EVALUATION OF DIFFERENT TYPES OF PACKAGES FOR HANDLING AND TRANSPORTATION OF VEGETABLES

K.G.L.R. Jayathunge, W.M.C.B. Wasala, H.M.A.P. Rathnayake, C.R. Gunawardane, H.C. Samarakoon, M.D. Fernando and K.B. Palipane

ABSTRACT

Fresh fruits and vegetables are termed perishable commodities because they have an inherent tendency for spoilage due to physiological reasons. Postharvest losses of these crops may occur at any point between harvest and consumption in the marketing process. In developing counties, where there is a profound lack of infrastructural and marketing facilities, postharvest losses of fresh produce vary between 25-50% of the total production, depending on the commodity. In Sri Lanka, it has been estimated that the Colombo Municipal Council discards 11 MT of fruits and vegetables as garbage from the Manning market (major wholesale market in Colombo) per day. Moreover, approximately 270000 MT of fruits and vegetables are lost during the postharvest operations and the value of this is approximately Rs. 9000 million. Improper post harvest handling, improper packaging and transportation, diseases and inadequate storage facilities are some of the major reasons for such high postharvesy losses. Losses of this magnitude represent a significant food loss and a considerable economic loss to the country. Furthermore, farmer gets low price for his commodities and consumer gets low quality products.

In Sri Lanka fresh fruits and vegetables are packed mainly in Poly-sacks for transportation and this practice leads to serious losses. Of the total postharvest loss occurring in fresh produce, the loss during handling and transportation alone amounts to approximately 20%. The use of rigid containers such as plastic crates, wooden boxes and fiber board boxes will minimize the serious damage occurring in fresh fruits and vegetables during handling and transportation.

Hence, a study was undertaken to identify suitable packages, both from an economical and technical point of view, for handling and transportation of fresh commodities in Sri Lanka.

Ten types of packages, selected from those available in the market and also those developed by various institutions were used for evaluation. The types of packages selected were: nestable plastic crate (large and small size), collapsible plastic crate (large and small), steel collapsible crate, wooden box designed by ITI, wooden boxes designed by IPHT, fiber board box and wax coated fiberboard box. The evaluation study was conducted by transporting the fresh produce from farmer's field to Keppetipola Economic Center and then to Manning market, Colonbo. The nestable plastic crate of dimensions 52.5x35.0x30.0 cm was identified as the most suitable package for handling and transportation of tomatoes and the nestable plastic crate of dimensions 60.0x42.5x30.0 cm was identified as the most suitable package for other vegetables such as beans, cabbage, brinjals and curry chilies.

1.0 INTRODUCTION

Fresh fruits and vegetables are termed perishable commodities because they have an inherent tendency for spoilage for physiological reasons. Postharvest losses can occur at any point between harvest and consumption in the marketing process. In developing countries, where there is a profound lack of infrastructural and marketing facilities, post harvest losses of fresh produce vary between 25-50 % of the total production, depending on the commodity. In Sri Lanka, it has been estimated that eleven tons of fruits and vegetables are discarded as garbage from the Manning Market per day by the Colombo municipal. More over, approximately 270000 tons of fruits and vegetables are lost during postharvest operations and the value of this loss is approximately Rs. Million 9000 (IPHT Technical Note, 2001). Poor postharvest handling during storage, improper packaging and transportation, diseases and inadequate storage facilities are some of major reasons for such high post harvest losses. Losses of this magnitude represent a significant food loss and a considerable economic loss to the country. Furthermore**,** farmer gets low price for his commodities and consumer gets low quality products.

In Sri Lanka fresh fruits and vegetables are packed mainly in poly-sacks for transportation and this practice leads to serious losses. Of the total post harvest loss occurring in fresh produce, the loss during handling and transportation alone amounts to approximately 20%. The use of rigid containers such as plastic crates, wooden boxes and fiberboard boxes can minimize the serious damage occurring in fruits and vegetables during handling and transportation (Anon, 1986). Hence, it is important to introduce suitable packages for handling and transportation of fresh fruits and vegetables in Sri Lanka. This study was undertaken to identify suitable packages, both from a technical and economic point of view, for handling and transportation of fresh commodities in Sri Lanka.

2.0 OBJECTIVES

1. To identify and evaluate characteristics and properties of different types of rigid containers available in Sri Lanka that suitable for handling and transportation of fresh vegetables.
2. To assess and compare the post harvest losses of fruits and vegetables, occurring in the chain when packed in existing (polysacks and traditional boxes) and introducing packages.
3. To select the most suitable package type for each commodity by considering the cost benefit analysis.
4. To study the constraints when introducing new packages instead of existing method.

3.0 METHODOLOGY

3.1. Assessment of properties and characteristics of rigid packages

Different types of rigid containers that are suitable to pack vegetables were identified. Rigid packages used for the study are listed below.

1. Nestable plastic crate (large) – available in local market
2. Nestable plastic crate (small) – available in local market
3. Collapsible plastic crate (large)
4. Collapsible plastic crate (small)
5. Steel collapsible crate - designed by NERD center
6. Wooden box (type 1) - designed by ITI
7. Wooden box (type 2) - designed by IPHT
8. Wooden box (type 3) - designed by IPHT
9. Fiberboard box – available in local market
10. Wax coated fiberboard box - available in local market

The number of containers that can be loaded to small, medium and large size lorry and weight of each type of empty package were measured. Information on durability, benefits and problems of each package type were collected by giving questionnaire to the target group. The price of each package type was obtained from the manufacturer.

3.2. Estimation of losses during handling and transportation

Suitability of each package type to transport vegetables from farmer to Manning market was tested. The treatments of nestable plastic crates, collapsible plastic crates, steel collapsible crates (cushioned), wooden boxes, fiberboard boxes and polysacks (control) in five replicates were laid out in a randomized complete block design (RCBD). Experiment was conducted by transporting fresh vegetables from farmer fields to Keppetipola Economic Center and Keppetipola Economic Center to Colombo Mannin market. The experiment was repeated for five times for each commodity and laid out in blocks. Commodities, which were packed in each package type were analyzed for weight loss %, physical injuries and diseases at each point of the chain.

3.3. Cost benefit analysis of packages

Economic feasibility of each package type for handling and transportation of each commodity was calculated using the cost-benefit analysis.

3.4. Evaluation of constraints when introducing rigid containers

Social survey was conducted to evaluate problems in introducing new packages for transportation of vegetables instead of using polysacks.

