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DEPARTMENT OF HORTICULTURE

ASSESSMENT OF THE POSTHARVEST HANDLING OF SIX MAJOR VEGETABLES IN TWO SELECTED DISTRICTS IN ASHANTI REGION OF GHANA.

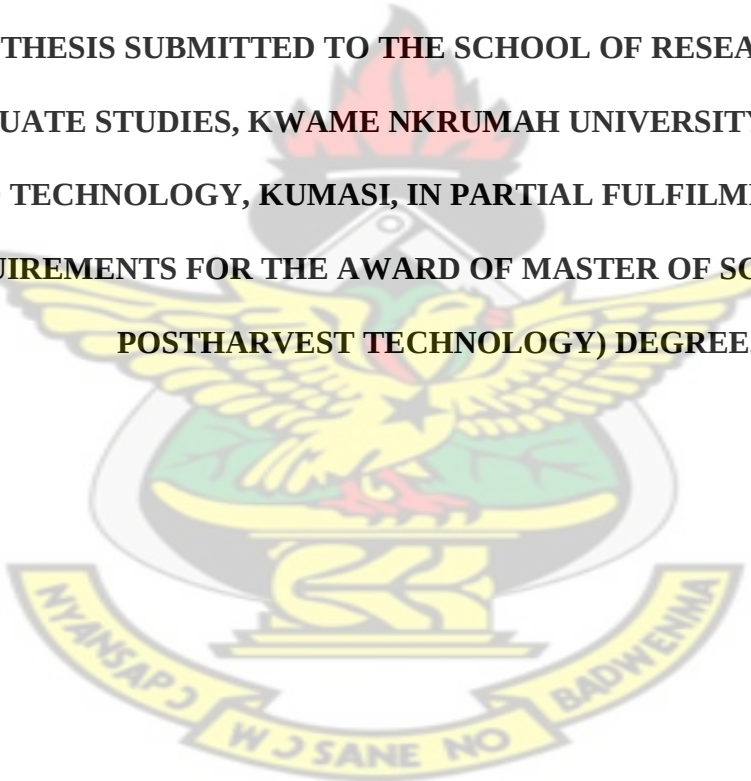
BY

ISAAC ADARKWA

SEPTEMBER, 2011

ASSESSMENT OF THE POSTHARVEST HANDLING OF SIX MAJOR VEGETABLES IN TWO SELECTED DISTRICTS IN ASHANTI REGION OF GHANA.

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MSC. POSTHARVEST TECHNOLOGY) DEGREE.



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DECLARATION

I, hereby declare that, except for references to other people's work which have been duly acknowledged, this write-up, submitted to the School of Research and Graduate Studies, KNUST, Kumasi is the result of my own original research and that this thesis has not been presented for any degree elsewhere.

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ABSTRACT

The survey was carried out in Mampong and Kumasi districts in the Ashanti Region of Ghana to assess the postharvest handling (precooling, transportation, packing, storage and value additions) of cabbage, carrots, onion, tomato, garden eggs and pepper. Three categories of respondents were sampled, namely, producers of these vegetables, vegetable marketers and consumers. The producers were assessed on practices such as precooling of vegetables, means of transporting their produce to the marketing centers. Marketers were also assessed on value addition to vegetables before sales, packaging materials used and the means of storing vegetables. Consumers who were sampled from educational institutions, hotels, restaurants, chop bars and individual households were assessed on methods of storing vegetables. Ninety percent and 60% of vegetable producers in Kumasi and Mampong respectively did not precool their produce after harvest. Eighty percent of producers in Kumasi used vehicles to convey produce to the marketing centers while 74% of producers in Mampong carried their vegetables on their heads to the marketing centers. In both study areas, producers had no storage facilities. Marketers preferred the use of polythene materials for packaging to sacks, baskets, plastic and metallic containers. Fifty six percent of respondents in Kumasi and 38% in Mampong used polythene. The value addition to vegetables was mainly washing, removal of unwanted parts and sprinkling of cold water on vegetables. Diseases and pests found on vegetables were not treated by all the three categories of respondents. Consumers of vegetables in Kumasi preferred refrigeration of vegetables to drying and steaming. Fifty eight percent refrigerated their vegetables while in Mampong only 14% did refrigeration. In Mampong 58% did not have any means of storing their vegetables as compared to 8% in Kumasi.

Table of Contents

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

1.0 INTRODUCTION

Vegetables play an important role in food security. They are the major sources of vitamins and minerals in the human diet (Pamplona, 2008). Vegetables have been identified as sources of chemicals vitally important for the protection of human health. Of most significance are lycopene, carotenoids and alicin. In the agricultural sector, they are important in the supply of raw materials to the agro-based industries, employment for people and generation of foreign exchange among others. Most vegetable produce are only easily available in certain seasons of the year and because vegetables are perishable, methods have to be developed for their careful postharvest handling and or preservation. Postharvest handling of these vegetables is the proper treatments given to vegetables to ensure their availability in desirable conditions in times of scarcity. Consumption of fresh food is preferable as preservation usually destroys some nutritional value (Drechel *et al.*, 2010).

Most farmers aim at increasing yield but may not pay sufficient attention to the quality of the produce, leading to low market value. Poor handling contributes to postharvest losses through the use of certain common practices or failure in using certain practices known to reduce losses and helping maintain produce quality and safety. Most of these improper practices and conditions cannot be labelled technical problems as they cannot be solved by initiating new research or simply by extending well-proven technical information (Kitinoja and Kashmire, 2002). Often postharvest losses take time to develop and the specific cause of quality problems may not be fully understood by produce handlers along the chain (Kader, 2002).

A variety of methods of postharvest loss assessment can be used to pinpoint the sources of problems and to identify potential constraints to changing handling practices. Most involve direct observation of handling practices and the interviewing of key individuals regarding their standard practices (Kader, 2002). The United Nations Food and Agriculture Organisation (UN FAO) has published loss assessment manual for various commodities that focus on increasing physical losses (change in weight or quality) and losses in value (quality changes or decrease in market price per unit). Any method used for loss assessment must attempt to understand losses within the context of the whole system of production, handling and marketing of the commodity in question since what are considered losses vary by culture and economic situation.

Postharvest loss assessment studies have provided information that suggests that there are a variety of incentives and barriers to the adoption of new postharvest handling practices

(Jill, 2003). Some consumer groups may prefer processed or fresh cut produce and be willing to pay more for the convenience offered by these products, while other consumers might avoid them due to perceived nutritional or health concerns. Beliefs regarding the environment may influence food choices and can affect how buyers perceive produce wrapped in containers. Some local customs or consumer preferences lead directly to quality problems. Other cultural factors that can affect adoption of changes in horticultural technology include religious traditions, gender barriers, the local definition of losses and traditional secondary uses of low quality produce (example, animal feed, and food bank) (Khaledi, 2007).

Appropriate production practices, careful harvesting and proper packaging, storage and transport all contribute to good produce quality (Bachmann and Earles, 2000). Although, there is high production of vegetables in the selected districts, farmers do not obtain the expected income from their efforts because of produce is loss through improper handling. Assessment of the postharvest handling of these vegetables would make a way as to the proper handling which would increase the shelf-life of vegetables.

The objective of the study was therefore to identify and assess the postharvest handling practices of six major vegetables in two selected districts in the Ashanti Region of Ghana.

The specific objectives were to assess the means of transport, storage, and value additions to the six vegetables (cabbage, carrots, onion, tomato garden eggs and pepper) and also to assess the most commonly used postharvest handling techniques for these vegetables.

2.0 LITERATURE REVIEW

2.1 ORIGIN AND DISTRIBUTION OF CARROT

The modern cultivar carrot has been derived from the wild carrot (*Daucus carrota* L) found in Europe, Asia and Africa (George, 1989). The subspecies *Sativus* has been cultivated from the early times in the Mediterranean region and is now widely distributed in many tropical areas. It has been reported that carrots with purple roots were domesticated in Afghanistan and spread to the Eastern Mediterranean area under Arab influence in the 10th to 12th centuries and to Western Europe in the 14th and 15th centuries. At the beginning of the 17th century, in the Netherlands, repeated selections resulted in carrots with fleshy orange roots, and these carrots provided the basis for modern cultivars of *Sativus species*. The crop was introduced by Europeans around 1930 into Ghana (Sinnadurai, 1992).

2.1.1 Botany of Carrot

Carrot is a dicotyledonous herbaceous crop grown for the enlarged tap root. The wild form is an annual but the cultivated crop which is believed to have been derived from the wild type is biennial. The main or the tap root becomes thickened and swollen, and varies in shape and size. The size of the root can vary from 2cm to 6cm in diameter and from 6cm to 9cm in length. The cross-section of the root reveals two distinct zones, the outer zone where sugar and carotene are mainly stored, and some white woody inner central core which tastes less palatable. The leaves are alternate 2-3 pinnate, segmented divided with normally long petiole and often forms stealth at the base. The inflorescence is compound umbel 3 to 7 in diameter, and is borne on a much branded stalk. The flowers which are normally white or pink are small with 5

sepals and petals with hairy ovary. Carrot's flowers are protandrous and are therefore cross pollinated, however, the possibility of self pollination always remains, because of its extended flowering period (George, 1989), the fruit is oblong to avoid in shape 3-4 mm long and ridges with hooked spines. The stem is solid and condensed at the proximal part of the root (Tindall, 1983).

2.1.2 Nutritional and Health Benefits of Carrot

Carrot is one of the major sources of vitamin A. This vitamin is required for the protection of most tissues of the body example; the respiratory tract, for vision and growth of children. Carrots are good source of vitamin A because although they do not possess the actual compound (retinol) their carotene content (also known as provitamin A) is converted by the body into vitamin A (Arthey, 1975). It also contains appreciable quantities of thiamine, riboflavin (Thompson and Kelly, 1957). The roots are used as vegetables and for preparing soups, stew curries and other dishes; the grated root is used in salads, the tender roots are prickled. The roots and tops can be fed to livestock. The seeds contain an essential oil which is used for flavouring and in perfumery (Purseglove, 1986).

2.2 ORIGIN AND DISTRIBUTION OF PEPPER

Peppers (*Capsicum spp*) are the world's second most important Solanaceous crop after tomato (Yoon *et. al.*, 1989). Its original home is tropical America specifically Mexico where there is evidence that it had been in use since 7,000 BC (Smith, 1968). The crop is said to have reached West Africa and for that matter Ghana through the Portuguese traders during 15th century (La Anyane, 1963). "Legon 18", "shito adope" and "bird eye" are the cultivars for production in the country (MOFA, 2007).

2.2.1 Botany of Pepper

An annual or short-lived perennial herb, up to 1.5 m in height. It has a well developed tap roots, branched, erect or semi-prostrate, fleshy, often soft woody at the base, round or slightly angular; growth normally indeterminate. The leaves; alternate, simple, ovate to lanceolate, margins entire, tip pointed, variable in size, up to 12 cm long, 7.5 cm wide. Single flower; sepals 5, campanulate, sometimes expanding with fruit development; petals 5 or 6, white green, up to 15 mm in diameter; anthers 5or 6, style with capitulate stigma. The fruit is a many seeded berry, hollow, rectangular to long, with 2 or more locules, variable in colour and pungency, 1-15 cm long, 1-4 cm in diameter. The seed is flattened and kidney shaped, 3-5 mm in length, pale yellow; 1000 seeds weigh approximately 5.5 g. Pepper is both self and cross pollinated. Cross pollination being about 16% (Purseglove, 1968).

2.2.2 Nutritional and Health Benefits of Pepper

All peppers are rich in vitamin A, C, and K, but red peppers are simply bursting with them. Antioxidant vitamins A and C help to prevent cell damage, cancer, and diseases related to aging, and they support immune function. They also reduce inflammation like that found in arthritis and asthma. Vitamin K promotes proper blood clotting, strengthens bones, and helps protect cells from oxidative damage. Red peppers are a good source of the carotenoid called lycopene, which is earning a reputation for helping to prevent prostate cancer as well as cancer of the bladder, cervix, and pancreas. Beta-cryptoxanthin, another carotenoid in red peppers, is holding promise for helping to prevent lung, cancer related to smoking and secondhand smoke. Besides being rich in phytochemicals, peppers provide a decent amount of fiber. Both hot and sweet peppers contain substances that have been

shown to increase the body's heat production and oxygen consumption for about 20 minutes after eating. The serving size of one pepper contains; fat-<1g, saturated fat-0g, carbohydrate-4g, protein-1g, dietary fiber-<1g, sodium-4g, vitamins A-538lU for green pepper, 428 lU for red pepper and vitamin C-64 mg. (Anon.,2011).

2.3 ORIGIN AND DISTRIBUTION OF TOMATO

Tomatoes (*Solanum lycopersicon*) originated from the area lying between Mexico and the West coast of the South America. After its introduction into Spain in the 16th century, it was widely spread throughout Africa. In Ghana, tomato is the most important crop in recently established dry season gardens in Northern and Upper East Regions and in the Southern Volta Region. It is fairly important cash crop in the outskirts of urban areas in the forest zone. A flourishing tomato production also occurs in the Greater Accra area and in the Akomadan and Wenchi districts in the Ashanti and Brong Ahafo regions respectively (Obeng-Ofori *et al.*, 2007).

2.3.1 Botany of Tomato

An annual up to 2 m tall. The stems are hairy with a strong oduor. The terminal bud often becomes an inflorescence and growth is continued by an auxiliary bud. The flowers which are up to 2cm in diameter are borne in inflorescences of 4-12 flowers. The leaves are spirally arranged up to 3cm long and 10-15cm across. The leaf blade is lobed and divided. The calyx is short and remains green when the fruit ripens. The 6 petals are yellow and up to 1cm in height. Root: vigorous tap root with extensive fibrous roots (Rice, 1993).

2.3.2 Nutritional and Health Benefits of Tomato

The health benefits of tomato include urinary tract infections, skin ailments, diabetes, lowers hypertension, good for gut health and eyesight. Tomato is considered both as a vegetable and fruit and forms an integral part of cuisine round the globe. It boosts up the health of a person if consumed daily. It contains numerous antioxidants which combat various types of cancer. They contain lycopene–one of the most powerful natural antioxidants. In some studies, lycopene, especially in cooked tomatoes, has been found to help prevent prostate cancer but other research contradicts this claim. Also tomato is rich in minerals and vitamins and also protects the heart from cardiovascular diseases. Also, tomato prevents urinary tract infections and hypertension and promotes eye health. The nutritional value contain in 100g of tomato include; protein – 1 gram, potassium – 360 mg, phosphorus – 27 mg, iron – 0.6 mg, calcium – 11 mg, vitamin C – 23 mg, thiamine (Vitamin B) – 0.06 mg, vitamin A – 1000 IU (Anon., 2011).

2.4 ORIGIN AND DISTRIBUTION OF CABBAGE

Cabbage (*Brassica oleracea var capitata*) is a temperate vegetable crop which has become very popular in tropical Africa. Its origin and centre of differentiation is thought to be in the west of the Mediterranean basin or in the Asia Minor (Romain, 2001). Cabbage was cultivated long before the dawn of human history. The ancient Greeks regarded it as an important vegetable. It was also very popular in Rome and it was introduced by the Romans into those lands which they conquered. The original home of cabbage is Southern Europe and the Mediterranean regions. The major areas of cultivation are Northern India, Indonesia, Malaysia, the Philippines, Central, East and West Africa, Central and South America and the Caribbean (Anon., 2011).

