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REVIEW PAPER

Post Harvest Handling System Practices in Horticultural Crops

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Fruits and vegetables are the most perishable, nutritious, valuable agricultural produces. India's diverse agro climate ensures availability of all varieties of fresh fruits & vegetables. India ranks second in fruits and vegetables production in the world, after China. During 2011-12 India produced 76.424 million metric tonnes of fruits and 156.33 million metric tonnes of vegetables. Post harvest handling is the stage of crop production immediately following after harvest, including cooling, cleaning, grading, packing and marketing. Post harvest handling largely determines final quality, whether a crop is sold for fresh consumption, or used as an ingredient in a processed food product. Post harvest sector includes all points in the value chain from production in the field to the food being placed on a plate for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing. The quality and condition of produce sent to market and its subsequent selling price are directly affected by the care taken during harvesting and field handling. Even though, number of post harvest handling practices is being recommended to minimize the post harvest losses at field level the fruits and vegetables growers are not following the recommended practices. Thus, the technologies vary from farmer to farmer according to their personal and socio-economic characteristics, perceived training needs, availability of factors of production and the practical problems in following post harvest handling.

Post harvest loss is a measurable quantitative and qualitative loss of a product at any moment during the post harvest chain and includes the change in the availability, edibility, wholesomeness or quality of the food that prevents its consumption (Buyukbay *et al*., 2011). Muntad, (2009) reported that both quantitative and qualitative losses of extremely variable magnitudes occurring at all stages in the post harvest handling from harvesting, through handling, storage, processing and marketing to final delivery to the consumer. Post harvest technologies include the objectives of maintaining the fresh quality of the produce in terms of appearance, texture, flavor, nutritive value, protecting produce, maintaining food safety, and reducing the average losses between harvest and consumption (Saraswathy *et al*., 2010). Considering the above points it is essential to understand the present status of post harvest handling practices, level of farmer's knowledge on post harvest handling practices and the constraints faced by farmers during post harvest handling would help to frame appropriate strategies to prevent the post harvest losses. This review paper literature related to post harvest handling are reviewed under the following headings.

Production and post harvest losses of selected fruits and vegetables

India produced 16.82 million tonnes of tomato and 7.34 million tonnes of cauliflower during the period 2011-12. Tamil Nadu had produced 3, 11,450 tonnes of tomato and 1, 17,200 tonnes of cauliflower. The production data for vegetables in Dindigul district revealed tomato production of 29,604 tonnes over an area of 2,467 ha and having the yield rate of 12,280 kg/ha. The cauliflower production of 8,100 tonnes was reported over an area of 405 ha and having the yield rate of 2021 kg/ha. Dindigul district ranks first in cauliflower production and it ranks third in tomato production followed by krishnagiri and dharmapuri districts.

In case of fruits India produced 28.45 million metric tonnes of banana and 2.51 million metric tonnes of guava during the period 2011-12. Tamil Nadu had produced 92,523 tonnes of guava and 4.88 million tonnes of banana**.** Madurai district having guava production of 11682 tonnes which was cultivated in 886 ha and having the yield rate of 13186 kg/ha. In case of banana, the production was 107662 tonnes and it was cultivated an area of 2715 ha having the yield rate of 42996 kg/ha. Madurai district ranks second in guava production followed by dindigul and it ranks third in banana production followed by Theni and Coimbatore districts. (National Horticulture Board, 2012 and Crop season Report of Tamil Nadu, 2012).

India waste 18 per cent of its fresh fruit and vegetable production worth of Rs. 13,300 crore every year because of inadequate post harvest handling practices. In this total amount of loss, banana contributes about Rs 1,275 crores, guava 407 crores, cauliflower Rs 208 crores, and tomato Rs 997 crores. Fruits and vegetables account for the largest portion of wastage in the overall agricultural production.(CIPHET Report, 2010).

