KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF DISTANCE LEARNING

A SURVEY ON POSTHARVEST HANDLING, PRESERVATION AND PROCESSING METHODS OF TOMATO (*Solanum lycopersicum*) IN THE DORMAA AND TANO SOUTH DISTRICTS OF THE BRONG AHAFO REGION OF GHANA.

BY

ANTHONY KWASI YEBOAH

SEPTEMBER 2011

A SURVEY ON POSTHARVEST HANDLING, PRESERVATION AND PROCESSING OF TOMATO (*Solanum lycoperssicum*) IN

THE DORMAA AND TANO SOUTH DISTRICTS OF

THE BRONG AHAFO REGION OF GHANA.

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A

MASTER OF SCIENCE DEGREE

IN POSTHARVEST TECHNOLOGY

BY

ANTHONY KWASI YEBOAH

BED, AGRIC. (MAMPONG)

SEPTEMBER 2011

DECLARATION

I hereby declare that except for references made of other people's publications and copyrighted posts, which have been duly acknowledged, this work submitted as a thesis to the Department of Horticulture, Faculty of Agriculture for the degree of Master of Science in Postharvest Technology is the result of my own research and has not been presented anywhere for the award of a degree.

…… ……...

ANTHONY KWASI YEBOAH DATE

(PG 3121809)

CERTIFIED BY

…….. ……..

DR. B. K. MAALEKUU DATE

(SUPERVISOR)

CERTIDIED BY

…… ……..

DR. B.K. MAALEKUU DATE

(HEAD OF HORTICULTURE DEPARTMENT)

ABSTRACT

The tomato industry serves as a source of income of many households in the study area. Tomato production and marketing are complex and require expertise in the various stages handling along the distribution chain such. The objective of the study was to assess postharvest handling, preservation and processing of tomato (*Solanum lycopersicum*) in the Dormaa and Tano South Districts of the Brong Ahafo Region of Ghana. Data were obtained through interviews with staff of the Ministry of Food and Agriculture (MOFA), farmers, traders and consumers, using semi-structured questionnaire, as well as field visits. It was observed that tomato production is one of the major sources of livelihood for the people of the two districts. The results of the study however revealed that farmers have still not achieved their maximum potential due to high postharvest losses. Traders also encountered high postharvest losses after purchasing from the farm gate. Lack of diversified uses of tomatoes is one main source of postharvest losses. This is because, consumers would not buy more if they have enough in storage. Traders on the other hand would not purchase from farmers since they may still have a lot in storage which may not have been bought and sometimes deteriorating. Thus, farmers encounter losses due to two main reasons; lack of technical knowledge and storage facilities to preserve the produce and lack of factories within the production area to process the surplus tomatoes. Other problems include bad access roads linking farms and market centres, which has limited the production capacities of 90% of farmers in these communities. It was therefore recommended that research should be conducted into cheap but appropriate postharvest handling and preservation methods of tomatoes and the introduction of appropriate methods for reducing mechanical injury to tomatoes during harvest and transport. It was also recommended that inexpensive but efficient small scale tomato processing methods should be introduced in the tomato producing areas to reduce waste.

ACKNOWLEDGEMENT

My utmost gratitude goes to the Almighty God for his grace, guidance and direction in my academic pursuits in particular and in all my endeavours.

I would like to express my deepest appreciation to Dr. Bonaventure K. Maalekuu who supervised the project to the completion stage for his tutelage and encouragement. I am also so very grateful to all lecturers of the Horticulture Department of KNUST, for imparting knowledge and adding value to me and instilling a great level of confidence in me.

My sincere thanks go to Rev. Sr. Leonora Tucker (SSND) for her invaluable support and prayers.

I am also thankful to my parents, my siblings and my dear wife for their immense support that facilitated my studies as well as my research.

Again, I am thankful to Mr. Patrick Yiedu (MoFA, Dormaa Municipal), Mr. John Offassey (MoFA, Tano South) and especially Mr. K. Mensah (2010 National Best Tomato Farmer) for their time in answering all the numerous questions and giving a very clear picture of farmers' problems as it is.

I am indeed very grateful to Mr. Salifu Abdul-Wahab (Lecturer, Wa Polytechnic) for helping me organize my work, Mr. Frederick Nkrumah (Lecturer, Kumasi Polytechnic) and Mr. Kenneth Atiemo for their encouragement and invaluable support.

TABLE OF CONTENTS

CHAPTER **PAGE**

LIST OF TABLES

TABLE **PAGE**

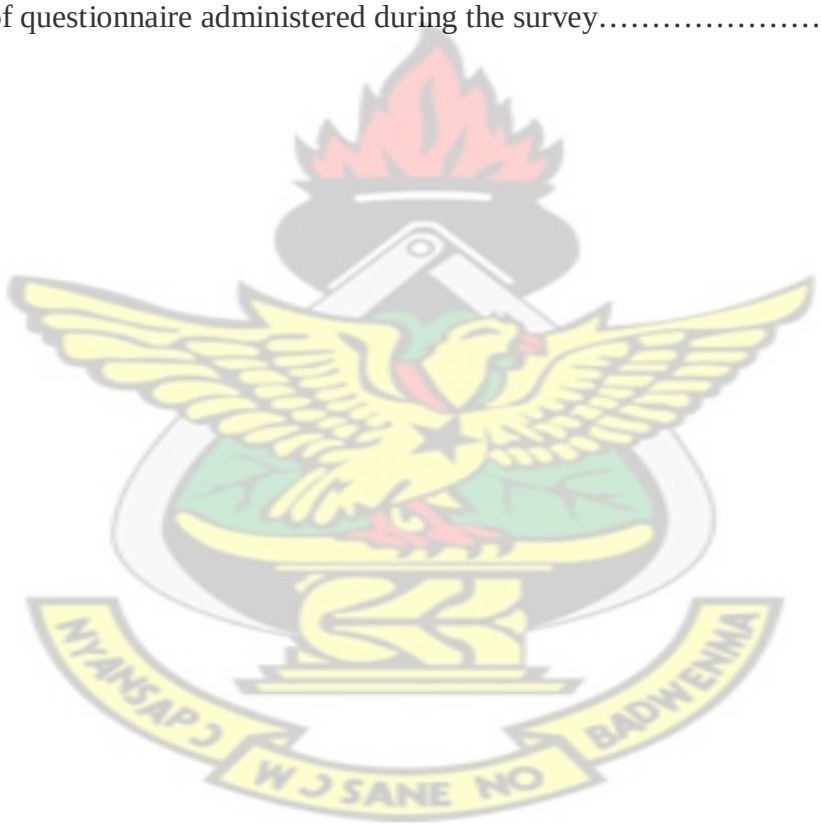
LIST OF FIGURES

FIGURE **PAGE**

LIST OF PLATES

PLATE **PAGE**

LIST OF APPENDICES



CHAPTER ONE

1.0 INTRODUCTION

Tomato, *Solanum lycopersicum*, of the nightshade family is consumed in diverse ways, including raw, as an ingredient in many dishes and sauces and in drinks (Alam *et al*., 2007).

The fruit of tomato, classified as a vegetable in trade, is a prominent "protective food" (Alam *et al*., 2007). Tomatoes and tomato-based foods provide a convenient matrix by which nutrients and other health-related food components are supplied to the body. In areas where it is eaten, it forms a very important part of human food (Beecher, 1998). Tomato, for example, forms a very important component of food consumed in Ghana and this is evident in the fact that many Ghanaian dishes have tomatoes as a component ingredient (Tambo and Gbemu, 2010).

Tomato is a rich source of folate and with phytonutrients, the most abundant in tomatoes are the carotenoids, lycopene being the most prominent, followed by beta-carotene and gamma-carotene, photoene as well as several minor carotenoids (Beecher, 1998). In spite of the modest levels of beta-carotene and gamma-carotene in tomato products, due to their provitamin A activity, a high consumption of the vegetable and its products results in a rich supply of vitamin A in the body. Lycopene, an antioxidant, purportedly fights the free radicals that can interfere with normal cell growth and activity. These free radicals according to Filippone (2006), can potentially lead to cancer, heart disease and premature aging.

These nutritional facts are good reasons to support the tomato industry of Ghana as far as the production, storage, processing, distribution and consumption are concerned.

1.1 STATEMENT OF THE PROBLEM

In Ghana, the focus of the various stakeholders in the tomato industry has mostly been on improved production capacities of farmers. However, after investing so heavily in producing the vegetables, farmers produce are lost in the postharvest chain. As observed by Robinson and Kolavalli (2010), in Ghana, the agricultural sector in general and the tomato sector in particular have not met their potential. In this sector, production seasonality, the dominance of rain fed agriculture, high perishability of the vegetable, lack of ready market, lack of a reasonable alternative uses of the vegetable and poor pricing are some problems faced by farmers. In addition, it is probable that, poor postharvest practices coupled with poor storage facilities account for the recurrent seasonal postharvest losses of tomatoes.

Also, traders may be lacking the appropriate postharvest skills of prolonging the shelf life of tomatoes in commercial quantities. The unavailability of large scale processing factories in the tomato production areas to help preserve the surplus produce for future use leaves farmers with no option but to watch their produce go waste any time there is no ready market. These scenarios are most obviously diminishing the fortunes of tomato farmers at the same time when foreign producers are indirectly financed by the government of Ghana and businesspersons through the importation of tomato products from the foreign market.

1.2 JUSTIFICATION OF THE STUDY

There are efforts by farmers to increase production of tomatoes to meet the demand of the local market. This notwithstanding, Ghana continues to import several tonnes of tomato and tomato products into the country. According to a ghanaweb.com (2006) report, the European Union reportedly exported 27, 000 tonnes of preserved tomatoes to Ghana in 2003. Although

figures of the subsequent years were not given, the trend suggests that in each year Ghana's import volume of tomato paste increased by an average of 23%.

Aryeetey (2006), confirmed that Ghana is second only to Germany as the largest importer of tomato paste, consuming an average of twenty five thousand (25,000) tonnes of tomato paste in a year at a total cost of about $25 million dollars. Considering that Ghana experiences annual gluts during the major seasons when a high percentage of the harvested produce is lost, there is the need to identify causes of such losses.

Obviously, any degree of postharvest losses of tomatoes has consequences to farmers, traders and consumers. The study seeks to identify the various stages of losses along the tomato postharvest distribution chain. It is expected that in the end, problems that account for inefficiencies in the local production industry would be identified to help build a stronger industry. This is also expected to reduce Ghana's importation of tomato products to improve foreign exchange reserves and provide employment and development opportunities in the rural communities of the country.

1.3 OBJECTIVE

The main objective of the study was to assess the various postharvest handling, processing and storage methods used by tomato farmers, traders and consumers in the two administrative districts (Tano South District and Dormaa Municipality) of the Brong Ahafo Region of Ghana. The specific objectives were to identify:

(i) the causes of postharvest losses of fresh tomatoes in the two districts.

(ii) the various problems faced by tomato producers and traders in the study area.

(iii) other uses of tomato aside the traditional use a vegetable and to promote them.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 TOMATO (*Solanum lycopersicum*)

Tomato (*Solanum lycopersicum*) is a typically red edible fruit and belongs to the Nightshade family (Solanaceae) except for the tiny current tomato (online family doctor.com, 2011). This family is the most variable of all crop species in terms of agricultural utility and the third economically most important crop family, exceeded only by grasses and legumes and the most valuable in terms of vegetable crops (van der Hoeven *et al.* 2002).

According to Knapp *et al*. (2004), the very diverse and large Solanaceae family is believed to consist of 96 genera and over 2800 species distributed in three subfamilies, *Solanoideae* (to which *Solanum* belongs), *Cestroideae*, and *Solanineae*.

The tomato plant has compound leaves with the entire leaf is connected to the stem by the petiole. The leaflets are connected to the rachis of the leaf by the petiolule with some of the leaflets on this leaf being compound as well (Rost, 1996). Tomato also has perfect flowers grouped in compound inflorescences known as a cyme. Each inflorescence usually includes 4 to 8 flowers, and each plant may produce as many as 20 or more successive inflorescences during its life cycle (Tigchelaar, 1986). The small yellow flowers of tomatoes have five pointed lobes on the corolla. Tomato fruits are green when unripe and become deep red when ripe. There are also yellow, orange, green and brown varieties. The shape can vary from small cherry tomatoes, pear shaped tomatoes to large irregular shaped tomatoes (phytochemicals.info, 2011).

A frequently asked question is whether tomato is vegetable or a fruit. The Webster's

Revised Unabridged Dictionary (1913) describes Tomato as the fruit of a plant of the Nightshade family *(Solanum lycopersicum)* as well as the plant itself. According to Alam *et al.* (2007), tomato is botanically a fruit but classified as vegetable in trade. The oxford dictionary online service (2011) explains that, the confusion about 'fruit' and 'vegetable' arises because of the differences in usage between scientists and cooks. Scientifically speaking, a tomato is a fruit but as far as cooking is concerned, some things which are strictly fruits, such as tomatoes or bean pods, may be called 'vegetables' because they are used in savoury rather than sweet cooking. Therefore, the answer to the question is that tomato is technically the fruit of the tomato plant, but used as a vegetable in cooking.

2.1.1 Tomato as a food

According to Kybal (1993), the tomato was not eaten until the nineteenth century because Mattiolus had called it *mala insane* (unhealthy flower) and scientific textbooks kept insisting it was poisonous. In North America, tomato became common in the early part of the 19th century. As in most of Europe, tomato was considered poisonous until its acceptance around 1840 as a nutritious vegetable (Paran and van der Knaap 2011). This is because when the tomato was first introduced to the Europeans, they considered it poisonous for having qualities similar to other known poisonous plants and was therefore only grown as an ornamental plant.

People were reported to have gotten sick from eating it but this, according to Lewis (2007) might have come from their plates they ate from and not from the tomato itself. Plates were made from pewter, a soft metal that often had lead, a very poisonous metal which could be caused to seep out by the acid in tomatoes. However, Barceloux (2008) and (2009) wrote that

like many other plants in the nightshade family, tomato leaves and stems contain atropine and other alkaloids including the tomatine that can be quite toxic if ingested.

Paran and van der Knapp (2011) believe that the Italians were probably the first group of Europeans to eat the tomato. This claim is from a written record by Mattiolus where he is said to have described human consumption of tomatoes with oil and salt, suggesting that tomato was already established in the Italian cuisine by the early 16th century this contradicts Kybal (1993) who reported Mattiolus to have described the tomato as poisonous .

2.1.2 Classification of Tomatoes

(i) Classification by fruit type

Tomatoes can be classified either by fruit type or growth pattern characteristics. By fruit type, the most commonly grown types are cherry, plum (Roma), and the common table varieties (Jansen and Shock 2009). Relf *et al.* (2009) on the other hand classify tomatoes based on their fruit characteristics as the cherry tomatoes, beefsteak type tomatoes, paste tomatoes, winter storage tomatoes and tomatoes classified by the colour of the fruit.

(ii) Classification by growth pattern

Reader (2003) and Jansen and Shock (2009) by growth characteristics agree on two types of tomato, determinate and indeterminate. They describe determinate vine growth to mean that the plant will grow a certain amount of foliage and then future growth is directed towards fruit production. They describe indeterminate growth pattern plants as those that are generally vining and continue to grow new stems and leaves throughout the growing season, along with fruit setting on a continuing basis.

However, Dillard and Reiners (2010) identify a third group, the semi-determinate with characteristics between the two types. Relf *et al.* (2009) agree to these three groups as well but rather prefer to describe them as Compact or determinate, Indeterminate and Midget, Patio, or Dwarf.

2.1.3 Nutritional Value of Tomatoes

Hippocrates, the father of Western medicine said, "Let your food be your medicine, and your medicine be your food." It is a fact that every single nutrient needed by man to thrive abound in plants i.e. fruits, leaves, stem, roots etc., as well as plant products (Bradley, 2003). Tomatoes are considered one of the best health foods in the American diet (Bradley, 2003). They abound with essential nutrients such as vitamins and minerals with one cup of cherry tomatoes for example containing approximately 31 calories,7 grams of carbohydrates, and only 0.5 grams of fat (Bradley, 2003).

Tomatoes are also noted to have a variety of nutrients including fiber and potassium according to the USDA National Nutrient Database (2010). The nutrient value changes based upon the type of tomato. The USDA National Nutrient Database (2010) gives the nutritional content of an average 123-gram red, ripe raw tomato as follows;

Alpha carotene: 124 mcg

Beta-carotene 552 mcg

Beta cryptoxanthin: 0.0 mcg

Calcium: 1.2 mg

Carbohydrate: 4.7 g

Cholesterol: 0.0mg

Copper: 0.073 mg

Dietary Fibre: 1.5 g

Energy: 22.14 kcal

Fat: 0.2g

Folate (Dietary Folate Equivalents DFE): 18mcg

Iron: 0.33 mg

IU Vitamin A: 1025

IU Vitamin D: 0

Lutein + zeaxanthin: 151 mcg

Lycopene: 3165 mcg

Magnesium: 1.4 mg

Manganese: 0.140 mg

Moisture content: 116.26 g

Niacin: 0.731 mg

Pantothenic acid: 0.109mg

Phosphorus: 3.0 mg

Potassium: 292 mg

Protein: 1.0 g

RAE Vitamin A: 52

Riboflavin: 0.023 mg

Selenium: 0.0 mcg

Sodium: 6 mg

Thiamin: 0.046 mg

Total Choline: 8.2 mg

Total monosaturated fatty acids: 0.038 g

Total polyunsaturated fatty acids: 0.102 g

Total saturated fatty acid: 0.034 g

Total Sugars: 3.23 g

Vitamin B-12: 0.0 mcg

Vitamin B-6: 0.098 mg

Vitamin C (total ascorbic acid): 16.9 mg

Vitamin D2 + D3: 0.0 mcg

Vitamin E - alpha-tocopherol: 0.66 mg

Vitamin K (phyloquinone): 9.7 mcg

Zinc: 0.21 mg

2.1.4 Antioxidant properties and other health benefits of tomatoes

According to Keith (1999), over the last 20 years, scientists have been able to demonstrate a common link among the various chronic diseases that currently plague the American people. For example, conditions such as cancer, Alzheimer's disease, rheumatoid arthritis, cardiovascular disease, and cataracts as well as the actual aging process itself may all be, in part, caused by a phenomenon known as oxidative or free radical damage. The term oxidative is used because oxygen is frequently involved (Keith, 1999). According to Keith (1999), antioxidants can prevent, stop, or reduce oxidative damage.

Antioxidants are naturally occurring chemicals in many foods, especially fruits and vegetables. Foods rich in antioxidants help protect us from disease attack and they slow the

aging process (Sun *et al.* 2009). The balance between free radicals and antioxidants will determine the amount of oxidative stress a person is undergoing. Decreasing free radical production, increasing dietary antioxidant intake or both can reduce oxidative stress (Keith, 1999).