Cabbage is believed to have originated from Europe where the wild types are still found in Denmark, North-Western France and Eastern England. The crop was probably introduced by the British into Ghana. There is no record of the time of its introduction but the crop was grown on a small scale around 1940. It is still not a popular crop in the rural areas. It is a popular crop around urban towns and cities where the bulk of the crop is produced for the foreigners in the country (Obeng-Ofori *et al*., 2007).

2.4.1Botany of Cabbage

It belongs to the family Cruciferae (*Brassicaceae*). Cabbage is a biennial herb with a short, thickened stem surrounded by a series of overlapping expanding leaves which form a compact head. The head may be pointed or round and leaf colour and shape are variable (Timpo and Idun, 2010). Although, it is a biennial, it is cultivated as an annual. The leaves are undulating, broad, thick smooth or crinkled and covered with a waxy substance. These are clumped around a central bud on a short, stocky stem and form the head. The adult plant develops a root system with a secondary root branching out from the main roots between 45 and 60cm below the soil surface. Cabbage is not sensitive to photoperiod and flowering is triggered mainly by temperature below 10^{o}C. Because of this requirement for vernalization, seed production is difficult under tropical conditions. Depending on the growing season and the cultivar grown, yields vary between 10 and 40 tonnes per hectare. The best yields are obtained in cool, dry season with heads weigh between 2 and 2.5 kg. During the hot rainy season, a yield of an average weight of head is between 1 and 1.5kg (Romain, 2001).

2.4.2 Nutritional and Health Benefits of Cabbage

Cabbage has a very high nutritive value, supplying essential vitamins, proteins, carbohydrates and vital minerals (Norman, 1992). Tindall (1983) listed the nutritive components of cabbage leaves per 100g edible portion as follows: water – 93ml, calories – 23ml, protein – 1.5g, fat –0.2g, carbohydrates - 4g, fibre – 0.8g, calcium – 40mg, iron – 0.5, vitamin potency – 30iu,

thiamine – 0.05mg, riboflavin – 0.05mg, niacin – 0.3mg and ascorbic acid – 40mg. It has been known for the past 20 years that phyto-nutrients work as antioxidants to disarm free radicals before they can damage DNA cell membrane and fat containing molecules such as cholesterol. Now, new research is revealing that phytonutrients in crucifers such as cabbage work at a much deeper level. These compounds actually signal our genes to increase production of enzymes involved in detoxification. Recent studies show that those eating the most cruciferous vegetables have a much lower risk of prostate, colorectal and lung cancer -even when compared to those who regularly eat other vegetables (Lin, 2008). A University of Utah School of Medicine study on 600 men revealed that those who ate the most cruciferous vegetables had a much lower risk of colon cancer. A well known remedy for healing peptic ulcers is by drinking cabbage juice. A medical study at Stanford University's School of Medicine gave thirteen ulcer patients five doses a day of cabbage juice. All were healed within seven to ten days (Allen and Allen, 2009).

2.5 ORIGIN AND DISTRIBUTION OF ONION

Onion is believed to have originated in Central Asia, possibly in the Iran-Pakistan region. It has been cultivated since ancient times in the Middle East and India. It 'was

a popular food in ancient Egypt, where it is depicted on tombs as early as 3200 BC and has been found in mummies. The Sanskrit equivalent for onion is palandu which has been mentioned in the Garuda Purana. The great Indian sages, Maharishi Atreya and Lord Dhanwantri have described the use of onions in details. It is referred to in the Bible, when the Israelites complained of their hardships while being led by Moses from Egypt to the land of Canaan about 1500 BC remembering the onions that they ate in Egypt. Onion is frequently referred to in the literature from Hippocrates, 430 BC down to the present time. It is on record that the Jews loved onions so much that they named a city after it Onion. This city was built in 173 BC near the Gulf of Suez. Onion is now cultivated in most parts of the world, including India, Malaysia, Indonesia, Burma, Philippines, China, Egypt, West and East Africa, tropical South and Central America arid the Caribbean (Anon., 2011).

2.5.1 Botany of Onion

Allium cepa (L) belongs to the family, *Alliaceae*. Onions were formerly placed by some authorities in either the family *Liliaceae* or *Amaryllidaceae*. The *Alliaceae* family is an intermediate between the two. The onion is a biennial grown as an annual. It is characterized by a pungent alliaceous compound, allyl-propyl-disulphide. The onion bulb consists of thickened bases of leaves attached to a small conical steam. The bulbs vary from flat to round in shape. The leaves are long, round and hollow, often bluish in colour. The flowers are small in terminal umbel and corolla colour is often greenish white (Obeng-Ofori *et al*., 2007).

2.5.2 Nutritional and Health Benefits of Onion

Onions, and other *Allium species*, are highly valued herbs possessing culinary and medicinal value. Some of their beneficial properties are seen after long-term usage. Onion may be a useful herb for the prevention of cardiovascular disease, especially since they diminish the risk of blood clots. Onion also protects against stomach and other cancers, as well as protecting against certain infections. Onion can improve lung function, especially in asthmatics. The more pungent varieties of onion appear to possess the greatest concentration of health-promoting phytochemicals. Onions have a universal appeal. They are safely consumed by most people. However, consuming large quantities of onions can lead to stomach distress and gastrointestinal irritation that may result in nausea and diarrhea. There are no known interactions with drugs except that they can potentiate the action of anticoagulants (Winston, 2011). The onion bulb contains 88% water. A100 g edible portion contains energy, 31 cal; protein, 1.5g fat, 0.6g; total sugar, 7.2g; other carbohydrates, 0.3g; vitamin A, nil; thiamin, 0.04 mg; riboflavin, 0.02 mg ; niacin, 0.1 mg; Vitamin C, 7 mg, 30 mg; Fe, 0.5 mg; Mg, 16.5 mg; K, 150 mg; and Na, 7 mg (Obeng-Ofori *et al.*, 2007).

2.6 ORIGIN AND DISTRIBUTION OF GARDEN EGGS

[Garden eggs (*Solanum melongena*) is considered haven originated in the East Indies. Most of the European names for the plant are a corruption of the Indian name “brinjal”, e.g. in Portugal “berinjela”. The word “egg plant” derived from an early introduction of fruits which were small, white and ovoid (Messiaen, 1994). Grubben and Denton (2004) explain that garden egg is the result of the domestication of one wild and one semi-domesticated *Solanum* species that grow in tropical Africa (*S. anguivi* and *S. distichum*). The crop is widely cultivated across most of the African

continent, and more intensively in West and East Africa. Garden egg is also produced in Brazil (known as 'jilo') and occasionally in southern Italy and France (Grubben and Denton, 2004). Unlike in these latter countries, in Ghana garden egg is locally abundant, lacks significant knowledge and research investment, and has significant public and private value that has not been fully realized (Horna and Gruère, 2006).

2.6.1 Botany of Garden Eggs

Garden egg is scientifically known as *Solanum melongena* and belongs to the family Solanaceae. (Obeng-Ofori *et al*., 2007). The fruits may be pear shaped, round or long and cylindrical depending on the variety. The local types have white or red fruits. They can grow up to 90cm in height (Norman, 1992). Obeng-Ofori *et al*. (2007) also reported that the plant can attain a height between 0.6 to 1.2m and the root may extend to depths from 75 to 90cm in homogeneous soil. The plant can grow up to 1.5m.The Plant Resource of Tropical Africa (PROTA, 2004) reported that the plant can grow up to 2.0 m tall with much branches and alternate simple leaves with petiole up to 11cm long. Thus different plant heights may be obtained under different environment based on the variety.

2.6.2 Nutritional and Health Benefits of Garden Eggs

Some medicinal properties are attributed to the roots and fruits. They are described as carminative and sedative, and used to treat colic and blood pressure (Grubben and Denton, 2004). The nutritional content of garden egg is comparable to that of tomato, but it has a lower content of vitamin C. Nutritional value of 100g of garden eggs contain; water 90.6 g, energy 32 kcal, protein 1.5 g, fat 0.1 g, carbohydrate 7.2 g,

fiber 2.0 g, calcium 28 mg, phosphorus 47 mg, iron 1.5 mg, vitamin a - 70 iu, b carotene 0.35 mg , thiamin 0.07 mg , riboflavin 0.06 mg, niacin 0.8 mg, ascorbic acid 8 mg (Grubben and Denton, 2004).

2.7 POSTHARVEST QUALITY OF VEGETABLES

In recent years, consumption of vegetables has been increasing, especially as a result of changes in the consumer life style. This is particularly the case with ready-to-eat or minimally processed fruit and vegetables (Ragaert *et.al.*, 2004). Mechanical damage may cause alterations in the levels of antioxidants (Tomas-Barberan *et al*., 1997). Fresh-cut products are wounded tissues, and consequently they deteriorate more rapidly and their physiology differs from that of intact fruit and vegetables. Many of the postharvest treatments and storage conditions applied to fresh-cuts are designed to ameliorate the initial effects of wounding and wounding-induced responses. For both fruit and vegetables, wounding and mechanical injury result in increased rates of respiration and production of ethylene, with effects being observed very rapidly, often within minutes to a few hours (Rosen and Kader, 1989). As a result of physiological and microbial deterioration occurring during storage and marketing of fresh produce, and especially fresh-cut produce, there is an urgent need to develop effective, non-damaging treatments for maintaining the quality (appearance, flavour, texture, nutritional value) and food safety of fresh harvested produce (How, 1990).

2.8 PRODUCTION PRACTICES

Production practices have tremendous effect on the quality of fruits and vegetables at harvest and on post harvest quality and shelf life. In addition environmental factors

such as soil type, temperature, frost and rainy weather at harvest can have an adverse effect on storage life and quality. For instance, carrots grown on muck soils do not hold up as well in storage as carrots on lighter, upland soils (Herner, 1989). Environmental conditions and cultural practices during production have tremendous effects on produce quality, safety, and shelf life. Produce stressed by too much or too little water (by irrigation or rainfall), high rates of nitrogen fertilization, or mechanical injury (scrapes, bruises, abrasions) are susceptible to postharvest diseases. Brassicas are prone to bacterial soft rot if nitrogen is applied as foliar feed, thus nitrogen should be applied to the soil. Nitrogen above the optimal level did not result in reduced shelf life, while spraying nutrient solution appeared to be beneficial as it retarded yellowing. Potassium sulfate application also enhanced chlorophyll content and extended shelf life. Stress during growth has different effects on produce quality and shelf life. Sustained and intermittent water stress had mostly negative effects for vegetables (Jiang and Pearce, 2005).

2.9 PREHARVESTING INSPECTION

It is important to carry out field preharvesting inspection for crop maturity, quantities to be harvested and labour required. Before planting varieties chosen should be able to withstand harsh and adverse environmental conditions. The prevention of rot should be based on integrated program of good hygiene, careful handling and harvesting, minimum mechanical damage and reduced microbial attack. These are the most effective, non chemical and safe way to reduce wastage in the crop. Presence of pesticides and other chemicals on produce during this time reduces quality; therefore spraying should be at the correct time (Haleegoah *et al*., 2006).

2.10 HARVESTING

The method of harvest can determine the extent of variability in maturity and physical injuries, and consequently influence nutritional composition of fruits and vegetables. Mechanical injuries such as bruising, surface abrasions, and cuts can result in accelerated loss of vitamin C. The incidence and severity of such injuries are influenced by the method of harvest and handling operations. Proper management to minimize physical damage to the commodity is a must whether harvesting is done by hand or by machine (Ezell *et. al*., 1947). Fresh fruits and vegetables as living tissues are subject to continual changes after harvest. Such changes cannot be stopped but can be controlled within certain limits by using various postharvest procedures (Kader and Morris, 1978). Quality cannot be improved after harvest, only maintained; therefore, it is important to harvest at the proper maturity stage and at peak quality. Immature or over mature produce may not last as long in storage as that picked at proper maturity. Common cabbage and Chinese cabbage heads are harvested when firm and mature (Cantwell and Suslow, 2006). Compactness (firmness, hardness, solidity) of heads may be determined by hand pressure. A compact head can be only slightly compressed with moderate hand pressure. Delaying harvest even a few days beyond maturity can result in split or cracked heads and increased incidence of rots. Immature heads are puffy or have hollow spaces because the inner leaves are not fully developed and hence, loosely arranged, which make them susceptible to damage (Bautista and Acedo, 1987). When harvested immature, yield decreases and shelf life is shorter than that of mature heads. In certain cases, some sample heads of common cabbage or Chinese cabbage are cut longitudinally to observe the internal stem; if the stem is too long, the head is already over mature (Chen, 2007). Physiological age of the vegetable or the leaves within a plant could affect the rate of

postharvest quality loss. Young leaves (20–25 days after emergence) are more prone to moisture loss and subsequent wilting than older ones (40 days) (O'Hare *et al*., 2001).

2.10.1 Time of Harvesting

The time of the day when harvesting is done also affects produce quality and shelf life. In general, harvesting during the coolest time of the day (e.g. early morning) is desirable; the produce is not be 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 heat, weight loss, and wilting. Research showed that harvest time of day could affect quality. Vegetables harvested at these times maintained highest water potential, resulting in a slower rate of wilting than those with lower water potential (Jiang and Pearce, 2005). However, harvesting later in the day has an added advantage because sugar levels were found to be higher as a result of photosynthesis during the day (O'Hare *et al*., 2001).

2.10.2 Harvesting Method

Harvesting is done manually; hence the harvesters have a major influence on produce quality They should be made aware of the importance of good sanitation practices, proper maturity selection, and careful handling to avoid mechanical injuries. A cabbage head is harvested by bending it to one side and cutting it with a knife, which should be sharpened frequently to reduce effort and lessen picker fatigue. Cabbages and other leafy vegetables are harvested and trimmed using a special knife (Chen, 2007).

2.11 FIELD HANDLING

Postharvest fruits and vegetables are usually exposed to varying surrounding temperatures during handling, transportation, storage and marketing. During marketing, the surrounding temperature is usually higher than during shipping or storage (Cameron *et al*., 1993). Results from (Nunes *et al*., 2001). indicated that, even for short periods of time, fluctuating and/or high temperatures during handling might result in rejection of the whole load. Given such facts, it is obvious that something needs to be done in order to improve the conditions endured by horticultural products during postharvest handling in order to reduce losses and provide consumers with products of the best possible quality and safety. The harvested produce is usually placed in collection containers, which may be plastic crates or bamboo baskets with cotton or paper cushioning or padding (Chen, 2007). Throwing harvested produce into the collection container or vehicle should be avoided to prevent physical injuries. Handling aids such as boxes, farm trailer, or a simple conveyer can be used. Exposure of harvested produce to the heat of the sun is detrimental except in a few cases. Leafy vegetables left in the sun after harvest may reach temperatures as high as 50oC (Kanlayanarat, 2007). High product temperature accelerates quality deterioration due to increased water loss and respiration. If packed and transported without cooling, wilting and other deteriorative processes rapidly set in (Jiang and Pearce, 2005).

2.12 SORTING/GRADING

Systematic sorting or grading coupled with appropriate packaging and storage, will extend shelf life, maintain wholesomeness, freshness, and quality, and substantially reduce losses and marketing costs. Sorting is done to separate poor produce from

good produce, and further classify the good produce based on other quality parameters, such as size (Bautista and Acedo,1987).