Sharma and Singh, (2011) reported the post harvest losses of various vegetable crops in Uttarakhand. The study indicated that the post harvest losses of tomato and cauliflower at various stages of post harvest handling, a total of 23.19 per cent loss occurs during post harvest handling of tomato in that total amount, the loss occurs at farm level was 15.16 per cent and loss at retailer level was 8.03 per cent. The farm level loss includes the loss of 7.01 per cent at harvesting, 1.59 per cent at grading and packaging, 6.42 per cent in handling and transportation, 0.14 per cent in marketing. A total of 13.43 per cent loss occurred during post harvest handling of cauliflower in that total amount 8.27 per cent loss occurred at farm level and 5.16 per cent loss occurs at retailer level. The farm level

loss includes the loss of 1.38 per cent at harvesting, 2.82 per cent at grading and packaging, 2.46 per cent in handling and transportation, 1.60 per cent in marketing.

The Planning Commission of India, (2011) reported the post harvest losses of various fruits and vegetables in Bihar and UP. The post harvest losses of banana, guava, cauliflower and tomato were reported as 18, 15, 18, and 39 per cent in Bihar and 14, 14, 18 and 35 per cent in Uttar Pradesh during post harvest handling.

Post harvest handling system and post harvest loss assessment

Shufang Zheng *et al*., (2001) in China conducted post harvest handling assessment depending upon crop and season in different production areas and markets. Every operation relating to post harvest handling and the losses at each step were recorded and analyzed, from harvesting, through pre-cooling, packaging, and transportation, to marketing. At same time, farmers, businessmen, wholesalers, and retailers were interviewed about their operations and their level of skills in post harvest techniques. Accordingly, Udas *et al*., (2005) carried out a study in the Eastern hills of Nepal during the year 2001/2002 on post harvest handling of four major vegetables namely cauliflower, cabbage, radish and tomato. Information was collected on harvesting time and methods, timing and availability of transport, grading, pre-cooling, packaging and storage. The study found that the post harvest losses of cauliflower, cabbage, radish and tomatoes from the farmer's field to the collection centers were 6, 9, 6 and 3 per cent respectively. The losses were mainly due to spoilage, bruising and trimmings in cauliflower and cabbage, breaking in radish and rupturing and spoilage in tomatoes. The losses incurred in above four vegetables at retailer's level were 41, 34, 4.5 and 7 per cent respectively for the four vegetables. Physically damaged, sorted vegetables and trimmed parts were sold at a lower price to feed livestock. The main factors responsible for post harvest losses in Nepal were inappropriate packaging, transportation and grading systems.

Olayemi *et al*., (2010) conducted a survey to assess the post harvest challenges of small scale farm holder of three different vegetables, tomatoes (*Solanium lycorpesicum*), bell pepper (*Capsicum annuum*) and hot pepper (*Capsicum chinense*) in four Local Government Areas namely Danbatta, Bunkure, Kura and Dawakin Tofa of Kano State of Nigeria. The primary data used for the investigation were obtained through the use of questionnaire. One hundred and twenty farmers were randomly sampled and selected for the study; the farming experience of respondent, stage and time of harvest of produce, percentage loss of produce during harvesting and transportation, on-farm storage facilities utilized by respondents and mode of transportation and packaging materials utilized by the respondents were looked into. The results obtained revealed that most of the tomatoes, ball and hot pepper farmers experience losses of 10-30 per cent during harvesting and transportation stages. The farmer harvest mostly when they have buyer, harvest at fully ripe stage (90 %) and most still use the traditional basket and sacks as their packaging material in conveying produce resulting into massive post harvest losses (62.5%). These practices by the farmers often result in reduction of profit and unavailability of these products all through the seasons.