Lycopene is the pigment responsible for the characteristic deep red colour of ripe tomatoes and their products (Ibitoye *et al.*, 2009). According to Lindshield *et al.* (2006) lycopene has earned a plethora of interest for its use as a preventative measure and possible treatment for cardiovascular disease, skin health, eye health, and prostate cancer. Lycopene has also been shown to be the most potent antioxidant produced by the carotenoid pathway (Di Mascio *et al.*, 1989; Cox, 2001). According to Challem (1999), the evidence is so convincing that the National Cancer Institute recommends consumption of at least five servings of fruits and vegetables a day to ward off cancer (Cox, 2001). Consumption of fruits and vegetables is linked to lower incidence and lower mortality rates of several types of cancer (Doll, 1990; Dragsted *et al.*, 1993; Ames *et al.*, 1993; Willett, 1994; Cox, 2001). These positive effects on human health are attributed in large part to the antioxidant compounds found in high quantities in fruits and vegetables (Ames, 1983; Gey, 1990; Cox, 2001).

Carotenoids are a group of at least 600 compounds manufactured by plants accounting for many of the bright colors in the plant kingdom. Only about 14 carotenoids are found in appreciable levels in human tissues (Khachik *et al.*, 1995). According to Giovannucci (2002), of the 14 carotenoids found in human serum, tomato and tomato products contribute to nine and are the predominant source of about one-half, including lycopene. Giovannucci (1999) also reported that lycopene, a carotenoid, is believed to help prevent cardiovascular disease and certain cancers. However, Dumas *et al.* (2003) reported that tomato cultivars and genotypes vary greatly

in lycopene, with processing types generally higher in lycopene than salad or normal types. For instance, Naika *et al.* (2005) reported that yellow tomatoes have higher vitamin A content than red tomatoes, but red tomatoes contain more lycopene, this anti-oxidant that may contribute to protection against carcinogenic substances. Lycopene is thought to inhibit proliferation of cancerous cells (Matsushima *et al*., 1995). Recent epidemiologic studies have suggested a potential benefit of this carotenoid against the risk of prostate cancer, particularly the more lethal forms of this cancer (Giovannucci, 2002; Engelhard *et al.*, 2004).

Siler *et al*. (2004) and Herzog *et al.* (2005) added that in addition to antioxidant properties, giving supplements results in high concentrations of lycopene accumulation in areas of high androgen sensitivity, such as the prostate. This unique feature has been shown to locally modify androgen metabolism in normal prostates and prostatic tumors.

Research findings by Garmyn *et al.* (1995) on the one hand and (Arab *et al.* (2002) on the other have found that lycopene is likely to also play a role in the prevention of skin and lung cancers respectively. Also, Nkondjock *et al.* (2005) after a research reported that the dietary intake of lycopene from tomatoes was associated with a 31% reduction in pancreatic cancer risk among men.

According to Cox (2001), a University of California Davis survey ranked the tomato as the single most important fruit or vegetable of Western diets in terms of overall source of vitamins and minerals. Aside lycopene, tomatoes are also an excellent source of flavonoids and polyphenols, which are also associated with lower cancer risk (Campbell *et al.*, 2004).

It has also been demonstrated that dietary intake of tomatoes especially in the cooked form, are associated with a decreased risk cardiovascular diseases. Cooked tomatoes according Knekt *et al.* (2002) contain significant amounts of absorbable naringenin and chlorogenic acid.

Aside its unique and amazing ability to actually stimulate DNA repair in prostate cells, an increased intake of the flavonoid naringenin has been shown in epidemiological research to be associated with the reduced risk and beneficial effect on vascular diseases and asthma.

Sesso *et al.* (2003) also found that lycopene might help reduce risk of heart disease. One study found that women who ate at least seven servings a week of tomato-based products had a 30% reduced risk of cardiovascular diseases. Lycopene works synergistically with the other phytochemicals in whole tomatoes to provide a wide range of health benefits. New evidence shows that the protective effects of tomatoes against cancer and cardiovascular disease are due to a combination of lycopene and the other phytonutrients naturally present in the fruit and skin of the tomato. In other words, you will not obtain all the nutrients if you skin the tomatoes (Heber and Lu, 2002).

Finnish researchers Knekt *et al.* (2002) investigated the relation between serum lycopene concentration and the thickness of the inner lining of the carotid artery (found on each side of the neck) in 1,028 men, aged 46-64, from 1991-1993. A low serum lycopene concentration was associated with a thicker carotid artery, suggesting that the serum lycopene concentration may play a role in the early stages of atherosclerosis. Increased thickness of the inner lining of the carotid artery has been shown to predict stroke and cardiovascular disease; thus, the researchers concluded that lycopene intakes and serum concentrations might have clinical and public health relevance.

Italian researchers *Riso et al.* (2006) at the University of Milan reported that a daily glass of a commercial tomato juice could lower one of the primary markers of inflammation by almost 35% in less than one month.

Uhrman *et al.* (1997) at the Technion Faculty of Medicine in Haifa, Israel, found that

giving a dietary supplement of lycopene to men for a 3-month period resulted in a significant 14% reduction in the men's plasma LDL cholesterol concentrations.

In addition, in a recent study at the University of the Negev in Beer Sheva, Israel, Engelhard *et al.* (2006) evaluated the effect of a tomato extract containing lycopene on systolic and diastolic blood pressure in patients with hypertension, as well as the serum lipoproteins, plasma homocysteine and oxidative stress markers. The researchers found that a daily dose of lycopene helped lower blood pressure among 31 men and women with mild hypertension. On average, the subjects' systolic pressure dropped 10 points, while their diastolic pressure, or bottom number, dipped 4 points.

After a six year research in nuns, Gross and Snowdon (2001), reported that lycopene might also improve longevity in women. Sharma *et al.* (2003) explain that this might be because lycopene is an antioxidant that reduces oxidative stress, which plays a major role in numerous health concerns for women including breast cancer, cervical cancer, cardiovascular disease, and preeclampsia.

According to Rao *et al.* (2007) one of the more exciting recent discoveries about the relationship between Lycopene intake and disease has been in the study of osteoporosis risk. Rao *et el.* (2007) further reported that postmenopausal women with higher intakes of lycopene had lower laboratory markers of bone turnover (a major risk factor for osteoporosis). These women also had decreased levels of oxidative stress when consuming higher levels of lycopene.

From the various uses of tomato, it is evident that tomato passes through several processing stages before consumption. Due to this, a study was conducted to evaluate the stability, isomeric form, bioavailability and *in vivo* antioxidant properties of lycopene. Fortunately, unlike many such nutrients in food, lycopene was found to be somehow

stable even after many stages of processing and a considerable length of storage (Honglei *et al.*, 2001). Lycopene content of tomatoes remained unchanged during the multistep processing operations for the production of juice or paste and remained stable for up to 12 months of storage at ambient temperature (Honglei *et al.*, 2001).

From these findings, it can be seen that an increase in the consumption of tomatoes comes with a great preventive and curative effects for many common ailments in Ghana.

2.2 VARIETIES OF TOMATO

There are many varieties within the two main types and this can often confuse a beginner tomato grower (Sacco 2008). Sacco describes these two main types of tomato as the hybrid and the open pollinated. Other authors however describe what Sacco refer to as types, as groups. Hybrid tomatoes are a cross between two different tomatoes often with a positive and negative aspect (Sacco 2007). The positive aspect is the fact that they carry desired traits of either parent such as size of fruit, resistance to some diseases and even odour. On the negative front, their seeds could revert to either of the parent plant or would become sterile and will not produce seeds at all.

According to Sacco (2008), there are more tomato varieties sold worldwide than any other vegetable. Gould (1992) reported that although not specifically documented, early tomatoes were probably small fruited, since they were most likely of the small-fruited *cerasiforme* variety cultivated by the Aztecs. Additionally, later emphasis on breeding for smooth skinned cultivars suggests that early cultivars initially had rough skin.

Open pollination promotes continual small changes in the plant's production and immunities (Edlin, 2009). This therefore means that through open pollination, new varieties are

obtained over a period and if are isolated from other varieties to prevent further out crossing, this new variety becomes an heirloom..

Heirloom tomatoes, as described by The Market Corner Newsletter (2005), are open-pollinated plants, grown directly from the seed of a previous fruit, from a variety that has been around for fifty years or more. The variety must have a history or folklore of its own (Vivrina *et al.*, 2003) and (Watson, 1996). No matter which definition one chooses to go by, there is one major quality that all heirlooms must share, open pollination (Edlin, 2009).

Domesticated tomatoes (*Solanum lycopersicum*) are naturally self-pollinating. Since they do not outcross very often, strains quickly become homogenous and produce 'true to seed' (Edlin, 2009). Colors of heirlooms range from yellow, red, orange, purple, white, green, and bicolor combinations of them all (Plate 2.1). There is also wide variety in their shapes and sizes. One can find tiny cherries and huge two-pounders in the same garden, along with globe, flattened, oblong, pumpkin, egg, pear, and pepper shaped fruits.

Plate 2. 2 Phenotypic diversity of tomato fruit.

(Source: Journal of Experimental Botany: 2007)

2.2.1 Major Tomato Varieties Grown in Ghana

According to a Ministry of Food and Agriculture resource (2008), the recommended varieties of tomato in Ghana are the Roma VF, Pectomech, Pectomech VF, Tropimech, Rio Grande, Cac J, Wosowoso, Laurano 70. The main source of seeds by farmers is reputable seed dealers. Robinson and Kolavalli (2010) describe the Pectomech variety as suitable for processing and preferred by consumers and achieving a premium price over the local varieties. Clottey *et al.* (2009) in their research on the tomato industry in Northern Ghana reported the major tomato varieties in Vea, a notable tomato growing area as Pectomech, Tropimech, Roma and a variety the farmers could not name. Adubofour *et al*. (2010) also cited two varieties of tomato grown in

Ghana as the Bolga and Ashanti.

Other authors such as Robinson and Kolavalli (2010), described other varieties as Power Rano, grown widely under rain-fed conditions and being the variety that is grown widely in Brong Ahafo Region and "No name", another variety believed to be Pectomech and widely grown in the Upper East Region under irrigated condition. They also cited other varieties as "Burkina", grown under rain-fed conditions mostly in the Grater Accra Region and believed to be a Pectomech from Burkina Faso. Other varieties are Nimagent F1, supplied by Trusty Foods, grown under both irrigated and rain- fed conditions in the Greater Accra Region and Ada Lorry Tyre and Meenagiant all mostly grown in the Greater Accra Region under rain fed conditions.

Lastly, Robinson and Kolavalli (2010)[2] mentioned yet another variety as Techiman, grown under rain-fed conditions in the Greater Accra Region and under irrigated condition in the Upper East Region. Identifying key local open pollinated varieties that farmers can wash and recycle, they mentioned varieties such as Rasta, Power, Power Rano, and Wosowoso, with Power Rano often being preferred due to its high tolerance and/or resistance to diseases. Ellis *et al*. (1998) describe the `Power' variety as the predominant variety for cultivation in Ghana.

2.3 WORLD PRODUCTION OF TOMATOES

Tomato (*Solanum lycopersicum L*.) is one of the most widely grown vegetables in the world (Srinivasan, 2010). It is estimated to be grown on more than 5 million hectares with a production of nearly 129 million tonnes. China tops the chart of tomato growers worldwide. Other high growers include the USA, Turkey and India (Table 2.1). In Africa, Egypt Nigeria, Tunisia and Morocco are the leading producers (Table 2.1).

Table 2. 3 World's leading producers of tomato

Rank	Area	Production (Int $1000)	Flag	Production (MT)	Flag
1	China	8034699	*	39938708	
2	USA	3250246	*	13718200	
3	India	2441089	*	10303000	
4	Turkey	2212343	*	10985400	
5	Egypt	2180726	*	9204100	
6	Italy	1416109	*	5976910	
7	Iran	1143518	*	4826400	
8	Brazil	916363	*	3867660	
9	Spain	905664	*	4049750	
10	Mexico	695809	*	2936770	
11	Russian Federation	459338	*	1938710	
12	Uzbekistan	457274	*	1930000	*
13	Nigeria	403017	*	1701000	
14	Ukraine	353523	*	1492100	
15	Greece	317154	*	1338600	
16	Morocco	310925	*	1312310	
17	Chile	300901	*	977000	F
18	Tunisia	277208	*	1170000	
19	Syrian Arab Republic	275620	*	1163300	
20	Portugal	271900	*	1147600	

* : Unofficial figure F : FAO estimate

Source: FAOSTAT. 2008

From the history of its introduction into European and American cuisine, the importance of tomato has increased over the years. This increased importance in the worldwide market has

consequently been a driving force to expand the acreage and export share for many countries, especially for those located close to the major importing countries (Nicola *et al.,* 2009). For example, according to The China Business Intelligence Portal (2010), growing price hike of tomato sauce in 2008 has increased the worldwide area of tomato planting with output of processing tomatoes increasing by 115.6% year-on-year to 42.317 million tonnes.

Although tomato requires a relatively cool, dry climate for high yield and better quality, it is adapted to a wide range of climatic conditions from temperate to hot humid tropics (Naika *et al.,* 2009; Srinivasan 2010). Production of tomatoes during the hot-wet season in tropical and subtropical climates suffers a limitation by unfavorable conditions that among others include such factors as high temperature and high incidence of diseases (Nicola *et al.* 2009).

2.3.1 Tomato Production in Ghana

Ghana's commitment to the tomato sector has its roots in the 1960s when three large tomato processing plants were established in the country (Robinson and Kolavalli, 2010)[2]. Three state run enterprises dominated the food processing industry in Ghana then, all built by a Yugoslavian company in 1967 and set up as part of President Nkrumah's government's overall development plan for Ghana (Ablorh-Odjidia, 2003). These were the GIHOC cannery at Nsawam (Eastern Region), Pwalugu Tomato Factory at Pwalugu (Upper East Region), and the GIHOC Tomato Cannery -TOMACAN of Wenchi (Brong Ahafo Region). According to Ablorh-Odjidia (2003), by the late 1980s, a combination of structural reforms promoted by the World Bank and IMF, frequent breakdowns in the face of lack of spare parts and obsolete machinery coupled with technical incompetence and poor financial management and marketing, resulted in the closure of these.

According to Robinson and Kolavalli, (2010)[2], tomato production appears to be falling since 2000 in spite of report by Ellis *et al.* (1998) that the cultivation of tomatoes in Ghana is on the average three times a year. The tomato sector in Ghana has failed to reach its potential, in terms of attaining yields comparable to other countries, in terms of the ability to sustain the few processing plants and in terms of improving the livelihoods of the many households involved in tomato production and the tomato commodity chain (Robinson and Kolavalli (2010)[2]. According to the authors, in spite of government interventions that include the establishment or refurbishment of a number of tomato processing plants in recent times, farmers do not only refuse to grow the right quality (as they still prefer planting local varieties) but also most importantly, they cannot produce the right quantity for commercial agro processing.

Robinson and Kolavalli (2010) report that average yields in Ghana remain low, typically, less than ten tonnes per hectare and that, due to production seasonality, high perishability, poor market access and competition from imports, some farmers are unable to sell their tomatoes, which are left to rot in their fields. In the midst of this situation, they uphold that yet other farmers in Ghana have achieved higher tomato yields, production is profitable and many farmers in Ghana continue to choose to grow tomatoes over other crops. The above information from Robinson and Kolavalli (2010)[3] is based on a survey of about 100 growers conducted in three regions over the 2008–2009 season: Greater Accra, Brong Ahafo, and Upper East. In a related research, Ellis *et al.* (1998) reported of a rampant abuse of agrochemicals by most farmers.

2.3.2 Major Tomato Productions Seasons in Ghana

Tomato production in Ghana is not uniform and varies from production area to production area. Major tomato growing communities in Ghana are Bolgatanga in the Upper East

Region, Begoro, Oda and Nsawam in the Eastern Region and Agogo, Kumawu, Akomadan in the Ashante Region. The rest are Derma, Techimantia, Tuobodom, Tanoboase, Amoma and Dormaa Ahenkro in the Brong Ahafo Region and the capital, Accra in the Greater Accra Region.

Tomato cultivation in the year begins at Bolgatanga in the dry season. Cultivation is under irrigation. The Begoro production area follows from about the January 10 to February 10, harvesting by April. Next is the Kumawu area, from early February to early March. Tanoboase, Amoma, Tuobodom and Agogo have the same growing plan. They do their nursery from the mid-February to mid-March. There is only one-week interval between this growing season and that of Akomadan. Although a few farmers in the Derma/Techimantia/Dwomo production area begin in February, the majority begin their nursery establishment from mid March to mid April. The Oda production areas establish their nurseries in early May, transplanting in June. The last group to get on is the Dormaa production area, where nurseries are established either in September or mainly in October. They mostly do water their crops and do harvest their produce around January where there is severe drought. They have only one growing season in a year. With the exception of Bolgatanga where they operate fully under the irrigation and the Dormaa and Accra production areas where they most often do water their crops, all the others operate a rain-fed production system (Charles Mensah, 2010 National Best Tomato Farmer).

The minor season begins with Nsawam between late May and early June. This is followed by Accra by early June and then by Begoro by mid June and Tuobodom by late June. By early July towards the end of the month, the Techimantia, Derma and Dwomo growing areas do their nursery. Oda has no minor production season so do produce once in a year like Dormaa.

Aside the major and minor rainy season productions as in detail described above, some areas such as Tuobodom, Derma, Dwomo and Techimantia do have a third production season

during the dry season and fully irrigated. This system is locally referred to as 'Petraa".

2.4 VALUE CHAIN IN TOMATO PRODUCTION

2.4.1 Tomato Production Considerations

Tomato production requires warm day and cool night temperatures for optimum yield since high temperatures and low humidity cause excessive flower drops and therefore reduces yields drastically (MOFA, 2008). However, according to Orzolek *et al.* (2006), tomatoes are sensitive to cool night temperatures (below 13°C) and that the best temperature range is 16° and 32°C since temperatures outside these slow growth, pollination and maturation of the crop. Although tomatoes require a constant supply of moisture during the growing season, excess water at any time during growth, especially after fruit set, may increase the fruit's susceptibility to cracking (both radial and concentric), which can reduce fruit quality and yield (Orzolek *et al.*, 2006).

Virtually all postharvest quality characteristics of horticultural crops are genetically programmed and will naturally vary by cultivar (Kitinoja and Gorny 2009). According to Robinson and Kolavalli (2010)[2], varietal choice influences yields (Table 2.2), although there are other conditions that may also influence yield.

Table 2. 4 Farmers' choice of variety and average yields, 2008/9 season

	Average yields (and number choosing variety in parentheses)			
	Greater Accra (Rainfed)	Greater Accra (Irrigated)	Brong Ahafo (Rainfed)	Upper East (Irrigated)
Power Rano			16.0 (17)	
Pectomech		8.8 (4)	10.1 (13)	13.8 (14)
Ada Lorry Tyre	4.8 (8)			
Burkina	14.6 (2)			
"No Name"				15.7 (18)
Meenagiant	2.0 (1)			
Nimagent F1	2.8 (4)	3.1 (5)		
Techiman	4.2 (2)			11.1 (1)
Wosowoso	1.1 (2)			
Other	1.8 (2)	1.8 (1)		8.9 (1)
Average yields	4.5 (21)	5.2 (10)	13.7 (30)	14.6 (34)

Source: Robinson and Kolavalli 2010; Three Region Survey 2009

Clottey *et al.* (2009) also realized that farmers do not invest in using pure seed but rather re-use seed from the previous crop, often resulting in lower yields and increasing disease persistence. They attributed this to the fact that there was no incentive in investing in good seed since the fruit prices are the same irrespective of the variety and seed quality.

