POSTHARVEST HANDLING PRACTICES OF CABBAGE AND CAULIFLOWER IN SELECTED AREAS OF MYANMAR

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POSTHARVEST HANDLING PRACTICES OF CABBAGE AND CAULIFLOWER IN SELECTED AREAS OF MYANMAR

A thesis presented by

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The thesis attached hereto, entitled **"Postharvest Handling Practices of Cabbage and Cauliflower in Selected Areas of Myanmar"** was prepared under the direction of chairperson of the candidate's supervisory committee and has been approved by all members of that committee and board of examiners as partial fulfillment of the requirements for the degree of **MASTER OF AGRICULTURAL SCIENCE (HORTICULTURE).**

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DECLARATION OF ORIGINALITY

This thesis represents the original works of the author, except where otherwise stated. It has not been submitted previously for a degree at any other University.

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DEDICATED TO MY BELOVED MOTHERS,

DAW CHO CHO AND DAW SU SU HLAING

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Postharvest Handling Practices of Cabbage and Cauliflower in Selected Areas of Myanmar

Dr. Than Than Soe Thandar Hnin

ABSTRACT

The study was conducted to investigate the existing handling practices and postharvest losses of cabbage and cauliflower in selected areas of Myanmar from December 2011 to May 2012. A total of 211 respondents from Aung Ban, Nay Pyi Taw and Yangon were randomly selected and interviewed using structural questionnaires. At the grower sites, the losses of cauliflower in Tatkone were significantly higher than that of Aung Ban due to pest, disease and climatic condition at preharvest stage. The harvesting losses and transportation losses of cabbage and cauliflower at the grower site in Aung Ban were significantly higher than that of Tatkone due to improper harvesting, unsystematic handling practices and poor transportation. The harvesting loss of cabbage at the broker site in Tatkone was significantly higher than that of Aung Ban. The losses of both crops were highest significantly at grower sites among the stakeholders. However, there were no significant differences in losses along the supply chain between growers and wholesalers. Postharvest losses of cabbage and cauliflower at wholesalers in Yangon were significantly higher than that of Nay Pyi Taw due to prolong transportation period while the losses of both crops at the retailers in Nay Pyi Taw were significantly higher than that of Yangon due to different types of transportation vehicles. The losses of cauliflower stakeholders were higher than that of cabbage stakeholders due to its inflorescence crop type and discoloration of the curd. The suitable and mostly used position during storage and transportation for cabbage is upside down and side by side position for cauliflower. Packaging of mesh bag, plastic bag and bamboo basket at the retailers were commonly employed. It was observed that cabbage and cauliflower without packaging materials were currently practiced during transportation.

Keywords: handling practices, harvesting loss, postharvest, transportation and supply chain

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INTRODUCTION

Myanmar has huge potential for production of various kinds of horticultural crops such as tomato, cabbage, cauliflower, radish and mustard. They are cultivated year round or seasonally in different parts of the country. Vegetables are sources of vitamins, minerals, dietary fiber and plant proteins. Vegetables play an important role in human nutrition and leafy types, are a rich source of essential nutrients such as vitamin A and folic acid (Aye, 2007). The availability of vegetables in Myanmar is less than 50% and the recommended daily dietary intake of vegetables is (300g/day) (FAO 2009). In Myanmar, cabbage and cauliflower are grown annually on about 30,272 and 26,698 hectares, respectively (DAP 2011). Aung Ban areas produce a variety of vegetables while Tatkone areas specialize in growing many kinds of kitchen crops like chili, onion, cabbage, cauliflower and okra.

Postharvest handling is a set of operations undertaken from the time of harvest up to the time just before consumption or just before processing (Kanlayanarat 1997). According to FAO (2004), in developing countries postharvest losses of fruits and vegetables are more serious than those in well developed countries. Postharvest losses of fruits and vegetables are estimated 5-20% in developed country and 20-50% in developing countries (Mashav 2010). The perishability of the product, which is very high for fruits and vegetables; the bulkiness of the product, which adds to transportation inconveniences, storage and labor cost; the quality of the products such as color, freshness, smell e.t.c. (Mbuk et al. 2011).

Postharvest handling procedures are not fully recognized in less developed countries until 1989 (FAO 1989). Surveys have revealed that a substantial portion of the harvest is wasted in the region annually due to improper harvesting and postharvest practices, disease, pest and lack of facilities and technology to extend their storage life. This continues to cause heavy losses in revenue to the growers, wholesalers, retailers and exporters and inconvenience to the consumers and lowers export potential of these commodities (Damunupola 2011). The middlemen/brokers collect the produce from the farm and bring it to the wholesale market using cow-driven carts. In Myanmar, handling practices are unsystematic and postharvest technology is insufficient, except water washing and cleaning the harvested produce. Marketing systems vary from region to region and from crop to crop. There is no or very few quality assurance system for vegetables (Aye, 2007).

Efficient production and market channel is an important means to raise the income levels of growers and to promote the economic development of the stakeholders in the country. An efficient marketing system is one capable of moving goods from producer to consumer level at the lowest cost consistent with the provision of the services that consumer demand (Oo, 2008). Quality management throughout the commodity chain is mainly based on local knowledge, resources, and traditional wisdom (Aung et al. 2005). Usually, losses occur from poor storage conditions in the markets and poor packaging during transportation. Due to the physiological behavior of fruits and vegetables, they deteriorate easily in transit and storage, especially under conditions of high temperature and humidity and as a result, heavy losses occur in these crops (Idah et al. 2007).

In Myanmar, the largest wholesale markets are Thiri Mingalar market in Yangon and Aharrthukha market in Nay Pyi Taw. Both markets are working 24 hours every day and the busiest time is 12 p.m. to 7 a.m. with wholesalers and retailers from nearby areas. The supply period of cabbage and cauliflower for Yangon and Nay Pyi Taw wholesale market is October to February from Aung Ban whereas the supply period is December to May in Nay Pyi Taw. Trucks are mainly used for long distance transportation without packaging. Commodities are transported from growing area to wholesale markets by mean of truck or else; whereas, brokers, collectors and off-takers are served as middleman among the producers, wholesalers and retailers; urban wholesalers sell to retailers in nearby markets and send to other markets.

Postharvest handling practices include harvesting, storage, cleaning, grading, packing, transportation and sorting (Mrema and Rolle 2002). The most important goals of postharvest handling are to keep the product cool, thereby avoiding moisture loss and slowing down undesirable chemical changes and to avoid physical damage such as bruising to delay spoilage. This in turn will help ensure increased food security and then result beyond food production to include distribution and marketing, adequate and stable supply, and accessibility to food (Idah et al. 2007).

Quantitative and qualitative losses of fruits and vegetables in postharvest stage are very high, even in developed countries (Yune 1995). The reduction of losses, quality maintenance and freshness of harvested products prior to consumption is extremely important in both local and export markets (Damunupola 2011). In Myanmar, there is paucity of research paper in relation to postharvest handling practices and losses in horticultural crops. Postharvest handling practices for cabbage

and cauliflower are not systematically conducted along the supply chain. Therefore, the present survey had been carried out with the following objectives;

1. To investigate the postharvest handling practices of cabbage and cauliflower in study areas
2. To diagnose the highest losses by the stakeholders along the supply chain in study areas

CHARAPTER II

LITERATURE REVIEW

2.1 Origin of Brassica Crops

Cole crops are a group of related vegetables belonging to mustard family, Brassicaceae (formerly Cruciferae). They include broccoli, cabbage, cauliflower, Brussels sprouts and kale. Cole crops grow well in cool weather. Cole crops are biennials, but are generally grown as annuals. Cabbage (*Brassica oleraces* var. capitata, tuba and sabauda) is thought to be an early ancestor of the wild Brassica species. Compared to all of the vegetables that originated in Europe, the cabbage family has one of the longest histories. Many botanists believe that the modern brassicas evolved from the wild sea kale (*B. oleraccea*), which is native along the western and southern sea coasts of Europe (Nieuwhof 1969). Cabbage originated in the eastern Mediterranean or Asia Minor, and the hard-headed varieties produced today were grown in Europe by the ninth and tenth centuries. Cabbage is bursting with various health-giving properties such as an abundant supply of vitamin C, vitamin A, as well as other minerals, phosphorus, calcium and iron. Cabbage also has lactic acid which helps digestion and is low in calories (Tan 2005).

Cauliflower (*Brassica oleracea* var *Botrytis*) is part of a large group of plants known as cole Crops. Cauliflower came from the Mediterranean region. The brassica family is quite cold resistant, making them well adapted to cool season production. With most Cole crops, a cold period is necessary for flowering, however each crop has its own temperature tolerance. Young, hardened cauliflower plants can withstand temperature of 0°C for less than 36 hours. The minimum and maximum growing temperatures for cauliflower are 0 and 30°C, with the optimum growing temperature for this crop between 15 and 22°C (Tan 2005).

2.2 Factors Affecting the Quality of Cabbage and Cauliflower

The quality of cabbage and cauliflower is influenced by a number of interacting factors, which may be preharvest, harvest, and 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 of technical and scientific technologies, inefficient commercialization and marketing systems, lack of logistics support, and

lack of enabling policy for the use and administration of human, economic, technical, and scientific resources (Kader and Rolle 2004).

2.2.1 Preharvest factors

The effects of preharvest factors on postharvest quality of vegetables have been reviewed by several authors (Kader and Lee 2000, Sams 1999). A diverse range of biotic and abiotic factors can alter the appearance of vegetables prior to harvest. Even under optimum conditions, a portion of every crop is invariably downgraded due to appearance defects (Kays 1999). If poor management decisions are made during crop production, the texture of the product which reaches consumers may be undesirable (Sams 1999).

2.2.1.1 Genetic factors

The quality of any crop is largely influenced by the genetic factors, the variety used. Most of the vegetables have limited storage life even under optimum storage conditions. The potential storage life is partly under genetic control and can be manipulated by breeding. Breeding for long shelf life and desired shipping quality is needed most in developing countries with hot and humid climates where refrigerated facilities are lacking due to high initial and operational cost (Kanlayanarat 2007).

More efforts are now exerted to develop varieties with long shelf life, desired shipping and processing attributes, and high levels of nutrients, in addition to developing tropical (high temperature-resistant) varieties of otherwise temperate or semi-temperate vegetables such as the brassicas (e.g. cabbage, Chinese cabbage). Breeding leafy vegetables with high carotenoids content has been reported and results in lettuce proved to be promising due to observed genetic variations in β-carotene and lutein contents (Fonseca 2004). β-carotene and lutein contents were further observed to be higher in leaves with higher chlorophyll content (Acedo 2007).

2.2.1.2 Climatic factors

Temperature. The temperature at which a plant grows affects not only its yield but also its maturation rate and its quality at harvest. High temperatures during the preharvest phase influence the shelf life and quality of plant parts. Excessive heat results in increased water loss, and may lead to water stress as the rate of transpiration exceeds the rate of water uptake. Plants that experience heat stress show an increase in water uptake. Eventually heat stress leads to an increased rate of senescence. It is crucial that plants are are grown at the correct temperature to limit stress. If it is possible, lowering the temperature prior to harvest is ideal for practicing to reserve

more carbohydrates (sugar and other reserves) to help plants last (Perry 1998).

Light. Climatic conditions including light have a strong influence on the chemical composition of horticultural crops and nutritional quality of vegetables (Klein and Perry 1982).

Rainfall. Rainfall affects the water supply to the plant, which may influence composition of the harvested plant part and its susceptibility to mechanical damage during subsequent harvesting and handling operations (Kader 2002).

Relative humidity (RH). Relative humidity (RH) can influence water loss, decay development and incidence of some physiological disorders. The rate of water loss depends on the vapor pressure deficit between the commodity and the surrounding ambient air, which is influenced by temperature and RH. At a given temperature and rate of air movement, the rate of water loss from the commodity depends on the RH. At a given RH, water loss increases with the increase in temperature (Kader 2002).

Wilting and shriveling are likely to occur in most vegetable crops when stored at low RH (Gast et al 1991). However, RH close to 100% can be ideal for the growth of microorganisms and can cause surface cracking in some produce (Wills et al 1998).

2.2.1.3 Production practices

Cultural practices during production have a tremendous effect on produce quality, safety, and shelf life. For example, lettuce harvested during a period of rain does not ship well and product losses are increased. Produce that has been stressed by too much or too little water (by irrigation or rainfall), high rates of nitrogen fertilization, or mechanical injury (scrapes, bruises, abrasions) is particularly susceptible to postharvest diseases (Jiang and Pearce 2005).

The effects of mineral and elemental uptake from fertilizers by plants are, however, significant and variable (Goldman et al. 1999, Kader 1988). The application of additional nitrogen fertilizer is necessary as a side dressing when plants are well established (Delahaut 1997). Brassicas are susceptible to bacterial soft rot if nitrogen is applied as foliar feed, thus nitrogen should be applied to the soil (Jiang and Pearce 2005). Applying nitrogen above the optimal rates resulted 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 of Brassicas. Increasing the period of shading before harvest further reduced sugar content and increased moisture loss during storage.

For successful production of the cole crops, one of the key factors is insect and disease control in the planting. Principal insect and disease problems in growing the crops are cabbage looper, cabbage root maggot, imported cabbage worm, aphid, flea beetle, blackleg, black rot, club root and yellows. Other important cultural practices for cole crop production include weed control (mulching), watering if necessary during dry periods (Delahaut 1997).