2.13 TEMPERATURE MANAGEMENT

Temperature management is the most important tool to extend shelf-life and maintain quality of fresh fruits and vegetables. Delays between harvesting and cooling or processing can result in direct losses due to water loss and decay and indirect losses such as those in flavor and nutritional quality (Kader and Morris, 1978). The most important parameter for preserving produce quality and inhibiting pathogen development during the postharvest life, is an adequate storage temperature (Jacxsens *et.al.*, 1999, 2002). It is well known that low temperatures slow down plant metabolic processes such as respiration, ethylene production and, in general, enzyme activity. The best way to maintain the quality of fresh fruits and vegetables is undoubtedly by maintaining an adequate temperature throughout the postharvest handling chain. But as discussed above, a constant and optimum temperature is rarely either attained or maintained. (Nunes *et. al.,* 1995) In normal circumstances, vegetables are cooled by air blast cooling or in cold storage. However, this requires large storage surface area if vegetables are to be cooled correctly. In addition, in many cold storage installations vegetables are stacked in crates with a relatively small quantity of product per crate (Greidanus, 1971). The maintenance of a constant optimal temperature throughout postharvest handling chain (i.e. from the grower to the retail display) is one of the most difficult tasks and is far from being universally attained. Even when transport by truck or sea can provide satisfactory temperatures within the limits of acceptability, the transport time may be too long for short-life products to be transported over long distances (Emond *et. al*., 1996). In fact, the

fluctuating temperatures often encountered during the handling chain can have a very negative effect on the quality of horticultural crops (Nunes *et al*.,1999); Nunes *et al*., 2001). However, low temperatures may induce chilling injury and compromise produce quality. Correct storage temperature can vary from species to species and cultivar to cultivar. The most frequently used temperature is 4 ◦C, considered the optimal for many vegetables (Jacxsens *et al*., 2002). Because of the difference in the rates of change of permeability and respiration rate with temperature, a film that produces a favourable atmosphere at the optimal storage temperature may cause excessive accumulation of CO_2 and/or depletion of O_2 at higher temperatures, a situation that could lead to metabolic disorders (Beaudry *et al*., 1992). Results from (Nunes *et al*., 2001) indicated that, even for short periods of time, fluctuating and/or high temperatures during handling might result in rejection of the whole load. Given such facts, it is obvious that something needs to be done in order to improve the conditions endured by horticultural products during postharvest handling in order to reduce losses and provide consumers with products of the best possible quality and safety (Nunes *et al*., 2001). The most important vitamin in fruits and vegetables for human nutrition is vitamin C. More than 90% of the vitamin C in human diets is supplied by fruits and vegetables (Wills *et al*., 1984).

2.14 QUALITY CHARACTERISTICS OF VEGETABLES

Quality is a combination of characteristics, attributes or properties that give a commodity value in terms of human food. Quality makes a produce what it is: the combination of attributes or characteristics of a product determining its degree of acceptability. Produce quality requirements refers to market, storage, transport, eating and processing qualities. Post-harvest behaviour and quality of horticultural

products, which are mostly perishable, reflect the pre-harvest cultural and environmental conditions to which the produce is exposed. (Olympio and Kumah, 2008).

2.15 PRODUCE PACKAGES

Different kinds of containers are used for vegetables, depending on the market and value of the produce. For export and high-value vegetables, more rigid and presentable but expensive containers are used, such as foam box and cartons. For the local markets, bamboo baskets of different sizes and shapes are used (Adhikari, 2006). Rigid containers (plastic or wooden crates, cartons) are far much better than non-rigid containers (mesh bags, plastic bags) for protection of produce from damage during handling and transport. Rigid packages are also easier to stack or palletize. The different packages are described as follows: *Basket:* Usually refers to containers made of woven materials, which may be bamboo, rattan or plastic strips. *Box:* Usually refers to containers made of corrugated fibre board or Styrofoam. It may be a two-piece telescoping box, or a carton that closes with top flaps. The contents can be place-packed with liners and layer dividers, or bulk-filled. *Crate:* Usually refers to a wooden or plastic container. Wooden crates are usually wire-bound and may be collapsible (Adhikari, 2006). Plastic containers, a relatively new type of container, have good stacking strength and are water-resistant. Plastic crates for handling and transportation of vegetables were introduced recently in some developing countries. Plastic crates are increasingly used by farmers and traders, particularly in situations where their return and reuse can be guaranteed; the crates have been reported to reduce postharvest losses and improve quality and safety of vegetables (Adhikari, 2006). Container liners and cushions minimize physical injuries. Containers need to

be vented to effectively lower and maintain produce temperature for storage. Low density polyethylene (PE) film is generally used for packing fresh vegetables and fruit owing to its high permeability and softness compared with high density PE (Somjate, 2006). PE can be sealed easily, has good O_2 and CO_2 permeability, low temperature durability, good tear resistance, and good appearance. However, high-density PE also has been found to markedly reduce water loss of produce (Ben Yehoshua, 1978). Since PE bags are non-rigid, product volume per bag should be limited. In a study on packing 5, 10, and 15 kg vegetable per PE bag, it was found that losses due to weight loss, bruising and trimming increased with increasing product volume and were about 5.6%, 6.9% and 13.1%, respectively (Amuttiratana and Passornsiri, 1992). Plastic film packaging effectively reduced moisture loss and wilting and was considerably more effective than manual misting or treating leaves with anti-transpirant chemical (O'Hare et al., 2001). Plastic packaging maintains a very high relative humidity (RH), which necessitates sanitary washing before packing to avoid bacterial rot. In another modified atmospheric packaging (MAP) trial under supermarket conditions (ambient temperature of 28°C) using plastic film wrap (clingwrap), it was found that semi-packed performed better than fully packed and non-packed (Jiang and Pearce, 2005). Although the fully packed produce had less water loss, it tended to have more rot. Supermarkets preferred the semi-pack option from an aesthetic standpoint, as the fully packed produce tended to fog due to moisture condensation (Jiang and Pearce, 2005).

2.16 PRECOOLING

Precooling has been reported as among the most efficient quality enhancements for commercial producers and was found to rank as the most essential of the value-added

marketing activities, especially if cold storage facilities are available (Sullivan *et al*., 1996).

Research confirms that lowering the respiration rate of fresh vegetables is essential to preserving market quality and the most important technology for lowering respiration rates remains proper precooling of produce within hours of harvest. Proper precooling preserves product quality by: (1) inhibiting the growth of decay producing microorganisms; (2) restricting enzymatic and respiratory activity; (3) inhibiting water loss; and (4) reducing ethylene production. There are different precooling methods and among these, forced-air cooling and hydrocooling were found to be the most effective and economical in preserving optimum quality and increasing market life. Rapid cooling either by hydrocooling alone or in combination with package icing (ice packing) is essential to maintain the quality of leafy vegetables. Hydrocooling by dipping in cold water is simpler, but hydrocooled produce must be kept cool in order to prolong shelf life. Hydrocooling Chinese kale in 4oC water for 5–10 minutes prior to 7oC storage was found to reduce water loss and yellowing and extend shelf life (Kanlayanarat, 2007). Ice packing is a cheap form of cooling to extend shelf life but has not been widely adopted because growers were seldom in a position to easily access the loose ice and plastic packing containers required, which would lead to additional costs. Furthermore, the effect of ice is transitory; without proper insulating material, it melts quickly and the temperature returns to near ambient (Jiang and Pearce, 2005).

2.16.1 Optimum Storage Conditions

The optimum storage temperature for most temperate or semi-temperate/subtropical leafy vegetables, such as many brassicas, is close to 0°C while tropical produce, >10^{o}C. Relative humidity (RH) can influence water loss, decay development, and incidence of some physiological disorders. Condensation of moisture on the commodity (sweating) for a long time favors decay development. For most vegetables, RH requirement usually ranges from 90-98%. (Kader, 2002; Kader and Rolle, 2004). Optimum temperature is achieved by mechanical refrigeration. In refrigerated chambers, RH can be increased by (1) adding moisture (water mist or spray, steam) to air by humidifiers; (2) regulating air movement and ventilation; (3) maintaining temperature of the refrigeration coils within about 1^{o}C of the air temperature; (4) providing moisture barriers that insulate walls of storage rooms and transit vehicles; or (5) wetting the floor. Evaporative cooling principle can also be employed during packaging and transport. This technique can be used during transport of produce and after arrival at the destination market; however, the produce has to be taken out from the container because prolonged exposure to wet condition favours decay development. Covering the container with wet cloth can also cool the produce. In addition, the transport load can be transformed into an evaporative cooling and/or modified atmosphere chamber by lining it with wet cloth and/or plastic film (Chen, 2007).

2.17 ETHYLENE REMOVAL FROM POSTHARVEST CHAIN

Ethylene, being a senescence hormone, is destructive to the quality of vegetables as it accelerates different deteriorative processes. Ethylene removal from the postharvest chain, therefore, has far-reaching benefits. Preventing ethylene build up around the

product in packages and during storage, transport, and marketing is often the simplest method of reducing the damaging effects of ethylene. For ethylene-sensitive products such as leafy vegetables, it is important to avoid storing them with products that produce high levels of ethylene. Increasing the ventilation rate of the storage area is another way of reducing ethylene around fresh produce. Ethylene can be removed through different chemical processes. Potassium permanganate is usually used because it reacts with ethylene to produce carbon dioxide and water. To scrub the air efficiently, it is best to spread the potassium permanganate over as large a surface area as possible, either in trays or within highly permeable bags. An ethylene scrubber made of potassium permanganate impregnated onto clay-ash chip (a propriety Philippine product) has been developed. Ayoub *et al* (1987) also tested ethylene absorbing blankets containing alumina coated with potassium permanganate in two mixed loads of fruits and vegetables in two marine containers.

2.18 QUALITY DETERIORATION

Wilting due to water loss, senescence-associated discoloration (yellowing or browning), mechanical injury, high respiration rate, and decay or rotting are the main causes of quality deterioration and postharvest loss of leafy vegetables. These causes of quality loss are physiological, pathological, and mechanical in nature (Kanlayanarat, 2007).

2.18.1 Physiological Deterioration

Water loss and wilting. Leafy vegetables are mostly water (>90%) and have the propensity to lose water through transpiration (evaporation of water from plant tissues). Water loss is the main cause of weight loss (loss in saleable weight) and

wilting. A loss of 5-10% of fresh weight would make leafy vegetables to appear wilted and become unusable (Kanlayanarat, 2007). Water loss also induces degradation of nutritional components (e.g. vitamin C loss) and imposes stress (i.e. water stress) that increases respiration and ethylene production. Wilting is primarily due to water loss through the stomata (O'Hare *et al*., 2001). Water loss was measured at 2.8% per hour at 35°C. Complete closure of all stomata occurs between 10-15% moisture loss. *Respiration and ethylene production.* Prolonged exposure to ethylene, as low as 0.01 ppm, could cause significant losses of fresh produce. Ethylene easily accumulates in packages, packinghouses, storage areas, and even markets. All plant tissues produce ethylene, although at varying levels. In markets (wholesale, retail, distribution centers), the main sources of ethylene, in addition to the fresh produce, include ripening fruit, decaying produce, and exhaust gases of vehicles; concentration could reach 0.02-0.06 ppm, which can cause a 10-30% loss in product shelf life (Wills *et al*., 2000). The effect of ethylene is cumulative, so continuous exposure to a low concentration throughout marketing can cause significant harm. The loss of shelf life will be most frustrating for the final consumer, as the loss of quality will not be obvious during marketing and retail. Aside accelerating aging, ethylene increases product susceptibility to decay. Yellowing is found to be controlled by the sugar level (the main energy substrate) rather than ethylene, which explains the poor performance of anti-ethylene agents (e.g. 1-methylcyclopropene) in extending shelf life (O'Hare *et al.*, 2001).

2.18.2 Pathological Decay

Vegetables are susceptible to postharvest diseases that render the produce unfit to sell. Postharvest diseases can be spread through field boxes contaminated by soil or

decaying produce or both, contaminated water used to wash produce before packing, decaying rejected produce left lying around the packinghouse, and contaminated healthy produce in packages.

Microbial infection can occur both before and after harvest. The infection after harvest can be found at any time between the field and final consumer (Kanlayanarat, 2007).

2.18.3 Mechanical Injury

Vegetables are very susceptible to mechanical injury (physical damage). Tearing and crushing, midrib breakage, and head cracking or bursting are common forms of damage. Physical injuries increase physiological deterioration through browning as a result of oxidation of phenolics substances, and susceptibility to decay. Postharvest rots have been found to be more prevalent in bruised or damaged produce. Mechanical damage also increases moisture loss by as much as 3-4 times more than that of undamaged produce (Bachmann and Earles, 2000).

2.19 PREPROCESSING OPERATIONS

Vegetables may be washed with water in three different ways: soaking, washing by agitation, and spraying (Diamante, 2007). Washing vegetables with water can be manual or mechanized, depending upon the scale of operation. Soaking is not in itself an effective means of removing dirt but it is useful as a preliminary treatment to washing by spray or agitation. If the vegetables are agitated in water, the efficiency of the soaking process is greatly enhanced. Washing by means of water spray is by far the most satisfactory method. Vegetables that are heavily contaminated with soil

or other objectionable material should first be soaked thoroughly to loosen adhering soil before washing under spray. The efficiency of a spray of water for washing depends upon the pressure of the water, its volume, and also the distance of the spray nozzle from the vegetable to be washed (Diamante, 2007).

2.19.1 Washing and Sanitizing

Most vegetables are washed in clean water to remove dirt and other debris and surface contaminants. This is especially important during rainy weather as the produce often is contaminated with soil. In heading type of cabbages, washing is not advisable as it could favour bacterial soft rot if the heads are not properly dried. The wrapper leaves also keep the inner edible part clean. Sanitation is essential to control the spread of diseases from one item to another and limit the pathogen load in wash water or in the packinghouse air. Waterborne microorganisms, including postharvest plant pathogens and agents of human illness, can be rapidly acquired and taken up on plant surfaces (Kader, 2006). Natural plant surface contours, natural openings, harvest and trimming wounds can be points of entry and provide safe harbor for microbes. Chlorine in the form of sodium hypochlorite (NaOCl) solution (e.g. Chlorox or commercial bleach) or as a dry, powdered calcium hypochlorite, can be used in wash water as a disinfectant. For the majority of vegetables, chlorine in wash water should be maintained in the range of 75–150 ppm (Suslow, 1997; Bachmann and Earles, 2000). The antimicrobial form, hypochlorous acid, is most available in water with a neutral pH (6.5 to 7.5). Concentrations above 200 ppm may injure some vegetables (e.g. leafy greens and celery) or leave undesirable off-flavors. A 100 ppm chlorine solution can be prepared by mixing 4 tablespoons of commercial bleach (5.25% NaOCl) per gallon of water (Bautista and Acedo, 1987). Chlorine is routinely

used as a sanitizer in wash, spray, and flume waters used in the fresh fruit and vegetable industry (Beuchat and Ryu, 1997). Antimicrobial activity depends on the amount of free available chlorine (as hypochlorous acid) in water that comes in contact with microbial cells. Hydrogen peroxide (food grade) also can be used as a disinfectant. Concentrations of 0.5% or less are effective for inhibiting development of postharvest decay caused by a number of fungi (Bachmann and Earles, 2000).

2.19.2 Cutting

Vegetables require different cutting methods. For example, cabbage heads may be sliced into quarters as in the case in Cambodia (Buntong and Vanndy, 2007). However, there are fermentation procedures that require slicing (Thanh, 2007).

2.19.3 Blanching

Vegetables must be heated to a minimal temperature to inactivate natural enzymes before processing or storing, even when processed as frozen product (Diamante, 2007). This special heat treatment to inactivate enzymes is known as blanching. Blanching is not indiscriminate heating. Too little is ineffective, and too much damages vegetables by excessive cooking, especially when the fresh character of the vegetable is to be preserved by further processing. Two of the more heat-resistant enzymes in vegetables are catalase and peroxidase. If these are destroyed, then other enzymes that contribute to deterioration will be inactivated also. Effective heat treatments for inactivating catalase and peroxidase in different vegetables are known, and sensitive chemical tests have been developed to detect the amounts of these enzymes that might survive the blanching treatment (Diamante, 2007).