2.4.2 Harvesting, postharvest handling, processing and storage of tomatoes

2.4.2.1 Harvesting

Postharvest activities include harvesting handling, storage, processing, packaging, transportation and marketing (Mrema and Rolle, 2002). The principles that dictate at which stage of maturity a fruit or vegetable should be harvested are crucial to its subsequent storage and

marketable life and quality. Post-harvest physiologists distinguish three stages in the life span of fruits and vegetables: maturation, ripening, and senescence. Maturation is indicative of the fruit being ready for harvest (FAO, 2008).

Harvesting marks the end of the growth cycle of tomatoes and the beginning of a series of stages of very important activities that ensure that the consumer gets the vegetable in the preferred state and at the best of desired quality. Harvesting fresh-market tomatoes is labor intensive and requires multiple pickings (Orzolek *et. al.*, 2006). According to Orzolek *et al.* (2006), tomatoes for the wholesale market should usually be picked at the mature green to breaker stage to prevent the fruit from becoming overripe during long transportation/shipping and handling. They recommend leaving tomatoes on the vine to ripen if they can be brought to market quickly and in good condition and that, it is when market is available that tomatoes should be vine-ripe before harvesting.

Usually, fresh market tomatoes are harvested by hand with harvesting operation varying among growers. For the harvesting operation, Kitinoja (2008) recommends the use of plastic buckets for harvesting fruits that are easily crushed, such as tomatoes. These should be smooth without any sharp edges that could damage the produce.

In harvesting, Hurst (2010) advises that a good harvesting management especially in picking high quality tomatoes, since the riper the tomato, the more susceptible it is to bruising. He also advises harvest crews to carefully place fruits into picking containers instead of dropping them since research has demonstrated that a drop of more than 6 inches onto a hard surface can cause internal bruising that is not evident until after the tomato is cut open. Also, Hurst (2010) advises against overloading of bins. He explains that extreme tomato weight will provide a force of compression to cause bruise damage to the tomatoes. He also recommends shading of

harvested tomatoes to minimize heating-up while waiting to be taken to the packinghouse based on the research findings that, bulk bin tomatoes held in the hot sun for just one hour can be as high as 25 degrees F warmer than fruit held in the shade and that field heat can speed up breakdown.

2.4.2.2 Postharvest handling of fresh tomatoes

According to Kitinoja and Gorny (2009), postharvest handling of fresh vegetables has a direct link with its shelf life. They reported that, handling starts right from harvesting and put estimates of losses in developing countries in the range of 20% to 50% tracing causes of losses to the field, during transport and marketing.

Tomatoes are highly perishable and very susceptible to mechanical damage with poor handling and transportation (Bani *et al.*, 2006). In addition, at the usually high temperatures fruits and vegetables transpire and respire at high rates therefore the need shade from the sun's heat (Harvey and Harris, 1986; D'sousa and Ingle, 1989; Eckert and Eaks, 1989; Robbins and Moore, 1992). It is also recommended the produce be harvested in the morning to ensure that they are at the coolest possible temperature during the delay between harvest and initial cooling.

Most often also, losses of fresh vegetables occur along the long chain of supply from the producer to the consumer. Losses occur at the stages of sorting, packaging, storage, transport and marketing stages of the life the fresh horticultural produce. Kitinoja (2008)[2] summarizes the various stages and causes of losses with the diagram in Figure 2.1.

As a remedy, Kitinoja and Gorny (2009) recommend that when handling fresh produce at its market destination, it is important to avoid rough handling, minimize the number of handling steps and strictly follow a temperature and relative humidity management. Stacking of non-

uniform containers should also be done with care to prevent collapse of weaker packages and heavier cartons should always be placed at the bottom of a stack (Kitinoja and Gorny, 2009).

Conversely, according to the World Resource Institute (1998), post-harvest losses for horticultural produce are difficult to measure. The authors affirm that in some cases everything harvested may end up being sold to consumers whiles in others, losses or waste may be considerable. Use of average loss figures is thus often misleading. Also, there could be losses in quality, as measured both by the price obtained and the nutritional value, as well as in quantity (World Resource Institute, 1998).

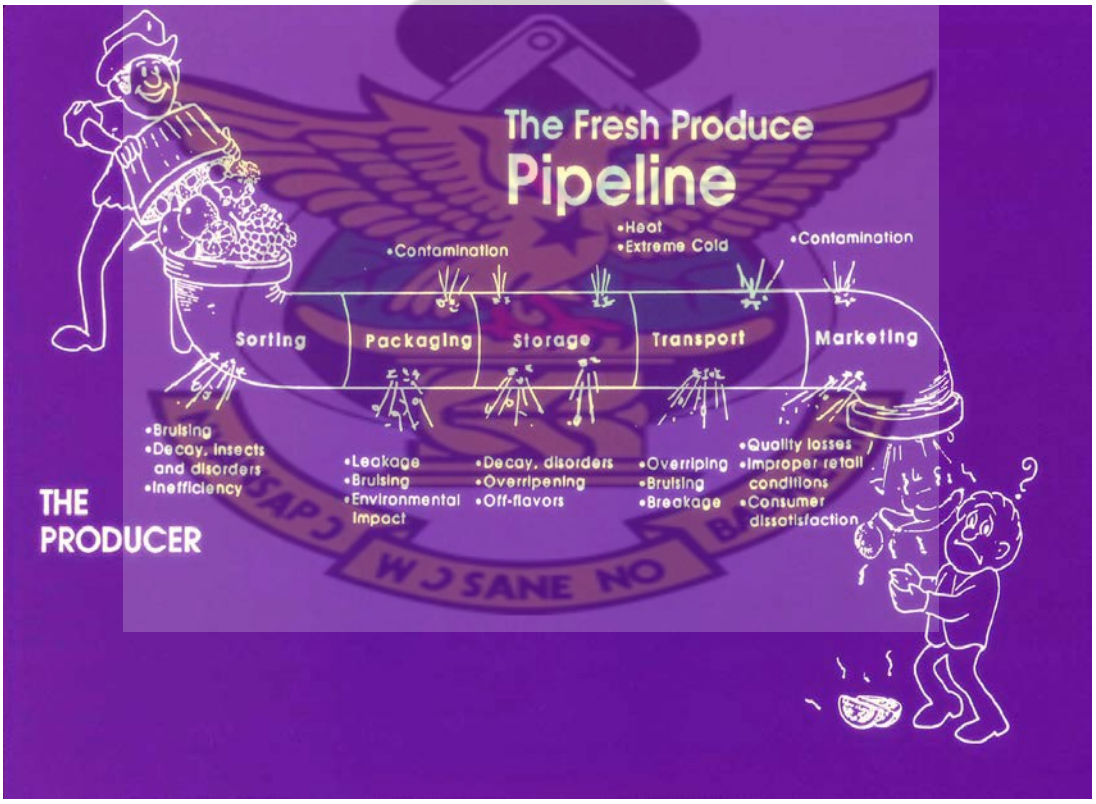


Figure 2. 1 Postharvest losses of harvested horticultural produce.

Source: Kitinoja: (2008).

Bani *et al.* (2006) in a research conducted in Ghana to assess losses of tomatoes from Bolgatanga to Accra revealed that losses along the route alone amounted to 20%. Losses of horticultural produce are a major problem in the post-harvest chain. They can be caused by a wide variety of factors, ranging from growing conditions to handling at retail level. Not only are losses clearly a waste of food, but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water (World Resource Institute, 1998).

2.4.2.4 Processing of Tomatoes

Right after harvesting, if the tomato is to be processed, little handling is required before they are transported to the processing plant in the shortest possible time. Once at the plant, they should be processed immediately or at least stored in the shade (Gould, 1992). The flowchart in Figure 2.3 summarizes the various tomato-processing methods for processing tomatoes into juice, paste, whole, sliced, or diced tomatoes.

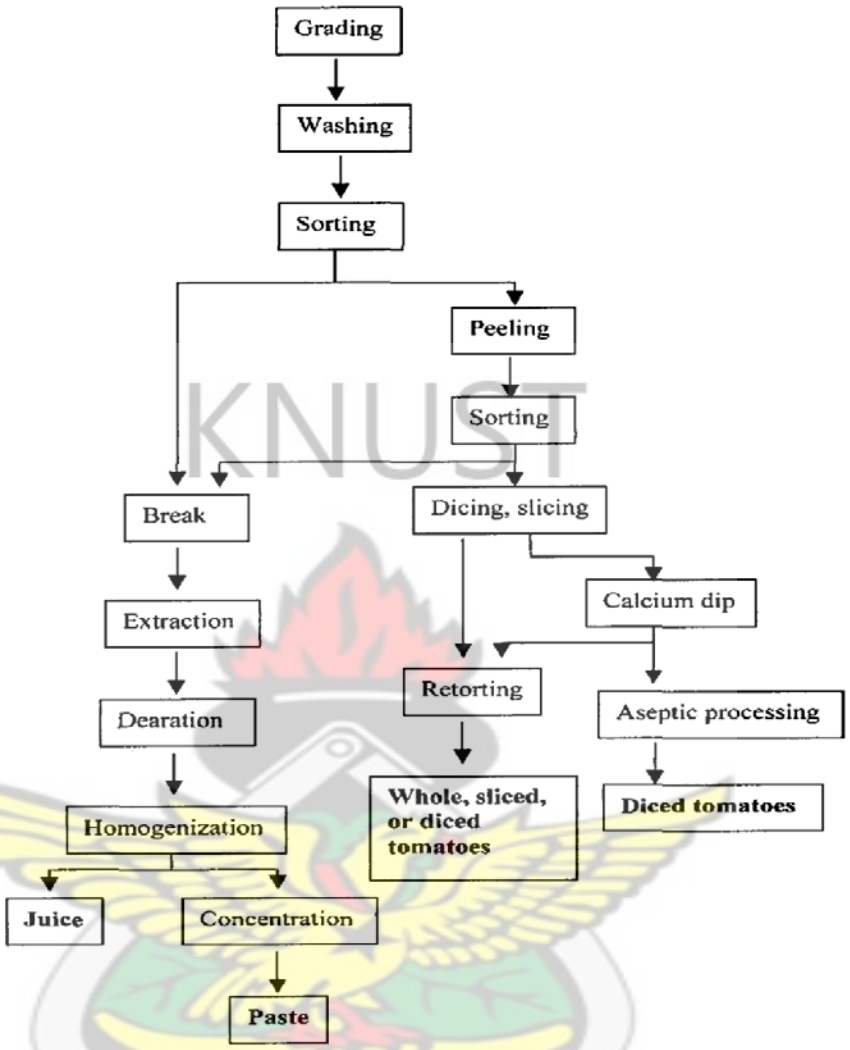


Figure 2.2 Flowchart of various tomato-processing methods

2.4.2.5 Storage of fresh tomatoes

According to Kitinoja and Gorny (2009), in developing countries, there is lack of storage facilities on-farm or at wholesale or retail markets and lack of ventilation and cooling in the very few existing on-farm facilities. Others include over-loading of cold stores (where available) including placing warm produce into the cold room, stacking produce too high (beyond container strength) and the practice of mixing produce with others with different temperature and relative

humidity requirements. There are few key factors to consider when storing fresh produce. Because some cultivars have a naturally longer storage potential than others of the same commodity Kitinoja and Gorny (2009) recommend first determining which varieties would give you the best results. Insect pests can cause a considerable deterioration and spoilage of fresh vegetables by damaging the integrity of the food.

According to Hurst *et al.* (1993), insects do not destroy tomatoes by consuming large quantities of it, but once they damage the product, further deterioration results from microbial invasion.

FAO (2008)[2] reported that when stored at 10^{o}C with the optimum humidity of about 80%, green tomatoes can be stored for 16 - 24 weeks. In another report, Ashby (2000) recommend 13^{o} to 21^{o}C and a relative humidity of between 90 to 95% as the best transport conditions for green-mature tomatoes.

In Ghana, Ellis *et al.* (1998) observed that farmers carry out neither on-farm nor off-farm storage of the fresh tomato fruits and that, the major postharvest problems of the farmers are the need for permanent purchasing outlets as well as the stabilization of the unit price per box of tomato.

2.4.3 Processing and Preservation of Tomatoes

According to Robinson and Kolavalli (2010), in Ghana, many reports simply repeat the mantra that processing offers a way of buying up the glut. However, the reality is that "tomato gluts" is an annual feature, that occurs only for a few weeks of the year and usually results from the production of large volumes of rain-fed local varieties that are unsuitable for processing.

Ellis *et al.* (1998) reported that although tomato is a highly perishable crop, the rate and extent of spoilage depends on several factors and that, to overcome this problem calls for the need to develop simple, cost-effective and easily adaptable preservation techniques. They added that doing this requires a better understanding of the farm management system of farmers.

Tomatoes can be processed into many forms to be consumed instantly or preserved for future use. For example, according to Kitinoja and Gorny (2009), horticultural produce are usually processed to become part of the following categories: Beverages (juices, sparkling fruit-flavored waters), Condiments (salsas, pickles, chutneys, herb-vinegars, jams, jellies and preserves), Confections (fruit-based candies, cookies, cakes) and Miscellaneous (bottled herbed-mushrooms, fruit or vegetable-based snack-foods).

Adubofour *et al.* (2010) also reported about formulating four cocktail juices in different ratios from a combination of carrots, tomatoes (Bolga variety) and two varieties of orange and pineapple. A promotion of this could help increase the consumption of the vegetable whiles helping swab the excess.

On preservation, Kitinoja and Gorny (2009) recommend the use of brine or vinegar to pickle vegetables such as the tomato. Due to the acidic nature of vinegar, there is no need for further processing if it is decanted into sterilized containers before being filled with the tomatoes.

Ashby (2005) described a simple home-drying method for stewing tomatoes. Ripe tomatoes are steamed or dipped into boiling water to loosen skin, chilled in cold water, peeled and cut into sections about ¾ inch wide, or slice. These are blanched for three minutes and dried in the dehydrator for 10 – 18 minutes or twice this time using the conventional oven.

Other preservation methods are described by the Food and Agriculture Organization (FAO) and the Information Network on Post-Harvest Operations (INPhO). FAO and INPhO (1998) describes pulping method, the drying method and the peeled tomato preservation method.

2.5 MARKETING OF TOMATOES

Six basic marketing alternatives are available to the tomato grower: wholesale markets, cooperatives, local retailers, roadside stands, pick-your-own operations, and processing firms (Orzolek *et al.*, 2006). Marketing cooperatives generally use a daily-pooled cost and price, which spread price fluctuations over all participating producers..

Fresh and processed produce can be marketed on the farm, at the farm gate, locally or regionally via wholesale or retail operations, or through exports to other countries. When deciding how to market your fresh and processed produce, each postharvest handling step taken provides an opportunity to make additional profits (Kitinoja, 2004). Kitinoja (2004) compared the domestic and international marketing practices using Ghana and the United States markets as example (Table 2.4). The difference in product preferences shows the degree of difficulty likely to be encountered by exporters to the American market and the need to train farmers to be able to produce for the international market. As clearly indicated, in both markets, post-harvest handling is key to quality.

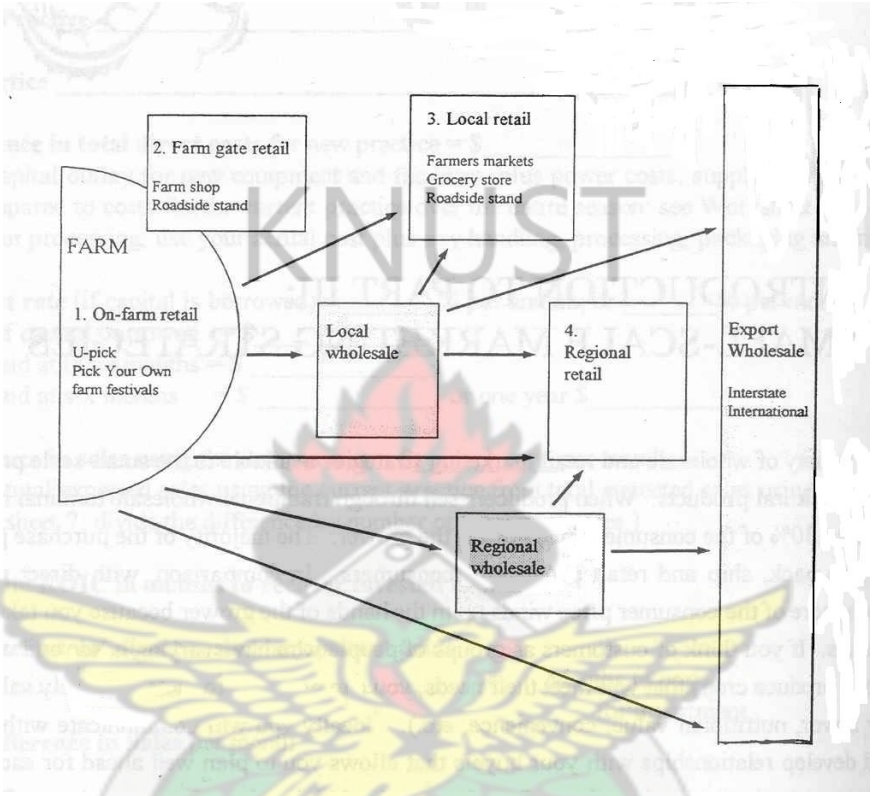


Figure 2. 3 Market options available to producers of fresh tomatoes.

Source: Kitinoja and Gorny: 1999.

Table 2.3 Domestic vs. international marketing practice

Accra	**United States**
A. Customer selects from available Produce	A. Product is delivered according to customer demands
B. Customer gets the quality delivered	B. Customer demands specific quality
C. Whatever packaging is available is used	C. Packaging specified by buyer
D. Inferior quality delivered to market	D. Superior quality required for market
E. Available land transport used	E. Air or ocean transport required
F. Minimal, if any phytosanitary issues	F. Stringent phytosanitary issues
G. Local competition	G. International competition
H. Transport takes hours – days	H. Transport takes days-weeks
I. Domestic regulations	I. International regulations
J. Post-harvest handling is key to quality	J. Post-harvest handling is key to quality

Source: Kitinoja: 2004.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA LOCATION

The major tomato growing communities of the Tano South District and the Dormaa Municipality of the Brong Ahafo Region of Ghana constitute the study area (Figure 3.1)

Tano South District is one of the 22 Districts in the Brong Ahafo Region of Ghana. It lies between latitudes 7º00' N and 7º25' N and between longitudes 1º45 W and 2º15 W. The District has a total land area of 635 square kilometres, which is 1.54 percent of the total land area of the Brong Ahafo Region. The district is predominantly made up of many farming communities. The major crop cultivated on a commercial scale is tomato. The communities selected for the study in this district include Akobro, Derma, Mansen, Subriso and Techimantia.

