi, Bogra and Dhaka districts. The results revealed that most farmers (100%) and traders (97-100%) showed positive attitudes towards crop maturity, safe tomato, importance of good packaging, consumers' awareness, and took various pre- and postharvest measures for keeping tomatoes safe for the consumers. The estimated average postharvest losses were 4.57% and 11% at farm and traders' level respectively. At farm level, these losses occurred during sorting & grading (1.24%), transportation (0.95%), harvesting (0.94%), storage (1.03%) and other causes (0.41%). The highest loss was recorded for retailer (4.71%) and the lowest for *Faria* (1.82%). This study identified seven supply chains for tomato marketing. The longest and prominent channel was *Farmer >Bepari>Urban Arathdar>Urban Retailer>Urban Consumer*. Farmers and *Farias* used different local carriers like bicycle, rickshaw, van, and push cart to transport tomato. Trucks and pick up van were mostly used by *Bepari* to transport tomato from assemble markets to distant wholesale markets. Retailer received the highest net profit (Tk. 7,858/ton) due to higher sale price and lower marketing cost followed by *Faria* (Tk.2,444/ton) and *Bepari* (Tk. 1,852/ton). Major marketing problems in the supply chain were delayed sale (64.3%), spoilage (61.4%) and lack of buyers (52.9%). Both farmers and traders suggested various measures to reduce postharvest losses and keep tomatoes safe for the consumers.

Key words: Tomato, supply chain, postharvest loss, food safety, food quality, post-harvest handling

1. INTRODUCTION

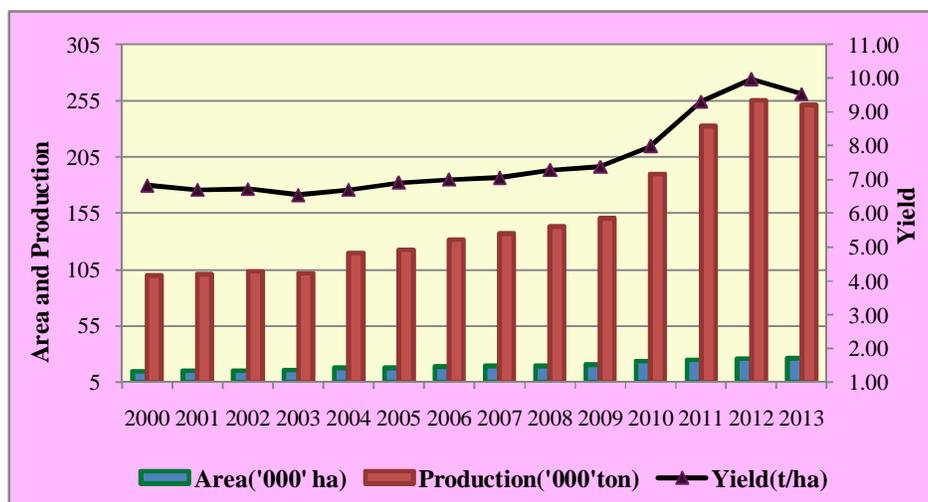
The importance of vegetables in the human diet is universally recognized. Vegetables are the major sources of vitamins and minerals without which the human body cannot maintain proper health and develop resistance to diseases. They also contain pectin, cellulose and various energy giving substances (www.choosemyplate.gov/vegetables-nutrients-health). The per capita per day consumption of vegetables in Bangladesh is 166.1gm. However, sharp increase (18.22%) was taken place in the per capita consumption of vegetables in the country over the period from 2000 to 2010 (HIES, 2010).

Tomato (*Lycopersicon esculentum*) is one of the major popular vegetable crops in Bangladesh. It is a tasty vegetable and promotes healthy nutritional balance as it is a good source of vitamin A and C. It is also an excellent source of lycopene (a powerful antioxidant) that helps preventing the development of many forms of cancer (Wener, 2000). It occupies a total area of land 26.32 thousand hectares with a total production of 250.95 thousand tons and having an average yield of 9.54 ton/ha (BBS, 2013). In the last three years, tomato production is increasing due to the introduction of improved varieties and production techniques as well as increased market demand and entry of modern market outlets, in particular supermarkets, hotels and restaurants (Fig 1).

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Fig 1. Area, production and yield of tomato, 2000-2014



Both pre-harvest and post-harvest measures are responsible for postharvest produce losses. But postharvest loss is much more painful and costlier than pre-harvest loss both in terms of money and man-hours. Different factors responsible for postharvest losses include poor pre-harvest measures, adoption of poor production techniques, non-application of pre-harvest recommended practices, harvesting at immature stage and inappropriate care during harvest. Postharvest losses are usually occurred due to mechanical injuries, moisture condensation causing pathogen infestation, packaging in bulk without sorting and grading, improper handling, inadequate storage, poor transportation & distribution system, and delayed transportation in the retail market. A huge amount of tomatoes are damaged and contaminated every year due to their perishability, seasonality, bulkiness, poor infrastructure, and poor pre- and postharvest practices in Bangladesh that need to be taken into consideration. Due to absence of proper storage and marketing facilities, farmers are forced to sell their produces at throwaway prices. Nevertheless, indiscriminate use of pesticides by the producers and application of various chemical agents for ripening of tomato are causing problems for human health and the environment. This issue is now considered an enormous burden for the nation's public health system. Therefore, the knowledge of postharvest management for vegetables is very much important at producers' and various stakeholders' levels for reducing postharvest losses and ensuring food safety for the consumers.

The retail markets of tomato are mainly dominated by unorganized retailers and the existing market structure does not adequately address the complex problems of farmers. The retail market has low marketing efficiency, high postharvest losses and does not foster competitiveness. A modern innovative system that can reduce the vested interests of a large intermediary chain, create competition, assure quality and modernize operations in handling of tomatoes, is necessary to raise income of actual farmers. Again, the changing demand in domestic markets for tomato creates both challenges and opportunities. Therefore, efficient marketing is very much important to reduce enormous postharvest losses, and risk and uncertainty in timely delivery of quality and safe produces at reasonable prices to the consumers.

The study was conducted with the view to develop capacity to Reduce Postharvest Losses in Horticultural Chains in SAARC countries to promote, support and implement good practices in order to minimize postharvest losses and improve quality and safety in horticultural supply chains. Therefore, the study was conducted with the following objectives:

1. To assess the knowledge, attitude and practices (KAP) of key stakeholders (producers, traders and consumers) toward food safety, food quality, post-harvest handling, and post-harvest losses in winter tomato supply chains.
2. To assess the status of market opportunities through analysing supply chain for winter tomatoes in Bangladesh.

2. REVIEW OF LITERATURE

The knowledge of postharvest management for tomato is very much important at producers' and various stakeholders' levels for reducing postharvest losses and ensuring food safety for the consumers. But, there have been very few systematic attempts to assess the knowledge, attitude and practices (KAP) of key stakeholders (producers, traders and consumers) toward food safety, food quality, post-harvest handling, and post-harvest losses in winter tomato supply chains. Different studies were conducted on tomato marketing based on small-scale studies and experiments, but did not reflect the real situation. Some of the related studies conducted at home and abroad have been reviewed in the sub-sequent paragraphs.

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

Khatun et al., (2014) identified and estimated postharvest practices and losses of tomato at farmers' and intermediaries' level in Bangladesh. The major post-harvest activities practiced by the farmers and intermediaries were harvesting, grading, cleaning, storing, packaging and transporting. The average post-harvest losses were estimated to be 15.37% and 10% at the farmers' and intermediaries level respectively. The harvesting loss was found highest compared to grading, packaging, storing and transporting. The losses of tomato were found to be the highest for *Beparis* (6.3%) followed by *Paikers* (2%) and retailers (1.5%) due to transportation and delayed selling. Farmers incurred loss at farm level was Tk.78,540/ha and at traders level it was Tk. 128,258 per season. At national level monetary loss was estimated at Tk.52.31 crore during 2009-10. Important factors leading harvesting losses were due to early and delayed harvesting and insect infestation. Product price, farming experience and good packaging materials had negative relationship, and total production and rainfall had significant positive relationship with total post-harvest losses.

In Cambodia, *Buntong et al., (2013)* assessed and introduced possible handling improvements in traditional and modern supply chains for tomato. Traditional chain involved farmers and collectors in Kandal Province, and wholesalers and retailers in wet markets in the capital of Phnom Penh. In the modern chain, only one intermediary between farmers and supermarkets was involved. Postharvest losses in the traditional and modern chains were 23% and 22.5%, respectively. Farmers' losses were mainly due to pre-harvest damage by insect-pests and diseases, and immaturity while losses during subsequent handling were due to physical damage, rotting, weight loss and/or over-ripening. Improved packaging, pre-cooling and sanitizing treatments as individual handling improvements were tried in the traditional chain. Use of 20kg capacity plastic crate with 50 μ m-thick low density polyethylene bagging and 20

kg capacity bamboo basket lined with newsprint reduced tomato damage at the wholesale and retail stages relative to the conventional packaging of using 20kg capacity 50µm-thick high density polyethylene.

In Nigeria, *Ayandiji et al., (2011)* estimated postharvest losses of tomato in their study. It reveals that about 72% farmers used van/pick up to transport their produce from farm to the market. No storage facilities were used in the study areas to preserve the tomato from rotten after harvesting. The average gross margin with postharvest losses was less than the average gross margin when no damage occurred in tomatoes thus showing that post harvest losses reduce the mine of farmers in the study area. The effect of all the independent variables (pre harvest working days, harvest working days, distance from the farm to the market (km), days fruit spent on the farm (days), age of fruit at harvest (months), area of land cultivated (ha), days fruit spent in the market before getting to the consumer (days), and no. of basket that was harvested) on the dependent variable (quantity of fruit loss) tested were significant at 5% probability level. The effects of postharvest losses lead to wastage of the products and tend to frustrate the efforts put into production and their income on the produce.

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

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

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

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

3. METHODOLOGY

3.1 Study Area Selection

Tomato is an important vegetable of Bangladesh. It grows more or less every parts of the country. However, two important tomato growing districts namely Rajshahi and Bogra were

purposively selected for conducting the baseline survey. Again, two suitable *Upazilas* in terms of the availability of data, ease of data collection, accessibility, and logistic support from each district were selected in consultation with DAE personnel and BARI scientists for administering KAP survey. The selected *Upazilas* were Godagari and Paba under Rajshahi district, and Sadar and Shibgonj under Bogra district.

3.2 Sampling Procedure

For conducting baseline survey at household and market level, a complete list of farmers cultivating tomato was prepared with help of DAE personnel. At first, a total of 60 tomato farmers (30 from each district) were selected from the list for interview by applying simple random sampling technique to collect primary data. Secondly, a total of 91 traders and 25 consumers were randomly selected and interviewed from different assemble, wholesale and retail markets (i.e. *Upazila/district/Dhaka City*). Thus, the total sample size was 176.

3.3 Period of Study

Primary data were collected by interviewing tomato farmers and traders using a structured and pre-tested interview schedule during August-September, 2015. The researcher himself along with trained enumerators collected data and information for this study.