Some preventive measures include (1) avoiding application of fresh animal manure or slurries to a field or to an area immediately adjacent to a field near harvest maturity, (2) cleaning equipment that has been used to apply manure on one field before moving it to another field, (3) avoiding using irrigation water from a farm pond used by livestock, and (4) avoiding contact of produce with soil during growth (this can be done by mulching) or harvest (Bachmann and Earles 2000).

In the case of cauliflower, blanching of the head is necessary. Blanching can be done by tying the outer leaves over the developing curd. In some cauliflower varieties, the leaves naturally cover the developing curd (Delahaut 1997).

2.2.2 Harvest factors

2.2.2.1 Harvest maturity

The quality of horticultural crops is mainly based on appearance (e.g. fresh-looking, well-formed or well-shaped, right size, right maturity, right color, turgid or not wilted, free of defects such as rot, physical damage, yellowing, or wilting) and to a certain extent, other attributes that cannot be seen but can be felt by the other human senses, such as firmness, tenderness, and taste. For cabbage, the heads should be light green, compact but not over mature (no seed stalk), right size, and free of defects. Freshness of cabbages can be tested by rubbing two heads together; if they are fresh, they will make a squeaking sound (Kanlayanarat 2007).

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 produce picked at proper maturity. Cabbage heads are harvested when firm and mature (Bautista and Acedo 1987; Boyette et al.1992; Stephens, 2003; 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 rot. 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 also decreases and shelf life is shorter than that of mature heads (O'Hare et al. 2001).

2.2.2.2 Harvest time

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 is desirable because the produce would not be exposed to the heat of the sun and the efficiency of the harvesters would be high. If harvesting during the hotter part of the day could not be avoided, the harvested produce should be kept shaded in the field to minimize weight loss and product heat. Handle produce gently during harvesting and field handling (Jiang and Pearce 2005).

2.2.2.3 Harvest method

Cabbage and cauliflower can be 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. The head should not be removed by snapping or twisting, as this practice damages the head and results in inconsistent stalk length and trim. Broken stalks are also more susceptible to decay. The stalk should be cut flat and as close to the head as possible, yet long enough to retain two to four wrapper leaves. Extra leaves act as cushions during handling and may be desired in certain markets. Yellowed, damaged, or diseased wrapper leaves should be removed. Heads with insect damage and other defects should be discarded. It is essential that heads can be left undamaged in the field because the heads may be harvested as many as three times for maximum yield (Jiang and Pearce 2005).

2.2.2.4 Field handling system

Harvested cabbage can be placed in bags, boxes, wagons, or pallet bins. Washing is not advisable in common cabbage. Other leafy vegetables should be transported to the packing shed as soon as possible as they are particularly susceptible to wilting and other damage from high temperatures (Vanndy and Buntong 2007). Harvesting aids can significantly reduce labor costs, improve harvest efficiency and cabbage quality, and speed the harvest operation dramatically. Aids may be as simple as a modified farm trailer for transporting boxes. Throwing of harvested cabbages to the container or collection vehicle should be avoided; instead, has someone catch the head for proper placement to prevent physical injuries.

2.2.3 Postharvest factors

After harvesting the crop, postharvest handling practices are required to ensure quality produces reaching the consumer: preparation for fresh market (packinghouse operations such as cleaning, trimming, sorting, curing, grading, packing), cooling (the cold chain system as the means to maintain high quality), storage (to balance day-to-day fluctuations between produce harvest and sales), modes of transportation (road, rail, water), and temperature management during transportation (air circulation, refrigeration, load patterns and sizes, modified atmospheres) (Wills et al. 1998**).**

2.2.3.1 Packinghouse operations

Trimming. The outer leaves (wrapper leaves) of cabbages are trimmed off except for 3-4 wrapper leaves to protect the head from injuries during handling and transport (Bautista and Acedo 1987). However, wrapper leaves could not fully protect the head from too much force due to impact or compression, which usually results in head bursting.

Washing. In cabbages and cauliflower, washing is not advisable since it could favor bacterial soft rot if they are not properly dried. The inner edible part is kept clean by the wrapper leaves. Most leafy 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 is often contaminated with soil (Kader 2006).

Sorting and Grading. 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). Systematic grading coupled with appropriate packaging and storage will extend postharvest shelf life, wholesomeness, freshness, and quality, and will substantially reduce losses and marketing cost. Most vegetables are usually sorted/ graded based on maturity, size, shape, color, weight, and freedom from defects such as insect, disease, and mechanical damage. Cabbage and cauliflower are graded usually based on size that means the diameter of the head.

In developing countries, implementation of grade standards as well as safety standards for leafy vegetables and other fresh horticultural produce faces formidable difficulties that contribute to the lingering problem of high postharvest losses. Grade standards, if enforced properly, are essential tools of quality assurance during marketing. They provide a common language for trade among farmers, handlers, processors, and marketers, maintain orderly marketing and equity in the market-place, and protect consumers from inedible and poor quality produce (Kader 2006).

Packaging. Proper packing is essential to maintain the freshness of leafy vegetables. Packaging should be designed to prevent deterioration of product quality, in addition to serving as a handling unit (Bautista and Acedo 1987). As protection, packages should prevent or reduce physical injury to the produce during transit and handling, provide ventilation to hasten cooling and escape of heat caused by respiration, and reduce water loss from the produce (Gast 1991). Some packages promote sale of the produce.

Produce packages. Rigid containers (e.g. plastic or wooden crates, cartons) are far better than non-rigid containers (e.g. mesh bags, plastic bags) to protect produce from damage during handling and transport. Rigid packages are also easier to palletize. The different packages are described as follows:

Basket: Usually refers to containers made of woven materials such as bamboo, rattan, or plastic strips.

Box: Usually refers to containers made of corrugated fiberboard 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. Plastic containers, a relatively new type of container, have good stacking strength and are water resistant. The use of plastic crates for handling and transportation of vegetables was introduced recently in some developing countries. In Nepal, the use of plastic crates is increasing among 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). In Sri Lanka, losses of vegetables were reduced from 30% with the use of poly sacks to 5% with the use of plastic crates (Fernando 2006).

Mesh bags: Well-ventilated condition to the contents is achieved in the mesh bag. The netting with openings between strands of 3 to 6 mm allows free movement of air to and from the interior of the bag. Mesh bags are fabricated from several materials, the most common of which are fine plastic strands, cotton thread, and twisted strands of processed paper. The important advantages of mesh bags are (a) excellent ventilation for heat exchange during precooling, (b) avoidance of high relative humidity in the bag for commodities and situations in which high relative humidity is undesirable, (c) good visibility of product, and (d) easy closure (Will et al 1998).

2.2.3.2 Transportation

Minimizing losses during transport necessitates that special attention be given to vehicles, equipment, infrastructure, and handling. Fresh produce is transported using both refrigerated and non-refrigerated vehicles. Non-refrigerated vehicles generally are open-sided trucks with wire mesh frames. This type of transport is inexpensive and convenient, and is usually used in developing countries. Fresh produce must not be watered prior to loading, as this will lead to decay, rotting, and extensive losses. Major causes of losses during non-refrigerated transport of fresh produce are improper handling during loading and unloading, overloading without separation of produce, which leads to overheating and mechanical injury to produce at the bottom of the stack, rough roads, and lack of ventilation of the produce. Postharvest operations must address these problems. Careful handling is a well-known method of reducing postharvest losses as is the provision of adequate shipping containers to protect the produce from physical damage. Highly perishable but high value demand vegetable such as cabbage, cauliflower produced from different area in different seasons are transported to urban assembly markets and wholesale market by wholesalers (FAO 2001).

2.2.3.3 Storage

Temperature management is the most important tool to extend shelf-life and maintain quality of fresh fruits and vegetables (Kader and Lee 2000).Temperature also influences the effect of ethylene (Jones 1959), reduced oxygen and elevated carbon dioxide (Kader 2002). Low temperatures reduce ethylene production and sensitivity (Barden and Hanan 1972; Maxie et al. 1973). Moreover, the spore germination and growth rate of pathogens are greatly influenced by temperature (Kader 2002).

Temperature is the single most important factor affecting the deterioration rate of harvested commodities (Kader 1992). The rate of deterioration is proportional to the respiration rate of the commodity, which is temperature-dependent. For each 10°C reduction in temperature, the respiration rate of a wide range of produce can be reduced 2 to 4 times than normal conditions (Wills et al 1998). Moreover, the activity of postharvest pathogens and insects is also suppressed by low temperatures (Raghavan 1996). Therefore, cooling and refrigeration are important to preserve the quality of fresh fruits and vegetables and to extend their storage life. The ideal storage temperature varies from product to product, and the temperature maintained in the

storage area should be within 1°C of that level. Too low temperature for each crop may cause chilling injury and can reduce the storage life of the product (Wills et al 1998).

Freshly harvested Brassica vegetables should rapidly cool to below 2°C and stored between 0°C to 2°C. Pre-cooling and storage at low temperatures slow down the physiological and biochemical processes associated with deterioration and decay. Low temperatures also reduce water loss through transpiration and delay the growth of micro-organisms which can cause rotting. An increase in the temperature of 10°C can increase the rate of respiration and deterioration that resulted in decay by two to three times (Tan 2005).

Brassica vegetables should be stored at RH higher than 90%. Although the RH of air increases when air is cooled, it is still necessary to check that the RH in a cool room is satisfactory (Tan 2005). Vegetables should be stored in a ventilated place with a relative humidity of 85-90% to reduce water loss. Cauliflower can be stored two to three weeks and cabbage even longer. Storage at high temperature rapidly causes deterioration of cauliflower quality and shelf life. Both hydro cooling and vacuum cooling are effective methods to remove field heat for cauliflower. In addition, forced-air cooling can be used. Cauliflower that is destined for storage is preferable cut slightly immature, otherwise the curds may separate.

Air movement is essential in refrigerated storage to remove the heat generated by stored fruits and vegetables. However, such air movement also tends to decrease the layer of moist air surrounding the product (the boundary layer). This increases the water vapor pressure difference near the surface of the product and thus increases transpiration. Restricting the airflow around produce in cold storage can, therefore, reduce the rate of water loss. This can be achieved after initial cooling by decreasing the amount of air movement generated by the fans, either by running them at lower speeds or by reducing the length of time that they are operating. Open rooms with natural ventilation can also be modified to restrict airflow. However, there must be sufficient air movement to prevent large temperature gradients forming within the storage room (Wills et al 1998).

2.3 Causes of Postharvest Losses in Cabbage and Cauliflower

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). Postharvest loss estimates in developing countries are alarming (e.g. 20-50% of production) but efforts are lacking to specify the seriousness of the problem and the interventions that are really needed. In the AVRDC-ADB postharvest projects, postharvest losses were determined at specific stages in the supply chain in Cambodia, Laos and Vietnam and outright volume loss of specific vegetables including the leafy types (e.g. Chinese cabbage) was estimated at an average of 17% (Weinberger et al. 2007).

Main causes of quality deterioration and postharvest loss of vegetables are wilting, yellowing, mechanical injury, high respiration rate, and decay (Kitinoja and Kader 2002). These loss factors can be categorized into physiological, pathological, and mechanical causes.

2.3.1 Physiological deterioration

Water loss and leaf wilting. Horticultural crops contains 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. It also induces degradation of nutritional components (e.g. vitamin C loss) and imposes stress (i.e. water stress) that increases respiration and ethylene production (O'Hare et al. 2001).

Respiration and ethylene production. Cabbages generally have lower respiration and ethylene production rates due partly to their morphology, in which the young inner leaves are fully covered by the more mature outer leaves, as compared to Chinese kale, mustard greens, and culinary herbs. However, they are sensitive to ethylene (senescence hormone), which causes yellowing, epinasty (leaf curving), and abscission (Cantwell and Suslow 2006; Jobling 2006).

Physiological disorders. Chilling injury is induced by storage below the recommended low temperature requirement but above the freezing point of tissues usually between -2°C to 0°C. For common cabbage, physiological deterioration during storage is associated with stem or seed stalk growth (bolting), root growth, internal breakdown, leaf abscission, discoloration, and black speck (Cantwell and Suslow 2006).

2.3.2 Pathological decay

Bacterial soft rot is the major disease problem in many vegetables, particularly the brassicas. It is caused by various bacterial species including *Erwinia, Pseudomonas,* and *Xanthomonas* and is characterized by slimy breakdown of infected tissue with offensive foul odor. The disease usually develops at the cut portion (butt end) and injured leaves of cabbages. Other common decays in cabbage are watery soft rot (*Sclerotinia*), gray mold rot (*Botrytis cinerea*) and alternaria leaf spot (*Alternaria* spp.) (Cantwell and Suslow 2006).

2.3.3 Mechanical injury

Forms of mechanical injury include leaf tearing, midrib breakage, and leaf or head cracking and crushing. Physical injuries increase the rate of physiological deterioration, including browning, as a result of oxidation of phenolics substances and the susceptibility to decay. Postharvest rots have been found to be more prevalent in bruised or otherwise damaged produce (Bachmann and Earles 2000). Mechanical damage also increases moisture loss by as much as 3-4 times.

2.4 Ways to Reduce Postharvest Losses

Strategies for loss prevention include use of genotypes that have longer postharvest life, use of an integrated crop management system that result in good keeping quality, and use of proper postharvest handling systems that maintain quality and safety of products (Kader 2003, Armitage and Laushman 2003).