3.5 Statistical analysis

Data of this experiment were subjected to variance analysis using the SAS package. Treatment means were compared at $p<0.05$ according the Duncan mean separation procedure.

4.0. RESULTS AND DISCUSSION

4.1. Characteristics and properties of rigid containers used for the study

4.1.1 Nestable plastic crate - large

	Top	Bottom
Length	60.0cm	50.0cm
Width	42.5cm	30.0cm
Height	30.0cm	

Cost		- Rs.559.00
Number of crates per lorry		
	Large	-165
	Medium	-108
	Small	- 45
Weight		- 2.5 kg
Durability		
Number of uses		-215
Cost per turn		-Rs. 2.60

Advantages

- Nestable and empty crates need ¼ th of total truck capacity
- Stackable
- Rigid
- Easy to handle and clean
- Facilitate ventilation
- Returnable
- Water proof

Disadvantages

- High capital investment

4.1.2 Nestable plastic crate - small

	Top	Bottom
Length	52.5cm	42.5cm
Width	35.0cm	30.0cm
Height	25.0cm	

Cost - Rs.453.00

Number of crates per lorry -

Large	-306
Medium	-175
Small	-180

Weight - 1.75 kg

Durability

Number of uses	-215
Cost per turn	-Rs. 2.10

Advantages

- Nestable and empty crates need ¼ th of total truck capacity
- Stackable
- Rigid
- Easy to handle and clean
- Facilitate ventilation
- Returnable
- Water proof

Disadvantages

- High capital investment

4.1.3 Collapsible plastic crate - large

Length	53.0cm
Width	42.0cm
Height	27.0cm

Cost - Rs.450.00

Number of crates per lorry

Large	- 225
Medium	- 160
Small	-200

Weight - 1.9 kg

Durability

Number of uses	-144
Cost per turn	-Rs. 3.12

Advantages

- Collapsible and empty crates need 1/5 th of total truck capacity
- Stackable
- Rigid
- Easy to handle and clean
- Facilitate ventilation
- Returnable
- Water proof

Disadvantages

- High capital investment

4.1.4 Collapsible plastic crate - small

Length	60.0cm
Width	39.0cm
Height	13.0cm

Cost		- Rs.350.00
Number of crates per lorry		-
	Large	-520
	Medium	-330
	Small	-324
Weight		- 1.1 kg
Durability		
Number of uses		-144
Cost per turn		-Rs. 2.43

Advantages

- Collapsible and empty crates need 1/3rd of total truck capacity
- Stackable
- Rigid
- Easy to handle and clean
- Facilitate ventilation
- Returnable
- Water proof

Disadvantages

- High capital investment

4.1.5 Steel collapsible crate

Length	63.0cm
Width	32.0cm
Height	31.0cm

Cost		- Rs.350.00
Number of crates per lorry		-
	Large	-230
	Medium	-156
	Small	-176
Weight		-2.0 kg.
Durability		
Number of uses		-36
Cost per turn		-Rs. 9.72

Advantages

- Collapsible and empty crates need ¼ th of total truck capacity
- Stackable
- Rigid
- Facilitate ventilation
- Returnable
- Water proof

Disadvantages

- High capital investment
- Difficult in handling

4.1.6. Wooden box -type 1

Length	57.5cm
Width	33.75cm
Height	27.5cm

Cost		- Rs.150.00
Number of crates per lorry		-
	Large	-252
	Medium	-180
	Small	-192
Weight		- 4 kg
Durability		
Number of uses		-36
Cost per turn		-Rs. 4.16

Advantages

- Stackable
- Rigid and strong
- Facilitate ventilation
- Returnable

Disadvantages

- Not nestable
- Absorb water
- Difficult in handling

4.1.7. Wooden box -type 2

Length	49.0cm
Width	41.0cm
Height	21.0cm

Cost		- Rs.145.00
Number of crates per lorry		-
	Large	-330
	Medium	-196
	Small	-210
Weight		- 4 kg
Durability		
Number of uses		-36
Cost per turn		-Rs. 4.03

Advantages

- Stackable
- Rigid and strong
- Easy to handle and clean
- Facilitate ventilation
- Returnable

Disadvantages

- Not nestable
- Absorb water
- Difficult in handling

4.1.8. Wooden box -type 3

Length	41.0cm
Width	41.0cm
Height	38.0cm

Cost		- Rs.169.00
Number of crates per lorry		-
	Large	-240
	Medium	-120
	Small	-144
Weight		- 5.5 kg
Durability		
Number of uses		-36
Cost per turn		-Rs. 4.69

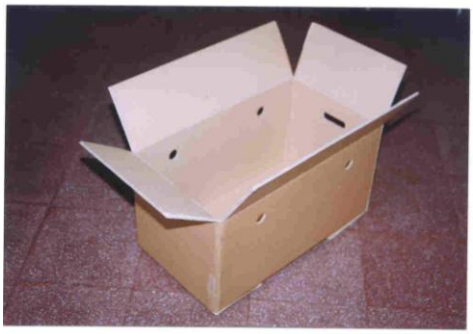
Advantages

- Stackable
- Rigid and strong
- Easy to handle and clean
- Facilitate ventilation
- Returnable

Disadvantages

- Not nestable
- Absorb water

4.1.9 Fiberboard boxes



Length	59.0cm
Width	33.0cm
Height	31.0cm

Cost		- Rs. 60.00
Number of boxes per lorry		-
	Large	-230
	Medium	-156
	Small	-160
Weight		- 1.0 kg
Durability		
Number of uses		- 2
Cost per turn		- Rs. 30.00

Advantages

- Light to carry
- Smoothed surfaced
- Easy to handle and clean
- Facilitate ventilation

Disadvantages

- Not nestable
- Not stackable
- Not reusable, therefore expensive running cost
- Easily damaged by water and rough handling

4.1.10 Wax coated fiberboard boxes

Length	78.0cm
Width	40.0cm
Height	24.0cm

Cost		- Rs.150.00
Number of boxes per lorry		-
	Large	-180
	Medium	-100
	Small	-90
Weight		- 1.8 kg
Durability		
Number of uses		- 4
Cost per turn		- Rs. 37.50

Advantages

- Smoothed surfaced
- Facilitate ventilation
- Collapsible and empty boxes need 1/3rd of total truck capacity
- Light to carry
- Stackable
- Wax coat facilitates water proofability
- Easy to handle

Disadvantages

- Easily damaged by rough handling

4.2. Estimation of losses during handling and transportation of vegetables packed in polysacks and rigid containers

Selection of suitable package types is a must to minimize postharvest losses during handling and transportation of vegetables. According to the results, beans, brinjals, cabbage and curry chilies show the highest postharvest losses when packed in polysacks (Tables 1-12). The reason for high post harvest losses is mainly due to compression, abrasion and vibration damage to commodities when handling and transportation after packaged in polysacks.