3.4 Analytical Technique

The collected data were edited, tabulated and analyzed applying simple descriptive methods. However, marketing margins of the key actors in the tomato supply chain were calculated by the following equations.

$$GM_i = PR_i - PP_i \dots\dots\dots (1)$$

Where,

GM_i= Gross margin (Tk/ton) for ith intermediary

PR_i = Price received (Tk/ton) for ith intermediary

PP_i = Price paid (Tk/ton) by ith intermediary

$$NM_i = GM_i - MC_i - CPL_i \dots\dots\dots (2)$$

Where,

NM_i = Net margin (Tk/ton) for ith intermediary

MC_i = Marketing cost incurred (Tk/ton) by ith intermediary

CPL_i = Cost of postharvest loss incurred (Tk/ton) by ith intermediary

$$CPL = Q_{cd} \times P_p + Q_{pdu} \times P_p - Q_{pds} \times P_s \dots\dots\dots (3)$$

Where,

CPL = Cost of postharvest loss (Tk/ton)

Q_{cd} = Quantity damaged completely (ton)

P_p = Average purchase price (Tk/ton)

Q_{pdu} = Quantity damaged partially that could not be sold (ton)

Q_{pds} = Quantity damaged partially that could be sold with less price (ton)

P_s = Average sell price (Tk/ton)

4. RESULTS AND DISCUSSION

4.1 Knowledge, Attitudes and Practices of Key Actors of Tomato Supply Chain

The key stakeholders involved in the winter tomato supply chain are farmer, *Faria* (petty trader or collector), *Bepari* (wholesale trader), *Arathdar* (commission agent), retailer, and consumer (for details pl. see the end note). They were asked many questions related to their knowledge, attitudes and practices (KAP) usually done in the production and marketing of winter tomato and other related issues. The asked questions were related to postharvest practices at farmers' and traders' level, safe tomato, toxicity, and quality of packaging.

4.1.1 Status of Pre-harvest Practices at Farm Level

Pesticides use: The important insect pests of tomato were fruit borer, aphid, and fruit fly. Again, leaf curl, wilting, and root rot were important diseases of tomato. Among diseases, leaf curl (a viral disease) was found to be the most serious that causes damage to tomato crop. All the respondent tomato farmers in the study areas reported to use different types of pesticides. They could not imagine the production of tomatoes without use of pesticides. Respondent tomato farmers mentioned the names of 29 types of locally available and frequently used pesticides which were produced by different pesticides companies. They applied pesticides more than 12 times per season started before flowering to harvesting (Table 1). Nevertheless, farmers also used plant growth regulators (PGR) in tomato, especially to increase the size of fruits. The commonly used PGR are Okozim, Okolim and Voxal Super.

Table 1. Frequency and stages of application of pesticides in tomato cultivation

Name of pesticides/PGR	No. of application (No./season)	Dose	Stages of application
Karate 25EC, Dursban 20EC, Tafgor 40EC, Bavistin, Rovral 50 WP, Endocol-45, Diathen-M45, Safin, Sevin powder, Ripcot, Vascan, Furadan, Skailan, Shabicon, Admire, Reject, Publin, Score, Giter, Malatheon, Cebicrom, Basudin, Asker, Volcan, Dasper, Secure, Redomil, and Acrvit. The PGR were Okozim, Okolim and Voxal super	12-16 times	1.0 ml or gm per 1.0 liter water	Before flowering to harvesting

Perception on crop maturity: Harvesting of crops at maturity stage is a paramount importance for attaining desirable quality. The level of maturity actually helps in selection of storage methods, estimation of postharvest shelf life, selection of processing operations for value addition (Dhatt and Mahajan, 2007). Proper knowledge on crop maturity is very much important to reduce postharvest losses. Key stakeholders in the supply chain were asked to response on crop maturity and its perceived characteristics. Farmers and traders generally identify tomato maturity through observing physical outlook. All the respondents expressed positive response on tomato maturity meaning that they know the maturity stage and characteristics of tomato. It is revealed from Table 2 that most of the respondents (59-100%) mentioned that radish colour spread on the lower part of full matured tomato. The other mentioned maturity characteristics were hard skin, large size, and flower drops from lower part of tomato.

Table 2. Knowledge on crop maturity and perceived characteristics of tomato maturity

Quality characters	% of responses by farmers and traders				
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All (n=130)
A. Idea on tomato maturity					
Positive response	100	100	100	100	100
Negative response	--	--	--	--	--
B. Characteristics of tomato maturity					
1. Red colour spread on the lower part	59	100	100	93	79.5
2. Hard skin	--	65	65	80	38.5
3. Large size	44	10	5	27	28.8
4. Flower dropping	--	30	5	20	10.0
5. Others	28	--	--	17	16.8

Stages of harvesting: Harvesting of crop in proper time is an important task in crop farming. Tomato farmers in the study areas harvest tomato at both mature and immature stages. However, majority of the respondent farmers (93.3%) harvested tomatoes at matured period followed by at green stage (30%) and ripening stage (20%). The farmers in Rajshahi district usually transplant tomato seedling at early and harvest immature tomatoes for early marketing and receiving good price (Table 3).

Table 3. Stages of harvesting of tomato in the study areas

Stages of harvest	No. of respondent (n=60)	% of responses
1. Mature stage	56	93.3
2. Green stage (not fully mature)	18	30.0
3. Ripening stage (starts ripening)	12	20.0
4. Immature stage	3	5.0

Mode of harvesting: Harvesting of crop at the right time and in the right way maximizes crop yield and minimizes crop losses and quality deterioration. Harvesting at mature stage is also an important operation of tomato farmers. All the respondent farmers harvested tomato by hand picking. The time of harvesting varied from farmer to farmer, but it was reported that tomatoes were not harvested during early morning with moist weather. More than 46% farmers reported that they harvest tomato in the afternoon, whereas 43.3% farmers harvested it during sunny morning. A good percentage of farmers also harvested tomatoes both in the morning and noontime (Table 4).

Table 4. Mode and time of harvesting of tomato in the study areas

Particular	No. of respondent (n=60)	% of responses
A. Means of harvesting		
By hand	60	100
B. Time of harvesting		
1. Afternoon	28	46.7
2. Sunny morning	26	43.3
3. Morning & Noon	17	28.3
4. Noon	6	10.0

Use of harvesting container: Harvesting containers should be made in such a way so that these should reduce mechanical damage to produce. Different types of containers were reported to use during harvesting of tomatoes. Irrespective of variety, size and maturity, about 67% farmers used bamboo basket and 35% farmers used both plastic and jute sac as harvesting

container. Plastic crates are relatively expensive to purchase, but are reusable and easy to clean. It has good stacking strength, ventilation holes and long life. But, only one respondent farmer placed his harvested tomatoes in plastic crates (Table 5).

Table 5. Placing container of tomato immediate after harvest

Type of container	No. of respondent ($n=60$)	% of responses
1. Bamboo basket	40	66.7
2. Plastic sac	21	35.0
3. Jute sac	21	35.0
4. On ground	1	1.7
5. Plastic crates	1	1.7
6. Others	4	6.7

Use of ripening chemicals: Ripening is a dramatic event in the life of a fruit crop during which structure and composition of unripe fruit is so altered that it becomes acceptable to eat. The use of ripening chemicals is required for many horticultural crops marketing in commercial purposes. In order to the assurance of produce quality, uniformity in fruit colour, taste, and flavour is prerequisite. A number of chemicals are available in the market and is approved for post-harvest use on fruits crops for enhancing ripening. Ripening agents are generally using at growers' level in the study areas.

Respondent tomato farmers tried to hide about the use of ripening chemicals at the first time since its use seems harmful for health. However, many respondent farmers in Rajshahi district use different types of chemicals for ripening tomatoes quickly and uniformly. Rajshahi farmers harvested immature tomatoes for early market and higher price. Tomtom was reported to be the highest used ripening chemical for ripening tomato followed by Ripen-15. Some tomato farmers used Raizen, Harvest and Eden as ripening chemicals (Table 6).

Table 6. Use of ripening chemicals in the study areas

Name of chemical	No. of farmer used ($n=60$)	Dose (ml)
1. Tomtom	30 (18)	Mix 1 ml chemical with 1 ml water
2. Ripen-15	15 (9)	
3. Raizen	2 (1)	
4. Harvest	2 (1)	
5. Eden	2 (1)	

Note: Figures in the parentheses are no. of farmer

Harvested tomatoes are firstly spread over an open floor/field that covered with polythene or straw and then spray ripening chemicals on it. After some times, make a heap with these sprayed tomatoes and covered it with jute sac or polythene and left for 2-3 days until ripen. In most cases, the same procedure is repeated again for proper and homogenous ripening (Fig 2).



Fig 2. Use of ripening chemicals on green tomatoes

4.1.2 KAP of Key Actors on Safe Tomato

Product safety standard is a set of regulations to the design and production of consumer products to make sure of the safety of consumer and to not represent any hazard (<http://thelawdictionary.org>). The respondent key players in the tomato supply chain were asked about safe tomato and its related factors. More or less all the respondents gave positive response on it. Majority of the respondents considered those tomatoes safe for human consumption which is free from poisons and diseases and physical appearance is clean and healthy. Some of them opined that safe tomatoes must be matured and washed with clean water (Table 7).

Table 7. Related knowledge and factors associated with safe tomato for the consumers

Reason	% of responses by farmers and traders						
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	Arathdar (n=21)	Consumer (n=25)	All (n=176)
A. Idea on safe tomato							
Positive response	97	100	100	100	100	100	99.0
Unknown/ignorant	3	--	--	--	--	--	0.0
B. Factors of safe tomato							
1. Poison free	93.3	100.0	100.0	93.3	61.9	76.0	88.6
2. Disease free	90.0	100.0	90.0	86.7	9.5	84.0	80.1
3. Clean and hygienic	83.3	75.0	75.0	90.0	57.1	84.0	79.5
4. Matured	15.0	15.0	15.0	53.3	9.5	--	18.7
5. Wash with clean water	10.0	10.0	5.0	26.7	33.3	--	13.6
6. Others	3.3	10.0	25.0	3.3	28.6	8.0	10.2

The key factors that make tomatoes unsafe for consumption were use of ripening chemicals and pesticides imprudently, infection of diseases, and infestation of insects. Some of the respondents also opined that tomatoes are considered to be unsafe for human consumption when it is contaminated with birds' dropping, unsafe water, formalin and chemical fertilizers (Table 8).

Table 8. Factors contributing to make tomato unsafe for the consumers

Reason	% of responses by farmers and traders						
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	Arathdar (n=21)	Consumer (n=25)	All (n=176)
1. Ripening chemical use	73.3	60.0	85.0	90.0	81.0	92.0	79.5
2. Pesticides use	85.0	85.0	70.0	80.0	57.1	88.0	79.5
3. Infection of diseases	66.7	55.0	60.0	46.7	--	16.0	46.0
4. Dropping of birds	18.3	15.0	15.0	20.0	14.3	8.0	15.9
5. Insects infestation	20.0	5.0	20.0	13.3	28.6	--	15.3
6. Unsafe irrigation water	5.0	5.0	--	--	--	44.0	8.5
7. Immature harvest	8.3	5.0	5.0	16.7	--	--	6.8
8. Use of formalin	--	10.0	20.0	6.7	--	--	4.6
9. Use chemical fertilizer	--	--	--	--	14.3	12.0	3.4

All the key players in the tomato supply chain believed that measures should be taken to keep tomatoes toxic free for the consumers. They mentioned different measures that will ensure tomatoes toxic free for the consumers. The highest reported measures were harvest mature tomatoes, using recommended pesticide dose, ripe tomatoes naturally, harvest tomatoes after 3 days of applying pesticides, using sex pheromone trap, and do not use formalin. Besides, a good number of respondents also considered some measures such as neat & clean tomatoes, using clean container, separation of damage tomatoes from good ones, and development of

awareness among farmers and traders that keep tomatoes toxic free for the consumers (Table 9).

