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A review on the status of post-harvest loss in vegetable crop and their management options

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Abstract
Today, one of the main global challenges is how to ensure food security for a world growing population whilst ensuring long-term sustainable development. Increasing emphasis on higher value farm products to meet the changing diets of urban consumers has focused renewed attention on post-harvest systems, while unacceptably high losses due to poor handling and lack of appropriate infrastructure have reduced economic benefits to small producers. Post-harvest activities are an integral part of the food production system which mainly includes vegetables which can be defined as any edible and usually succulent, portion of plant or part of a plant other than a sweet fruit or seed with savory flavor. These edible portions include roots, tubers, stems, buds, bulbs, leaves, flowers, seeds and fruits. Vegetables are diverse in their morphological structure, nutritional composition and general physiology. By nature, all vegetables have a high moisture content which renders them to be highly perishable such, that if not handled properly, a high-value nutritious product can deteriorate and decay in a matter of days or even hours (Kader, 2002). In some areas of the country, root crops particularly potatoes and sweet potatoes are used as staple food for considerable portion of the population. The expression "post-harvest losses" means a measurable quantitative and qualitative loss in a given product.in the other Post-harvest activities include cooling, curing, handling, storage, processing, packaging, transport and the market phase. Post-harvest losses can occur as a loss in edibility, nutritional quality, caloric value, or consumer acceptability. The factors contributing to these losses includes; the initial quality of the crop, mechanical injury, temperature, humidity, handling given to the crop and storage atmosphere. In view of these factors, a good sanitation management in all pre and post-harvest operations in vegetable crops will help in eliminating sources of infection and reducing levels of contamination.

Keywords: loss, quality, postharvest, package

Introduction
Today, one of the main global challenges is how to ensure food security for a world growing population whilst ensuring long-term sustainable development. According to the FAO, food production will need to grow by 70% to feed world population which will reach 9 billion by 2050. (Nellemann, 2009) [1].
The need to increase food production has become a policy mantra. Populations are growing, so we need more food. But much of what is produced never makes it past the farm gate, especially in developing countries. Eliminating those losses is a way to increase food availability without requiring additional resources or placing additional burdens on the environment.
Post-harvest loss (PHL) happen at every stage of the supply chain, but in developing countries losses are the most significant. Harvesting, drying and storage are all stages which see substantial losses, both quantitative (physical losses caused by rodents, insects or infestations) and qualitative (loss of quality and value). (FAO, 2012).
Many factors contribute to postharvest losses in fresh vegetables. These include environmental conditions such as heat or drought, mechanical damage during harvesting and handling, improper postharvest sanitation, and poor cooling and environmental control. Efforts to control these factors are often very successful in reducing the incidence of disease. For example, reducing mechanical damage during grading and packing greatly decreases the likelihood of postharvest disease because many disease-causing organisms (pathogens) must enter through wounds. Chemicals have been widely used to reduce the incidence of postharvest disease.
Post-harvest losses negatively impact the economic benefit derived from vegetable production (Weinberger and Acedo, 2008) [3]. Vegetables are essential parts of human diets, but they are perishable by nature. Losses between farms and consumers are highest in developing countries where there is a lack of knowledge, skills, technologies, techniques, and facilities for produce handling and processing. This loss of nutritious food and economic opportunities contributes to poverty, unemployment, and malnutrition. Increased interest in the proper postharvest handling of fresh vegetables has prompted the widespread use of flumes, water dump tanks, spray washers, and hydro coolers. Even a partial reduction in post-harvest losses can significantly reduce the overall cost of production and lessen our dependence on marginal land and other scarce resources.
Increasing emphasis on higher value farm products to meet the changing diets of urban consumers has focused renewed attention on post-harvest systems, while unacceptably high losses due to poor handling and lack of appropriate infrastructure have reduced economic benefits to small producers. Analyses the status of post-harvest losses in vegetable crops, are with high levels of poverty,

malnutrition and food insecurity, and assesses approaches to reducing these losses. Post-harvest activities are an integral part of the food production system. A working knowledge and understanding of the technical factors that impact on the safety, quality and value of agricultural produce, an appropriate infrastructural support base, proper logistical arrangements, good stakeholder interaction within post-harvest value chains and effective government support services are prerequisites to gaining market access, reducing post-harvest losses and increasing returns to producers. (FAO, 2012).

1.2. Vegetable production in Ethiopia

Ethiopia has a variety of vegetable crops grown in different agro ecological zones by small farmers, mainly as a source of income as well as for food. The production of vegetables varies from cultivating a few plants in the backyards, for home consumption, to large-scale production for the domestic and home markets. According to CSA Crop land Area, Production and Yield of Belg Crops For Private Peasant Holdings For Belg Season 2014/15 (2007 E.C.)the area under these crops (vegetables and root crops) was estimated to be 309,930 hectares. In holders living near to urban centers largely practice vegetable farming. Vegetable farms are not commonly practiced by the rural private peasant holders which is evidenced by the small volume of production recorded as indicated by the survey result. Vegetables account about 2.89% of the area under all crops at national level during the Belg season. Out of the total area under vegetables, 77.16% and 8.83% are accounted for Ethiopian Cabbage and Tomato, respectively (See Statistical Table 2) (CSA; 2007 e.c).