Postharvest technology is one of the important functions in the vegetable sector and needs attention. The problems of postharvest technologies are faced by every country, which has domestic or export trades of fresh vegetables. This important factor is more critical in the case of developing tropical countries than in the case of temperate countries. This is because of the poor infrastructural facilities, transportation bottlenecks and high temperatures (FAO 2001).The cold chain system probably is a foremost technology to enhance marketing efficiency through reducing marketing losses, though it entails additional marketing costs.

Physical damage to the produce is usually inflicted during packing, transport, and their associated handling activities (e.g. loading and unloading). To reduce damage, necessary care must be employed and if possible, the tender-loving-care principle in product handling should be followed. Specific measures that can be adopted to reduce product damage are as follows:

1. use lining and cushioning materials in the pack
2. employ individual wrapping for some produce
3. use cell dividers, trays for layer packing in a pack, and other similar materials like foam cups particularly for export commodities
4. avoid or eliminate sources of damage during packing (e.g. dropping of produce into the package, presence of sharp materials in the hand)
5. immobilize the produce inside the pack
6. do not overpack or underpack
7. secure the package properly
8. use a package size enough to be carried by one person to avoid dropping
9. immobilize the packages inside the transport vehicle
10. do not overstack
11. use horizontal wooden dividers between layers of baskets in a stack
12. for mixed loads, consider compatibility of the different produce for temperature, humidity, ethylene production and sensitivity, and product odor
13. minimize delay
14. protect the produce from heat, rain, and wind
15. provide proper ventilation to avoid hot spots and stagnant high-ethylene air
16. ensure proper condition of transport vehicle (e.g. suspension system)
17. emphasize proper driving of vehicle to avoid damaging impact and vibration forces
18. observe care in loading and unloading of packages of produce and other handling activities during transport from production points to destination outlets
19. Provide necessary education and/or training for people involved in product handling (Kanlayanarat and Acedo 2000).

2.5 Market Handling

Wholesale markets: Wholesale markets constitute the basic source of supplies for retailers, the outlet for producers or commission agents, and the center for the sale of imported produce and for the dispatch of produce to export markets. At this market, supply and demand find an equilibrium price and this becomes the major determinant of prices throughout the area. Wholesale markets are usually owned by private corporations, public benefit corporations (market authorities), states or

municipalities (direct public ownership), cooperatives of market users, farmers, or traders, or by mixed corporations. They have a component administrative body and offer various services in relation to the distribution system.

Wholesalers may fall to one or more of the following categories

1. service wholesalers that supply produce to independent and/or chain retail stores and to food services distributors;
2. car-lot receivers that divide and sell large quantities to retailers, brokers, jobbers, purveyors, and institutions;
3. commission merchants who consigned shipments on a fixed percent commission and may also service retailers;
4. jobbers who handle products from car-lot receivers to small, independent retailers;
5. mixers who buy from other wholesalers and make up mixed loads for transport to distant markets;
6. importers who sell or resell to domestic markets and who may also be buyers, shippers, brokers, or exporters;
7. wholesale auctions that sell produce on a price-bid basis;

Retail markets: Retailing is selling to consumers. In retail markets, the produce is placed before the consumers for acceptance or rejection. The retail market is the only means of access to the essentials of living and the ultimate point of contact with the users of produce. The retailer is the principal partner of the wholesaler in the distribution process. Retailers may consist of direct marketing outlets that include farmer's markets or roadside stores. Some handling activities at retail markets are similar to that at wholesale markets and may include the following:

1. re-sorting due to non-uniformity of quality, maturity of ripeness
2. cleaning to make produce on display more appealing to consumers
3. storage usually at ambient by roadside markets and these markets rely heavily on quick turnover to avoid handling problems; some supermarkets may use refrigerated shelves (Kanlayanarat 2000).

2.6 Market System

The marketing system is a part of the whole postharvest system and is concerned more with the channels, mainly market levels and personalities, through which the produce moves, and with changes in price margins or profit margins

(economics aspect). The marketing chain starts with the producer and essentially ends in the retail store where the battle of the market is fought to the final conclusion. The consumer is also the final point in the postharvest system but in the much broader system, the production-postharvest system, the starting point should be the consumers also. This is because the consumers' expectations of quality ideally constitute the primary force on how the product must be produced and on how the harvested produce must be handled. Also, the postharvest system includes both the marketing channels and the handling operations (Kanlayanarat 2000).

Marketing channels. The most direct channel goes from the producers straight to the consumers, but many other variations are possible and are frequently used in actual marketing operations. Thus, marketing of fresh produce operates through a complex matrix potentially involving many individuals and organizations, many channels and many different geographic locations. The complexities of the marketing channels will vary with the characteristics of the commodity, nature of production, type of market, or with consumption patterns of the consumers (Kanlayanarat 2000).

Marketing Characteristics. In Asian countries, there is a striking dichotomy in produce marketing (and handling). On the one hand, highly integrated and efficient marketing system exists for the export produce while on the other, domestic produce marketing is highly fragmented and problematic. Some characteristics of domestic produce marketing are as follows:

1. numerous, highly integrated middlemen doing specialized value-added activities to facilitate distribution. These middlemen can be categorized into merchant middlemen who take title to product and buy and sell the product for own profit (e.g contract buyers, wholesalers, retailers) and agent middlemen who do not take title to the product and only sell services for a fee or commission (e.g commission agents, brokers);
2. buying at farmgate is largely an informal contract purchase arrangement or marketing tie-up, usually entailing cash advances to farmers;
3. buying from farmers on assortment basis

Marketing problems and recommendations. The common problems in the marketing of fresh produce in developing countries are the poor physical infrastructures (farm-to-market roads, transportation, communication, and postharvest facilities), lack of market facilities, and lack of market support services (market

information, credit, grade standards, market policies). Thus, efficiency in marketing system will largely depend on how the aforesaid problems are addressed. A more organized marketing structure must be developed and essential infrastructures such as road system, transport facilities, communications systems, and packinghouse and storage facilities should be set in place. A rational marketing regulations and policies should also be instituted. Accurate and timely information about markets, pricing, etc. are needed to allow producers to plan their production and marketing personnel to make quick decisions. Marketing cooperatives or organizations must be strengthened also considering that the agricultural produce industry is dominated by small scale operators. Practical grade standards are also important. These strategies together with appropriate production and postharvest handling systems and a quality assurance program can ensure much reduced losses, increased and sustainable profits to producers and postharvest handlers, and good quality and safe produce to consumers (Kanlayanarat 2000).

2.7 Current Status of Cabbage and Cauliflower Production in Myanmar

In Myanmar, cabbage and cauliflower are generally grown in winter season, in Mandalay Region. However, in the Shan state, cabbage and cauliflower can be grown starting from August until December. The sown acreage of cabbage and cauliflower was 32337 hectares and 26609 hectares, respectively in 2011-2012. Harvested areas were 32337 hectares for cabbage and 26609 hectares for cauliflower. Production of cabbage and cauliflower was 471235 MT and 333780 MT, respectively (DAP 2012). During November to February is the on season of cabbage and cauliflower that is the lowest price in the market. Aung Ban area is the main production source and also high production area of cabbage and cauliflower in upper Myanmar. So, cost of cabbage and cauliflower being lowest during the production season in the market. In Aung Ban area, price of cabbage and cauliflower was 152 and 131 Ks, respectively. In Nay Pyi Taw, price of cabbage and cauliflower was 227 and 265 Ks, respectively. The price of cabbage and cauliflower was 352 and 387 Ks respectively in Yangon (MIS 2008). It is situated in the lower part of the Myanmar. Yangon area is either distribution source of goods or production area that is received the goods from almost all parts of Myanmar. Therefore, the distances of transportation become longer and high transportation charges were formed. The price of the products in Yangon area is

higher than Aung Ban and Nay Pyi Taw areas. The marketing system of cabbage and cauliflower in Myanmar is shown in figure 2.1.

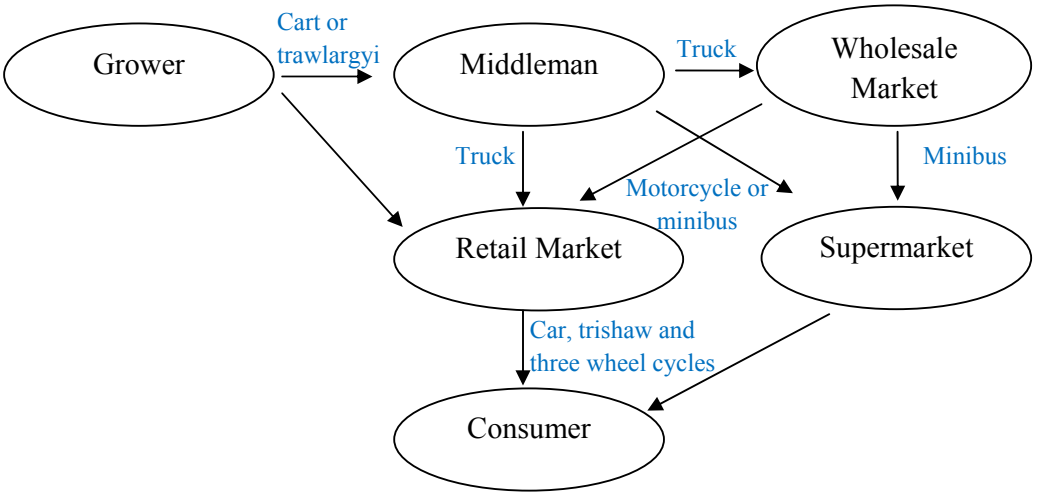

Figure 2.1 Conventional marketing systems of cabbage and cauliflower in Myanmar

CHARAPTER III
RESEARCH METHODOLOGY

3.1 Selection of Study Areas

Aung Ban and Nay Pyi Taw (Tatkone) areas are important for agriculture because it is well known as a major vegetables production areas. They produce cabbage, cauliflower, radish, mustard and various kinds of kitchen crops. These are the main areas for cabbage and cauliflower supplying market of Myanmar during winter season. This study focused on the current situation of postharvest losses of cabbage and cauliflower. It aimed to find out the reasonable solutions for postharvest chain weakness of cabbage and cauliflower in Aung Ban and Nay Pyi Taw areas from production to market distribution. Data collections were conducted along through production sites and broker sites at Aung Ban and Nay Pyi Taw and wholesale and retail markets at Yangon and Nay Pyi Taw.

3.1.1 Aung Ban

Aung Ban is situated in Kalaw Township, Southern Shan State. It is located at 20° 40´ N and 96° 38´ E coordinates. It is the largest vegetables production area in Myanmar. The growing area of cabbage and cauliflower in Kalaw Township are 871 and 251 acres, respectively in 2010. The most important vegetables grown intensively are cabbage, cauliflower, mustard and chayote which are exported to every corner of Myanmar throughout the year. The main market destination of cabbage and cauliflower from Aung Ban is Yangon.

Aung Ban broker site is the focal point of internal trade. It is the important vegetables distribution of upper Myanmar and its products are entered Yangon city by truck.

3.1.2 Nay Pyi Taw

Nay Pyi Taw is the capital of Myanmar and located at 19° N and 96° E coordinates. Tatkone area produces many kinds of vegetables such as cabbage, cauliflower, chili, eggplant, radish and mustard. The growing areas of cabbage and cauliflower in Tatkone Township are 302 and 289 acres, respectively in 2010. Tatkone is the prime engine of supplying large quantity of cabbage and cauliflower to the Yangon and Nay Pyi Taw wholesale markets during the winter season.

Nay Pyi Taw broker site is the focal point of internal trade. This site is also important for Tatkone cabbage and cauliflower. These were distributed to the Yangon

and Nay Pyi Taw wholesale markets and other distant markets. Fresh commodities are entered Yangon city by truck.

Aharrthukha market in Nay Pyi Taw is a wholesale fresh produce market for Nay Pyi Taw Region. It is situated near Kinpundan Village, Pyinmana Township. Crops are distributed to Nay Pyi Taw retail markets and other distant markets.

Nay Pyi Taw retail markets distribute vegetables for Nay Pyi Taw consumers. It is an important terminal and also major transit market for Nay Pyi Taw residents.

3.1.3 Yangon

Yangon is located in lower Myanmar at the convergence of the Yangon and Bago Rivers about 30 km away from the Gulf of Martavan at 16°N and 96°E. Yangon is the focal point of the internal and external trade. Agricultural produce from other states and regions enter Yangon City by highway road, railway and waterway. In Yangon City, Thiri Mingalar market is the wholesale market for fresh produces. Yangon Thiri Mingalar market has also terminal and transit functions of vegetable crops are distributed to Yangon retail markets and other distant markets.

Yangon retail markets distribute vegetables for Yangon consumers. It is an important terminal market and also a major transit market for Yangon inhabitants.

3.2 Data Collection

Questionnaires were prepared to be able to identify the postharvest chain weakness of cabbage and cauliflower. Random sampling procedure was done to interview 50 and 27 cabbage and cauliflower growers from 6 villages in Kalaw Southern Shan State and 41 and 25 cabbage and cauliflower growers from 4 villages in Nay Pyi Taw (Tatkone) during December 2011 to May 2012. In order to overview the initial stages in collecting, packaging, storage and distribution of cabbage and cauliflower for 10 and 8 brokers in Kalaw, Southern Shan State and Tatkone in Nay Pyi Taw , 10 and 5 wholesalers in Yangon and Nay Pyi Taw were interviewed. Moreover, 20 and 15 retailers in Yangon and Nay Pyi Taw were interviewed to overview the postharvest losses during retailing of cabbage and cauliflower. Different surveys were conducted at Aung Ban, Nay Pyi Taw and Yangon markets to overview the losses assessment on postharvest handling of cabbage and cauliflower by interviewing the wholesalers and retailers. The data were collected from stakeholders with structural interview questionnaire. They were concerned with demographic data of the sample respondents in selected areas such as sex, age, educational status and

their working experience. In addition, grading, packing, temporary storage, loading system, preharvest losses, harvesting losses, postharvest losses (transportation and storage), farmers' perception and time lag were collected in the study area.