Table 9. Measures could make tomato toxic free for the consumers

Type of measures	% of responses by farmers and traders						
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	Arathdar (n=21)	Consumer (n=25)	All (n=176)
A. Should tomato keep toxic free?							
Positive response	100	100	100	100	100	100	100
Negative response	--	--	--	--	--	--	--
B. Measures to keep tomato toxic free							
1. Harvest mature tomato	28.3	10.0	5.0	63.3	61.9	64.0	38.6
2. Use recommended pesticide dose	53.3	40.0	25.0	16.7	--	20.0	31.2
3. Ripe tomato without chemicals	20.0	20.0	20.0	26.7	19.0	60.0	26.7
4. Using sex pheromone trap	23.3	60.0	70.0	--	--	--	22.7
5. Harvest after 3 days of applying pesticides	31.7	25.0	35.0	--	9.5	12.0	20.5
6. Make tomato neat & clean	6.7	35.0	40.0	30.0	--	24.0	19.3
7. Maintain recommended dose of ripening chemicals	23.3	--	--	13.3	47.6	12.0	17.6
8. Use clean container	1.7	55.0	20.0	23.3	33.3	--	17.0
9. Keep tomato formalin free	8.3	5.0	15.0	26.7	19.0	12.0	13.6
10. Separate damage tomatoes from good ones	3.3	--	5.0	13.3	57.1	--	10.8
11. Grow tomato without pesticides	11.7	15.0	15.0	--	--	--	7.4
12. Application of organic fertilizer	13.3	--	--	--	--	12.0	6.2
13. Keep tomatoes in cold storage	--	--	--	--	9.5	4.0	1.7
14. Develop awareness among farmers and traders	--	--	--	--	--	32.0	4.5
15. Monitoring market	--	--	--	--	--	12.0	1.7
16. Others	--	--	--	6.7	--	16.0	3.4

Note: Others included ensure fair price for safe tomato, develop cool supply chain, proper grading and packaging, quick transport, etc

Many farmers in practice took several measures to make tomatoes safe and toxic free for the consumers. The highest proportion of farmers (38.3%) used recommended dose of pesticides, 30% farmers harvest matured tomatoes, nearly 27% farmers harvested tomatoes 2-7 days after applying pesticides, and 25% respondent farmers used limited dose of ripening chemicals. A small parentage of farmers followed Integrated Pest Management (IPM) technology and used sex pheromone traps to control fruit fly attack instead of applying pesticides (Table 10).

Market intermediaries like *Faria*, *Bepari*, retailer and *Arathdar* also took some practical measures to make tomatoes safe and toxic free for the consumers. They cleaned dirty tomatoes with cloth, did not use formalin or ripening chemicals, used clean and safe container/packet, and separated damaged tomatoes from good ones to avoid contamination. Retailers usually clean purchased tomatoes with clean water before sale (Table 10).

Table 10. Measures practiced at farmers and traders levels to make tomato toxic free

Type of practice	% of responses by farmers and traders				
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	Arathdar (n=21)
1. Use recommended pesticides dose	38.3	--	--	--	--
2. Harvest in mature stage	30.0	--	--	--	--
3. Harvest after 2-7 days of applying pesticides	26.7	--	--	--	--
4. Use limited dose of ripening chemicals	25.0	--	--	--	--
5. Use of sex pheromone trap	6.7	--	--	--	--
6. Harvest before spraying	5.0	--	--	--	--
7. Clean dirty tomato by cloth	6.7	25.0	60.0	36.7	14.3
8. Don't use formalin/ripening chemicals	15.0	30.0	30.0	23.3	--
9. Use clean and safe container/packet	3.3	5.0	20.0	20.0	52.4
10. Separate damage tomato from good ones	6.7	--	--	26.7	52.4
11. Wash with clean water	--	--	--	6.7	--

4.1.3 KAP of Key Actors on Disease Free Tomato

The respondent tomato farmers were asked about the importance of keeping tomatoes disease free for the consumers. All the respondent farmers reported that adequate measures should be taken to make tomatoes disease free and healthy for the consumers. Forty five percent farmers each emphasized on planting good quality and disease free seedlings and applying recommended pesticides dose for controlling insects and diseases as the precautionary measures for keeping tomato disease free. Nearly 37% farmers pointed out about soil curing before planting seedlings and 13% farmers advocated for keeping land weed free. Some farmers told about increased use of organic fertilizers and uprooting disease attacked seedlings from the field in order to keep tomato disease free (Table 11).

Table 11. Farmers' attitudes and measures towards keeping tomato disease free for the consumers

Particulars	No. of respondent (n=60)	% of responses
A. Should tomato keep disease free?		
Positive response	60	100
Negative response	--	--
B. Measures needed to keep tomato disease free		
1. Use good quality and disease free seedling	27	45.0
2. Use recommended dose of pesticides	27	45.0
3. Curing soil	22	36.7
4. Limited use of pesticides	12	20.0
5. Keep land weed free	8	13.3
6. Increased use of organic fertilizers	6	10.0
7. Rouging/uprooting disease infested seedlings	5	8.3
8. Irrigate the crop in proper time	2	3.3
9. Use of growth hormones/vitamins	1	1.7

In practice, many farmers carried out several actions to make tomatoes safe and disease free for the consumers. The highest percentage (45%) of farmers used recommended dose of fungicides followed by 28.3% farmers uprooted disease infested seedlings from the field and 26.7% used good quality and disease free seedlings to keep tomatoes disease free. A good

number of farmers also performed curing of soil and applied pesticides in a limited scale. Some of them used organic fertilizers and irrigated the crop in proper time to keep tomatoes disease free (Table 12).

Table 12. Practices usually done by farmers to make tomato disease free for the consumers

Type of practices	No. of respondent (n=60)	% of responses
1. Use recommended dose of fungicides	27	45.0
2. Rouging/uprooting disease infested seedlings	17	28.3
3. Use good quality and disease free seedlings	16	26.7
4. Curing soil	14	23.3
5. Limited use of pesticides	11	18.3
6. Keep land weed free	5	8.3
7. Use of organic fertilizers	4	6.7
8. Irrigate the crop in proper time	2	3.3

4.1.4 KAP of Key Actors on Clean Tomato

Cleaning products are used to help remove unwanted microbial contaminants from a surface. It plays a crucial role in our daily lives by providing important public health benefits to consumers. Keeping surfaces clean and free of soil not only helps reduce the opportunities for spreading of germs, but helps extend the life of our personal possessions (<http://www.aboutcleaningproducts.com>). The farmers in the study areas were asked to response on the significance of keeping tomatoes clean for the consumers. All the respondent farmers reported that adequate measures should be taken to make tomatoes clean for the consumers. More than 88% farmers thought that dirty tomatoes should be cleaned by cloths, but 26.7% farmers suggested cleaning tomatoes through washing. About 42% farmers considered using clean container as a prerequisite for clean tomatoes, whereas 18.3% farmers prohibited harvesting tomatoes in foggy weather. In order to keep tomatoes clean, some farmers suggested not to place tomatoes on the ground immediately after harvesting and damaged tomatoes always be separated from good ones (Table 13).

Table 13. Farmers' attitudes and measures towards keeping tomato clean for the consumers

Particulars	No. of respondent (n=60)	% of responses
A. Should tomato keep clean?		
Positive response	60	100
Negative response	--	--
B. Measures needed to keep tomato clean		
1. Clean dirty tomatoes by cloth	53	88.3
2. Use clean container	25	41.7
3. Wash tomato with clean water	16	26.7
4. Don't harvest in foggy weather	11	18.3
5. Don't keep tomato on ground just after harvesting	4	6.7
6. Separate rotten/spotted/damage tomato from good ones	3	5.0

In practice, majority of the farmers performed different actions to make tomatoes clean for the consumers. Eighty percentage of the respondent farmers cleaned dirty tomatoes using cloths, whereas 27% washed them with clean water. More than 48% farmers used clean container and nearly 22% farmers harvested tomatoes in sunny weather to maintain tomatoes clean and fresh (Table 14).

Table 14. Practices usually done by farmers to make tomato clean for the consumers

Type of practices	No. of respondent (n=60)	% of responses
1. Cleaning dirty tomatoes by cloth	48	80.0
2. Use clean container	29	48.3
3. Washing tomato with clean water	16	26.7
4. Harvest tomato in sunny weather	13	21.7
5. Separate rotten/spotted/damage tomatoes from good ones	5	8.3

4.1.5 Perceptions of Key Actors on Good Quality Tomato

The actors in the supply chain were asked to point out some important characteristics of a good tomato, and they mentioned some characteristics in this respect. The highest reported character was large size (60-93.3%) followed by attractive colour (66.7-85%), good maturity (14.3-95%), clean & fresh (15-76.2%), and firm (8.3-81%). A good percentage of retailers talked about good variety (Table 15).

Table 15. Quality characters that are generally considered for a good quality tomato

Quality characters	% of responses by farmers and traders					
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	Arathdar (n=21)	All (n=151)
1. Large size	85.0	70.0	60.0	93.3	85.7	81.4
2. Attractive colour	66.7	70.0	85.0	83.3	76.2	74.2
3. Matured	95.0	60.0	80.0	43.3	14.3	66.9
4. Clean and fresh	53.3	--	15.0	70.0	76.2	47.7
5. Firm	8.3	--	--	76.7	81.0	29.8
6. Good variety	--	--	15.0	63.3	--	14.6
7. Free from ripening chemicals	--	--	5.0	--	--	0.7

The respondents were also asked to mention some qualities that ensured them about good quality tomato. They stated more or less same characteristics mentioned in the previous section. However, two characteristics namely high demand and good variety were stated here more strongly than before (Table 16).

Table 16. Quality characters that ensure farmers and traders about good quality tomato

Quality characters	% of responses by farmers and traders				
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All (n=130)
1. Large size	71.7	75.0	85.0	63.3	72.3
2. Attractive colour	51.7	90.0	85.0	73.3	67.7
3. High demand	15.0	95.0	95.0	76.7	53.9
4. Good variety	8.3	90.0	75.0	70.0	45.4
5. Mature	55.0	50.0	40.0	13.3	42.3
6. Firm	35.0	45.0	35.0	46.7	39.2
7. Clean and fresh	31.7	5.0	5.0	23.3	21.5
8. Spotless	15.0	--	--	6.7	8.5
9. Free from ripening chemicals	15.0	--	5.0	3.3	8.5

The actors in the tomato supply chain opined regarding possible steps that should be practiced at assembling or primary market for ensuring product quality and safety. They opined different views in this regard which are shown in Table 17. On an average, more than 46% of the respondents suggested that farmers and traders should be encouraged to sell safe tomato. About

43% of the respondents opined that market committee should monitor market on a regular basis. The other suggestions were government should take initiative to stop toxic tomato sell (35.1%), ensure fair price of the quality tomato (22%), advise on limited use of ripening chemicals (15.4%), and arrange cold & clean place at the market premises for short-time storage (14.3%). Some of the respondents suggested punishing those persons selling toxic tomato, good packaging, limited use of pesticides, poster circulation on toxic tomato, set up billboard regarding safe tomato, and consumers' awareness (Table 17).