2.19.4 Salting Technology

Salting is done to draw water from the vegetables, impart a salty taste, inhibit or kill some of the microorganisms on the vegetables, and permit the survival of useful microorganisms.

Useful microorganisms (e.g. LAB) produce acids and flavor compounds by fermentation of sugars in the vegetables. A salting technology for Chinese cabbage was developed in Australia to supply the Japanese market with a raw material for pickled vegetable (Thompson *et al*., 2001).

2.19.5 Fermentation Technologies

Fermented vegetables are foods in which the acid is produced from sugar in the food product by fermentation with lactic acid bacteria (LAB) (Diamante, 2007). Nearly all vegetables can be fermented by LAB. They contain sugars and are nutritionally adequate as substrate for growth of LAB and other microorganisms. Relatively few species of bacteria are responsible for the fermentation of the majority of vegetable products. They develop in a natural sequence of species. The relative role of each species is governed primarily by environmental conditions.

Lactic acid fermentation enhances the nutritional value of a food product through increased vitamin levels and improved digestibility. It is extremely important in meeting the nutritional requirements of a large proportion of the world's population (Diamante, 2007).

2.19.6 Drying/Dehydration Technologies

Dehydration or drying is the simplest and most natural form of food processing (Srilaong,

2007). It preserves fresh produce by removing most of its free water. Reducing the water content of the produce slows the rate of respiration, enzymatic action, and overall deterioration rate, making the product less susceptible to decay and facilitating transport and long-term storage. It also reduces the cost of packaging, handling, storing, and transporting the material by converting it to a dry solid, thus reducing its weight and volume. While all vegetables can be dried, not all would be of high quality and good taste when dried. Most vegetables are dried to <5% moisture (Diamante, 2007). The vegetables can dry naturally in the sun (direct solar drying), via solar assisted methods (indirect solar drying), or with added ventilation and heat to speed the process (electric, gas, diesel or solar cell powered drier). Drying in the sun is the least expensive method, and quite viable if the climate is hot and dry during harvest time. However, it is the slowest method and often results in products of lower overall quality. Pre-drying treatments, such as steam or boiling water blanching and ascorbic acid dips, can help in reducing losses of flavor, color, and nutritional quality during the drying process. Value can be added to dried vegetables by enhancing flavor during drying, such as by adding spices. In general, during drying, the ambient air is heated and the heated air is brought into contact with food to remove moisture. When the air passes through the heater, the temperature of the air increases and the relative humidity decreases. The hot air will then pass through a bed of moist food and gives up heat that is used to evaporate free water from the food. Proper drying requires knowledge of three fundamental parameters (Kyi, 2007).

2.19.6.1 Simple drying

Solar drying. The simplest method for solar drying is to lay produce directly upon a flat black surface and allow the sun and wind to dry the crop (Srilaong, 2007). Solar drying works best in a hot and dry climate. When drying produce in the sun, the produce is exposed to the sun for the first 2-3 days, and then transferred to a ventilated shady spot to complete drying. In locations with a high relative humidity, solar drying may take too long to produce a high quality product. Solar dryers have glass or clear plastic windows that cover the produce, providing some protection from insects while capturing more of the heat of the sun. To improve drying efficiency, some sort of structure must be used to capture solar radiation (Srilaong, 2007).

2.20 PACKAGING AND PACKING

Packaging should ensure identification, and provide information including variety, weight, number of units, selection or quality grade, producer's name, area of origin, handling instructions and appropriate storage temperature for product display (Lopez Camelo, 2004). If the 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 plates provide excellent protection for produce and adequate ventilation during handling, cooling, transport and storage. Some plastic plates are collapsible or can be nested when stacked for easier handling when empty (Kitinoja and Kader, 2002).

2.20.1 Packaging Dried Vegetables

The dried products can be packed in airtight jars, plastic or glass bottles, or plastic bags. The container should be filled with the dried produce as full as possible to remove air before sealing. Heat- or vacuum-sealing plastic bags can further .extend shelf life of the dried product. The packed produce should be kept in a cool, dark, dry place (Kyi, 2007; Srilaong, 2007).

2.20.2 Storage and Transport

Local produce, often characterized by seasonal production, its small volume and short transport distance, could require less storage facilities and technology. In this case, the lead time between harvesting and customer sale could be limited to less than a day. It is important to know that that effective distribution of the produce is more important than its preservation in storage. However, storage is a strategy for achieving higher returns. The produce can be held temporarily to overcome fluctuations in supply and demand (Lopez Camelo, 2004). Transport to road side stands and product display at road side stands or farmers' market can often result in produce being exposed to direct sunlight, warm or even high temperatures, and low relative humidity levels. Rapid water loss under this condition can cause fruits and vegetables to deteriorate (Suslow, 1997). By providing postharvest cooling before and during transport and a shading structure during display, the produce will last longer.

2.20.3 Loss of Freshness in Produce

The keeping and the preparation of fresh produce after harvest affects its nutritional value in several ways, for example: Dry matter content (the energy supply) is

reduced with time as the continuation of living processes within the produce uses up stored food reserves. Vitamin C content decreases with time after harvest, and little may remain after two or three days.

The enhancement of produce shelf life and the maintenance of quality will require careful manipulation of the storage environment or conditions (Maalekuu,2008). Many growers know how to increase yields but do not pay sufficient attention to the quality of the produce, leading to low market value. Many handlers unknowingly contribute to postharvest losses by using common practices or by not using certain practices known to reduce losses and help maintain produce quality and safety. Each example above is considered an improper practice since it has definite negative effects on fresh produce, leading either to increased waste and losses, quicker quality deterioration, or food safety problems (Kitinoja and Kashmire, 2002). Most of these improper practices and conditions cannot be labelled "technical problems," and they cannot be solved by initiating new research projects or simply by extending existing well-proven technical information. Often, postharvest losses take time to develop, and the specific cause of quality problems may not be fully understood by produce handlers along the chain. Other times, the handler may deliberately choose not to use a practice known to protect produce because of its cost or because consumers perceive the practice as undesirable. On occasion, a lack of reliable supplies, market information, or other infrastructural problems may make changes in handling impractical. Postharvest losses and changes in quality affect both the volume and perceived value of produce as it moves from the field to its final destination market, and any changes in practices will also have an effect. Part of any potential technical solution, therefore, is a consideration of the socioeconomic, cultural, and institutional

constraints facing growers, handlers, and marketers when they attempt to make changes in the way they handle and market horticultural crops (Kitinoja and Kashmire, 2002).

2.21 POSTHARVEST LOSS

Quality deterioration results in partial or total loss of fresh produce. It is predisposed by a number of interacting factors, which may be preharvest, harvest and/or postharvest in origin, such as poor crop variety, unfavorable climate, inadequate cultural practices, and lack of harvesting techniques, improper handling, and poor storage conditions. Non-technological factors also contribute to postharvest loss, such as lack of capable human resources, lack of knowledge about technical and scientific technologies, inefficient commercialization and marketing systems, lack of logistical support, and lack of enabling policy for the use and administration of human, economic, technical, and scientific resources. Postharvest losses of vegetables vary with commodity, location, growing season, and other factors such as standards of quality and consumer preferences and purchasing power, which differ greatly among countries and across cultures (Kader and Rolle, 2004). Losses of fresh fruits and vegetables after harvest may reach very high values depending on the species, harvest methods, length of storage, marketing conditions, etc. Losses are particularly high in underdeveloped countries (almost 50%) and most of them are due to pathogen attacks (Wilson and Wisniewski, 1989).

3.0 MATERIALS AND METHOD

3.1 SURVEY AND SAMPLING AREAS

The major vegetable production, marketing and consuming areas identified served as the sampling area for producers, marketers and consumers. These consisted of Mampong Municipalilty and Kumasi Metropolitan Assembly in the Ashanti Region of Ghana. In Mampong Municipal, farmers, and consumers in places such as Aframso, Edudwan, Kofiasi, Mampong, Nsuta Bonkro, Owuobuoho and Nkwanta where carrots, cabbage, onion, tomato, garden eggs and pepper were intensively cultivated were surveyed. Marketing agents who bought from these farmers or the farmers who doubled as marketers of their own vegetables were also surveyed. In Kumasi Metropolitan, areas such as, Nyankyerenease, Denkyemuoso, Tanoso, Denyame, Atimatim, Kronum-Kwapra etc. where vegetables were cultivated either for subsistence or for sale were studied. In both Mampong Municipal and Kumasi Metropolitan Assembly, consumers were sampled from educational institutions, hotels, chop-bar operators, restaurants, fast food makers and individual households. Marketing agents in the survey were hawkers of vegetables, people selling on the road side, at the farm gates and at the local markets among others.

3.2 QUESTIONNAIRE DESIGN

Structured questionnaires were designed for data collection. The respondents were in three categories; producers of the vegetables, marketing agents and the various consumers of the vegetables. For the producers, some of the parameters considered included the bio-data of respondents such as age, sex, educational background, marital status, location of the farm/garden, pre-planting practices such as seed

handling, land preparation activities like weeding, stumping, nursery bed making, and planting operations like sowing. Post planting activities like weeding, fertilizer application, insect/disease prevention and control, irrigation as well as farmers' knowledge and experiences about postharvest handling of vegetables and their effects on shelf life were also assesed. The questionnaires for the marketers covered their bio data, sources of vegetables, transportation, storage, value addition, packaging materials among others. That of the consumers included parameters like their bio data, sources of acquisition, storage and preservation among others.

3.3 PRELIMINARY SURVEY (PRETESTING OF QUESTIONNAIRE)

A preliminary survey was conducted to sample views from producers, marketers and consumers of major vegetables from Nyankyerenease, Denkyemuoso, Tanoso, Denyame, Atimatim, Kronum-Kwapra in Kumasi and, Edudwan, Kofiasi, Mampong, Nsuta Bonkro, Owuobuoho and Nkwanta in Mampong Municipal. Interviews were also used to gather the required data from respondents who could not read nor write English.

3.4 QUESTIONNAIRE ADMINISTRATION

Questionnaires were administered to producers, marketing agents and consumers of vegetables. Fifty questionnaires each were administered to producers in Kumasi and Mampong making a total of hundred questionnaires for producers, and the same was done for marketers and the consumers. In all, a total of three hundred (300) respondents were surveyed. Respondents were given the liberty to respond to the questionnaires after which questionnaires were collected. Explanations were made in

the local dialect for the illiterates to understand and respond without any input from the questionnaire administrator.

3.5 STATISTICAL ANALYSIS

Data obtained from the survey were analyzed statistically. The Statistical Package for the Social Scientist (SPSS) version 16 was used for the analysis. The data were presented in tables, graphs and values in percentages.

4.0 RESULT

4.1 BIO-DATA OF RESPONDENTS

The respondents namely producers, marketers and consumers of vegetables (cabbage, carrot, onion, tomato, garden eggs and pepper) were sampled (hundred each). Table 4.1 indicates the ages, gender, educational background and the marital status of the people sampled within the Mampong Municipality and Kumasi. In Kumasi 44.0% of producers were between the age group 41-50 but in Mampong, 40.0% of respondents (producers) were between 31-40 years. Thirty eight percent of marketers in Kumasi were between 31-40 years and in Mampong the same age group was 40.0%. Forty four percent (44.0%) of the consumers in Mampong were between 41-50 years. Fifty two percent of the respondents (consumers) in Kumasi were between the ages 41-50.

Gender was not balanced for the respondents in the three categories. In Kumasi, 82.0%, of producers were male, 94.0% were female-marketers and 58.0% were male-consumers respectively. Only 18.0% of the females surveyed cultivated vegetable in Kumasi. Females who market vegetable in Kumasi was very high registering 94.0%, indicating that the vegetable marketing industry is female dominated. In Mampong Municipal, 66.0% of males produced vegetables, only 34.0% were females. Seventy two (72.0%) of the respondents were into marketing compared to 28.0% males. The male consumers were 52.0% and female were 48.0%. From Table 4.1 all the respondents in Kumasi had formal education from the primary to tertiary level. Sixty percent (60.0%) of the producers had middle school education, 2.0% completed Junior Secondary School/Junior High School. In both Kumasi and

Mampong none of the marketers had completed tertiary education. Sixty percent (60.0%) of the respondents from Mampong who were producers had middle school education. Only 2.0% of the respondents had tertiary education. Thirty two percent (32.0%) of the marketers had primary education. Respondents with tertiary education had the highest percentage (40.0%) for vegetable consumption. Fifty percent (50.0%) of the Kumasi producers were married with or without children, 46.0% market vegetable as their occupation and 50.0% formed the consumers sampled. The widowed were the least in terms of production, marketing and consumption of vegetables. The widowed producers were 10.0%, marketers 10.0%and consumers 6.0%. In Mampong, 52.0% of producers were married and 4.0% were widowed. The unmarried formed 26.0%. Fifty eight percent (58.0%) of the respondents (marketers) were married and 62.0% of the married were consumers.

Table 4.1: Bio data of Respondents

Bio - data	Kumasi						Mampong					
	Producers		**Marketers**		**Consumers**		**Producers**		**Marketers**		**Consumers**	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Ages												
Below 20	3	6.0	3	6.0	5	10.0	6	12.0	8	16.0	3	6.0
21-30	10	20.0	8	16.0	3	6.0	17	34.0	6	12.0	2	4.0
31-40	7	14.0	19	8.0	9	18.0	20	40.0	20	40.0	13	26.0
41 50	22	44.0	18	36.0	26	52.0	5	10.0	10	20.0	22	44.0
Above 50	8	16.0	2	4.0	7	14.0	1	2.0	6	12.0	10	20.0
Total	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**
Gender												
Male	41	82.0	3	6.0	29	58.0	33	66.0	14	28.0	26	52.0
Female	9	18.0	47	94.0	21	42.0	17	34.0	36	72.0	24	48.0
Total	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**
Educational Background												
Nursery	0	0.0	4	8.0	3	6.0	0	0.0	4	8.0	1	2.0
Primary	5	10.0	6	12.0	3	6.0	4	8.0	16	32.0	13	26.0
JSS/JHS	1	2.0	13	26.0	12	24.0	9	18.0	11	22.0	9	18.0
Middle school	30	60.0	10	20.0	6	12.0	30	60.0	10	20.0	2	4.0
Voc/Technical	14	28.0	5	10.0	1	2.0	4	8.0	1	2.0	4	8.0
Tertiary	0	0.0	0	0.0	23	46.0	1	2.0	0	0.0	20	40.0
None	0	0.0	12	24.0	2	4.0	2	4.0	8	16.0	1	2.0
Total	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**
Marital Status												
Single	9	18.0	14	28.0	15	30.0	13	26.0	10	20.0	15	30.0
Married	25	50.0	23	46.0	25	50.0	26	52.0	29	58.0	31	62.0
Divorced	11	22.0	8	16.0	7	14.0	9	18.0	11	22.0	2	4.0
Widowed	5	10.0	5	10.0	3	6.0	2	4.0	0	0.0	2	4.0
Total	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**	**50**	**100.0**

4.2 VEGETABLE CROPS AND VARIETIES GROWN

The vegetable crops grown are listed in the table 4.2.1 below. In Kumasi, 8.0% of the respondents cultivated tomato (Power Rano) while 10.0% of the respondents cultivated the tomato in the Mampong Municipalility. Ten percent 10.0% of the respondents cultivated "Wosowoso" variety in Mampong as compared to 2.0% in Kumasi. "Legon 18" and "makohwam" were the pepper varieties cultivated in Kumasi. Sixteen percent of the respondents cultivated the "Legon 18". In Mampong, the cultivation of "shito adope" was 2.0% and "makohwam" was also 2.0%. Twelve percent 12.0% and 2.0% of producers cultivated spring onion production in both Kumasi and Mampong respectively. The "white lady (woroworo) variety of garden eggs was also produced. Eight percent (8.0%) respondents in Kumasi and 10.0% in Mampong cultivated this variety. In addition to "white lady," 8.0% of the respondents cultivated aubergine in Mampong. A total of 18.0% of the respondents cultivated cabbage in Kumasi and 20.0% cultivated this variety in Mampong. Out of the 18.0% in Kumasi, 10.0% cultivated KK Cross and Oxylos, respectively. In Kumasi, 18.0% of the vegetable producers cultivated carrots (tokita) and in Mampong, 20.0% of the producers also cultivated the same variety.