Vegetable crops play a significant role in developing country like Ethiopia, both in income and social spheres for improving income and nutrition status. In addition, it helps in maintaining ecological balance since horticultural crops species are so diverse. Further, it provides employment opportunities as their management being labor intensive, production of these commodities should be encouraged in labor abundant and capital scarce countries like Ethiopia. (Yohannes Agonafar 1998) [4].

Currently, the majority of the vegetable crops product comes from the peasant smallholder farms. However, their areas of production and their contribution to the country's total agricultural output were not known much. Based on the survey per capital consumption of the annual fresh production assorted vegetables is about 4.86 million tons.(CSA, 2007 E.C).From the total volume of horticultural products, 95% is fresh vegetable production. There is no processing of vegetables in the peasant smallholder farm. Production of canned and bottled vegetables is mainly in the Ministry of Trade and Industry (MTI) and Ministry of Agriculture and Rural Development (MARD) (Bekele Wolde, 1989).

Table 1: Cropland Area**,** Production and Yield **of** Belg Crops for Private Peasant Holdings For Belg Season 2014/15 **(**2007 E.C.)

Crop Name	Number of Holders	Crop land Area in Hectares	%	Production in Quintals	Yield QT/Hec	%
Vegetables....	2572564	41641.19	100	2695255.51	100	64.73
Lettuce.....	3312	*	*	*	*	*
Head Cabbage.....	90453	*	*	*	*	*
Ethiopian Cabbag....	2369577	32131.25	77.16	2265432.93	84.05	70.51
Tomatoes.....	106385	3677.86	8.83	227883.11	8.46	61.96
Green peppers.....	135347	2066.26	4.96	*		
Red peppers.....	23918	422.01	1.01	5358.11	0.2	12.7
Root Crops.....	4314445	226648.55	100	21440046.88	100	94.6
beetroot.....	55223	624.51	0.28	21478.16	0.1	34.39
Carrot.....	36300	282.2	0.12	13968.2.1	0.07	49.5
Onion	289910	21047	9.29	844378.48	3.94	40.12
Potatoes.....	3535194	186595.23	82.33	18499952.45	86.29	99.14
Yam/'Boye'...	87606	802.69	0.35	119525.8	0.56	148.91
Garlic...	317065	7197.74	3.18	500462.73	2.33	69.53
Taro/'Godere'	145452	1779.3	0.79	120344.3	0.56	67.64
Sweet potatoes.	260913	8319.27	3.67	1319936.75	6.16	158.66

Source: (CSA; 2007 E.C.)

2. Concept of post-harvest losses

The expression "post-harvest losses" means a measurable quantitative and qualitative loss in a given product. These losses can occur during any of the various phases of the post-harvest system. This definition must also take into account cases of product deterioration (FAO, 2009).

Post harvest activities include cooling, curing, handling, storage, processing, packaging, transport and the market phase. Post harvest management is about maintaining quality from production in the paddock to the vegetables being placed on a plate for consumption. Maintaining vegetable quality requires good systems and communication throughout the supply chain as each step is influenced by the previous; it is a chain of interdependent activities. Post harvest losses can occur as a loss in edibility, nutritional quality, caloric value, or consumer acceptability.

2.1. Types of postharvest losses

The common categories of postharvest loss are quantitative and qualitative losses in the post harvest system.

2.1.1. Quantitative loss

Quantitative loss also referred to as physical loss cause a reduction in product weight. A downgrade in quality leads to loss of consumer appeal and is frequently described by comparison with locally accepted standards for premium quality such as appearance, taste, texture and nutritional value. There is revenue lost from both quantitative and qualitative losses. The cost of postharvest losses cuts across the entire food supply chain and negates on the potential profits of every actor involved in the

vegetable handling and marketing system. The economic losses also influence the marketing prices of each commodity.

Although the causes of losses may be readily apparent, the complexity and heterogeneity within vegetable marketing systems makes it difficult to quantify postharvest losses. Literature reports on quantitative losses of vegetables as an entity are limited. Reports on vegetables losses are often combined with those of fruits. However, vegetables are very diverse in their morphology and this is an important determinant of postharvest quantitative losses. Leafy vegetables are more perishable than roots and tubers and also easily susceptible to wilting, mechanical injury and decay (Kitinoja, 2010).

2.1.2. Qualitative losses

Qualitative losses are much more difficult to assess than quantitative losses. Losses in quality are evidenced by a decrease in the market value of the product. Any vegetable which is misshaped or has some blemishes may be as tasty and nutritious as one that is perfect in appearance. For most vegetable trades this may entail making price cuts and produce specials for imperfectly shaped produce including products that have passed their "sell by date". for all consumers at large. Nutritional value of vegetables defines the presence of those essential substances that are important to support life such as vitamins, phyto-chemicals and proximate composition. Changes in fresh produce nutritional quality is not visible but plays an important role in making correct food choices. Nutritive losses are primarily due to improper postharvest handling and prolonged storage. Postharvest nutrient losses impact negatively on the nutritional well being of consumers because it is the quality, and not just the quantity of food in a diet that determines the nutritional status of an individual.

Fresh vegetables are highly perishable and subject to rapid quality deterioration after harvest due to incorrect stage of produce maturity, water loss, unfavorable climatic condition, physical damage, contamination by pathogens and insect pests, improper handling and poor storage conditions. Other factors also contribute to postharvest loss, such as lack of capable human resources, lack of knowledge about technical and scientific technologies, inefficient marketing systems, poor/lack of transportation infrastructures etc.