Gudila *et al.,* (2013) conducted a study on harvesting practices and post-harvest losses of fruits along the supply chain in Bagamoyo District of Tanzania. 142 farmers, 50 retailers and 10 wholesalers dealing with fruits were involved in the study. Data were collected using structured questionnaires. The results indicate that, 90.14 per cent of the respondents harvested fruits when they are just ripe and the great market losses were reported to occur due to rotting (microbial) at (63 %) physiological at (20 %) and (17 %) by insects and rodents. Along the supply chain, mechanical damage was observed to be the major type of loss during harvesting (79 %) and transportation (56 %) while microbial damage was observed by majority (67 %) during marketing. Poor infrastructure from farm to the market was observed to account for large percentage of losses in the market. According to Chikhale *et al., (*1998) conducted a study in Amaravati district of Maharashtra state on adoption of post harvest handling practices by orange growers. The data depicted that 25 per cent of respondents were following recommended practices to control decaying of fruits.

Deshmukh *et al.,* (1998)carried out a studyin Aurangabad district of Marathwada region reported that nearly 60 per cent of custard apple growers were following recommended harvesting practices. Waman and Patil, (1998) state that almost all the onion growers of Yeola tehsil of Nasik district in Maharashtra were harvested onion crop at appropriate stage and do the recommended storage practice (85.33 %). Kubde *et al.,* (2000)carried out a studyamong potato farmers in Ambegaon Panchayat Samiti of Pune district in Maharashtra and reported that 83 per cent of cultivators were following recommended storage method and about 71 per cent of farmers were practicing precautionary measures during storage of potato. But none of the growers were using chemicals to control the sprouting during storage.

Palande *et al.,* (2001)conducted a study on onion crop growers in Khatav tehsil of Maharashtra by reported that 40 per cent of respondents followed proper timing of harvesting, while 38.33 per cent respondents had the practice of withholding irrigation three weeks before harvesting as recommended and 28.33 per cent of the respondents adopted neck topping. Whereas, only 8.34 per cent of respondents adopted application of MH- 40 (Mali hydrazine) before 20 days of harvesting. The study conducted by Govinda Gowda and Narayana Gowda (2004) in Bijapur and Bangalore rural districts of Karnataka on adoption of sustainable post harvest handling practices in grape, highlighted that 65 per cent of small grape cultivators around 40 per cent of other growers of Thompson seedless were found to store their produce in community based cold storage units. However all the respondents were using correct packing materials to pack their produce. Further, the study highlighted that nearly 90.00 per cent of farmers prepared their raisins by chemical dipping method, whereas only few farmers (11 %) adopted sulphur fumigation method for raisin preparation.

The investigation carried out by Moulasab, (2004) with regard to the in adoption of post harvest handling practices by mango growers of North Karnataka indicated that only 15 per cent of the sample farmers followed hand sorting. Very few mango growers were found to use paper bag (4.10%), trace/porous packaging (6.66%) and recommended grading method (6.66%). Selvarani and Manoharan, (2004) stated that the practice of separating pest and disease attacked potato tubes and recommended method of storage was followed among 70.83 and 25.00 per cent of sample farmers respectively in tribal area of Nilgiris district. Sunil Kumar, (2004) conducted a study on adoption of post harvest handling practices by tomato growers of Belgaum district and noticed that two-third of respondents (66.67%) were found to adopt manual sorting followed by practices of manual grading among 46.67 per cent of farmers. However all the respondents had the practice of packing tomato produce in bamboo basket.

Post harvest factors influencing the quality of fruits and vegetables

Good post harvest practices are necessary to reduce commodity damage. The aim of the post harvest handling of locally grown produce is to deliver quality produce to the consumer. Quality cannot be improved after harvesting; therefore it is important to harvest fruits and vegetables at the proper stage, size and maturity (Bachmann and Earles, 2000). Lee and Kader, (2000) reported that the relationship between pre harvest factors and post harvest quality is complex, and not well-understood. For example, the vitamin C content of fruit and vegetable crops is affected by cultural factors, genotype and weather conditions. The post harvest life can be maintained and extended by optimized handling and reducing damage through the application of correct post harvesting techniques. The time duration during which a produce is exposed to any adverse condition is directly proportional to the decrease of quality of any horticultural produce. Pre harvest temperature plays a crucial role in post harvest quality of fruits (Woolf *et al*., 2000; Pineiro and Diaz, 2007; Leblanc and Vigneault, 2008)