The traditional boxes are used to transport tomatoes and show the highest post harvest loss among other packages (Tables 13-15). Even though the traditional boxes are also rigid containers, the losses are high may be due to poor qualities of packages. The rough surface and in excess of height of the traditional boxes, facilitate damages to tomatoes.

Nestable plastic crate shows the lowest loss in beans, brinjal and tomatoes. The smoothness of inner surface of nestable plastic crates minimizes damages during handling and transportation of commodities. Strength of the nestable plastic crate, stabilize well during transportation and minimizes the damages. Due to low empty weight of the nestable crate facilitates easy handling. Moreover, the space required to transport empty crates could be reduced to ¼th of the total lorry capacity for the return journey due to its nestable facility. Hence, the profit gain increases automatically.

Steel collapsible crates, shows the lowest losses and the highest profit for cabbages (Table 4-6). The steel collapsible crates are cushioned with styrofoam nets. Hence, due to cushioning effect it shows the lowest post harvest losses for cabbages in terms of weight loss, physical damages and diseases. The collapsible nature of the crates reduces the space required to transport empty crates up to 1/3rd of the total lorry capacity. However, handlings of steel collapsible crates are more difficult in comparison to plastic crates. The sharp edges in steel crates, could be damaged to handlers when loading and unloading crates to lorries.

Packaging commodities in collapsible plastic crates also minimizes the losses and increases the profit. However the crates show lower durability than nestable crates considering the strength.

Wax coated fiberboard boxes show the lowest loss in curry chilies. The smoothed inner surface of the wax coated fiberboard boxes reduces the loss up to 1.8 % in comparison to 26.1 % loss when packaged in polysacks (Table10-12). Though the losses are low, the durability of wax coated fiberboard boxes is 4 times and cost of the packages is high. Hence profit gaining reduces to $1/3^{rd}$ as profit gaining by packaging in polysacks in transportation.

Fiberboard boxes also show lower post harvest loss compare to polysacks in packaging of beans (Table 1-3). However, fiberboard boxes show the lowest durability among all the packages types that have tested due to low strength. Hence the cost for packages has increased and as a result, the profit gain has reduced.

Wooden box (type 1) also has the same capacity as the traditional box used in tomatoes. However the box has better smoothness, appropriate height compare to traditional box used by farmers and hence minimizes damages to tomatoes. The durability of the box also high due to the strength, as compare to the traditional box. Therefore, use of wooden box (type 1) for handling and transportation of tomatoes could be beneficial to increase the profit gain for farmers as well as wholesalers. Wooden box (Type 3) also shows the lower losses in brinjals compare to polysacks. However, use of wooden boxes need high cost to transport empty wooden boxes and handling of wooden boxes is difficult due to high weight of the box.

4.2.1 Losses in beans during handling and transportation

Table 1 : Effect of different package types on postharvest loss of beans during handling and transportation from farmer to wholesaler at Keppetipola.

Parameters	Package types			
	Polysacks	Nestable plastic crate (large)	Collapsible plastic crate (large)	Fiberboard box
Initial weight (kg)	45.0±1.9	16.0±2.0	11.0±1.5	16.5±1.8
Final weight (kg)	44.62±1.9	15.9±2.0	10.5±1.5	16.5±1.8
Weight loss (kg)	0.38±0.04	0.1±0.04	0.05±0.01	0.0
Quantity of physical injuries (kg)	1.28±0.26	0.05±0.02	0.04±0.01	0.18±0.03
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	1.66	60.15	0.09	0.18
Total loss (%)	3.7 a	0.9 c	0.8 c	1.1 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 2 : Effect of different package types on postharvest loss of beans during handling and transportation from wholesaler at Keppetipola to buyer at Manning market.

Parameters	Package types			
	Polysacks	Nestable plastic crate (large)	Collapsible plastic crate (large)	Fiberboard box
Initial weight (kg)	45.0±1.9	16.0±2.0	11.0±1.5	16.5±1.8
Final weight (kg)	43.9±1.9	15.7±2.0	10.71±1.5	16.3±1.8
Weight loss (kg)	1.1±0.3	0.3±0.1	0.29±0.1	0.2±0.1
Quantity of physical injuries (kg)	7.14±0.9	0.29±0.1	0.26±0.1	0.62±0.2
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	8.24	0.59	0.55	0.82
Total loss (%)	18.3 a	3.7 c	5.0 b	5.0 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 3 : Effect of different package types on cumulative postharvest loss of beans during handling and transportation from farmer to buyer at Manning market.

Parameters	Package types			
	Polysacks	Nestable plastic crate (large)	Collapsible plastic crate (large)	Fiberboard box
Initial weight (kg)	45.0±1.9	16.0±1.8	11.0±1.9	14.5±2.0
Final weight (kg)	43.52±2.0	15.6±1.9	10.66±1.8	14.3±1.7
Weight loss (kg)	1.48±0.2	0.4±0.1	0.34±0.01	0.2±0.02
Quantity of physical injuries (kg)	8.42±0.4	0.34±0.02	0.30±0.01	0.8±0.01
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	9.9	0.74	0.64	1.0
Total loss (%)	22.0 a	4.6 d	5.8 c	6.1 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

4.2.2. Losses in cabbage during handling and transportation

Table 4 : Effect of different package types on postharvest loss of cabbage during handling and transportation from farmer to wholesaler at Keppetipola.

Parameters	Package types			
	Polysacks	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	57.0±2.3	21.0±1.9	14.5±1.2	23.0±1.5
Final weight (kg)	56.01±2.3	20.75±1.9	14.0±1.2	22.96±1.5
Weight loss (kg)	0.99±0.2	0.25±0.1	0.05±0.01	0.04±0.01
Quantity of physical injuries (kg)	2.88±0.2	0.0±0	0.15±0.08	0.10±0.02
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	3.87	0.25	0.20	0.14
Total loss (%)	6.8 a	1.2 c	1.4 b	0.6 d

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 5 : Effect of different package types on postharvest loss of cabbage during handling and transportation from wholesaler at Keppetipola to buyer at Manning market.