`

Table 4.2 Vegetable Crops Cultivated

Vegetable	Varieties	Kumasi		Mampong	
		Freq.	%	Freq	%
Tomato	Wosowoso,	1	2.0	5	10.0
	power Rano	4	8.0	5	10.0
	pectomech	1	2.0	3	6.0
Pepper	Shoti adope,	0	0.0	1	2.0
	bird eye	0	0.0	0	0.0
	Legon 18	8	16.0	0	0.0
	Makohwam	3	6.0	1	2.0
Onion	Shallot	1	2.0	0	0.0
	Spring onion	6	12.0	1	2.0
	Red creole	2	4.0	0	0.0
Garden eggs	White lady	4	8.0	5	10.0
	Aubergine	1	2.0	4	8.0
	Zebrina	1	2.0	1	2.0
Cabbage	KK cross	5	10.0	5	10.0
	Oxylos	4	8.0	5	10.0
Carrot	Tokita	9	18.0	10	20.0
	Kuroda	0	0.0	4	8.0
Total		**50**	**100.0**	**50**	**100.0**

4.3 COMMON FIELD PESTS FOUND ON VEGETABLE

The common pests identified on the vegetables fields were; whiteflies, caterpillars, fruit borers, stem borers, spiders and maggots. Field infestation by stem borers were 24.0% in Kumasi and 30.0% in Mampong. Spiders did not attach the crops directly; they webbed and folded the leaves of vegetable crops. Caterpillars' infestation was 20.0% in Kumasi and 8.0% in Mampong.

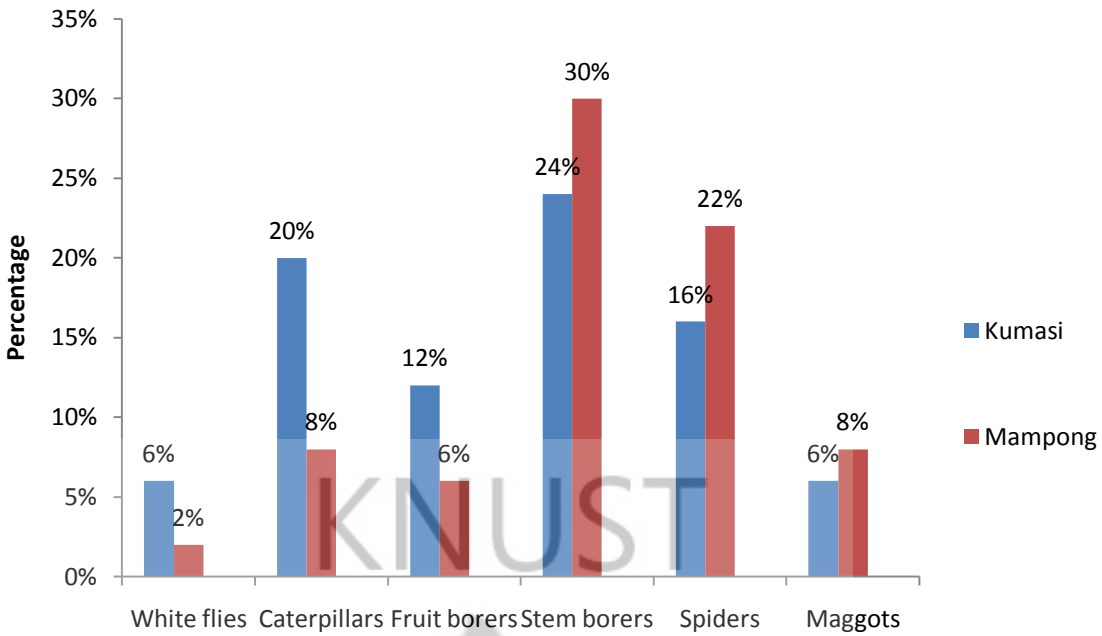

Figure 4.1 Pests found on Crops

4.4 TIME OF HARVESTING

Figure 4.2 shows the time that farmers harvested their produce. Eighty eight percent (88.0%) of the producers in Kumasi and 94.0% in Mampong harvested their produce in the morning. Farmers in Kumasi, (2.0%) and Mampong (4.0%) harvested in the afternoon. Ten percent (10.0%) of respondents in Kumasi and 2.0% in Mampong harvested in the evening.

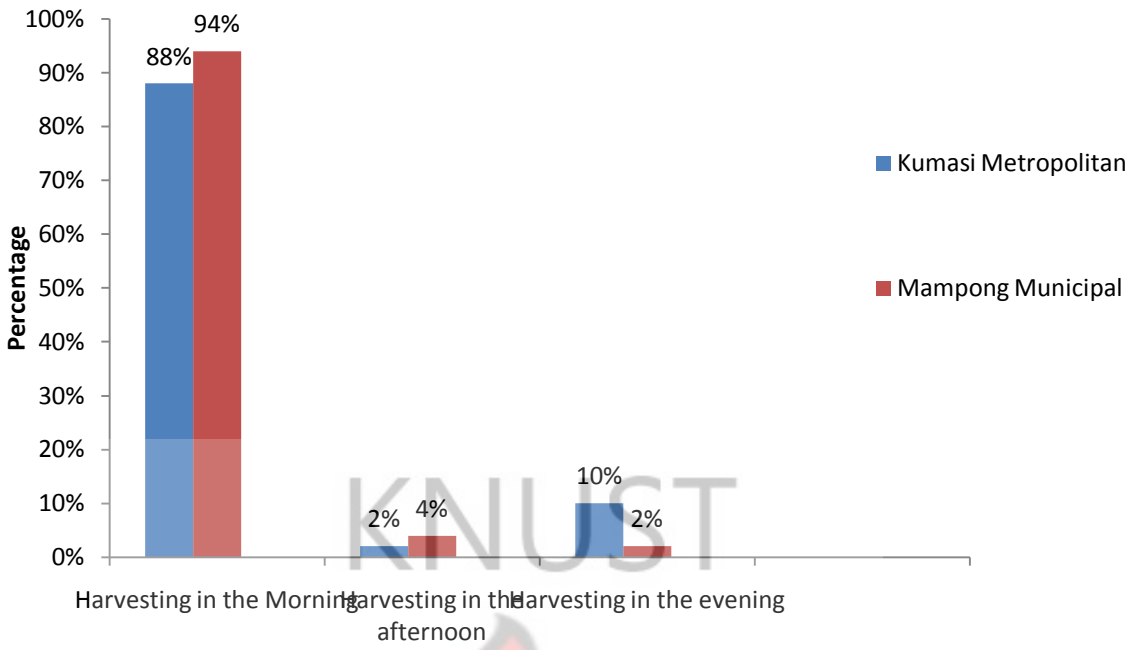

Figure 4.2 Time of Harvesting

4.5 METHODS OF HARVESTING VEGETABLES.

Most of the producers did not use any proper tool for harvesting produce in both study areas, 46.0% and 50.0% of the respondents used bare hands in Kumasi and Mampong, respectively. No gloves or padding were used to reduce the impact of the direct handling on produce. The harvested produce was put in sacks, baskets, plastics or metallic containers. In Kumasi, 36.0% of the respondents used cutlass to harvest onion and carrots while the 30.0% used cutlass in Mampong (Table 4.3). Cabbage head were severed from the main plant with shape knives.

Table 4.3 Methods of Harvesting Vegetables

			Kumasi		Mampong	
Harvesting Method	Crops involved	Tools used	Freq.	%	Freq.	%
Hand picking of vegetables	tomato, garden eggs pepper	none	23	46.0	25	50.0
Cutting using knives	cabbage garden eggs	knives	9	18.0	10	20.0
Uprooting of Vegetables	onion carrots	cutlass	18	36.0	15	30.0
Total			**50**	**100.0**	**50**	**100.0**

4.6 TREATMENT GIVEN TO VEGETABLES IMMEDIATELY AFTER HARVESTING

Forty six percent (46.0%) of vegetable producers in Kumasi and 38.0% in Mampong pre-cooled their vegetables under tree shades, sheds and beneath sheets of leaves to reduce the incidence of heat build-up in the produce. Four percent (4.0%) of the respondents in Kumasi and 2.0% in Mampong just sprinkled water on the produce but would not keep the produce under shade. Ninety percent (90.0%) and 62.0% of responses in Kumasi and Mampong respectively did no pre-cooling of produce after harvest.

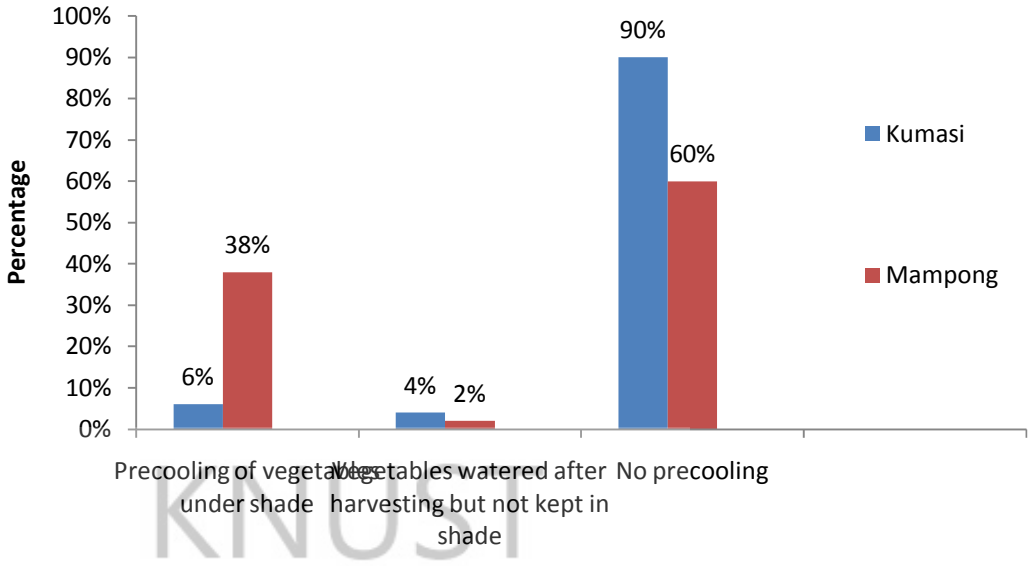

Figure 4.3 Treatment given to Vegetables immediately after Harvesting

4.7 SORTING OF PRODUCE

Producers (88.0%) in Kumasi sorted vegetables in order to grade them, 72.0% in Mampong did same. The producers that did no sorting were 12.0% and 28.0% for Kumasi and Mampong, respectively (Figure 4.3). The vegetables were sorted based on visual quality criteria such as size, colour and freshness and eye appeal.

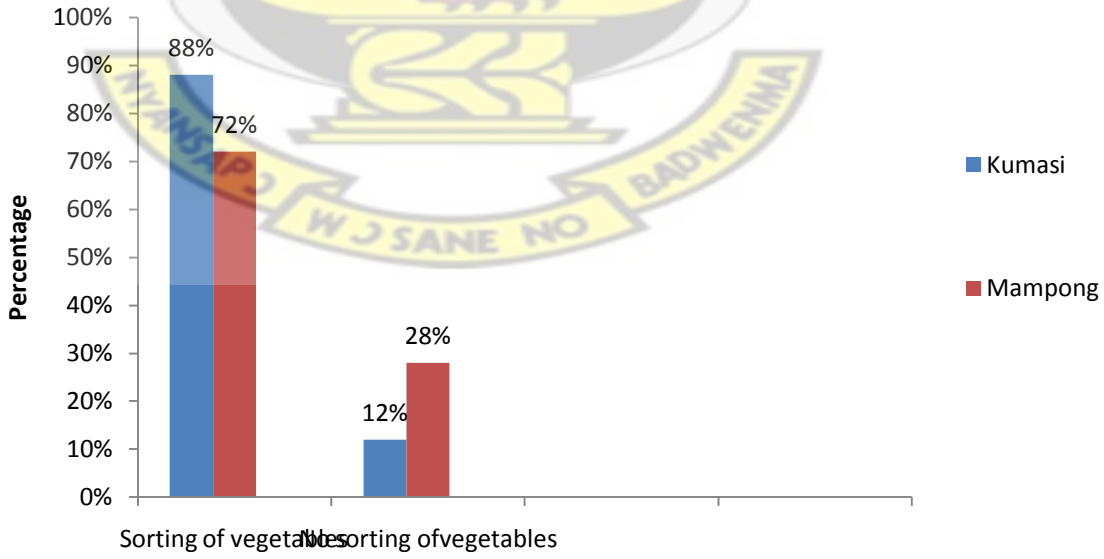

Figure 4.4 Sorting of vegetable

4.8 TRANSPORTATION OF VEGETABLES

Eighty percent (80.0%) of the respondents in Kumasi used vehicles to convey their produce. The vehicles used were the “trotro”, taxi and KIA trucks with open sides. The other 20.0% used other means, such as, carrying produce in baskets or sacks on their heads. In Mampong 74.0% transported produce on their heads using baskets, sacks, and polythene. Twenty six percent of the respondents in Mampong used vehicles to convey produce to the market.

Table 4.4 Transportation of Vegetables by Producers

	Kumasi		Mampong	
Means of transport	Freq	%	Freq	%
Vehicle	40	80.0	13	26.0
Head load	10	20.0	37	74.0
Total	**50**	**100.0**	**50**	**100.0**

4.9 SOURCES OF PRODUCE FOR MARKETERS

Marketers in Kumasi bought their produce from the local markets, producers’ farms, and from other marketing agents. In Kumasi seventy two percent (72.0%) of the respondents bought from the market but in Mampong 58.0% of marketers bought their vegetables from the producers’ farm. In Kumasi 4.0% imported vegetables from countries such as Burkina Faso, Niger and China.