3.3 Losses Assessment

In losses assessment, there are three types of losses such as preharvest, harvest and postharvest (transportation and storage). The total number of cabbage and cauliflower were accounted on losses by the symptoms of any damage, bruises, cracking, rot and infected crops. The data were expressed as (%) on losses by the above mentioned symptoms.

3.4 Data Analysis

The Statistical Package for Social Science (SPSS) version 16.0 Software and Microsoft Excel Program were used for data analysis. Descriptive statistics were used to identify the demographic factors of cabbage and cauliflower growers, brokers, wholesalers and retailers. The Paired-sampled t-test and One way ANOVA F test were used to compare the postharvest losses of cabbage and cauliflower growers, brokers, wholesalers and retailers in selected study areas. Total of 211 respondents were given by variable name, numerical codes, measurement levels and descriptive statistics were done to analyze the postharvest losses of cabbage and cauliflower.

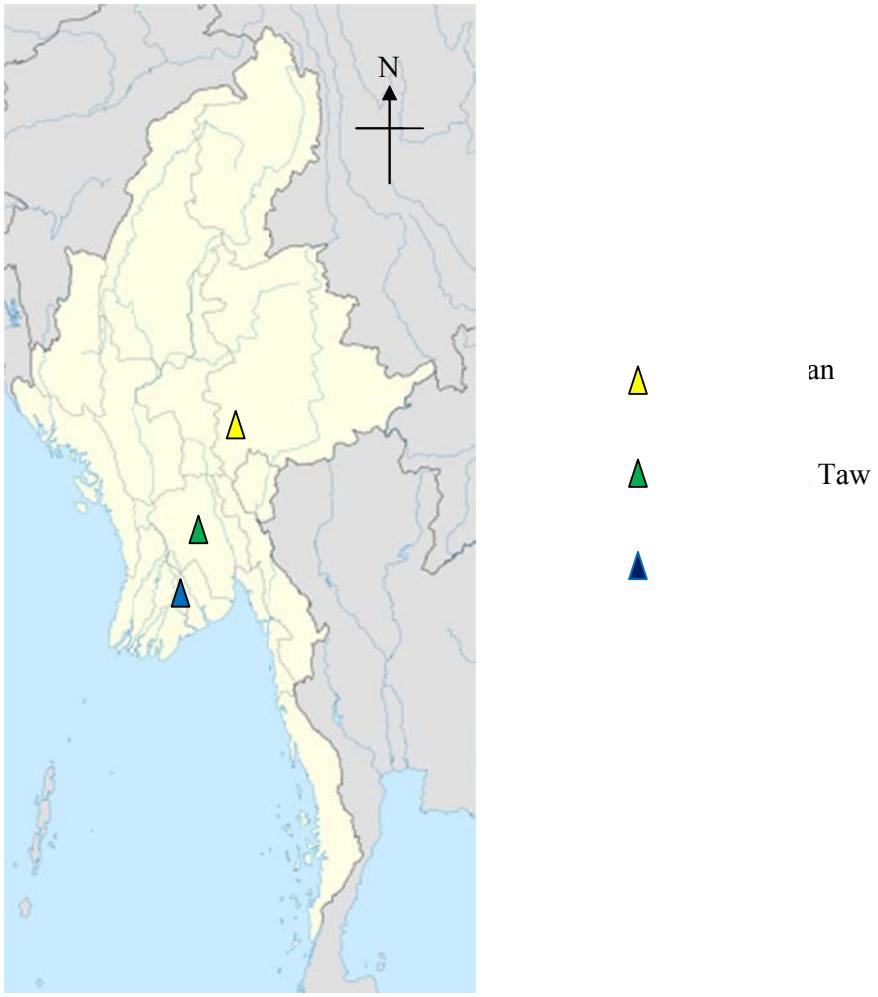

Figure 3.1 Study areas in Myanmar

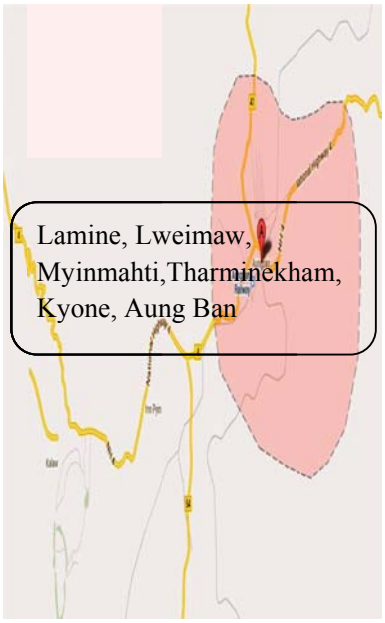

Figure 3.2 Study areas in Aung Ban Area

Figure 3.3 Study areas in Tatkone Area

Table 3.1 Sample villages and number of respondents in Aung Ban Area

Village	No. of respondents			
	Cabbage		Cauliflower	
	Frequency	Percentage	Frequency	Percentage
Lamine	8	16.00	3	11.11
Lweimaw	7	14.00	5	18.52
Myinmahti	15	30.00	14	51.85
Tharminekham	3	6.00	1	3.70
Kyone	10	20.00	-	-
Aung Ban	7	14.00	4	14.82
Total	50	100.00	27	100.00

Table 3.2 Sample villages and number of respondents in Tatkone Area

Village	No. of respondents			
	Cabbage		Cauliflower	
	Frequency	Percentage	Frequency	Percentage
Kyartaaing	22	53.66	4	16.00
Nweyit	19	46.34	16	64.00
Seihteit	-	-	3	12.00
Ywadagone	-	-	2	8.00
Total	41	100.00	25	100.00

Table 3.3 Sample markets and number of respondents

Township	Market	No. of respondents (%)	
		Wholesaler	Retailer
Nay Pyi Taw	Arharrathukha	5(33.33)	
	Yezin		5 (14.29)
	Pa La Ka at YAU		5 (14.29)
	Pyinmana		5 (14.29)
Yangon	Thiri Mingalar	10(66.67)	
	Haymawon		5 (14.29)
	Yandanar		5(14.29)
	Sanpya		5 (14.29)
	Thingankyun		5 (14.29)
Total		15(100.00)	35 (100.00)

Table 3.4 Number of respondents in selected areas

Township	No of respondents				
	Grower	Broker	Wholesaler	Retailer	Total
Aung Ban	77	10	-	-	87
Nay Pyi Taw	66	8	5	15	94
Yangon	-	-	10	20	30
Total	143	18	15	35	211

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Demographic Factors of Cabbage and Cauliflower Stakeholders

Demographic factors of cabbage and cauliflower stakeholders include sex, age, education and working experience. In Aung Ban area, 90.00% of the growers were male and 70.00% of the brokers were female. In Nay Pyi Taw area, 87.80% of the growers, 87.50% of the brokers, 100.00% of the wholesalers and 60.00% of the retailers were male. In Yangon area, 80.00% of the wholesalers were male and 75.00% of the retailers were female (Appendix 1).

The age of the sample respondents were as follow. In Aung Ban area, 62.00% of the growers were within the age of 41-60 years and 60.00% of the brokers were within the age of 21-40 years. In Nay Pyi Taw area, 48.80% of the growers and 60.00% of the wholesalers were within 41-60 years and 62.50% of the brokers and 46.67% of the retailers were within 21-40 years. In Yangon area, 60.00% of wholesalers and retailers were at the age of 21-40 years (Appendix 1).

The educational status of respondents ranged from primary to graduated level. In Aung Ban area, most growers (54.00%) and brokers (50.00%) had primary education. In Nay Pyi Taw area, 34.10% of the growers, 37.50% of the brokers, 60.00% of the wholesalers and 46.67% of the retailers had attended the secondary school. In Yangon area, 60.00% of the wholesalers and 55.00% of the retailers reached secondary level (Appendix 1).

The working experience of respondents ranged from one year to about 60 years. In Aung Ban area, 32.00% of the growers have 11 to 20 years and 40.00% of the brokers have one to ten years experience in growing and selling cabbage. In Nay Pyi Taw area, 46.30% of the growers and 62.50% of the brokers had 11 to 20 years experience and 60.00% of the wholesalers and 80.00% of the retailers had one to ten years experience in growing and selling cabbage. In Yangon area, 60.00% of the wholesalers had 11 to 20 years experience and 80.00% of the retailers had one to ten years working experience (Appendix 1).

Among the respondents, 85.20% and 100.00% of the growers were male in Aung Ban and Nay Pyi Taw areas, respectively. Most of the growers (51.90%) were at the age of 41-60 years in Aung Ban area and 52.00% of growers were at the age of 21-40 years in Nay Pyi Taw areas. In Aung Ban area, 59.30% of growers had primary education and 40.00% of the growers in Nay Pyi Taw areas reached secondary school.

In this study, 33.30% of the growers had 11 to 20 years experiences in Aung Ban area and in Nay Pyi Taw areas 40.00% of the growers had one to ten years' and 11 to 20 years experiences. All cauliflower brokers, wholesalers and retailers were the same as cabbage stakeholders in the study areas because one stakeholder invested in both crops (Appendix 2).

The farm size of cabbage and cauliflower growers ranges from one acre to about 4 acres. In Aung Ban area, 58% of cabbage growers possessed 0.5 to 1.5 acres and 42% of grower possessed 2 to 3 acres. However, 93% of the cauliflower growers possessed 0.5 to 1.5 acres and 7% of the grower possessed 2 to 3 acres. Cauliflower was grown by 93% of grower due to high price (Figure 4.1).

In Nay Pyi Taw area, 84% of cabbage and 61% of cauliflower growers who possessed 0.5 to 1.5 acres, respectively. Cabbage growers of 12% were possessed 2 to 3 acres and 4% of growers possessed 4 to 5 acres. For cauliflower, 29% of the growers owned 2 to 3 acres and 10% of the growers possessed 4 to 5 acres (Figure 4.1).

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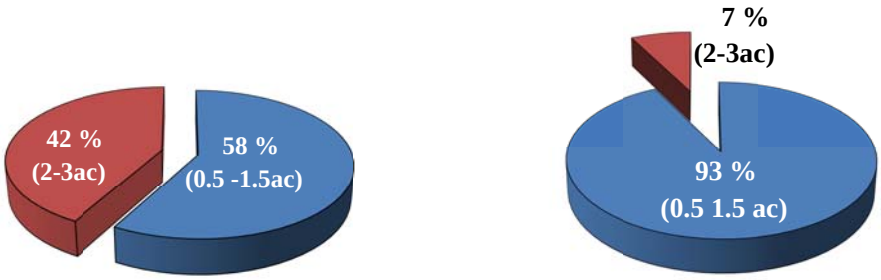
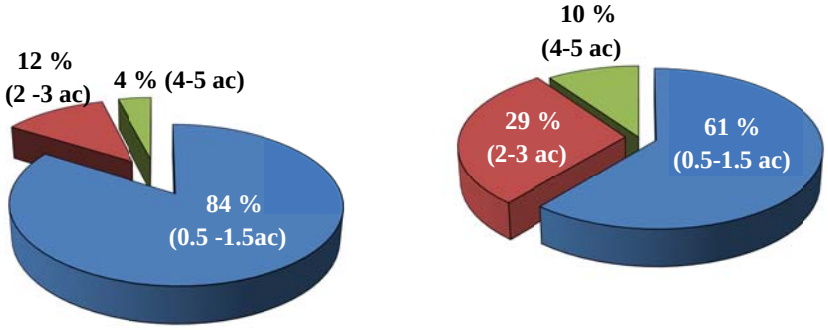


Cabbage **Cauliflower**

(A) Farm size of cabbage and cauliflower in Aung Ban area



Cabbage **Cauliflower**

(B) Farm size of cabbage and cauliflower in Nay Pyi Taw area

Figure 4.1 Farm Sizes of the Cabbage and Cauliflower Respondents in Selected Study Areas

4.2 Preharvest Losses, Harvesting losses, Temporary Storage Practices and Transportation Losses of Cabbage and Cauliflower at Grower Sites

At the grower site, harvesting of cabbage were highly significant in Aung Ban than that of Tatkone. However, preharvest losses of cabbage at grower site were no significant differences between Aung Ban and Tatkone (Table 4.1). The losses might be come from the improper harvesting, time of the day of harvesting and careless of labor.

The preharvest losses of cauliflower at the grower site were significantly higher in Tatkone than that of Aung Ban due to insects, diseases and climatic condition. However, the harvesting losses of cauliflower in Aung Ban were significantly higher than that of Tatkone due to unsystematic harvesting, time of the day (afternoon) and careless of labor (Table 4.1). Kader (1992) stated that harvesting is done early in the morning and placed under the shade (cool environment can result in reduced product heat). It can be assumed that harvesting at afternoon in open field is the main deleterious effect on harvesting loss.