Table 17. Practices needed at assembling market for ensuring product quality and safety

Possible steps	% of responses				
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	Arathdar (n=21)	All (n=91)
1. Encourage farmers and traders to sell safe tomato	40.0	30.0	50.0	61.9	46.2
2. Market committee should monitor market regularly	35.0	45.0	36.7	57.1	42.9
3. Government should take step to stop toxic tomato sell	35.0	25.0	53.3	19.0	35.1
4. Ensure fair price of the quality tomato	45.0	25.0	20.0	--	22.0
5. Advise on limited use of ripening chemicals	10.0	20.0	6.7	28.6	15.4
6. Arrange cold & clean place for short-time storage	30.0	20.0	3.3	9.5	14.3
7. Punishment for selling toxic tomato	10.0	10.0	--	--	4.4
8. Ensuring good quality packaging	--	15.0	--	4.8	4.4
9. Advise on limited use of pesticides	5.0	5.0	3.3	--	3.3
10. Poster circulation on toxic tomato	--	5.0	6.7	--	3.3
11. Consumer should avoid toxic and unsafe tomato	--	--	--	28.6	6.6

4.1.6 KAP of Key Actors on Good Packaging

Good packaging clearly communicates its product's features and allows the product to be displayed in the best possible way to highlight those features (<http://www.davison.com>). It is also very much important for maintaining product quality, transport to distant places, and reduce postharvest losses.

Majority of the respondent agreed that good packaging has vital role in maintaining product quality and attracting consumers. Most farmers and retailers opined that plastic crate was the most important packaging instrument that could maintain product quality during transportation and handling. Due to lower cost and availability, bamboo cage/basket with paper or straw lining was reported by majority of the traders except retailers as a good packaging instrument for tomato transportation. Some *Farias* (25%) and *Beparis* (20%) did not talk about any particular packaging device, but they opined such a packaging system in which tomato will not be damaged during transportation and handling (Table 18).

In practice, on an average 55.4% stakeholders in the tomato supply chain used bamboo case with straw lining as tomato packaging instrument. The highest percentage of retailer (53.3%) and the lowest percentage of *Bepari* (10%) used plastic crates with paper lining as packaging instrument for tomato. A good percentage (20-40%) of farmers and traders also used plastic sac for packaging and transporting tomato in the study areas (Table 18).

Table 18. Role of good packaging and type of packaging used for maintaining product quality

Particulars	% of responses by farmers and traders				
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All (n=130)
A. Role of good packaging					
Positive response	100	95.0	95.0	93.0	96.8
Negative response	--	5.0	5.0	7.0	3.2
B. Type of packaging needed					
1. Plastic crates	91.7	20.0	--	83.3	64.6
2. Bamboo cage using paper & straw lining	28.3	95.0	100.0	36.7	51.5
3. Wooden box with tiny hole (like apple/egg packaging)	8.3	10.0	5.0	23.3	11.5
4. Packaging in such way so that tomato will not be spotted or spoiled during handling	1.7	25.0	20.0	--	7.7
C. Type of packaging used					
1. Bamboo case using straw lining	56.7	35.0	90.0	43.3	55.4
2. Plastic crates with paper lining	13.3	20.0	10.0	53.3	23.1
3. Plastic sac	23.3	20.0	40.0	--	20.0
4. Others	11.7	15.0	25.0	--	11.6

4.1.7 Perceptions of Key Actors on Consumers' Awareness

The perceptions of traders on consumers' awareness about food safety in the supply chain are very much important in promoting any product in the market. Therefore, they were asked to respond on the consumers' awareness about food safety. Table 19 revealed that most of the traders more or less aware of the consumers' reactions on food safety. More than 74% traders seemed that consumers are concerned about getting sick from the food they eat. About 66% traders know that consumers are concerned about the residual effect of pesticides. Consumers are also concerned about formalin use to prevent spoilage and fertilizer use in the cultivation.

Table 19. Traders' perceptions on consumers' awareness about food safety

Particular	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Concerned about getting sick from the food they eat	60.0	85.0	76.7	74.3
2. Concerned about pesticide residue	60.0	70.0	66.7	65.7
3. Concerned about formalin use	20.0	20.0	36.7	27.2
4. Concerned about fertilizer use	20.0	15.0	3.3	11.4
5. Others	35.0	50.0	20.0	32.9

4.2 Supply Chain of Winter Tomato

The sequences of stages involved in supply of inputs to the farm and transferring produces from farm to consumers is generally referred to as a supply chain. The stages are pre-production, production, post-production and consumption. In this section, the analyses of pre-production such input supply and management practices are not considered in this study.

4.2.1 Socioeconomic Profile of Farmer and Trader

The socioeconomic profile of tomato farmers and traders is presented in Table 20. All the respondent tomato producers and traders included in the study were male. In fact, no female respondents were available for taking part in the interview. The highest percentage of farmers (36%) belonged to the age group of 41-50 years and the lowest was in the age group of 61-70 years. A good percentage of younger farmers (37%) aged between 20-50 years were also involved in tomato farming. The level of education of the highest 38% tomato farmers was

class VI to X. About 22% farmers were illiterate. Almost all farmers sell tomatoes in the primary or assemble market. The average cultivated tomato area was 51.95 decimal (Table 20).

Table 20. Socioeconomic profile of tomato farmers and traders in the study areas

Particular	% of responses			
	Farmer (n=60)	Faria (n=20)	Bepari (n=20)	Retailer (n=30)
1. Gender				
Male	100	100	100	100
Female	--	--	--	--
2. Age range (years)				
20-30	15	40	10	43
31-40	22	20	25	23
41-50	36	20	40	23
51-60	20	15	25	7
61-70	7	5	--	3
3. Literacy level				
Illiterate	22	35	25	50
Class I-V	20	25	10	55
Class VI-X	38	25	60	45
SSC-HSC	15	15	5	--
Degree & above	5	--	--	--
4. Operate in the market				
Assemble market	100	100	100	--
Secondary market	--	--	100	100
5. Tomato area (decimal)	51.95	--	--	--

Table 20 also reveals that different types of traders with different ages were involved in the tomato supply chain. The highest percentage of *Faria* (40%) belonged to the age group of 20-30 years, whereas in case of *Bepari* and retailer it was 41-50 years and 20-30 years respectively. Most of the respondent *Farias* and retailers were illiterate, but the level of education of 60% *Beparis* was reported to be class VI to class X. However, a good percentage of *Beparis* (25%) were also illiterate. About 55% retailers had primary level of education. *Farias* usually operate in the primary/assemble market, whereas *Beparis* operate both in the primary and wholesale markets. Retailers operate only in the secondary market in the study areas.

4.2.2 Factors Influencing Tomato Business

The actors in the tomato supply chain mentioned various reasons for doing tomato business. The majority of the traders (75.7%) performed tomato business only because of its profitability. Good relations with fellow traders and the availability of market information were other two important reasons stated by 45.7% and 41.4% traders respectively for doing this business. Twenty percent traders each reported that they performed tomato business due to its plenty supply and good quality. Some traders also interested with this business because of its good demand and less capital requirement (Table 21).

Table 21. Factors influencing traders to undertake tomato business

Influencing factors	% of responses by traders			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Profitable business	70.0	70.0	83.3	75.7
2. Good relations with traders	40.0	60.0	40.0	45.7
3. Availability of market information	60.0	45.0	26.7	41.4
4. Plenty supply	25.0	30.0	10.0	20.0
5. Good quality product	10.0	25.0	23.3	20.0
6. Adequate demand	10.0	15.0	13.3	12.8
7. Required less business capital	10.0	--	10.0	7.1

4.2.3 Disposal Pattern and Damages of Tomato at Farm Level

Disposal pattern of tomato at farm level is shown in Table 22. The highest quantity of tomato produced and sold in the peak period in the study areas. The highest percentage (92.62%) of tomato was sold by the farmers. About 1.54% of the tomatoes were used for family consumption by the tomato farmers and 1.27% was gifted to relatives or others (Table 22).

Table 22. Disposal pattern and postharvest losses of tomato at farmers' level

Key players	Peak season		Lean season		All season	
	Quantity (ton)	% of total	Quantity (ton)	% of total	Quantity (ton)	% of total
Sale	241.33	94.09	58.42	87.02	299.75	92.62
Consumption	3.37	1.31	1.62	2.41	4.99	1.54
Gift	2.67	1.04	1.43	2.12	4.10	1.27
Damage	9.13	3.56	5.67	8.44	14.793	4.57
Total	256.50	100	67.13	100	323.63	100

On an average, the postharvest loss of tomatoes was 4.57% of the total production. It is revealed from Figure 4 that these losses occurred in the stage of sorting & grading (1.24%), transportation (0.95%), harvesting (0.94%), storage (1.03%) and other causes (0.41%). However, the rate of damage in lean season was much higher compared to peak season. In the lean season, most tomatoes are reported to be over matured and ripped and for this the rate of damage was comparatively high (Table 22). Khatun et al., (2014) estimated the average postharvest loss of tomato to be 15.37% at farmers' level in Dinajpur, Jessore and Comilla districts. Ahmed and Haque (2013) estimated loss of tomato at the rate of 10% at farm level. The rate of losses estimated in earlier studies were much higher compared to the present study. The low postharvest loss at farm level might be due to farmers' more consciousness about postharvest losses and management.

Respondent farmers reported some causes for the damage of tomatoes at farm level. The damage was realized during the period of harvest, sorting and grading, short period storage during ripening, and improper transportation system. At the farmers' level, cuts and bruises were the predominant types of spoilage. The cuts, spotted, disease infected, and cracked tomatoes are usually discarded from good ones during sorting and grading. That's why the rate of damage was reported high at this stage. The rate of damage for other causes was more or less same.



Fig 3: Sorting & grading at farm level, Godagari, Rajshahi

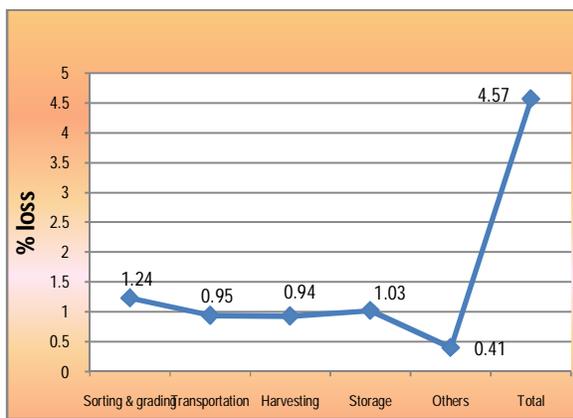


Fig 4: Percent of postharvest losses of tomato at farm level

Different primary factors responsible for losses during production including poor pre-harvest measures, adoption of poor production techniques, non-application of pre-harvest recommended practices, harvesting at immature stage and inappropriate care during harvest; and post-harvest problems, moisture condensation causing pathogen infestation, packaging in bulk without sorting and grading of produce, improper transportation and storage, and distant and time consuming market distribution (Kader, 1992).