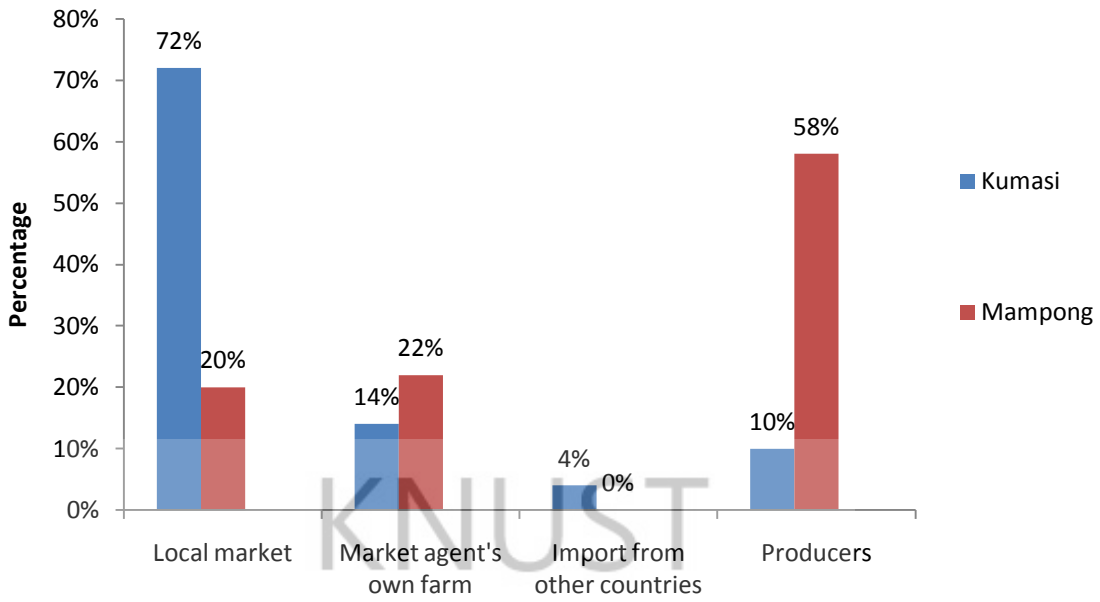

Figure 4.5 Sources of Vegetables for Marketers

4.10 VALUE ADDITION TO VEGETABLES BEFORE SELLING BY MARKETERS

Figure 4.6 shows the various value additions to vegetables before they were sold to consumers. Forty two percent 42.0% of the respondents sprinkled water on the vegetables such as cabbage, carrots, tomato, spring onions, garden eggs and pepper in Kumasi as compared to 46.0% in Mampong who sold directly to consumers. Thirty eight percent (38.0%) of respondents in Kumasi and 34.0% in Mampong removed unwanted parts such as old leaves and foreign materials from the produce. Six percent (6.0%) in Kumasi did not add value to the produce. Twelve percent (12.0%) of marketers in Mampong intermittently sprinkled water on their produce. Six percent (6.0%) and 2.0% of the respondents in Kumasi and Mampong respectively washed vegetables such as carrots with fresh water and sponge. Produce like pepper and onion were sometimes dried or cured as some consumers preferred these to the fresh vegetables, 8.0% and 6.0% of the respondents indicated that they dry their produce and sold during the lean season.

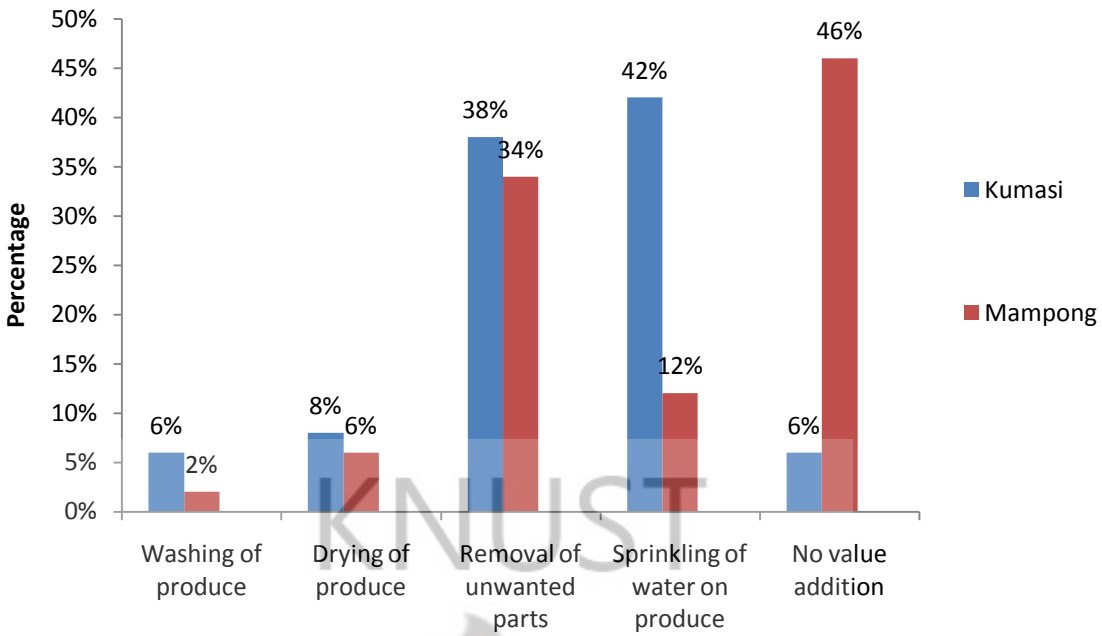

Figure 4.6 Value additions to vegetables before selling

4.11 SOURCES CONSUMERS GET VEGETABLES TO BUY

Consumers forming 36.0% responded buying their produce from the local markets and 22.0% from Mampong also responded same. Ten percent (10.0%) in Kumasi obtained vegetables from the supermarket, 20.0% in Kumasi and 24.0% from Mampong obtained vegetables from vegetables hawkers. Twenty percent (20.0%) and 6.0% bought from the road side in Kumasi and Mampong, respectively. Four percent 4.0% and 32.0% in Kumasi and Mampong respectively responded to buying vegetables from the farm, 10.0% and 16.0% (from Kumasi and Mampong) responded that they obtained vegetables from the marketers' residence as (Figure 4.7).

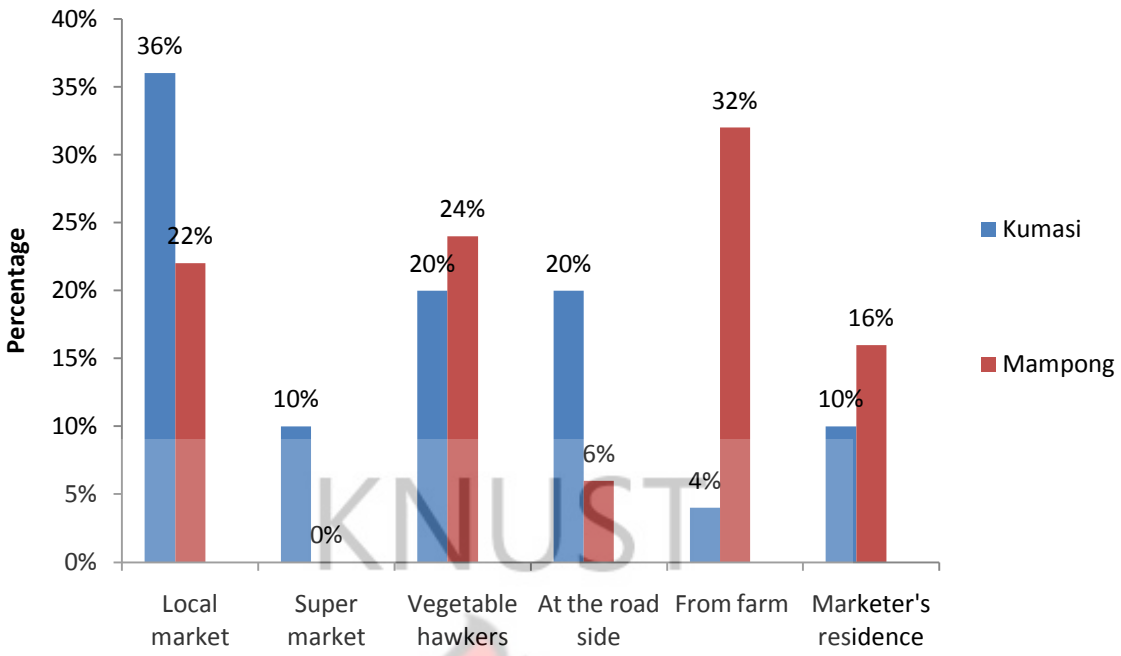

Figure 4.7 Sources of Vegetables for Consumers

4.12 PACKAGING MATERIALS

In Kumasi and Mampong, 56.0% and 38.0% of respondents respectively used polythene as a medium for carrying vegetables. Sixteen percent (16.0%) and 34.0% used baskets in Kumasi and Mampong, respectively. Six percent (6.0%) and 2.0% in Kumasi and Mampong respectively used metallic containers (Figure 4.8).

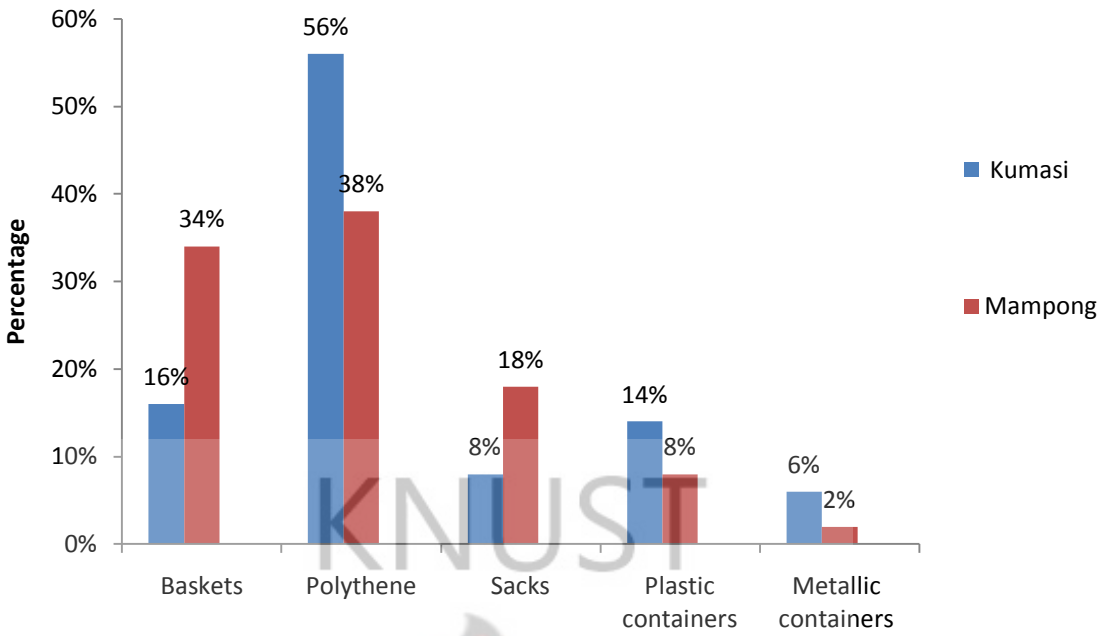

Figure 4.8 Packaging Materials used by Marketers

4.13 METHODS FOR STORING VEGETABLES BY CONSUMERS

Consumers forming 58.0% and 14.0% kept their vegetables in refrigerators in Kumasi and Mampong, respectively. In Mampong 58.0% of respondents consumed vegetables without any form of storage as against 8.0% in Kumasi. Drying or curing of vegetables was 22.0% and 18.0% in Kumasi and in Mampong, respectively. Twelve percent (12.0%) steamed vegetables such as pepper in Kumasi and that of Mampong was 10.0% (Figure 4.9).

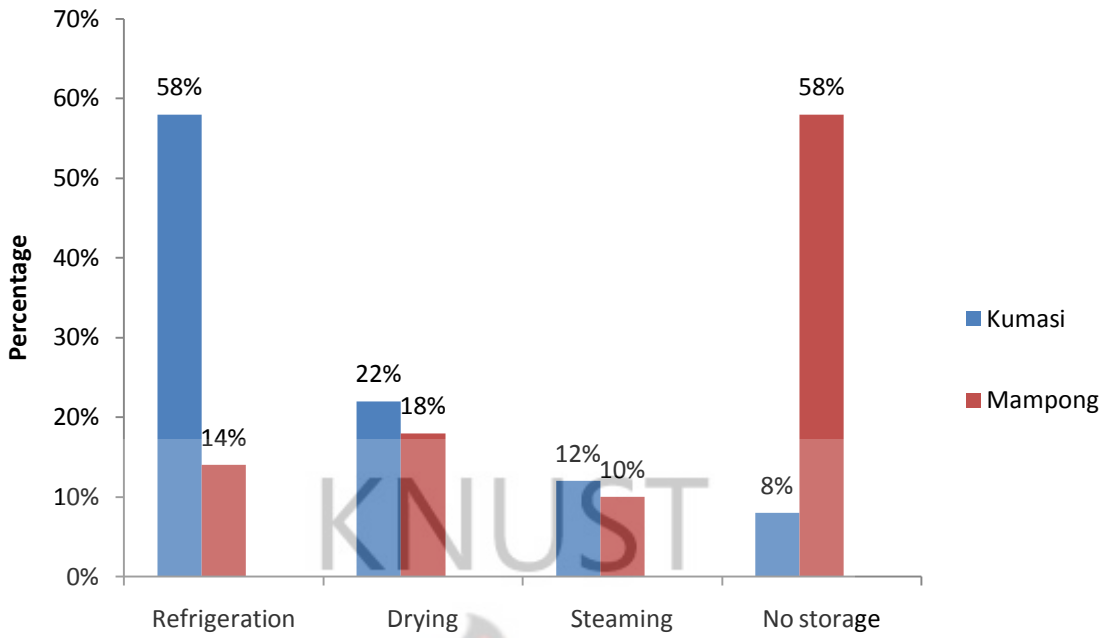

Figure 4.9 Methods for storing vegetables

4.14 DISEASES AND PESTS FOUND ON THE VEGETABLES AFTER HARVEST

Maggots were the major pest found on the vegetables. In Kumasi (40.0%) and Mampong (14.0%). Fruit borers' infestations were 22% and 30% for the respondents from Kumasi and Mampong, respectively. Two percent (2.0%) and 28% responded that mould infection was the problem in Kumasi and Mampong respectively. Rot accounted for 24.0% and 22.0% loss of vegetables in the hands of consumers in Kumasi and Mampong respectively. Moulds infestation was 2.0% in Kumasi and 28.0% in Mampong. However, 12.0% and 6.0% of the respondents did not observe mould infestation on their vegetables.

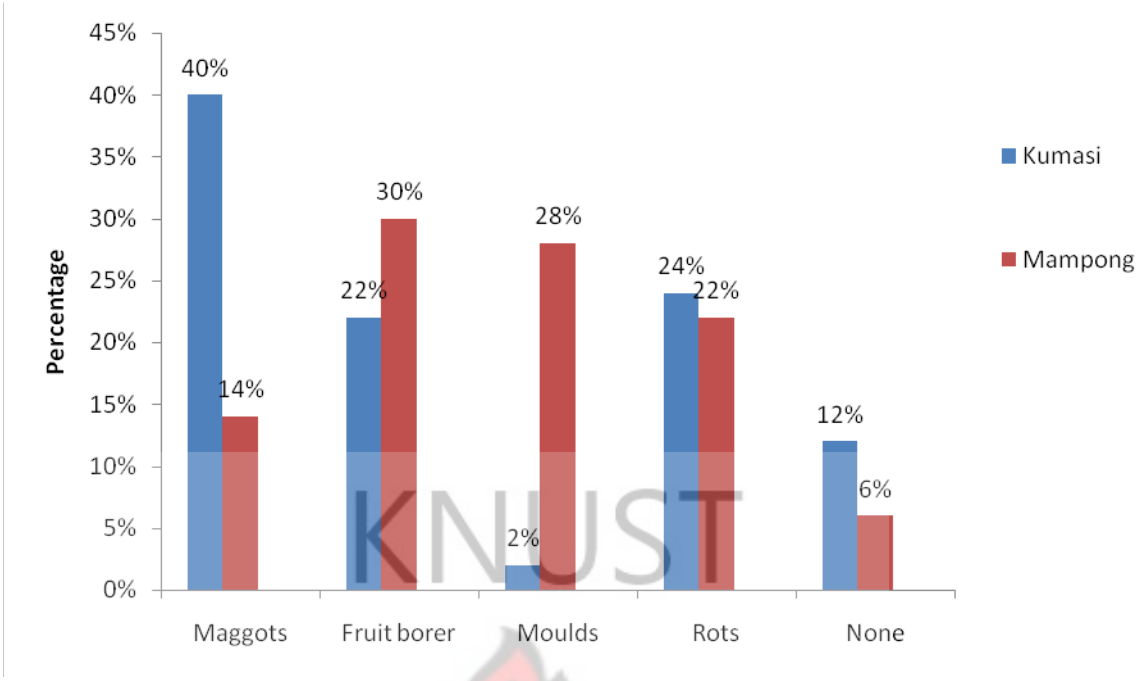

Figure 4.10 Diseases and Pests on Vegetables

5.0 DISCUSSION

5.1 BIO-DATA OF RESPONDENTS

The vegetable producers below the age of twenty were 6.0% each for Kumasi and Mampong. The reason for this low percentage could be that this age group did not find vegetable cultivation very lucrative, still in school or engaged in other ventures that looked more promising. The age group above 50 years was also low in production, marketing and consumption of vegetables. The producers who responded to the cultivation of vegetables in Kumasi and Mampong were 16% and 2% respectively. It could be that they find the work (weeding, making of bed and general cultural practices) very difficult because at the age 50 and above one is likely to be weak.