On the other hand, the Dormaa Municipality is located at the Western part of the Brong Ahafo Region. It lies within longitudes 3^{o} West and 3^{o} 30' West and latitudes 7^{o} North and 7^{o} 30' North. The Municipality has a total land area of 1,368 square kilometres, which is about 3.5 percent of the total land area of Brong Ahafo Region and about 0.6 percent of that of the country. The communities selected for the study in the Municipality include Dormaa Ahenkro, Duasidan, Sromani, Kyeremekrom and Yawbofokrom.

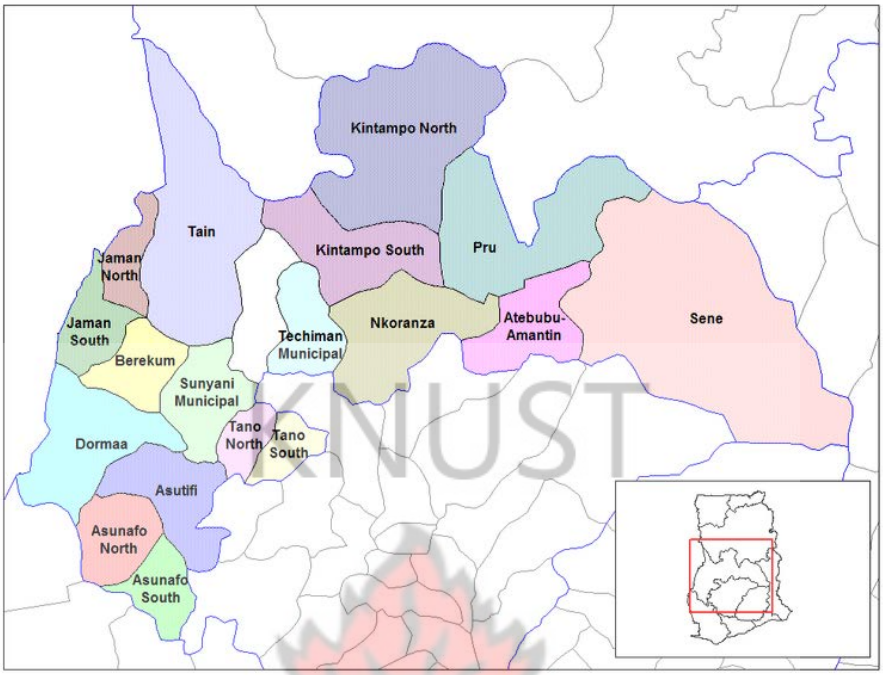


Figure 3. 3 Map of the Brong Ahafo Region showing the twenty-two Districts

3.2 CLIMATE AND VEGETATION OF STUDY AREA

The area experiences two rainy seasons, the major rainy season extending from the month of March to July and the minor rainy season extending from September to November. In between the rainy season period are two dry seasons, the first commencing from July and ending in August with the second and the severer one starting from the end of November to the end of February. The area also experiences a warm, dry and humid weather with a somewhat cold weather during the month of December. The mean annual rainfall for the area over that past ten years is about 1182mm with a mean monthly temperature figures ranging between 32.3^{o} C to about 21.2^{o}C. According to Orzolek *et al.* (2006), tomatoes do best in a temperature range of 16° and 32°C. Tomato fruit is 95 percent water and for that matter, it needs lots of water to grow and develop fruit (Trinklein, 2010). Falling within the Moist Semi-deciduous Forest Zone of Ghana,

(Figure 3.2), the study areas gather the required environmental conditions for commercially significant production of tomatoes.

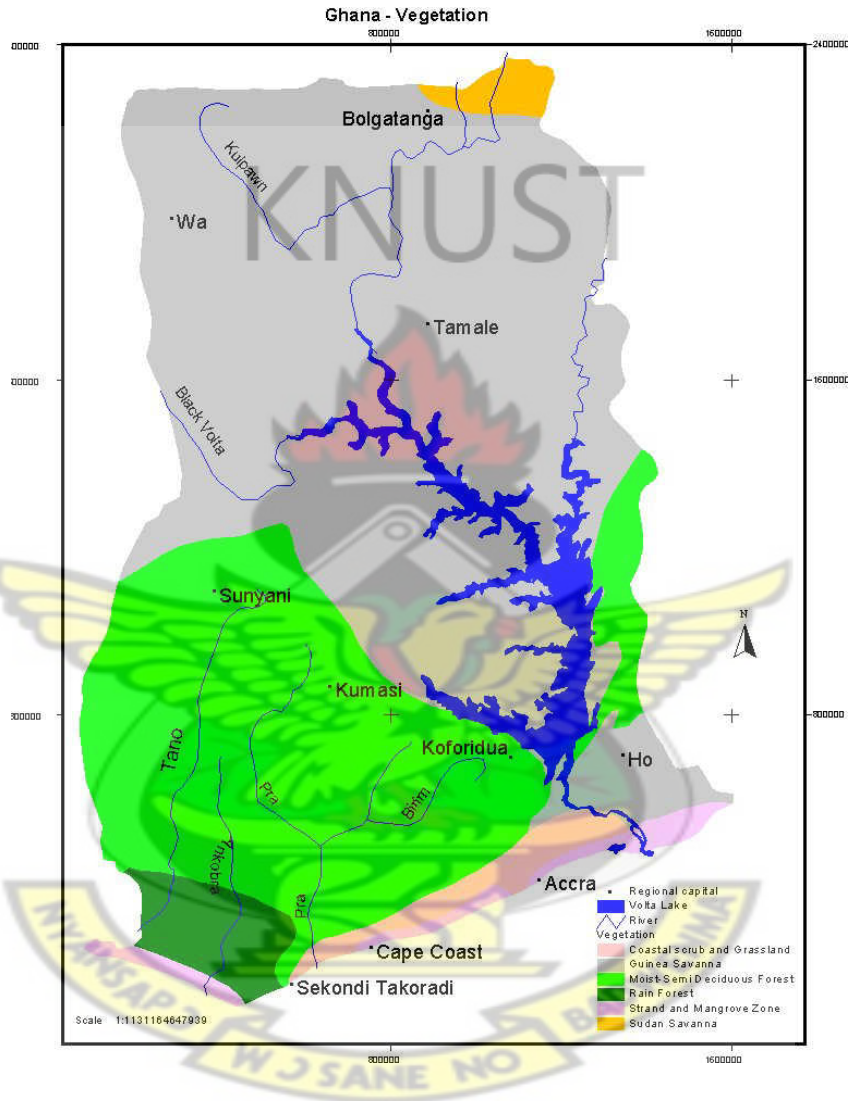


Figure 3. 4 Vegetation Types of Ghana

Source: FAO: 2011

3.3 METHODOLOGY USED IN SURVEY

Due to the intricate nature of the subject matter for the research and the diversity of outlook of individuals, which drive them in their day-to-day decision-making vis-a-vis the various categories of individuals that the research sought to engage, a number of procedures and strategies were adopted to gather the necessary information to address the objectives of the study. The methods used were;

(a) Consultation with staff of the Ministry of Food and Agriculture

(b) Field visits to farms of selected farmers

(c) Visit to market centres

(d) Individual interviews and discussion using semi-structured questionnaires

(e) Group discussions

(f) Personal informal interviews with tomato farmers and traders

3.3.1 Pre-sampling activities

Consultations were made with staff of the District Directorates of the Ministry of Food and Agriculture and the Regional Town and Country Planning. In addition, farmer cooperative group leaders and farmers representatives in the selected farming communities were contacted. Also, the queens of tomato markets in the selected communities were identified and visited for their support in getting the cooperation of their 'subjects' – tomato traders. This pre-study consultation with these organizations and individuals respectively were to get information on;

(a) the important tomato producing communities, contact persons among the farmers in each community as well as the state of tomato production in the district.

(b) the specific geographical locations of the districts of the study

(c) the most convenient time and place to meet tomato farmers in the communities

(d) the best days and time to meet wholesale tomato traders for the interview.

3.3.2 Selection of communities

Ten out of eighteen very important tomato producing communities in the two districts, five each from the two districts were chosen using a random selection method. The selected communities in the Dormaa Municipality were Dormaa Ahenkro, Duasidan, Sromani, Kyeremekrom and Yawbofokrom and those selected in the Tano South District were Akobro, Derma, Mansin, Subriso and Techimantia.

3.3.3 Selection of tomato farmers

Preliminary visits were made to the selected communities to establish contacts with farmer leaders recommended by the MOFA staff. In all, an average of 18 farmers per community or 90 farmers per district (based on the number of farmers obtained in the first community) were selected and interviewed. Where the number was greater than expected, stratified random sampling was used to pick the eighteen (18) farmers by the use of numbers.

3.3.4 Selecting Tomato Traders

Two categories of traders were identified. These are the wholesale traders who directly buy the produce from the farm gate and the retailers who directly sell to consumers. Seventy five (75) traders were selected from each district. Fifteen (15) wholesale traders were interviewed in each district. The remaining 60 were retailers at the retail market mostly of the major towns in the districts, namely, Derma, Bechem and Techimantia in the Tano South District and Dormaa

Ahenkro and Kyeremaasu in the Dormaa Municipality. The tomato queens in these towns facilitated the study by first providing an overview of tomato trade in the communities and as well as informing some of the traders of the local markets before the date of interview.

3.3.5 Selecting Agriculture Extension Officers

Inclusion of Agriculture Extension Agents in this study was based on two reasons; to serve as first contact persons in knowing the major tomato production communities of the districts as well as helping in getting to know some farmers in the communities. They also provided information on the programme of the MOFA for the tomato industry in their respective districts. One resource person each was selected from each district.

3.3.6 Selecting Consumers

Consumers were included in the study because at any given point in time they also store some reasonable quantities of the produce in their homes which they also handle, preserve or process. In all, one hundred (100) respondents made up of fifty (50) from each district were selected.

3.4 DATA COLLECTION

Information on handling and preservation practices of farmers and traders as well as processing methods (if they do) were collected. This same information was as well collected from consumers.

3.4.1 Problems encountered during data collection

Many problems, were encountered in the course of the study. The major and most prohibitive one was the transportation to some of the communities.

Besides some of the communities being far from the major towns, the farms were also far from the communities and with very bad access roads making vehicular movements available only at some particular times of the day before and after which it was impossible to go or return.

Another problem was the difficulty in interviewing the so many respondents involved especially with the farmers and traders most of whom were not appreciably lettered to respond to the items in the questionnaires all by themselves. This problem was however overcome through the help of volunteers from the communities who offered to help conduct the questionnaires alongside.

Another problem encountered was with the reluctance on the part of farmers to cooperate since they felt the study was of not going to benefit them in any way. A few of the traders were also reluctant since they felt it was a government policy aimed at truncating their business.

3.4.2 Data Analysis

Relevant data obtained from farmers, traders and consumers were subjected to statistical analysis using the Statistical Package for Social Scientists (SPPS) and the results expressed using frequency and cross tabulation count tables.

.

CHAPTER FOUR

4.0 RESULTS

4.1 INFORMATION ON FARMERS, TRADERS AND THE STUDY AREA

4.1.1 General socio-economic characteristics of the area of study

From a pre-interview interaction with opinion leaders and agriculture extension agents designated to these communities, it was revealed that about 70% of the adult residents of these communities are crop farmers with most of them producing tomato. Some of the farming communities of the study area have important amenities such as good roads that facilitate transportation and electricity but others are typically rural with bad access roads and low level of development.

4.1.2 Socio-demographic information on farmers and farming activities

4.1.2.1 Age characteristics of farmers

The study showed that farmers within the 25-40 years age group (76 or 42.2% of the total sample size) are in the majority. Two farmers, both from the Tano South District were under 18 years with 6.1% of the farmers being above 55 years. Table 4.1 gives a detailed description of the age distribution of farmers in the study area

.

Table 4.1 Age characteristics of farmers

Age structure of farmers (Years)	Dormaa Municipal		Tano South District		Total frequency	Percent. (%)
	Frequency	Percent. (%)	Frequency	Percent. (%)		
Below 18	0	0	2	2.2	2	1.1
Between 18-24	21	23.3	20	22.2	41	22.8
Between 25-40	35	38.9	41	45.6	76	42.2
Between 41-55	29	32.2	21	23.3	50	27.8
Above 55	5	5.5	6	6.6	11	6.1
Total	90	100	90	100	180	100

4.1.2.2 Education level of farmers

Information gathered showed a generally low level of education among farmers in the two districts (Table 4.2). Only four (4) farmers, 2 from each district had a diploma or a degree qualification. Those with Junior High School education had the highest number of 44 (24.4%). A total of 30 (16.7%) farmers from both districts had no formal education.

Table 4.2 Education level of farmers

Education level of farmers	Dormaa Municipal		Tano South District	
	Frequency	Percent. (%)	Frequency	Percent (%)
Diploma/Degree	2	2.2	2	2.2
Certificate	5	5.6	4	4.4
Secondary/SHS	13	14.4	19	21.1
Middle school	17	18.9	20	22.2
JHS/JSS	23	25.6	21	23.3
Primary	19	21.1	15	16.7
None	11	12.2	9	10.0
Total	90	100.0	90	100.0

4.1.2.3 Years of experience in tomato farming

It was observed that 63 (35%) farmers had between 6 – 10 years experience in tomato farming. This distribution among the two districts were 34 or 37.9% for the Dormaa Municipal and 29 or 32.2% for the Tano South District. Farmers with 1 – 5 years of experience had the least frequency with a total of 28 (16.7%) of the sample size. Overall, 152 farmers or 84.4% had over five years experience with farmers in the Dormaa Municipality generally having more years of experience than farmers in the Tano South district (Table 4.3).

Table 4.3 Farmers' years of experience in tomato farming

Years of experience	Dormaa Municipality		Tano South District	
	Frequency	Percentage (%)	Frequency	Percentage
1-5 years	13	14.4	15	16.7
6-10 years	34	37.9	29	32.2
11-15 years	21	23.3	27	30
Above 15 years	22	24.4	19	21.1
Total	90	100.0	90	100.0

4.1.2.4 Tomato varieties grown by farmers in the study area

The tomato varieties grown in the study area included Akoma (believed to be a Pectomech), Pectomech VF, Atoaa, Tropimech, Namagent 1 and Power Rano (popularly referred to as local). Almost all the farmers cultivated more than one variety for various reasons. It can be seen from Table 4.4 below that Pectomech is the most cultivated variety in the Dormaa Municipal (cultivated by 91.1% of farmers) with Power Rano predominating the Tano South District area (cultivated by 87.7%). The least cultivated variety is the Namagant 1 which is cultivated by 5 farmers in the Tano South and not cultivated at all in the Dormaa Municipal area.

Table 4.4 Tomato varieties grown by farmers per study area

Tomato variety	Dormaa Municipal		Tano South District		Total Frequency
	Frequency	Percent. (%)	Frequency	Percent. (%)	
Nimagent 1	0	0	5	5.5	5
Royal Sluice	18	20	4	4.4	22
Atoaa	44	48.9	48	53.3	92
Akoma	29	32.2	55	61.1	84
Tropimech	39	43.3	42	46.7	81
Pectomech	82	91.1	61	67.8	143
Power Rano	66	73.3	79	87.7	135

4.1.2.5 Description of farming activity by farm size

Farm size ranged from half an acre to thirty-two acres which have been grouped into small scale (> 1 acre – 10 acres), medium scale (11 acres – 25 acres) and large scale (above 25 acres). When a farmer had more than one farm, the acreage of all farms were added to arrive at the data analyzed. By this grouping, the total land area under tomato production is higher in the Tano South district than the Dormaa Municipality (Table 4.5).

Table 4.5 Description of farming activity by farm size

Farming activity by farm size	Dormaa Municipal		Tano South District		Total frequency	Percentage (%)
	Frequency	Percentage (%)	Frequency	Percentage (%)		
Small scale	77	85.5	63	70	145	80.5
Medium scale	13	14.5	25	27.7	33	18.4
Large scale	0	0	2	2.3	2	1.1
Total	90	100	90	100	180	100

4.1.2.6 Production output characteristics per district

Although only 2 (1.1%) farmers, kept written records, all farmers monitored trend of their progress (Table 4.6). A total of 122 (67.8%) farmers experienced a fluctuating trend in production output. In the respective districts the number was distributed as 67 (76.7%) for Dormaa Municipal and 55 (61.2%) for The Tano South District. A total of 2 farmers, from the Tano South District reported a perpetual downward trend in output.

Table 4.6 Production output characteristics per district

Production output	Dormaa Municipal		Tano South District	
	Frequency	Percent(%)	Frequency	Percent(%)
Increasing	17	18.9	22	24.3
Fluctuating	67	76.7	55	61.2
Stagnant	6	6.7	11	12.3
Decreasing	0	0	2	2.2
Total	90	100	90	100

4.1.2.7 Gender of farmers

The study showed that tomato farming in the two districts is male dominated with 87.7% male:12.2% female and 90% male:10% female respectively, for the Dormaa Municipal and Tano South District.

4.1.3 Information on traders

4.1.3.1 Age characteristics of traders

The study showed that traders were aged between 18 and 60 years (Table 4.7). Traders between the 25-40 years age group in the majority (38% percent). The age distribution was 27 (18%) and 30 (20%) for the Dormaa Municipal and Tano South District, respectively. Traders above 55 years made up 5.3%

Table 4.7 Age characteristics of traders

Age structure of traders (Years)	Dormaa Municipal		Tano South District	
	Frequency	Percentage (%)	Frequency	Percentage(%)
Below 18	3	4	4	5.3
Between 18-24	15	20	19	25.4
Between 25-40	27	36	30	40
Between 41-55	26	34.7	18	24
Above 55	4	5.3	4	5.3
Total	75	100	75	100

4.1.3.2 Level of education of traders

The study showed that none of the traders had education beyond the Senior High School level. A total of 10 (13.3%) traders from the Dormaa Municipal had completed high school as compared to 14 (18.7%) from the Tano South District (Table 4.8)

Table 4.8 Level of education of traders

Level of education of traders	Dormaa Municipal		Tano South District	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Diploma/Degree	0	0	0	0
Certificate	0	0	0	0
Secondary/SHS	10	13.3	14	18.7
Middle school	27	36	21	28
JHS/JSS	13	17	15	20
Primary	14	18.7	16	21.3
None	11	14.6	9	12
Total	75	100.0	75	100.0

4.1.3.3 Traders' years of experience in tomato trading

This information was gathered to determine the impact of the depth of experience on the ability to better handle, preserve or process the produce. A total of 85.2% of traders from the Dormaa Municipal had more than 6 years of experience as against 86.7% of traders from the Tano South District (Table 4.9).