Storage practices of cabbage and cauliflower were upside down, pile up, line up, by bamboo basket, with wrapper leaf and side by side position. In this study, 44.00% and 43.90% of the cabbage growers mostly used upside down storage position in field of Aung Ban and Tatkone areas, respectively. It was found that 51.84% and 36.00% of cauliflower growers mostly used side by side storage position in the field of Aung Ban and Tatkone areas, respectively (Table 4.2). Temporary storage is currently necessary to wait for distant and local market. This statement was in line with the report of Kanlayanarat and Acedo (1997). They reported that storage is also necessary to wait for transport to market, balance day-to-day fluctuations in the market supply.

At the grower sites, local transportation is necessary to broker and local market. Local transportation losses of cabbage and cauliflower were significantly higher in Aung Ban than that of Tatkone area (Table 4.3). This may be due to local and distant market is a little far from farm in Aung Ban area than that of Tatkone area. Moreover, the labors at grower sites mostly used unsystematic handling practices that resulted in losses of cabbage and cauliflower.

Table 4.1 Preharvest losses and harvesting losses of cabbage and cauliflower at grower sites

Kind of losses	Losses (%)		t - test
	Aung Ban	Tatkone	
Cabbage			
Preharvest loss	15.76	16.11	-1.40^{ns}
Harvesting loss	8.13	6.88	2.96**
Cauliflower			
Preharvest loss	18.32	19.76	-9.36**
Harvesting loss	16.38	10.45	8.53**

** significantly different at 1% level ns = non significant

Table 4.2 Temporary storage practices of cabbage and cauliflower at grower sites

Storage Practices	Growers (%)			
	Aung Ban		Tatkone	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Upside down	44.00	-	43.90	-
Pile up	26.00	18.50	21.95	32.00
Line up	30.00	22.21	34.15	20.00
By bamboo basket	-	3.70	-	12.00
With wrapper leaf	-	3.70	-	-
Side by side	-	15.85	-	36.00
Total	100.00	100.00	100.00	100.00

(a) n = 50; (b) n = 27; (c) n =41; (d) n = 25

Table 4.3 Transportation losses of cabbage and cauliflower at grower sites

Crop	Transportation losses (%)		t – test
	Aung Ban	Tatkone	
Cabbage	8.27	6.47	4.23**
Cauliflower	15.08	6.41	12.15**

**significantly different at 1% level

4.3 Harvesting Losses, Temporary Handling Practices and Losses of Cabbage and Cauliflower during Storage at Broker Sites

At the broker site, harvesting loss of cabbage in Tatkone area was significantly higher than that of Nay Pyi Taw area (Table 4.4). Harvey (1978) reported that harvesting of vegetables should be done as carefully as possible to minimize mechanical damage such as bruises, scratches and damage to the crops and should be carried out during early morning or late evening. In this study, some of the brokers directly purchased the crop from the farm. It can be assumed that the losses might be come from the unsystematic harvesting and careless of labor at the field. For cauliflower, harvesting losses were no significant differences between Aung Ban and Nay Pyi Taw.

Handling practices of cabbage and cauliflower during storage were upside down, pile up and side by side. In this study, 60% and 50% of the cabbage brokers used upside down storage position in field at Aung Ban and Nay Pyi Taw areas, respectively. For cauliflower, side by side and pile up storage position were used by 50% of the brokers in Aung Ban and Tatkone areas. It can be assumed that brokers had the strong experience and knowledge in storage of their products (Table 4.5).

At the broker sites, storage losses of cabbage and cauliflower were no significant differences between Aung Ban and Tatkone areas (Table 4.6). Mostly, temporary storage is currently necessary at least one day to wait for distant transportation.

4.4 Size, Loading System and Losses during Transportation of Cabbage and Cauliflower at Broker Sites

In Aung Ban area, 60.00% of the brokers used large sized cabbage and cauliflower. In Nay Pyi Taw area, 37.50% of brokers used large and medium sized of cabbage and cauliflower. Kanlayanarat and Acedo (1997) reported that quality grades parameters are maturity, shape, size, color, free from any defects and external quality. It was found that cabbage and cauliflower are graded by visual appearance depending on the size in selected study areas. In current situation, three quality parameters were found of large (> 6 cm), medium (5 ~ 6 cm) and small size (< 4 cm). The price will be different depending on the size (Table 4.7).

The loading systems refer to crop position in the truck. The loading systems of cabbage during transportation at broker sites were upside down, line up, cabbage under the cauliflower and with wrapper leaf. In Aung Ban area, only 40.00% of the brokers was used upside down position for cabbage. It may be due to drain cell sap by the cabbage that resulted in prolonging shelf life. In Nay Pyi Taw area, 25.00% of the brokers used all of the loading system above mentioned on the truck by open proof (Table 4.8).

The loading systems of cauliflower during transportation at broker sites were side by side, line up, cabbage under the cauliflower and with wrapper leaf. Among them, brokers (60.00%) mostly used side by side position in Aung Ban area on their truck. In Nay Pyi Taw area, 37.50% of the brokers used two types of loading system which were side by side and cabbage under cauliflower position in truck (Table 4.8). FAO (2001) stated that systematic handling practices have a major effect on the extent of postharvest shelf life, final product quality and market value of crops. Therefore, it can be assumed that brokers had some experience and knowledge in handling practices of their products that resulted to reduce crop losses**.**

Transportation losses of both crops at the broker site were no significant differences between Aung Ban and Tatkone areas (Table 4.9). It took about one hour for transportation to local market and about 12 hours for distant market.

Table 4.4 Harvesting losses of cabbage and cauliflower at broker sites

Crop	Harvesting losses (%)		t - test
	Aung Ban	Tatkone	
Cabbage	12.40	20.30	-7.50**
Cauliflower	19.36	18.50	1.00ns

**significantly different at 1% level ns = non significant

Table 4.5 Temporary handling practices of cabbage and cauliflower during storage at broker sites

Storage Practices	Brokers (%)			
	Aung Ban		Tatkone	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Upside down	60	-	50	-
Pile up	40	50	50	50
Side by side	-	50	-	50
Total	100	100	100	100

(a) n = 10; (b) n =10; (c) n =8; (d) n = 8

Table 4.6 Storage losses of cabbage and cauliflower at broker sites

Crop	Storage losses (%)		t - test
	Aung Ban	Tatkone	
Cabbage	5.40	5.38	-24.33ns
Cauliflower	9.10	7.63	1.67ns

ns = non significant

Table 4.7 Size of cabbage and cauliflower accepted by broker sites

Size (cm)	Brokers (%)			
	Aung Ban		Tatkone	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Large (> 6)	60.00	60.00	37.50	37.50
Medium (5 ~ 6)	20.00	20.00	37.50	37.50
Small (< 5)	20.00	20.00	15.00	15.00
Total	100.00	100.00	100.00	100.00

(a) n = 10; (b) n = 10; (c) n =8; (d) n = 8

Table 4.8 Loading system of cabbage and cauliflower during transportation at broker sites

Item	Brokers (%)			
	Aung Ban		Tatkone	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Upside down	40.00	-	25.00	-
Line up	20.00	20.00	25.00	25.00
Cabbage under the cauliflower	20.00	10.00	25.00	37.50
With wrapper leaf	20.00	10.00	25.00	-
Side by side	-	60.00	-	37.50
Total	100.00	100.00	100.00	100.00

(a) n = 10; (b) n =10; (c) n =8; (d) n = 8

Table 4.9 Transportation losses of cabbage and cauliflower at broker sites

Crop	Transportation losses (%)		t - test
	Aung Ban	Tatkone	
Cabbage	14.85	13.75	1.46^{ns}
Cauliflower	20.13	21.15	-1.40^{ns}

ns = non significant

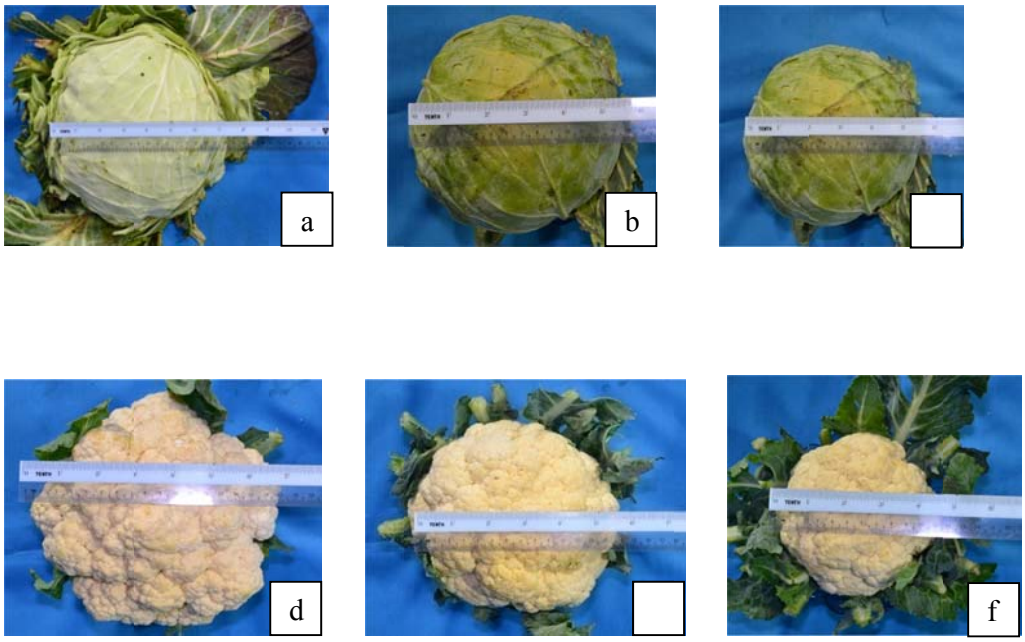


Plate 4.1 Size of cabbage and cauliflower: - (a) (d) Large size (> 6 cm),

(b) (e) Medium size (5 ~ 6 cm), (c) (f) Small size (< 5 cm)

Plate 4.2 Loading system of cabbage and cauliflower during transportation:-

(a) upside down, (b) side by side, (c) line up, (d) cabbage under the cauliflower, (d) with wrapper leaf

4.5 Transportation Losses and size of Cabbage and Cauliflower at Wholesaler Sites

At the wholesaler sites, transportation losses of cabbage and cauliflower in Yangon area were significantly higher than that of Nay Pyi Taw area (Table 4.10). It took at least 12 hours for transportation from broker to distant market (mainly wholesale markets). The result was in line with the report of Singh et al. (2008). They reported that severe losses occur because of poor transportation facilities and poor management by market intermediaries. Moreover, Rolle (2006) also stated that poor handling, unsuitable and improper packaging during transportation is the causes of bruising, and other forms of injury in fresh fruits and vegetables. Most of respondents used open proof during transportation from broker to wholesale market that resulted in higher transportation loss for distant market. It was found that the longer the distant market, the higher the losses have occurred.

In Myanmar, non-refrigerated (open proof) and open-sided trucks are generally used. Nowadays, this type of transportation is inexpensive, convenient and easy to manage. No special lining or cushioning materials were placed between the truck's floor and produce in order to prevent injury and heat generation from head of the truck. The horizontal wooden dividers between layers of produce were not used in truck and should be avoided over stacking and over packing. Proper driving of vehicle must be done to avoid damaging impact and vibration forces.

In Nay Pyi Taw area, 40% of the wholesalers used large and medium sized cabbage and cauliflower. In Yangon area, 60% of the wholesalers used large sized cabbage and cauliflower. It can be assumed that cabbage and cauliflower are graded by visual appearance depending on the size in selected study areas. In current situation, three quality parameters were large (> 6 cm), medium (5 ~ 6 cm) and small size (< 4 cm). Depending on the size the price will be different. The larger the size, the higher the price will get by the respondents (Table 4.11).

4.6 Handling Practices, Losses and Time Lag during Storage in Cabbage and Cauliflower at Wholesaler Sites

Handling practices of cabbage and cauliflower at wholesaler sites were pile up, spread out and by bamboo basket. It was found that 50% of the cabbage and cauliflower wholesalers mainly used spread out storage position in Yangon area. In Nay Pyi Taw area, 80% of cabbage wholesalers and 60% of the cauliflower

wholesalers mainly stored spread out storage position (Table 4.12). It can be assumed that most of the wholesalers used spread out because there was no need to pay for labour and material cost and then easy to store. Kanlayanarat and Acedo (1997) stated that quality deterioration of produce can be retarded effectively by proper storage systems by refrigerated storage, cool storage, and evaporative cooling system and ventilated cooling. In this study, storage losses at wholesaler were no significant differences between Yangon and Nay Pyi Taw for both cabbage and cauliflower (Table 4.13). Most of the wholesalers used unsystematic handling practices and there were no cooling facilities and no specialties for crop storage.

It was found that most of the 80% of the cabbage and 40% of the cauliflower wholesalers stored for 1 day (time lag) for sale in Yangon area and Nay Pyi Taw area (Table 4.14).