Eighty two percent (82%) and 66% of the respondents (producers) were males from Kumasi and Mampong respectively indicating that vegetable production in the two study areas was male dominant. The females were 18% in Kumasi and 34% in Mampong. The females found vegetable production tedious. The age group from 41 to 50 mostly (44.0%) engaged in vegetable production meaning that production of vegetables was their main livelihood. In Mampong, respondents in the same age group who cultivated vegetables were 10%. The low percentage could be that at the time of questionnaire administration, most of the town folks in this age group were attending other social functions such as funeral. However, 40% of respondents who were within 31-40 years cultivated vegetables which indicates that the production of vegetables in Mampong were dominated by the physically active age group. Marketers in Kumasi between the ages 31-40 and 41-50 were 38% and 36%

respectively, forming a total of 74% and were the least educated and could not get employed in any other available formal industries and so sold vegetables which does not require any formal training.

In Mampong, marketers between the ages 31-40 and 41-50 were 40.0% and 20.0% respectively. These formed 60.0% of the respondents indicating a very high percentage. They had the least education and did not have any alternative means of livelihood beside the sale of vegetables. The marketers in Kumasi and Mampong below the age 20 were 6.0% and 16.0% respectively forming 22%. These people were school drop-out and had no means to pursue any formal education so production of vegetables was a way of life to them.

The vegetable consumers in Kumasi who were between the ages 41-50 were 52.0% were mostly employed and therefore could purchase vegetables. However, marketers of the produce at the study areas were female dominating. Kumasi had 94% responses and Mampong 72% and could be attributed to the fact that the sale of vegetables is traditionally thought to be for females.

Unlike the marketing, consumption of vegetables in Kumasi and Mampong took a different turn. Male respondents were 58% and 52% for Kumasi and Mampong respectively. These males were mostly employed and therefore could afford to buy vegetables. As mentioned above, they also formed the bulk of the producers and therefore had access to their own produce. The level of education had influence on the vegetable production, marketing and consumption. Sixty percent (60%) each of the producers in Kumasi and Mampong were middle school leavers who could not

further their education or learn any other trade. However, the respondent who had tertiary education and produced vegetables was 2% in Mampong, with none in Kumasi. This clearly showed that higher education enables people to get employed in other job sectors neglecting the agricultural sector. There was no respondent who had tertiary education and was producing vegetables in Kumasi. The marketers of vegetables in terms of educational level varied in both Kumasi and Mampong although, they all had low levels of education. In Kumasi 8.0%, 12.0%, 26.0% and 20.0% completed nursery, primary, JSS/JHS and the middle school respectively. Twenty four percent 24.0% had no level of education.

The situation in Mampong was no different, 8.0%, 32.0%, 22.0% and 20.0% completed nursery, primary, JSS/JHS and middle school in that order. There were 16.0% respondents who had no formal education showing how serious lack/low level of education could push people into the marketing of vegetables. From the above analyses, it could be seen that the most available venture for the lowly educated people in Kumasi and in Mampong was the production and marketing of farm produce.

The consumption of vegetables in the study area did not correlate with production and the marketing trends. People with higher education who did not produce nor market vegetables were the major consumers. The Kumasi, consumers' responses were 46.0% and that of Mampong was 40.0%. The respondents had knowledge about the nutritional composition of vegetables, Pamplona (2008) reported that vegetables are the major sources of vitamins and minerals in the human diet. There is no substitute to the role vegetables play in our meals (Drechel *et al.*, 2010).

With respect to marital status, the married in both Kumasi and Mampong who responded to the cultivation of vegetables were 50.0% and 52.0% respectively. This was their only source of livelihood. The widowed respondents who were into vegetable production were 10.0% in Kumasi and 4.0% in Mampong. These people were aged and did not have the energy the production of vegetables demands. The married were the major sellers of vegetables in Kumasi (46.0%) and at Mampong (58.0%). The high percentage could be due to the fact that they considered the sales of vegetables as an avenue to get income. Again, the married consumed more vegetables than the single, divorced or the widowed. In Kumasi, 50.0% of the respondents (married) and Mampong 62.0% consumed vegetables. Also, since women dominated the selling of vegetables in Kumasi (46.0%) and in Mampong (58.0%), they used some of the produce to prepare meals at home.

5.2 VARIETIES OF VEGETABLES GROWN IN THE STUDY AREAS.

In Kumasi, 8.0% of the respondents cultivated tomato variety (Power Rano) as against 10.0% in Mampong. Power Rano has thicker peel and could withstand pressure from long distance travels. Producers in Mampong carted vegetables on trucks and on their heads to longer destination as against the producers in Kumasi who travelled shorter distances to marketing centres and so choice of variety would not matter to them. Moreover, the "wosowoso" variety is highly susceptible to damage. Only 2.0% of producers were into its cultivation as fast food vendors in Kumasi preferred tomatoes that were firm, meaty, and so, this pushed producers to cultivate what consumers wanted. Producers (10%) in Mampong preferred "wosowoso" because it has good resistance to diseases in the field.

Sixteen percent (16.0%) cultivated “Legon 18” variety of pepper in Kumasi, but nobody responded to the cultivation of this variety in Mampong. The reason for this high number was that consumers preferred that to the other varities.

Six percent (6.0%) as against 2.0% of producers cultivated “makohwam” in Kumasi and Mampong respectively. The variations could be as a result of the availability of the seeds to producers.

Spring onion was highly preferred to the other varieties in Kumasi, as 12.0% responded to the cultivation of spring onion. Producers in Kumasi produced all year round as the demand was high due to the creation of more fast food vendors who used this onion for the making of salads and also food garnishing at the restaurants and hotels.

White lady (aworoworo) variety of garden eggs dominated in terms of production in Kumasi (8.0%) and in Mampong (10.0%). Aubergine ranked second (8.0%) in Mampong and 2.0% in Kumasi. The reason for this high percentage is because of the availability of market for the white lady Kumasi and in Mampong.

The K.K cross and oxylos varieties of cabbage were much cultivated in both study areas. There was no much variation in terms of the type farmers cultivated. The varieties grown at both areas were as a result of the availability of seeds and not as a choice by the producers. Responses indicated that the varieties mentioned are the only ones imported into the country.

Carrots varieties (tokita and kurado) were cultivated. In Kumasi, 18.0% of the respondents sowed tokita while that of Mampong was 20.0%. The producers

responded that these varieties gave good yield and also had resistance against diseases.

5.3 HARVESTING TIME

Harvesting in the morning was preferred much to the afternoon and evening. The reasons for the early morning harvesting, according to the farmers, were that buyers arrived early in the morning to purchase vegetables. Also early harvesting gave them enough time to attend to other farming activities such as weeding. In all, 88.0% of producers in Kumasi and 94% in Mampong, harvested in the morning, because of the above reasons. Producers who harvested in the afternoon and evening were the backyard farmers who used their vegetables for subsistence. This group indicated either using the produce for home consumption or selling to people who had ordered them to be used as salad in fast food preparation in the evening.

5.4 HARVESTING METHODS

Producers (46%) and 50% in Kumasi and Mampong used their bare hands to hold and break off vegetables as a method of harvesting. None of the producers had ever harvested wearing gloves, pad or any gadget that could reduce the impact of touching. During harvesting, vegetables were bruised as a result of harvesters using cutlasses and knives which could lead to infection and subsequent mould and rots.

Farmers of Mampong harvested onion and carrots using cutlasses and other sharp objects which injured the produce and hastened deterioration of produce in storage.

5.5 TREATMENT OF PRODUCE AFTER HARVESTING

Only 6% of the respondents in Kumasi and 38% in Mampong precooled their vegetables after harvesting. According to Olympio and Kumah (2008), if produce is exposed to high temperatures caused by solar radiation, it will deteriorate rapidly. Produce left in the sun after harvesting may reach temperatures as high as 50 degree Celsius. This could lead to a high rate of respiration and if packed and transported without cooling or adequate ventilation, it will become unusable. However, 90% and 60% of respondents in Kumasi and Mampong respectively did not precool their produce. The vegetables were either sold directly to buyers on farm or used in the preparation of daily meals.

Four percent (4%) and 2% of respondents in Kumasi and Mampong poured water on the produce and did not precool under shade. They practiced this when the vegetables were to be transported immediately to long distances and did not keep them under shade. Producers in both study areas did not consider precooling as a very necessary requirement in prolonging the shelf life of produce.

5.6 SORTING OF VEGETABLES

Majority of the vegetable producers interviewed sorted their produce into grades and sold those produced based on physical characteristics such as size, colour, level of wholesomeness and appeal. In Kumasi, 88% did sorting as against 72% in Mampong. Sometimes, the buyers did the sorting themselves based on their own quality criteria. The chop bar operators took advantage of the bruised vegetables for meal preparation however, the operators of hotels and popular restaurants preferred vegetables of very high quality. Twelve percent (12%) of the producers in Kumasi

and 28% in Mampong sold without sorting. The reason for not sorting was that their vegetables were sold at cheaper prices and also considered sorting as part of the marketer's work.

5.7 TRANSPORTATION OF VEGETABLES

The transport of vegetables was by vehicles and carry on the head. Eighty percent 80% of the respondents in Kumasi used vehicles to carry vegetables to the selling points. There were no specially designed vehicles to transport vegetables. Booths of passenger vehicles and open KIA trucks were used. In Mampong, 74% of the respondents carried produce on their heads to the markets. The road network in this area was undulating and therefore vehicle were reluctant to ply the roads. Moreover, because of the bad nature of the roads leading to most of the farms, producers preferred carting their own produce on their heads.

5.8 SOURCES OF PRODUCE BY MARKETERS

Marketers in Kumasi obtained most of their produce from the local markets and on specific marketing days, 72% got vegetables from the market. At the marketing centres, there were always enough producers who wanted buyers and so they sold their vegetables at beat down prices. In Mampong, 58% of marketers bought directly from the farmers at the farm gates. The vegetables were also cheaper since they had to transport the produce themselves. Only 4% imported vegetables in Kumasi and vegetables such as Creole onion and pepper from Burkina Faso and Niger was recorded. A supermarket run by a Chinese imports vegetables from China and these were patronized by the Chinese expatriates in Kumasi. Fourteen percent (14%) and

22% of respondents in Kumasi and Mampong respectively were producers but they also served as marketers of their own produce.

5.9 VALUE ADDITION TO PRODUCE BEFORE SELLING

Before marketing to consumers, market agents carried out practices such as washing of produce, drying, removal of unwanted parts, and sprinkling of fresh water on produce. Six percent of marketers in Kumasi and 2% in Mampong responded to washing their produce particularly carrots to attract buyers. They mentioned that some consumers bought and ate the produce while travelling so washing made it convenient for them to buy their produce. Dehydrated carrots were also put in fresh water to gain turgidity. Eight percent (8%) of respondents in Kumasi and 6% in Mampong respectively dry/cure their produce (pepper and onion) during the bumper harvest and later sold to consumers. The drying of the produce reduce moist for longer storage. Vegetables such as cabbage and sometimes onion (spring) had the outer coverings removed to expose the fresh part which looked more attractive. Thirty eight percent (38%) and 34% of respondents in Kumasi and Mampong respectively removed the older leaves of cabbage.

Regularly, marketers sprinkled fresh water on fresh carrots, cabbage, spring onion, tomato, garden eggs and pepper. Sellers in Kumasi metropolis who sold by hawking indicated that they added alum to the water they use for sprinkling. They mentioned that this enabled the produce stay wet and fresh for a long time. However, 6% and 46% of the respondents in Kumasi and Mampong respectively sold without any value addition and responded that some buyers would want to do the value addition

in their own homes because some consumers believed the seller would not do wash the produce properly.

5.10 S0URCES OF VEGETABLES FOR CONSUMERS.

Consumers in the study area obtained their vegetables from the local markets, supermarket, hawkers, road side, farm and marketers' home. In Kumasi 36% of respondents bought vegetables from the local market, but in Mampong only 22% bought from the local market. The higher percentage in Kumasi must be that it was the main market centre, and thus attracted producers from different districts. Moreover, consumers obtained cheaper produce from the market as compared to buying from the supermarket. In Mampong there was no supermarket for vegetables so consumers had no other option than to buy from the other available sources. Hawkers moving from houses to house amidst shouting to advertise their produce also accounted for 20% in Kumasi and 24% in Mampong. These hawkers reached out to consumers even in institution, residential areas, camps and lorry parks where there was no market. Twenty percent of consumers responded that they obtained their vegetables from the road side during the day. Producers and marketers' who did not have stalls at the market normally stationed themselves at vantage point on the road side where travelers patronized their vegetables. In Mampong 6% of the respondents bought from the road side. This small percentage could be as a result of the fact that most consumers got their produce from the farm (32%) and again most of the respondents believed eating vegetables from a known source (farm) was more healthier. In Kumasi 4% bought vegetables from the farm and this could be because most of the consumers were into white collar jobs and so getting vegetable from farms was difficult.

Mostly in the evening and the other days such as Saturday when funerals and other social events were held, consumers bought vegetable from the marketers' residence. None of the consumers ever responded seeing the sellers wearing gloves, aprons even at the supermarket. Again facilities such as toilet at the market centre were not in good hygienic conditions for the sellers and buyers.

5.11 PACKAGING MATERIALS USED.

Basket accounted for 16% of the respondent in Kumasi and 37% in Mampong. They were mostly used by producers and marketers to carry produce to and from the market centres since they could weave the baskets themselves. Polythene was the mostly used packaging material in both study areas. Kumasi had 56% of respondents using it and in Mampong 38%. In both areas respondents said they were cheaper and also available. Most dealers in vegetable used this material since it is considered portable and neater than the other packaging materials. This material does not also occupy much space and therefore can be folded and carried with ease. Eight(8%) percent of respondents in Kumasi and 18% of respondents in Mampong used sacks, 14% and 8% of respondents in Kumasi and Mampong respectively used plastic containers. Six percent 6% and 2% in Kumasi and Mampong used metallic containers respectively. The sacks were used to carry garden eggs, carrot and onions which were not as delicate as pepper, tomatoes and cabbage. The sacks accounted for 18% in Mampong. This could be because producers and marketers found them suitable for carrying garden eggs and carrot. Plastic containers were not used much as respondent found them bulky and inconvenient to carry.