Fresh fruits and vegetables are living tissues, and subject to continual changes after harvest. Fresh produce consumes photosynthates that are stored in the product. The consumption rate depends on the respiratory activity of a particular commodity and its temperature. Delays between harvesting and cooling or processing can result in direct losses, due to water loss and microbial contamination, and indirect losses, such as flavor and nutritional quality (Thompson *et al*., 2001). The rate of product deterioration is proportional to the rate of respiration, which increases exponentially with temperature. Shriveling and loss of fresh, glossy appearance are two most noticeable effects of cooling delays, particularly for commodities that lose water quickly and show visible symptoms of shriveling at low levels of water loss, like leafy vegetables. A correlation has been found between respiration rate and shelf life (Ninfali and Bacchiocca, 2004; Cantwell, 2007a).

The rough handling creates areas that darken, soften and make the produce vulnerable to pathogen attacks. Microbes readily attach to cut leafy vegetable surfaces reducing the safety and nutritional quality. Post harvest losses due to parasitic diseases increase with an increase in time between harvest and consumption. Post harvest decay results in major losses of fruits and vegetables (Takeuchi and Frank, 2001; Janisiewicz and Korsten, 2002). Kader, (2002)reported that the fresh produces are susceptible to deterioration between harvest and consumption and this may reach very high values after harvest, depending on the species, harvesting and handling methods, processing, duration and temperature of storage, distribution, market conditions. A longer shelf life, therefore, depends on a combination of correct cooling storage throughout the entire supply chain, modified atmosphere packaging conditions and good manufacturing and handling practices.

Harvesting

Harvesting is the first step in ensuring quality. Harvesting at optimum maturity is best for consumption quality. Locally grown fresh fruits and vegetables can often be harvested at advanced maturity, although small farmers may lack the technology to cool the produce immediately following harvesting. For this reason, harvest techniques are of special importance to many local producers. Fruits and vegetables picked at peak maturity also deteriorate more rapidly, particularly when they are stored under the less-than-optimal conditions typical of local handling systems. The stage of maturity of fruit and vegetables destined for fresh-cut processing is a critical factor that helps to determine the potential quality and shelf life of the product. The eating quality and shelf life of fresh-cut fruit products are influenced by the stage of ripeness at cutting (Gorny *et al*., 2000).

Early morning harvesting is important because these are typically the coolest hours of the day, and allow for lower temperatures and respiration rates. It is cheaper to keep the produce cool at this time, rather than to cool it when its temperature rises. Harvesting in the early morning or at night helps supply a high-quality product at a desired temperature. Harvest timing is especially useful when pre-cooling facilities are unavailable. It is recommended that harvest bins or containers be covered with a reflective pad or placed in a shaded area to reduce solar heating, water loss and premature senescence. (Cantwell, 2007a).

Perkins - Veazie, (1999) stated that the harvesting method, whether by hand or mechanical, and handling can determine the variation in maturity and physical injury, and consequently can influence the nutritional composition of vegetables. The use of good pre harvest, harvest and handling practices is necessary to reduce commodity damage. Placing the harvested produce quickly under shade, in opaque or dark boxes, or using white tarpaulins to reflect heat from the filled bins can cut the load temperature by 30 per cent. Harvesting in the heat period of the day causes wilting; shriveling, softness and a high respiration rate, and shorten shelf life considerably

Harvesting directly affects the appearance and shelf life of the final product. The safety and the quality of fresh-cut produce depend not only on the cultural practices and post harvest conditioning, but also on the harvesting and handling procedures. Factors that can affect the microbial

condition in the raw material include the climatic conditions which the plants are produced in, and the temperature and air conditions at which the produce is stored after harvest. (Perkins - Veazie, 1999). Prussia and Woodroof, (1986) revealed that factors during harvesting operations that can influence post harvest quality include the degree of severity of mechanical damage induced by machine or human, the accuracy of selecting acceptable and unacceptable fruit, the time of day of harvest and the pulp temperature at harvest.