Table 4.9 Traders' years of experience in tomato trading

Years of experience	Dormaa Municipality		Tano South District	
	Frequency	Percentage (%)	Frequency	Percentage (%)
1-5 years	11	14.8	10	13.3
6-10 years	29	38.6	24	32
11-15 years	23	30.6	27	36
Above 15 years	12	16	14	18.7
Total	75	100.0	75	100.0

4.1.3.4 Tomato varieties sold by traders

The survey showed that all traders from both study areas sold more than just one variety of tomato. Pectomech and Power Rano were the predominant varieties in the Dormaa Municipal and Tano South District, respectively. All traders in the Dormaa Municipal sold Pectomech as against 86.7% of traders in Tano South while 94% of traders in the Tano South sold Power Rano as against 69.3% traders in the Dormaa Municipal (Table 4.10)

Table 4.10 Tomato variety sold by traders sampled for the study

	Dormaa Municipality		Tano South District	
Tomato varieties	Frequency	Percent. (%)	Frequency	Percent. (%)
Namagent 1	0	0	0	0
Royal Sluice	0	0	0	0
Techiman	33	44	31	41.3
Atoaa	65	86.7	52	69.3
Akoma	54	72	66	88
Daagyene	2	2.7	4	53.3
Burkina	11	14.7	14	18.7
Pectomech	75	100	65	86.7
Local (Power Rano)	52	69.3	72	96

4. 2 POSTHARVEST HANDLING OF TOMATO BY FARMERS AND TRADERS

4.2.1 Postharvest handling of tomatoes by farmers

In both districts, harvesting was done manually either directly into boxes (bins) or first into buckets and emptied into the boxes. In both study areas some farmers used hired labour harvest produce. However, more farmers in the Tano South District 79 (87.8%) used hired labour as compared to 62 (68.9)% in the Dormaa Municipality. Wages of these harvesting brigades according to the farmers depended on quantity of tomatoes harvested per day.

It was observed on some of the farms visited, especially in the Tano South District, that harvested produce were poured from head height from buckets into bins due to the competition among the harvesting groups. This practice was however not observed in the Dormaa Municipality.

A hundred percent (100%) of farmers in the Tano South District harvested their produce

into wooden boxes (Plate 4.1). In the Dormaa Municipality however, some traders have adopted the use of light and conducive plastic bins approved for use in tomato trading in neighbouring La Cote I'voire (Plate 4.2). A total of 44 (48.9)% of farmers in the Dormaa Municipality reported an occasional use of plastic bins for harvesting.

It was observed that wooden boxes encouraged over-packing as the produce are usually heaped far above the upper limit the boxes (Plate 4.3). However, with the plastic boxes, due to the handles and the interlocking spaces for normal stacking, over-packing cannot be done.

One poor handling practice observed was that some farmers harvested their produce into any available container and left them by the roadside hoping to either get buyers from among travelers or transport to the market (Plate 4. 3 and Plate 4.4). The produce could be left in the sun for many days before being sold. This was more prevalent in the Dormaa Municipality where some of the communities are located along the main road.

All farmers from both districts did not practice any form of pre-cooling before packing produce into bins. In all, 85 (94.4%) of farmers in the Dormaa Municipality did not have any idea about pre-cooling as against 82 (91.1%) of farmers in the Tano South District. The remaining 5 (5.6%) and 8 (8.9%) farmers from the respective study areas had knowledge of the importance of pre-cooling but did not practice it. It was observed that harvested produce were left in the hot sun until the whole harvesting exercise was over.

Farmers in both districts mostly harvested in the morning which happened to be the time traders normally arrived. Although almost every farmer knew that tomatoes are best harvested in the morning, only 13 (14.4%) of the 180 respondents were aware of the postharvest implication of the time of harvest on the produce. A total of 44 or 48.9% and 15 or 16.7% farmers in the Dormaa Municipality harvested in the morning and evening respectively, while 31

or 34.4% and 12 or 13.3% of farmers in the Tano South District harvested in the morning and evening respectively (Table 4.11).

Table 4.11 Time of harvest of tomatoes in the study area

Time of harvest	Dormaa Municipal		Tano South District	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Morning	44	48.9	31	34.4
Afternoon	22	24.4	29	32.3
Evening	15	16.7	12	13.3
No specific time	9	10	18	20
Total	90	100	90	100

Plate 4.1 Wooden box mostly used by tomato traders in the Tano South District

Plate 4.2 Plastic box used mostly by tomato traders in the Dormaa District

Plate 4.3 Tomato lined up along the roadside awaiting prospective buyers

Plate 4.4 A farmer sorting out tomatoes for sale along the roadside

4.2.2 Handling of tomatoes by traders

A total of 12 (16%) traders in the Dormaa Municipality (who mostly deal with buyers from La Cote d'ivoire) used the plastic bins (Plate 4.2) together with the wooden boxes (Plate 4.1). however, a hundred percent (100%) of traders in the Tano South District use the wooden bins only. It was observed that wooden bins were packed beyond their edge. Three or 20% each of the 15 wholesalers from each study area explained that this practice did not cause crushing of tomatoes during loading onto trucks since the levels were reduced into other empty containers. However, the rest admitted that sometimes the heap is not reduced enough ending up in crushing of tomatoes in transit and leading to losses.

All the wholesale traders admitted to not making any effort to shade the produce during transportation. One poor handling practice by traders was at the market where, the already red-ripe produce was poured from one container to another. This practice was observed in the markets in both study areas. At the market centre, most retailers although have stalls to keep their produce in the shade, left them under the sun from morning until evening.

4.3 TOMATO PROCESSING AND PRESERVATION METHODS

4.3.1 Methods used for commercial processing and preservation of tomatoes by farmers

Preservation methods used by farmers included pouring the produce on the bare cemented floor. This was used by 38 (42.2%) farmers in the Dormaa Municipal and 29 (32.2%) farmers in the Tano South District. Also, 35 (38.9%) farmers from The Dormaa Municipal stored their produce in shallow baskets as compared to 22 (24.4%) farmers from the Tano South District. Another preservation method occasionally used by farmers is to keep tomatoes in cold water for some time. 14 (15.6%) of farmers in the Dormaa Municipality used this method as

against 21 (23.2%) farmers from the Tano South District. A total of 58 (64.4%) farmers in the Dormaa Municipality reported being able to reduce the rate of senescence of the fruit before harvest through mist application of Dithane M45. This claim was disputed by other farmers, mostly in the Tano South District although this method is used by 23 (31.1%) farmers in this study area (Table 4.12)

Table 4.12 Methods used for commercial preservation of tomatoes by farmers

Commercial preservation method used by Farmers	Dormaa Municipality		Tano South District	
	Frequency	Percent.(%)	Frequency	Percent.(%)
Fresh Frozen	0	0	0	0
Boiled Frozen	0	0	0	0
Fresh Refrigerated	0	0	0	0
Irradiation	0	0	0	0
Boiled Refrigerated	0	0	0	0
Poured on bare cemented floor	38	42.2	29	32.2
Ground and frozen fresh	0	0	0	0
Storage in shallow baskets	35	38.9	22	24.4
Cold water bath	14	15.6	21	23.3
Other	58	64.4	28	31.1

On processing, it was seen that no farmer from any of the two study areas is into any form of processing of tomatoes (Table 4.13).

Table 4.13 Methods used for commercial processing of tomatoes by farmers

Commercial processing method used by Farmers	Dormaa Municipality		Tano South District	
	Frequency	Percent.(%)	Frequency	Percent.(%)
Ground and frozen fresh	0	0	0	0
Pureed and sealed with oil in jars	0	0	0	0
Boiled and sealed packs	0	0	0	0
Pickling	0	0	0	0
Pulping	0	0	0	0
Drying	0	0	0	0
Peeled tomato preserves	0	0	0	0

4.3.2 Methods used for commercial preservation and processing of tomatoes by traders

Since wholesalers sometimes retail, the results presented cover both preservation and processing carried out by both traders. A total of 48 (64%) of traders in the Dormaa Municipality apply water or dip their produce in cold water to keep them fresh as compared to 51 (68%) of traders in the Tano South District. Also, 21 (23.3%) of traders of the Dormaa Municipality preserved their produce by spreading them on the bare cemented floor as against 25 (27.8%) traders in the Tano South District.

As shown in Table 4.14 another preservation method used by traders in the study areas included shallow basket storage used by 58 (64.4%) traders in the Dormaa Municipality as compared to 49 (5.4.%) of traders in the Tano South District (Plate 4.5).

Plate 4.5 Tomato preserved in shallow basket.

Table 4.14 Commercial preservation methods used by traders

Commercial preservation method used by traders	Dormaa Municipality		Tano South District	
	Frequency	Percent. (%)	Frequency	Percent. (%)
Fresh Frozen	0	0	0	0
Boiled Frozen	0	0	0	0
Fresh Refrigerated	5	5.6	3	3.3
Irradiation	0	0	0	0
Boiled Refrigerated	0	0	0	0
Poured on bare cemented floor	21	23.3	25	27.8
Ground and frozen fresh	0	0	0	0
Storage in shallow baskets	58	64.4	49	54.4
Cold water bath	48	64	51	68
Other	0	0	0	0

A few traders do some small scale processing in both study areas (Table 4.15). Fourteen (18.7%) traders of the Dormaa Municipal do make tomato puree for sale as against 6 (8%) of traders from the Tano South. The all complained about low patronage by consumers. Only two traders (2.6%) from the Dormaa Municipal had ever tried commercial tomato drying but explained they were unsuccessful with marketing

Table 4.15 Commercial processing methods used by traders

Commercial processing method used by traders	Dormaa Municipality		Tano South District	
	Frequency	Percent.(%)	Frequency	Percent.(%)
Ground and frozen fresh	0	0	0	0
Pureed and sealed with oil in jars	14	18.7	6	8
Boiled and sealed packs	0	0	0	0
Pickling	0	0	0	0
Pulping	0	0	0	0
Drying	2	2.6	0	0
Peeled tomato preserves	0	0	0	0
Other	0	0	0	0

4.4 CAUSES OF POSTHARVEST LOSSES OF TOMATOES

4.4.1 Causes of postharvest losses of tomatoes from farmers' viewpoint

The various causes of postharvest losses in the communities were identified and almost all farmers attributed losses to more than one reason (Table 4.16). A total of 144 (80%) of all farmers interviewed attributed the greatest of pre-harvest and postharvest losses of their produce to heavy rains prior to harvest which they attributed to turgidity and subsequent cracking of the tomato. This situation was aggravated by lack of buyers during certain periods of the season

when the rains make roads leading to farms impassable. A total of 71 (79.9%) farmers from the Dormaa Municipal and 55 (61.1%) from the Tano South District believed that losses could be reduced or even eliminated if there were processing facilities within the production areas.

Interestingly,71.1% of farmers of both districts indicated lack of storage facilities did not constitute any major problem to shelf life of tomatoes.

Table 4.16 Farmers' observed causes of postharvest losses in the study area

Farmers' observed causes of postharvest losses	Dormaa Municipal		Tano South District	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Heavy rains	66	73.3	78	86.7
Limited market avenues	31	20.7	49	54.4
Lack of processing facilities	71	78.9	55	61.1
Poor storage technology	15	16.7	26	28.9
Limited alternative uses	41	45.6	32	35.6
Bad roads	21	23.3	51	56.7
Unreliable transport	61	67.8	71	78.9
Limited alternative use of the produce	28	31.1	38	42.2
Drought	62	68.9	41	45.6

4.4.2 Causes of postharvest losses of tomatoes from traders point of view

It was gathered through this study that all 150 (100%) traders had ever experienced losses of their produce and most of the losses were recurrent. In all, 94.1% and 100% respectively for

Dormaa Municipality and Tano South District attributed losses to lack of financial support. This followed by lack of storage facility (78.8% and 73.3%), limited alternative uses of tomatoes (68% and 52%) and bad state of arrival of tomatoes to the market (37.3% and 58.7%). Lack of processing unit was considered the least cause of losses by traders. Drought was also cited as a pre-harvested factor of postharvest losses. Table 4.17 is a summary of traders' response.

Table 4.17 Causes of losses of tomatoes from traders point of view

Cause of losses from traders' observation	Dormaa Municipality		Tano South District	
	Frequency	Percent. (%)	Frequency	Percent. (%)
Lack of ready market	21	28	19	25.3
Lack of means of transport	11	14.6	15	20
Lack of storage facility	59	78.7	55	73.3
Bad state of arrival on market	28	37.3	44	58.7
Bad roads to farms	12	16	66	88
Lack of financial support	71	94.7	75	100
Lack of processing units	14	18.7	18	24
Bad state of conveyer trucks	21	28	44	58.7
Limited alternative uses of produce	51	68	39	52

4.5 PROBLEMS FACED BY TOMATO FARMERS AND TRADERS

4.5.1 Problems faced by farmers

Farmers recounted their problems as lack of credit (91.1% to 95.5%), high costs of inputs (88.9% and 92.2%) and lack of irrigation water near farms (45.6 and 60%) for farmers in the Dormaa Municipality and Tano South Districts, respectively (Table 4.18). Bad access roads and source of irrigation water were the major problems of farmers in the Tano South District (Plate 4.6 and Plate 4.7)

.

Table 4.18 Problems faced by farmers

Problems faced by farmers	Dormaa Municipal		Tano South District	
	Frequency	Percent.(%)	Frequency	Percent.(%)
Lack of credit	82	91.1	86	95.5
High cost of inputs	80	88.9	83	92.2
Poor pricing	46	51.1	30	33.3
High cost of labour	23	25.6	49	54.4
Irrigation problems	41	45.6	54	60
Bad roads	12	13.3	68	75.6
Lack of technical support	23	25.6	64	71.1

Plate 4.6 Road to major tomato producing area at Derma in the Tano South District

Plate 4.7 The 2010 national best tomato farmer collecting water from a stream

4.5.2 Problems faced by Traders

Problems faced by tomato traders included bad access roads to the farms (34% and 76%), unreliable transport (44% and 78%), high cost of transportation (88% and 82%), lack of financial support (92% and 100%) respectively for traders in the Dormaa Municipality and Tano South District. Others included lack of appropriate storage facilities and lack of preservation technological knowhow for tomato preservation.

4.6 SUBSTITUTES AND ALTERNATIVE USES OF TOMATO

All consumers interviewed consumed tomato in one form or the other. Eighteen (18) consumers, representing 12% responded positively to knowing a substitute for the vegetable. These included ripe fruits of the *Solanum torvum* and spices such as the Maggi cube and monosodium glutamate.

On the alternative uses of tomatoes, 6 (4%) consumers mentioned the use of the juice of tomato as an effective jewelry polisher, 12 (8%) claimed it was a good blood clotting agent while 2 (1.3%) indicated that tomato juice is an effective stain remover in fabrics. Other alternative uses of the tomato were given as a shake of tomato puree and malt as a remedy for anaemia (8 or 5.3% of the sampled population) and the use of tomato puree as a skin toning agent (3 or 2%). In all, 114 (76%) had no idea about any alternative use of tomatoes (Table 4.19)

Table 4.19 Alternative uses of tomatoes

Alternative	uses of tomatoes	Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Tomato juice	6	6.0	6.0	6.0
	Tomato Jam	1	1.0	1.0	7.0
	Shining or polishing copper & gold Jewels	12	12.0	12.0	19.0
	Inducing blood clotting	2	2.0	2.0	21.0
	Mixed with malt & taken as a blood tonic	7	7.0	7.0	28.0
	NA	72	72.0	72.0	100.0
	Total	100	100.0	100.0	

CHAPTER FIVE

5.1 DISCUSSION

5.2 SOCIO-ECONOMIC AND SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE STUDY AREA

The study showed that tomato farming is a major occupation of many residents in the Dormaa Municipality and the Tano South District and therefore one of the major sources of income for many families. Supporting tomato farmers in these communities would therefore help boost the rural economy in these areas.

Results of the demographic profile of tomato farmers and traders sampled as shown in Table 4.1 and Table 4.7 respectively indicate that farmers and traders are generally within the years of active life (18-40 years). This was attributed to the fact that work on tomato farms requires a great deal of dedication and energy that cannot be provided by very young and old people. Also, with tomato trading, especially, with the wholesale business, it requires strenuous efforts that goes beyond the capabilities of very young and old people.

5.1.1 Educational level of farmers and traders

The survey showed that there is generally low literacy level among farmers and traders. Although only 3% of all farmers are illiterate, just 16.5% had secondary/high school level of education with the remaining 80.5% with education between these two levels. Farmers and traders in the two areas of the study had basically the same educational level.

Farming and trading require some degree of understanding of some basic principles. For

example, a farmer with low level of education would find it difficult to appreciate the basic principles of production that can have negative postharvest consequences. They may also be unresponsive to the principles underlying perishability of tomatoes which would inform them on steps to take to reduce or prevent losses. Also, they may not strictly adhere to manufacturers' instructions on use of their products culminating in their rampant abuse which is one major cause postharvest losses (Ellis *et al.*, 1998). Kodjogbe *et al*. (2010) described the main causes of postharvest losses to have their root at producer level to the use of local seeds/ auto-propagated seeds, excessive use of fertilizers and pesticides (pesticide residues), poor harvesting practices and poor handling (practices, packaging, etc.) which cause losses during transport and storage.

The low educational level of traders also makes it difficult for them to appreciate and discontinue some practices that constitute bad handling which affects the preservation of the produce.

With about 89 % of the sampled farmer population being male with only 11% of the respondents being female it can be concluded that tomato farming in these communities is male dominated. A similar trend was reported of the Dangme West District of the Greater Accra Region by Tambo and Gbemu (2010) in their survey where, tomato farming is a male dominant activity with the men making up 88% of the respondents sampled. Adoeti *et al.* (2011) also reported that about 92% of market-oriented vegetable producers were males while 8% were females. According to Adoeti *et al.* (2011) this pattern is due more to the culture of the people where men are expected to bring food home and besides, it is believed that vegetable production demands more physical strength that men can provide. In these communities of study, the main reasons were that women could not commit all the time needed to take care of the vegetable from nursery to harvest due to their schedule as housekeepers.

5.3 POSTHARVEST HANDLING OF TOMATOES IN THE STUDY AREA.

Harvesting in the morning has many advantages. From Table 4.11, it can be seen that more farmers from the Dormaa Municipal (44 or 48.9%) harvested their produce in the morning as compared to 31 (34.4%) of farmers from Tano South. However, the study has shown that farmers in the two study areas generally do not pre-arrange market before harvesting and even when they do, they only harvested when traders arrived.

The success of any good postharvest handling method depends largely on the initial ambient conditions the freshly harvested tomato is subjected to. Gould (1992) recommended cold water bath (or pre-cooling under shade) as a method to cool harvested tomato fruit since they are typically harvested during the hot hours of the day. The study showed that farmers in both study areas do not practice pre-cooling of harvested produce before packing fruits into bins, instead, the produce are left in the sun until the harvesting is over for the day. It was evident that farmers generally do not know about the principle of pre-cooling.