Social/Indirect Costs of Postharvest losses aggravate hunger by causing less food to be available for consumption (FAO, 2009). In addition, consumers are deprived of getting a premium product for every qualitative loss. Vegetable production is a resource intensive industry and any means of loss translates into resource waste. The world's already limited natural resources are not spared from wastage by the losses. (Munhuewyi, K, 2012) [7].

For many vegetables, the optimum eating quality is reached before full maturity (true for leafy vegetables and immature fruits including cucumbers, sweet corn, green beans, and peas). With these crops delayed harvest results in lower quality at harvest and faster deterioration after harvest.

The causes of post harvest loss and poor quality are usually specific to each crop. With potatoes and sweet potatoes there are problems with improper curing, sprouting and rooting, water loss, and chilling injury. With tomatoes problems involve bruising, over-ripeness and softening, water loss, and chilling injury. With lettuce, spinach, and cabbage there are problems with water loss causing wilting, loss of green color, and high respiration rates. With cucumbers problems involve over-maturity at harvest, water loss and shriveling, bruising, and chilling injury, and all of the above suffer from decay. (Kitinoja, Lisa, and Adel A. Kader. 2004).

2.1.2.1. Quality criteria for fresh produce

A. Appearance

Appearance is the key factor for consumers in making purchases of fresh produce. As the multiple retail sector has come to dominate food retailing in many countries, consumers have come to expect fresh produce to have near perfect visual appearance. Displays of vegetables are characterized by uniformity of size, shape and color. Vital components of visual quality include color and color uniformity, glossiness, and absence of defects in shape or skin finish and freedom from disease.

The importance of appearance in the processing industry will depend on which part of the produce is used in the product and whether the appearance can readily be enhanced during processing, for example by the use of natural coloring additives. In most products, the peel will be removed from the produce, so purely surface blemishes will be of little consequence. Internal flesh color is usually more important than peel color. Size and shape may be highly important where processing is automated rather than manual. Some vegetables undergo color changes as part of the ripening process. In some cases, fruit color is a strong indicator of eating quality and shelf-life, for example, tomatoes. Many pre-harvest factors can affect fruit color independently of other ripeness characteristics. So, for example, the peel of oranges grown in tropical regions may remain green despite having attained acceptable eating quality. Yellowing of green vegetables such as broccoli and spinach will reduce their quality as may browning of cut tissues, for example butt-ends of Brussels sprouts. Other aspects of appearance which reduce quality include the loss of freshness, like the wilting of leafy crops, loss of surface gloss or skin wrinkling and the development of external and internal defects caused either by natural senescence, physiological disorders or the growth of disease organisms.

B. Texture

Eating quality includes a complex of textural properties which are not readily defined or measured. Crisp firm tissues are generally desired in vegetable crops; however, the development of tough fibers during storage in stem crops such as asparagus is not at all acceptable. Some aspects of texture can be judged visually as described above, for example, where produce has begun to wilt or shrivel. Although some degree of softening is required for optimal quality in fruit, over softening is undesirable and is a sign of senescence or internal decay. The maintenance of textural quality is often critical in certain types of processing, for example in canning and freezing.

2.1.3 Flavor and aroma

Flavor is a complex of taste and aromatic components. Total flavor can rarely be assessed by the consumer prior to purchase but it is critical in the repeat purchase of a particular product or product cultivar. Key taste components in fresh produce are sweetness, acidity, astringency and bitterness. Sweetness of some fruits may increase dramatically during ripening owing to starch to sugar conversions, for example in apples, bananas, mangoes and pears. Sugar levels of fruits are often measured to determine whether produce has reached the required ripeness for marketing.

Sugar levels do not usually fall significantly during storage; however, maintaining the sugar to acid balance can be important to the fruit flavor balance, for example, in citrus species and grapes. Acid levels generally decrease during storage. If the acid/sugar ratio falls too low, the product can become bland and lose acceptable eating quality. This will also be of importance in processed products in which extra sugars or acids are not added. Bitter components can develop in various fruits and vegetables under certain storage conditions. Aroma can be determined to some extent before purchase by the consumer but it tends to be important as a positive factor only in highly aromatic products such as certain cultivars of melons. With the emphasis on visual quality which has dominated retailing, it has been claimed that flavor and aroma have been lost from many fresh products as breeding has concentrated on cultivars which will survive the rigors of post-harvest handling without loss of visual and textural quality.

The specific qualities required in vegetables will depend on their endues and the selection of appropriate cultivars for particular products is of paramount importance. The quality of an individual product is also affected by its specific preharvest 'experience'. So, for example, the position of a fruit on the tree will determine its nutrient and water status and its exposure to environmental factors such as sunlight or pests and diseases. All these factors may ultimately influence post-harvest shelf-life (Hofman and Smith, 1994) [10].

3. Vegetable post harvest loss in Ethiopia

Agriculture in Ethiopia has not made such a contribution in the past because of the various constraints associated with it. Such constraints include the lack of integrated post-harvest technology. Losses after harvest are a major source of food loss. Farmers growing horticultural crops are facing high economic loss, because there have been no methods of increasing the shelf life of these crops. Besides the country is not getting foreign exchange from horticultural crops due to the low levels of postharvest technology, which makes the product of inferior quality, with no chance of competing in the world market. There are not enough processing plants and the country is losing foreign currency by importing processed products. On the other hand, the post-harvest losses of perishable (vegetable) food crops amounted to about 30 -50 percent. High moisture content, insect infestation and damage during handling (packaging, storage and transportation) were the main causes of crop losses. Appropriate packaging materials, proper storage facilities and transportation are required to minimize these losses. Absence of toxicity and anti-nutritional factors in the raw materials are also important conditions in determining the quality and safety of processed foods (Shimelis Admassu, 2011) [13].