Harvesting techniques should cause minimal mechanical damage if possible. It is important to avoid unnecessary wounding, bruising, crushing or damaging of produce by equipment or containerizing, because more mature produce is sometimes more susceptible to mechanical damage. Bruises are more common, yet less noticeable at harvesting. Gentle digging, picking and handling will help to reduce crop losses, especially for produce that must be stored. Damage can be prevented by handling each fruit or vegetable as little as possible and by field packing wherever possible (Cantwell, 2007b). The main benefit of hand harvesting compared to mechanized harvesting is that skilled workers are able to select the produce at its correct stage of ripeness, and grade the product gently. This results in less damaged products and fewer post harvest losses. If workers are hired for the harvest season, training is necessary to improve their grading and harvesting skills (Lopez Camelo, 2004).

Pre-cooling

'It is often critical that fresh produce should rapidly reach the optimal temperature for short-term storage or shipping in order to maintain the highest quality, flavor, texture and nutritional content. The cooler should be in close proximity to the field to reduce delays from harvesting to cooling. Several methods and techniques of pre-cooling are available, primarily to meet the requirements of large producers and markets (Kienholz and Edeogu, 2002). Kienholz revealed that the fresh horticultural products should be cooled after harvesting and during transport. The absence of pre-cooling system is quite common situation in many small farms, it is important to consider that room cooling is only appropriate for small amounts of produce or produce that does not deteriorate rapidly. For some produce, the use of top icing is effective for pre-cooling. Room cooling is only appropriate for small quantities of produce, or produce that does not deteriorate rapidly. Top icing is an effective method to cool produce adaptable to small-scale operations. Ice has characteristics that make it very effective for pre-cooling of fruits and vegetables, especially for small-scale farmers. These characteristics include its versatility as a cold source for several pre-cooling methods, its thermal storage capacity and its portability. The ice should be made from clean water, free of chemical, physical and biological hazards.

Sorting and grading

Lopez Camelo, (2004) stated that the sorting and grading may be carried out in the field in a permanent, temporary or mobile structure or in a protected area. The two systems are not mutually exclusive. In many cases partial field preparation may be completed later at the farm the first operation is to remove rejects. This involves the removal of overly mature, inferior sized, severely damaged, deformed or rotten produce Locally-grown distribution channels may not use written grade standards, but the products are sorted and sized to some extent. In small-scale packing operations, one or a few grading tables may suffice. In such operations, the sorting and grading are performed manually by skilled workers. The tables and equipment should have a smooth, soft surface, and the dumping and grading operations should be gentle to minimize injury. Unnecessary drops, bumping and abrasion should be avoided. Particular attention should be paid to grading the produce in order to avoid the mixture of damaged, decayed, or decay-prone products in bulk or packed units damaged produce can easily be detected, and is usually removed during grading and packing (Lopez Camelo, 2004).

Packaging

The packaging of fruits and vegetables should satisfy three basic objectives: the standardization of the number of units or weight inside the package, the protection of the product from injuries, poor environmental conditions or unsanitary conditions during transport, and the placement of produce in a clean area. Packaging should also ensure identification, and provide information including variety, weight, and number of units, selection or quality grade, producer's name, country, area of origin, handling instructions, and appropriate storage temperature for product display. Packaging systems should be designed for rapid and efficient cooling to prevent physical damage to the produce and to ease handling and storing processes (Boyette *et al.,* 1996; Vigneault *et al*., 2009). If produce is packed for handling, waxed cartons, wooden crates or rigid plastic crates are preferable to bags or open baskets, because bags and baskets do not protect the produce when stacked. For domestic marketing, plastic crates provide excellent protection for produce and adequate ventilation during handling, cooling, transport and storage. Some plastic crates are collapsible or can be nested when stacked for easier handling when empty. Packing methods can affect the stability of products during shipping, and influence how well the container protects their quality. For best results, containers should be neither too loosely, nor too tightly filled with produce. Loose products may vibrate against others and cause bruising, while over-packing results in compression bruising (Kitinoja and Kader, 2002).

