Present Status of Postharvest Practices and Losses of Economically Important Fruits and Vegetables in Sri Lanka

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Abstract— *The study was conducted to find the present status of postharvest practices and losses in selected commercially grown fruits and vegetables. Economically important four and twelve vegetables were selected. A cross sectional analysis was used to analyze the present status of the postharvest practices of fruits and vegetables in the country through questionnaire survey and direct observations. Information related to the postharvest operations were collected from 1829 of main actors of the supply chain; farmers, collectors, whole sellers, transporters and retailers. Loss assessment study was performed in major six perishable supply chains in the country. Weight losses of commodities were measured at different stages and results were compared with previous findings. Most of farmers well aware about maturity indices of fruits and vegetables, and majority of them consider correct maturity for harvesting selected crops. But, 5-31 % of farmers do not consider maturity indices. Further, small scale farmers generally do not have adequate facilities to sort and grade their harvest. The close truck category is dominant in transporting majority of commodities while guava, bitter guar, long bean and potato are transported in open trucks. Only around 3% of fruits and vegetables were found transported in refrigerated trucks. Commodities are packed four types packaging methods during post harvest handling; polysack bags, plastic crates, wooden boxes and corrugated fibreboard boxes. Most of vegetables (76% in average) are still transported in polysack bags. However, 94 % of papaya is transported in plastic crates while 54 % of guava is also transported using plastic crates and corrugated fiberboard boxes. All the actors mainly use polysack bags for transporting commodities. Majority of stakeholders in Sri Lankan fruit supply chain have adopted to use safe packaging methods. Previous loss assessment studies conducted in Sri Lanka exhibited that post harvest loss of fruits and vegetables were 30 – 40%. However, according to the present study, postharvest loss of fruits remain at 15-20% and it is 20-30% in vegetables which could be considered as considerable reduction due to many programs launched during last two decades.*

Keywords— Postharvest Losses, Mechanical Damages, Packaging Methods, Supply Chain.

I. INTRODUCTION

Agriculture plays a major role in developing the countries. It directly affects on food safety and national food security. But, postharvest sector of agricultural crops still lags behind creating many problems. The postharvest loss and inappropriate postharvest practices during supply and value chains of agricultural crops leads to low prices at farm gate and high prices at consumer level as well as to low quality of produce. And also, this has led to less profit in agriculture which creates less employment or unemployment especially in rural community (Dharmathilake *et al.* 2020).

Furthermore, many intermediaries are playing an active and a major role in the supply chain of fresh commodities in Sri Lanka. Farmers, collectors, transporters, whole sellers, retailers, processors are the main actors of the supply chain and 30-40% amount of postharvest loss has been identified at each of these points (Rajapaksha *et al.* 2021). Many factors contribute to this situation. Some of them are harvesting practices, maturity at harvesting, handling and transportation, lack of storage facilities, lack of processing and value addition done, etc. (Iordachescu *et al*. 2019). Reducing this post-harvest food loss will become increasingly important over the coming decades to help sustainably feed a growing human population (Buzby and Hyman, 2012). Generation of new technologies required to rectify these malpractices is highly essential. Furthermore, transmission of technologies to relevant stakeholders is also vital in order to reduce the postharvest loss, popularize using appropriate

technologies etc. However, in order to do so, proper understanding of the existing situation is a must. This will facilitate proper planning and execution of development activities and further research aimed towards the uplifting of the industry.