Table 4.10 Transportation losses of cabbage and cauliflower at wholesaler sites

Crop	Transportation losses (%)		t - test
	Yangon	Nay Pyi Taw	
Cabbage	21.82	15.40	3.06*
Cauliflower	23.00	19.82	8.43*

*significantly different at 5% level

Table 4.11 Size of cabbage and cauliflower accepted by wholesaler sites

Size (cm)	Wholesalers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Large (> 6)	60	60	40	40
Medium (5 ~ 6)	20	20	40	40
Small (< 5)	20	20	20	20
Total	100	100	100	100

(a) n = 10; (b) n = 10; (c) n =5; (d) n = 5

Table 4.12 Handling practices of cabbage and cauliflower during storage at wholesaler sites

Item	Wholesalers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Pile up	10	20	20	20
Spread out	50	50	80	60
By bamboo basket	40	30	-	20
Total	100	100	100	100

(a) n = 10; (b) n = 10; (c) n =5; (d) n = 5

Table 4.13 Storage losses of cabbage and cauliflower at wholesaler sites

Crop	Storage losses (%)		t - test
	Yangon	Nay Pyi Taw	
Cabbage	11.70	9.80	-1.98^{ns}
Cauliflower	19.01	20.00	1.87^{ns}

ns = non significant

Table 4.14 Time lag of cabbage and cauliflower at wholesaler sites

Time lag (days)	Wholesalers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
1	80	80	40	40
2	20	20	20	20
3	-	-	20	20
4	-	-	20	20
Total	100	100	100	100

(a) n = 10; (b) n = 10; (c) n =5; (d) n = 5

Plate 4.3 Storage practices of cabbage and cauliflower at wholesaler sites: -

(a) pile up, (b) spread out, (c) bamboo basket

4.7 Packaging, Size and Transportation Losses of Cabbage and Cauliflower at Retailer Sites

Packaging materials of cabbage and cauliflower at retailer sites were bamboo basket, mesh bag, wadding bag and plastic bag. The packaging of cabbage and cauliflower from wholesaler to retailer sites were 40% of the respondents by using mesh bag in Yangon area. Packing by plastic bag was currently used by 40% of cabbage and cauliflower retailers in Nay Pyi Taw area (Table 4.15). It was agreed with the report of FAO (2011). It was reported that packaging generally provides protection for the product, to reduce spoilage and losses and to enhance the value of produce. Plastic bags are the most widely accepted for vegetables in most countries. It can be assumed that plastic were used to reduce transpiration rate and that can prolong shelf life and to maintain the product quality.

In Yangon area, 60.00% and 50.00% of the retailers used medium sized cabbage and cauliflower, respectively. In Nay Pyi Taw area, 46.70% of the retailers used medium sized cabbage, however, retailers (46.70%) used large sized cauliflower **(**Table 4.16). It can be assumed that cabbage and cauliflower are graded by visual appearance depending on the size in selected study areas. It was found that the larger the size, the higher the price will pay by the consumers.

At the retailer sites, transportation losses of cabbage and cauliflower were significantly higher in Nay Pyi Taw than that of Yangon (Table 4.17). This might be due to the different kinds of transportation vehicle such as motorcycle; thrawlargyi and cart were used in local market.

4.8 Handling Practices, Losses and Time Lag during Storage for Cabbage and Cauliflower at Retailer Sites

Handling practices during storage for cabbage and cauliflower at the retailer sites were spread out, by bamboo basket, natural condition, in the plastic bag and covered with wet cloth. Among them, bamboo baskets were mostly used because it is an indigenous packaging material for most vegetable crops in these days. Moreover, it is easy to be available and cheaper cost. It was found that 35.00% of the retailers used bamboo basket in storage for cabbage and cauliflower at Yangon area. In Nay Pyi Taw area, most of the retailers (66.70%) used plastic bag for cabbage and cauliflower in storage (Table 4.18). It can be assumed that there is no cooling facility (cool

storage room and refrigerators) in Myanmar. Therefore, the retailers still use conventional storage practices.

At the retailer sites, storage losses of cabbage were significantly higher in Nay Pyi Taw than that of Yangon area. For cauliflower, storage losses were no significantly differences between Yangon and Nay Pyi Taw (Table 4.19). Idah et al (2007) reported that storage losses occur from poor storage conditions in the markets and due to the physiological changes of vegetables; they deteriorate easily in transit and storage, especially under conditions of high temperature and humidity.

In Yangon area, 55% of cabbage respondents stored for 3 days (time lag), however, 50.00% of cauliflower respondents stored for 2 days. In Nay Pyi Taw, 66.70% of the cabbage and cauliflower retailers stored for 2 days (Table 4.20).Therefore, time lag of Yangon were one day longer than that of Nay Pyi Taw. It can be assumed that Yangon is urban area and far away from farm.

Table 4.15 Packaging materials for cabbage and cauliflower at retailer sites

Packaging materials	Retailers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Mesh bag	40.00	40.00	13.30	13.30
Bamboo basket	25.00	25.00	26.70	26.70
Wadding bag	25.00	25.00	20.00	20.00
Plastic bag	10.00	10.00	40.00	40.00
Total	100.00	100.00	100.00	100.00

(a) n = 20; (b) n = 20; (c) n =15; (d) n = 15

Table 4.16 Size of cabbage and cauliflower accepted by retailer sites

Size (cm)	Retailers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Large (> 6)	30.00	20.00	26.70	46.70
Medium (5~ 6)	60.00	50.00	46.70	26.70
Small (< 5)	10.00	30.00	26.70	26.70
Total	100.00	100.00	100.00	100.00

(a) n = 20; (b) n = 20; (c) n =15; (d) n = 15

Table 4.17 Transportation losses of cabbage and cauliflower at retailer sites

Crop	Transportation losses (%)		t - test
	Yangon	Nay Pyi Taw	
Cabbage	8.40	12.40	-9.95**
Cauliflower	13.79	23.00	-10.47**

**significantly different at 1% level

Table 4.18 Handling practices of cabbage and cauliflower during storage at retailer sites

Item	Retailers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
Spread out	20.00	20.00	13.30	13.30
By bamboo basket	35.00	35.00	20.00	20.00
In the Plastic bag	20.00	20.00	66.70	66.70
Natural condition	10.00	10.00	-	-
Covered with wet cloth	15.00	15.00	-	-
Total	100.00	100.00	100.00	100.00

(a) n = 20; (b) n = 20; (c) n =15; (d) n = 15

Table 4.19 Storage losses of cabbage and cauliflower at retailer sites

Crop	Storage losses (%)		t - test
	Yangon	Nay Pyi Taw	
Cabbage	6.41	9.27	-6.00^{**}
Cauliflower	12.63	11.53	2.08^{ns}

**significantly different at 1% level ns = non significant

Table 4.20 Time lag of cabbage and cauliflower at retailer sites

Time lag (days)	Retailers (%)			
	Yangon		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
1	5.00	5.00	33.33	33.33
2	20.00	50.00	66.70	66.70
3	55.00	45.00	-	-
4	20.00	-	-	-
Total	100.00	100.00	100.00	100.00

(a) n = 20; (b) n = 20; (c) n =15; (d) n = 15

Plate 4.4 Packaging materials of cabbage and cauliflower at the retailer sites:-

(a) Mesh bag, (b) Bamboo basket, (c) Plastic bag, (d) Wadding bag






Plate 4.5 Unsystematic loading of cabbage and cauliflower during transportation from wholesaler to retailer sites

Plate 4.6 Storage practices of cabbage and cauliflower at retailer sites:-

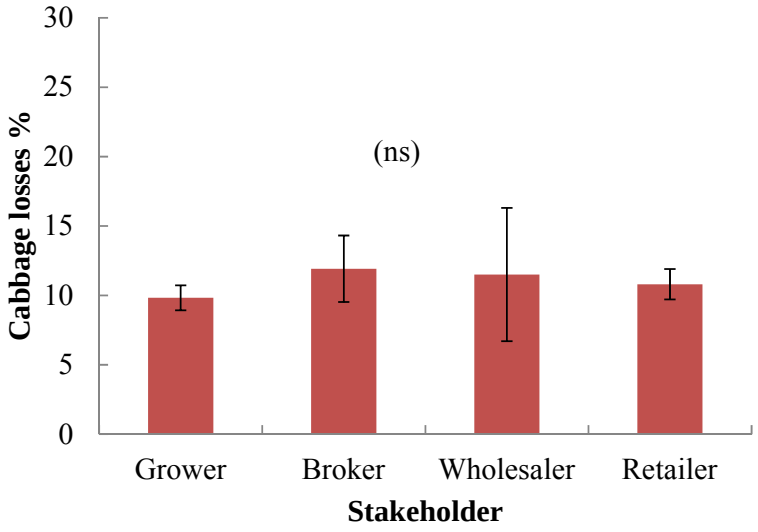
(a) spread out, (b) by bamboo basket, (c) covered with wet cloth, (d) in the plastic bag, (e) natural condition

4.9 Losses of Cabbage and Cauliflower along the Supply Chain at Nay Pyi Taw Area

The cabbage losses were no significant differences among the stakeholders. For cauliflower, losses were no significant differences between growers and brokers. Losses of cauliflower were significantly highest at retailers among the stakeholders followed by the wholesalers (Figure 4.2). It can be assumed that different types of transportation vehicle at retailer sites and discoloration of the curds are the more serious losses in cauliflower. The result was similar to the statement of Hassan (2010). He stated that discoloration is also the major kind of damage to curd of cauliflower at retailers' levels that renders the curds unsalable and ultimately causes loss. Moreover, Hazarika (2008) reported that in developed countries, the losses of cauliflower (9.4%) were higher than that of cabbage (5.33%) at retailer level.

4.10 Losses of Cabbage and Cauliflower along the Supply Chain in Selected Study Areas of Myanmar

For cabbage, the losses at grower and wholesaler were significantly higher than that of retailer. The losses of cauliflower at grower level were significantly highest and losses of cauliflower at retailer level were significantly lowest among the stakeholders (Figure 4.3). Sharmaa and Singhb (2011) demonstrated that the losses were maximum at the growers' level in all vegetables. In this study, the losses at grower and wholesaler levels were no significant differences between them for both crops. The losses of cauliflower were higher than that of cabbage. It can be assumed that losses of cauliflower might be due to its inflorescence crop type.



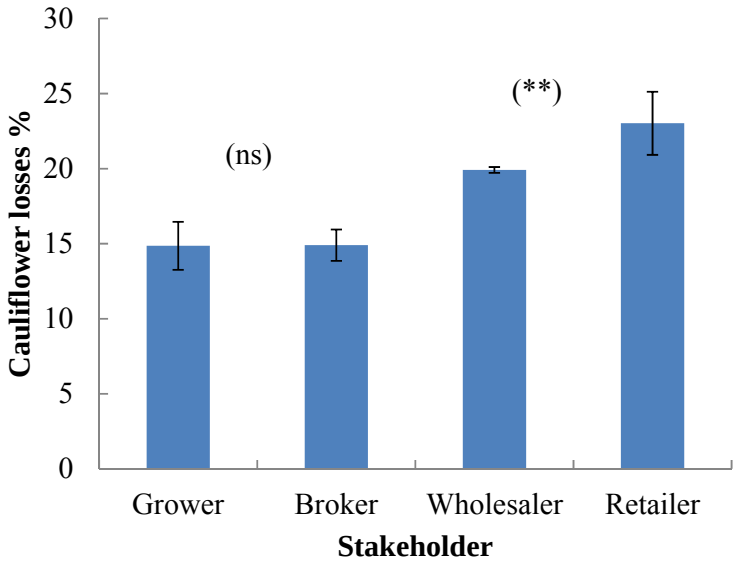


Figure 4.2. Losses of cabbage and cauliflower along the supply chain at Nay Pyi Taw area (During harvesting and postharvest period)

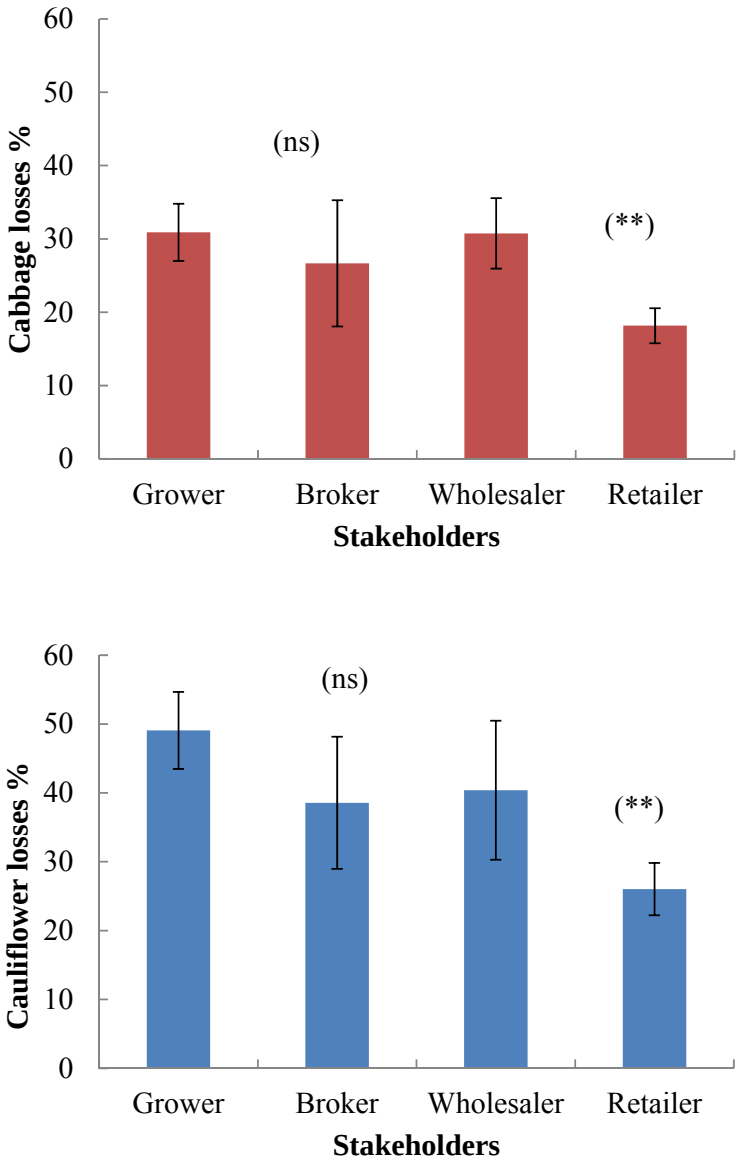


Figure 4.3. Losses of cabbage and cauliflower along the supply chain in selected study areas of Myanmar