Transport

Mechanical damage occurs during loading, unloading and stacking operations or from shock and vibration during transport. Mechanical damage is caused by one or more types of loading compression, impact, and vibration as in normal fruit packing lines where damage is produced by forces such as pressure between fruit and machinery, surface abrasion, packing and handling so attention should be paid when loading containers, regardless of their dimensions. Several reports have shown that bruising is linearly related to impact energy, and mechanically stressed fruit exhibit visible degeneration of mesocarp and endocarp during storage. (Garcia *et al.,* 1995; Chonhenchob and Singh, 2003).

Marketing

Suslow, (1997)reported that the farmers markets can often result in the produce being exposed to direct sunlight warm or even high temperatures, and low RH levels. Rapid water loss under these conditions can cause fruits and vegetables to deteriorate. By providing post harvest cooling before and during transport and a shading structure during display, the produce will last longer. For direct marketing (in-store, roadside stand) farmers should make sure their products are fresh by misting them with water regularly or by storing them in insulated cartons prior to display. Some of these cartons can be converted into display cartons by removing the tops. Some highly perishable items may only be offered for sale if displayed in ice or water containers (Marr and Gast, 1995).

Storage

Storage is a strategy for achieving higher returns. The ideal storage temperature often depends on the geographic origin of the product. Tropical plants have evolved in warmer climates, and therefore cannot tolerate low temperatures during storage. These must be stored at temperatures above 12°C. Plants which have evolved in temperate, cooler climates, on the other hand, can be stored at 0°C. Fruits and vegetables are divided into three groups in terms of temperature and RH requirements: Group 1 (0–2°C, 90–98% RH), Group 2 (7–10°C, 85–95% RH) and Group 3 (16–18°C, 85–95% RH**)** (Thompson and Spinoglio, 1996; Boyhan *et al*., 2004).

The shelf life of a fruit or vegetable during storage is dependent on its initial quality, its storage stability, the external conditions and the handling methods. Shelf life can be extended by maintaining a commodity at its optimal temperature, relative humidity (RH) and environmental conditions, as well as by the use of chemical preservatives or gamma irradiation treatment (Shewfelt, 1986; Lee and Kader, 2000).

Storage conditions of refrigerated and controlled atmosphere should be chosen and maintained to retard the deterioration of the perishable produce due to: (1) aging, ripening, softening, color changes, undesirable metabolic changes and respiratory heat production (3) moisture loss and the resulting wilting (4) spoilage by invasion of bacteria, fungi or yeasts and undesirable physiological processes such as sprouting (Kader, 2002; Alvo *et al*., 2004; Leblanc and Vigneault, 2008)

In general, harvesting should be done in the early morning hours to minimize field heat. Harvested produce should avoid direct exposure to sun, or field-cool before transport to packing or transportation facilities. Produce will then be cooled to safe storage temperatures. Produce should be shipped to market as soon as possible, and practice first-in-first-out (FIFO) rotation. Improper harvest and post-harvest practices result in losses due to spoiling of the product before reaching the market, as well as quality losses such as deterioration in appearance, taste and nutritional value.

Knowledge level of farmers in post harvest handling

Bhople *et al.,* (1996) conducted a study in Norkhed Panchayat Samit of Nagpur district of Maharashtra revealed that 62.77 per cent of orange growers had knowledge about grading. The investigation carried out by Ahire *et al.,* (1999) on grape growers of Bhokardhan Panchayat Samit of Jalna district in Maharashtra state revealed that correct stage of harvest, time of harvest and grading and packing of grape was known to 34.66, 26.66 and 26.66 per cent of sample farmers, respectively.