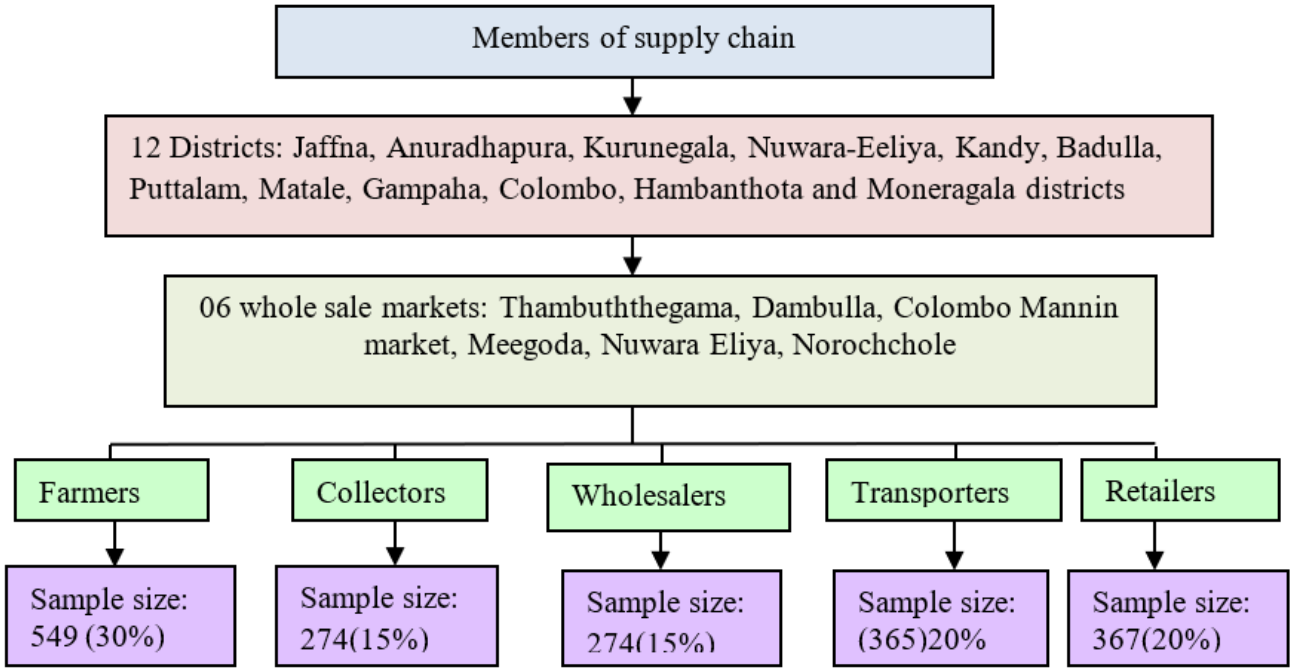
Although some of the practices are common in some crops, many vary depending on the crop, cultivation patterns, persons involved etc. During last two decades, many loss reduction measured have taken in national level and appropriate postharvest technologies have also been introduced to agriculture supply chain such as awareness creation, safe packaging and ripening methods etc. however the impact was not assessed in national level. Therefore, a more detailed study was needed to identify these postharvest practices and losses in a more generalized form which would represent the whole scenario. National Institute of Post Harvest Management (NIPHM) carried out a study on present status of postharvest practices and losses in selected commercially grown fruits and vegetables.

II. MATERIALS AND METHODS

Four economically important fruits; banana, guava, papaya, mango and twelve vegetables; carrot, capsicum, cabbage, tomato, bitter gourd, green chilli, long bean, brinjal, potato were selected for the study. Study was conducted during 2021 – 2023 years period.

2.1 Field survey:

A cross sectional analysis was taken to study the present status of the postharvest practices of fruits and vegetables in the country. The primary modes of data collection were questionnaire survey and direct observations. Data were collected via a field survey using semi-structured, pre-tested questionnaires. The details for the study were gathered from all the supply chain actors actively involved in the selected crops taken for the study. Furthermore, the postharvest practices initiating from harvesting till retail practices were also collected. The average quantities handled, handling methods, devices and equipment used, postharvest loss, etc. were also taken. Data were collected from five main categories of the supply chain; farmers (30%), collectors (10%), whole sellers (15%), transporters (15%) and retailers (30%). The study was performed on the main cultivation areas, collection areas as well as in the consumer areas of the country. The main consumer areas were Gampaha, Colombo, Kandy, Kurunegala. The cultivation areas were Jaffna, Anuradhapura, Kurunegala, Nuwara-Eeliya, Kandy, Badulla, Puttalam, Matale, Hambanthota and Moneragala districts. In addition information was gathered from Thambuththegama, Dambulla, Meegoda, Nuwara Eliya, Norochchole economic centres and Colombo Mannin market.



Furthermore, information were collected through interviewing key informants such as officers from Department of Agriculture, Department of Agrarian Development, Sri Lanka Mahaweli Authority, Chairmen of Farmer Organizations and Traders Associations, Managers of Economic centers in these areas and other related personals. Direct observations and secondary sources were also used to collect the information. Data were analyzed by using Minitab statistical package.