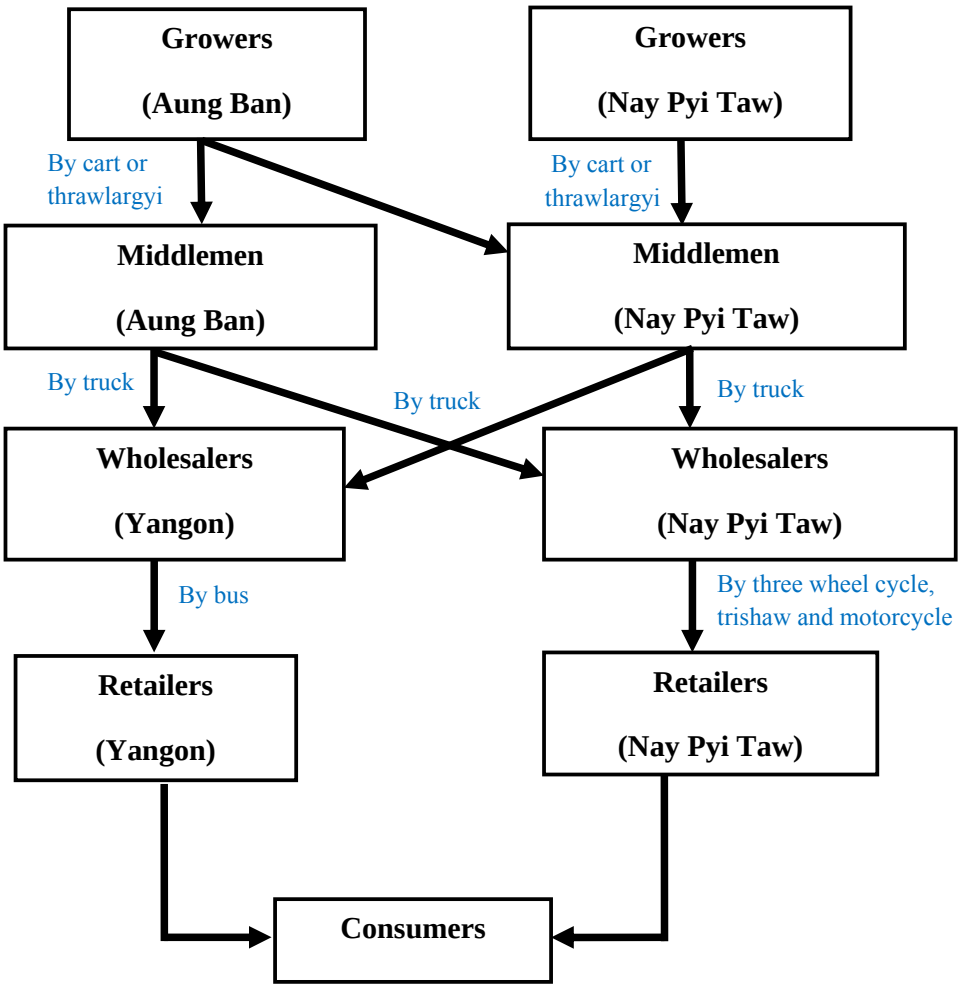
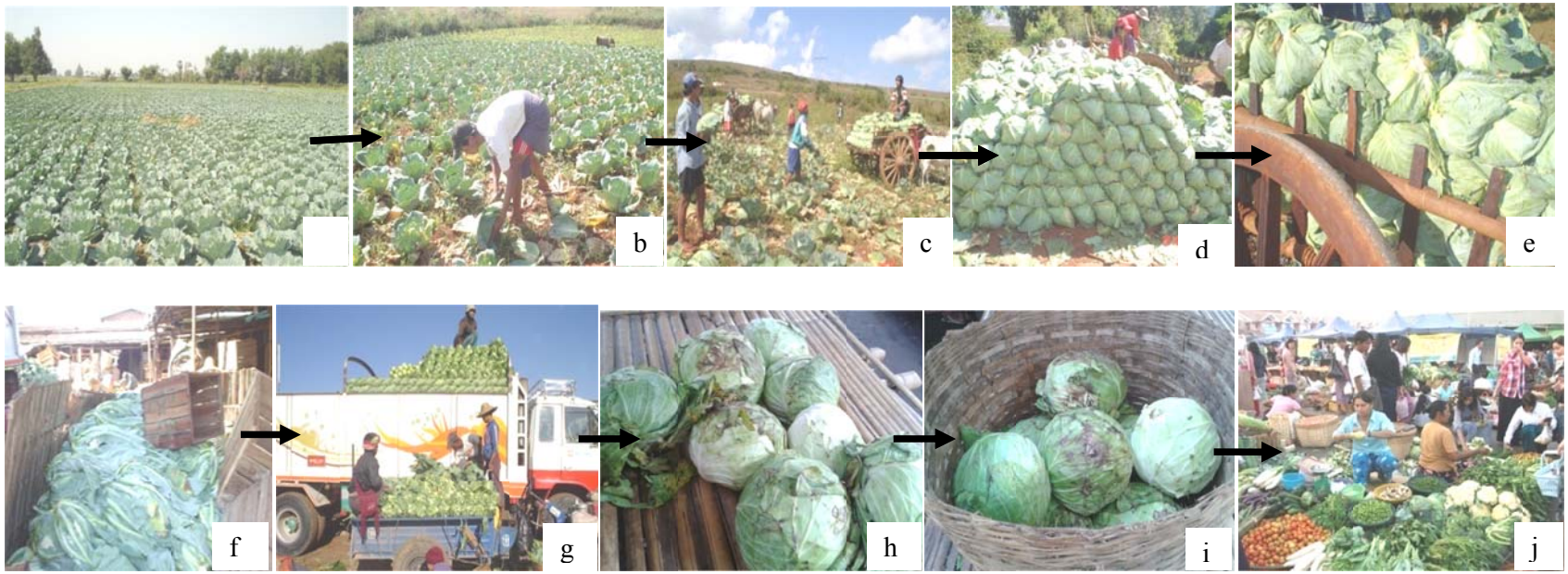


Figure 4.4. Supply chain system of cabbage and cauliflower in selected areas of Myanmar



(a) Production site (farm), (b) Unsystematic harvesting, (c) Spread out in the field, (d) Pile up in the open field, (e) Unsystematic transportation, (f) Temporary storage at wholesaler, (g) Transportation from wholesaler to retailer, (h) Temporary storage by natural condition, (i) Temporary storage at retailer by bamboo basket and (j) Selling to the consumer

Plate 4.7 Current supply chain system of cabbage and cauliflower from grower site to reach consumer hand

4.11 Comparison of Losses on Cabbage and Cauliflower at Aung Ban, Nay Pyi Taw and Yangon

At the grower site, postharvest losses of cabbage in Aung Ban area were significantly higher than that of Nay Pyi Taw area. This might be due to different climatic condition and time of the day of harvesting between these two areas. However, at the broker site postharvest losses of cabbage were no significant differences between them. For cauliflower, postharvest losses were no significant differences between Aung Ban and Nay Pyi Taw in both grower and broker sites (Figure 4.5).

In this study, wholesaler and retailer sites were mainly selected in Yangon and Nay Pyi Taw areas. At the wholesaler sites, postharvest losses of cauliflower in Yangon area were significantly higher than that of Nay Pyi Taw area. At the retailer sites, postharvest losses of cauliflower in Nay Pyi Taw area were significantly higher than that of Yangon area. The reason may be due to the poor storage facility and packaging materials. For cabbage, postharvest losses of wholesaler and retailer site were no significant differences between Yangon and Nay Pyi Taw (Figure 4.6).

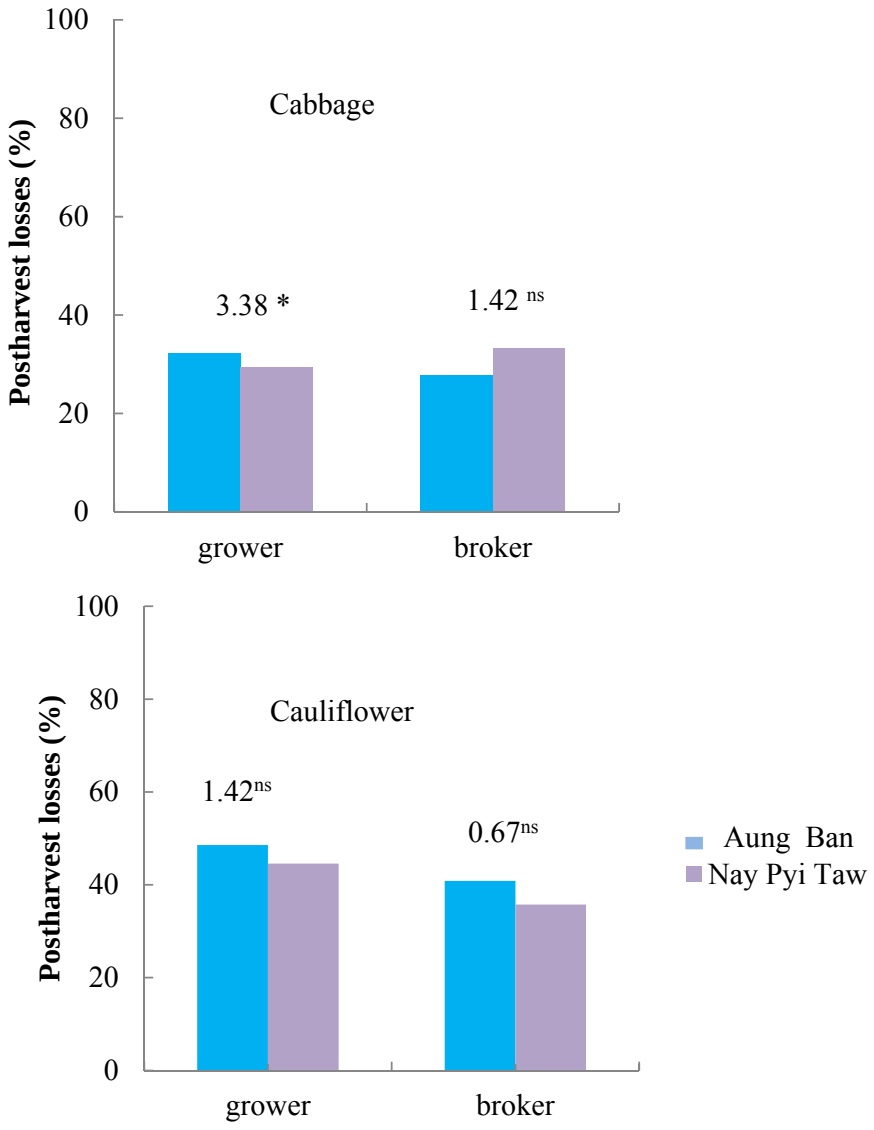


Figure 4.5.Comparison of losses on cabbage and cauliflower at Aung Ban and Nay Pyi Taw