Different factors were reported contributing to postharvest losses of tomato at farm level. The majority of farmers (58.3%) mentioned that the majority of the losses were due to black spots on tomato which was due to lying plants and tomatoes on soil. More than half of the respondent farmers reported insects' infestation and 38.3% mentioned bad weather and fertilization as the causes of postharvest loss of tomato. The other causes of postharvest loss were faulty harvest, application of ripening chemicals on spotted and injured tomatoes, destroy or injured by birds, fungal infection, late harvest, delayed sell, and immature harvest (Table 23).

Table 23. Factors contributing to postharvest losses of tomato at farm level

Reason	No. of responses (<i>n</i> =60)	% of responses
1. Spotted due to lying plants and tomatoes on soil	35	58.3
2. Insects infestation (fruit borer attack)	31	51.7
3. Spotted/rotten due to bad weather and fertilization	23	38.3
4. Loss during harvest from the field	16	26.7
5. Application of ripening chemicals on spotted and injured tomatoes	16	26.7
6. Destroy or injured by birds	12	20.0
7. Infection of diseases (fungus attract)	12	20.0
8. Late harvest or not harvest of tomatoes	12	20.0
9. Delayed selling	7	11.7
10. Harvest of immature tomatoes	5	8.3
11. Others	4	6.7

4.2.4 Marketing of Tomato at Traders Level

4.2.4.1 Supply chain in tomato marketing

The process of tomato marketing started with the producers and continued different actors through certain chains until the produce reached to the final consumers. The chain of tomato marketing varied location to location. Direct and indirect transactions between the producers and consumers were found in tomato marketing system. The indirect transaction (i.e. involved

middlemen in the chain) was found to be more prominent than the direct one. A number of intermediaries such as *Bepari*, *Faria*, and Retailer were involved in the transaction. It was found that *Bepari* and *Faria* were the most important middlemen in the process of tomato marketing in both Rajshahi and Bogra area. *Bepari* traded a large volume of tomatoes in both peak and lean seasons. *Farias* traded volume was much lower than *Bepari*. Usually they do not store tomatoes for even one night. The following major chains were identified in the study areas for tomato marketing (Fig 5). The channel *Farmer >Bepari>Urban Arathdar>Urban Retailer>Urban Consumer* was ranked first in terms of the volume of transaction (71.5%). Matin et al., (2008) also showed that the channel *Farmer-Bepari-Arathdar (Dhaka)-Retailer (Dhaka)-Consumer* possesses the highest marketing efficiency.

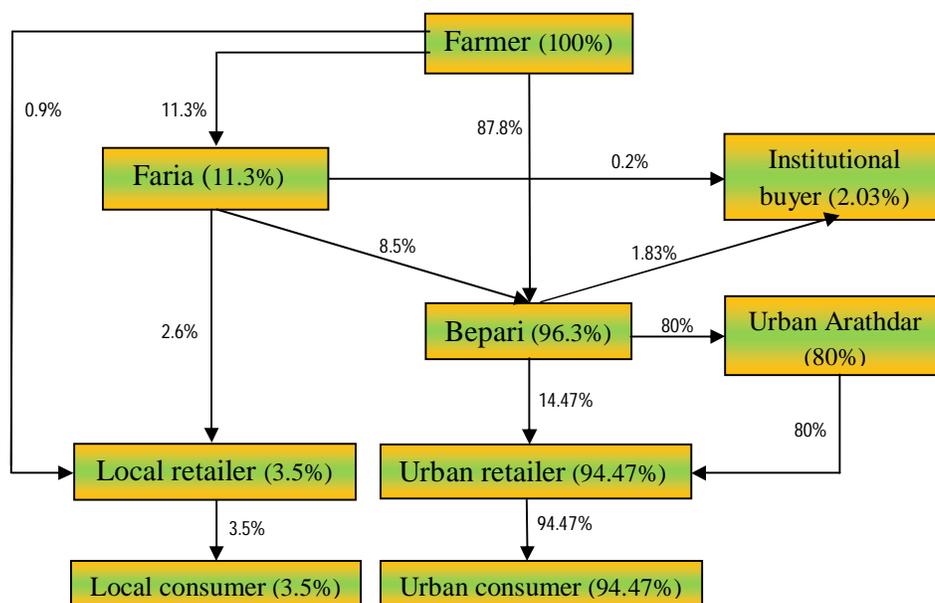


Figure 5: Flow diagram of tomato supply chain

The following major chains were identified in the study areas for tomato marketing.

<u>Marketing channel</u>	<u>% of product flow</u>
1. Farmer >Faria>Bepari>Urban Arathdar>Urban Retailer>Urban Consumer	8.50
2. Farmer >Bepari>Urban Arathdar>Urban Retailer>Urban Consumer	71.50
3. Farmer >Bepari>Urban Retailer>Urban Consumer	14.47
4. Farmer >Faria>Local Retailer>Local consumer	2.60
5. Farmer >Local Retailer>Local consumer	0.90
6. Farmer >Faria>Institutional buyer	0.20
7. Farmer >Bepari >Institutional buyer	1.83

4.2.4.2 Volumes traded and seasonality of tomato

It was observed that the volume of tomato traded by the sample traders varied from season to season, availability of product in the market, financial capacity of the traders, transportation facility, demand at wholesale markets, etc (Table 24 & 25). In the peak season² *Bepari* and *Faria* traded more than double quantities of tomato compared to lean season, whereas retailer traded about three times higher volume that that of lean season³. On average, *Bepari* bought about 93% tomatoes from farmers and the rest from *Faria* (Table 24). On the other side, they sold the lion share (84%) of tomatoes to *Arathdar* followed by directly to retailers (Table 25). *Bepari* also sold a small percentage (3.6%) of purchased tomatoes to other fellow colleagues (*Bepari*). Sometimes, it was happened when they could not purchase transportable quantities for distant places. In that case they sold their quantity to other *Beparis*. The *Beparis* of Rajshahi district supplied a small proportion of tomato (1.9%) to institutional buyer (Seazan's pulp centre) mainly in the lean season when the price and demand of tomatoes both are low in the study areas.

Table 24. Volume of tomatoes bought from different sellers at intermediaries' level

Key players	Peak season		Lean season		Overall	
	Quantity (t)	%	Quantity (t)	%	Quantity (t)	%
A. Bepari buys from:	5321.92	100	2128.20	100	7450.12	100
Farmer	5061.12	95.1	1850.20	86.9	6911.32	92.8
<i>Faria</i>	260.80	4.9	278.00	13.1	538.80	7.2
B. <i>Faria</i> buys from:	633.41	100	257.24	100	890.65	100
Farmer	633.41	100	257.24	100	890.65	100
C. Retailer buys from:	115.48	100	42.93	100	158.41	100
Farmer	49.47	42.8	18.69	43.5	68.16	43.0
<i>Arathdar</i>	44.09	38.2	19.92	46.4	64.02	40.4
<i>Faria</i>	11.60	10.0	2.78	6.5	14.38	9.1
<i>Bepari</i>	10.32	8.9	1.54	3.6	11.86	7.5

Faria is an important trader in the tomato supply chain. However, they purchased entire volume of tomatoes from farmer and sold them to different buyers such as *Bepari*, retailer, and sometimes to institutional buyer (Seazan's pulp centre). They sold nearly 76% tomatoes to *Bepari* immediately after purchase (Table 24 & 25).

Retailer is also an important trader in the tomato supply chain. They purchase tomatoes from different traders where they get good products with lower price. However, they purchased the highest volume of tomatoes directly from farmers (43%) followed by *Arathdar* (40.4%) and *Faria*. Retailer sold their entire tomatoes to the final consumers.

² The peak seasons were ranged from Mid November to Mid January and Mid January to late Mid March for Rajshahi and Bogra districts respectively.

³ In Rajshahi and Bogra districts, the lean seasons were ranged from Mid January to Mid March and Mid March to late April respectively.

Table 25. Volume of tomatoes sold to different buyers at intermediaries' level

Key players	Peak season		Lean season		Overall	
	Quantity (t)	%	Quantity (t)	%	Quantity (t)	%
A. Bepari sold to:	5014.80	100	2103.32	100	7118.12	100
Arathdar	4111.96	82.0	1840.36	87.5	5952.32	83.6
Retailer	615.04	12.3	157.16	7.5	772.20	10.8
Bepari	231.80	4.6	28.00	1.3	259.80	3.6
Inst. Consumer	56.00	1.1	77.80	3.7	133.80	1.9
B. Faria sold to:	590.20	100	284.20	100	874.40	100
Bepari	481.60	81.6	181.64	63.9	663.24	75.9
Retailer	104.72	17.7	102.56	36.1	207.28	23.7
Inst. Consumer	3.88	0.7	--	--	3.88	0.4
C. Retailer sold to:	110.79	100	40.17	100	150.95	100
Consumer	110.79	100	40.17	100	150.95	100

4.2.4.3 Postharvest loss at traders' level

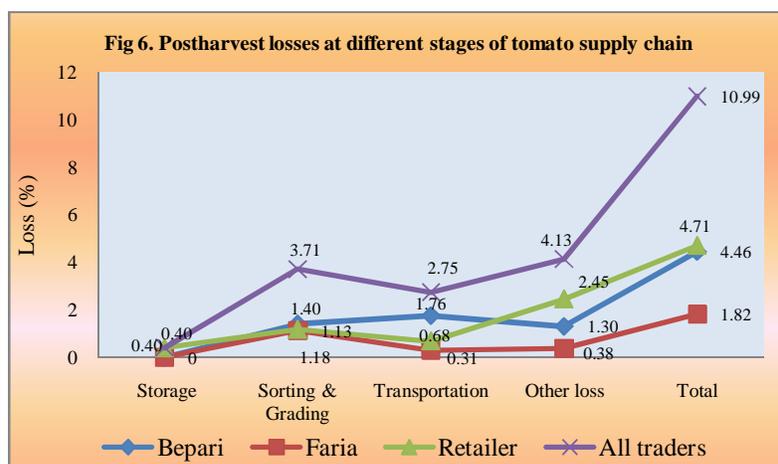
The post harvest losses of tomato at different intermediaries level in the supply chain is presented in Table 26. The total postharvest loss at trader's level was estimated at 11%. Among intermediaries, the highest loss was estimated at retailer's level (4.71%) followed by *Bepari* (4.46%) and *Faria* (1.82%) level. The highest or lowest loss is dependent on the length of selling. The retailer sold small quantity and hold comparatively longer time, therefore, retailer's loss was reported to be the highest among intermediaries.

Khatun et al., (2014) estimated average postharvest loss of tomato to be 10% at traders' level in Dinajpur, Jessore and Comilla districts. An AVRDC study (Ahmed and Haque, 2013) estimated total postharvest loss of tomato at traders' level at 15.7% which was higher than the loss estimated in the present study. Most of the traders currently used plastic crates to transport tomato from assembling market to distant market that ensure lower post harvest loss in the study areas.