2.2 Loss assessment study:

Loss assessment studies were conducted through following major fruits and vegetables supply chains in Sri Lanka that represents the whole country,

- Thambuttegama to Meegoda (Green chili, long bean, papaya, mukunuwenna, bnana)
- Thambuttegama to Veyangoda (Brinjal, okra, tomato, long bean, bitter guard)
- Kalpitiya to Colombo (Long bean, cabbage, okra, capsicum)
- Nuwara-Eliya to Dambulla (Carrot, potato, cabbage)
- Nuwara-Eliya to Colombo (Carrot, capsicum, cabbage, banana)
- Jaffna to Dambulla (Brinjal, papaya, okra)
- Omaragolla to Colombo (Mango)

Commodities were transported in polysack bags as conventional post harvest practice and as improved practices they were transported using plastic crates simultaneously at ambient conditions. The temperature and relative humidity, both in-pack and in-fruit, were measured at the starting point of the journey, during transport, at the end of the journey and at the levels. Mechanical damages and physiological weight loss of selected crops were measured at farmer, transporter/wholesaler and retailer stages of supply chains in both conventional and improved methods. Mechanically damages due to compression; abrasion and vibration and the combined effect were distinguished visually and weights were taken. Percentage of mechanical damages was calculated for different samples using the following equation (Dadzie and Orchard, 1997).

$$MD = \frac{W_2}{W_1} \times 100 \quad (1)$$

Where MD is the percentage of mechanical damage, W_2 is the damaged fruit weight (kg) and W_1 is the initial sample weight (kg).

Physiological weight loss was determined using weight different among handling stages and presented as percentage values. Postharvest loss included both mechanical damages and physiological weight loss percentages.

III. RESULTS AND DISCUSSIONS

3.1 Present status of postharvest practices:

The fruits and vegetables are sold at farm gate or through the middle man who go to the farm and buy the produce and selling through middle man is widely practiced, as large volume of products are collected by middle man and sells it by bringing to the wholesaler and retailer (Bhattarai, 2018). Therefore, they are playing different roles in agriculture supply chain. Harvesting of produce at correct maturity is an important practice of agriculture. The harvesting time of fruits should be at physiological maturity when they attain maximum dry weight and that of vegetable should be harvested at horticultural maturity or field maturity (Pokhrel, 2021).

Figure 01 presents the adaptation levels of farmers to harvest fruits and vegetables at correct maturity stages in Sri Lanka. Harvesting of agriculture commodities at correct maturity is an important practice to reduce the postharvest loss. As depicted by the study, most of farmers well aware about maturity indices of fruits and vegetables, and majority of them consider correct maturity when crops are harvested. All the papaya farmers (100%) participated to the survey consider correct maturity for harvesting. Among farmers, 5-31 % of farmers do not consider maturity indices during the harvesting of selected crops. According to their respond, market demand, availability of transport vehicles, price fluctuations, labour availability and weather conditions are considered for harvesting rather than maturity. Fernando, (2006) stated that the majority of vegetables have previously been harvested at incorrect mature stages resulting significant post harvest losses. In addition, the small scale farmers generally do not have adequate facilities to sort and grade their produce. But, commercial level farms have these facilities and sorting is practiced at the farm to remove the malformed, diseased and mechanically damaged commodities. Njuguna, *et al.* (2001) also previously have revealed similar situations.