According to Ethiopian Agricultural Research Organization (EARO), 2000. The major problem is that post-harvest technology has been given less emphasis both by concerned bodies and the public. Consequently, consumers show little interest in consuming processed foods, and remain with their traditional food habits. Therefore, lack of awareness has negatively affected the development of the post-harvest sector throughout the country (EARO, 2000).

Interviews conducted in Ethiopia reported a very wide range of estimations of postharvest losses (Tadesse, 1991).

Table 2: Estimated Postharvest Losses **of** Fruits **&** Vegetables in Ethiopia based on Interviews

No	Vegetable	Loss of %
1	Tomato	19.4
2	Melon	16.7
3	Onion	10.7
4	Potato	6.0
5	Sweet potato	2.9
6	Beet root	2.7
7	Green bean	2.2
8	Sweet pepper	2.0
9	Cabbage	1.1
1o	Carrot	1.1

Source: (Tadesse, 1991).

4. Post-harvest loss Management options on vegetable crops

4.2. Traditional management methods of post-harvest loss in vegetable crop

The post-harvest loss and quality deterioration were prevented by traditional methods such as tree shade, storing in small hut or house, covering with clean straw, leaves and sorghum stalks for insulation and to avoid direct sun burn. Another traditional method used to protect post-harvest loss and quality deterioration of vegetable crop was maintaining relative humidity by reducing temperature of the product or container or storage in order to reduce the evapo- transpiration. The second technique used to maintain the relative humidity was by increasing the moisture of the air around the commodity by sprinkling, spraying and wetting the floor of store room, container or the commodity itself. In addition, vapor barrier materials such as polyethylene liner and bags and sacks, cloth coated boxes, fresh leaves and grasses and other variety of inexpensive and recyclable packaging materials were used. Despite these, wilting, shriveling, shrinking, and flaccid, decrease in weight and textural changes were commonly. Curing of tuber crops such as sweet potatoes and potatoes was practiced to be stored for a length of time. They store the product at high temperature and high relative humidity in order to minimize wilting and decaying.

The use of farm field for temporary storage was practiced by a few respondents for some commodities by storing under big tree, caves or burying under the soil. The temporary storage of horticultural crops in the farm and human residence was in poor quality.

4.3. Success of postharvest technologies

Successful postharvest handling of vegetables requires carful coordination and integration of the various steps from harvest operations to consumer level in order to maintain the initial product quality. Two of the most critical means for maintaining vegetable quality during postharvest handling are minimizing mechanical injury and managing temperature. there is an urgent need to minimize postharvest losses through proper handling, temperature management preservation & processing activities significantly reduce losses due to decay and accelerated senescence.

Reducing post-harvest losses through appropriate post-harvest technologies has far-reaching benefits. As developing countries integrate into the world economy, the implementation of post-harvest technologies can enable these countries to improve the quality of their agricultural produce in domestic and international markets at competitive price.

1. Harvesting

Many post harvest losses are a direct result of production management. Vegetables that are affected by weeds, pests and diseases, inappropriately irrigated and fertilized, generally of poor quality before harvesting, or harvested past optimum maturity can never be improved by post harvest treatments. Harvested Vegetables are living, breathing parts of plants and contain 65 to 95% water. Once harvested their internal food and water reserves decline over time and vegetables deteriorate and rot. Anything that increases the rate at which food and water reserves are used up increases the rate of deterioration.

Quality cannot be improved after harvest. Produce must be harvested at optimum maturity. Produce harvested when the sun is up has high temperature which increases quality loss; so, allow them to dissipate heat under shade. Determination of maturity indices for each vegetable is important in enhancing the knowledge of growers through training and extension. Vegetables are harvested over a wide range of maturities, depending upon the part of the plant used as food. The following table provides some examples of maturity indices of vegetable crops.

Table 3: Maturity indices of vegetable crops**.**

Crop	Index
Root, bulb and tuber crops	
Radish and carrot	Large enough and crispy (over-mature if pithy)
Potato, onion, and garlic	Tops beginning to dry out and topple down
Yam bean and ginger	Large enough (over-mature if tough and fibrous)
Green onion	Leaves at their broadest and longest
Fruit vegetables	Well-filled pods that snap readily
Cow pea, nap bean,	
sweet pea, and winged bean	Desirable size reached and the tips of which can be snapped readily
Okra	Desirable size reached but still tender (over-mature if color dulls or changes and seeds are tough)
Eggplant,	Exudes milky sap from kernel if cut
Sweet corn	Seeds slipping when fruit is cut, or green color
Sweet pepper Tomato	Deep green color turning dull or red turning pink
Flower vegetables	Curd compact (over-mature if flower cluster elongates and become loose)
Cauliflower	
Broccoli	Bud cluster compact (over-mature if loose)
Leafy vegetables	Big enough before flowering
Lettuce	
Cabbage	Head compact (over-mature if head cracks)
Celery	Big enough before it becomes pithy

Source: (Bautista, O.K. and Mabesa, R.C. (eds). 1977.) [16].