Achieving good results in posthavest handling and preservation goes with several factors, including but not limited to the stage of maturity of the produce. This is because at an advanced stage of maturity, the produce is liable to physiologival deterioration. It was observed that, irrespective of the distance to the target market, tomatoes were harvested at the red-ripe state. According to Orzolek *et al.* (2006), tomatoes for the wholesale market are best picked at the mature green to breaker stage to prevent the fruit from becoming overripe during long transportation/shipping and handling and recommend that tomatoes should be left on the vine to ripen if they can be brought to market quickly and in good condition. This practice was not followed in both the districts of the study.

Another factor of concern to the postharvest shelf life of tomatoes is the improper

handling of fruits during harvesting where the fragile produce are poured from head height into boxes. Furthermore, poor nature of the roads lead to these produce being shaken vigorously during transportation (Plate 4.7). These potentially cause mechanical injuries to the produce which then accelerate the rate of respiration and consequent quicker rate of senescence. According to Gould (1992), tomatoes are typically transported in a water flume to minimize damage to the fruit. Such conditioning is not just complex but also very expensive for traders to adopt. Secondly, the wooden bins, which are made too big and too deep are over packed with tomatoes which are already peaked and liable to quick deterioration.

In some cases, harvested tomatoes are left in the hot sun by the roadside by farmers and traders awaiting the conveying trucks, which sometimes take several days to arrive. With no proper storage facilities at the market places and inefficient storage technologies and most of the tomatoes reach the market are smashed and rotten to a certain degree. From the traders' and farmers' experience in both study areas it is evident that the more they handle fresh tomatoes, the more the chances of loss recorded.

It was also observed that some retailers of tomato put their produce in empty big sized tomato cans and sometimes exposed them to the hot sun. These cans which are good heat conductors soon get hot and transfer heat by conduction to the produce and hasten the process of deterioration. As compared to those who sold tomato in plastic containers and baskets, it was realized that tomatoes could keep twice longer.

5.3 PRESERVATION AND PROCESSING METHODS USED IN THE STUDY AREA

The commonest preservation methods used by farmers and traders included spreading the produce of the bare floor with only a few small scale traders storing their produce in

refrigerators. Keeping the produce on the bare floor is basically to reduce the temperature of the produce hence the rate of respiration. Though this method was well known by traders, its low rate of adoption was due to the fact that the farmers and traders do not have enough space in their market stalls for this method. Refrigeration would have been a desired method for preserving tomatoes but, the overhead cost may constitute a good reason for increasing the price of the commodity, which may not be feasible within the culture and economic situation of the study area.

Other preservation methods such as cold water bath and storing in shallow baskets were described by traders in both districts as not always being effective. The FAO and INPhO (1998) explains that tomatoes left in the sun for long do not make good preserves and would not store long. According to Kodjogbe *et al.* (2006), vegetables are highly perishable and experience high losses before they can reach the market and recommend that an improvement and promotion of postharvest technology by the various stakeholders is critical to boost rural economies.

During the survey, it was observed that only a few farmers, traders and consumers knew about dried tomatoes but almost a hundred percent of all respondents knew about either tomato pulp, tomato paste or tomato puree except that their adoption is not commercialized. An FAO and INPhO (1998) recommends the introduction of easy to prepare tomatoes products with longer shelf life and therefore also rural community friendly as a way of boosting the tomato industry in developing Africa.

Almost all the consumers interviewed expressed willingness to patronize locally processed tomato on conditions that they are affordable, gives the needed customer satisfaction and have long shelf life.

5.4 CAUSES OF POSTHARVEST LOSSES OF FRESH TOMATOES

Main causes of losses of tomatoes were attributed to many factors by farmers and traders. Both groups in the study areas considered lack of financial support as the major cause of losses. Bad roads to main production areas deterred drivers of trucks from going to farms. Traders and farmers therefore find it difficult in getting trucks to convey the produce to the market. A delay in conveying the produce to the market makes the produce begin to deteriorate before finally getting to the market. Tomatoes therefore sometimes get to the market already spoilt.

Lack of appropriate storage facilities and storage technology makes it difficult for farmers to prolong the shelf life of their produce. Small market stalls with poor ventilation are not conducive enough for storage of tomatoes and this adds up to the external factors that have already reduced the shelf life of the produce such as injuries and field heat accumulation.

Kodjogbe *et al*. (2006) in a related research in Ghana and Benin gathered that the causes of postharvest losses of fresh vegetables in general include, the use of local or auto-propagated seeds, excessive use of fertilizer, poor irrigation system, poor harvesting practices, supply exceeding demand, handling, i.e. poor transport and storage and insects and fungi. From observation and analysis of data collected and information gathered it can be seen concluded, the causes of postharvest losses of fresh tomatoes are almost the same in all the major tomato growing communities in Ghana in line with the observation made by Kodjogbe *et al.* (2006).

5.5 PROBLEMS FACED BY FARMERS AND TRADERS

Farmer and traders in both districts recounted many problems notable among which was lack of credit facilities from financial institutions. It could be deduced that financial institutions were unwilling to advance credit facilities to farmers and traders due to the uncertainties of the

output and trade dynamics. They would however readily advance such facilities to importers of finished tomato products who flood the market with their products that compete with locally produced fresh tomatoes.

From interaction with farmers, it was noted that inputs such as fertilizer and other agrochemicals were so expensive that they sometimes made only marginal profit or could not break even. This is heightened by poor pricing by traders (at some times of the year) who capitalize on the perishability of the produce and the fact that farmers do not have alternative market avenues.

Having to go very long distances for irrigation water makes it difficult for farmers to irrigate their farms whenever the rains delay or fail. In such situations, they hired trucks at very high costs to supply them water with those who cannot afford looking on for their produce to get destroyed. Lack of technical support on postharvest management of harvested produce is one problem faced by both traders and farmers. Stakeholders mainly seem to focus more attention on production than on postharvest management of the produce. The result is that, farmers are able to improve upon yields more easier than improve upon reduction of postharvest losses. Secondly, whenever there is any postharvest innovation, stakeholders basically seem to focus more attention on the training of farmers and not of traders with whom the product spend most of its unprocessed postharvest shelf life.

5.6 ALTERNATIVE USES OF TOMATOES

Alternative uses here refer to uses other than for cooking. Whereas all respondents knew about the conventional uses of the vegetable in the local cuisine, only a few (38%) knew other alternative uses of tomatoes.

Other interesting alternative uses of the vegetable as given by consumers included the use of tomato juice to polish jewelry and to remove stains in fabrics. Other alternative uses included using the juice as a blood-clotting agent by washing the surface of fresh sores with tomato juice. This claim is however disputed by reputable authors. For example, according to the Online Medical Journal Healthcare Review (2011), British scientists led by Duttaroy have established that eating tomatoes can help prevent airline passengers from developing deep vein thrombosis (DVT), a potentially fatal condition that is characterized by blood clotting which occurs when people sit down for a long period. The research shows that tomato contains a unique chemical, which thins blood. These chemicals are said to be found in the yellow liquid surrounding the tomato seeds and which contain flavonoids, which help prevent heart attack. The use of tomato as a blood-clotting agent is therefore scientifically not proven yet..

Further to this, there was a claim that taking the shake of tomato puree with malt is an effective treatment for anaemia. This claim is however also disputed by research findings. Allsup (2011) reported that in spite of the fact that tomato is rich in iron, an important raw material for blood formation, when trying to overcome anemia, it is best to avoid eating foods with high levels of oxalic acid such as rhubarb, tomatoes, spinach, and chocolate because oxalic acid can interfere with the absorption of iron from non-plant sources. Although the researchers explain that boiling reduces the oxalic acid levels, other researchers have a divergent opinion. Whatever the case may be, tomato has more to offer than just correcting or preventing anaemia.

Lastly, other respondents alluded to the cosmetic property of tomatoes when the skin is masked with tomato puree. This assertion is widespread and yet the cosmetic industry has not fully incorporated tomato as a major ingredient, a demonstration of the fact that the health benefit attained from eating tomatoes outweighs the cosmetic capability of the vegetable

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

The study has shown that tomato production is a very big industry in Tano South and Dormaa Municipal of the Brong Ahafo Region, being the main source of livelihood for many families. It has also shown that the tomato production output of these communities is undoubtedly enormous considering the number of people that are into it as a full time occupation and the assessment of the entire acreage of land under tomato cultivation.

In about 80% of the communities of the study, between 60% - 75% of all adults (mainly male) are into the tomato production business either as farmers, traders or as permanent or casual labourers on tomato farms. This show how vibrant the industry is in these communities especially considering the fact that over 90% of these people are within the ages of active service (18-55). This scenario depicts a well organized workforce whose welfare should be an area of priority in any developing country. It provides grounds for the introduction of supportive programmes to boost the industry and therefore the rural economic and living conditions whiles cutting down on imports and saving foreign exchange for general development.

The tomato industry in the Dormaa Municipality and Tano South Districts of the Brong Ahafo Region of Ghana is one faced with a myriad of problems notable among which is the lack of direction as a rural industry, lack of access to credit facilities in the form of cash and physical inputs, lack of the requisite postharvest handling skills, lack of appropriate processing and storage technologies and poor market.

Many farmers in these communities have not had much benefit (if any at all) from research works and recommendations that may have already been put out by governmental and non-governmental organizations as well as designated state research institutions and the academia.

It is clear from the research that there is a wide gap to fill as far as the dissemination of research findings as well as ensuring its sustainability for example is concerned. This is because many farmers and traders are desirous of creating a profitable venture to hold on to, but this never being realized in spite of their immense potential coupled with the numerous stakeholders who, working together, have the mandate to ensure the growth and development of the rural economy in communities with such socio-economic characteristics as those of these two districts.

This gap is due to the probable lack of coordination between the various stakeholders in the industry. For example, the situation where tomato-processing industries do not buy from local tomato producers because they do not produce processing varieties should not have been the case if there was a proper coordination, between the various stakeholders. The current trend of events need to be reversed to forestall an imminent collapse of the industry which hitherto is not too distant away. Evidence of a gradual collapse of the industry is the massive importation of tomatoes and tomato products into the country from as close as Burkina Faso to as far as Europe, Asia and in fact all over the world as reported by Aryeetey (2010), in spite of the nation's great potential to produce for the local and export market. Until this gap of inefficiency is closed, farmers as well as the government shall not derive the maximum benefit from efforts at the various levels aimed at bettering the rural economy as a means of poverty alleviation, rural development and national development.

The survey also revealed the plethora of nutritional and medicinal properties of tomatoes unknown to almost all the respondents. Tomato's possession of robust antioxidant properties from its constituent phytochemicals which makes it a useful preventative and possible treatment agent for cardiovascular diseases, skin health, eye health, and prostate cancer, osteoporosis and slowing down of the aging process among a host of other need was unknown to almost all the consumers interviewed. Propagating this information is a possible positive way of reinvigorating the industry since it shall help promote tomato and its products, which hitherto would not have attracted much consumer attention. However, no matter the publicity given to tomato and its products, if there is no effort by the major stakeholders to help tomato farmers and traders with the requisite financial, technical and logistical support as well as establishing or helping establish and promoting community based processing facilities nothing significant can be achieved.

6.2 RECOMMENDATIONS

The results of the study showed that the tomato industry in the Tano South and Dormaa Municipal is constrained by a combination of factors that are social, economic, technological in nature. There is the need for further research work to be conducted in the following areas to ensure effective and sustainable tomato production industry as a way of developing the rural economy of the study area and other communities with similar socio-economic backgrounds.

These include:

(i) Research into and introduction of inexpensive, unsophisticated but efficient small scale tomato processing methods

(ii) Introduction of cheap but appropriate postharvest handling and preservation

methods of tomatoes for farmers and traders.

(iii) Introduction and promotion of non-traditional tomato products into the Ghanaian homes to encourage an increase in the consumption of the produce.

(iv) Introduction of appropriate methods for reducing mechanical injury to tomatoes during harvest.

(v) Research into and introduction of effective methods of transporting the produce from the farm to the market

(vii) introduction and promotion of tomato juice to help as an alternative use of tomato.

REFERENCES

Ablorh-Odjidia, E. (2003). From Pwalugu to Cancun: Toward fair agricultural trade policies. Modern Ghana, September 29.Pp 1-23

Adeoti, A.I., Oladele, O.I. and Cofie, O. (2011). Sustainability of livelihoods through Urban Agriculture: Gender dimensions in Accra, Ghana. Life Sc. Journal, 2011; 8(2). Pp 944.

Adubofuor, J. E., Amankwah, A., Arthur, B. S. and Appiah, F. (2010). Comparative study related to physico-chemical properties and sensory qualities of tomato juice and cocktail juice produced from oranges, tomatoes and carrots. African Journal of Food Science Vol. 4(7), pp. 427 – 433.

Alam, T., Tanweer, G. and Goyal, G.K. (2007). Stewart Postharvest Review, Packaging and storage of tomato puree and paste. Research article, Volume 3, Number 5, October 2007, pp. 1-8(8). Publisher: Stewart Postharvest Solutions. DOI: 10.2212/spr.2007.5.1

Allsup, A. D. (2011). Anemia sufferers - Improve your absorption of iron. Article Published by: Truth Publishing International, LTD. http://www.naturalnews.com/033078_anemia_iron.html . Accessed on July 28,2011. 3:44pm GMT.

Ames, B.M., Shigena, M.K., Hagen, T.M. (1983). Oxidants, antioxidants and the degenerative diseases. Science 221:1256-1263

Arab, L., Steck-Scott, S., Fleishauer, A.T. (2002). Lycopene and the lung. Exp Biol Med (Maywood). Vol.227(10). Pp: 894-9.

Aryeetey, E. (2006). ISSER-Merchant Bank Development Seminar Series. Ghanaweb. (Online) http://www.ghanaweb.com/GhanaHomePage/election2008/artikel.php?ID=101256. Accessed: 12 April, 2011. 11:6am GMT

Ashby, H. (2000). Protecting Perishable Foods during Transport by Truck. Transportation and

Marketing Programs. USDA Handbook No. 669. Pp 1-

Bani, R. J., Josiah, M. N. and Kra, E. Y. (2006). Postharvest Losses of Tomatoes in Transit. Agric Mech Asia Afr Lat Am. Journal Code: S0084B. Vol.37: NO.2. Pp.84-86

Barceloux, D. G. (2009-06). (Potatoes, Tomatoes and Solanine Toxicity (Solanum tuberosum, L., Solanum lycopersicum L.). Disease-a-Month 55 (6): Pp. 391- 402.

Barceloux, D. G. (2008). (Potatoes, Tomatoes and Solanine Toxicity (Solanum tuberosum, L., Solanum lycopersicum L.) pp. 77-83. Published by Elsevier Inc. in: Barceloux DG. Medical Toxicology of Natural Substances: Foods, Fungi, Medicinal Herbs, Toxic Plants, and Venomous Animals. Hoboken, NJ: John Wiley & Sons.

Beecher, B. R. (1998). Nutrient content of tomatoes and tomato products. National Center for Biotechnology Information, U.S. National Library of Medicine. (Online) http://www.ncbi.nlm.nih.gov/pubmed/9605204. 09/11/2010. 9:25pm GMT. Accessed: March 3, 2011. 12:23pm GMT

Benefits and Uses of Tomato.(2011)(Online) http://www.online-familydoctor.com/fruits/tomato.html Accessed: 10th January, 2011. 11:04pm

Bradley, K. L. (2003). Tomatoes in the Desert Garden. Horticultural News & Research Journal. Published: The Univ. of Arizona Press

Campbell, J.K., Canene-Adams,K., Lindshield, B.L., Boileau, T.W., Clinton, S.K., Erdman, J.W. Jr. (2004).Tomato phytochemicals and prostate cancer risk. Am J Nutr. Vol. 134(12 Suppl):3486S-3492S

Challem, J. (1999). Good pill hunting. Modern Maturity May-June:62-63

Clottey, V.A., Karbo, N. and Gyasi, K. (2009). The tomato industry in Northern Ghana:

production constraints and strategies to improve competitiveness. A Report Article Published by: African Journal of Food, Agriculture, Nutrition and Development. Geographic Code:

Cox, S. E. (2001). Lycopene analysis and horticultural attributes of tomatoes. MSc. Thesis. Univ. of Colorado. Pp iv – 133.

Cox, S. E. (2001). Lycopene analysis and horticultural attributes of tomatoes.Thesis in partial fulfillment of the requirements for the Degree of Master of Science. Colorado State Univ. pp: v-ix

Cox, S. E. (2000). History of the Tomato. I Say Tomayto, You Say Tomahto...Article. (Online) http://www.landscapeimagery.com/articles.html. April 10, 2011. 9:54pm GMT. Accessed: March 14, 2011.

Cucina,T. R. (2005). The most expensive tomatoes in the world. (Online) http://cucinatestarossa.blogs.com/weblog/2005/03/the_most_expens.html Accessed: May 11, 2011. 12:43am GMT

D'Sousa, M.C. and M, Ingle. (1989). Effect of delayed cooling on the post storage flesh firmness of apples. J. Food Sci. Vol. 54: Pp 493-494.

Danso, G., Cofie, O., Annang, L., Obuobie, E. and Keraita, B. (2004). Gender and Urban Agriculture: The case of Accra, Ghana. Paper presented at the RUAF/IWMI/ Urban Harvest Woman Feeding Cities Workshop on Gender Main streaming in Urban Food Production and Food Security. 20-23 September 2004. Accra, Ghana.

Di Mascio, P., Kaiser, S. and Sies, H. (1989). Lycopene as the most efficient biological carotenoid singlet oxygen quencher. Arch. Bichem. Biophys. 274(2):Pp 532-538.

Dillard, H. and Reiners, S. (2010). Diagnosing Tomato Problems. Univ. of Cornell. Coll. of

Agric & Life Sci. New York State Agric. Experiment Station Bulletin (1885-1970): [961]

Doll, R. (1990). An overview of the epidemiological evidence linking diet and cancer. Proc. Nutr. Soc. Vol. 49:119-131

Dragstead, L.O., Strube, M., Larsen, J.C. (1993). Cancer-protective factors in fruits and vegetables: biochemical and biological background. Pharmacol. Toxicology 72 (Suppl 1):116-135.

Dumas, Y., Dadomo, M., Di Lucca, G. and Grolier, P. (2003). Effects of environmental factors and agricultural techniques on antioxidant content of tomatoes. J. Sci. Food Agric. 83:369-382

Eckert, J.L. and Eaks, I.L. (1989). Postharvest disorders and diseases of citrus fruits. In: The Citrus Industry., W. Ruther et al. (eds) Vol. 5: Pp 179-260. Univ. Calif. DANR Pub. No. 3326.