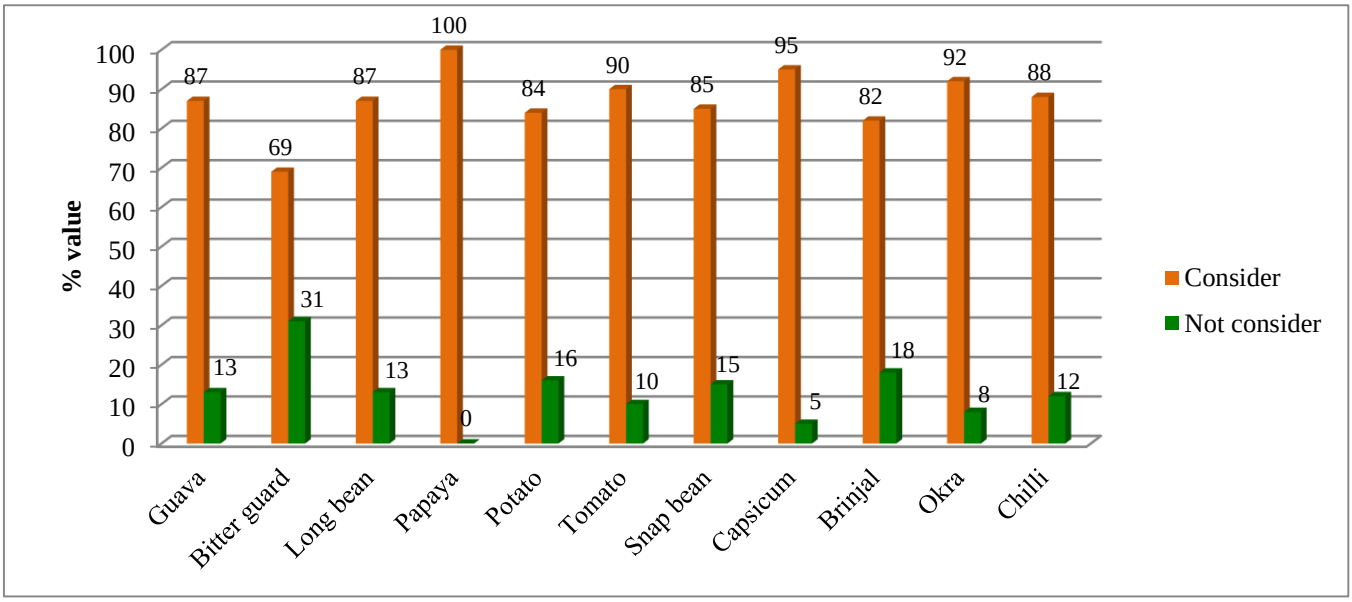


FIGURE 1: Adapting for correct maturity at harvesting

3.1.1 Mode of transport used for different crops:

A major part of the losses occurs during transportation from former to retail outlets through collector, wholesale markets and transport agents (Fernando, 2006; Kitinoja *et al*. 2012). Figure 02 exhibits the different types of vehicles used for transporting fruits and vegetables in Sri Lanka. The majority of stakeholders in perishables supply chains in Sri Lanka, transport fruits and vegetables using different types vehicles. These can be mainly categorized in to four groups: open trucks, close trucks, refrigerated trucks and other means of transportation. Small slow-running vehicles such as three wheelers and two - and four-wheel tractors are considered in the "others" category. The close truck category is dominant in transporting majority of commodities while guava, bitter guar, long bean and potato are transported in open trucks. Only snap bean and capsicum were found transported in refrigerated trucks. It is also around 3%. Open trucks do not have covers to protect (especially from sunburn, rain) fruits and vegetables during transport. Hence, lack of proper transportation modes and method of transportation apparently result low quality of produce received to retail markets and consequently to final consumer and high wastage. Vidanapathirana *et al*. (2018) has earlier mentioned that of transportation method is one of the major main factors affecting quality of commodities, especially for most perishable produce.