2. Time of harvesting

A critical time for growers of fruit and vegetables is the period of decision on when to harvest a crop. Normally any type of fresh produce is ready for harvest when it has developed to the ideal condition for consumption.

Harvesting should be carried out as carefully as possible to minimize mechanical injury such as scratches, punctures and bruises to the crop. This should be carried out during the cool part of the day, which is early morning and late evening harvest crop at a matured green state. Immature fruits may not ripen and fruits which are already ripe will have short storage life.

Harvesting in vegetable crops is the most important phase. Unless this operation is carried out with maximum efficiency, later prevention of food loss activities may be a waste of time. If, for example, roots and tubers are bruised or otherwise damaged during harvesting, consideration of improved handling or packaging is not likely to be worthwhile, since an early infestation with moulds and virus will occur and rotting will have started.

If harvesting operations are correctly undertaken there is greater scope for later introduction of improved methods. Provision of the proper tools and equipment for harvesting and training workers in their correct use should be a priority prevention of vegetative loss activity.

Use of proper harvesting equipment also reduces mechanical damage. Washing after harvesting is important for the removal of field heat. Use of proper sorting and grading systems increases the shelf life of produce, as well as grower income. The harvested crop should be taken to a shady place, packed at a "Packaging Center." (©Asian Productivity Organization, 2006) [15].

In general, harvesting during the coolest time of the day (early morning) is desirable; the produce is not exposed to the heat of the sun and the work efficiency of the harvesters is higher. If harvesting during the hotter part of the day cannot be avoided, the produce should be kept shaded in the field to minimize product weight loss and wilting. Carefully harvest in early morning when plants are brittle and prone to damage. Do not harvest during or just after rain as wet conditions favor product spoilage. If not, washing and drying must be done (Bautista, O.K. and Mabesa, R.C. (eds). 1977) [16].

3. Harvesting technique

A. By hand: In developing countries, most produce for internal rural and urban markets is harvested by hand. Larger commercial producers may find a degree of mechanization an advantage, but the use of sophisticated harvesting machinery will be limited for the most part to agro-industrial production of cash crops for processing or export or both. In most circumstances, harvesting by hand, if done properly, will result in less damage to produce than will machine-harvesting.

B. Machine-harvesting: is usually viable only when an entire crop is harvested at one time. Most staple roots and tubers that

grow beneath the soil are likely to suffer mechanical injury at harvest because of digging tools, which may be wooden sticks, machetes (or cutlasses, pangs or bolos), hoes or forks. Harvesting of these crops is easier if they are grown on raised beds or mounds, or "earthed up" as is common in potato-growing. This enables the digging tool to be pushed into the soil under the roots or tubers, which then can be levered upwards, loosening the soil and decreasing the possibility of damage to the crop. Other root crops, such as taro, carrots, radishes, etc. can be loosened from the soil in a similar manner by inserting the tool into the soil at an angle and levering the roots upwards. In Vegetables (leafy vegetable) **e**ither the whole or a part of vegetative growth can be harvested by hands only or sharp knives. Knives must be kept sharp and clean at all times or they may spread virus diseases from plant to plant. Harvesting methods vary with plant parts harvested:

- above-ground part of the plant (cabbage, lettuce): the main stem is cut through with a heavy knife, and trimming is done in the field (the cut stem must not be placed on the soil);
- Bulbs (green onions, leeks, mature bulb onions): immature green onions can usually be pulled from the soil by hand; leeks, garlic and mature bulb onions are loosened by using a digging fork as for root crops (such as carrots) and lifted by hand.. Simple tractor implements are available for undermining bulbs and bringing them to the surface.
- Immature flower heads (cauliflower, broccoli) can be cut with a sharp knife and trimmed in the field; broccoli can be snapped off by hand and subsequently trimmed (FAO; 1985) [8].

4. Field handling

Proper implements and care in handling produce from field to pack house reduce damage and preserve quality. Sorting and packing (packinghouse operations), and loading to vehicle for transport to market can be done in the field.

Mechanical injury provides sites for pest attack and increases physiological losses. Therefore, avoid mechanical injury to the crop while handling. Because of their soft texture, all horticultural products should be handled gently to minimize bruising and breaking of the skin. Vegetables should not be exposed to the sun. Crops should be transferred promptly after harvest to a clean, cool, well-ventilated shed.

5. Pack-house operation

Activities to prepare produce for markets; include cleaning, sorting/grading, commodity treatments, and packing. Facility for the various preparatory activities, Preparing harvested vegetables as per the requirement of the market, Maintaining harvest quality as long as possible, reducing damages during the handling processes Infrastructure requirement of pack-house to meet the type of vegetables, the standard required by the market (for fresh market or processing industry),the volume of produces, Cost, Skill and availability of labor. Harvest quality must be maintained throughout the pack-house operations.

Packing of the roots is usually done in the field. Farmers commonly pack the roots and strategically place the large roots at the top on the bag to quickly attract the buyer on first sight. Packing should minimize deterioration of the roots within the container and cushion against impact and compression. During packing in the field care must be taken to minimize physical damage that results from impact bruises due to stacking and overfilling of bags, abrasion or vibration bruises due to root movement against each other. Therefore packages should be neither loose (to avoid vibration bruising during transport) nor overfilled, and should provide good aeration (Bautista, O.K. and Mabesa, R.C. (eds). 1977) [16].