Parameters	Package types			
	Polysacks	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	57.0±2.3	21.0±1.9	14.5±1.2	23.0±1.5
Final weight (kg)	54.05±2.3	20.5±1.9	14.34±1.2	22.62±1.5
Weight loss (kg)	2.95±0.2	0.5±0.1	0.16±0.1	0.38±0.05
Quantity of physical injuries (kg)	6.8±1.1	0.8±0.3	0.61±0.06	0.66±0.16
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	9.75	1.3	0.77	1.04
Total loss (%)	17.1 a	6.1 b	5.3 c	4.5 d

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 6 : Effect of different package types on cumulative postharvest loss of cabbage during handling and transportation from farmer to buyer at Manning market.

Parameters	Package types			
	Polysacks	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	57.0±2.0	21.0±0.9	14.5±1.7	23.0±1.8
Final weight (kg)	53.06±1.8	20.25±1.5	14.29±1.4	22.58±2.0
Weight loss (kg)	3.94±0.4	0.75±0.01	0.21±0.01	0.42±0.01
Quantity of physical injuries (kg)	9.68±0.3	0.80±0.01	0.76±0.01	0.76±0.01
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	13.62	1.55	0.97	1.18
Total loss (%)	23.9 a	7.4 b	6.7 c	5.1 d

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

4.2.3. Losses in brinjal during handling and transportation

Table 7 : Effect of different package types on postharvest loss of brinjal during handling and transportation from farmer to wholesaler at Keppetipola.

Parameters	Package types				
	Polysacks	Wooden box (type 3)	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	55.0±2.1	12.5±1.3	16.0±1.4	12.5±1.1	15.5±1.3
Final weight (kg)	54.33±2.1	12.46±1.3	15.95±1.4	12.44±1.1	15.46±1.3
Weight loss (kg)	0.67±0.18	0.04±0.01	0.05±0.01	0.06±0.01	0.04±0.01
Quantity of physical injuries (kg)	3.97±0.97	0.18±0.06	0.08±0.02	0.12±0.04	0.08±0.03
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0	0.0
Total loss (kg)	4.64	0.22	0.13	0.18	0.12
Total loss (%)	8.4 a	1.8 b	0.8 d	1.4 c	0.7 d

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 8 : Effect of different package types on postharvest loss of brinjal during handling and transportation from wholesaler at Keppetipola to buyer at Manninng market.

Parameters	Package types				
	Polysacks	Wooden box (type 3)	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	55.0±2.1	12.5±1.3	16.0±1.4	12.5±1.1	15.5±1.3
Final weight (kg)	52.54±2.1	12.32±1.3	15.61±1.4	12.16±1.1	15.16±1.3
Weight loss (kg)	2.46±0.25	0.18±0.05	0.39±0.13	0.34±0.14	0.34±0.1
Quantity of physical injuries (kg)	8.73±1.9	0.49±0.16	0.47±0.14	0.43±0.10	0.92±0.3
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0	0.0
Total loss (kg)	11.19	0.67	0.86	0.77	1.26
Total loss (%)	20.3 a	5.4 d	5.4 d	6.2 c	8.1 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 9 : Effect of different package types on cumulative postharvest loss of brinjal during handling and transportation from farmer to buyer at Manning market.

Parameters	Package types				
	Polysacks	Wooden box (type 3)	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	55.0±1.8	12.5±1.7	16.0±1.6	12.5±1.5	15.5±1.2
Final weight (kg)	51.87±1.5	12.28±1.6	16.56±1.8	12.10±1.2	15.12±1.3
Weight loss (kg)	3.13±0.2	0.22±0.01	0.44±0.02	0.40±0.02	0.38±0.02
Quantity of physical injuries (kg)	12.7±0.5	0.67±0.01	0.55±0.01	0.55±0.01	1.0±0.01
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0	0.0
Total loss (kg)	15.83	0.89	0.99	0.95	1.38
Total loss (%)	28.7 a	7.2 d	6.2 e	7.6 c	8.8 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

4.2.4. Losses in curry chilies during handling and transportation

Table 10 : Effect of different package types on postharvest loss of curry chilies during handling and transportation from farmer to wholesaler at Keppetipola.

Parameters	Package types				
	Polysacks	Wax coated fiberboard box	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	38.0±1.7	11.0±0.7	16.0±0.9	12.0±1.0	12.0±0.9
Final weight (kg)	37.94±1.7	11.0±0.7	15.95±0.9	11.96±1.0	11.95±0.9
Weight loss (kg)	0.06±0.03	0.0±0	0.05±0.02	0.04±0.01	0.05±0.01
Quantity of physical injuries (kg)	3.09±0.50	0.05±0.01	0.16±0.05	0.14±0.04	0.18±0.02
Quantity of disease affected (kg)	0.2±0.02	0.0	0.0	0.0	0.0
Total loss (kg)	3.35	0.05	0.21	0.18	0.23
Total loss (%)	8.8 a	0.4 e	1.3 d	1.5 c	1.9 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 11 : Effect of different package types on postharvest loss of curry chilies during handling and transportation from wholesaler at Keppetipola to buyer at Manning market.

Parameters	Package types				
	Polysacks	Wax coated fiberboard box	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	38.0±1.7	11.0±0.7	16.0±0.9	12.0±1.0	12.0±0.9
Final weight (kg)	36.61±1.7	10.95±0.7	15.81±0.9	11.81±1.0	11.7±0.9
Weight loss (kg)	1.39±0.77	0.05±0.01	0.19±0.09	0.19±0.03	0.3±0.1
Quantity of physical injuries (kg)	4.69±0.14	0.1±0.05	0.37±0.06	0.54±0.11	0.61±0.21
Quantity of disease affected (kg)	0.5±0.14	0.0	0.0	0.0	0.0
Total loss (kg)	6.58	0.15	0.56	0.73	0.91
Total loss (%)	17.3 a	1.4 e	3.5 d	6.1 c	7.6 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 12 : Effect of different package types on cumulative postharvest loss of brinjal during handling and transportation from farmer to buyer at Manning market.