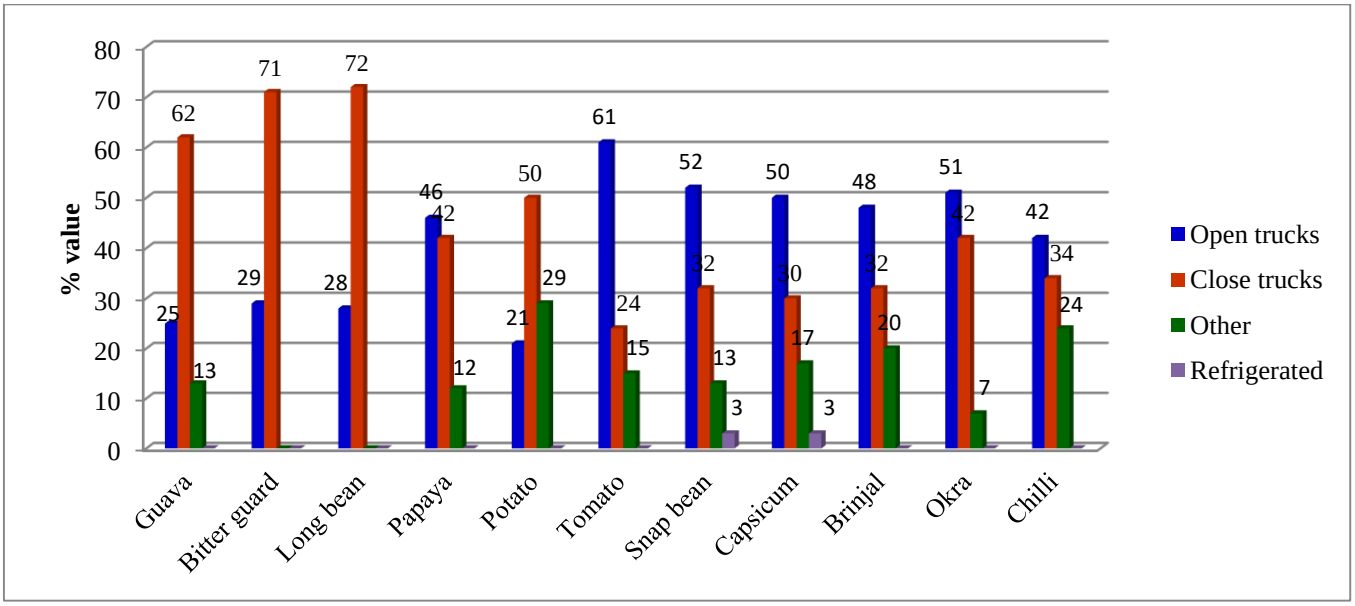


FIGURE 2: Different types vehicles used for transport fruits and vegetables

3.1.2 Use of different packaging methods for fruits and vegetables:

Use of proper packaging methods is considered as one of the important aspects for post harvest loss reduction in fruits and vegetables. It protects commodities from mechanical injuries, tampering, and contamination from physical, chemical, and biological sources which also enables (Arah *et al*. 2016). Figure 03 illustrates the use of different packaging method for fruit and vegetables during the handling transportation in Sri Lanka. As the study reveals, fruits and vegetables are packed four types packaging methods during post harvest handling; polysack bags (PS), plastic crates (PC), wooden boxes (WB) and corrugated fibreboard boxes (CFB). As indicated by Pokhrel, (2021), for varies fruits and vegetables, different packaging materials methods of like corrugated cardboard boxes, various sizes of plastic trays, nylon sacks, wooden crates, polythene bags are used mostly in developing countries to minimize post-harvest loss. According to the results, most of vegetables are still transported in polysack bags (76% in average). Majority of polysack bags are mesh type while woven polysack bags are used to transport okra. 94 % of papaya is usually transported in plastic crates while 54 % of guava is also transported using plastic crates and corrugated fiberboard boxes. Further, majority of tomatoes (83%) are packed in wooden boxes which are not scientifically manufactured packaging type that leads to certain amount of damages. This is a certain level of satisfactory condition compared to previous situation. According to Dharmasena and Sarananda (2012), 97 %of the fruits and vegetables in Sri Lanka were handled through the conventional distribution chains in which agricultural produce is channeled through economic centres with the involvement of middlemen using improper handling practices. Chhetri *et al*. (2023) also mentioned that a large portion of stakeholders of agriculture supply chain still depend on traditional methods of packaging though newer technologies and methods are implemented for fruits and vegetable to minimize post-harvest loss.