A. Trimming

Removing undesirable parts of harvested vegetables are outer leaves of cabbage & cauliflower, Feeding roots of tuberous roots, Top parts of carrots. Cabbage was handled manually at all of the visited farms by trimming the stems with a sharp knife and peeling leaves. The speed of this operation is entirely dependent on the efficiency of the workers and the quality of the crop (Blanchard, Chris Works, Flying Rutabaga, 2013) [17].

B. Curing

Spreading or heaping of harvested produces under shade to harden skins (potato, S. potato, onion), facilitate healing of cut portions (potato,onion) At harvest, growers take steps to fully dry the outer layer and seal the neck of the bulb and the leaf pores against water loss and the invasion of disease-causing bacteria and fungi.

Thorough curing greatly eases and speeds the removal of dirt, loose skin, tops, and roots. When removing dried alliums from refrigerated storage, condensation can cause the skins to soften and become difficult to clean (Blanchard, Chris Works, Flying Rutabaga, 2013) [17].

C. Sorting and cleaning

Sort out damage crops from undamaged crops. Remove dirt from sound crop before putting into transport containers. Injured, bruised, cut, over-sized, under sized, decayed, shriveled vegetables are sorted out, removes unwanted items from the lot. it is important in vegetable crops,Reduces chances of spoilage, It makes grading easy, It improves the quality of the produce For example removing wrapper leaves except for 3-4 for protection in cabbage and of damaged and yellowed leaves in Chinese kale, wiping tomato, bitter gourd, cucumber, and eggplant with clean soft cloth, washing to remove adhering soil and other debris. At a very small scale, most market farmers choose to use a tray and a hose to wash roots. By attaching an index-pensive shut-off valve to the hose, a pressurized spray can be achieved by closing it part way, similar to putting one's thumb over the end of the hose (s e e p h o t o b e lo w)

D. Grading

Vegetables, in particular those destined for sale in traditional markets, are neither sorted nor graded. Physical and quality losses are incurred owing to mechanical damage and to contamination of good quality produce by physically damaged and poor quality produce. Grading systems for vegetables are generally far from satisfactory, and are usually based on subjective personal judgment. This subjective evaluation includes consideration for physical attributes of the produce such as size, quality, and variety, rather than well-defined and highly acceptable standards. Market players are often reliant on specifications set by buyers. Thus, there is a need to establish grades and standards for vegetables that are acceptable to all stakeholders of the vegetable industry Graded vegetables have good demand in the market & also fetch high prices & high aesthetic value.

E. Packaging

Proper packing is essential to maintain the freshness of leafy vegetable. Packaging should be designed to prevent premature

deterioration in product quality, in addition to serving as a handling unit (Bautista and Acedo, 1987) [18]. Use clean, smooth and ventilated containers for packaging. This is a very important factor in cutting down losses in these crops during harvesting, transportation, marketing and storage. Use containers that are appropriate for the crop.

The "Fresh Produce Concept" introduced by the Institute of Postharvest Technology is mainly focused on introducing maturity indices, time of harvest, sorting and grading of produce followed by suitable packaging material to reduce handling and transport losses in vegetables. The introduction of returnable and testable plastic crates in postharvest handling will reduce postharvest losses in vegetables, particularly during transportation. The use of plastic crates was found to reduce mechanical damage and senescence of fruits and vegetables, thereby providing high quality fresh produce to the end user (©Asian Productivity Organization, 2006) [15].

Poor quality packages such as sacks or baskets will allow the produce to be bruised, squashed and receive abrasions during handling and transport to market, and this damage will allow postharvest decay organisms to gain easy entry. Most postharvest organisms cannot gain a foothold if the produce has not been damaged or allowed to become stressed (from heat or water loss), so avoiding any abrasions, cuts or bruises will immediately reduce decay rates.

G. Pre-cooling

Pre-cooling units facilities removing of field heat from harvested vegetables especially during hot weather as soon as possible after harvest. This technology leads to a reduction in plant or plant part the following, Ethylene production, pathogen infection, delaying ripening and it reduces physiological losses caused by respiration and transpiration, It retard ripening and senescence and losses in quality, It prevents the growth & development of spoilage microorganisms, thus prevents decay. Pre-cooling concept still limited for small-scale growers. Some horticultural crops such as tomatoes require forced air cooling to avoid excessive water loss, and provide high humidity cooling air. Methods used to pre-cool vegetables: Hydro cooling (dipping in cold water) alone or together with ice packing can be done without use of expensive equipment),Top icing: placing ice on vegetables or in package, Forced air cooling, vacuum cooling (for leafy vegetables), Cold storage.

H. Transport to packing house

Where produce is placed awaiting transportation Fresh produce must be placed in the shade as they are still alive and carrying out physiological activities; away from source of contamination. Use of appropriate vehicle and loading loose versus packaged (avoid mechanical damage), Loose cushioning vehicle; Packaged.

6. Storage

According to Yohannes Agonafar (1998) [4]. One of the major problems in potato production and marketing in Ethiopia is high post-harvest loss. A post-harvest loss of 30-50% of the produce was reported in some studies. Lack of adequate storage is the major reason for post-harvest loss. He study, 63% of the producers in AtsibiWonbertata and 62% in Saesi-TseadaEmba stated shortage of warehouse as the major problem resulting in post-harvest losses (Yohannes Agonafar, 1998) [4].

