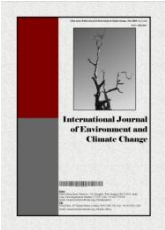

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Assessment of Post-harvest Losses of Major Vegetables in Rangareddy District of Telangana

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Objective: Keeping in view the non-availability of systematic studies on post-harvest loss in Telangana, the current study was undertaken to assess the extent of post-harvest losses in major vegetables viz., tomato and brinjal and to identify the factors affecting post-harvest losses at farm level.
Methods: Tabular analysis was used to calculate the post-harvest losses, the data was summarized using statistical tools such as average and percentage and multiple linear regression analysis was carried out to examine the factors affecting post-harvest losses at farm level. The present study was conducted in Rangareddy district which is the leading vegetable growing district in Telangana with a sample of 30 farmers,6 wholesalers and 6 retailers for each crop.
Findings: The overall post-harvest loss in tomato and brinjal was 28.51 and 23.27 kg per quintal respectively and maximum losses was occurring at farm level for both crops. Functional analysis revealed that the factors such as age, education, extent of crop production and labour dummy

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(where family contribution is >50% in total labour demand '1', else '0') was significant in both crops studied. Timely plant protection measures in case of brinjal also significantly reduced the post-harvest losses. On an average, the per quintal monetary loss was relatively more for brinjal (Rs.239.6/q) than tomato (Rs.236.6/q). The total monetary loss at state level was Rs.251.6 crores for the study crops.

Conclusion: It is evident from the results that losses are occurring in the value chain due to poor infrastructure and lack of post-harvest management techniques. Proper training on pest management and policies ensuring labour availability during peak harvesting period can aid in reducing the losses.

Keywords: Post-harvest loss; vegetables; factors; tomato; brinjal; cost of cultivation; monetary loss; Telangana.

1. INTRODUCTION

Horticultural crops are vital for balanced nutrition as they are rich source of nutrients, vitamins, minerals, and dietary fibers. India is the second largest producer of fruits and vegetables in the world after China. The cultivation of all kinds of fresh fruits, vegetables, and medicinal plants is attained by India's diverse agro-climatic conditions. Area wise horticulture crops occupies about 26.2 million ha in India with a production of 319.6 million tons during 2019-20. Vegetables play an important role in the horticulture sector, occupying an area of 10.3 million ha as per 2019-20, with a total production of nearly 189.5 million tons [1]. Horticulture crops play a significant part in the Indian economy by creating employment, offering raw materials to different food processing companies, and enhancing farm profitability through increased production and foreign exchange export revenues. But the sector is still dealing with several difficulties, including substantial post-harvest losses and shortcomings in the infrastructure of the supply chain and post-harvest management.

Post-Harvest Food Loss (PHL) is defined as the considerable qualitative and quantitative food loss along the supply chain, from the time of harvest till its consumption [2]. Often, harvested horticultural crops including vegetables are highly prone to degradation. However, it can be challenging to quantify post-harvest losses for horticultural produce. In general, PHL of fruits and vegetables is influenced by many factors such as pathological rot, insect damage, mechanical injury etc. Also, environmental conditions such as temperature and humidity are responsible for rendering fruits and vegetables susceptible for pathological attacks [3]. Further, PHL of vegetables due to fungal and bacterial decay are threatening in tropical and subtropical regions because of warm and humid conditions favour the rapid growth of most of the microorganisms [4]. The extent of post-harvest losses also depends on the length on marketing channel and the state of marketing infrastructure used i.e., mode of transportation, grading, packing, storing, etc [5].

Specifically, in India, the losses in vegetables varied from 7.32% (Potato) to 12.44% (Tomato) owing to harvesting, sorting/grading, transportation, storage at wholesaler and retailers' levels. A range of scientific postharvest practices must be practiced immediately after harvest to reduce this degradation. Timely harvesting, storage, packaging, transport, and other handling technologies are not adequate due to which considerable amount of produce is lost. In India, the highest contribution towards economic loss was from horticulture sector (fruits and vegetables-34%) which amounted to Rs. 14842 crores followed by cereals (22.3%) and livestock produce (20%) [6]. The reasons for high economic loss in fruits and vegetables are high market prices of fruits and vegetables, soft texture, high water content, and perishable nature make it difficult to handle and store.