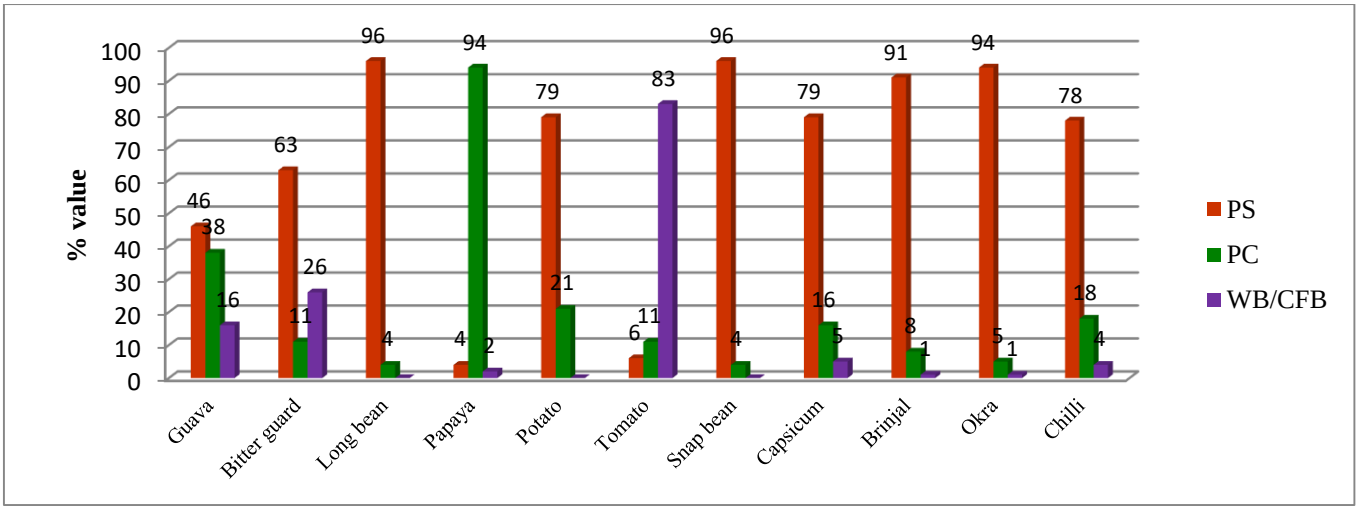


FIGURE 3: Use of different packaging materials for perishables

Use of different packaging methods by different stakeholders of vegetables supply chain is indicated by figure 04. There are several players involved in fulfilling the needs of the consumer in the supply chain management of fruits and vegetables such as farmers, local traders, transporters, processors and retailers (Vidanapathirana, *et al*.2018). As depicted by figure 04, majority of farmers, collectors, wholesalers, transporters and retailers (79-91%) use polysack bags for packing vegetables during handling and transportation. 5-12 % of them used to handle vegetables in plastic crates while 4 -11% of stakeholders in vegetables supply chain use wooden boxes and corrugated fibre board boxes. In addition, collectors and wholesalers have adapted to use other types of packaging methods for vegetables such as polyethylene, wooden compartments in transport vehicles, paper wrappings.

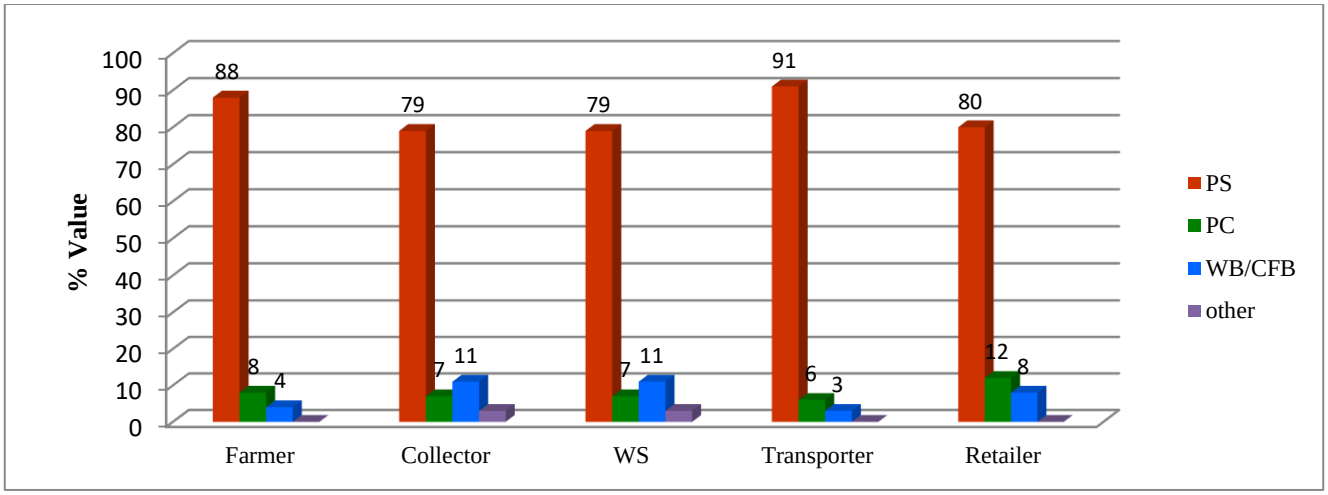


FIGURE 4: Different packaging methods used for vegetables by different stakeholders