Table 26. Quantity of postharvest losses at traders' level at different stages of tomato marketing

	Postharvest loss (ton) at different activity levels					Loss (kg) per ton	% of total purchase
	Storage	Grading	Transportation	Other	Total loss		
Faria	--	10.02	2.75	3.42	16.19	18	1.82
Bepari	--	100.87	127.33	93.80	322	45	4.46
Retailer	0.64	1.86	1.08	3.87	7.45	47	4.71
All traders	0.64 (0.02)	112.75 (3.59)	131.16 (4.17)	101.09 (3.21)	345.64 (10.99)	110	10.99

All the intermediaries stated that the loss incurred in the supply chain due to spoilage (not suitable for marketing) caused by short-time storage (1-1.5 days), inappropriate handling during sorting & grading, and transportation. The percentage shares of postharvest losses at different stages in the supply chain are shown in Figure 6. It was revealed that *Bepari* and *Faria* had no postharvest loss at storage level because they did not storage at all. The highest loss at transportation level (1.76%) was incurred for *Bepari* due to inappropriate transportation facility. In the case of *Faria*, the highest loss (1.13%) incurred during sorting and grading due to inappropriate handling. The postharvest losses due to other causes (2.45%) were found to be the highest for retailer. Irrespective of traders, the highest loss was for other losses (4.13%) followed by sorting and grading (3.71%) and transportation (2.75%).



4.2.4.4 Tomato price and its influencing factors

The price of tomato depends mainly on different factors such as season, variety, size, colour, freshness, nature of supply, etc. Irrespective of these factors, the average purchase prices of tomato prevailed in the study areas were estimated at Tk. 14359, Tk. 14820 and Tk. 23871 per ton respectively for *Faria*, *Bepari* and retailer. However, the price of tomato estimated at lean season was much lower compared to peak season. The demand for tomato at the lean season remained low in one hand, but the supply of low-quality tomato was reported in plenty. In the lean season, *Bepari* does not buy and send tomatoes to distant wholesale markets because it is not cost-effective to them. That's why, the price become low during the lean season. More or less similar trend was observed in the selling price of tomato in the study areas (Table 27).

It has been stated earlier that tomato price is depended on many factors. Tomato size was one of the most important characters that highly influenced tomato price. The second highest factor was tomato growing season which was reported by 80% traders in the study areas. It was stated that the price remained very high during early season and the lowest in the late season. Many farmers did not show interest to harvest lean season tomatoes from the field only because of low price. They could not cover labour wage with the harvested tomato during lean season. The other important factors were tomato variety, plenty supply in the market, and attractive colour (Table 28).

Table 27. Buying and selling price of tomato over the season in the study areas

Intermediaries	Purchase price (Tk/ton)			Selling price (Tk/ton)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
A. Peak season						
Faria	10000	25000	17226	11250	35896	21492
Bepari	11902	31786	17880	17500	39899	25322
Retailer	9312	50391	27260	14172	66250	37869
B. Lean season						
Faria	5000	27500	11491	10000	30000	14847
Bepari	7500	25000	11760	7500	37500	18380
Retailer	8611	50431	20481	10000	60495	31073
C. Overall						
Faria	7500	26250	14359	10625	32948	18170
Bepari	9701	28393	14820	12500	38700	21851
Retailer	8962	50411	23871	12086	63373	34471

Table 28. Factors influencing the price of tomato

Influencing factors	% of responses by traders			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Product size	100.0	90.0	96.7	95.7
2. Season	60.0	90.0	86.7	80.0
3. Variety	55.0	55.0	56.7	55.7
4. Product quality	55.0	25.0	53.3	45.7
5. Plenty supply	30.0	45.0	30.0	34.3
6. Attractive colour	15.0	15.0	13.3	14.3
7. Quality of imported tomato	25.0	10.0	6.7	12.9
8. Product defect due to transportation	--	20.0	13.3	11.4
9. Lower price of imported tomato	10.0	10.0	10.0	10.0

4.2.4.5 Marketing cost, margins and profit at trader's level

The costs and margins of tomato marketing of different traders are shown in Table 29 and 30 respectively. Tomato traders spent on various activities during tomato marketing. Among different traders, *Bepari* incurred the highest marketing cost of Tk. 4957/ton followed by retailer (Tk.1176/ton) and *Faria* (Tk. 669/ton). The highest marketing cost was incurred by *Bepari* due to its higher transportation cost (Tk.1824.10/ton) because *Bepari* covered a long distance and his volume of business is also high and the next highest cost item was Arathdar's commission (Tk.1283.49/ton). On the other hand, transportation shared the highest cost to the total costs for *retailer*. In the case of *Faria*, miscellaneous cost (i.e. personal expenses, entertainment to traders, etc) shared (18.9%) the highest cost to the total cost followed by market toll (17.8%).

Retailers received the highest average gross margin of Tk. 10,658 per ton followed by *Bepari* (Tk. 7,782/ton) and *Faria* (Tk. 3,445/ton). The traded volume of retailers was found to be the lowest, but their net margin was the highest (Tk. 7,858.28/ton) due to higher selling price and lower marketing cost. On the contrary, the traded quantity was the highest for *Bepari*, but their net margin was the lowest (Tk.1,851.57/ton) due to higher marketing cost. *Farias* received reasonable net margin from tomato marketing. Generally, they purchase the entire volume of tomato directly from farmers and sell it to *Bepari* and other customers immediately after purchase (Table 30).

Table 29. Marketing cost at traders' levels

Cost heading	Bepari		Faria		Retailer	
	Tk/ton	%	Tk/ton	%	Tk/ton	%
Transportation	1824.10	36.8	84.75	12.7	508.60	43.2
Arathdar's commission	1283.49	25.9	--	--	--	--
Loading & unloading	554.35	11.2	40.30	6.0	126.83	10.8
Market toll	274.95	5.5	118.98	17.8	140.31	11.9
Packaging	245.30	4.9	30.50	4.6	30.67	2.6
Cleaning & grading	197.95	4.0	115.00	17.2	5.96	0.5
Personal expenses	99.98	2.0	115.80	17.3	108.83	9.3
Transportation <i>Chada</i>	67.48	1.4	--	--	--	--
Electricity charges	38.57	0.8	--	--	19.53	1.7
Shop rent	36.41	0.7	37.57	5.6	99.09	8.4
Miscellaneous cost	334.10	6.7	126.31	18.9	136.60	11.6
Total	4956.68	100.0	669.21	100.0	1176.42	100.0

Table 30. Gross margins and net profit received by different intermediaries

Trader type	Average purchase price (Tk/ton)	Average sale price (Tk/ton)	Gross margin (Tk/ton)	Average marketing cost (Tk/ton)	Average postharvest loss (Tk/ton)	Net profit (Tk/ton)
<i>1</i>	<i>2</i>	<i>3</i>	<i>4=3-2</i>	<i>5</i>	<i>6</i>	<i>7=4-5-6</i>
Faria	15623	19068	3445	669.21	331.50	2444.29
Bepari	16142	23924	7782	4956.68	973.75	1851.57
Retailer	24722	35380	10658	1176.42	1623.30	7858.28

4.2.4.6 Mode of transportation

The key actors in the supply chain used different types of vehicles to transport tomato. The use of vehicles varied from traders to traders and the distance of the destination markets. Farmers transported tomato by using different local carriers like bicycle, rickshaw, van, push cart and so on. Trucks and vans were mostly used for tomato transportation from the assemble markets to the destination wholesale markets. Majority of the *Farias* (50%) and retailers (48%) used rickshaw/van and *Nosimon* to transport their tomatoes.

These low-cost vehicles are very common in the study areas. Some *Farias* (5-10%) also used pickup van and motor cycle. The highest numbers of vehicles were reported to use for transporting tomatoes by retailer. Most *Beparies* used truck to transport tomatoes from assembling market to distant destination markets (Fig 7). Sometimes, they used pickup van for transporting tomato to comparatively less distant market. Generally, *Beparis* used rickshaw or van to transport purchased tomatoes from assembling place to local *Arath* or near to truck (Table 31).



Fig-7: Loading tomatoes in plastic crates

Table 31. Mode of transportation used by tomato traders

Mode of transport	% of responses by traders		
	Faria (<i>n</i> =20)	Bepari (<i>n</i> =20)	Retailer (<i>n</i> =30)
1. Rickshaw/van	50.0	5.0	46.7
2. CNG driven vehicle (<i>Nosimon</i>)	45.0	--	26.7
3. Truck	--	90.0	--
4. Pickup van	5.0	10.0	13.3
5. Motor cycle	10.0	--	10.0
6. Head load by porter (coolie)	--	--	10.0
7. Bus	--	--	6.7

Faria needed to transport tomatoes on average 21km from assemble market to destination markets, whereas it was 361km for *Bepari* and 5km for retailers. Some *Farias* and retailers did not need any transportation because their buying and selling markets were same (Table 32).

Table 32. Distance between buying and selling markets and time required for transportation

Particular	Faria (n=20)	Bepari (n=20)	Retailer (n=30)
1. Average distance (km)			
Minimum	0.0	120	0.0
Maximum	270	560	20.0
Average	21.0	361	5.0
2. Time required (hour)			
Minimum	0.20	3.0	0.0
Maximum	10.0	16.0	2.5
Average	1.9	9.7	0.9

4.2.4.7 Destination markets for buying and selling

Key actors in the supply chain purchase tomatoes from wholesale or retail markets in the study areas. Table 33 shows that both *Bepari* and retailer purchased their entire quantity of tomatoes from wholesale market, whereas 60% *Farias* purchased it from wholesale market and the rest 40% of them purchased from retail market. In the case of selling, 100% *Farias* and retailers sold tomatoes in the local market. Dhaka was the destination selling markets of the highest percentage (45%) of *Bepari* followed by Chittagong wholesale market. Some *Beparis* also sold tomatoes at Sylhet, Comilla, Feni, Gazipur, Rangpur, and Gopalpur districts.

Table 33. Main destination markets of traders for buying and selling of tomato

Type of destination market	% of responses by traders		
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)
A. Purchasing market			
Wholesale market	60	100	100
Retail market	40	--	--
B. Selling market			
Chittagong	--	30	--
Dhaka	--	45	--
Sylhet	--	5	--
Comilla	--	5	--
Local market	100	--	100
Feni	--	5	--
Gazipur	--	5	--
Rangpur	--	5	--
Gopalpur	--	5	--

Majority of the actors purchased tomato daily during tomato season. Only 30% *Faria* and 15% *Bepari* purchased tomatoes once per week. A good percentage (49%) of retailers purchased it twice per week. Some *Farias* and *Beparis* also purchase tomatoes twice per week in the study areas (Table 34).

Table 34. Frequency of buying tomatoes for different intermediaries

Mode of purchase	% of responses by traders		
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)
Daily	60	80	60
Once per week	30	15	--
Twice per week	10	5	40

4.2.4.8 Problems of tomato marketing

The key actors in the supply chain encountered various problems with the tomato on arrival at the market. The highest reported problem was delayed sale (64.3%) and lack of buyers (52.9%) due to lack of adequate demand. *Bepari* and retailers faced this problem to a great extent compared to *Faria*. All the actors experienced partial or complete damage of produces to some extent. Sometimes, *Farias* and retailers unable to sell a portion of their tomatoes due to bad weather, political unrest (*Hartal*), and many other causes (Table 35).