Waman and Patil, (1998) stated that all the onion growers of Yeola tahsil of Nasik district in Maharashtra were knowledgeable about appropriate stage of harvesting for storage purpose. The knowledge of cutting bulbs leaving 2 cm neck length was noticed with 80.66 per cent of respondents. Less than 50.00 per cent of the respondents had knowledge about identification of various pests and diseases (42.00%) and control measures for these pests and diseases (36.00%) during storage period of onion produce. However, very less percentage of respondents possessed knowledge about curing of bulb (16.66%), improved method of storage (14.00%) and implements for harvesting (10.00%).

It was noticed from the findings of Mehta *et al.,* (2000) that among the respondents around three-fourth of minor fruit crops growers (62 %) in Sindhdurg district of Konkan region had medium knowledge about post-harvest technology, whereas low and high level knowledge about post harvest technology was noticed with 22 and 16 per cent, respectively. But, majority of the respondents did not possessed knowledge about equipments for testing of TSS (67 %), purposes of using preservatives (66 %) and (57.00%) uses preservatives during processing

Achuta Raju *et al.,* (2002) stated that in Guntur district of Andhra Pradesh all the beetle vine growers had the knowledge of packing beetle vine and followed by the practice of grading (95 %) and harvesting (87.50 %). Moulasab, (2004) conducted a study on mango growers of Northern Karnataka and reported that 25 per cent of respondents possessed the knowledge of mechanical harvesting and only 12.50 per cent were aware of mechanical means of sorting and cleaning of mangoes. The knowledge about means of transportation and mango packing was known to all the farmers and 81.66 per cent were aware of cold storage followed by knowledge about processing of mango to make juice (58.33%), but only 23.33 and 20.83 per cent had the knowledge about scientific grading and packing, respectively.

Sunil Kumar, (2004) found that a high per cent of tomato growers in Belgaum district of Karnataka had the knowledge about the manual sorting (86.66%), manual grading (70 %), bamboo basket packing (74.16%), whereas, knowledge about processing of tomato was noticed with 55 per cent, respondents. Gudila *et al.,* (2013) conducted a study on knowledge and post harvest losses of fruits along the supply chain in Bagamoyo District of Tanzania. They investigated 142 farmers, 50 retailers and 10 wholesalers dealing with fruits were involved in the study. The finding shows that all farmers (100%) interviewed have no knowledge on post-harvest losses and handling. In the view of the findings, it can be concluded that, post- harvest handling practices and knowledge of stakeholders involved

in fruit sub sector in the country are not good enough to prevent the losses. It is therefore imperative to improve educational knowledge, skills and fruits quality from the field to reduce post-harvest losses.

Constraints experienced by farmers during post harvest handling:

Sharma *et al.,* (1995) in their study on marketing of vegetables in Himachal Pradesh reported that, costly wooden boxes, time consuming manual grading, distant markets, high transportation charges, malpractices in the market and lack of market information were the major problems faced by growers in storage, transportation and marketing of vegetables. An investigation was carried out by Srinivas Reddy, (1995) in Kolar district of Karnataka on mango growers and it is reported that, problems faced by mango growers were more pest and disease incidence, high cost of fertilizers, high cost of plant protection chemicals, non-availability of labour, lack of technical guidance, rain during harvest and problem of weed. Accordingly, Saravanakumar, (1996) conducted a study on mango growers in Dharmapuri district of Tamil Nadu and reported that, majority of the respondents faced the problems like lack of technical guidance (82.50%), inadequate irrigation facilities (70.00%), non-availability of labor (61.67%) and low price for the produce (60.83%). Vijayakumar, (1997) in his study in Bangalore district observed that, the problems faced by rose growers of Bangalore district were lack of storage facilities, inadequate local markets and exploitation by wholesalers. Kumar, (1998) in his study on banana growers in Bangalore district reported that, the farmers faced the problems like technical guidance, pests and disease, high investment, low price for the fruits, fluctuation in the prices and exploitation by the middleman.