Only crops with high initial quality can be stored successfully; it is therefore essential to ensure that only crops of the highest quality (mature, undamaged) are stored. Shelf life can be extended by maintaining a commodity at its optimal temperature, relative humidity and environmental conditions (Bautista, O.K.; Acedo, A.L. Jr. 1987) [18].

If produce is to be stored, it is important to begin with a high quality product. The lot of produce must not contain damaged or diseased units, and containers must be well ventilated and strong enough to withstand stacking. In general, proper storage practices include temperature control, relative humidity control, air circulation and maintenance of space between containers for adequate ventilation, and avoiding incompatible product mixes.

Commodities stored together should be capable of tolerating the same temperature, relative humidity and level of ethylene in the storage environment. High ethylene producers (such as ripe bananas, apples, and cantaloupe) can stimulate physiological changes in ethylene sensitive commodities (such as lettuce, cucumbers, carrots, potatoes, sweet potatoes) leading to often undesirable color, flavor and texture Changes.

Temperature is the single most important factor in the keeping quality of stored potatoes. Respiration, sprouting, water loss, relative humidity, chemical composition and the development of storage diseases are all influenced by temperature. Length of dormancy during storage is determined by variety, temperature and the physiological age of the tubers, all of which vary from year to year. At temperatures below 4.0oC most potato varieties will remain dormant during a normal storage season (up to 8 months) (Dr. Khalil I. Al-Mughrabi).

Temperature management during storage can be aided by constructing square rather than rectangular buildings.

The air composition in the storage environment can be manipulated by increasing or decreasing the rate of ventilation (introduction of fresh air) or by using gas absorbers. Such as potassium permanganate or activated charcoal. Large-scale controlled or modified atmosphere storage requires complex technology and management skills; however, some simple methods are available for handling small volumes of produce (Kader, A.A, 1993).

According to (T*essema Genanew, 2013)* [20]. the attainment of maximum possible storage is the goal of storage studies; usually combinations of treatments are used. Thus, waxing, low O2, high CO2 and ripening inhibitors are now and then combined to prolong storage life [6]. Conversely, optimum treatments for each ripening inhibition, endogenous ethylene (C2H4) are always a problem. Thus, many chemical formulations have been tried to keep the ethylene below the threshold level. Ethylene absorbents, such as Calcium chloride (CaCl2) and Potassium per management (KMnO4), in conjugation with controlled storage atmosphere have a notable commercial potential in the future (T*essemaGenanew, 2013)* [20].

The following three things must be done to ensure successful storage of fresh roots and tubers.

1. Carefully select only top quality roots and tubers without any signs of handling or pest or disease damage for storage;
2. Keep them in specially designed stores and
3. Check the stores at regular intervals. Many farmers do not routinely store fresh roots and tubers, but leave them in the ground until required. It is possible to store fresh roots successfully in specially constructed pits or in mounds, or clamp stores. For example, when storing potatoes, a field storage clamp is a low cost technology that can be designed

using locally available materials for ventilation and insulation. (Technical paper on FAO; Post-Harvest Losses ©ACF-January 2014) [21].

Seed storage is not easy, especially because temperature fluctuations and excessive light exposure cause its deterioration, availability of quality seed materials. It is crucial to guarantee a good seed storage method for communities that depend heavily on potato production. An efficient practice to overcome the storage problems of potato seed material is the use of DLS, which can be adapted to any existing on-farm storage. If a farmer is able to store his own seed potatoes in good condition, it enhances the probabilities of a good harvest the following season. DLS uses indirect natural light and good ventilation or airflow instead of low temperature to control excessive sprout growth and associated storage loss of seed potatoes. DLS is a low-cost method of storing seed potatoes and has been found to extend their storage life and improve their productivity. (*Gebremedhin Woldegiorgisa, KassayeNegasha, Atsede Solomona, AbebeChindia and BergaLemagab, 2003)* [22].

7. Transportation

Temperature management is critical during long distance transport, so loads must be stacked to enable proper air circulation to carry away heat from the produce itself as well as incoming heat from the atmosphere and off the road. In many developing countries traditional baskets and various types of trays or buckets are used for transporting produce to the house or to village markets. These are usually of low cost, made from readily available material and serve the purpose for transport over short distances. But, they have many disadvantages in large loads carried over long distances (i.e. they are difficult to clean when contaminated with decay organisms). However, packaging can be a major item of expense in produce marketing, especially in developing countries where packaging industries are not well developed. The selection of suitable containers for commercial scale marketing requires very careful consideration. Among the various types of packaging material that are available: natural and synthetic fiber sacks and bags as well as mould plastic boxes seem to be more suitable and have greater promise for packaging roots and tubers and for their transport to distant markets (Kiaya, Victor; 2014).

A complete description of compatible and incompatible commodities is available (Ashby *et al*., 1987). Fields and rural roads are usually bumpier than highways; thus, vehicles hauling the harvested crop from field to packaging house are generally not as capable of preventing shock and vibration damage as the tractor-trailer rigs will do. The delay of cooling of a crop is affected by the time required to load a vehicle in the field, the distance from field to packinghouse, the speed of the vehicle and the number of vehicles waiting to be unloaded at the packinghouse (Garner *et al*., 1987).