Table 35. Main problems encountered with the tomato on arrival at the market

Major reason	% of responses by traders			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Delayed sale	50.0	70.0	70.0	64.3
2. Lack of buyers	60.0	65.0	40.0	52.9
3. Partial decay/damage	10.0	65.0	30.0	34.3
4. Spoilage/damage	15.0	30.0	33.3	27.1
5. Unable to sell	35.0	--	10.0	14.3

The traders sometimes have to reject some portion of their purchased tomatoes after arrival in the market due to various reasons. The reasons were spoilage of tomatoes, absence of buyers, low demand, plenty supply, poor quality of produce and political unrest (Table 36). Among these problems tomatoes with decay/rotten/damage was reported to be the major problem (45.7%) followed by low demand (38.6%) and plenty supply in the market (32.9%).

Table 36. Main reasons for rejecting or not selling tomato in the market

Major reason	% of responses by traders			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. With decay/rotting/damage	40.0	55.0	43.3	45.7
2. Absence of buyers/low demand	55.0	50.0	20.0	38.6
3. Plenty supply	40.0	30.0	30.0	32.9
4. Very small size/poor quality	5.0	40.0	30.0	25.7
5. Others (e.g. political unrest)	20.0	10.0	3.3	10.0

4.2.4.9 Steps for minimizing transportation damages

Tomato traders suggested different steps for reducing damage during transportation. Majority of the traders suggested using plastic crates or bamboo case with paper lining for minimizing damage of tomato. A good percentage of *Bepari* and retailer suggested avoiding transport large volume of tomatoes at a time. About 55% *Beparis* thought that transportation loss could be minimized through buying tomatoes from nearby markets. Nearly 16% traders suggested using clean container to minimize transportation loss. Some traders recommended that good tomatoes should be separated from rotten, bad quality, damaged, and contaminated tomatoes during transportation (Table 37).

Table 37. Probable steps needed during transportation for minimizing damage to tomato

Possible steps	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Use plastic crates or bamboo cage for packaging	40.0	85.0	56.7	60.0
2. Avoid large volume transport at a time	--	20.0	30.0	18.6
3. Purchase from nearby markets	--	55.0	3.3	17.1
4. Use clean container	10.0	30.0	10.0	15.7
5. Separate rotten, bad quality, damage and contaminated tomatoes	10.0	--	23.4	12.9
6. Avoid transporting chemical used tomato	10.0	15.0	13.3	12.8

4.2.4.10 Steps for attracting consumers

The key actors in the supply chain mentioned various practices that were needed during selling tomato to attract customers. The highest percentage of traders (58.6%) suggested that tomato must be made neat and clean before placing in the container. They suggested to wash tomato with clean water and sometimes should be used shampoo. Nearly 46% traders expected that consumers might be attracted if they are confident about safe tomato. Mature tomato also attracts most of the consumers which reported by about 39% traders in the study areas. Some traders thought that tomatoes should be graded before selling and placed them in a clean container to attract the consumers (Table 38).

Table 38. Probable practices needed during selling tomato to attract customers

Possible steps	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Make tomato neat and clean	45.0	55.0	70.0	58.6
2. Sell toxic free tomato	50.0	40.0	46.7	45.7
3. Sell mature tomato	40.0	45.0	33.3	38.6
4. Grade before selling	5.0	15.0	20.0	14.3
5. Use clean container	10.0	10.0	6.7	8.6
6. Others	40.0	25.0	40.0	35.7

All traders want to maximize their profit by selling at a maximum level, but it could not always be possible for various reasons. Different factors are preventing them from implementing required practices on a regular basis to attract the customers. More than 37% traders could not perform required practices due to lack of time. A good percentage of traders did not show interest doing required practices to attract consumers because they could not receive fair price of the product and got less profit from tomato business. Some traders claimed that they could not implement required practices only because of lacking proper place and fresh tomatoes for sale (Table 39).

Table 39. Factors preventing sellers from implementing required practices on a regular basis to attract customer

Factors	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Lack of time	45.0	30.0	36.7	37.2
2. Not getting fair price	35.0	10.0	30.0	25.7
3. When business is less profitable	15.0	20.0	16.7	17.2
4. Lack of proper place	10.0	--	10.0	7.1
5. Non-availability of fresh tomato	--	10.0	3.3	4.3
6. Others	15.0	5.0	13.3	11.4

Note: Others included low supply, higher labour cost, nothing to do, etc

4.3 Consumers' Perceptions and Preferences

The respondent consumers in the study areas purchased tomato from farmers, retailers and super market during peak season and off-season, but most of them purchased from retailers. On an average, they purchased 10 kg, 20.6 kg and 21kg of tomatoes per month from farmer, retailer and super market in the peak season respectively. However, the quantity purchased during peak season was much higher compared to off-season due to plenty supply and lower price (Table 40). Eighty eight percent consumers purchased tomatoes once a week and 20% consumers purchased it twice a month (Table 41). Forty percent of the consumers reported that they also purchased imported tomatoes during off-season. Forty percent imported tomato buyers stated that they purchased it in the special occasions and for guests. Again, 20% buyers purchased imported tomatoes when the price of imports was lower than locally produced tomatoes (Table 42).

Table 40. Quantity of tomato purchased per month during peak and off-season

Type of seller	Peak season		Off-season	
	Respondent (N=25)	Quantity (kg)	Respondent (N=25)	Quantity (kg)
Farmer	3	10.0	1	4.0
Retailer	25	20.6	24	10.3
Super market	2	21.0	2	13.0

Table 41. Frequency or type of purchase

Frequency of purchase	No. of respondent	% of responses
Daily	4	16
Once a week	22	88
Twice a month	5	20

Note: Due to multiple responses, the total response is more than hundred

Table 42. Reasons for purchasing imported tomato

Particulars	No. of respondent	% of responses
A. Do you buy imported tomato?	<i>N=25</i>	
Yes	10	40
No	15	60
B. Time of buying	<i>N=10</i>	
1. Off-season	9	90
2. When the price of imports is lower than locally produced tomatoes	2	20
3. Good quality	1	10
4. Others (guest, special occasions, etc.)	4	40

The average purchase prices of tomato per kilogram were Tk.31 and Tk. 79.2 during peak season and off-season respectively. The overall peak season prices reported in the study areas were much lower than off-season price due to the availability of products except Rajshahi district (Table 43). In the off season, the price of tomato become very low because distant *Beparis* (wholesalers) do not purchase low quality tomato from Rajshahi district and due to low demand a plenty of tomatoes are not harvested from the field.

Table 43. Average purchase price of tomato per kilogram

Study area	No. of respondent	Peak season	Off-season
Rajshahi	10	28.0	11.5
Bogra	10	31.0	90.5
Dhaka	5	37.0	192.0
All area	25	31.0	79.2

Different factors influenced consumers to take decision in purchasing tomatoes. The highest reported (84%) factor was the quality of tomato. Low price (72%) and availability (52%) of tomato were the next crucial factors that influence consumers greatly to purchase tomato. Nevertheless, good relations with traders and improved packaging were also reported to be the influencing factors of consumers' decision (Table 44).

Table 44. Factors influencing consumers' decision for tomato purchase

Influencing factors	No. of respondent (n=25)	% of responses
1. Good quality	21	84
2. Good price or low price	18	72
3. Availability in the market	13	52
4. Good relations with traders	3	12
5. Improved packaging	2	8
6. Others	4	16

4.4 Preferences of Institutional Consumer: A case study

Some leading limited companies namely Pran Group of Industries, Sajeeb Group of Industries, Square Food and Beverage, and Yame Food Industries are producing tomato ketchup and sauces and marketing those products throughout the country. The researchers able to conduct an interview with the personnel of *Hashem Agro-processing Ltd.*, Godagari, Rajshahi to know the information about tomato purchase and factors influence their purchase decision. It was reported that the company purchased 1800 tons of tomato in the last year (2016) from *Bepari* (main supplier) with the prices ranged from Tk.5000 to Tk.7000 per ton. They purchased tomatoes only for three months (Table 45). In this period, the demand and price of tomato in

the local market became very low, because distant *Beparis* (wholesalers) did not purchase tomato from the study areas. Due to low demand and price, a plenty of tomatoes were not even harvested from the field. However, the company does not import any tomato from foreign countries. Different factors influenced them to take decision in purchasing tomatoes. The price of tomato was reported to be a principal factor that influenced them to a great extent followed by tomato quality and the ability of collector to supply on a regular basis.

Table 45. Information on tomato purchased during off-season in 2016

Product name	Manufacturer	Quantity purchased (ton)	Purchase period	Purchase frequency	Type of supplier	Purchase price (Tk/ton)
Sajeeb tomato ketchup	Hashem Agro-processing Ltd. Sajeeb Group	1800	Mid Jan-Mid April	Daily	Bepari	5000-7000

4.5 Information and Communication

Different traders collected information regarding tomato supply chain from various sources. Most of the *Farias* (80%) and retailers (83.3%) collected relevant information from neighbours or tomato farmers. Again, majority of the *Bepari* (60-65%) collected relevant information from fellow traders and *Arathdars*. *Faria* and retailers also gathered information from fertiliser dealers and newspaper (Table 46).

Table 46. Sources of information relevant to tomato supply chain

Information sources	% of responses		
	<i>Faria</i> (n=20)	<i>Bepari</i> (n=20)	Retailer (n=30)
1. Neighbour/ farmers	80.0	35.0	83.3
2. Other traders/Bepari	45.0	65.0	--
3. Arathdar	20.0	60.0	16.7
4. Fertiliser & pesticides dealers	25.0	--	26.7
5. Newspaper	15.0	--	23.3

The traders were asked to how they assess collected information in terms of accuracy and reliability. They assessed the collected information in many ways. About 46% traders reported that the collected information is accurate and reliable when they get benefit from the information. Some traders (22.8%) assessed collected information to be accurate and reliable when it is true in practice. When traders collected information from their business partner, they considered it accurate and reliable. Sometimes *Faria* and retailer verified their collected information through consultation with fellow traders (Table 47).

Table 47. Assessment of collected information in terms of accuracy and reliability

Assessment criteria	% of responses			
	<i>Faria</i> (n=20)	<i>Bepari</i> (n=20)	Retailer (n=30)	All traders (n=70)
1. If we get benefit from the information	35.0	40.0	56.7	45.7
2. If information is true in practice	10.0	20.0	33.3	22.8
3. If collect from business partner	15.0	35.0	16.7	21.4
4. Verify information	40.0	--	16.7	18.6
5. If collect from reliable person	10.0	30.0	13.3	17.1

The best credible source of information to the traders was mobile phone. Using this device they can collect tomato trade related information from different sources. Direct observation and

Arathdar sources were reported to be other two creditable sources of information. They mentioned various reasons for their creditability. Half of the respondent traders opined that these sources of information required less cost and time. They could easily get correct information using these sources. A good section of traders also mentioned that they used these sources because many traders use it and correct information could help reducing postharvest losses (Table 48).