Parameters	Package types				
	Polysacks	Wax coated fiberboard box	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Initial weight (kg)	38.0±1.8	11.0±1.1	16.0±1.4	12.0±1.3	12.0±1.2
Final weight (kg)	36.55±2.0	10.95±1.5	15.76±1.5	11.77±1.3	11.65±1.3
Weight loss (kg)	1.45±0.1	0.05±0	0.24±0.01	0.23±0.01	0.35±0.01
Quantity of physical injuries (kg)	7.78±0.5	0.15±0.01	0.53±0.01	0.68±0.01	0.79±0.01
Quantity of disease affected (kg)	0.70	0.0	0.0	0.0	0.0
Total loss (kg)	9.93	0.15	0.77	0.91	1.14
Total loss (%)	26.1 a	1.8 e	4.8 d	7.6 c	9.5 b

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

4.2.5. Losses in tomato during handling and transportation

Table 13 : Effect of different package types on postharvest loss of tomato during handling and transportation from farmer to wholesaler at Keppetipola.

Parameters	Package types			
	Traditional wooden box	Nestable plastic crate (small)	Collap. plastic crate (small)	Wooden box (type 1)
Initial weight (kg)	19.0±1.1	14.5±1.3	10.9±0.7	19.0±1.1
Final weight (kg)	18.95±1.1	14.47±1.3	10.86±0.7	18.96±1.1
Weight loss (kg)	0.05±0.02	0.03±0.01	0.04±0.01	0.04±0.01
Quantity of physical injuries (kg)	0.95±0.42	0.23±0.07	0.18±0.03	0.33±0.05
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	1.0	0.26	0.22	0.37
Total loss (%)	5.3 a	1.8 c	2.0 b	1.9 bc

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 14 : Effect of different package types on postharvest loss of tomato during handling and transportation from wholesaler at Keppetipola to buyer at Manning market.

Parameters	Package types			
	Traditional wooden box	Nestable plastic crate (small)	Collap. plastic crate (small)	Wooden box (type 1)
Initial weight (kg)	19.0±1.1	14.5±1.3	10.9±0.7	19.0±1.1
Final weight (kg)	18.66±1.1	14.44±1.3	10.9±0.7	18.95±1.1
Weight loss (kg)	0.34±0.15	0.06±0.05	0.2±0.04	0.05±0.03
Quantity of physical injuries (kg)	1.29±0.39	0.43±0.04	0.61±0.04	0.97±0.02
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	1.63	0.49	0.81	1.07
Total loss (%)	8.6 a	3.4 d	7.4 b	5.6 c

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

Table 15 : Effect of different package types on postharvest loss of tomato during handling and transportation from farmer to buyer at Manning market.

Parameters	Package types			
	Traditional wooden box	Nestable plastic crate (small)	Collap. plastic crate (small)	Wooden box (type 1)
Initial weight (kg)	19.0±1.3	14.5±1.5	10.9±1.4	19.0±1.6
Final weight (kg)	18.61±1.6	14.41±1.3	10.66±1.2	18.91±1.3
Weight loss (kg)	0.39±0.01	0.09±0.00	0.24±0.01	0.09±0.00
Quantity of physical injuries (kg)	2.24±0.01	0.66±0.01	0.68±0.01	1.30±0.02
Quantity of disease affected (kg)	0.0	0.0	0.0	0.0
Total loss (kg)	2.63	0.75	0.92	1.39
Total loss (%)	13.9 a	5.2 d	8.4 b	7.3 c

Mean ± standard deviation

Each value represents the mean of twenty-five replicates. Similar letters followed by raw are not significantly different at $p<0.05$.

4.3. Cost-benefit analysis of packages at farm gate

Table 16: Cost benefit analysis for beans packed in polysacks and rigid containers at farm gate (to sell 1000 kg of beans)

Parameters	Polysacks	Nestable plastic crate (large)	Collapsible plastic crate (large)	Fiberboard box
Production cost for1000 kg	Rs. 20000	Rs. 20000	Rs. 20000	Rs. 20000
Capacity				
Average weight /unit	45.0 kg	16.0 kg	11.0 kg	16.5 kg
Num. of packages needed	23	63	91	61
Capital cost				
Unit cost of packages	Rs. 15.00	Rs. 559.00	Rs.450.00	Rs.60.00
Cost for packages	Rs. 345.00	Rs.35217.00	Rs.40950.00	Rs.3660.00
Fixed cost				
Life span of a package	2	215	144	2
Depreciation of package	Rs. 172.50	Rs. 163.80	Rs.284.35	Rs.1830.00
Variable cost				
Handling charge/unit	Rs.15.00	Rs15.00	Rs.15.00	Rs. 15.00
Handling charges	Rs.345.00	Rs.945.00	Rs.1365.00	Rs.915.00
Total revenue				
Losses/load	37.0 kg	9.0 kg	8.0 kg	11.0 kg
Selling price	Rs.30.00	Rs.30.00	Rs.30.00	Rs.30.00
Total revenue	Rs.28890.00	Rs. 29730.00	Rs.29760.00	Rs. 29670.00
Total expenditure	Rs.20517.50	Rs.21108.80	Rs.21549.35	Rs.22745.00
Gross profit	Rs. 8372.50	Rs. 8621.20	Rs. 8210.65	Rs. 6925.00

Table 17: Cost benefit analysis for cabbage packed in polysacks and rigid containers at farm gate (to sell 1000 kg of cabbage)

Parameters	Polysacks	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Production cost for1000 kg	Rs.12000	Rs.12000	Rs.12000	Rs.12000
Capacity				
Average weight /unit	57.0 kg	21.0 kg	14.5 kg	23.0 kg
Number of packages needed	18	48	69	44
Capital cost				
Unit cost of packages	Rs.15.00	Rs. 559.00	Rs. 450.00	Rs. 350.00
Cost for packages	Rs. 270	Rs. 26832	Rs. 31050	Rs. 15400
Fixed cost				
Life span of a package	2	215	144	36
Depreciation of package	Rs. 145.00	Rs. 124.80	Rs. 215.60	Rs. 427.78
Variable cost				
Handling charge/ unit	Rs. 15.00	Rs. 15.00	Rs. 15.00	Rs. 15.00
Handling charges	Rs. 270.00	Rs.720.00	Rs.1035.00	Rs.660.00
Total revenue				
Losses/load	68.0 kg	12.0 kg	14.0 kg	6.0 kg
Selling price	Rs.20.00	Rs.20.00	Rs. 20.00	Rs. 20.00
Total revenue	Rs.18640.00	Rs. 19760.00	Rs. 19720.00	Rs.19880.00
Total expenditure	Rs.12415.00	Rs. 12844.80	Rs. 13250.60	Rs.13093.78
Gross profit	Rs.6225.00	Rs.6915.20	Rs.6469.40	Rs.6787.00

Table 18: Cost benefit analysis for brinjal packed in polysacks and rigid containers at farm gate (to sell 1000 kg of brinjal)