Agriculture forms the backbone contributing to around 16 per cent in the Telangana's state domestic product. The state stood at 16th in terms of vegetable area under cultivation and 15th position in its production. Among all, tomato and brinjal are the major vegetables cultivated in the state. Tomato is cultivated in an area of about 25901.6 ha and brinjal in an area of 5448.6 ha [7]. Since considerable area is there, loss also will be there which is not estimated. Thus, the main objective of this study is to quantify the magnitude of postharvest losses at different levels for the selected crops (tomato and brinjal) and to identify the determinants for the losses at farm level.

2. MATERIALS AND METHODS

2.1 Study Area

Rangareddy district was purposively selected for the study. The District is located in the Central Part of the Deccan Plateau at an altitude of 544 meters. Temperature generally varies between 22 to 40 ^{0}C in summer and 13.8 to 22 ^{0}C in winter. The district has a normal rainfall of 781.5 mm, bulk of which is received through the South-West Monsoon (June to September), during this season the relative humidity is generally high (70 to 80 %). While the driest part of the year is the summer season when the humidity is generally between 30 and 35 percent in the afternoon.

Multistage sampling technique was used for the selection of study area and sampling units. In the first stage, Rangareddy district was selected purposively as it has the highest area under vegetable cultivation in the state. Further, Chevella and Ibrahimpatnm mandals were selected respectively for tomato and brinjal based on the highest area under crops cultivation (Table 1). From each mandal, three villages were selected randomly i.e., Allawada, Devuniyerravally and Pamena from Chevella and Kappapahad, Adibatla and Ibrahimpatnm (khalsa) from Ibrahimpatnm. From each study village, ten farmers were selected randomly thus forming a total sample size of 30 for each crop. The sample size consists of 15 marginal (<1 acre), 9 small (1-2 acre) and 6 medium (> 2 acre) farmers. Since large farmers were not found in the study area their weightage was not considered in the sample selection. Thus, a total sample of 60 farmers were interviewed for the two study crops. The data was collected from the respondents through personal interviews with the help of pre-structured questionnaire. Additional supply chain actors namely i.e., six wholesalers and six retailers were also interviewed for quantifying the extent of post-harvest losses beyond the farm level.

2.2 Methodology

2.2.1 Tabular analysis

Household data was collected from farmers and value chain actors through primary survey conducted in the study areas of Telangana state during the agricultural year 2021-22. The data collected was subjected to tabular analysis for comparison among farm categories and crops. The data was summarized using suitable statistical measures such as averages and percentages. Information about post-harvest losses was also obtained from farmers during different operations such as harvesting, handling and transportation etc. Further, the extent of losses at various level of value chain nodes were also collected from intermediaries. Finally, the total post-harvest losses were estimated as sum of all these losses.

2.2.2 Functional analysis

Multiple linear regression analysis was carried out to examine different factors affecting the extent of post-harvest losses at farm level.

The following multiple linear regression function was applied for analysis:

$$Y= a_0 + a_1X_1+ a_2X_2+ a_3X_3+ a_4X_4+ a_5X_5+ a_6X_6+ a_7X_7+ e$$

Where,

- Y = Post-harvest losses in vegetables at farm level (quintals/ha)
- X_1 = Age of respondent farmer in years
- X_2 = Education level of farmer (completed years)
- X_3= Total operational landholding (ha)
- X_4 = Extent of crop production (quintals/ha)

Table 1. Area and production of Tomato and Brinjal in the study area (2020-21)

Crop	Telangana		Rangareddy	
	Area (Acres)	**Production (Tonnes)**	**Area (Acres)**	**Production (Tonnes)**
Tomato	63,977	8,88,611	15,956	2,20,048
Brinjal	13,458	1,72,796	1,676	21,771

Source 1: Telangana statistical abstract, 2021
Source 2: Horticulture Department, Telangana

X_5 = Expenditure on plant protection chemicals (Rs/ha)
X_6 = Total manual labour used (man days per ha)
X_7 = Labour dummy [family labour participation > 50% of total demand 1, else 0]
a_0 = intercept
a_1-a_7 = Regression coefficients
e = random error

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of Sample Farmers

Table 2 shows the socio-economic characteristics of the sample farmers in vegetable cultivation. Age is an important factor that will determine the experience in farming as well as leading to better control on the PH losses. It was found that share of young farmers (< 30 years) in the sample were less in both crops. Majority (76.6 and 66.7 per cent) of the sampled farmers belong to the age group of 41 and above in both tomato and brinjal respectively. The lion shares of the sampled farmers had education and were literate. Literacy level is also an important factor as educated farmers will be more receptive towards new technology and that can help in adopting new methods for effective management of the PH losses. Majority of sampled farmers were living jointly, and the mean family size ranges from 3.5 to 3.9. Relatively, the proportion of family members participation in agricultural operations was more in tomato compared to brinjal.