Table 48. Credible sources of information and the reasons of its credibility

Particulars	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
A. Credible source of information				
1. Mobile phone	65.0	85.0	46.7	62.9
3. Direct observation	15.0	5.0	36.7	21.4
2. Arathdar	20.0	5.0	13.3	12.8
4. Business partner	--	5.0	3.3	2.8
B. Reasons for its credibility				
1. Incurred less cost	50.0	60.0	43.3	50.0
2. Required less time	50.0	65.0	30.0	45.7
3. Get correct news/information	25.0	30.0	46.7	35.7
4. Many people use it	20.0	15.0	13.3	15.7
5. Correct news reduce postharvest loss	10.0	--	20.0	11.4
6. Source is reliable with us	10.0	5.0	--	4.3

Most of the traders usually share their collected information with other persons to confirm its reliability. Among traders the highest percentage of *Bepari* (90%) shared collected information with others. The sharing persons were reported to be other traders, farmer, *Arathdar* and business partner. About 39% traders mentioned that they shared information with others in order to due to know the market price and product supply situation in the market. Nearly 29% and 26% traders reported that they shared information with others for searching loss reducing tomato varieties and getting reliable information respectively (Table 49).

Table 49. Share collected information with others and the reasons of sharing

Particulars	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
A. Share information with others				
Yes	85.0	90.0	63.3	77.1
No	15.0	10.0	36.7	22.9
A. Sharing persons:				
1. Other traders	65.0	40.0	60.0	55.7
2. Farmer	15.0	25.0	13.3	17.1
3. Arathdar	5.0	45.0	3.3	15.7
4. Business partner	10.0	20.0	--	8.6
B. Reasons of sharing				
1. Knowing market price and supply	55.0	40.0	26.7	38.6
2. Loss reducing tomato variety	30.0	35.0	23.3	28.6
3. Getting reliable information	30.0	25.0	23.3	25.7

Table 50 shows that most of the traders (70%) told that other persons also discussed information with them. Thirty percent traders told that other persons did not share information with them. Among other persons, the percent of other traders was reported to be the highest

followed by farmers. The highest percentage of other persons (68.6%) discussed about daily market price of the produces followed by supply and demand situation (38.6%), good place for tomato (11.4%) and quality and variety of tomato (11.4%).

Table 50. Other persons discuss information with respondent traders

Particulars	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
A. Other persons discuss with you?				
Yes	80.0	75.0	60.0	70.0
No	20.0	25.0	40.0	30.0
B. Persons discussed				
1. Other traders	70.0	60.0	60.0	62.9
2. Farmers/neighbours	40.0	40.0	30.0	35.7
3. Others (Agril. office, com. agent)	15.0	--	3.3	5.7
C. Subjects of discussion				
1. Daily market price	80.0	80.0	53.3	68.6
2. Supply and demand situation	35.0	30.0	46.7	38.6
3. Tomato supplying places	15.0	15.0	6.7	11.4
4. Quality and variety of tomato	10.0	15.0	10.0	11.4
5. Information on road & transport	--	15.0	3.3	5.7

4.5.1 Type of Information Needed

The key actors in the tomato supply chain were asked about the necessity of information pertinent to food safety, food quality and reducing post harvest losses. More than 91% traders felt the necessity of information regarding food safety, food quality and reducing post harvest losses. They needed different types of information such as political program like *Hartal*, transport strike, technique of quality maintenance, low-cost storage, safe tomato, product supply situation in the destination market, good quality packaging, and exact dose of ripening chemicals (Table 51).

Table 51. Need of information pertinent to food safety & food quality and reducing post harvest losses

Particulars	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
A. Information Need:				
Yes	90.0	95.0	90.0	91.4
No	10.0	5.0	10.0	8.6
B. Type of information needed				
1. Political program	35.0	65.0	23.3	38.6
2. Quality maintenance information	35.0	35.0	30.0	32.9
3. Low cost storage	25.0	10.0	40.0	27.1
4. Knowing safe tomato	10.0	5.0	30.0	17.1
5. Daily market price	15.0	15.0	16.7	15.7
6. Product supply situation	20.0	15.0	10.0	14.3
7. Good quality packaging	10.0	5.0	6.7	7.2
8. Exact dose of ripening chemicals	10.0	5.0	3.3	5.7
9. Variety of tomato	5.0	10.0	3.3	5.7
10. Presence or concentration of buyers	--	5.0	3.3	2.8

Tomato traders were also asked about their preferred broadcast media through which they like to get their required information. In this regard they mentioned various broadcast media. The highest percentage of traders (67.2%) preferred television as the broadcast media because they enjoy it on a regular basis. The second most preferred broadcast media was reported (34.3%) to be Billboard. It will easily be visible to most of the traders in the market. The other favorite broadcast medias were showing video, conducting discussion meeting, distributing brochure or pamphlets, mobile phone and conducting training (Table 52).

Table 52. Preferred broadcast media of the intermediaries

Particulars	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Television	75.0	45.0	76.7	67.2
2. Billboard	25.0	40.0	36.7	34.3
3. Showing video	20.0	30.0	23.3	24.3
4. Discussion meeting	20.0	15.0	23.3	20.0
5. Brochure or pamphlets	10.0	25.0	6.7	12.9
6. Mobile phone	10.0	15.0	10.0	11.4
7. Training	15.0	15.0	3.3	10.0

4.5.2 Type of Educational Activity Needed

The actors in the supply chain needed some educational activities that will help promoting safety and quality of the produce and reducing losses in the postharvest handling of tomato. Most of the traders (97.1%) wanted to take hand-on training that will help in promoting safety and quality of the produce and reducing losses in the postharvest handling. More than 57% traders thought that regular meeting among farmers and traders obviously enrich their current state of knowledge on food safety and quality and reducing postharvest losses. Some traders gave emphasis on the regular field visits of extension workers with farmers which will reduce postharvest loss at farm level to a great extent (Table 53).

Table 53. Traders needed educational activities to promote food safety & quality and reduce postharvest losses of tomato

Educational activities	% of responses			
	Faria (n=20)	Bepari (n=20)	Retailer (n=30)	All traders (n=70)
1. Hand-on training	100	100	93.3	97.1
2. Meeting among farmers/traders	40.0	55.0	70.0	57.1
3. Regular field visits of extension workers	30.0	10.0	6.7	14.3
4. Study tour	--	--	10.0	4.3

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Tomato is a popular and nutritious vegetable in Bangladesh. Due to the lack of appropriate pre- and post-harvest measures and inefficient marketing system, a plenty of tomatoes are spoiled every year. Adequate data and information regarding these issues are lacking in Bangladesh. Therefore, an attempt has been made to assess the knowledge, attitude and practices (KAP) of key stakeholders in winter tomato supply chains and the status of market opportunities in Bangladesh.

The study reveals that most of the stakeholders in the supply chain show positive attitudes towards crop maturity, safe tomato, clean and disease free tomato, good packaging and consumers' awareness, and take various pre- and postharvest measures keeping tomatoes safe for the consumers. In most cases farmers harvest tomatoes at mature stage and use bamboo container during picking. Although Rajshahi farmers know the bad effect of ripening chemicals on health, more or less all the farmers apply it for early market and good price. In order to reduce spoilage and keep tomato safe, many *Beparis* use plastic crates to transport tomato from assemble markets to distant wholesale markets.

The average postharvest losses are 4.57% and 11% at farm and traders' level respectively. At farm level, these losses occur due to sorting & grading, transportation, harvesting, storage, and using ripening agents. The highest loss has been recorded for retailer and the lowest for *Faria*. The study identifies seven supply chains for tomato marketing. The longest and prominent channel is *Farmer>Bepari>Urban Arathdar>Urban Retailer>Urban Consumer*. Farmers and *Farias* use different local carriers like bicycle, rickshaw, van, and push cart to transport tomato. Trucks and pick up van have been mostly used by *Bepari* to transport tomato from assemble markets to distant wholesale markets. Major marketing problems in the supply chain are delayed sale, spoilage & damage, and lack of buyers.

5.2 Recommendations

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

1. Farmers must be motivated to adopt **Good Agricultural Practices (GAP)** (i.e. use of improved variety, disease free seedlings/saplings, less use of pesticides, use of more organic and less chemical fertilizers, use of sex pheromone traps as well as bio-pesticides etc.), harvest at optimum maturity stage, harvest at least 20 days after applying pesticides, and use of clean container during harvest. The Department of Extension (DAE) should play a key role in this regard.
2. The technical know-how of using plant growth regulators should be disseminated to the respective growers. BARI in collaboration with DAE may arrange regular training and demonstration programs addressing the issue.
3. Supply chain stakeholders should be motivated for packaging of tomato after proper sorting and grading (i.e. separate spotted, injured, and semi-spoiled tomatoes from good ones). In this regard, a short-term training on post-harvest packaging and handling of produces may be provided to the respective stakeholders.
4. Loss reduction strategies must be introduced in the supply chain. Therefore, the donor agencies and the government would provide fund for undertaking pilot project in establishing packhouse and cool chain management system.
5. Limited number of low temperature storage facilities should be established in major production hubs and assembling/wholesale markets for high-value crops.
6. To minimize wastage of tomato, small-scale processing facilities should be established in the intensive growing areas. Employment generation and women's involvement would be improved through this initiative.
7. Appropriate measures should be adopted in assembling, wholesale and retail markets in order to maintain quality and safe tomato for the consumers. The doses of the recommended ripening chemicals need to be ascertained by the continuous monitoring of DAE and law enforcing authority. Government and donor agencies may take initiative to establish ethylene gas based ripening chamber at assembling/wholesale market levels.
8. The concerned authorities (Market Development Committee, Department of Agricultural Marketing and Agriculture Information Services etc.) should take necessary steps for the development of awareness regarding food safety, food quality and postharvest losses among stakeholders in the tomato supply chain. In this regard, technical know-how and technology related to postharvest management and nutrition should be disseminated through TV, radio, billboard, video, meeting, brochure and mobile phone apps, which would have much impact on the reduction of postharvest losses.
9. A small percentage of traders have been using plastic crates as packaging materials. Therefore, all players in the tomato supply chain must be motivated to use insertable plastic crates for tomato packaging. To achieve this goal government should provide subsidy to the manufacturing company, so that the user can afford with lower price.
10. Continuous research is essential to mitigate diverse problems prevailing in the tomato supply chain in Bangladesh. Therefore, BARI and Agricultural Universities in Bangladesh should strengthen their existing capacity in terms of postharvest research and development.

End Note:

Faria: *Faria* is a petty trader or small scale businessman that purchases produces from the farmers at village or local assemble market, and offer the same to the *Bepari* or *Arathdar*. Sometimes, he sells his produces directly to the local retailers or consumers. Their volume of purchase is generally low and use small local vehicle (i.e. rickshaw, van, bicycle, etc) for transporting produces from field to assemble market.

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

Arathdar: *Arathdar* is a commission agent who has a fixed establishment and operates between *Bepari* and retailer, or between *Bepari* and *Paiker*, or between *Faria* and *Bepari*. They take commission from both of the parties but generally they do not follow any standard rule to take commission. The rate of commission in the study areas varied from 8-10% of the total sell.

Paiker: Wholesaler in the consuming area is known as *Paiker*, who purchase from *Bepari* through *Arathdar* and sell those to the retailer. In tomato marketing, the researcher did not find any *Paiker* in the study areas.

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

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