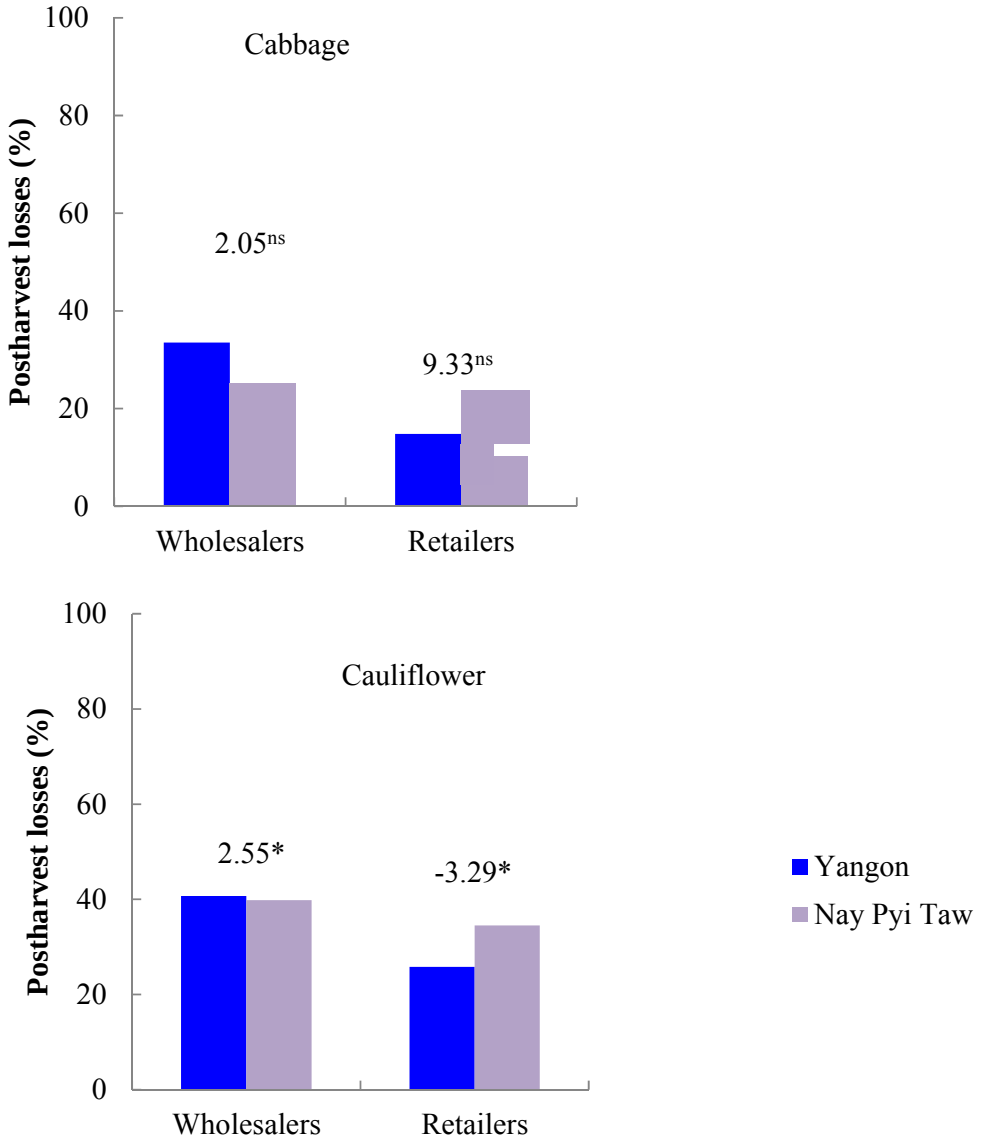


Figure 4.6 Comparison of losses on cabbage and cauliflower at Yangon and Nay Pyi Taw

4.12 Losses of Cabbage and Cauliflower at Each Stage along Supply Chain in Selected Study Areas

In Aung Ban area, the highest losses of cabbage and cauliflower were found by the 15.76% and 18.32%, respectively in preharvest stage at the grower sites. At the broker sites, the highest postharvest losses of cabbage and cauliflower were obtained by the 14.85% and 20.13% respectively due to improper transportation conditions (Table 4.21 and 4.22).

In Nay Pyi Taw area, the losses were the highest by 16.11% and 29.80%, respectively at the grower sites due to preharvest factors. FAO (2004) reported that damage can be caused by too much rain or irrigation and pest and disease infections which can lead to decay and crack of crops. At the broker sites, the losses of cabbage were the highest due to harvesting condition, however, the losses of cauliflower were the highest due to transportation condition in Nay Pyi Taw area. At the wholesaler sites, the highest postharvest losses of cabbage and cauliflower were found due to transportation and storage condition, respectively. The postharvest losses of cabbage and cauliflower were the highest due to transportation condition at the retailer sites (Table 4.21 and 4.22). This statement was agreed with the findings of Fejokwu (1992). It was reported that vibration damage during transportation resulted in undulations and irregularities on the produce, contributing greatly to postharvest losses.

In Yangon area, transportation losses of cabbage and cauliflower were the highest at wholesaler and retailer sites. The above statement was agreed with the findings of McGregor (1987). It was reported that vibration damage during transportation may cause severe bruising or other types of mechanical injury. Mukaminega (2008) further suggests that losses of vegetables also occur in transit due to long distance to markets, poor and inadequate infrastructures and the method of transportation.

Table 4.21 Losses of cabbage at each stage along the supply chain in selected study areas

Item	Losses (%)							
	Aung Ban		Nay Pyi Taw				Yangon	
	Grower	Broker	Grower	Broker	Wholesaler	Retailer	Wholesaler	Retailer
Preharvest	15.76	-	16.11	-	-	-	-	-
Harvest	8.13	12.40	6.88	19.42	-	-	-	-
Postharvest (Transportation)	8.27	14.85	6.47	13.75	15.40	12.40	22.60	8.40
Storage	-	5.40	-	5.38	9.80	9.27	11.70	6.41
Total	32.16	32.65	29.46	38.55	25.20	21.67	34.30	14.81

Table 4.22 Losses of cauliflower at each stage along the supply chain in selected study areas

Item	Losses (%)							
	Aung Ban		Nay Pyi Taw				Yangon	
	Grower	Broker	Grower	Broker	Wholesaler	Retailer	Wholesaler	Retailer
Preharvest	18.32	-	29.76	-	-	-	-	-
Harvest	16.38	19.36	10.45	18.50	-	-	-	-
Postharvest (Transportation)	15.08	20.13	6.41	21.15	19.82	23.00	21.68	13.79
Storage	-	9.10	-	7.63	20.00	11.50	19.01	12.63
Total	49.78	48.59	46.62	47.28	39.82	34.50	40.69	26.42

4.13 Farmers' Perception on the Causes of Preharvest Losses

The farmers' perception on the causes of preharvest losses by the respondents was shown (Table 4.23). The respondents had their own set of criteria for causing of preharvest losses. It was assumed that cabbage growers (48.79%) in Nay Pyi Taw area and 42.00% of the cabbage and 48.15% of the cauliflower growers in Aung Ban area were the losses due to pest infestation and climatic condition. Cauliflower grower (32.00%) reported that losses were due to pest, disease infestation and climatic condition in Nay Pyi Taw area. In the study areas, all growers wanted to obtain commercial price for their product but they faced adverse weather condition, other pest and disease infestations. In these days, the growers have to face pest and disease infestations and they cannot solve losses of cabbage and cauliflower.

Table 4.23 Farmers' perception on the causes of preharvest losses

Item	Respondents (%)			
	Aung Ban		Nay Pyi Taw	
	Cabbage [a]	Cauliflower [b]	Cabbage [c]	Cauliflower [d]
1. Pest & climatic condition	42.00	48.15	48.79	24.00
2. Disease	4.00	7.41	-	-
3. Climatic condition	10.00	7.41	7.32	20.00
4. Pest & disease	12.00	3.70	2.44	-
5. Pest	18.00	22.22	4.88	24.00
6. Pest & disease & climatic condition	14.00	3.70	36.59	32.00
7. Disease & climatic condition	-	7.41	-	-
Total	100.00	100.00	100.00	100.00

(a) n = 50; (b) n = 27; (c) n = 41; (d) n = 25

CHAPTER V

CONCLUSION AND RECOMMENDATION

The losses at grower and wholesaler were significantly higher than the retailer at the selected study areas. Postharvest losses of cauliflower stakeholders were higher than that of cabbage stakeholders. The losses at each stage in supply chain of cabbage and cauliflower were not significantly difference between growers, brokers and wholesalers in selected study areas. At the grower sites, losses of cauliflower due to preharvest condition in Tatkone area were significantly higher than that of Aung Ban area and while harvesting and postharvest losses of cabbage and cauliflower were significantly higher in Aung Ban area than that of Tatkone area. At the broker sites, harvesting losses of cabbage in Tatkone area were significantly higher than that of Aung Ban area. At the wholesaler sites, postharvest losses (transportation) of cabbage and cauliflower in Yangon area were significantly higher than that of Nay Pyi Taw area, however, at the retailer sites, postharvest losses of these crops were significantly higher in Nay Pyi Taw area than that of Yangon area. The stakeholders of cabbage and cauliflower have strong knowledge on different storage positions of upside down, side-by-side, line up, pile up and with wrapper leaf for cabbage and cauliflower at temporary storage. Among them, the suitable and mostly used position during storage and transportation for cabbage was upside down and side by side position for cauliflower. Cabbage and cauliflower without packaging were commonly practiced for distant transportation and sale processes of cabbage and cauliflower from the farm to the wholesalers. However, packaging materials of mesh bag, wadding bag, plastic bag and bamboo basket were mostly employed by retailers.

Stacking of many layers of produce which results in high percentages of loss by mechanical damage and reduces produce quality. Therefore, handling practices and packaging system should be systematically managed to reduce losses and to maintain the quality of the produce. Cabbage and cauliflower produce from wholesale markets were sold to small retail markets by various types of vehicles that may cause excessive weight loss and quality loss. Temperature plays a significant role in maintaining produce quality and shelf life of produce. Temperature management in supply chains in tropical countries is a key solution to improve quality and prolong the shelf life of the produce.

Therefore, cooling facilities (cool storage room, cooling trucks and refrigerators) are needed for cabbage and cauliflower stakeholders in Myanmar to reduce severe postharvest losses. Transporting produce in unrefrigerated trucks or unrefrigerated conditions may shorten the shelf life of produce and reduce nutritional value that in turn leads to lower market value. Therefore, cooling truck and temporary cold storage are necessary by the help of government or other organization.

Postharvest horticulturists need to coordinate their efforts with those of production horticulturists, agricultural marketing economists, engineers, food technologists, and others who may be involved in various aspects of the production and marketing system. During loading and unloading, systematic postharvest handling practices for middlemen, retailers, transporters should be educated at wholesale depot. All of infrastructures, such as processing equipment, packing houses, grading and sizing machines should be provided to growers and wholesalers to reduce severe quality losses. Famers association, Myanmar Vegetable Producers and Exporter Association (MFVPA), growers cluster should be cooperated with effective structural institutional organizations. The stakeholders of cabbage and cauliflower along the supply chain should be trained on postharvest handling practices to reduce the losses. It is suggested that good agricultural practices (GAP) should be needed for the growers. Moreover, in Myanmar, systematic handling practices, harvesting and packaging system will also be needed for all labor including (farm labor) along the supply chain.

CHAPTER VI

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APPENDICES

Appendix 1. Demographic Factors of Respondents for Cabbage (Percent)

Items	Aung Ban		Nay Pyi Daw				Yangon	
	G [a]	B [b]	G [c]	B [d]	W [e]	R [f]	W [g]	R [h]
Sex								
Male	90.00	30.00	87.80	87.50	100.0	60.00	80.00	25.00
Female	10.00	70.00	12.20	12.50	0	40.00	20.00	75.00
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Age								
≤ 20	2.00	0	2.40	12.50	0	33.30	0	10.00
21-40	30.00	60.00	31.70	62.50	40.00	46.70	60.00	60.00
41-60	62.00	20.00	48.80	25.00	60.00	20.00	40.00	30.00
>60	6.00	20.00	17.10	0	0	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Educational status								
Read and write	8.00	10.00	17.10	12.50	0	13.33	0	0
Primary	54.00	50.00	29.30	37.50	0	40.00	30.00	40.00
Secondary	28.00	40.00	34.10	37.50	60.00	46.70	60.00	55.00
High	4.00	0	12.20	12.50	20.00	0	10.00	5.00
Certificate & other	2.00	0	2.40	0	20.00	0	0	0
Graduate	4.00	0	4.80	0	0	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Experience (year)								
1-10	22.00	40.00	22.00	12.50	60.00	80.00	0	80.00
11-20	32.00	30.00	46.30	62.50	40.00	20.00	60.00	20.00
21-30	22.00	10.00	19.50	12.50	0	0	40.00	0
31-40	16.00	20.00	22.20	12.50	0	0	0	0
> 41	8.00	0	0	0	0	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(a) n = 50; (b) n =10; (c) n = 41; (d) n = 8; (e) n = 5; (f) n = 15; (g) n = 10; (h) n = 20

G = grower, B = broker, W = wholesaler and R = retailer

Appendix 2. Demographic Factors of Cauliflower Stakeholders (Percent)

Items	Aung Ban		Nay Pyi Daw				Yangon	
	G [a]	B [b]	G [c]	B [d]	W [e]	R [f]	W [g]	R [h]
Sex								
Male	85.20	30.00	100.0	87.50	100.00	60.00	80.00	25.00
Female	14.80	70.00	0.0	12.50	10.00	40.00	20.00	75.00
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Age								
≤ 20	0	0	4.00	12.50	0	33. 30	0	10.00
21-40	37.00	60.00	52.00	62.50	40.00	46.70	60.00	60.00
41-60	51.90	20.00	36.00	25.00	60.00	20.00	40.00	30.00
>60	11.10	20.00	8.00	0	0	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Educational status								
Read and write	11.10	10.00	8.00	12.50	0	13.30	0	0
Primary	59.30	50.00	24.00	37.50	0	40.00	30.00	40.00
Secondary	14.80	40.00	40.00	37.50	60.00	46.70	60.00	55.00
High	3.70	0	20.00	12.50	20.00	0	10.00	5.00
Certificate & other	3.70	0	4.00	0	20.00	0	0	0
Graduate	7.40	0	4.00	0	0.00	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Experience (year)								
1-10	18.50	40.00	40.00	12.50	60.00	80.00	0	80.00
11-20	33.30	30.00	40.00	62.50	40.00	20.00	60.00	20.00
21-30	14.80	10.00	12.00	12.50	0	0	40.00	0
31-40	22.20	20.00	8.00	12.50	0	0	0	0
>41	11.10	0	0	0	0	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(a) n = 27; (b) n = 10; (c) n = 25; (d) n = 8; (e) n = 5; (f) n = 15; (g) n = 10; (h) n = 20

G = grower, B = broker, W = wholesaler and R = retailer