Edlin, D. J. (2009). Heirloom and Hybrid Tomato Yield and Quality in Organic and Conventional Production Systems" Masters Theses & Specialist Projects. Paper 135. (Online): http://digitalcommons.wku.edu/theses/135
Accessed: March 29, 2011. 3:18pm GMT

Ellis, W.O., Olympio, N.S., Mensah, E. P., Adu-Amankwa, A., Tetteh,Y. (1998). Postharvest problems of tomato production in Ghana - Field studies of some selected major growing areas in Ghana. Journal of the Ghana science association volume 1 number 1, July (1998) pp. 55-59. ISSN: 0855-3823

Engelhard, Y.N., Gazer, B. and Paran, E. (2006). Natural antioxidants from tomato extract reduce blood pressure in patients with grade-1 hypertension: a double-blind, placebo-controlled pilot study. Am Heart J. Vol:151(1). Pp:100.

Etminan M, Takkouche B, & Caamano-Isorna F (2004). The role of tomato products and lycopene in the prevention of prostate cancer: a meta-analysis of observational studies. Cancer Epidemiol Biomarkers Prev 13, 340-345

FAO (2011). Vegetations Types of Ghana. (Online) http://www.fao.org/ag/AGP/agpc/doc/Counprof/Ghana/ghanaveg.htm. Accessed June 6, 2011. 10:54am GMT

FAO and INPhO (1998). Fruit and vegetable processing. Methods for tomato preservation. Infonet-biovision. (Online) http://www.infonetbiovision.org/default/ct/216/farmPlanningAndMarketing#1081 Accessed: 21st February 2011. 9:18pm GMT.

Filippone, P.T. (2006). Tomato and Health. From: (Heinz Institute of Nutritional Sciences, 1998). http://homecooking.about.com/od/foodhealthinformation/a/tomatohealth.htm. 10/11/2010. 12:26pm GMT. (Online). Accessed: June 6, 2011. 11:50am GMT

Food and Agriculture Organization (2008). FAOSTAT. http://faostat.fao.org. (Online) Accessed May 27, 2011, 1:02pm GMT).

Food and Agriculture Organization (2008)[2]. Basic Harvest and Post-harvest Handling Considerations for Fresh Fruits and Vegetables. Postharvest Training CDRom on Food Processing/FAO manual food handling and preservation/CHAPTER 2

Freshplaza.com (2008). Ghana: Boost for tomato production. (Online) http://www.freshplaza.com/news_detail.asp?id=13782. Accessed: March 3, 2011. 9:50pm GMT.

Gandhi, R. V., Hanchinal, S. N., Shivamurthy, M. and Hittalmani, S. (2008). Adoption of

Integrated Pest Management Practices among Tomato Growers. Karnataka J. Agric. Sci., 21 (1). Pp 17-19.

Garmyn, M., Ribaya-Mercado, J.D., Russel, R.M., Bhawan, J., Gilchrest, B.A. (1995). Skin lycopene is destroyed preferentially over beta-carotene during irradiation in humans. Exp Dermatol. Vol. 4(2). Pp: 104-11.

Gey, K.F. (1990). The antioxidant hypothesis of cardiovascular disease: Epidemiology and mechanisms. Biochem. Soc. Trans. 18:1041-1045

Ghanaweb.com, (2010). Ghana -2nd Largest Importer of tin tomato). Business News of Monday, 20 March 2006. Source: Public Agenda. (Online) http://www.ghanaweb.com/GhanaHomePage/election2008/artikel.php?ID=101256, 09/09/2010, 12:35amGMT. Accessed: March 3, 2011 11:14pm GMT

Giovannucci, E. (1999). Tomatoes, tomato-based products, lycopene, and prostate cancer: Review of the epidemiologic literature. J. Natl. Cancer Inst. 91:317-331.

Giovannucci, E., Rimm, E. B., Liu, Y., Stampfer, M. J. and Willett, W. C. (2002). A prospective study of tomato products, lycopene, and prostate cancer risk. J. Natl. Cancer Inst. 94:391-398

Giovannucci, E. (2002). A Review of Epidemiologic Studies of Tomatoes, Lycopene, and Prostate Cancer. Exp. Biol. Med. Vol. 227 Number 10. Pp: 852-859

Gould, W. A. (1992). Tomato production, processing and technology. Third edition, Woodhead Publishing Limited. Pp 2-158.

Gross, M.D. and Snowdon, D.A. (2001). Plasma lycopene and longevity: findings from the Nun Study. FASEB Journal VOL 15. NO.4. Federation of American Societies for Experimental Biology. Pp. A400.

Hanson, P., Chen, J.T., Kuo, C.G., Morris, R., and Opeña, R.T. (2001). Seed Production of Open-Pollinated Tomato Lines. International Cooperators Guide. AVRDC pub # 01-52

Hanson, P., Chen, J.T., Kuo, C.G., Morris, R., and Opeña, R.T. (2001). Suggested Cultural Practices for Tomato. AVRDC Extension Material. AVRDC pub # 1-52

Harvey, J.M. and Harris, C.M. (1986). In-storage softening of kiwifruit: effects of delayed cooling. Int. J. Refrig. Vol. 9: Pp 352-355.

Heber, D. and Lu, Q.Y. (2002). Overview of mechanisms of action of lycopene. Exp Biol Med (Maywood). Vol.227(10). Pp: 920-3

Herzog, A., Siler, U., Spitzer, V., Seifert, N., Denelavas, A., Hunziker, P.B., Hunziker, W., Goralczyk, R. and Wertz, K. (2005). Lycopene reduced gene expression of steroid targets and inflammatory markers in normal rat prostate. FASEB Journal 19. Express article 10. Pp 272-274

Honglei, S., Agarwal, S. and Rao, A.V. (2001). Lycopene Content of Tomato Products: Its Stability, Bioavailability and In Vivo Antioxidant Properties. Journal of Medicinal Food. Published in Vol. 4 Number 1. Published by Mary Ann Liebet Inc.

Hurst, W. C. (2010). Harvest, Handling and Sanitation Commercial Tomato Production Handbook B 1312. CAES Publications.Univ. of Georgia. (Online) http://www.caes.uga.edu/publications/pubDetail.cfm?pk_id=7470. Accessed: May 2, 2011. 1:08am GMT

Hurst, W. C., Reynolds, A. E., Schuler, A. G. & Christian, J. A. (1993). Maintaining Food Quality in Storage. Cooperative Extension Service Bulletin 914. Univ. of Georgia College of Agric & Env. Sc. (Postharvest Training CDRom/Food Processing/Food processing/ Food quality storage).

Ibitoye, D.O., Akin-Idowu, P.E. and Ademoyegu, O.T. (2009). Agronomic and Lycopene Evaluation in Tomato (*Lycopersicon lycopersicum* Mill.) As a Function of Genotype. World Jour. of Agricultural Sciences 5 (S): 892-895. IDOSI Publication. ISSN 1817-304

Jaiteh, F. (2010). Screening tomato (Solanum lycopersicum l.) genotypes for resistance to root-knot nematodes (Meloidogyne species). MSc. Thesis, KNUST.

Jensen, L. and Shock, C. (2009). Common Tomato Varieties. US Dept. of Agric & Oregon State Ext. Serv. Oregon State Univ. (Online) http://www.cropinfo.net/CommonTomatoVarietiesApril2010.pdf. Accessed:April 14, 2011. 14:15pm GMT.

Keith, R. E. (1999). Antioxidants and Health. Pp: 1-4. Pub: Alabama Cooperative Extension System Pub ID: HE-0778

Khachik, F., Beecher, G. and Smith, J.C. Jr. (1995). Lutein, lycopene, and their oxidative metabolites in chemoprevention of cancer. J Cell Biochem (Suppl 22):236–246

Khor, M. (2006). The Impact of Globalization and Liberalization on Agriculture and small farmers in Developing Countries: The experience of Ghana. Pp. 32-38. ICCO Utrecht, Ned.

Kitinoja, L. and Gorny, J. (2009)[1]. Storage Practices and Structures. Postharvest Technology for Fruit & Vegetable Produce Marketers. Chapter 7.Pp 1.1 – 20.6

Kitinoja, L. (2004)[1]. Small-Scale Marketing Strategies Manual. UC PTRIC Hort Series No. 21.

Pp. 1-8.

Kitinoja, L. (2008)[2]. Causes and Sources of Postharvest Problems. Postharvest Training CDRom\Sample Presentations. From Ghana. Pp 1 -19.

Knapp, S., Bohs, L., Nee, M., Spooner, D.M. (2004). Solanaceae-a model for linking genomics with biodiversity. Comp. Funct. Genom. 5, 285–291.

Knekt, P., Kumpulainen, J., Järvinen, R., Rissanen, H., Heliövaara, M., Reunanen, A., Hakulinen, T. and Aromaa, A. (2002). Flavonoid intake and risk of chronic diseases. Am J Clin Nutr. Vol. 76(3).Pp:560-8.

Kodjogbe, G., Pali, C., Agyemang, N. F., Asamoah, M., Kouame, C., Batchep, R., Gnonlonfin, B., Hell, K., and Coulibaly, O. (2006). A commodity system analysis to reduce postharvest losses of vegetable. AVRDC. Pp 2-20.

Kodjogbe, G., Pali, C., Agyemang, N. F., Asamoah, M., Kouame, C., Gnonlonfin, B., Hell, K., and Coulibaly, O. (2010). A commodity system analysis to reduce postharvest losses of vegetable. AVRDC. Pp 20.

Kotey, D.A., Gbewonyo, S. K. and Afreh-Nuamah, K. (2008). High Chlorpyrifos levels on vegetables in Ghana. Pesticides News 80

Kybal, J. (1993). Plantas Aromaticas y Culinarias (Madrid Susaeta, 1993), 122: Simon Varey, Rafael Chabrań, Dora B. Weiner (2000). Searching for the secrets of nature: the life and works of Dr. Francisco Hernandez. Published by Stanford University Press. Pp 167.

Lewis, K. (2007). All about Tomatoes. Backyard Gardening Jalic Inc. 2005-201. (Online) http://www.backyardgardening.net/article/tomatoes-profile/
Accessed: May 18, 2011. 12:16pm GMT

Liebenow, J.G. (1986). African Politics: Crises and Challenges. Indiana University Press,

Bloomington, INC

Lindshield, B.L., Canene-Adams, K., and Erdman, J.W. Jr. (2006). Lycopenoids: Are lycopene metabolites bioactive? Arch. Bichem. Biophys .Volume 458, Issue 2. Pages 136-140. Pub: Elsevier Inc.

Male, C.J. (1999). 100 heirloom tomatoes for the American gardener. Workman, N.Y.

Mari, J.F. and Knottnerus, R. (2007). The struggle of tomato farmers in Northern Ghana. ICCO and EED.

Matsushima, N.R., Shidoji,Y., Nishiwaki, S., Yamada, T., Moriwaki, H. and Muto, Y. (1995). Suppression by carotenoids of microcystin-induced morphological changes in mouse hepatocytes. Lipids Vol. 30, Number 11. Pp 1029-1034, DOI: 10.1007/BF02536288. AOCS Press.

MoFAIR Centre, (2008). Production Guide For Tomato. Ministry Of Food And Agriculture Information Resource Centre, Accra-Ghana. (Online) http://www.mofaircentre.info/production-guide-for-tomato/ Accessed"19th May 2011. 10:23pm GMT.

Mrema, C. G. and Rolle, S. R. (2002). Status of the postharvest sector and its contribution to agricultural development and economic growth. 9th JIRCAS International Symposium – Value Addition to Agricultural Product, pp. 13-20

Naika, N., van Lidt de Jeude, J., de Goffau, M., Hilmi, M. and van Dam, B. (2009). Cultivation of tomato, production, processing and marketing. Agrodok-series No. 17

Nicola, S., Tibaldi, G. and Fontana, E. (2009). Tomato production systems and their application to the tropics. Acta Hort. (ISHS) 821: pp. 27-33.

Nkondjock., A, Ghadirian, P., Johnson, K.C., Krewski, D. (2005). Dietary intake of lycopene is

associated with reduced pancreatic cancer risk. J Nutr. Vol:135(3). Pp: 592-7

Online etymology dictionary, (2001). © 2001-2010 Douglas Harper. (Online) http://www.etymonline.com/index.php?term=tomato. Accessed: 17/03/2011. 11:06pm

Online-familydoctor.com (2011). Benefits and Uses of Tomato (Online) http://www.online-familydoctor.com/fruits/tomato.html Assessed: 10th January, 2011. 11:04pm

Orzolek, M.D., Bogash, M.S., Harsh, M. R., Lynn, F., Kime, L.F.,Jayson, K., Harper, J.K. (2006). Tomato Production. Agricultural Alternatives Pub. Code # UA291. Pp. 2-3.

Paran, I. and van der Knaap, E. (2007). Genetic and molecular regulation of fruit and plant domestication traits in tomato and pepper. J. Exp. Bot. (2007) 58 (14): 3841-3852.doi: 10.1093/jxb/erm257. Oxford journals.

Pio, F.Q. (1980). Plantas medicinales: El Dioscorides Renovado 8th Ed. (Barcelona: Labour, 1980), pp. 588: Simon Varey, Rafael Chabrań, Dora B. Weiner (2000). Searching for the secrets of nature: the life and works of Dr. Francisco Hernandez. Published by Stanford University Press. Pp 167.

Plants with Phytochemicals. Property of Top Cultures and Protected by Belgian and international copyright laws. http://www.phytochemicals.info/plants/tomato.php. Monday, February 28, 2011, 9:44PM GMT.

Poulter, N. (1998). Crop Post-Harvest Programme Annual Report 1997/98. Natural Resources International Limited: Chatham, UK. FIND ON POSTHARVEST IN GHANA DOC.

Rao, L.G., Mackinnon, E.S., Josse, R.G., Murray, T.M., Strauss, A. and Rao, A.V. (2007). Lycopene consumption decreases oxidative stress and bone resorption markers in postmenopausal women. Osteoporosis Int. Vol.18 (1). Pp: 109-15.

Reader, L. (2003). Tomatoes in the Desert Garden. Univ. of Arizona Coop. Ext. Master Gardener

Journal. Pub. Maricopa County Master Gardeners. (Online) http://ag.arizona.edu/maricopa/garden/html/pubs/0103/bountiful.html Accessed: 18th April, 2011.

Relf, D., McDaniel, A. and Morse, R. (2009). Tomatoes. Virginia Cooperative Extension Publication 426-381.

Rick,C.M. (1995). Tomato. In: J Smartt and NW Simmonds (eds), Evolution of Crop Plants. Longman Scientific and Technical, Essex, England. pp 452-457

Riso, P., Visioli, F., Grande, S., Guarnieri, S., Gardana, C., Simonetti, P., Porrini, M. (2006). Effect of a tomato-based drink on markers of inflammation, immunomodulation, and oxidative stress. J Agric Food Chem. Vol. 5;54(7). Pp: 2563-6.

Robbins, J. and Moore, P. P. (1992). Fruit quality of stored fresh red raspberries after a delay in cooling.HortTechnology, Vol. 2(4):Pp468-470.

Robinson, J. Z. E. and Kolavalli, S. L. (2010). The Case of Tomato in Ghana – Marketing. (International Food Policy Research Institute - IFPRI). (Online) http://www.ifpri.org/publication/case-tomato-ghana-marketing. 09/11/2010. 09:44am Accessed: March 9, 2011.

Robinson, J.Z.E. and Kolavalli, L. S. (2010)[1]. The Case of Tomato in Ghana: Processing. Working Paper # 21. Development and Strategy Governance Division, IFPRI, Accra, Ghana: Ghana Strategy Support Program (GSSP) GSSP. Pp: 1-10.

Robinson, J.Z.E. and Kolavalli, L. S. (2010)[2]. The Case of Tomato in Ghana: Productivity. Working Paper # 19. Development and Strategy Governance Division, IFPRI,Accra, Ghana: Ghana Strategy Support Program (GSSP) GSSP. Pp: 1-9.

Robinson,J.Z.E. and Kolavalli, L.S. (2010)[3]. The Case of Tomato in Ghana: Institutional

Support. GSSP Working Paper No. 22. Development and Strategy Governance Division, IFPRI, Accra, Ghana: Ghana Strategy Support Program (GSSP) GSSP. Pp: 1-6.

Rost, L. T. (1996). Tomato anatomy. Leaf anatomy. Univ. of California Davis. (Online) http:/wwwpld.ucdavies.edu/labs/rost/tomato/Reproductive/flranat.html. Accessed:, 2011. 11:39 GMT.

Sacco, A. (2008). Genetic Mechanisms underlying Tomato Quality Traits. Università Degli Studi Di Napoli Federico II. Pp. 1 – 16

Sarah, J., Laurie, H., and Dale, T. L. (2008). Selecting Tomatoes for the Home Garden. Published by University of Nebraska – Lincoln Extension, Institute of Agriculture and Natural Resources. (online). http://elkhorn.unl.edu/epublic/pages/publicationD.jsp?publicationId=1029. June 2008, 11:33 GMT. Accessed: June 1, 2011.

Sciencenewsline medicine. (August 31, 2010). Three hundred years of history in a tomato. University of Leicester. (Online) http://www.sciencenewsline.com/medicine/2010083100003915.html#. 01/02/2011. 09:14PM GMT. Accessed: May 3, 2011.

Sesso, H.D, Liu, S., Gaziano, J.M., Buring J.E. (2003). Dietary lycopene, tomato-based food products and cardiovascular disease in women. Am J Clin Nutr. Vol;133(7). Pp: 2336-41.

Sharma, J.B., Kumar, A., Kumar. A., Malhotra, M., Arora, R., Prasad, S. and Batra S. (2003). Effect of lycopene on pre-eclampsia and intra-uterine growth retardation in primigravidas. Int J Gynaecol Obstet. Vol. 81(3). Pp: 257-62.

Siler, U., Barella, L., Spitzer, V., Schnorr, J., Lein, M., Goralczyk, R. and Wertz, K. (2004). Lycopene and vitamin E interfere with autocrine/paracrine loops in the Dunning prostate cancer model. FASEB Journal 18. Pp: 1019-1021.

Srinivasan, R. (Ed.) (2010). Safer tomato production methods: A field guide for soil fertility and

pest management. AVRDC – The World Vegetable Centre, Shanhua, Taiwan. AVDRC Publication No. 10 – 740. Pp 2 - 97.

Sun, T., Simon, P.W., Tanumihardjo, S.A. (2009). Antioxidants and Antioxidant Capacity of Biofortified Carrots (Daucus Carota, L.) of Various Colors. USDA Journal of Agricultural and Food Chemistry. Vol. 57(10):Pp4142-4147.

Tambo, J.A. and Gbemu, T. (2010). Resource-use Efficiency in Tomato Production in the Dangme West District, Ghana. Conference on International Research on Food Security, Natural Resource Management and Rural Development. Tropentag, ETH Zurich,Swzld.

The Market Corner Newsletter of the Berkeley Farmers' Market (2005). Ecology center. (Online). http://www.ecologycenter.org/bfm/newsletters/200508.pdf
Accessed: April 2, 2011. 9:44pm GMT.

The Vertical Portal for China Business Intelligence (2010). China Tomato Products Industry Report, 2009-2010.(Online)
http://www.researchinchina.com/Htmls/Report/2010/5896.html.
Accesed: July 6, 2011. 8:55PM GMT.