3.2 Particulars of Operational Land Holdings

The average total operational area was nearly the same for tomato and brinjal farmers. About 92.8 and 86.7 per cent of tomato and brinjal farmers were cultivating vegetables on their own land (Table 3). Area under tomato constituted about 28.6 per cent to the total operational area while other major crops grown in Chevella mandal were carrot, beetroot, and paddy. The major crops cultivated in Ibrahimpatnm mandal sample farmers were tomato, cotton, and paddy. Brinjal constitutes about 33.3 per cent of their total operational area.

Table 2. Socio-economic characteristics of sample farmers

Variable	Categories	Tomato (n=30)	Brinjal (n=30)
Age	20-30	0 (0.0)	2 (6.7)
	31-40	7 (23.3)	8 (26.7)
	41-50	10 (33.3)	9 (30.0)
	51 and above	13 (43.3)	11 (36.7)
Literacy level	Illiterate	5 (16.7)	3 (10.0)
	Primary (1 st to 5 th)	3 (10.0)	1 (3.3)
	Secondary (6 th to 10 th)	16 (53.3)	12 (40.0)
	Intermediate (12th standard)	3 (10.0)	9 (30.0)
	Graduate	3 (10.0)	5 (16.7)
Family size	Less than 4	12	11
	4 to 6	18	19
	Average family size	3.5	3.9
	Avg. no. of family members engages in agriculture	1.4 (40.0)	1.5 (38.5)

**Figures in parenthesis indicate percentage to total*

Table 3. Particulars of operational holdings

Crop	Own land holding (ha)	Operational land holding (ha)	Area under study crops (ha)
Tomato (n=30)	1.3	1.4	0.4 (28.6)
Brinjal (n=30)	1.3	1.5	0.5 (33.3)

**Figures in parenthesis indicate percentage to total operational area*

Table 4. Cost of cultivation of tomato and brinjal (Rs/ha.)

Sl. no	Particulars	Tomato	Brinjal
1.	Total costs of cultivation (Rs/ha.)	153066.5	150392.6
2.	Yield (t/ha) *	29.4	24.0
3.	Average price received by farmers (Rs/t)	8293	10333
4.	Gross income (Rs/ha.)	243814.2	247992.0
5.	Net income over total costs (Rs/ha.)	90747.7	97599.4

** Yields are calculated exclusively of post-harvest losses*

3.3 Cost of Cultivation of Tomato and Brinjal (Rs/ha.)

The total costs of cultivation was relatively higher for tomato (Rs.153066.5) compared to brinjal (Rs. 150392.6). Expenditure on labour (hired+family) constituted major share in the total cost i.e., 54.6 and 50.3 in tomato and brinjal respectively. It was followed by expenditure on plant protection chemicals per ha. It was relatively more in case of brinjal (15.6%) compared to tomato (9.8%) as brinjal is more vulnerable to pest and disease attacks. Even though the mean yield levels are more in tomato compared to brinjal, net income per ha received by tomato farmers were lower compared to brinjal because of poor price realization in the market and constant price fluctuations in case of tomato (Table 4).

3.4 Post-harvest Losses

3.4.1 Losses at farm level

3.4.1.1 Tomato

In general, tomato was harvested manually by pulling the matured fruits. During the harvesting, the fully matured fruits used to fall or are disposed-off which amounts for on average 2.18 kg per quintal of harvest. The harvested fruits were placed in plastic crates of 25 kg capacity. The fruits were graded and sorted, and the diseased/damaged fruits were thrown away, no other operations were carried out like precooling, etc. In general, tomatoes are graded according to the size for better price realization in the market. During the sorting/grading stage, maximum PHL losses were reported for tomato i.e., 7.84 kg per quintal of produce. The result was in line with the previous study [8]. The study farmers used to send the produce to Gudimalkhapur wholesale market located at about 35 km from the village for better price realization when compared to nearby Chevella market. If the quantity of harvest was low, the sample farmers prefer to send to Chevella market instead of Gudimalkhapur market. The main mode of transport was minivan/lorry. The sample farmers used to harvest in evening time and transport the produce during night and keep in the wholesale market for early morning sale if the destination market is gudimalkapur, otherwise they preferred to harvest in morning to afternoon time for sale in the same day. During the transportation, around 3.43 kg per quintal of produce will be lost because of damage during loading and unloading and crates compression issues in transport. Thus, the overall losses at the farm level accounted for 13.45 kg per quintal of yield. Among different category of farmers, medium (14.30 kg/q) category farmers incurred more losses when compared to small (13.77 kg/q) and marginal (12.93 kg/q) farmers because of their bulk production and other difficulties in production and transport (see Fig. 1). Except during the stage of handling and transportation, all other stages showed significant differences in the extent of losses among the categories of farmers.