Narappanavar and Bavur, (1998) examined the problems in storage, transportation and dissemination of market information in potato, during marketing in Dharwad district of Karnataka state. The results of the study revealed that, farmers were not facing severe problems in transportation because of large number of tractors in the village. Similarly, farmers were making suitable arrangements for storage of potato on the farm itself. Anis Mohammed *et al.,* (1999) found that lack of storage facilities, unavailability of preservation industries in the area, perishable commodity results in economic losses, chances of theft, high mortality of plants during initial stages and lack of technical know-how were the priority and important constraints experienced by Mandarien growers.

Atibudhi, (1999) reported that, the capital available with small and marginal farmers was not adequate to meet the production expenses, some of them were forced to depend upon commission agents for arranging transportation, packing etc in Cuttack district of Orissa. This enabled the commission agents to cheat the innocent cultivators by charging exorbitant prices for such facilities. Therefore, it is necessary to provide the credit facility for marketing operations by treating as a part of cost of cultivation. Vasudev and Choudhary, (1999)observed that the lack of grading facilities, absence of market information and spoilage and malpractices were the major problems in productions and marketing of tomato in the regions of Andhra Pradesh. They have concluded that providing these facilities can improve the marketing efficiency and will help the farmers in realizing better prices.

Karpagam, (2000) conducted a study on turmeric growers of Tamil Nadu state and reported that price fluctuation, high cost of inputs and scarcity of labor and non-availability of credit are the major problems faced by turmeric growers. Govinda Gowda, (2004) in his study on sustainable grape cultivation reported the important constraints in grape marketing as, no fixed price, low price, lack of regulated markets, exploitation by middle men, lack of cold storage facility, no guidance on marketing aspects and lack of transportation facilities. Further, constraints perceived by them in availing credit were non availability of credit in time and inadequate quantity of credit.

Sunil Kumar, (2004) in his study on tomato growers in Belgaum district of Karnataka reported that, majority of the farmers (75.83%) faced the problem of technical knowledge and guidance in post-harvest technology. Whereas 65.00 per cent of the respondents faced the problem of high fluctuation in market price, followed by high transportation cost (62.53%), labor shortage and high wages (55.83%) and power shortage (46.66%). Nagesh, (2006) reported that the major constraints faced by pomegranate growers were lack of storage facility and lack of processing units.

Strategies to improve post harvest handling practices at farm level:

A systematic analysis of each commodity production and handling system is the logical first step in identifying an appropriate strategy for reducing post harvest losses it is important to select the technologies that are appropriate for the size of each post harvest enterprise (Kitinoja and Gorny, 1999). An evolution of priorities within the post harvest sector of developing countries from a primarily technical focus geared towards the reduction of losses, to a more holistic approach designed to link on-farm activities to processing, marketing, and distribution. However, the major constraints continue to be high post harvest losses, poor marketing systems, weak research and development capacity, and inadequacies in policies, infrastructure, and information exchange.

CONCLUSION

Farmers facing major problem in marketing followed by transport and harvesting and all the farmers reported the problem of lack technical guidance for post harvest handling of fruits and vegetables. Giving of equal importance to post production operations that of crop production will prevent the loss and helps to achieve food security. Framing of suitable schemes and policies based on the perceived needs, crop and farm profile of farmers. Improve the nation economy, socio economic status of farmers, Nutritional and health status of people by increasing the availability through prevention of post harvest loss and proper post harvest handling practices of fruits and vegetables. Establishment of strong network between scientists, farmers, extension workers and others who are all involved in post harvest handling and supply chain to tackle the problems in post harvest handling and development, transfer of suitable technology to overcome the problem. Regulation

of post harvest handling of fruits and vegetables. Identification of loss and implementation of corrective action in each step of post harvest handling. Reduction of technology gap in post harvest handling of fruits and vegetables.

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