Tigchelaar, E.C. (1986). Tomato Breeding, p 135- 171. In Breeding of Vegetable Crops, M. Bassett (ed.). AVI Publishing Company, INC. 584 p.

Trinklein, D. H. (2010). Growing Home Garden Tomatoes. Pub: Univ. of Missouri Extension. Publication No. G6461. (Online)
http://extension.missouri.edu/publications/displaypub.aspx?p=g6461
Accessed:July 06, 2011. 11: 12PM GMT.

Twumasi-Ankrah, K. (1995). Rural-Urban Migration and Socioeconomic Development in Ghana: Some Discussions. Journal of Social Development in Africa (1995), 10, 2, 13-22.

Uhrman, B., Elis, A. and Aviram, M. (1997). Hypocholesterolemic effect of lycopene and ß-carotene is related to suppression of cholesterol synthesis and augmentation of LDL receptor activity in macrophages. Biochem Biophys Res Commun 233. Pp: 658–662.

USDA National Nutrient Database for Standard Reference, (2008). (Online) http://nutritiondata.self.com/facts/vegetables-and-vegetable-products/2682/2, 04/11/2010. 6:15pm GMT. Accessed: June 3, 2011

USDA National Nutrient Database for Standard Reference (2010). SR23 - Reports by Single Nutrients. Release # 23. Pp 1-26. US Dept. of Agric. Agric. Research Service.

van der Hoeven, R. S., Ronning, C., Giovannoni, J. J., Martin, G. and Tanksley, S. D.(2002). Deductions about the number, organization, and evolution of genes in the tomato genome based on analysis of a large expressed sequence tag collection and selective genomic sequencing. The Plant Cell 14, pp. 1441–1456.

Vavrina, S. C., Armbrester, K. and Pena, M. (2003). Growing Heirloom Tomato varieties in Southwest Florida. Univ. of Florida IFAS Ext. Publication #HS921.

Vegetable Gardener (2009). How to Grow Beefsteak Tomatoes. Kitchen Gardener Magazine, archive. The Taunton Press. (Online) http://www.vegetablegardener.com/item/3583/how-to-grow-beefsteak-tomatoes Accessed: April 4, 2011

Villareal, R. L. (1980). Tomatoes in the tropics. pp. xvii + 174pp. Publisher: Bowker Publishing Company. ISBN 0- 0-89158-989-9.

Watson, B. (1996). Taylors Guide to Heirloom Vegetables. Houghton Mifflin Co., New York, New York. Pp. 343.

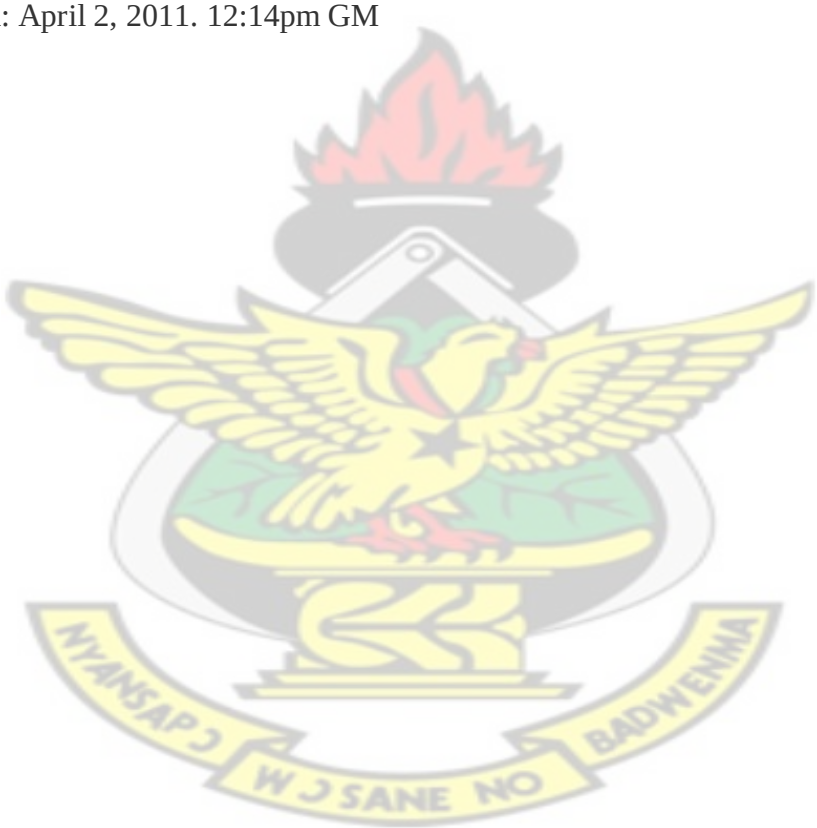
Webster's Revised Unabridged Dictionary (1913). Publishers: Oxford University Press. (Online)

(http://www.dictionary.net/tomato) 27/December, 2010. 11:17PM GMT. Accessed: May 7, 2011.

Willett, C.W. (1994). Diet and Health: What should we eat? Science 264: 532-537

World Resources Institute (1998). Disappearing Food: How Big are Postharvest Losses?. EarthTrends.

Worldatlas.com (2011).World Map, South America, Peru. (Online) http://www.worldatlas.com/webimage/countrys/samerica/pe.htm. Accessed: April 2, 2011. 12:14pm GM



APPENDICES

APPENDIX I

FARMERS REASONS FOR CHOICE OF TOMATOES CULTIVATED

DORMAA MUNICIPALITY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	good market	46	51.1	51.1	51.1
	High yield	18	20.0	20.0	71.1
	Land Characteristics	12	13.3	13.3	84.4
	Longer shelf life	4	4.4	4.4	88.9
	NA	10	11.1	11.1	100.0
	Total	90	100.0	100.0	

TANO SOUTH DISTRICT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	good market	41	45.6	45.6	45.6
	High yield	26	28.9	28.9	74.5
	Land characteristics	3	3.3	3.3	77.8
	Longer shelf life	16	17.8	17.8	95.6
	NA	4	4.4	4.4	100.0
	Total	90	100.0	100.0	

SINGLE MOST IMPORTANT CAUSES OF LOSSES FROM TRADERS POINT OF VIEW

DORMAA MUNICIPAL

	Frequency	Percent
Lack of ready market	21	28.0
Lack of storage facility	43	57.3
Lack of postharvest management skills	11	14.7
Total	75	100.0

TANO SOUTH DISTRICT

	Frequency	Percent
Lack of ready market	14	18.6
Lack of storage facility	39	52
Lack of postharvest management skills	22	22.7
Total	75	100.0

APPENDICES

APPENDIX III

SOME SLIDES FROM THE FIELD

Tomato fruits damaged by drought

Yawbofourkrom, a major tomato production community in the Dormaa Municipality

APPENDIX III (CONTINUED)

Thirty two acre farm of 2010 National Best Tomato farmer with no storage facility

A retail tomato trader displaying her produce in the sun

APPENDICES

APPENDIX IV

SAMPLE OF QUESTIONNAIRE ADMINISTERED DURING THE SURVEY

SECTION A–DEMOGRAPHY (FARMERS AND TRADERS ONLY)

Please tick [√] where applicable

1. Age range:

Below 18 years [ ] Between 18 – 24 years [ ] Between 25 – 40 years [ ]

Between 41 -55 years [ ] Above 55 years [ ]

2. Sex: Male [ ] / Female [ ]

3. Nationality: Ghanaian [ ] / Non Ghanaian [ ]

If a Non Ghanaian

i. Please state your nationality and number of years you have stayed in Ghana.

……

ii. Is farming the main driving force that brought you to Ghana?

Yes [ ] / No [ ]

4. Location / Region: Dormaa [ ] / Tano North [ ]

5. Marital status? Married [ ] Divorced [ ] Widowed [ ] Separated [ ]

Living with other [ ] Single [ ]

6. Do you have children? Yes [ ] / No [ ]

7. If "Yes", how many are they?

Between 1 – 3 [ ] Between 4 – 6 [ ] Above 6 [ ]

APPENDIX IV (CONTINUED)

8. Are they in school? Yes [ ] / No [ ]

9. If "No" which of the following is / are your reason(s)?

Financial [ ] Support on farm [ ] Religious [ ]

Other [ ] (Please specify) ……..

EDUCATIONAL BACKGROUND

10. What is your level of education?

None [ ] Primary [ ] JHS/JSS[ ] Middle school [ ] Secondary [ ]

Technical/ Vocational/ Technical [ ] Certificate [ ]

Diploma/ Degree [ ] Other [ ] (Please specify)……

SECTION B – QUESTIONS FOR FARMERS ONLY

11. How long have you been farming?

1 – 5 years [ ] 6 – 10 years [ ] 10 – 15 years [ ] Above 16 years [ ]

12. How would you describe your farming activity?

Subsistent [ ] Small scale [ ] Medium scale [ ] Large scale [ ]

13. Is tomato the only crop you cultivate? Yes [ ] / No [ ]

14. If "No", is tomato the major crop you cultivate? Yes [ ] / No [ ]

15. What other vegetable crops do you cultivate?

Lettuce [ ] Cabbage [ ] Beans [ ] Pepper [ ] Green Pepper [ ]

Eggplant [ ] Others [ ] (Please specify)……

16. What tomato variety / varieties do you cultivate?

…….

APPENDIX IV (CONTINUED)

17. Is there any special reason for your choice of variety? Yes [ ] / No

18. Can you share it with us?

……

19. Do you keep records on your farming activity? Yes [ ] / No [ ]

20. How would you describe your output in tomato production over the years?

Stagnant [ ] Fluctuating [ ] Decreasing [ ] Increasing [ ]

NB. (If your answer was (c), please continue from Q. 22)

21. If your answer to Q. 18 is 'a', 'b' or 'c', what do you think accounts for this?

Lack of financial support [ ] Lack of technical support [ ]

Unwilling to expand [ ] Poor market for produce [ ]

Other [ ] (Please specify)……...

22. What do you think accounted for that

Good production practices [ ] Financial support [ ] Technical support [ ]

Good market [ ] Minimal postharvest losses [ ]

Other [ ] (Please specify)……...

23. Which of the following challenges do tomato farmers face in your community?

Lack of storage facilities [ ] Lack of financial support [ ]

Lack of technical support [ ] Lack of ready market [ ]

Unreliable transport system [ ] High cost of production [ ]

Low pricing [ ]

Other [ ] (Please specify)…….....

24. Do you get any form of support to help improve on production?

APPENDIX IV (CONTINUED)

25. Yes [ ] / No [ ]

26. What form of support do you usually get?

Financial [ ] Subsidy of farm equipments [ ] Technical [ ]

Free farm equipments [ ] Free Agrochemical supply [ ] Subsidy on agrochemicals [ ] Other [ ] (Please specify)…….

27. Would you describe this support as useful / beneficial to farmers?

Yes [ ] / No [ ]

28. Is there a ready market for your produce? Yes [ ] / No [ ]

29. Are you usually able to store your produce to prevent / reduce spoilage?

Yes [ ] / No [ ]

30. If "Yes", did you acquire this knowledge through a special training in storage?

Yes [ ] / No [ ]

31. Where did you get this training?

School [ ] Farmer's forum [ ] MOFA farmers' field day [ ]

Traditional [ ] Other [ ] (Please specify)……

32. Do farmers in your community often get training in postharvest management of tomatoes? Yes [ ] / No [ ]

33. Do you think you need such training? Yes [ ] / No [ ]

34. Are you willing to adopt innovative storage methods if they prove more effective than what you currently use? Yes [ ] / No [ ]

35. Do you get any financial / or infrastructural support to help store your produce?

Yes [ ] / No [ ]

APPENDIX IV (CONTINUED)

36. Is there any cooperative farmer group in your community? Yes [ ] / No [ ]

37. 36. Are you a member of this group? Yes [ ] / No [ ]

38. What are the various causes of postharvest losses of tomato in your community?

(Tick as many as applicable)

a. Lack of market avenues [ ]

b. Unreliable means of transport to transfer produce to market [ ]

c. Lack of adequate storage facilities [ ]

d. Lack of adequate storage technology [ ]

e. Non exposure to modern trends of tomato production [ ]

f. Lack of processing plants [ ]

g. Limited alternative uses of the produce [ ]

h. No idea [ ]

i. Other [ ] (Please specify)……

39. Have you experienced any massive loss of your produce before?

Yes [ ] / No [ ]

40. Which of the following forms was / were the losses?

Breakages [ ] Rot [ ] Other [ ] (Please specify)……

……

41. If the loss was due to breakages, did you identify what led to this?

Yes [ ] / No [ ]

42. If "Yes", could you please share them with us?

……

APPENDIX IV (CONTINUED)

43. If the loss was due to rot, did you identify what led to this?

Yes [ ] / No [ ]

44. If "Yes", could you please share them with us?

……

45. If the loss was due to any other reason, did you identify what led to this?

Yes [ ] / No [ ]

46. If "Yes", could you please share them with us?

……

……

47. On how many occasions have you experienced this?

At least once [ ] At least twice [ ] More than twice [ ]

48. Do you have a personal storage facility for your produce?

Yes [ ] / No [ ]

PRE-HARVEST AND POSTHARVEST PRACTICES

49. Do you pre arrange for market before harvesting? Yes [ ] / No [ ]

50. Do the buyers do the harvesting? Yes [ ] / No [ ]

51. At what time of the day do you usually harvest your produce?

Morning[ ] Afternoon [ ] Evening [ ] No specific time [ ]

52. Do you have any special reason for harvesting at a specific time of the day?

Yes [ ] / No [ ]

APPENDIX IV (CONTINUED)

53. Does your reason have anything to do with the shelf life of the produce?

Yes [ ] / No [ ]

54. At what stage of maturity do you harvest your produce?

Mature unripe [ ] Half ripe [ ] Red ripe [ ] Other [ ](Please specify)……

55. What packaging material do you use for your produce?

Shallow wooden boxes [ ] Long big wooden boxes [ ]

Other [ ] (please specify)……

56. Do you subject the produce to any special condition before packaging them for market?

Yes [ ] / No [ ]

57. If "Yes", can you share them with us?

……

……

58. How do you prolong the shelf life of your produce in case there is no ready market?

Stored in a specially conditioned storage facility [ ]

Frozen fresh [ ] Boiled and stored [ ]

Formed into puree and stored [ ] None of the above [ ]

Others [ ] (Please specify) ……

SECTION C – QUESTIONNAIRE FOR TRADERS ONLY

59. How long have been trading in tomatoes?

Less than a year [ ] Between 1 – 4 years [ ]

Between 5 – 8 years [ ] Over 8 years [ ]

60. What type variety of tomato do you deal in?

……

61. Do you have any reason for your choice? Yes [ ] / No [ ]

62. Can you share them with us?

……

63. Have you ever experienced a great loss of your goods through spoilage?

Yes [ ] / No [ ]

64. Has this situation been recurrent? Yes [ ] / No [ ]

65. Which of the following accounted for the losses?

Lack of ready market [ ] Lack of transport of produce [ ]

Lack of storage facility [ ] Poor storage [ ]

Pest attack [ ] Others [ ] (Please specify……

66. What generally do account for spoilage of tomatoes in your community?

Lack of ready market [ ] Lack of transport of produce [ ]

Lack of storage facility [ ] Poor storage [ ]

Pest attack [ ] Others [ ] (Please specify)……

67. Which of them do you consider the single most important cause of postharvest loss of tomato? Lack of ready market [ ] Lack of transport of produce [ ]

Lack of storage facility [ ] Lack of postharvest management skills [ ]

Poor storage [ ] Pest attack [ ]

Others [ ] (Please specify)……..

68. Are you often able to prolong the shelf life of your goods?

Yes [ ] / No [ ]

69. If "Yes", did you learn this skill from a special training? Yes [ ] / No [ ]

70. What organization organized this training?

Traders association [ ] MOFA staff [ ]

NGO [ ] (Please specify)……

71. Do you know of any other effective method of preserving farm produce aside what you have learnt from this/these organization (s)? Yes [ ] / No [ ]

72. If "Yes", can you share them with us?

……

73. Would you change your method of if another method it is proven more effective?

Yes [ ] / No [ ]

74. How would you assess the rate of tomato spoilage in your area over the years?

Very high [ ] High [ ] Low [ ] Very low [ ] Stable [ ] Reducing [ ]

75. Do you believe in the practice of increasing the production to compensate for losses?

Yes [ ] / No [ ]

76. If "Yes", do you practice that? Yes [ ] / No [ ]

77. How would you rate your profit margin over the years?

Stagnant [ ] Increasing [ ] Decreasing [ ] Not aware [ ]

SECTION C – QUESTIONNAIRE FOR MOFA STAFF ONLY

78. Does the Ministry have any special focus on tomato production?

Yes [ ] / No [ ]

79. Does the Ministry have any records on tomato production in the Region?

Yes [ ] / No [ ]

80. How does the Ministry rate tomato production in the Region?

Very high [ ] High [ ] Low very low [ ] No data [ ]

81. Are all the tomatoes consumed in the Region cultivated in the Region?

Yes [ ] No [ ] No idea [ ]

82. Does the Ministry have data on postharvest losses of tomato in the region?

Yes [ ] / No [ ]

83. How would you rate postharvest losses of tomato in the Region?

Very serious [ ] Serious [ ] Fairly serious [ ]

84. What are the major causes of postharvest losses of tomato in the District / Region?

Lack of ready market [ ] Lack of transport of produce [ ]

Lack of storage facility [ ]

Lack of postharvest storage technologies for the produce [ ]

Poor storage practices [ ] Disease attack [ ]

Others [ ] (Please specify)……

85. Does the Ministry train tomato farmers in postharvest storage technology?

Yes [ ] / No [ ]

86. Is the Ministry aware of any traditional postharvest practices used by farmers?

Yes [ ] / No [ ]

87. Has the Ministry ever researched the efficiency of these traditional methods?

Yes [ ] / No [ ]

SECTION C – QUESTIONNAIRE FOR CONSUMERS ONLY

88. Do you eat tomato? Yes [ ] / No [ ]

89. How often do you take tomato?

At least once daily [ ] At least twice daily [ ]

In all meals [ ] Not often [ ]

90. Do you have any information on the nutritional values of tomato?

Yes [ ] / No [ ]

91. Do you know of any substitute for the vegetable? Yes [ ] / No [ ]

92. Can you share it with us?

……

93. At what stage of maturity do you usually consume tomatoes?

Red ripe [ ] Half ripe [ ] Mature unripe (green) [ ]

Immature [ ] All of the above [ ]

94. Do you sometimes get more of the vegetable than you can use?

Yes [ ] / No [ ]

95. If "Yes", what do you do with the excess?

Frozen fresh [ ] Boiled and frozen [ ] Formed into puree and stored [ ]

Others [ ] (Please specify) …….

96. Would you classify these storage methods as very effective?

Yes [ ] / No [ ]

97. Are you aware of any other uses of the vegetable aside the traditional uses?

Yes [ ] / No [ ]

98. If "Yes", could you please share them with us?

. ……