3.4.1.2 Brinjal

Matured brinjal fruits are harvested in the morning to afternoon time period manually, by pulling from the plants. The harvest time losses reported was on average 2.05 kg per quintal of harvest due to over matured/damaged fruits. After harvest, the fruits were packed in the plastic bags of 30 kg or 50 kg capacity. Other than grading and sorting no other operations were carried out like washing, precooling etc. During the grading and sorting, the diseased/pest affected/un matured fruits were thrown away which accounted for 6.32 kg per quintal of yield. Sample farmers encountered maximum losses during this stage of harvest. This is corroborated by the results of previous works [8-10]. Majority farmers reported the major losses were mostly due to the attack of fruit borer. Similar problem was reported in a previous study where 16.74 per cent loss at farm level was reported due to fruit borer pest [5]. Sample farmers used to market their produce in ibrahimpatnam market which is located at a distance of 6 kms. Few

sample farmers also market their produce in LB nagar market which is located 20km away from the study village. The major modes of transportation were auto and mini vans. During transportation, around 1.79 kg per quintal of produce will be lost because of damage (during loading and unloading) and compression issues in transport. The losses during retail marketing at mandis was about 2.04 kg per quintal. This is mostly due to the refusal of borer attacked fruits by the customers including the loss of perishability of the produce. Thus, the overall loss estimated at farm level for brinjal was 12.21 kg per quintal of produce harvest. Among different category of farmers, marginal farmers (12.40 kg/q) incurred more losses when compared to small (12.03 kg/q) and medium (11.98 kg/q) farmers. This is because most of the marginal farmers market their produce by themselves compared to other categories. So, it increases the marketing losses due to the perishability of the produce (see Fig. 2). Expect for marketing stage, all other stages the losses incurred were more for small and medium farmers compared to marginal farmers.

3.4.2 Losses at wholesaler/trader and retailer level

At the wholesaler/trader level, the produce was found to be unloaded, then weighed and kept aside for selling to retailers. No further operations or value additions were carried out. Storage facility was almost absent among all sample wholesalers in the study. If any produce is left behind or not traded, it will be kept overnight