Parameters	Polysacks	Wooden box (type 3)	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Produ. cost for1000 kg	Rs. 15000	Rs. 15000	Rs. 15000	Rs. 15000	Rs. 15000
Capacity					
Average weight /unit	55.0 kg	12.5 kg	16.0 kg	12.5 kg	15.5 kg
Number of packages needed	19	80	63	80	65
Capital cost					
Unit cost for packages	Rs. 15.00	Rs. 169.00	Rs. 559.00	Rs. 450.00	Rs. 350.00
Cost for packages	Rs. 285.00	Rs. 13520	Rs. 35217.00	Rs. 36000.00	Rs. 22750.00
Fixed cost					
Life span of a package	2	36	215	144	36
Depreciation of package	Rs.142.50	Rs. 357.56	Rs. 163.80	Rs. 250.00	Rs. 631.94
Variable cost					
Handling charge/unit	Rs. 15.00	Rs. 15.00	Rs. 15.00	Rs. 15.00	Rs. 15.00
Handling charges	Rs.285	Rs. 1200	Rs. 945	Rs. 1200	Rs. 975
Total revenue					
Losses/load	84.0 kg	18.0 kg	8.0 kg	14.0 kg	7.0 kg
Selling price	Rs. 20.00	Rs. 20.00	Rs. 20.00	Rs. 20.00	Rs. 20.00
Total revenue	Rs.18320.0	Rs.19640.0	Rs. 19840.0	Rs. 19720.0	Rs. 19860.0
Total expenditure	Rs.15427.5	Rs.16557.50	Rs. 16108.80	Rs.17558.80	Rs.16606.94
Gross profit	Rs.2892.50	Rs.3082.50	Rs. 3731.20	Rs.2161.20	Rs.3253.06

Table 19: Cost benefit analysis for curry chilies packed in polysacks and rigid containers at farm gate (to sell 1000 kg of curry chilies)

Parameters	Polysacks	Wax coated fiberboard box	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Produ. cost for1000 kg	Rs.35000	Rs. 35000	Rs. 35000	Rs. 35000	Rs. 35000
Capacity					
Average weight /unit	38.0 kg	11.0 kg	16.0 kg	12.0 kg	12.0 kg
Number of units needed	27	91	63	84	84
Capital cost					
Unit cost for packages	Rs. 15.00	Rs. 150.00	Rs. 559.00	Rs. 450.00	Rs. 450.00
Cost for packages	Rs. 405.00	Rs.13650.00	Rs.35217.00	Rs.37800.0	Rs.37800.00
Fixed cost					
Life span of a package	2	4	215	144	36
Depreciation of pack.	Rs.202.50	Rs. 3412.50	Rs. 163.80	Rs. 262.50	Rs. 1050.00
Variable cost					
Handling charge/unit	Rs.15.00	Rs.15.00	Rs.15.00	Rs.15.00	Rs.15.00
Handling charges	Rs. 405.00	Rs.1365.00	Rs. 945.00	Rs.1260.00	Rs.1260.00
Total revenue					
Losses/load	88.0 kg	4.0 kg	13.0 kg	15.0 kg	19.0 kg
Selling price	Rs.44.00	Rs. 44.00	Rs.44.00	Rs. 44.00	Rs. 44.00
Total revenue	Rs.40128.0	Rs.43824.00	Rs.43428.00	Rs.43340.0	Rs.43164.0
Gross profit	Rs. 4520.5	Rs. 4046.50	Rs.7319.20	Rs. 6817.5	Rs.5854.00

Table 20: Cost benefit analysis for tomato packed in traditional box and rigid containers at farm gate (to sell 1000 kg of tomato)

Parameters	Traditional wooden box	Nesta. plastic crate (small)	Collap. plastic crate (small)	Wooden box (type 1)
Produ. cost for1000 kg	Rs.32000.00	Rs.32000.00	Rs.32000.00	Rs.32000.00
Capacity				
Average weight /unit	19.0 kg	14.5 kg	10.9 kg	19.0 kg
Number of units needed	53	69	92	53
Capital cost				
Unit cost for packages	Rs. 35.00	Rs. 453.00	Rs. 350.00	Rs. 150.00
Cost for packages	Rs. 1855.00	Rs. 31257.00	Rs. 32200.00	Rs. 7950.00
Fixed cost				
Life span of a package	4	215	60	36
Depreciation of package	Rs.463.75	Rs. 145.38	Rs.536.67	Rs.220.83
Variable cost				
Handling charge/unit	Rs.15.00	Rs. 15.00	Rs.15.00	Rs. 15.00
Handling charges	Rs.795.00	Rs.1035.00	Rs.1380.00	Rs. 795.00
Total revenue				
Losses/load	53.0 kg	18.0 kg	20.0 kg	19.0 kg
Selling price	Rs.45.00	Rs.45.00	Rs.45.00	Rs.45.00
Total revenue	Rs.42615.00	Rs.44190.00	Rs.44100.00	Rs.44145.00
Total expenditure	Rs.33258.75	Rs.33180.38	Rs.33916.67	Rs.33015.83
Gross profit	Rs.9356.25	Rs.11009.62	Rs.10183.33	Rs. 11129.17

4.4. Cost benefit analysis of packages at Manning market

Table 21: Cost benefit analysis for beans packed in polysacks and rigid containers at Manning market (to sell one truck load of beans)

	Polysacks	Nesta. plastic crate (Large)	Collap. plastic crate (large)	Fiberboard box
Capacity				
Average weight/unit	45.0 kg	16.0 kg	11.0 kg	16.5 kg
No. of units transported	80	108	160	156
Total lorry load	3600 kg	1728 kg	1760 kg	2574 kg
Capital cost				
Cost for packages	Rs. 1200.00	Rs. 60372.00	Rs. 52800.00	Rs. 9360.00
Fixed cost				
Life span of a package	2	216	144	2
Depreciation of package	Rs. 600.00	Rs. 279.50	Rs. 500.00	Rs. 4680.00
Variable costs				
1. Cost of vegetables				
Farm gate purchasing price	Rs. 30.00	Rs. 30.00	Rs. 30.00	Rs. 30.00
Total cost for vegetables	Rs.108000.00	Rs. 51840.00	Rs. 52800.00	Rs. 77220.0
2. Transport costs				
Keppetipola-Manning market	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00
Return journey	Rs. 0.00	Rs.1750.00	Rs. 1400.00	Rs. 7000.00
Handling charges	Rs.400.00	Rs. 540.00	Rs. 800.00	Rs. 780.00
Total revenue				
Losses/load	658.8 kg	63.94 kg	88.0 kg	128.7 kg
Selling price	Rs. 40.00	Rs. 40.00	Rs. 40.00	Rs. 40.00
Total revenue	Rs.117648.00	Rs.66562.40	Rs.66880.00	Rs. 97812.0
Gross profit	Rs. 1648.00	Rs.5052.90	Rs.4380.00	Rs.1132.00