3.1.3 Use of packaging methods by different stakeholders of fruit supply chain:

As shown by figure 05, all the stakeholders in fruit supply chain mainly use plastic crates (46 – 53%) for handling and transportation of fruits resulting low postharvest losses of fruits. The second most packaging methods used for fruits are wooden boxes and corrugated fibre board boxes (26-33%). 16 – 23 % of stakeholders still use polysack bags for packing fruits. According to the results of the survey, majority of stakeholders in Sri Lankan fruit supply chain have adopted to practice correct post harvest handling methods so that fruit quality could be preserved and better market price could be obtained. Vidanapathirana *et al.* (2018), also have revealed that unlike for vegetables, safe packages are used for packing and transporting fruits such as mango, papaya and guava in conventional supply chains. Mostly used safe packages were plastic crates, corrugated fiberboard boxes and wooden boxes.

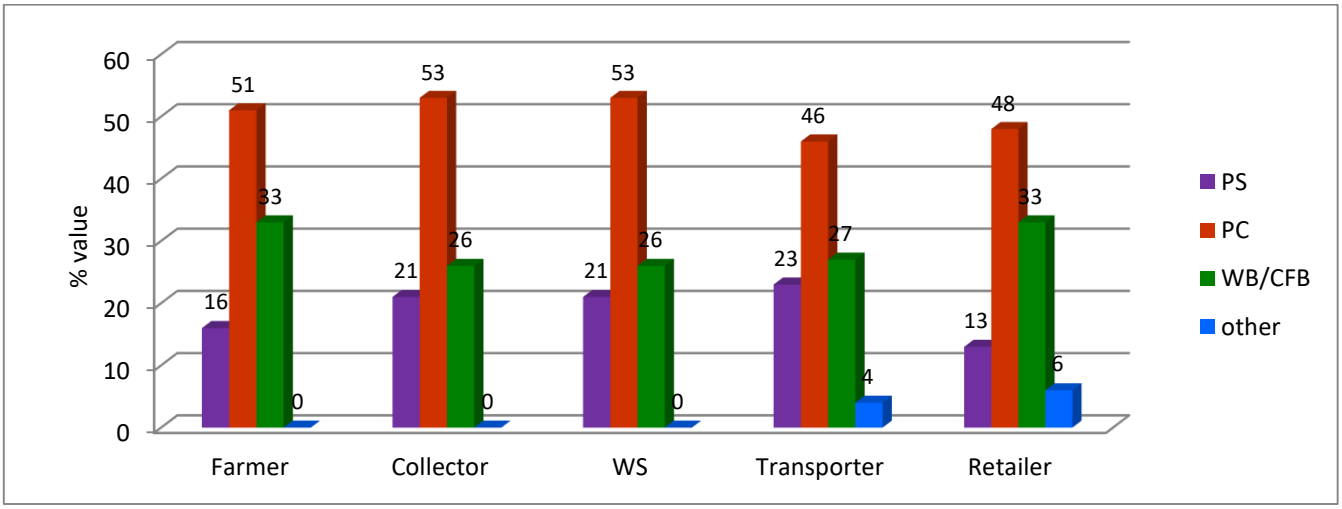


FIGURE 5: Different packaging methods used for fruits by different stakeholders

3.2 Postharvest losses:

The term "post-harvest losses" in the PHL system refers to the quantitative and qualitative loss of food in various post-harvest operations (Abass *et al.* 2014). Fresh fruits and vegetables are highly susceptible to mechanical injury due to soft texture and high moisture content. Poor handling and improper packaging methods for transportation are the causes of bruising, cutting, breaking, impact wounding and other forms of injury in fresh fruits and vegetables.