8. Processing and preservation

The unavailability of processing factories or redundancy in the available ones is also other challenge vegetable producers in developing countries are faced with. The solution to this challenge is to promote the use of low cost postharvest processing technologies that can be used to process the raw materials into a more durable form.(Isaac KojoArah 1* Ernest Kodzo Kumah2 EtornamKosi Anku2 Harrison)

Root and tuber crops (cassava, sweet potato, yam etc…) are both important household food security and income generating crops in many developing countries. Overcoming the perish ability of the crops, improving marketing, enhancing nutritional value and adding economic value through processing are the main strategic areas in for reducing postharvest losses. The various processing techniques are listed below: peeling and washing, grating, pressing/fermentation, sieving, frying/drying. All these techniques can be divided into: Traditional methods such as drying (production of dehydrated chips); improved methods of production of dehydrated chips such as: simple processing machinery developed by the International Potato Center "CIP" (washer, peeler, slicer and dryer). An important aspect of processing is that it is often intended to prolong the preservation period of a product under ambient conditions. The most appropriate products in this respect are dehydrated root and tubers products such as: potato products (starch and flakes).

Besides permitting better preservation, the drying and processing of root and tubers into dried chips and flour offers other advantages such as: facilitating transport and increased shelf life, creating new opportunities for the farmer such as new markets and new sources of income. Metal storage bins or water tanks made from smooth or corrugated galvanized metal sheets are used for storing dried products. Dehydration or sun drying is the simplest and lowest cost method of preservation and should be more widely promoted and used in developing countries because it converts a perishable commodity into a stable item with long storage life.(Technical paper on Post-Harvest Losses ©ACF-January 2014) [21].

9. Vegetable Marketing Systems

The vegetable postharvest and marketing system includes operations such as grading, packaging, transportation, wholesaling and retailing. Additional operations that might be included in the system are trimming, pre-cooling, storage, disease and insect control treatments, as well as prepackaging. Improvement at only one point of the marketing chain to preserve produce quality may be futile when the other points may serve as bottlenecks. A systems approach or an integrated improvement program covering all postharvest operations and procedures is necessary to guarantee success. For instance, if two operations in the postharvest handling system need to be improved, all other elements of the chain must be simultaneously improved. Improvement of only one operation may prove ineffective

10. Minimizing pathogen contamination during harvesting and postharvest handling

During harvesting operations field personnel may contaminate fresh fruits and vegetables by simply touching them with an unclean hand or knife blade. Portable field latrines as well as hand wash stations must be available and used by all harvest crew members. Monitoring and enforcement of field worker personnel hygiene practices such as washing hands after using the latrine are a must, to reduce the risk of human pathogen contamination. Workers who are ill with hepatitis A or who have symptoms of nausea, vomiting or diarrhea should not be assigned to harvest fresh produce.

Produce once harvested should not be placed upon bare soils before being placed in clean and sanitary field containers. Field harvesting tools and gloves should be clean, sanitary and not be placed directly in contact with soil. Field containers should be cleaned and sanitized on a regular basis as well as being free of contaminants such as mud, industrial lubricants, metal fasteners or splinters. Do not allow workers to stand in field bins during harvest to reduce pathogen spread by shoes.

Plastic field bins and totes are preferred to wooden containers since plastic surfaces are easier to clean and sanitize, which should be done after every use. If containers are not cleaned and sanitized after every use, they may become contaminated and then contaminate the next products which are placed in the container. Wooden containers or field totes are almost impossible toto sanitize since they have a porous surface and wooden or metals fasteners such as nails from wooden containers may accidentally be introduced into produce. Cardboard field bins if reused should be visually inspected for cleanliness and lined with a polymeric plastic bag before reuse to prevent the risk of cross contamination. Depending upon the commodity, produce may be field packaged in containers that will go all the way to the destination market or be temporarily placed in bulk bins, baskets or bags which will be transported to a packing shed. Employees, equipment, cold storage facilities, packaging materials and any water which will be contacting the harvested produce must be kept clean and sanitary to prevent contamination.

Shoe or boot cleaning stations may also be in place to reduce the amount of field dirt and contamination which enters the packing shed from field operations. Employee training regarding sanitary food handling practices should be done when an employee is hired and reviewed before they begin work each season (Kitinoja, Lisa Kader, Adel a, 2003)

11. Conclusion and Recommendations

Many factors contribute to post-harvest losses in fresh vegetables. The factors contributing to these losses includes; the initial quality of the crop, mechanical injury, temperature, humidity, handling given to the crop and storage atmosphere. It was also that a substantial amount of post-harvest losses have their origin in the pre-harvest stage for example used poor seed, improper application of mineral nutrition, poor Management of water frequently and traditional agronomic practices.

In view of these factors, a good sanitation management in all pre and post-harvest operations in vegetable crops will help in eliminating sources of infection and reducing levels of contamination. Proper timing and good methods of harvesting avoid of mechanical injuries will help in reducing quality and quantity loss in vegetable crops. It is clear that most post-harvest losses in perishable produce result from infection by fungi and bacteria (pre or post-harvest) and from inherent physiological activity although insect, rodents, nematodes and occasionally birds may cause significant losses under certain conditions. As developing countries integrate into the world economy, the implementation of post-harvest technologies can enable these countries to improve the quality of their agricultural produce in domestic and international markets at co0m000.0petitive price. Generally good sanitation practices in all post-harvest operations are a very important factor in eliminating sources of infection and reducing levels of contamination. Monitoring and enforcement of field worker personnel hygiene practices such as washing hands after using the latrine are a must, to reduce the risk of human pathogen contamination.

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