Table 22: Cost benefit analysis for cabbage packed in polysacks and rigid containers at Manning market (to sell one truck load of cabbage)

	Polysacks	Nestable Plastic crate (large)	Collapsible plastic crate (large)	Steel colla. crate
Capacity				
Average weight/unit	57.0 kg	21.0 kg	14.0 kg	23.0 kg
No. of units transported	80	108	160	156
Total lorry load	4560 kg	2268 kg	2240 kg	3588 kg
Capital cost				
Cost for packages	Rs. 1200.00	Rs.60372.00	Rs. 44800.00	Rs. 71760.00
Fixed cost				
Life span of a package	2	216	144	36
Depreciation of package	Rs. 600.00	Rs. 279.50	Rs. 500.00	Rs. 1516.67
Variable costs				
1. Cost of vegetables				
Farm gate purchasing price	Rs. 20.00	Rs. 20.00	Rs. 20.00	Rs. 20.00
Total cost for vegetables	Rs. 91200.00	Rs.45360.00	Rs. 44800.00	Rs. 71760.00
2. Transport costs				
Keppetipola-Manning market	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00
Return journey	0.00	Rs. 1750.00	Rs. 1400.00	Rs. 1750.00
Handling charges	Rs. 400.00	Rs. 540.00	Rs. 800.00	Rs. 780.00
Total revenue				
Losses/load	779.8 kg	138.3 kg	118.7 kg	161.4 kg
Selling price	Rs. 31.00	Rs. 31.00	Rs. 31.00	Rs.31.00
Total revenue	Rs.117186.00	Rs.66020.70	Rs.65760.30	Rs.106224.60
Gross profit	Rs.17986.20	Rs.11091.20	Rs.11260.30	Rs.23417.93

Table 23: Cost benefit analysis for brinjal packed in polysacks and rigid containers at Manning market (to sell one truck load of brinjal)

Parameters	Polysacks	Nestable plastic crate (large)	Collap. plastic crate (large)	Wooden box (type 3)	Steel colla. crate
Capacity					
Average weight/unit	55.0 kg	16.0 kg	12.5 kg	12.5 kg	15.5 kg
No. of units transported	80	108	160	120	156
Total lorry load	4400 kg	1728 kg	2000 kg	1500 kg	2418 kg
Capital cost					
Cost for packages	Rs. 1200.00	Rs.60372.00	Rs.72000.00	Rs.20280.00	Rs.54600.00
Fixed cost					
Life span of a package	2	215	144	36	36
Depreciation of package	Rs. 600.00	Rs. 279.50	Rs. 500.00	Rs. 563.33	Rs. 1516.67
Variable costs					
1. Cost of vegetables					
Farm gate purchasing price/kg	Rs. 20.00	Rs. 20.00	Rs. 20.00	Rs. 20.00	Rs. 20.00
Total cost for vegetables	Rs.88000.00	Rs.34560.0	Rs.40000.	Rs.30000.	Rs. 48360.0
2. Transport costs					
Keppetipola-Manning market	Rs. 7000.00	Rs. 7000.00	Rs.7000.0	Rs.7000.0	Rs. 7000.00
Return journey	Rs.0.00	Rs. 1750.00	Rs.1400.0	Rs.7000.0	Rs. 1750.00
Handling charges	Rs. 400.00	Rs. 540.00	Rs. 800.00	Rs. 600.00	Rs. 780.00
Total revenue					
Losses/load	893.2 kg	93.3 kg	124.0 kg	81.0 kg	195.9 kg
Selling price	Rs.32.00	Rs. 32.00	Rs.32.00	Rs.32.00	Rs.32.00
Total revenue	Rs.112217.6	Rs.52310.4	Rs.60032.	Rs.45408.	Rs.71107.0
Gross profit	Rs.16217.6	Rs.8190.9	Rs.10332.	Rs.244.67	Rs.11700.0

Table 24: Cost benefit analysis for curry chilies packed in polysacks and rigid containers at Manning market (to sell one truck load of curry chilies)

	Polysack bags	Wax coated fiberboard box	Nestable plastic crate (large)	Collap. plastic crate (large)	Steel collap. crate
Capacity					
Average weight/unit	38.0 kg	11.0 kg	16.0 kg	12.0 kg	12.0 kg
No. of units transported	80	100	108	160	156
Total lorry load	3040.0 kg	1100.0 kg	1728.0 kg	1920.0 kg	1872.0 kg
Capital cost					
Cost for packages	Rs. 1200.00	Rs.15000.00	Rs.60372.00	Rs.72000.00	Rs.54600.00
Fixed cost					
Life span of a package	2	4	216	144	36
Depreciation of package	Rs. 600.00	Rs.3750.00	Rs. 279.50	Rs. 500.00	Rs. 1516.67
Variable costs					
1. Cost of vegetables					
Farm gate purchasing price	Rs. 44.00	Rs. 44.00	Rs. 44.00	Rs. 44.00	Rs. 44.00
Total cost for vegetables	Rs.133760.	Rs.48400.00	Rs.76032.00	Rs.84480.00	Rs.82368.00
2. Transport costs					
Keppetipola-Manning market	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00
Return journey	Rs. 0.00	Rs.2333.33	Rs. 1750.00	Rs. 1400.00	Rs. 1750.00
Handling charges	Rs. 400.00	Rs. 500.00	Rs. 540.00	Rs 800.00	Rs. 780.00
Total revenue					
Losses/load	525.9 kg	15.4 kg	60.5 kg	117.1 kg	142.3 kg
Selling price	Rs.60.00	Rs 60.00	Rs.60.00	Rs.60.00	Rs.60.00
Total revenue	Rs.150846.	Rs 65076.00	Rs.100050.0	Rs.108174.0	Rs.103782.0
Gross profit	Rs.9086.00	Rs.3091.67	Rs.14448.5	Rs.13994.0	Rs.10367.31

Table 25: Cost benefit analysis for tomato packed in polysacks and rigid containers at Manning market (to sell one truck load of tomato)