3.2.1 Quantitative post harvest losses of fruits and vegetables:

As indicated by table 01and 02, previous loss assessment studies conducted in Sri Lanka have revealed that post harvest loss of fruits and vegetables were 30 – 40%. Cabbage exhibited the highest loss among vegetables while bitter guard showed the least value. According to loss assessment study, the present post harvest losses of vegetables in conventional supply chain is 12.46± 0.59 - 28.24 ± 0.41% while it is in improved value chain where correct postharvest handling methods are used is 5.01±

0.30 - 9.46± 1.03%. The main factors that are most consistently related to higher levels of postharvest losses include rough handling, use of poor quality packages, high postharvest handling temperatures and delays in marketing (Kitinoja and Hassan 2012; Kitinoja and Cantwell 2010; Molla *et al.* 2010). However, the present study exhibited that the prevailed postharvest losses of fruits and vegetables in Sri Lanka have reduced from 30 - 40% to 12 - 28 %. Further, the study clearly showed that the post harvest loses of fruits have reduced remarkably recently from 30 – 46 % to 20 % even in conventional fruit supply chain. Improved value chain showed 6 – 19 % value. Similar results have previously reported by Herath *et al.* (2021) and Wasala *et al.* (2014). As previously reported by Dissanayake *et al*. (2020) and Vidanapathirana *et al.* (2018), Several programs have been conducted during last two decades to minimize postharvest losses, with special emphasis on the improvement of supply and value chains of fruits and vegetables by conducting awareness creation program, introducing safe packages, introducing correct ripening methods, introducing pack-house operations and development of entrepreneurship via applying value added technologies to surplus production. Further, supermarkets and other upgraded markets, who handle 5% of the total production, have developed their supply chains by applying correct postharvest technologies; as a result, postharvest loss of their produce has decreased to nearly 5%.

TABLE 1
AVERAGE QUANTITATIVE POST HARVEST LOSSES OF VEGETABLES

Vegetable crop	Postharvest Loss (% weight)-previous	Postharvest loss (% weight) year 2023	Postharvest loss in improved value chains (% weight)
Snap Bean	40	23.84 ± 0.12	6.32 ± 0.19
Okra	40	28.24 ± 0.41	7.17 ± 0.26
Brinjal	30	20.31 ± 3.11	7.45 ± 1.22
Cabbage	43	20.43 ± 0.55	7.91 ± 0.61
Carrot	30	22.46± 0.65	6.51± 0.24
Capsicum	30-40	25.74± 0.95	8.29± 0.62
Long Bean	40	20.36± 2.16	9.38± 1.07
Potato	-	14.46± 0.28	5.01± 0.30
Mukunuwenna	-	12.46± 0.59	6.84± 0.35
Green chilli	30-40	19.62± 1.04	4.97± 0.23
Bitter gourd	25	24.71± 2.25	9.46± 1.03
Tomato	29	15.93± .84	7.31± 0.71

(Sarananda, 2005; Vidanapathirana,et al., 2018; Wasala et al., 2012; Gunawardhana et al., 2014)

TABLE 2
AVERAGE QUANTITATIVE POST HARVEST LOSSES OF FRUITS

Fruit crop	Postharvest Loss (% weight)-previous	Postharvest Loss (% weight) year 2023	Postharvest Loss in improved value chains (% weight)
Papaya	46	19.58 ± 2.13	11.40 ± 0.72
Guava	30-40	20.37 ± 0.98	6.47 ± 0.81
Banana	30-35	26.54 ± 3.04	18.65 ± 1.31
Mango	41	15.15 ± 1.03	5.96 ± 0.26

(Sarananda, 2005; Karunagoda et al. 2011)

IV. CONCLUSION

As depicted by the results and compared previous studies, the adaptation to the use of postharvest technologies by stakeholders for fruits and vegetables in Sri Lanka was comparatively higher at different operational stages. Majority of farmers are aware of correct maturity indices and they already have adapted to use them. Findings further exhibited that use of safe packaging materials for transportation of fruits has significantly expanded. However, introduction of safe packaging for vegetables should

be further required. Postharvest loss of fruits in Sri Lanka at present is around 15-20% while it is 20-30% in vegetables saving considerable volume of commodities after harvesting.

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