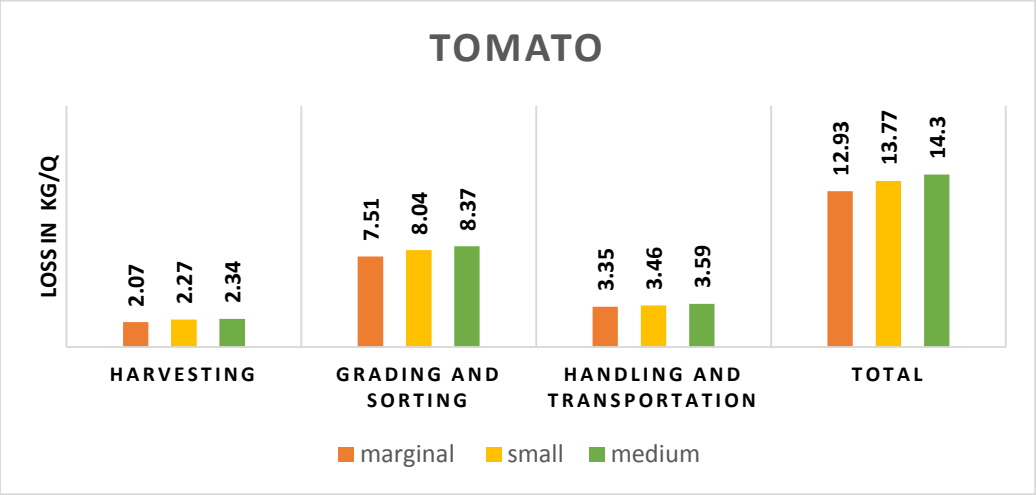

Fig. 1. Size-group wise PH losses in tomato

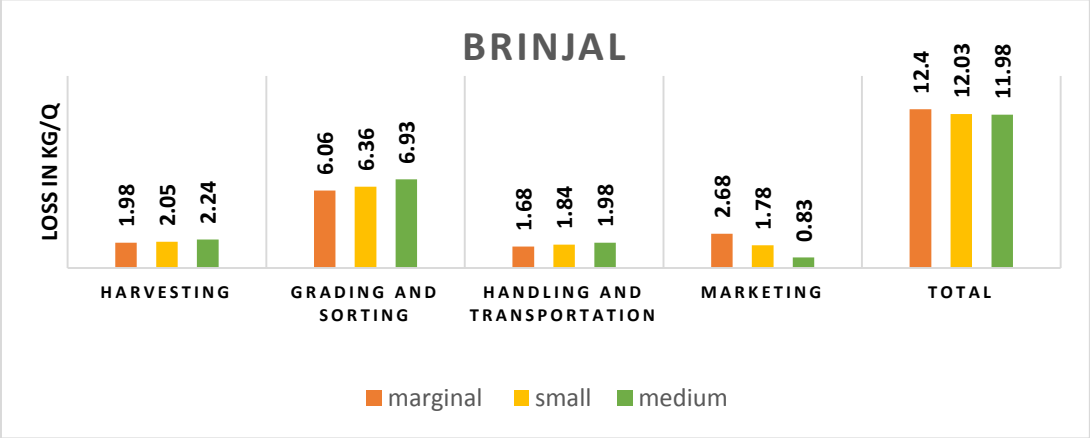

Fig. 2. Size-group wise PH losses in Brinjal

by covering with sacks in the market itself to sell in the market next day at a lower price. The losses observed during handling and transportation was 6.53 and 3.83 kg per quintal respectively for tomato and brinjal crops. Relatively, the PH losses were more in case of tomato as it is more perishable crop compared to brinjal. Further, tomato also ripens much faster than brinjal.

At the retailer level, the PH losses were reported higher for tomato (8.53 kg/q) when compared with brinjal (7.23 kg/q). Retailers used to do grading in tomatoes to remove the damaged produce and arrange them according to size for fetching better price. In case of brinjal, grading carried out only to remove diseased/damaged fruits from the stock. During retail marketing, brinjal losses are more because the consumers

Table 5. Total estimated post-harvest losses

Sl. No	Particulars	Post-harvest losses in tomato (in kg/q)	Post-harvest losses in brinjal (in kg/q)
1	At farm level		
	a) Harvesting	2.18	2.05
	b) Grading and sorting (including diseased and discorded)	7.84	6.32
	c) Handling and transportation	3.43	1.79
	d) Marketing	-	2.04
	Total(kg)	**13.45**	**12.21**
2.	At wholesale level		
	a) Handling and transportation	6.53	3.83
	Total (kg)	**6.53**	**3.83**
3.	At retail level		
	a) Grading	5.25	2.78
	b) Marketing (including perishability)	3.28	4.45
	Total(kg)	**8.53**	**7.23**
	Per quintal total post-harvest losses (kg)	28.51	23.27

Table 6. Factors affecting post-harvest losses at farm level

Sl. no	Explanatory variables	Tomato	Brinjal
1.	Intercept	21.8409***	23.8854***
		(5.8690)	(7.8581)
2.	Age of respondent	-0.2636***	-0.2334***
		(0.0686)	(0.0786)
3.	Education	-0.1274**	-0.1826*
		(0.0609)	(0.1002)
4.	Total operational landholding (ha)	0.3682	0.1141
		(0.2259)	(0.2430)
5.	Extent of crop production	0.0712**	0.0782*
		(0.0286)	(0.0444)
6.	Expenditure on plant protection chemicals per ha	-0.0001	-0.0006**
		(0.0004)	(0.0003)
7.	Total manual labour used (per ha)	-0.0069	-0.0120
		(0.0332)	(0.0469)
8.	Labour dummy (family labour participation > 50% 1, else 0)	-1.1679*	-2.7778***
		(0.6189)	(0.9342)
9.	Multiple R	0.9610	0.9269
10.	R^2	0.9236	0.8592
11.	Adjusted R^2	0.8993	0.8144
12.	F -value	38.00	19.17

*Figures in parentheses indicate standard errors of coefficients, ***, ** and * denote significance at 1, 5 and 10 per cent level, respectively*

will not prefer to purchase the fruit borer attacked fruits. In case of tomatoes, the retailers are not equipped with any storage facility which prevent fruit rotting losses. In general, retailers hold the vegetable produce for a much longer period when compared to wholesaler. Thus, the post-harvest losses estimated at retailer levels were higher compared to wholesale level. Earlier studies also reported more losses in retail level (7.96 kg/q) than wholesale level (6.10 kg/q) for tomato [11].