5.12 METHODS OF STORING VEGETABLES.

Refrigeration by respondents was 58% in Kumasi and 14% in Mampong. The high percentage in Kumasi might be that consumers of vegetable in Kumasi bought in bulk and therefore had to store the surplus in refrigerator which they found convinient. Again most respondent in Kumasi were in white collar jobs and because of time constraint found refrigeration more useful. At Mampong only 14% used refrigeration, this low percentage could be that because they have access to fresh vegetable always refrigeration as a way of preservation not very necessary. Twenty-two percent in Kumasi cure/dry vegetables such as onion, pepper to extend shelf life. Only 18% of the respondents dry in Mampong, this could be as a result of the availability of the vegetables and therefore no need to preserve by drying. Vegetables such as pepper was steamed and later refrigerated and then dried. In Kumasi 12% and Mampong 10% steamed. The respondents indicated that only few vegetable could be preserved by steaming. Response to no storage method used was 18% in Kumasi and 58% in Mampong, respondents in Kumasi bought in bulk and therefore had surplus to preserve, while those in Mampong like taking it fresh from the farm as shown in figure 4.6 above.

5.13 DISEASES AND PESTS FOUND ON VEGETABLES.

Maggots infestation was high (40%) according to respondents in Kumasi which could be due to improper storage or that produce were already infested from the field. Maggot infestation could also be as a result of mixing different vegetable with different quality produce in a package. The low percentage (14%) responses from Mampong could be as a result of respondents eating fresh produce and therefore did not store the vegetables. Fruit borer infestation was lower 22% in Kumasi than that

of Mampong (30%) which could be due to field infestation. Mould infestation was 2% in Kumasi and 28% in Mampong. The high percentage in Mampong could be due to low temperatures in Mampong as a result of the abundant of green vegetation and the mountainous nature of the land. Responses on rot was 24% in Kumasi and 22% in Mampong which could be as the result of rough handling during harvesting, packaging and transportation of produce. Produce were transported packed in booths of taxi, "trotro" and KIA trucks. Packaging materials like boxes, baskets and sacks were tightly packed crushing the produce leading to bruises and rot. The distances from the producing areas to marketing centres were longer; therefore, there was high probability of produce rot as a result of rapid temperature rise and accumulation of high concentration of carbon dioxide to possibly damaging levels, once produce is confined.

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

What is termed as the postharvest loss in vegetables such as cabbage, carrots, onion, tomato, garden eggs and pepper is a combined result of factors emanating from the pre-harvest, harvest and subsequent handling by producers, marketers and consumers. The development of postharvest technology in handling could contribute to securing a stable supply of food products in addition to an increase in income and improvement in the diet of the people in Kumasi and Mampong. The study showed that poor methods of harvesting vegetables, poor transportation system, inefficient or lack of storage facilities and ignorance about the proper handling of vegetables are the main causes of losses in vegetable. Losses may be due to a number of interacting factors, which may be pre-harvest, harvest and/or postharvest in origin, such as poor crop variety, unfavourable climate, inadequate cultural practices, and lack of harvesting techniques, improper handling, and poor storage conditions. Moreover, factors such as lack of capable human resources, inefficient commercialization and marketing systems, lack of logistical support in Kumasi and Mampong added to losses. Improper postharvest handling was one of the main causes of produce deterioration and subsequent loss.

6.2 RECOMMENDATION

- The Ministry of Food and Agriculture and the research institutions should assist farmers get access to improved high quality seeds and better production inputs.

- There should be mass education by the media and postharvest students on good practices of handling vegetables and on the dangers of bad handling on individual's health.
- Stakeholders such as the Ministry of Food and Agriculture, research institutions, FDB, EPA, farmer-groups and the Associations of Agrochemical dealers must form a common platform to fight mishandling of produce at the various levels of production, storage and retailing.
- KNUST- Horticulture Department on frequent basis should organize seminars and exhibitions for producers, marketers and the general public on handling of produce.
- There should be improved marketing centers for selling and buying of vegetables.
- Postharvest handling should be given more emphasis, so as to prevent crop losses and use agricultural products more efficiently to meet the changes in the food demand, especially the demand for processed foods.
- Further survey should be carried out by students to assess the postharvest handling of the major vegetables in different districts.

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APPENDIX

QUESTIONNAIRE A

PRODUCERS

Please tick (√) or write short answers where appropriate

1. Name (optional) .....

2. Residence .....

3. Age .....

4. Sex

( ) Male ( ) Female

5. Educational background

( ) Nursery ( ) Primary ( ) JHS/JSS ( ) SHS/SSS ( ) Middle

( ) Secondary ( ) Vocational/Technical/Commercial ( ) Post middle/Secondary Diploma/Degree ( ) Other (pleases specify) .....

6. . Marital status:

Single/never married ( ) Married ( ) Widow/widower ( ) Divorced

7. ( ) District/area/village where vegetable crop is cultivated .....

8. Type of vegetable crop cultivated

( ) Annual ( ) Perennial

Table 1 Showing information on variety and time of cultivation of vegetable

Name of vegetable grown	Variety	Time of cultivation

9. Farming system practiced

( ) Mixed cropping ( ) Mono cropping ( ) Organic farming

( ) Backyard garden /subsistence ( ) other (please specify).....

10. Cultural practices adopted

i. ..... ii. ..... iii.....

iv. others(specify)…….. ……. …….. …….

Table 2 showing information on fertilizer

Type of fertilizer	Kind/name	Time of application	Why this fertilizer is preferred

11. Method of fertilizer application

( ) Foliar ( ) Broadcasting ( ) Band placement ( ) Fertigation ( ) other(specify)…….

12. Number of times fertilizer was applied

( ) Once ( ) Twice ( ) More than two times

13. Source of fertilizer applied

( ) Local ( ) Imported ( ) Other (specify)……..

14. Sources of seed

( ) Imported ( ) Bought from the local market ( ) Farmers own (saved from previous cultivation

( ) Other (specify).....

Table 3 Showing information on seed sown

Conditions under which seeds were stored or kept before sowing	Facility for storing seeds	Method for storing seeds

15. Planting method used

( ) Direct sowing ( ) Nursery ( ) other (specify)……..

16. How long do the seeds store? .....

17. Time (weeks) taken for vegetable to mature after sowing.....

18. Treatment given to the soil before the seeds were sown .....

19. Source(s) of water for irrigation

.....

20. Insects/pests identified on the field

i. ..... ii. .....

iii. ..... .iv……..

21. Diseases identified on the field

i. ..... ii. .....

iii. ..... iv…….

22. How do you control pests on your field?

[ ] Handpicking [ ] Chemical control [ ] Biological control

[ ] Any other

(Please specify) .....

23. Any treatment given to the soil before seeds was sown?

.....

.....

24. Reason(s) why the treatment above was given to the seeds. .....

25. Time taken for the vegetable to be harvested after maturity…….

26. Time of day of harvesting of the vegetable

[ ] Morning [ ] Afternoon [ ] Evening

27. Was any agrochemical used that helped induce ripening?

[ ] Yes [ ] No

28. What is the name of the agrochemical used if any? .....

29. What other treatment was given to the crop before harvesting? .....

30. How was the harvesting done?

[ ] Vegetables dropped and were later handpicked [ ] Vegetables were cut from the plant using knives [ ] Vegetables were plucked using bare hands [ ] Vegetables were plucked with gloves [ ] other (specify)……

31. What was the state of the vegetable at harvesting?

[ ] Unripe [ ] Partly ripe [ ] Fully ripe [ ] other(specify)……..

32, The level of attack by pests on the vegetable

[ ] Not infested by pest [ ] Partly infested [ ] Fully infested by pests [ ] other (specify)……..

33. Kind of pest/insects found to attack the vegetables.

[ ] Biting and chewing insect [ ] Boring insect [ ] Piercing and sucking insect [ ] other(specify)……

34. The common names of the insects

i. ..... ii. ..... iii. .....

35. After the harvest of vegetable, what precooling treatment was given.

[ ] Vegetable was heaped under a shady tree [ ] Vegetable was put in water [ ] Vegetable was covered with a sheet of leaves [ ] Vegetable was not given any pre-cooling treatment [ ] other (specify)…….

36. Was any agrochemical applied during pre-cooling of vegetable?

[ ] No [ ] Yes

37. If yes, what chemical was used or applied .....

38. Was there any physical change in colour, shape, texture and flavour of vegetable after pre-cooling?

[ ] No [ ] Yes

39. Describe the condition of the vegetable after pre-cooling.

.....

.....

40. People who did the harvesting

[ ] Yourself [ ] Relatives [ ] Hired labourers [ ] "Noboa" group [ ] Other

(please specify) .....

41. The harvesters, were they skilful?

( ) No ( ) Yes

44. Have you worked with them before?

( ) No ( ) Yes

45. Do you pay them after work?

( ) No ( ) Yes

46. Do they take the bruised vegetable after harvesting?

( ) No ( ) Yes

47. Do you do sorting of your produce?

( ) No ( ) Yes

48. Do you equip the harvesters with the proper working tools?

( ) No ( ) Yes

49. If yes name the tools.....

50. Packaging material used

( ) Wooden boxes ( ) Jute bags ( ) Metal containers ( ) Plastic ( ) Other (specify)……

52. Source of the containers

( ) Self-made ( ) Bought from local market ( ) Imported ( ) Borrowed ( ) From co- operative ( ) Other (specify)……

53. Condition of the containers

( ) Very good ( ) Good ( ) Bad ( ) Very bad

54. Means of transportation

( ) Transport/vehicle ( ) Carts ( ) Head-loads ( ) Any other (specify).....

55. Type of van/vehicle used for transportation

( ) Van with cooling system ( ) Van without cooling system ( ) Van with sides open

( ) Van without sides open

56. Temperature in the transporting van .....

57. Condition of the road from the farm to the market/storage facility

( ) 1st class road ( ) 2nd class road ( ) Untarred ( ) Immotorable

( ) Other (specify).....

58. Was any chemical introduced to the vegetable at the time of transport?

[ ] Yes [ ] No

59. If yes what is the name of the chemical? .....

60. How long did the transportation to the storage facility last?.....

61. Storage facility used

[ ] Deep freezer [ ] Refrigerator [ ] Cooling room [ ] Shed/store room

[ ] Other (specify) ……..

62. Was there any value addition to the vegetable?

[ ] No [ ] Yes

63. If yes what value addition?

.....

.....

64. Is there toilet facility at the farm?

[ ] No [ ] Yes

65. Where is the vegetable marketed?

[ ] Farm gate [ ] Local market [ ] Hotels [ ] Households [ ] Road side [ ] Any other (specify).....

66. How long do the vegetable take at the storage? .....

67. Processing activity to the vegetable

[ ] Bottling [ ] Canning [ ] Drying [ ] Any other (specify)…….

68. Any other treatments/activities given to the vegetable aside those named above

.....

.....

69. Any other suggestion as to the proper way of handling produce to increase shelf-life.

……

……

QUESTIONNAIRE B

MARKET WOMEN

Please write the appropriate response in the box/space provided

1. Name (optional) .....

2. Town, Village/Community .....

3. Age .....

4. Sex

[ ] Male [ ] Female

5. Educational background

[ ] Nursery [ ] Primary [ ] JHS/JSS [ ] Middle [ ] Secondary

[ ] Vocational/Technical/Commercial [ ] Post middle/Secondary certificate

[ ] Diploma/Degree [ ] Others (pleases specify)

.....

6.Mainactivity/occupation.....

.....

7. Marital status

[ ] Single/never married [ ] Married [ ] Widow/widower [ ] Divorced

8. Where do you sell?

[ ] Market [ ] Road side [ ] Hotels/Hall [ ] Hawk from house to House

If any specify.....

9. Where do you get your produce to sell?

[ ] Own farm [ ] Vegetable producers [ ] Importation [ ] Other market woman

[ ] Other(pleasespecify).....

.....

10. Are you able to meet the demands of your customers?

[ ] Yes [ ] No

11. Do you have storage facility for your vegetables? [ ] No [ ] Yes

12. Name the storage facility

.....

13. How do you transport your produce from farm to selling point?

.....

14. What value do you add to your vegetables before selling?

[ ] Washing [ ] Salting [ ] Waxing [ ] Other (please specify) ……

15. Do you sell in packages?

[ ] No [ ] Yes

If yes what package type ? .....

16. How do you sell your vegetables?

[ ] Retail [ ] Wholesale

[ ] Other(please specify)

.....

17. Do you apply any agrochemical to your vegetable before selling?

[ ] No [ ] Yes

If yes name the chemical.....

18.If **Yes** or **No** to the above (17), explain why?.....

..... 19. Name the diseases and pests found on the vegetable.....

20. How do you treat diseases and pests found on the vegetable?.....

[ ] Apply appropriate chemical [ ] Use chemical free means to control 3. Do not treat any disease or pest

21. How do you dispose of spoilt vegetables?

[ ] Bury them [ ] Sell at cheap price [ ] Give as gift to others

[ ] Leave them to rot to rot [ ] other (specify)……

.....

QUESTIONNAIRE C

CONSUMERS

Please tick (√) or write short answers where appropriate

1. Name (optional) .....

2. Town, Village/Community .....

3. Age .....

4. Sex

[ ] Male [ ] Female

5. Educational background

[ ] Nursery [ ] Primary [ ] JHS/JSS [ ] Middle school [ ] SSS/SHS

[ ] Vocational/Technical/Commercial [ ] Post middle/Secondary certificate

[ ] Diploma/Degree [ ] Others (pleases specify)

.....

6.Mainactivity/occupation.....

.....

7. Marital status

[ ] Single/never married Married [ ] Widow/widower [ ] Divorced

8.Where do you get this vegetable to buy?

[ ] Market [ ] Super market [ ] Hawkers [ ] Roadside

[ ] other (please specify).....

9. Vegetable (type) consume .....

10. The form in which it is consumed

[ ] Fresh [ ] Cook [ ] Roast [ ] Other (please specify).....

11. How frequent do you consume this type of vegetable? .....

12. Why do you prefer this vegetable to the others? .....

13. Source of vegetable

[ ] Organic [ ] Inorganic

14. Why do you buy the vegetable?

[ ] Desire satisfaction [ ] Affordability [ ] Rich in nutrient

[ ] Good packaging [ ] Non-of the above [ ] Other

(please specify)…….

15. Nutritional value of the vegetable

[ ] High [ ] Low

16. How do you know the vegetable contains the nutrients you desire? .....

17. When is the produce eaten best?

[ ] Morning [ ] Afternoon [ ] Evening

18. How do you store the vegetable?

[ ] Refrigeration [ ] Salting [ ] Agro-chemical application [ ] Drying

[ ] Food [ ] additives other (specify) ……..

19. How long (days) do you keep the vegetable in storage? .....

.

20. Packaging material(s) used to carry the vegetable …….

21. How do you dispose of spoiled vegetable……

22. Any other way(s) you handle/treat vegetables before consumption (please specify)……..

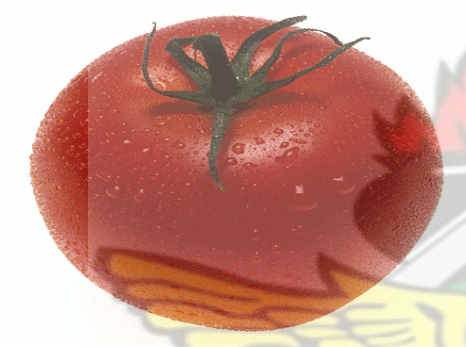
……

…

Carrots

Onion

Tomato



Garden eggs

Cabbage

Pepper