Parameters	Traditional box	Nestable plastic crate (small)	Collapsible plastic crate (small)	Wooden box (type 1)
Capacity				
Average weight/unit	19.0 kg	14.5 kg	10.9 kg	19.0 kg
No. of units transported	180	175	330	180
Total lorry load	3510 kg	2537.5 kg	3597.0 kg	3510 kg
Capital cost				
Cost for packages	Rs. 6300.00	Rs. 79275.00	Rs. 115500.00	Rs. 27000.00
Fixed cost				
Life span of a package	4	215	60	36
Depreciation of package	Rs. 1575.00	Rs. 368.72	Rs. 1925.00	Rs. 750.00
Variable costs				
1. Cost of vegetables				
Farm gate purchasing price	Rs. 45.00	Rs. 45.00	Rs. 45.00	Rs. 45.00
Total cost for vegetables	Rs. 157950.00	Rs. 114187.5	Rs. 161865.	Rs. 157950.0
2. Transport costs				
Keppetipola-Manning market	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00	Rs. 7000.00
Return journey	Rs. 7000.00	Rs. 1750.00	Rs. 2333.33	Rs. 7000.00
Handling charges	Rs. 900.00	Rs. 875.00	Rs. 1650.00	Rs. 900.00
Total revenue				
Losses/load	301.86 kg	86.27 kg	266.18 kg	196.6 kg
Selling price	Rs.57.00	Rs.57.00	Rs.57.00	Rs. 57.00
Total revenue	Rs.182863.98	Rs.139720.00	Rs.189856.74	Rs.188863.80
Gross profit	Rs. 8438.98	Rs. 15538.72	Rs. 15083.00	Rs.15263.00

4.5. Constraints arising when introducing packages

4.5.1 Constraints for farmers

1. Initially farmers need high initial capital to purchase rigid containers and farmers are unable to spend such investment.

2. The capacity of a polysack varies from 45-60 kg depending on the commodity. However, capacity of rigid packages varies from 15-23 kg per unit. Regardless of the capacity of the container handling charge (from field to the vehicle) for a packaging unit is the same. Therefore when rigid containers are used, handling charges and the time spending for handling of commodities will be increased by three times.

3. The purchasing prices of commodities are reduced after the noon due to the competitiveness in the market. When farmers use rigid containers instead of polysacks, handling and transportation time will be increased automatically resulting low prices for their commodities.

4. In the marketing chain, there may be chances to lose their rigid containers. If they lose one plastic container in the marketing chain, they cannot compensate it from the profit as the price of plastic containers are much expensive as compare to polysacks.

5. Eventhough, the quality of vegetables packed in rigid containers are better than the vegetables in polysacks, there is no price increment.

4.5.2 Constraints for collectors/wholesalers

1. Initially collectors also need high investment to purchase rigid containers and they have difficulties to spend such investment.

2. Some times collectors send their lorries to collect commodities from the field. If they use rigid containers instead of poly-sacks cost of handling and transportation and time required for the operation will be increased by two and three times.

3. As the capacities of rigid containers are approximately 1/3 rd of the poly-sack, the storage area to keep filled and empty rigid containers at the collecting centers is not sufficient for the daily requirement and the storage area should be increased by three times.

4. Handling and transportation cost will be increased by three times, as the capacity of a rigid container is 1/3rd of a poly-sack. Moreover, wholesalers/collectors have to spend additional cost for transportation of empty containers.

5. Wooden boxes are soaked in water for whole night prior to packaging and due to this empty weight of boxes are increased up to 6 kg. Normally collectors do not weigh empty weight of boxes and deduct 4 kg from the filled weight of the container. Hence, they will loss approximately 2 kg from a container.

4.5.3 Constraints for buyers at Manning market

1. Commodities are stolen by handlers at the Manning market due to rigid containers are open.

2. Since capacities of containers are approximately 1/3 rd of the polysacks, the handling charges will be increased three times.

3. Buyers at the Manning market have limited floor area to store their commodities. Hence they have to face much difficulty when rigid containers are used instead of polysacks due to inadequate floor area.

4.5.4. Social problems

1. When use rigid containers instead of polysacks number of transportation will be increased automatically and possibility to increase traffic problems and environmental pollution.

2. The road maintenance cost also is increased with parallel to above.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Among rigid containers evaluated in the study, namely nestable plastic crate, collapsible plastic crate, collapsible steel crate, wooden box, fiberboard box and wax coated fiberboard box, the nestable plastic crate is the most suitable package type for handling and transportation of vegetables, both in terms of technical and economic feasibility.

The durability of the collapsible plastic crate is less than that of the nestable plastic crate and also, the damage to the commodity in the former package is high as compared to the latter.

The collapsible steel crate is difficult to handle due to presence of sharp edges, which could cause injury to handlers. The durability of the steel crate is also low as compared to plastic crates.

The damage to produce in wooden boxes is high, due to presence of sharp edges. Further, the cost of transportation in these boxes is high as compared to nestable and collapsible crates because they occupy a large truck space on return of empty crates to the point of production.

The durability of fiber board and wax coated fiber board boxes is the lowest among the different rigid containers tested. Also, the loss of produce in these types of crates is appreciably high in comparison to the other rigid crate types.

When the most suitable rigid package, namely the nestable plastic crate is compared with conventional methods of packaging namely poly sacks and traditional wooden boxes, the latter for tomatoes, the loss occurring in the commodity in conventional methods is 22-30%. This loss could be reduced, on an average, to 5.8% when nestable plastic crates are used.

Even though there is a decrease in capacity by 50% when vegetables are transported in nestable plastic crates instead of polysacks, the reduction in commodity losses compensates more than adequately for this reduction in capacity. This is reflected in

the increase in net income of the farmer and trader by Rs 2500 and 5000 respectively per tuck load of vegetables as compared to transportation in polysacks.

6.0 SUGGESTIONS

1. Effective awareness programme for advantage of using containers, proper handling of containers must be conducted for farmers, handlers, collectors, retailers etc.

2. Floor area at economic centers must be increased in order to facilitate storage of empty and filled containers.

3. Lorry parking area in the economic centers should be increased in order to provide parking facilities for increased number of lorries.

4. Infrastructural facilities (especially roads) must be developed.

5. To prevent stolen of commodities from rigid containers, proper cover or net should be introduced.

6. Suitable rigid containers should be distributed in free of charge or at subsidized rate among farmers, collectors, buyers etc.

7. Proper chain should be built up to recycle damaged containers.

7.0 REFERENCES

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