Thus, the overall losses estimated were to be higher in case of tomato i.e., 28.51 kg per quintal compared with brinjal i.e., 23.27 kg per quintal of harvest. The observed losses were at higher due to the tender texture and high moisture content of tomato. Similar research findings were observed in previous studies carried out among the two studied crops [10,12-14]. Also, losses were observed highest at farm level for both crops like previous studies [8,15].

3.5 Factors Affecting Post-harvest Losses at Farm Level

Factors influencing the PH losses of selected vegetables at farm level have been portrayed in Table 6. The variation in the seven independent variables included in the regression model explained nearly 85 to 92 per cent of variation in the total post-harvest losses in brinjal and tomato crops respectively. The F-ratio was significant in both the study crops which indicated the good fit of the regression models. Out of the seven independent variables, four variables viz., age, education, extent of crop production and labour dummy for family labour participation was significant in both crops. Age was negatively significant, means with one year increase in age of producer farmers, the PH losses were decreased by almost one unit due to the experience gained in the respective crop cultivation which can aid in better post-harvest management. While the extent of production of crop was positively significant with PH losses implying with one unit increase in production, the corresponding PH losses will increase by one more unit due to the managerial weakness of the farmer to handle the increased production. A previous study had similar findings that with increase in production of tomato losses will increase [16]. The years of education and family labour dummy explanatory variables showed a negatively significant relationship with PH losses. This derives educated farmers were better-off in managing or reducing PH losses. Farmers who cultivate vegetable production with more than 50 per cent family labour engagement in the total requirement, the extent of PH losses among those farmers were lower per quintal. During vegetable cultivation, especially operations such as harvesting of crops are labour intensive. We presume that, engagement of more family labour ensures timely harvesting operations with utmost care when compared with dependency on labour from external market. Timely availability of hired labour in demanded quantities will have significant influence on the quality of harvesting. Similarly, hired labour will not care for PH losses as family labour does. Similar findings were reported that larger household size means decrease in post-harvest losses as the respondent farmer has enough labour availability at his/her disposal [17] and timely labour availability was a significant factor that affects post-harvest losses negatively [18].

The expenditure on plant protection chemicals per ha was negative and significant. Since the pest infestation was a major problem in brinjal crop compared to tomato, higher expenditure per ha was incurred to manage them. Improper management of pests and diseases in vegetable cultivation, leads to significant PH losses in the crop. Hence effective pests and disease management during crop cultivation will have less PH losses and vice-versa.

4. CONCLUSION

The study found that the extent of post-harvest losses was 28.51 and 23.27 kgs per quintal respectively for tomato and brinjal crops in Rangareddy district. The PH losses were the highest for both the study crops at farm level followed by retailer level and wholesaler level. The functional analysis revealed that the factors such as age, education, extent of crop production and labour dummy (where family contribution is >50% in total labour demand ‘1’, else ‘0’) was significant in both crops studied. Timely plant protection measures in case of brinjal also significantly reduced the post-harvest losses. Based on estimated total PH losses in the study area, the anticipated total physical losses at the state level (corresponding to the production during the year 2020-21) would be amounted to roughly 2.5 lakh tons per year in case of tomato which is valued at Rs.210.1 crores at the state level. Similarly, the estimated PH losses in case of brinjal will be nearly at 40 thousand tons per year which is valued at Rs.41.5 crores. The PH losses were estimated at state level by taking the

average price received by the farmers. Thus, on an average, the per quintal monetary loss was relatively more for brinjal (Rs.239.6/q) than tomato (Rs.236.6/q).

5. RECOMMENDATIONS

- State Government/horticulture department should build adequate cold storage facilities to minimize the PH losses of perishable commodities such as vegetables and fruits. This will not only minimize the losses but also allow better price realization of primary producers.
- Educating the vegetable growing farmers on scientific post-harvest handling and management including value addition opportunities which will enhance their incomes and livelihoods.
- Employment generation programs such as MGNREGA should be link-up with peak seasons of agricultural operations (sowing and harvesting) for timely execution of critical agricultural operations as well as minimize the costs of operation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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